IEA INTERNATIONAL ENERGY AGENCY

HYBRID & ELECTRIC VEHICLE IMPLEMENTING AGREEMENT

IA-HEV

Hybrid and Electric Vehicles

THE ELECTRIC DRIVE PLUGS IN

June 2011

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International Energy Agency

Implementing Agreement for co-operation on
Hybrid and Electric Vehicle Technologies and Programmes

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The electric drive plugs in.
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International Energy Agency

Implementing Agreement for co-operation on
Hybrid and Electric Vehicle Technologies and Programmes

Annual report of the Executive Committee and
Task 1 over the year 2010

Hybrid and Electric Vehicles
The Electric Drive Plugs In

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Report structure

This report consists of five main parts. Part A "About IA-HEV" describes the Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV), its activities, and its plans for the coming years. The Chairman's message in chapter 1 includes a summary of IA-HEV activities in 2010, as well as the current structure of the IA-HEV today. Chapter 2 explains the relationship between IA-HEV and the International Energy Agency (IEA), as well as describing the IA-HEV history, results, and current working programme. Chapter 3 presents the story of the IA-HEV clean vehicle awards.

Part B "IA-HEV task forces" presents the results of the work that is performed by the task forces working under this Agreement, called Tasks.

A general picture of hybrid and electric vehicles (H&EVs) around the globe is painted in part C, "H&EVs worldwide". The first chapter (13) in this section gives worldwide H&EV statistical information and general developments in 2010. More detailed information on H&EV activities in each IA-HEV member country is presented in chapters 14 through 30. Chapter 31 highlights H&EV issues in selected IA-HEV non-member countries.

Part D is dedicated to an outlook for the future of hybrid and electric vehicles through offering up a summary of the factors that should influence the uptake of these vehicles by the market as named by the members of the IA-HEV Executive Committee.

Finally, Part E gives practical information related to hybrid and electric vehicles and the Agreement, including a list of IA-HEV publications, definitions of vehicle categories, conversion factors for H&EV related units, a glossary of terms, abbreviations, and contact information of the IA-HEV participants.

1 Chairperson's Message

MANAGING EXPECTATIONS OF SCALE FOR ELECTRIC MOBILITY

Today the interest in hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs) has reached a very high level. No doubt these will be the leading technologies in the future, but it will be a long time before they achieve a dominant market share. New industries have to be created and built up. Specialists for electric drive systems and components have to be educated. International collaboration within the Implementing Agreement for Hybrid and Electric Vehicles in its 4th phase (2009–2015) will lower the hurdles for the market introduction of hybrid and electric vehicles.

Introduction

The past year, 2010, marked the first full calendar year of the 4th five-year phase of the IEA program, the Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). With Portugal as a new member country, we now have 15 IA-HEV members. This is the same number of members as 15 years ago in the mid-1990s when interest surrounding hybrid and electric vehicles first peaked. We expect more countries to join IA-HEV in 2011.

The IEA has identified 20 important technologies to lower carbon dioxide (CO_2) emissions by 2050. Electric and hybrid electric vehicles are included. The IEA technology roadmap *Electric and plug-in hybrid electric vehicles*, released in 2009, describes how sales for these vehicles may feasibly grow to several millions of units per year in 2020. This view is supported by our communication in 2010 (see also the IA-HEV annual report from March 2010, *Hybrid and Electric Vehicles. The Electric Drive Advances. Move Electric.*).

We are in an era of huge growth for the industry. The interest in hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (EVs) is currently at a very high level, with most major car manufacturers introducing HEV or PHEV models in 2011 and 2012. Countries are increasingly looking for alternative transportation solutions to combat greenhouse gas emissions (GHG) and lessen dependence on foreign oil imports.

Most IA-HEV member countries are supporting electric mobility to achieve larger energy goals. Even with all of this positive activity, EVs will still have a small market share when measured against the total worldwide vehicle sales. It is necessary to present a positive, yet realistic, picture of the EV industry, market, and challenges to the larger world outside of IA-HEV. However, many elected and appointed officials and the public believe the transition from internal combustion engines to electric mobility will occur immediately, which encourages “EV hype”. IA-HEV needs to manage expectations by presenting the more realistic scenario in which a sizable transition to electric mobility will occur over several decades. One of the main strategic objectives for the IA-HEV Phase 4 (which runs through February 2015) is to serve as a platform of reliable information on hybrid and electric vehicles.

There is no doubt that HEVs and PHEVs will be the leading technologies in the future, but it will be a long road to a dominant market share. New industries will need to be created and built up. Specialists for electric drive systems and components will need to be educated. We also expect the “EV hype” will be stabilized by steady market share growth for hybrid and electric vehicles. International collaboration that has already begun within IA-HEV, as well as complementary efforts such as the Clean Energy Ministerial’s Electric Vehicles Initiative, will lower the hurdles for hybrid and electric vehicles**.** Highlighted in the section below are some of the challenges to address and factors to consider for successful electric mobility markets.

NEW MODELS ON THE MARKET

Most car manufacturers in 2010 introduced or announced plans to introduce some type of EV, HEV, or PHEV in their vehicle line-up within the next few years. Based on the currently small production numbers, it will take pure EVs years to reach 1% of total new vehicle sales. The forecast is brighter for hybrid vehicles. However, hybrids are still just a “bridge technology” to full electric vehicles or to the plug-in-hybrids for long distance trips. The HEVs’ decrease in energy consumption is no improvement over the performance of 3.3-liter vehicles that were on the market in the late 1990s.

In November 2010 at the Electric Vehicle Symposium (EVS-25) in Shenzhen, we gained insights into the dynamic market of China. Electric bikes are a mass-market product in China. Other advanced vehicles such as buses, taxis, trucks, and passenger cars were displayed in large numbers.

BUILDING A NEW INDUSTRY WILL TAKE TIME

In addition to advanced batteries, HEVs, PHEVs, and EVs need specialized components such as motors, power electronics, and all their parts. Increasing production capacity for these components will take more than just a few weeks or months. However, identifying the need for more production capacity is a first step in overcoming this obstacle and avoiding the example in the following paragraph.

Last year the photovoltaic (PV) industry showed us an example of how dire the supply chain problems can be when an adequate supply of components is not addressed in the beginning stages of production. With the annual production volume of PV panels at about 20 GWp (gigawatts at peak power) in 2010, a serious shortage of inverter components blocked the PV market. The shortage of this key part of a solar installation came from a shortage of simple components that go into inverters such as electrolytic capacitors, magnetic components, etc. Delivery times for PVs went from days or weeks up to between one and two years.

If we assume that we will have about 8 million EVs and PHEVs in 2020 (according to the IEA *Electric and plug-in hybrid electric vehicles* roadmap), and if we also assume that an EV or PHEV has a drivetrain with a total power of 50 kW, the total need for power electronic parts would be 400 GW, or 20 times as large as the current size of the solar market. IA-HEV is planning ahead for this growth in demand, and therefore I welcome our new working group Task 17, "System integration and optimization of components for enhanced overall electric vehicle performance". Participating in this Task is a chance for all countries, research institutes, and components manufacturers with an interest in the commercialization of EV components to prepare for the opportunities in the rapidly growing electric drivetrain industry.

THE LONG JOURNEY TO A MASS MARKET

Market introduction goals are set in many IEA member countries (see section 12.2 of the IA-HEV annual report 2010). Often these sales targets are based on the idea that governments will pay high subsidies for EVs, but in fact, it is risky to believe that countries could subsidize EVs over several years. If the technology does not continue to improve or the price of EV batteries does not fall fast enough, elected or appointed officials could lose their interest in this technology and cease to support or promote EVs and PHEVs.

EVs, like all new products, need to make the long journey from the first purchases by the early adopters to selling to the mass market. In the sales process, the benefits of an EV need to be clearly described to the purchaser because the high initial price of the battery requires a different way of thinking about expenses. A plug-in electric vehicle has a greater initial purchase price, but a lower operating cost. Additionally, in order to inspire consumer confidence, charging infrastructure and service and repair points for EVs have to be built and employees need to be trained to provide those services. Car producers and the electric utility companies will need a common language for the charging network for EVs and PHEVs to operate as efficiently as the familiar system of petrol (or gasoline) stations.

In many cases, we are still waiting for series production of the planned PHEV models to become available to consumers. Determining realistic standards for the energy consumption (or fuel economy) of PHEVs could be a task for our Implementing Agreement.

CLEAN ELECTRICITY PRODUCTION NEEDED

Electric mobility is supplied by the energy mix in each country. The energy supplying EVs and PHEVs emits source pollution depending on the energy supply. In order to reduce CO_2 emissions from transport, the energy supply for vehicles will need to be from renewable sources. If the energy supplied for vehicles comes from fossil fuels, many early adopters may be discouraged from purchasing an EV or PHEV. Nuclear power supplies also may be a deterrent for vehicle purchase.

The production of the additional “green” electricity to support the growing fleet of plug-in vehicles is not a problem for many countries, while it is a challenge in other places. For example, Germany would need about 2 GWp of photovoltaic power plants to propel 1 million EVs, the country goal for 2020. In 2010, Germany built this 2 GWp of PV sources in three months. The electricity for EVs will also come from wind, hydro, and biomass plants.

The emerging world of electric mobility and vehicles plugging into the grid is very difficult for most of the utility companies to understand. These companies are struggling with market liberalization, which challenges their traditional business models that are rooted in price regulation. EVs could foster new business models, but it is unclear if the utility companies can seize this opportunity. The situation is similar to the telecommunication industry in the 1980s and 1990s, when many of the traditional businesses and companies disappeared and new companies arose in the wake of deregulation.

WHAT ARE THE CUSTOMER BENEFITS OF EVS, AND WHERE IS THE CUSTOMER?

Finally, for the mass market we have to answer the question: what are the real benefits for hybrid, plug-in hybrid, and electric vehicle users? Without a convincing answer, the customer will not buy these vehicles.

However, we have discovered over the past 25 years what is necessary for customers to adopt EVs. For the German goal of 1 million EVs in 2020, success means the following:

- Only 2% of drivers need to purchase EVs
- These EV drivers do not need special charging stations.
- They do not need long-range capabilities.
- They are able to pay more for this special car, which has cost.

Summary of IA-HEV activities during 2010

IA-HEV was very busy in 2010. The first Executive Committee (ExCo) meeting in London, United Kingdom (UK) in April was under the ash cloud of the volcano Eyjafjallajökull in Iceland. Although only a few delegates actually arrived in London because air traffic in Europe was grounded, some of us had extra time to learn about the UK's plans for electric mobility as a preview to the rescheduled ExCo meeting that then happened in June. The second ExCo meeting of the year preceded EVS-25 in Shenzhen, China, which many IA-HEV members were also attending.

Eight Tasks, or working groups, were active in 2010, and each held separate meetings and workshops. Additionally, the IA-HEV leadership, Task operating agents, and members attended many meetings of the International Energy Agency (IEA) in Paris and elsewhere. The new communication activities cumulated in a very comprehensive annual report 2010, which was received very well.

STRONGER COLLABORATION WITH IMPLEMENTING AGREEMENTS AND IEA HEADQUARTERS

We coordinate our activities with other IEA transport-related Implementing Agreements through the Transport Contact Group (TCG), led by the End-Use Working Party (EUWP) deputy chair for transport Mr. Nils-Olof Nylund. For example, the strong growth of new renewable energies for the production of electricity brings us new challenges. Electricity storage methods are an important condition for including high shares of renewable electricity in the grid. By using smart or intelligent charging of electric vehicles, we can store the excess "clean" energy in vehicle batteries at times of high production, such as photovoltaic electricity production during the day or wind power production at night and during winter. EVs used with a smart grid benefit both "clean" technologies and vehicles in market growth.

As announced in the annual report 2010, IA-HEV collaborated with the Implementing Agreement on Renewable Energy Technology Deployment (RETD) on its study of renewable energy use in the transport sector, which it finished and released during the year. For IA-HEV member representatives, our contributions have meant more meetings and more work. The introduction of the IEA roadmap for smart electricity grids also challenged us to contribute to other IEA-related working groups. We are well prepared to contribute due to our expertise in this field. Charging electric vehicles is an interesting aspect in a smart grid that also supports a cost-efficient and reliable electricity supply.

RISING INTEREST IN RUNNING NEW TASKS

Currently IA-HEV is running nine Tasks. The majority of IA-HEV work is conducted through Task participation. During 2010, Task 13 "Fuel cell vehicles" concluded and Task 17, "System Integration," and Task 18, "EV Ecosystems," began. Highlighted below are the brief descriptions of each Task. More in-depth information is available in the Task chapters.

TASK 13 "FUEL CELL VEHICLES" ROUNDED OFF SUCCESSFULLY

In November 2010, we closed Task 13 on fuel cell vehicles, which was managed by the Austrian Agency for Alternative Propulsion Systems (A3PS). As usual, in the first years the results are reserved for the participating countries of the Task. Project leader Andreas Dorda of A3PS) summarized some of the findings:

- Starting a fuel cell vehicle (FCV) at low temperatures is no longer a problem. This is an achievement of the last few years.
- Today costs are the main barrier for the market introduction of FCVs. One car producer believes that the cost reduction potential for FCVs is greater when compared with the cost reduction potential for EVs.
- Solid oxide fuel cells seem to be suitable for heavy-duty applications and currently receive a lot of attention.
- A key year for FCVs will be in 2015, because OEMs will offer the first FCVs on the market.

I congratulate Andreas Dorda and the A3PS agency for their management of this Task, and I thank the participating countries Austria, Switzerland, and the United States (U.S.) for their work.

Active Tasks

Information Exchange (Task 1)

This working group plays a key role in IA-HEV. It ensures regular information exchange on hybrid, electric, and fuel cell vehicle developments and promotion measures in the member countries as well as the most interesting non-member countries. The working group also serves as a "turntable" by publishing figures and basic information on the Agreement's website and producing this comprehensive Annual Report. The exchange of informal and current information, which is the specific benefit of participation, is only available for the member countries. Participation in this Task is included in the membership fee of the Implementing Agreement. The Task 1 Operating Agent is Kristin Abkemeier on behalf of the Vehicle Technologies Program at the U.S. Department of Energy (DOE).

Electrochemical Systems (Task 10)

This working group focuses on aspects that are not discussed elsewhere within the battery community or at battery conferences, such as experiences with specific test protocols or the abuse of batteries. The Operating Agent is James Barnes from the Vehicle Technologies Program of the U.S. DOE. Membership is free for IA-HEV member countries.

Electric Cycles (Task 11)

In several countries, electric two-wheeled vehicles have become a huge market segment in the transport sector, especially in China. In several European countries, electric bicycles are used for commuter trips and have become a successful market niche. Because of different quality standards, vehicles do not necessarily match both markets, and there are still a lot of open questions concerning standards, licensing, and market deployment. This group started its work in March 2006 and is planning to round off its work by mid-2011. The European Association for Battery, Hybrid and Fuel Cell Electric Vehicles (AVERE) is operating this Task. Robert Stüssi served as the Operating Agent in 2010.

Heavy-Duty Hybrid Vehicles (Task 12)

This working group aims at structuring the information about heavy-duty hybrid vehicle components and configurations. An important aspect of this task is to gain insight into existing and possible applications of heavy-duty hybrid vehicle technologies. Besides the obvious vehicle types like buses and trucks, other applications of conventional heavy-duty vehicle technology like dedicated and off-road vehicles may be candidates for hybridization. The Task also studies the current situation of existing hybrid prototypes and standard vehicles. The information gathering focused on applied technologies, costs and merits. This Task will be rounded off in mid-2011. The Operating Agent is Carlo Mol from the Belgian research institute VITO.

Market Deployment of Electric Vehicles: Lessons Learned (Task 14)

The "Lessons learned" Task analyzes the reasons for success and failure at introducing hybrid and electric vehicles to new markets. A previous task force, Deployment Strategies for Hybrid, Electric and Alternative Fuel Vehicles (Task 08), investigated 95 promotion measures run by governments or other public and private organizations to enable the market deployment of clean vehicle technologies. However, this earlier effort did not include gathering stories about the success or failure of these measures. This became the task of Task 14. Learning from past mistakes along with past success is an important aspect for consideration in current vehicle deployments.

The research group consists of specialists from the U.S., Japan, and Europe. Data collection for this Task was rounded off in 2010. The Task will submit the final report to the IEA to achieve a wider distribution. Tom Turrentine from the Plug-in Hybrid Electric Vehicle Center of the University of California, Davis serves as the Operating Agent.

Plug-in Hybrid Electric Vehicles (Task 15)

The new Operating Agent Danilo Santini (working for the Argonne National Laboratory, U.S) has prepared an updated work plan for the remaining year of this working group. New participants are still welcome in this Task. Interested research institutes, private companies (sponsors), and countries are invited to contact the Operating Agent for more information.

Fuel and Technology Alternatives for Buses (Task 16)

This is a joint Task with the Implementing Agreement (IA) on Advanced Motor Fuels and the IA on Bioenergy. Currently IA-HEV participation is under discussion. Nevertheless, the work in this Task has started and the exhaust emissions of a number of buses have been measured. Nils-Olof Nylund from the VTT research institute in Finland is the Operating Agent of this Task.

System Integration and Optimization of Components for Enhanced Overall Electric Vehicle Performance (Task 17)

This new Task (System integration) is based on the idea that an optimized integration of the electric drivetrain and components (electric motors, batteries, supercapacitors, internal combustion engines, and fuel cells) into the vehicle can provide a significant contribution to the feasibility of electric propulsion systems. For example, components could be combined in more efficient ways, such as integrating charging functions into existing systems or combining energy storage technologies, such as batteries and supercapacitors, in order to create a more effective storage system.

The first meeting for this Task was held in combination with the conference "Vehicle Integration and System Optimization" in Vienna in November 2010. New participants are welcome to join. Gabriela Telias from the A3PS is the Operating Agent.

Electric vehicle ecosystems, or EV ecosystems (Task 18)

Task 18 on EV ecosystems will capture practical experience from cities, regions, and businesses that are pioneering advanced EV pilot programs. The operation of thousands of EVs in cities will require changes to urban systems. This encompasses "hard infrastructure" such as recharging technologies, smart grids, and transport systems along with “soft infrastructure” such as regulation, business models, skills and community engagement. Blending this complex mix of technologies and services into the fabric of cities requires alignment between governments, municipal authorities and other key stakeholders from the automotive manufacturing sector, energy companies, and technology suppliers**.** The primary tasks are highlighted below.

- Roadmapping workshops with first-cut roadmaps tailored for each city
- An International Roadmap to establish a blueprint for provision of infrastructure for EVs based on the city roadmaps
- A global community of pioneering cities connecting international experts in an interactive web portal and a series of EV Congress meetings to facilitate policy exchange and problem solving

New members are welcome. David Beeton, Centre for Industrial Growth, UK, is the Operating Agent and Tom Turrentine, University of California at Davis, USA, is the Vice-operating Agent.

Tasks in the planning stage

We aim to start new working groups on two topics within the coming year:

- Life cycle assessment and e-waste management for e-mobility
- Lithium ageing accelerated testing procedures

Life cycle assessment and e-waste management for e-mobility (A potential new Task)

The objectives of the proposed Task are the following:

- To provide policy and decision makers with facts and figures in order to make informed decisions about energy and material issues related to electric mobility.
- To improve end-of-life management of EVs (and auxiliary systems) through the promotion of best available technologies and practices.
- To improve EV (and auxiliary systems) designs for optimal recyclability and minimal resource requirements and losses.

The work plan is currently being detailed and can still be adapted to the needs of the participants. Organizations that are interested in participating are invited to contact the IA-HEV secretary, Martijn van Walwijk.

Lithium ageing accelerated testing procedures (A potential new Task)

The main objectives of this new Task will be as follows:

- To inventory worldwide efforts on the development and application of accelerated testing procedures aimed at analyzing the ageing of Li batteries in various vehicle applications.
- To collect procedures and the expertise available in various laboratories to verify the compatibility of the approaches.
- To verify, even experimentally, differences and harmonization needs to render a standard testing procedure accepted in different member states and regions, taking into account various operating conditions.

The work plan is currently being detailed and can still be adapted to the needs of the participants. Organizations that are interested in participating are invited to contact the IA-HEV secretary.

We welcome Portugal as new member country and expect more members in 2011.

Because of the rising interest in electric and hybrid vehicles, more and more countries are interested in participating in IA-HEV. In 2010, we welcomed Portugal as a new IA-HEV member. Portugal is a front-runner in setting up an infrastructure to recharge EVs and currently has a countrywide system in place to pay for recharging. The European Commission, Germany, Ireland, and South Africa have also been formally invited to join the Agreement. We hope that we can welcome them as new members in 2011.

For all countries interested in electric and hybrid vehicles, membership and collaboration in our Implementing Agreement is a good choice. It is an indication of their commitment to the field of hybrid- and electric vehicles. We expect many new member countries in the coming years resulting in over twenty IA-HEV countries and organizations.

A word of thanks goes to the management team of our Implementing Agreement.

The past year, 2010, was the first full calendar year of the 4th phase of the IA-HEV. After the preparation efforts of 2009 for the current phase, we are now able to focus on the new Task 1 communication strategy and the Task work.

The management team along with secretary-general Martijn van Walwijk, appreciates the support of Patrick Leuthold, Margrit von Ballmoos, and Sigrid Kleindienst in the Switzerland office, who were most efficient in their contributions. Together with the information exchange and communication team from the U.S.—led by Kristin Abkemeier, with tremendous contributions from Alison Mize, we are well prepared for the coming years. As always, most of the work in the Agreement was done in the Tasks. I thank all the participants and especially the Operating Agents for their efforts.

Due to the growth of the Agreement, more efforts were made by the chairperson who thanks his home country Switzerland for its support. With his new position as Professor on the Berne University of Applied Science and with its Institute of “Energy and mobility”, the role of IA-HEV chairperson fits perfectly within his new work.

We look forward to making more progress in the coming year to advance electric mobility.

April 2011
Urs Muntwyler
IA-HEV chairperson

2

The IEA and its Implementing Agreement on Hybrid and Electric Vehicles

This chapter introduces the International Energy Agency (IEA) and its Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV).

2.1
The International Energy Agency

2.1.1
Introduction

The IEA acts as energy policy advisor for the governments of its 28 member countries (see box 2.1) and beyond to promote reliable, affordable and clean energy for the world's consumers. It was founded during the oil crisis of 1973-74 with a mandate to co-ordinate measures in times of oil supply emergencies. This is still a core mission of the agency. In June 2011, the 28 IEA member countries agreed to release 60 million barrels of oil in the following month in response to the ongoing disruption of oil supplies from Libya. This was the third time in its history that the IEA has been called upon to ensure an adequate supply of oil to the global market.

Box 2.1
IEA member countries - 2010

Australia	France	Republic of Korea	Slovak Republic
Austria	Germany	Luxembourg	Spain
Belgium	Greece	The Netherlands	Sweden
Canada	Hungary	New Zealand	Switzerland
Czech Republic	Ireland	Norway	Turkey
Denmark	Italy	Poland	United Kingdom
Finland	Japan	Portugal	United States

The European Commission also participates in the work of the IEA.

With the evolution of the energy markets, the IEA mandate has broadened. It now focuses well beyond oil crisis management. Energy efficiency, climate protection, energy technology collaboration, and sharing its accumulated energy policy experience with the rest of the world have become core agency objectives. In July 2005, the G8 leaders at the Gleneagles summit asked the IEA to provide advice on strategies for a clean, secure, and sustainable energy future.

The shared goals of the IEA form the basis of balanced energy policy making:

- **Energy security:** Promote diversity, efficiency, and flexibility within the energy sectors of the IEA member countries. Remain prepared to respond collectively to energy emergencies. Expand international co-operation with all global players in the energy markets.
- **Environmental protection:** Enhance awareness of options for addressing the climate change challenge. Promote greenhouse gas emission abatement, through enhanced energy efficiency and the use of cleaner fossil fuels. Develop more environmentally acceptable energy options.
- **Economic growth:** Ensure the stable supply of energy to IEA member countries and promote free markets in order to foster economic growth.

2.1.2
Structure of the IEA

The IEA meets its evolving mandate through the activities of its offices and focused international collaboration. Fostering energy technology innovation is a central part of the IEA's work. Development and deployment of safer, cleaner, and more efficient technologies is imperative for energy security, environmental protection, and economic growth. IEA experience has shown that international collaboration on these activities avoids duplication of effort, cuts costs, and speeds progress.

The IEA Committee on Energy Research and Technology (CERT) co-ordinates and promotes the development, demonstration, and deployment of technologies to meet challenges in the energy sector. The CERT has established four expert bodies: the Working Party on Fossil Fuels; the Working Party on Renewable Energy Technologies; the Working Party Energy on End-Use Technologies and the Fusion Power Co-ordinating Committee. In addition, expert groups have been established to advise on electric power technologies, R&D priority setting and evaluation, and on oil and gas (figure 2.1).

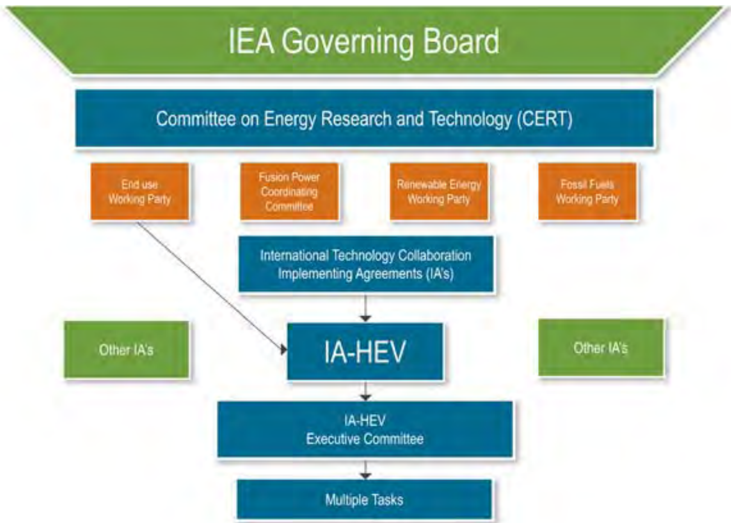

Fig. 2.1 The IEA energy technology network.

The IEA also provides a legal framework for international collaborative energy technology RD&D (research, development, and deployment) groups, known as Implementing Agreements (IAs). There are currently 42 Implementing Agreements covering fossil fuels, renewable energy, efficient energy use (in buildings, energy, and transport), fusion power, electric power technologies, and technology assessment methodologies. The Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) is one of them. It reports to the End-Use Working Party (EUWP). A full list of current Implementing Agreements is available on the IEA website at www.iea.org/techagr. For more information, see also section 2.1.3. below.

Under guidance from the CERT, the IEA Secretariat provides authoritative information and analysis on how energy technology can make a difference. It plays a strong role in IEA work under the 2005 Gleneagles summit mandate from G8 leaders to "advise on alternative energy scenarios and strategies aimed at a clean, clever, and competitive energy future."

2.1.3
IEA Implementing Agreements

Since its creation in 1974, the International Energy Agency (IEA) has provided a structure for international co-operation in energy technology research, development, and deployment. Its purpose is to bring together experts in specific technologies who wish to address common challenges jointly and share the fruits of their efforts. Within this structure, there are currently more than 40 active programmes, known as the IEA Implementing Agreements. Over three decades of experience have shown that these Agreements contribute significantly to achieving faster technological progress and innovation at lower cost. Such international co-operation helps to eliminate technological risks and duplication of effort, while facilitating processes like harmonization of standards. Special provisions are applied to protect intellectual property rights.

IEA Implementing Agreements are at the core of the IEA's international energy technology co-operation programme. This programme embraces numerous other activities that enable policy makers and experts from IEA-member and non-member countries to share views and experience on energy technology issues. Through published studies and workshops, these activities are designed to enhance policy approaches, improve the effectiveness of research programmes, and reduce costs.

The "IEA framework for international energy technology co-operation" sets out the minimum set of rights and obligations of participants in IEA Implementing Agreements. Participants are welcomed from OECD member and OECD non-member countries, from the private sector, and from international organizations.

Participants in Implementing Agreements fall into two categories: Contracting Parties and sponsors.

- Contracting Parties can be governments of OECD member countries and OECD non-member countries (or entities nominated by them). They can also be international organizations in which governments of OECD member and/or OECD non-member countries participate, such as the European Communities. Contracting Parties from OECD non-member countries or international organizations are not entitled to more rights or benefits than Contracting Parties from OECD member countries.
- Sponsors, notably from the private sector, are entities of either OECD member or OECD non-member countries that have not been designated by their governments. The rights or benefits of a sponsor cannot exceed those of Contracting Parties designated by governments of OECD non-member countries, and a sponsor may not become a chair or vice-chair of an Implementing Agreement.

Participation by Contracting Parties from OECD non-member countries or international organizations or by sponsors must be approved by the IEA CERT.

The Implementing Agreement mechanism is flexible and accommodates various forms of energy technology co-operation among participants. It can be applied at every stage in the energy technology cycle, from research, development, and demonstration through to validation of technical, environmental, and economic performance, and on to final market deployment. Some Implementing Agreements focus solely on information exchange and dissemination. The benefits of international co-operation on energy technologies in Implementing Agreements are shown in box 2.2.

Box 2.2
Benefits of international energy technology co-operation through IEA Implementing Agreements

- Shared costs and pooled technical resources
- Avoided duplication of effort and repetition of errors
- Harmonized technical standards
- A network of researchers
- Stronger national R&D capabilities
- Accelerated technology development and deployment
- Better dissemination of information
- Easier technical consensus
- Boosted trade and exports

Financing arrangements for international co-operation through Implementing Agreements (IAs) is the responsibility of each IA. Types of financing fall into three broad categories:

- Cost sharing, in which participants contribute to a common fund to finance the work.
- Task sharing, in which participants assign specific resources and personnel to carrying out their share of the work.
- Combinations of cost and task sharing (such as in the IA-HEV).

Effective dissemination of results and findings is an essential part of the mandate of each Implementing Agreement. Wide-ranging products and results are communicated by various means to those who can use them in their daily work. For its part, the IEA Secretariat circulates the on-line OPEN Energy Technology Bulletin, which reports on activities of the Implementing Agreements. IA-HEV activities are regularly highlighted in the OPEN Bulletin. The IEA also bi-annually issues a publication, “Energy technologies at the cutting edge”, that presents updates on the Implementing Agreements’ major achievements. These reports can be downloaded free of charge from the internet website: www.iea.org/Textbase/publications/free_all.asp.

In March 2008, the vice chairman for transport of the End-Use Working Party started a new initiative by organizing a Transport Contact Group (TCG) workshop for the transport-related Implementing Agreements, with the objective of strengthening their collaboration. IA-HEV actively participates in the Transport Contact Group.

2.1.4
IEA technology roadmap – electric and plug-in hybrid electric vehicles

The IEA has started to develop roadmaps for more than 20 major technologies which may counteract climate change. This was done at the request of the Hokkaido G8 summit that took place in July 2008. These technologies include electric vehicles and plug-in-hybrid electric vehicles. This EV and PHEV roadmap addresses technology targets, vehicle deployment infrastructure, and the required investments. The final report has been ready since October 2009 for the attention of international energy transport policy makers. The report may be found at the IEA website: http://www.iea.org/papers/2009/EV_PHEV_Roadmap.pdf. A brief summary of the report's main points is included here.

GLOBAL CO_2 CUT BY 2050: WHERE THE REDUCTIONS COME FROM

The roadmap study is based on two scenarios: the baseline with CO_2 emissions continuing to grow along current trends, and the more ambitious BLUE Map scenario. According to this latter scenario, introduced in the IEA publication *Energy Technology Perspectives 2008*, global CO_2 emissions could be reduced by 50% from 2005 levels by 2050. The chart (figure 2.2) shows the respective shares of the reduction from four different energy users: power production, industry, buildings, and transport.

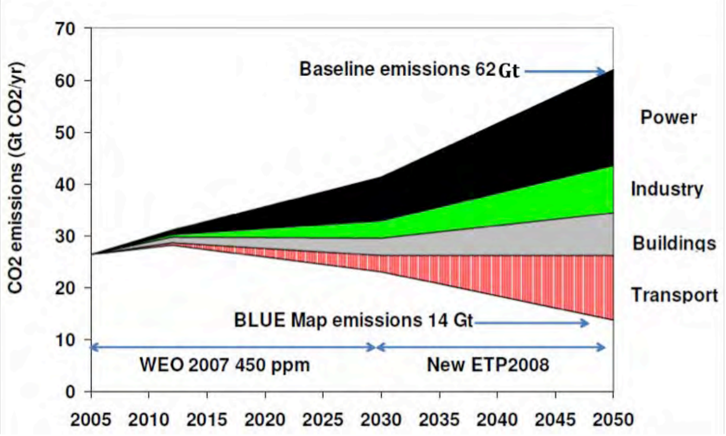

Fig. 2.2 Cutting carbon emissions from baseline growth to the BLUE Map scenario. (Source: *Energy Technology Perspectives 2008*, IEA.)

TRANSPORT ENERGY USE BY SCENARIO

In the BLUE Map scenario, transport energy consumption decreases almost to the level of 2005, including a more than 50% share of low-CO_2 fuels (see figure 2.3). The baseline scenario (IEA *World Energy Outlook* reference case) shows an 80% increase of fuel usage for transportation by 2050. This depends mainly on car sales and freight, which is sensitive to economic growth. Besides increasing fuel economy, improvement to vehicle electrification seems to be key to achieving the necessary reduction in fuel consumption, with the following factors in its favor:

- Costs for batteries and fuel cells are dropping.
- EVs may reach commercial production very soon.
- PHEVs appear to be a promising transition strategy.

Additional reductions may come from changes in the nature of travel.

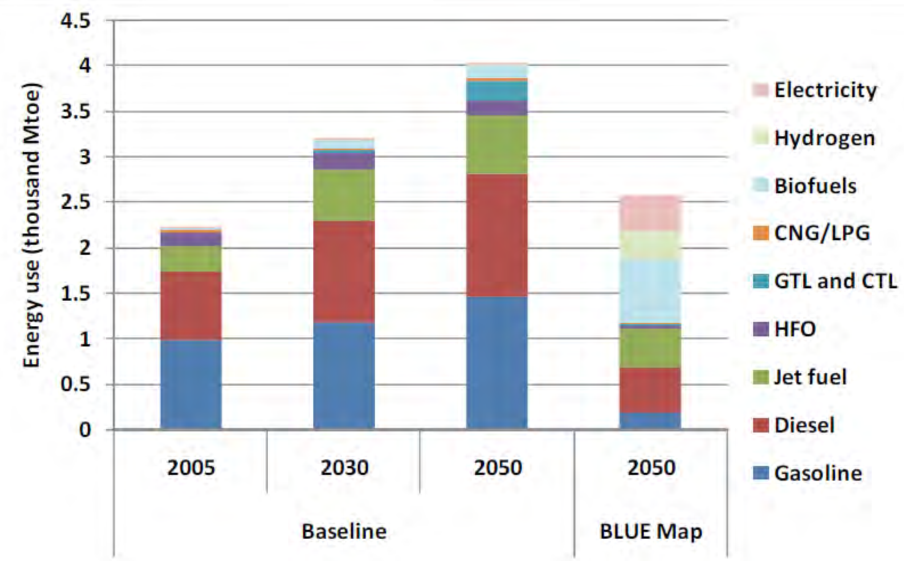

Fig. 2.3 ETP transport energy use by scenario. (Source: *Energy Technology Perspectives 2008,* IEA.)

BLUE MAP SCENARIO: ADVANCED TECHNOLOGIES MUST PLAY A MAJOR ROLE

The market penetration of new technologies is needed to support the transition to decreased carbon emissions. The BLUE Map scenario for passenger light-duty vehicles is shown in figure 2.4. Part of this scenario is a strong growth of passenger vehicle sales per year, which almost triple by 2050 compared to 2005. This growth happens in the developing countries such as China, India, Brazil, and Indonesia and could create shortages in raw materials. The key point is that the IEA roadmap sees rapid light-duty vehicle technology evolution over time.

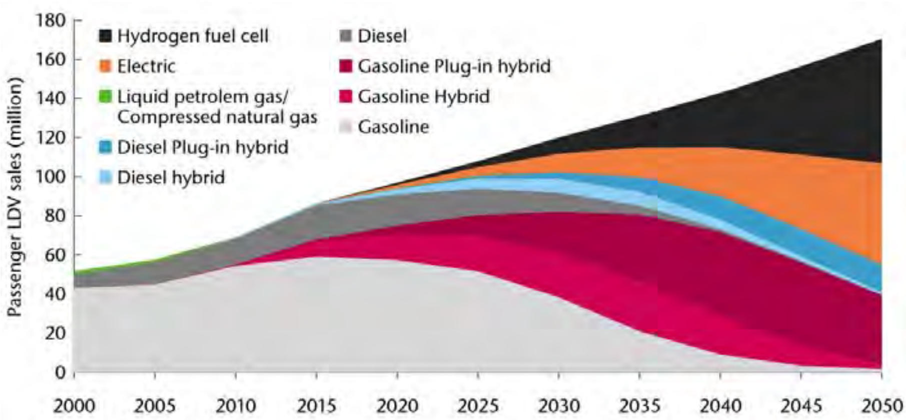

Fig. 2.4 Annual light-duty vehicle sales by technology type, BLUE Map scenario. (Source: *Technology Roadmap: Electric and plug-in hybrid electric vehicles,* IEA, 2009.)

BLUE MAP SCENARIO: EV AND PHEV SALES TRAJECTORY TO 2050

To reach the goals of the BLUE Map scenario, the sales of the two propulsion technologies of the future—EVs and PHEVs—must increase to 100 million units per year in 2050, as depicted in figure 2.5. This is a very ambitious goal, requiring that EV and PHEV sales reach a significant level by 2015 and rise rapidly thereafter. The magnitude of this challenge is easy to imagine if you compare with today's situation, where EVs and PHEVs have yet to break out of niche markets into the mainstream.

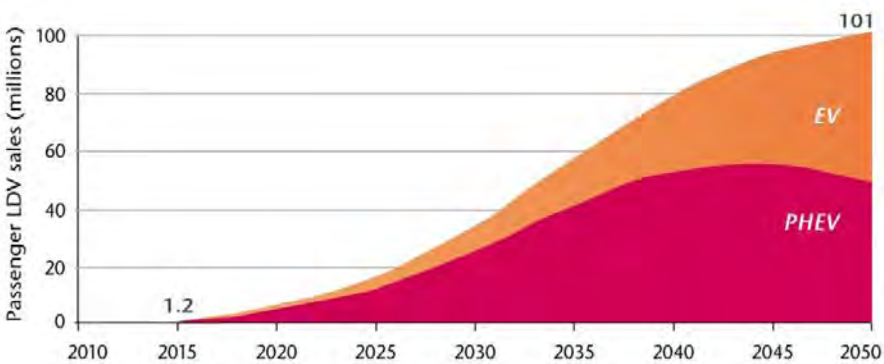

Fig. 2.5 Annual global EV and PHEV sales in BLUE Map scenario (Source: *Technology Roadmap: Electric and plug-in hybrid electric vehicles,* IEA, 2009.)

In order to achieve these deployment targets, many EV and HEV production plants are needed. The bottlenecks are the production capacities for the key components like motors, power electronics, and especially high-energy batteries. A key element will be the battery price, which must fall to US$300 per kWh if total EV vehicle costs are to be competitive with those of today's internal combustion engine cars and trucks.

The roadmap also offers a feasible growth scenario for reaching appreciable sales of EVs and PHEVs by 2020, which could evolve as shown in table 2.1. This scenario shows that sales per model must rise rapidly to reach the economic scale. At the same time, the number of producers and models must also rise rapidly.

Table 2.1 A scenario for ramping up sales of EVs and PHEVs between 2010 and 2020. (Source: *Technology Roadmap: Electric and plug-in hybrid electric vehicles,* IEA, 2009.)

Number of models and annual sales for EVs and PHEVs	Year			
	2010	2012	2015	2020
EV – number of models	2	4	8	20
Annual EV sales per model	2,000	10,000	50,000	120,000
Total annual EV sales	**4,000**	**40,000**	**400,000**	**2,400,000**
PHEV – number of models	2	4	16	40
Annual PHEV sales per model	2,000	10,000	50,000	120,000
Total annual PHEV sales	**4,000**	**40,000**	**800,000**	**4,800,000**

EV AND PHEV ROADMAP VISION OF SALES PER REGION

The roadmap lists 16 countries with EV and PHEV sales targets cited from different sources. Many governments have announced ambitious figures for the EV and PHEV sales in their respective countries. As shown in figure 2.6, in the starting phase the OECD countries will be dominant. After 2020 sales in the non OECD-countries like China and India will gain importance.

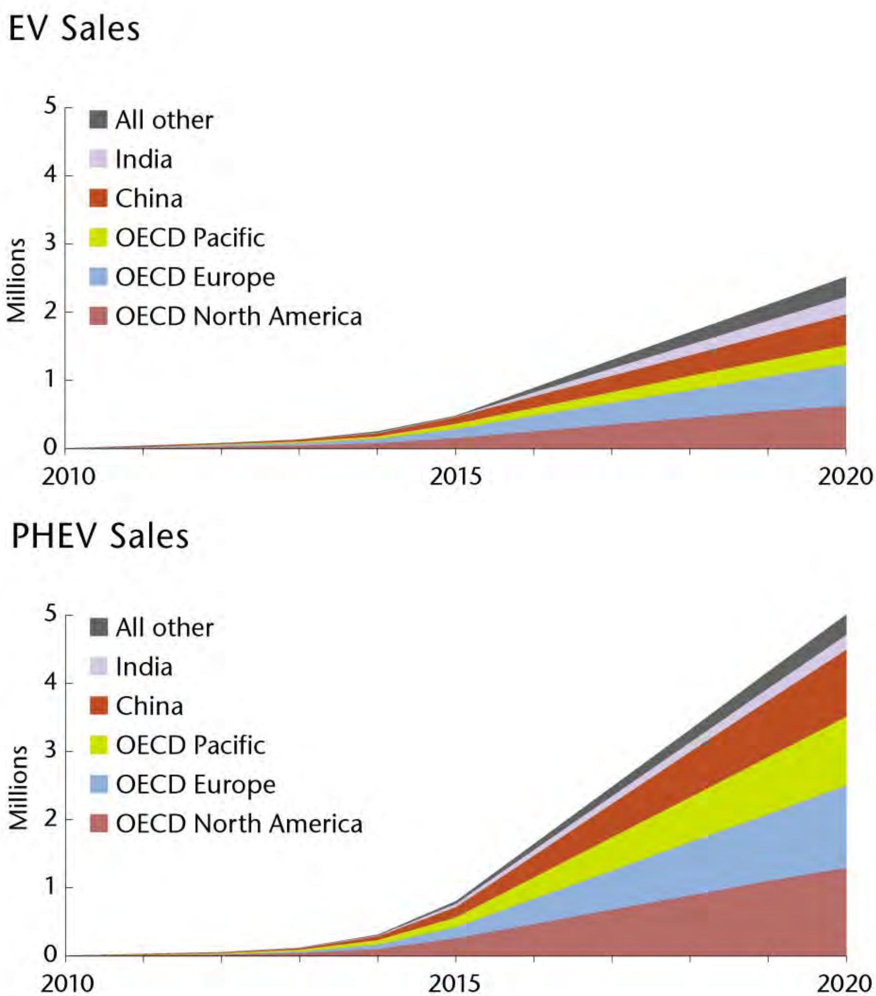

Fig. 2.6 EV and PHEV total sales by region through 2020: Sales figures for EVs (top) and PHEVs (bottom). (Source: *Technology Roadmap: Electric and plug-in hybrid electric vehicles,* IEA, 2009.)

NEAR-TERM ACTIONS FOR EV AND PHEV EXPANSION

To reach these ambitious sales figures, the automotive industry, governments, electric power companies, and other stakeholders must work together. The key actions are:

- Setting targets for electric vehicle sales.
- Developing coordinated strategies to support the market introduction of electric vehicles, including policy support and incentives which make the vehicles cost-competitive.

- Exploring new approaches such as battery leasing, which a fleet test in Mendrisio, Switzerland showed to be a very helpful measure to bring the vehicle purchase price to a competitive level.
- Improving understanding of consumer needs and behavior: Governments and industry must identify and target "early adopters" by using successful business models for vehicles with different driving ranges, performances, and price levels.
- Developing performance metrics for characterizing vehicles and to track progress in areas including driving range and battery performance.
- Expanding RD&D initiatives to reduce battery costs and address resource issues, because costs must come down from the current range of US$500–800 per kWh to US$300–400 per kWh by 2020.
- Developing and implementing recharging infrastructure. In the first market introduction phase, the infrastructure for EVs and PHEVs is not critical. It is important that electricity comes from clean and mainly new renewable sources. Availability of public infrastructure supports the market introduction of these vehicles. In the meantime, smart grid issues must be developed and introduced to provide the background for further market growth.

2.2
The Implementing Agreement on Hybrid and Electric Vehicles

Very few IEA countries do not have problems with urban air quality, and a few others are self-sufficient in oil, but all IEA countries have problems with greenhouse gas emissions from automobiles. There is a range of technologies available to address these problems, including hybrid and electric vehicles. This means that there is a sound basis for an IEA Implementing Agreement (IA) working on these vehicles. The IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) was created to collaborate on pre-competitive research and to produce and disseminate information. IA-HEV is now in its fourth five-year term of operation that runs from December 2009 until February 2015. The 16 active Contracting Parties (member countries) per July 2011 are Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States of America (U.S.).

Compared to the automotive industry and some research institutes, IA-HEV is a relatively small player in the field. By focusing on a target group of central and local governments and government-supported research organizations, and by providing a forum for different countries to co-operate in joint research and information exchange activities, IA-HEV can play a role. More countries are invited to join the

Agreement and to benefit from this international co-operation on hybrid and electric vehicles.

The work of IA-HEV is controlled by the Executive Committee (ExCo), which consists of one member designated by each Contracting Party. Contracting Parties are either governments of IEA countries or parties designated by their respective governments. The IA-HEV ExCo meets twice a year to discuss and plan the working programme. The actual work on hybrid and electric vehicles is being done by different task forces that work on specific topics. Each topic is addressed in a Task, which is managed by an Operating Agent (OA). (Prior to 2011, these task forces were called "Annexes".) The work plan of a new Task is prepared by an interim Operating Agent (either on its own initiative or on request of the ExCo) before it is submitted for approval to the IA-HEV Executive Committee. The Tasks that were active during 2010 and in early 2011 are described in part B (chapters 4 through 12) of this report. The activities regarding hybrid and electric vehicles in IA-HEV member countries can be found in part C.

The next two subsections (2.2.1 and 2.2.2) briefly report on IA-HEV activities and results in its second and third terms of operation (phase 2 and phase 3), respectively. The strategy for the current term of operation, phase 4 (2009-2015), and its details are reported in subsection 2.2.3.

2.2.1
Description and achievements of IA-HEV phase 2, 1999–2004

The second phase of IA-HEV started in November 1999 at a time when the first hybrid vehicle, the Prius, had just been introduced to the market, and battery electric vehicles were considered suitable for some market niches such as neighborhood electric vehicles, small trucks for local deliveries, or two- or three-wheel vehicles. Although good progress had been made in battery technology, low-cost, high-performance traction batteries were not yet commercially available. Progress with fuel cell technology led to optimism about a "hydrogen economy," and car manufacturers switched their attention to fuel cells and away from battery electric vehicles.

The Tasks in phase 2 and their main achievements are listed below:

- **Structured information exchange and collection of statistics (Task 1):** The format of today's Task 1 was established, with a website divided into both public and members-only portions. The ExCo also decided that all participating countries in the IA-HEV should automatically be participants in Task 1 and established the financial arrangements to support this.

- **Hybrid vehicles (Task 7):** This task force published reports on questions pertaining to hybrid vehicles. Issues included their current costs and estimated future cost reductions; the environmental performance, fuel efficiency, and advantages and disadvantages of the various types of hybrid vehicles; how hybrid vehicles could be most effectively introduced to the market; and questions on testing, licensing, and taxation. One of Task 7's most interesting findings was that the decision of a customer to purchase a hybrid is based more on reduced fuel costs and projecting an environmentally responsible image rather than on the cost of the vehicle.

- **Deployment strategies for hybrid, electric and alternative fuel vehicles (Task 8):** This Task considered 95 government programmes in 18 countries that were aimed at introducing clean vehicles and fuels. The scope of work included both vehicles and fuels, and for this reason the task force was a joint effort between two IEA Implementing Agreements, IA-HEV and the Implementing Agreement on Advanced Motor Fuels (IA-AMF). The objectives of the task force were to analyze how governments can accelerate the deployment of advanced automotive technologies in the market place and to make recommendations that will enhance the effectiveness of policies, regulations, and programmes. The final report made practical recommendations for future deployments, including how to apply lessons learned in previous deployments and among various countries, to avoid repeating mistakes.

- **Clean city vehicles (Task 9):** This Task arose because cities in many developing countries were growing very rapidly and were experiencing the same or worse air quality and traffic problems as cities in IEA countries. At the same time, innovative solutions and technologies had been worked out in some developing countries, and there was a lot that IEA countries could learn from them. Planning was initiated for a task force, which became Task 9, to study the application of clean vehicle and fuel technologies in developing countries. In 2002, a joint workshop with IEA headquarters in Paris included representatives from Bangladesh, China, Colombia, Costa Rica, India, Indonesia, Kenya, Mexico, Nepal, Peru, and Thailand. As a direct result of the workshop, representatives from Bangladesh subsequently travelled to Bogotá to learn about the bus rapid transit system there, to construct a similar system in Dhaka. This result was directly due to the workshop.

- **Electrochemical systems (Task 10):** During phase 2, this task force concentrated on the sharing of test methods for supercapacitors and batteries. Test procedures play a key role in moving new technologies from the laboratory to the market, and developing them involves a large amount of technical work and can easily cost more than a million dollars. Consequently, the sharing of test procedures can result in large savings. The Task also played a valuable role in co-ordinating the work of the fuel cell Implementing Agreement, the hybrid vehicle Task, and itself in the field of electrochemical technologies.

The publications chapter in part E of this report lists the most important publications of phase 2. Many of them are available on the IA-HEV website: www.ieahev.org.

2.2.2
Description and achievements of IA-HEV phase 3, 2004–2009

The emphasis during the third phase of the Agreement, from 2004 until 2009, was on collecting objective general information on hybrid, electric, and fuel cell vehicles. Governmental objectives of improving air quality and energy efficiency—and of reducing greenhouse gas emissions and dependence on petroleum fuel—ensured that the need continued for the IA-HEV's mission.

The third phase of the Agreement focused on collecting objective general information on hybrid, electric, and fuel cell vehicles, with the same value-added aspects as described for phase 2 in the previous section. Topics addressed during the third phase are shown in box 2.3.

Task 1 and Task 10 were the only Tasks remaining from phase 2, with the rest having concluded operation during phase 3 or before. Phase 3 saw the introduction of new Tasks on electric cycles (Task 11), heavy-duty hybrid vehicles (Task 12), fuel cell vehicles (Task 13), lessons learned from market deployment of hybrid and electric vehicles (Task 14), and plug-in hybrid electric vehicles (Task 15). Many of the Tasks active in phase 3 continued into phase 4, even if only to round off their activities. Therefore, specific details on each of these ongoing Tasks and their respective histories are collected in chapters 4 through 10 of this report.

IA-HEV's other achievements during phase 3 include contributing to the IEA's roadmap for electric and hybrid vehicles, as well as a move to interact more closely with different Implementing Agreements (IAs) of the International Energy Agency, especially between the seven IAs with transportation as an item in their work programme.

Box 2.3
Topics addressed in the third phase of IA-HEV (2004–2009)

- Information exchange (Task 3). The work includes: country reports, census data, technical data, behavioural data, information on non-IEA countries
- Electrochemical systems for EVs & HEVs (Task 10)
- Electric bicycles, scooters, and light weight vehicles (Task 11)
- HEVs & EVs in mass transport, and heavy-duty vehicles (Task 12)
- Market aspects of fuel cell electric vehicles (Task 13)
- User acceptance of HEVs; barriers for implementation (Task 14)
- HEVs & EVs for power correction or decentralized power production (Task 15)

2.2.3
Description and strategy for a fourth phase of IA-HEV, 2009–2015

Interest in HEVs, PHEVs, and EVs as a means to reduce energy consumption and emissions from road transport is strongly increasing worldwide. At the same time, many questions are still open regarding issues such as potential efficiency improvements, safety, durability, vehicle range, production potential, and raw material availability for batteries, impact on electricity grid management, standardization, the potential to introduce renewable energy in road transport, and market introduction strategies. There is a strong need for objective and complete information about these issues, to enable balanced policy making regarding energy security, economic development and environmental protection, and the role that hybrid and electric vehicles can play.

All of these reasons provided a sound basis for the continuation of the Implementing Agreement on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) after phase 3 concluded in November 2009. Therefore, during 2008 the IA-HEV Executive Committee (ExCo) prepared a Strategic Plan for a new phase of the Agreement, running from December 2009 until February 2015. In 2009, the Strategic Plan was presented to the IEA End-Use Working Party and to the IEA Committee on Energy Research and Technology and from both entities it received approval to enter into this new phase of operation.

The IA-HEV ExCo has formulated the following strategic objectives for its fourth phase (2009–2015):

1. To produce objective information for policy and decision makers on hybrid and electric vehicle technology, projects and programmes, and their effects on energy efficiency and the environment. This is done by means of general studies, assessments, demonstrations, comparative evaluation of various options of

application, market studies, technology evaluations, highlighting industrial opportunities, and so forth.
2. To disseminate the information produced to the IEA community, national governments, industries, and—as long as the information is not confidential—to other organizations that have an interest.
3. To collaborate on pre-competitive research projects and related topics and to investigate the need for further research in promising areas.
4. To collaborate with other transportation-related IEA Implementing Agreements (in Tasks, or joint Tasks), and to collaborate with specific groups or committees with an interest in transportation, vehicles, and fuels.
5. To be a platform for reliable information on hybrid and electric vehicles.

Besides defining its strategy for phase 4, the IA-HEV ExCo has also identified topics to address in this new phase. All Tasks that were active at the end of phase 3 continued into phase 4, with Task 13 rounding off its activities in 2010, and Tasks 11, 12, and 14 expected to issue final reports during 2011.

In 2010, the ExCo approved two new projects: Task 17 on system integration and optimization of components for enhanced overall electric vehicle performance, and Task 18 on "electric vehicle ecosystems," with an objective of mapping out the conditions required to support the market growth needed for mass adoption of EVs in cities. Specific details on these new Tasks as well as the continuing Tasks that were operating during 2010 are collected in chapters 4 through 12 of this report.

The IA-HEV ExCo has also identified a number of potential topics for new Tasks, shown in box 2.4. The list of topics reflects the issues that today are expected to be important in the time period until 2015. However, new topics may emerge during phase 4. The IA-HEV ExCo will continuously monitor developments that are relevant for hybrid and electric vehicles in fields ranging from vehicle technologies to policy making and market introduction. The ExCo may also start new Tasks on topics that are not yet mentioned in box 2.4. The actual number of new Tasks in phase 4 will depend on the level of interest inside and outside the Agreement. Outsiders who are interested in developing a new Task are invited to contact the IA-HEV chairman, secretary or one of the country delegates to discuss the possibilities.

Box 2.4
Potential new topics to be addressed in IA-HEV phase 4 (2009–2015)

- Vehicle to electricity grid issues, smart grids
- Battery electric vehicles
- Drive cycles
- Test procedures
- Future energies for HEVs & EVs
- Re-use and recycling of HEVs & EVs at the end of their operational life
- Lightweight constructions
- HEVs & EVs in mass transportation
- Market aspects of fuel cell electric vehicles
- HEVs & EVs for special applications
- HEVs & EVs in developing countries
- Testing standards and new vehicle concepts
- Impacts of HEVs & EVs on industry and the economy
- Driver response to advanced instrumentation inside the vehicle
- Universal battery cell design across electric drive systems
- Safety of first responders and rescue workers
- Life cycle analysis (LCA) of electric vehicles
- Trolley buses
- Mobile machinery such as fork lift trucks, earth moving equipment and forestry machinery
- Non-road electric “vehicles” like boats, (light) rail and airplanes
- Standardization issues
- Deployment strategies for hybrid and electric vehicles
- Special electric vehicles (like wheelchairs, one-person mobility, etc.)
- Electricity grid capacity issues
- Accelerated testing procedures for lithium battery life
- Second life of batteries
- Cross cutting technologies
- Fast charging of vehicle batteries

3 IA-HEV Clean Vehicle Awards

3.1 Introduction and background

To put a new technology on the market and create a market breakthrough are very ambitious goals. Yet this quickly changing society expects market breakthroughs within a very short time. When a complex technology like cars is introduced, such breakthroughs do not often occur; the attention of public and mass media turns quickly into disappointment, and they look for the next promising technology.

Continuous progress, however, does occur. It is driven by committed persons, teams and manufacturers. This is the reason why the IEA Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) launched its award program for those who dedicate their work to the dream of a clean and energy-efficient vehicle technology.The awards cover three categories:

- Clean Vehicle Award—This is granted to manufacturers with outstanding sales figures. There are four categories based on the number of vehicles sold: bronze for 25,000, silver for 50,000, gold for 100,000, and platinum for more than 250,000.
- Best Practice Award – This is granted to the organizers of an outstanding promotion project.
- Personal Award – This is granted to a person who has dedicated her or his work to the development or promotion of clean vehicles in an outstanding way.

3.2 The procedure

Each specialist in the field of hybrid, electric, or fuel cell vehicles worldwide is invited to nominate one or more candidates in the three award categories. It is preferred that nominees for the Best Practice and Personal Award be candidates from the region in which the World Electric Vehicle Association (WEVA) Electric Vehicle Symposium is held. The WEVA section of the applicable region is contacted to co-operate in the nomination process. In years when there is no WEVA Electric Vehicle Symposium, no regional restriction is made. An IA-HEV committee ranks the nominations. IA-HEV did not issue the Clean Vehicle Awards in 2010 and anticipates resuming the awards in 2011.

3.3
Winners of 2009 awards

The 2009 award ceremony took place at the EVS-24 opening ceremony in Stavanger. The Clean Vehicle Award was given to Honda Motor Co. Ltd. for achieving cumulative sales exceeding 250,000 units for its Civic hybrid vehicle. The Best Practice Award was given to the Energy Saving Trust for its extensive and influential work in developing programmes that have led to increased numbers of hybrid vehicles on roads in the United Kingdom as well as ongoing development of low-carbon technologies for road transportation. Finally, the Personal Award went to Steen V. Jensen of Denmark for his pioneering work in developing a production electric vehicle in the late 1980s that is still manufactured and sold today.

3.3.1
Clean Vehicle Award for Honda Motor Co. Ltd (Japan)

Honda has a long tradition in the development of clean vehicle technologies. As a precondition for a successful series production of hybrid vehicles, Honda developed the "Integrated Motor Assist (IMA)" system which applies a brushless 10 kW electric motor with a nickel-metal hydride battery to assist propulsion and acceleration from a 52 kW 1-L engine. The electric motor acts as a generator: up to 100 A can be generated from the batteries, and much of the energy of braking may thus be recaptured for recharging the propulsion batteries (so-called "regenerative braking"). The IMA system was first offered in the Insight introduced into the market in 1999. Although boasting very great efficiency, this model enjoyed only around 18,000 unit sales, the main reason being the fact that it was a 2-seater. In 2002, the 4-seater Civic hybrid followed, again using the IMA system. From both models based on the seventh and eighth generation of the gasoline version Civic, this hybrid has achieved more than 250,000 in unit sales worldwide between 2003 and February 2009. Adding in sales of the "mild" hybrid Accord, Honda has sold more than 300,000 hybrid vehicles worldwide.

Honda continues to market clean vehicle technologies. A new generation Insight with improved design became available in 2009, and sales figures of 200,000 units per year worldwide are expected for this model. Other hybrid models are in development, Honda is planning to put a new hybrid electric vehicle on the market in 2010 and 2011 as well.

3.3.2
Best Practice Award for the Energy Saving Trust (U.K.)

The Energy Saving Trust was founded in 1993 following the 1992 Earth Summit in Rio de Janeiro as a public-private partnership with the goal of elaborating and spreading independent information on energy efficiency, renewable energies, transport, water, and waste. Its sphere of interest encompasses home improvement, home power generation, and technical guidance for energy-efficient and low-carbon construction and transportation. For this purpose, beginning in 1996, the Trust set up a network of local advice centres across the United Kingdom. In addition, the Trust acts as consultant for the UK Government and Parliament, the European Commission, and other decision groups.

Within the transportation division, the implementation of the subsidy programme Power Shift constituted the most important step toward increasing the number of clean vehicles on the road. As a result, the Trust has been nominated as the organization to define the car technologies that are to be exempted from the London Congestion Charging Scheme. The PowerShift register listing these cars now provides essential information to Londoners wishing to avoid this congestion charge which can reach £1,300 annually, thus contributing to the increased sales of hybrid cars.

Today's Trust activities emphasize achieving the objectives of the Powering Future Vehicles Strategy of the Government published in 2002. The target of this strategy is the development of small cars that emit less than 100 g/km CO_2 in a well-to-wheel calculation – a rather ambitious goal. To push such clean vehicle technologies, the UK Department for Transport funded a promotion programme that subsidizes the development of low-carbon vehicle technologies, covering on the one hand industrial research and on the other vehicle projects in a pre-competitive development stage. The Energy Saving Trust is in charge of carrying out this programme. This is a shift from supporting existing technologies in the PowerShift programme to enabling the development of advanced technologies. Current projects cover the system integration of a lithium iron phosphate battery into a Modec or Zytec car (project "Develop & Scarlet" by Axeon); the development of a parallel hybrid diesel vehicle with integrated starter-alternator and a li-ion battery (project CV-ISA by Zytec); developing electronic management devices for a hybrid vehicle (project ADDZEV by Cranfield University); and the development of a fuel cell hybrid vehicle (project "Red Lion" by Ricardo and QinetiQ).

In addition, the Energy Saving Trust runs information campaigns for energy-efficient fleets, smart driving, and cleaner taxis.

Last but not least, the Energy Saving Trust has spawned many subsequent initiatives that have arisen to work for a reduction of CO_2 emissions in transportation, e.g., the Sustainable Transport Solutions Network (founded 2004) and the Low Carbon Vehicle Partnership, each of which fosters close partnership with the industry.

3.3.3
Personal Award for Steen V. Jensen (Denmark)

Mr. Steen V. Jensen was the developer of the most successful series production electric vehicle model to appear in the late 1980's and early 1990's, the CityEl (shown in figure 3.1). The story of the CityEl began after the first oil crisis in 1973 when Steen V. Jensen started to think about mobility. Starting in 1982, when he worked as a product development manager with the company Dronningborg Maskinfabrik which produced machines for farming, he transformed his mobility ideas into an actual vehicle. Mobility in Denmark meant an average distance to work of 11 km; and 92% of these commuters sat alone in their cars. Consequently Jensen developed a small lightweight electric vehicle with one seat. The vehicle first appeared in 1985 in a magazine under its project name U36, but shortly thereafter it acquired the name "Ellert", a combination of "electric" and the Danish word for moped, "knallert." As Dronningborg Maskinfabrik had no interest in producing this vehicle, Jensen collected money from 3,000 private investors, and in 1987 he started the series production of the vehicle in Randers.

Fig. 3.1 The "CityEl" is produced and sold in Germany today. (Photo coursey of Smiles Electromobility)

However, the Ellert had several early setbacks, such as incorrectly fixed electrical relays and melting fuses that in one case overheated the waste gas hose of the batteries causing a hydrogen-off-gas flameout. An expensive recall campaign led the press to publish several negative reports. Although the electronic devices and cabling were then improved and the motor was replaced by a more powerful one, the now so-called "MiniEl" suffered from the bad reputation of its predecessor, and the repair costs for first-generation Ellerts were high. Jensen had to sell the production to German investors in 1991, and since 1996 the CityEl (as the "MiniEl" was renamed) has been produced in Aub, Germany.

None of this detracts from Jensen's achievements. His concept of designing a vehicle by starting with an analysis of specific mobility needs was fundamentally new at that time. He understood that the electric drive demanded maximum efficiency of the overall system and light materials for the body. As a pioneer, he had to deal with technical imperfection, problems of series production, and market demands at the same time. Moreover, this was at a time when components for electric propulsion systems had to be developed in parallel with complete vehicles. His lifetime achievement, the CityEl, is still on the road. Together with his firm conviction that his signal contributions were the appropriate answer to the problems caused by individual mobility needs, and his will to realize his idea, Steen V. Jensen and his pioneering electric vehicle remain a shining example for emerging developers of clean vehicles.

We are grateful that we were able to recognize Steen Jensen before he passed away at the age of 68 years on December 31, 2010. In his death notice, his family wrote, "He was ahead of his time". Instead, we are convinced that now his time — the era of the electric vehicle — has finally come.

Fig. 3.2 Steen V. Jensen standing with a version of his CityEl. (Photo courtesy of Steen Jensen.)

3.4
Gallery of award winners

BOX 3.1 IA-HEV AWARD WINNERS SINCE 2005	
2005	
Clean Vehicle	Platinum: Toyota, Japan. More than 250,000 Prius models sold
Best Practice	Reggio Emilia, Italy. Application of EVs
Personal	René Jeanneret, Switzerland
2006	
Clean Vehicle	Silver: Honda, Japan. More than 50,000 hybrid models sold Silver: Toyota, Japan. More than 50,000 hybrid Lexus models sold Bronze: Ford, USA. More than 30,000 hybrid models sold
Best Practice	China. Electric bicycle and scooter fleet
Personal	Hans Tholstrup, Australia
2007	
Clean Vehicle	Silver: Ford, USA. More than 50,000 hybrid Escape models sold
Best Practice	The Plug-In Partners National Campaign, USA
Personal	Paul MacCready, USA
2008	
Clean Vehicle	None
Best Practice	Electricité de France
Personal	Karl Kordesch, Austria/USA
2009	
Clean Vehicle	Platinum: Honda, Japan. More than 250,000 Civic hybrids sold
Best Practice	The Energy Saving Trust
Personal	Steen V. Jensen, Denmark

4 Information Exchange (Task 1)

Members: Any IA-HEV member may participate.

4.1 Introduction

Information exchange is at the core of IA-HEV's work, enabling members to share key insights and best practices as well as identify common research interests in the rapidly growing international hybrid and electric vehicle field. Task 1 began in the first phase of IA-HEV, and it continues to be IA-HEV's main forum as well as its portal for announcing news and results to the broader IEA community.

The IA-HEV strategic plan for phase 4 (2009–2015) mentions that "a communication strategy will be established, to ensure that the different kinds of information that are generated by the Agreement reach their specific target public, and to increase the visibility of the Agreement and the results of its work. All possible communication tools will be considered to this end." Box 4.1 below lists all phase 4 objectives, which include communication.

Box 4.1
IA-HEV Phase 4 Objectives (2009–2015)

- Produce objective information for policy and decision makers
- Disseminate information produced by IA-HEV to the IEA community, national governments, industries, and other organizations
- Collaborate on pre-competitive research
- Collaborate with other IEA Implementing Agreements and groups outside the IEA
- Provide a platform for reliable information

4.2 Objectives

Task 1 serves as a platform for information exchange among member countries. The objectives are to collect, analyze, and disseminate information on hybrid, electric, and fuel cell vehicles and related activities. This information comes from both member countries and nonmember countries.

The main information exchange topics include:

- Research and technology development
- Commercialization, marketing, and sales

- Regulation, standards, and policies
- Activities of other IA-HEV Tasks

4.3 Working method

Country experts from member countries present information at meetings held in conjunction with the IA-HEV Executive Committee meetings that occur twice a year. They also provide country-specific information for IA-HEV publications. The Operating Agent (OA) of Task 1 is an individual who is responsible for coordinating these meetings, maintaining the IA-HEV website, and editing and supervising the production of the Executive Committee (ExCo) annual report. The OA also acts as liaison to the OAs for other Tasks and, through the Executive Committee Secretary, to the ExCo Chair and the International Energy Agency Desk Officer. Kristin Abkemeier serves as the Task 1 OA on behalf of The United States Department of Energy (DOE), Vehicle Technologies Program.

A significant component of the information exchange for the Task occurs at the experts' meetings, in which participants brief the other attendees on relevant reports, facts, and statistics pertaining to HEVs, PHEVs, and EVs in their home countries. These presentations generally cover current developments on the statistical and market situations for EVs and HEVs (national sales and fleet penetration, by vehicle type); the progress of international, national, or local programmes and incentives in the field; and new initiatives in vehicle and component development arising from both the private sector and public-private partnerships.

Any member country of the Implementing Agreement can automatically participate in Task 1. Each country designates an agency or non-government organization as their Task 1 expert representative. Frequently, invited experts from outside participate in Task 1 meetings to present their activities and to exchange experiences with IA-HEV participants. This is a valuable source for keeping up to date with worldwide developments.

4.4 Results

Thirty experts' meetings have been conducted since the inception of the IA-HEV. In 2010, two Task 1 meetings were held, the 2009 Annual Report was published, and an IA-HEV newsletter was issued. The Operating Agent along with a communications team at the U.S. DOE and members of the ExCo wrote a draft of a comprehensive IA-HEV communication plan with goals and objectives.

4.5 Further work

This report presents developments in hybrid and electric vehicles in member countries during 2010. A redesigned website is scheduled for completion in the fall of 2011. Along with the new website, IA-HEV digital brochures will be available for download, and the IA-HEV newsletter format will evolve to take advantage of the capabilities to be offered by the new website. These new communication tools will present the comprehensive work conducted by IA-HEV members to a larger audience.

Access to proprietary data and other "late-breaking" information will continue to be limited to participating members as an inducement to non-member countries to join. Items from both member and non-member nations may be posted.

Task 1 expert meetings will continue, scheduled to coordinate with the ExCo meetings. The basic plan of the meeting is that each expert is given half an hour in which to present the latest developments in hybrid and electric vehicles in his or her country. As the number of members has been increasing, it is not expected that every member country will present at each Task 1 meeting; rather, the focus is on sharing information that will be relevant to other members, who can then engage in discussion about these issues.

4.6 Contact details of the Operating Agent

For further information, please contact the Operating Agent:

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5 Electrochemical Systems (Task 10)

Members: Any IA-HEV member may participate.

5.1 Introduction

This Task addresses topics related to the chemistry and performance of electrochemical energy storage devices (batteries and ultracapacitors) of interest to the hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), and electric vehicle (EV) communities. Topics covered by the Task include basic electrochemical couples, battery materials, cell and battery design, and evaluation of the performance of these systems under normal and abusive conditions. The Task focus does not extend to the interface between batteries and the vehicle or circumstances of vehicular use because these areas are covered by other Tasks.

5.2 Objectives

The Task goal is to advance the state-of-the-art of battery and capacitor science and technologies for vehicle use. All aspects of batteries and capacitors for vehicles are covered from basic electrochemistry to the testing of full systems.

The objective of Task 10 is to facilitate relevant information exchange among technical experts from the electrochemical power sources field. In contrast with many governmental agencies, this Task will not try to fund or control research and development projects.

5.3 Working method

The Operating Agent for Task 10 is supported by the United States (U.S.) Department of Energy. Any IA-HEV member may participate at no additional cost. Participants in the Task are expected to cover their own incidental costs, such as time and travel.

The Task addresses selected topics in the form of focused working groups. Each working group meets one or twice to discuss a specific topic. Products from the working groups vary depending upon the nature of the discussions and may include publications in the open literature or restricted meeting notes. After an IA-HEV member joins Task 10, the member decides whether to participate in a working group based on their interest level in the subject matter. As a result, each working group has unique members, and a country or organization may participate in one working group without making a multiyear commitment to attend every Task meeting.

5.4 Results

WORKSHOPS IN 2010

Accelerated Life Testing of Batteries (Especially Lithium-ion Batteries) for Vehicles, Hawaii, U.S., January 2010

This workshop was jointly sponsored by the Battery Subtask of IA-HEV Task 15, Plug-in Hybrid Electric Vehicles. The location and date were chosen to coordinate with meetings of the International Battery Association and the Pacific Power Sources Symposium (PPSS). In order to allow for effective discussions, attendance at the workshop was limited and "off-the-record". Invitations were sent to battery companies, vehicle manufacturers, and representatives of governments and universities. Attendees of the PPSS were also invited. Over 30 people pre-registered for the meeting and 10 PPSS attendees requested invitations on-site. Attendees represented the following groups and companies:

- Governments and national laboratories: Austria, Canada, Italy (planned), Japan, Taiwan, U.S.
- Universities: Japan, Sweden, Taiwan, U.S.
- Battery manufacturers: A123Systems (U.S./China/Korea), DowKokam (U.S.), E-One Moli Energy (Canada/Taiwan), FMC Lithium (U.S.), IREQ (Hydro Quebec, Canada), Medtronic (U.S.), TIAX (U.S.)
- Vehicle manufacturers: GM (U.S./global), Volvo (Truck, Sweden)

The main topic of discussion centered on how to predict the life of a battery in normal use based on experiments done in less than two years. The workshop was needed because automotive manufactures want electric drive vehicle batteries to last the life of the vehicle, sometimes up to 15 years; but, currently manufacturers often have only two or three years of real-time data on new battery technology for vehicles.

Topics that were discussed included:

- The importance of Accelerated Life Testing
- Test procedures and approaches used by different organizations:
  - Battery companies
  - Vehicle manufacturers
  - National laboratories
  - Universities

Preliminary conclusions included the following:

- There is broad interest in such testing.
- Each continent/nation has its own set of procedures.
    - These procedures are similar, but not identical.
- There are some major questions to be answered.
    - How complex a charge/discharge cycle is needed?
- There is interest in collaborating to produce a “standard” set of international test procedures.
    - In June 2010, IA-HEV discussed forming a separate Task on this subject in order for it to be addressed in significant depth. The preliminary Operating Agent for this new Task would be from Italy.

Government Support for Vehicle Battery Manufacturing Facilities workshop, Valbonne, France, September 2010

ADEME, the French Environment and Energy Management Agency, hosted the workshop to coordinate with the Batteries 2010 conference which was held near Valbonne near Cannes, France. Attendees included a dozen people representing governments, national laboratories, and industry from Austria, France, Sweden, and the U.S. As with other workshops sponsored by this Task, the meeting was “off the record,” but the speaker presentations were distributed to attendees.

National battery manufacturing strategy was the workshop topic for the information exchange. Governments are supporting different aspects of battery manufacturing. Some governments have provided support for facilities to manufacture batteries for vehicles; other governments are providing different support to the electric drive vehicle market; and still other governments are considering providing such support.

The discussion included:

- Programs of government support
- Aspects of these programs that were most effective
- Issues/problems associated with aspects of these programs
- Industry effects of these programs
- Future plans of several governments

5.5
Further work

New working group meetings will be held on emerging topics that are highly relevant for advancement of battery and capacitor technology. Developments in hybrid and electric vehicle technologies and markets will impact the selection of future working group topics.

5.6
Contact details of the Operating Agent

Individuals interested in helping organize, host, or participate in a future working group meeting with a specific focus are urged to contact the Operating Agent.

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6 Electric Cycles (Task 11)

Participants: Switzerland, United States (U.S.)

6.1 Introduction

City governments view improving mobility in their urban areas as an important obligation. Urban mobility is a key issue due to the limited space that is available per vehicle, along with air and noise pollution and traffic safety. City governments must take a wide range of measures to address mobility, including improved public transport, facilitation of soft transport (non-motorized) modes like walking or cycling, and better roads and parking facilities. Many solutions have to be implemented using a smooth and convenient interface between solutions in order for inhabitants to enjoy a good quality of life.

These objectives are explained in the "Green Paper for new Urban Mobility Culture," the 2011 white paper "Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system," and others. For the past 10 years, these objectives have been practiced in the successive CIVITAS (CIty-VITAlity-Sustainability) projects in over 60 European cities.

Within this context, electric two-wheelers are an important component of an overall program to improve mobility. They require very little space and do not create pollution or make noise. They are perfectly suited for short vehicle trips or as a link in the multimodal chain of transport (see figures 6.1 and 6.2).

Fig. 6.1 Commuters find e-bikes an attractive urban transport option and also benefit traffic flow due to their size. (Photo courtesy of eGO Vehicles.)

Besides these benefits, electric two-wheelers reduce energy consumption compared to other transport modes, and they can also run on renewable energy sources. So why are they not seen on the roads more often? One of the main reasons is that some important actors are not sufficiently committed. The three major actors—consumers, industry, and governments—do not interact in a satisfying way for the following reasons.

1. Potential customers misjudge the benefits of these vehicles, and importers and dealers generally are not yet prepared to engage in active marketing efforts, although in some countries this has recently changed.
2. Authorities at national and local levels may recognize the benefits, but are not well-suited to take leadership in the market introduction of electric two-wheelers.
3. Last, but not least, are the manufacturers—who seem to have insufficient insight into the market demand, most likely because this varies strongly from country to country.

In summary, there seems to be an attractive opportunity to integrate electric two-wheelers as clean vehicles into existing transportation systems, but the activities of the consumers, governments, and industry need to be better coordinated. Within this context, IA-HEV decided to begin a Task on electric cycles in order to foster market adoption. Task members are the United States and Switzerland. Austria was an initial member, but later withdrew from the Task. Additionally, ITRI (Industrial Technology Research Institute, in Taiwan) supported the Task in its initial stage.

Fig. 6.2 The first wireless electric bicycle, the Shadow Ebike, will feature a 350W motor with a 36V, 10Ah lithium polymer battery. This revolutionary ebike uses frequency-hopping spread spectrum technology, ISM Wireless Frequency (2.4 GHz, to prevent interference). (Photo courtesy of Daymak.)

6.2 Objectives

The objectives of Task 11 have been to identify barriers for market penetration of electric cycles and to develop and test ways to overcome these barriers. The aim is to assist in the establishment of electric two-wheelers as a sustainable means of transport in many countries.

Subtasks focused on the following key issues:

- Assessing the role that two-wheeled electric vehicles can play in improving urban mobility and their interaction with other transport modes.
- Identifying e-bikes' energy-saving potential to justify governmental support.
- Recommending market introduction strategies directed at manufacturers, importers and dealers, as well as authorities at all levels.
- Identifying technology improvements that are required.
- Identifying infrastructure requirements.
- Sharing experiences and information obtained from ongoing and completed projects (extended dissemination).

6.3
Working method

The work of this Task has been performed in five well-integrated subtasks:

Subtask 1: Energy-saving and market potential

- Inventory of vehicles that are offered on the market, and also prototypes
- Successful fields of application
- Benefits of electric cycles for users and the public
- Success factors regarding market introduction
- Identification of desired governmental support

Subtask 2: Market introduction

- Analysis of the role of market actors in different countries
- Recommendations for national and local governments as well as for manufacturers, importers, and dealers regarding collaboration in market introduction.
- Promising networks for the market introduction of electric cycles

Subtask 3: Technology improvements

- State of the art of vehicle technology
- Requirements for electric and hybrid drive systems for electric two-wheelers in different market segments

Subtask 4: Infrastructure

- Public charging infrastructure for electric scooters
- Safe parking places and preferred parking facilities for electric cycles

Subtask 5: Sharing experiences

- Implementation and co-ordination of sharing experiences
- Technical visits

The Task launched in 2006 and held regular meetings in its initial phase, as indicated in Box 6.1.

Box 6.1 Task 11 Expert Meetings
Kick-off meeting. Taiwan, March 10–11, 2006, in conjunction with the LEV conference.
1st progress meeting. Paris, France, June 13, 2006, in conjunction with the Challenge Bibendum. 2nd progress meeting. Tokyo, Japan, October 24, 2006, in conjunction with EVS 3rd progress meeting. Hsinchu, Taiwan, March 24, 2007, again in conjunction with the LEV conference. 4th progress meeting. Chiasso, Switzerland, November 7, 2007, in conjunction with the EICMA exhibition. 5th progress meeting. Anaheim, USA, December 5, 2007, in conjunction with EVS-23.
Workshop. Geneva, Switzerland, March 11, 2008, in conjunction with the IAMF/EET-2008 conference.

Though the Task was inactive during 2009, it was reactivated in the middle of 2010 (at the 32nd meeting of the Executive Committee in London, June 23–24, 2010). Information dissemination has been the primary focus for Task 11 during the past year. The Task was presented and discussed by Robert Stüssi, who was the president of the Operating Agent AVERE (the European Association for Battery, Hybrid, and Fuel Cell Vehicles), at the following events:

- Advanced Vehicle Leadership Forum, Electric Vehicles Initiative, in Paris, France (September 30–October 1, 2010)
- EVS-25 in Shenzhen, China
  - IEA IA-HEV meetings (November 4–5, 2010)
  - Light Duty EV Industry Development Forum, at the 25th World Electric Vehicle Symposium (EVS-25) (November 6, 2010)
  - Post EVS-25 event (EV Parade & Exhibition & Seminar) in Hong Kong organized by CLP Power (November 10–12, 2010)
- LEV Conference in Hisinchu, Taiwan (March 13–15, 2011)
- Taipei Power Forum, in Teipei, Taiwan (March 17–18, 2011)
- EV Battery Forum in Barcelona, Spain (April 11–15, 2011)

Topics presented by AVERE ranged from the current status of the electric two- and three-wheelers market to policy and regulatory recommendations for market uptake.

In February 2011, AVERE together with four other organizations (UEAPME / NORMAPME / LEVA / Going Electric) endorsed Comments and Amendments sent to the European Commission by ETRA (European Two Wheeler Retail Association) on the "Proposal for a European Parliament and Council Regulation on the approval and market surveillance of two- or three-wheel vehicles and quadricycles—COM(2010) 542 final."

Task 11 is also working with partners to develop a handbook for bicycle policies for municipal decision makers to establish e-mobility in their communities. The organization ExtraEnergy and others are working within the framework of the European Union project “Go Pedelec!” to launch the handbook in early fall 2011.

6.4
Results

In early Task meetings, particular attention was paid to the market potential of electric cycles, and the task force identified the following as critical issues to address.

- The need to clearly explain why governments should support both electric bicycles and scooters.
- Safety aspects in manufacturing batteries, and in particular the social responsibility.
- “Adaptation sets” to convert conventional bicycles into electric ones.
- The issue of poor-quality products, which can lead to negative publicity.
- Homologation or labelling to ensure that existing regulations are respected.
- Charging facilities, which could remain a crucial issue for electric scooters. In areas with low requirements on e-scooter performance (range, speed, driver’s weight), an approach using removable batteries could be successful. However, for most of today’s applications, batteries are too heavy to be removed and charged at any outlet, which is common practice for most of the e-bikes.

Much information was gathered in the meetings from 2006–2008, allowing the Task to gain a broad vision on the electric cycle market and its actors, along with the market situation and governmental support measures. Regarding technology, an extensive investigation of product characteristics was made, as well as identification of the most important requirements for market introduction. The Task also focused on identifying which product characteristics of electric cycles would give the largest increase in customer satisfaction for the lowest investment, while also highlighting the main technological constraints.

In recent activities, while attending several conferences, the Task presented the vision of integrating e-bikes into the overall e-mobility and mobility policies and also collected conference materials in order to benchmark its own findings.

6.5
Further work

The Task is in its concluding year and will be rounded off with a report that Mr. Hannes Neupert of ExtraEnergy is writing for the EU project GoPedelec, scheduled to be published in autumn 2011.

6.6
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7 Heavy-duty hybrid vehicles (Task 12)

Participants: Belgium, Canada, Finland, the Netherlands, Switzerland, United States

7.1 Introduction

Heavy-duty vehicles encompass a wide diversity of applications and have specific technical requirements and economic boundary conditions compared to the passenger car market. Therefore, some IA-HEV members felt the need to begin a specific Task on heavy-duty hybrid vehicles. Task 12 was initiated and approved at the IA-HEV Executive Committee meeting in October 2006 and ran from January 1st, 2007 until November 30th, 2010.

Belgium, Canada, the Netherlands, and the United States have been participating in Task 12 since 2007. Finland joined in 2008, followed by Switzerland in 2010.

7.2 Objectives

Task 12 aimed to report on the current status of the heavy-duty hybrid vehicles "playing field". The status report focused on the available and emerging hybrid vehicle technologies and the current and expected state of the market.

A classification of heavy-duty hybrid vehicles according to purpose or operational application was agreed upon to pose fewer difficulties in combining the vehicles of Europe and the U.S. These are listed in Table 7.1.

Table 7.1 Classification of heavy-duty hybrid vehicles for Task 12 purposes.

Main categories	Sub categories
Bus	• City • Regional • Long distance
Truck	• City distribution/delivery truck • Regional distribution • Inter- and national transport
Mobile work machines	• Construction, mining, and earth moving: loaders, excavators, dumpers, bulldozers, etc. • Agriculture and forestry: tractors and their accessories, harvesters, forwarders, etc. • Transportation of goods and material handling: forklifts, straddle carriers, RTGs, terminal tractors, etc. • Municipal or janitorial machines: gardening, cleaning, etc.

To collect and organize the required information, three subtasks have been defined.

The first technology-oriented subtask aims at structuring the information on heavy-duty hybrid vehicle components, systems and configurations. This subtask identifies and illustrates the technical requirements, especially highlighting where they are different from light-duty requirements, the available technologies and their characteristics, and the system integration requirements. Additionally, there is a focus on powertrain configurations (topologies) and powertrain strategies for high efficiency and low emissions.

The second market-oriented subtask targets collecting market information on heavy-duty hybrid vehicles. The current market of existing hybrid prototypes and standard vehicles needs to be investigated. The information gathering will focus on the applied technology, as well as the costs and its merits in meeting customer expectations. In this way it complements the first subtask. This subtask will increase the insights into the applications where heavy-duty hybrids have been an effective solution and can thus provide essential information for future hybrid vehicle deployment projects. The lessons learned will not only focus on the technical barriers to overcome but also on the required framework (training of mechanics, support, etc.) for successful project implementations. To address the potential of heavy-duty hybrid vehicles it is useful to identify niche applications that may benefit to a great extent from hybridization.

The third dissemination-oriented subtask involves collecting and disseminating general information and promoting the Task 12 objectives and results to a broad range of stakeholders. This can be done by setting up a dedicated website, preparing papers, giving presentations at relevant conferences, and keeping up contact with relevant platforms by sharing information on heavy-duty hybrid developments.

7.3 Working method

The Operating Agent organized two expert meetings per year, predominantly in participating countries. Each meeting tried to include a technical visit to the participant's facilities and/or other interesting projects or events. This allowed the local participant to illustrate its capabilities and infrastructure in the field of heavy-duty hybrid vehicle technology. The Operating Agent chaired the meetings, prepared agendas and minutes, and reported to the Executive Committee of the Implementing Agreement. The Operating Agent provided project management and coordination, to ensure that activities were implemented and objectives were achieved.

A subtask leader was designated for each of the three main objectives to coordinate the progress of their subtasks and complete the respective reports.

Subtask I – National Renewable Energy Laboratory, U.S.
Subtask II – NL Agency, the Netherlands
Subtask III – VITO, Belgium

All other participants in the Task took part in the information exchange based on their specific interest and expertise and supported the subtask leaders in reaching their objectives.

The subtask reports as well as other documents are accessible for the members through the members' part of the Task 12 website (http://ieahev.vito.be). A document management system facilitated the exchange of working documents, final reports and other information. The full reports are initially only available to the countries that participated in this Task, but papers and presentations become public matter once they are published in proceedings and presented at conferences.

7.4 Results

Eight expert meetings have been organized and successfully executed.

Expert meetings of IA-HEV Task 12			
#	Date	Place	Country
1	February 9, 2007	San Diego	U.S.
2	May 10, 2007	Mol	Belgium
3	September 19, 2007	Istanbul	Turkey
4	February 6–7, 2008	Vancouver	Canada
5	October 16, 2008	South Bend	U.S.
6	October 30, 2009	Golden	U.S.
7	June 25, 2010	London	UK
8	October 11–12, 2010	Bellach	Switzerland

Combining the expert meetings with a local workshop, conference, or company visit has brought a lot of added value and information to Task 12.

The first expert meeting in 2007 in San Diego was combined with a heavy-duty hybrid vehicle workshop with some key speakers from the U.S. One of the other expert meetings in 2008 was held in South Bend, Indiana, U.S., in conjunction with the Hybrid Truck User Forum (HTUF) 2008. HTUF is a multi-year, user-driven program to accelerate the commercialization of medium- and heavy-duty hybrid technologies in the U.S. It is operated by CALSTART in partnership with the U.S. Army's National Automotive Center (NAC) (more info: www.htuf.org).

The expert meeting in 2009 took place at the National Renewable Energy Laboratory (NREL) that is the primary U.S. laboratory for renewable energy and energy efficiency research and development (R&D). NREL's mission and strategy are focused on advancing the U.S. Department of Energy's and U.S. energy goals. Their areas span from understanding renewable resources for energy, to the conversion of these resources to renewable electricity and fuels, and ultimately to the use of renewable electricity and fuels in homes, commercial buildings, and vehicles. It was again confirmed during the visit that NREL has a lot of experience from a research perspective, which has been of valuable input for the Task 12 final report.

Along with input from the R&D and government side, input from industry was crucial for a good overview on the latest trends in heavy-duty hybrid vehicles. As a result, Task 12 was very pleased with the contribution from Switzerland's designated Task representative, HESS AG. The company began in 1882 with the production of buses and utility vehicles and has been in family ownership for 5 generations. Together with its international licensees, HESS currently produces around 2,400 buses a year. HESS experience ranges from buses to trolleybuses, up to city buses in standard and hybrid versions (see figure 7.1). Their headquarters in Bellach employs around 260 personnel.

Fig. 7.1 HESS AG hybrid bus, Luxembourg – 2009. (Photo courtesy of HESS AG.)

Fig. 7.2 Attendees at the final Task 12 experts meeting held in October 2010 toured the HESS factory in Bellach, CH. From left to right: Alex Naef (CEO of HESS), Arie Brouwer (The Netherlands), Carlo Mol (Belgium), Jussi Suomela (Finland), Teemu Lehmuspelto (Finland), and Hans-Jörg Gisler (Technical Manager, HESS AG). (Photo courtesy of Solothurner Zeitung.)

The final expert meeting took place in October 2010 at HESS AG headquarters (see figure 7.2). This location choice enabled attendees to a visit the HESS factory, but the prime focus was the completion of the final report. All collected information was organized from the different subtasks' reports and will be aggregated into one final report. It can be concluded that the market of heavy-duty hybrid vehicles is growing from a prototype phase into more of a demonstration/commercial phase. Market activities indicate increasing developments in all categories of heavy-duty hybrid vehicles: trucks, buses and mobile work machines. The final report will be presented to the IA-HEV Executive Committee in November 2011 at its 35th meeting in Lisbon, Portugal, along with possible next steps and a final communication plan.

In the meantime, following dissemination activities have been executed:

- March 19, 2010: Presentation at the "Move it" Expo (Genk, Belgium)
- November 9, 2010: Paper and Presentation at the Electric Vehicle Symposium (EVS-25) "Trends and insight in heavy-duty vehicle electrification" (Shenzhen, China)
- December 1, 2010: Presentation at the Conference "New Horizons for Urban Traffic" (Luzern, Switzerland)

7.5 Contact details of the Operating Agent

Research institute VITO is the Operating Agent of this Task. For further information regarding this closed Task, please contact:

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8

Fuel cell vehicles (Task 13)

Participants: Austria, Switzerland, United States (U.S.)

8.1 Introduction

Fuel cells are a rapidly developing energy conversion technology. Offering higher efficiencies than conventional technologies, they also operate quietly and have a modular construction that is easily scalable. These fuel cell features are attractive for a range of potential applications, including combined heat and power, distributed power generation, and transport. Stationary fuel cell systems have been installed world-wide and have demonstrated excellent fuel efficiency and reliability. The transport industry, energy utilities, and producers of portable consumer products have been investing strongly in the development of this technology.

Many believe that the fuel cell engine—comprising a fuel processor, fuel cell stack and power conditioner—will ultimately take the place of the internal combustion engine as the dominant technology for vehicle power trains. Fuel cells offer a number of interesting options for vehicle design, including unique advantages concerning energy efficiency, possible driving distance in relation to pure battery electric vehicles (BEV), and the reduction of noise and exhaust emissions. Implementing these technologies in a hybrid fuel cell vehicle (FCV) may be the most feasible near-term transport solution. The energy recuperation and peak power capacity of batteries and supercapacitors provides an optimal combination with the efficient baseload capability of fuel cells.

However, limited lifetime and high production costs due to noble metal catalysts have until now impeded the broad market introduction of fuel cells beyond specialized niches such as space applications. In recent years the use of cheaper and more stable materials for separators and electrodes has contributed to major improvements for fuel cell technologies. An external policy driver that would improve the cost-competitiveness of FCVs is a more restrictive emission standard because it would increase aftertreatment costs of internal combustion engine emissions.

8.2
Objectives

Task 13 activities were concluded with a final report at the end of 2010. International cooperation assisted in identifying global technological trends and development processes. The desired output was an impartial analysis of the state of FCV activities worldwide.

IA-HEV Task 13 focused its activities on tuning fuel cell properties and using their high potential for successful application in vehicles. The main drivers to start the Task included specific demands for power, cost, lifetime, and the range of vehicles powered by fuel cells, batteries, and all types of hybrid solutions.

8.3
Working method

The primary tasks for Task 13 were technology assessments and information exchange between its member counties—Austria, Switzerland, and the U.S.—on national FCV-related research, development, and demonstration (RD&D) activities. Shared costs and broader data records were among the advantages of this cooperative work. International cooperation reduced the risk of overlooking regional technological trends or results in the global development process.

In November 2006, the IA-HEV Executive Committee formally started Task 13. The Task launched its work at the kick-off meeting in Graz, Austria in September 2007. Experts from six countries presented their work at this meeting. A detailed work plan was discussed intensively. Because the resources of each partner in this Task were limited, a focused work plan with a limited number of topics was created. These topics were:

- The fuel cell vehicle system
- Hybridization
- System integration and behavior
- Cross-cutting issues

Close cooperation with the International Energy Agency (IEA) Implementing Agreement on Advanced Fuel Cells ensured that information and knowledge from fuel cell experts was integrated into this Task and there was no duplication of work that was relevant for both Implementing Agreements.

In parallel to this Task, some IA-HEV member countries strongly supported fuel cell research in their national R&D programs and participated in regional and multilateral activities such as the Fuel Cells and Hydrogen Joint Technology Initiative of the European Union launched in late 2008.

The Task 13 main working method and activities from 2007–2010 consisted of:
1. Dissemination activities through published papers and presentations at international conferences
2. Expert workshops and Task meetings
3. A final report

8.4 Results

2010 Final report

Task 13 activities were concluded at the end of 2010 with a final report exclusive for Task members. This final report compiles an up-to-date, neutral, and comprehensive assessment of current trends in fuel cell technology (system configurations and components) including:

- Fuel cell vehicles' configuration
- Main components for FCVs: power electronics and electric machines, energy storage, and fuel cells
- Hydrogen production, storage in vehicle, dispensing (connectors) and distribution
- A detailed description of national efforts worldwide supporting this technology through RD&D

Overview

In spite of the current, largely increased development efforts for BEVs and plug-in hybrid electric vehicles, most of the relevant manufacturers are continuing with their research activities on FCVs. Regional and national programmes for deployment are under discussion and progressing with specific targets for FCV fleets.

The list of shortcomings of FCVs has been reduced in recent years. Power density range and cold start capability have been significantly improved. Durability is approaching the target range of 4,000–5,500 hours of operation. On the other hand, improved investment costs for the powertrain and the installation of fuelling infrastructure are needed. A feasible option, depending on the progress achieved on costs reduction, is the introduction of the fuel cell system as a "range extender" in combination with a battery (with or without a plug-in option).

The market segment and the market share of FCVs and BEVs in the market will be established based on a combination of factors, such as costs and convenience (autonomy, charging time, available infrastructure). Additionally, hybrid technology solutions might again be the bridge between mature and new technologies.

Review of FCV projects

FCV demonstration projects in Europe, Japan, and the U.S. were reviewed. Factors considered were the results on driving range, fuel economy, fuel cell specific power and durability, refuelling rates, vehicle maintenance data, well-to-wheel green house gas emissions, and efficiency where the data was available.

Two examples of major deployment efforts are the German Clean Energy Partnership (CEP) Programme and the California Fuel Cell Partnership.

Clean Energy Partnership (CEP)

In November 2004, CEP launched its demonstration project in Berlin, Germany. CEP is an international consortium with the following partners during the first phase: Aral, BMW, the Berlin Public Transport Company, Daimler AG, Ford, General Motors/Opel, StatoilHydro, Linde, TOTAL, Vattenfall Europe, and Volkswagen AG. As part of the German Federal Government-supported National Sustainability Strategy, the CEP demonstration project is the largest project in Europe demonstrating the use of hydrogen-fuelled vehicles in a real-life transportation environment.

1. CEP First Phase

The first phase of the CEP was completed on June 30, 2008 and was aimed at successfully demonstrating hydrogen drive systems and fuelling technologies over a period of several years. It confirmed the reliability of hydrogen-powered vehicles with fuel cells and hydrogen-powered internal combustion engines.

At completion of the first phase, the demonstration project consisted of up to 24 hydrogen-fuelled passenger vehicles. On average 17 hydrogen-powered vehicles were in use—15 using fuel cell technology, while the remaining two used hydrogen-powered internal combustion engines. Additionally, three of the vehicles were driven by liquid hydrogen, with the remaining 14 using compressed (35 MPa) gaseous hydrogen as fuel.

2. CEP Second Phase

The second phase of the CEP project concluded in 2010. The goals for this phase included further validation of technology under real world conditions and new technology development to aid in hydrogen market entry in future years. Efforts to expand the demonstration fleet to 40 vehicles are also in progress. The Berlin vehicle fleet, for example, has already added ten General Motors/Opel HydroGen4 vehicles which use 70 MPa compressed gas hydrogen vessels for on-board hydrogen fuel storage.

3. CEP Third Phase

The third phase of the project began in 2011 and will end in 2016. This final phase will focus on preparing the market for the introduction of hydrogen in the transportation sector. The primary focus will be on technology development and validation resulting in advancements in hydrogen storage, refuelling, and codes and standards.

California Fuel Cell Partnership

Launched in 1999 with the goal to facilitate the commercialization of fuel cell vehicles, the California Fuel Cell Partnership currently has 31 members, including auto manufacturers (Honda, Toyota, Nissan, Volkswagen, Daimler, Hyundai, General Motors and Chrysler), energy companies, fuel cell technology companies, and government agencies. The demonstration phase concluded in 2009 and an action plan for early market preparation for the next 4 years was published.

The 2010 funding provided by the California state government was US$ 22 million, with proposed 2011 funding up to US$ 14 million. Eight new hydrogen stations are planned for the period 2010–2011.

Table 8.1 provides an overview of the targets set for the future phases of the project.

Table 8.1 California Fuel Cell Partnership - Roll-out plan (reference: Action Plan 2009)

	Phase 1: 2011	Phase 2: 2012-2014	Phase 3: 2015-2017
Passenger vehicles	712	4,300	49,600
Buses	15	20-60	150

Papers and presentations

1. "Comparison of different R&D approaches on Fuel Cell Vehicles around the world," presented at the International Advanced Mobility Forum, Geneva, Switzerland, 2009.
2. "Worldwide Promotion and Deployment of Fuel Cell Vehicles," presented at the 24th World Electric Vehicle Symposium (EVS 24), Stavanger, Norway, 2009.
3. "RD&D Cooperation for the Development of Fuel Cell, Hybrid, and Electric Vehicles within the International Energy Agency, " presented at the 25th World Electric Vehicle Symposium (EVS 25), Shenzhen, China, 2010.

Workshops
Much of the information-sharing activity of this Task occurred during three workshops which took place in 2008 and 2009. The main topics of discussion at these workshops are listed below.

Cold start behaviour of fuel cell vehicles, in Geneva, Switzerland, 2008.
The workshop conclusions were that:

- Considerable work on degradation mechanisms of components due to freezing had already been done, and the degradation models were suitable for special applications.
- Further basic research in the area of membranes, catalysts, stack design, and degradation mechanisms was still needed.
- From an industry point of view, the problem can be solved with available technology, for reasonable costs and moderate energy consumption.
- Additional information was still necessary for a proper understanding of the complex “fuel cell vehicle system” (e.g., energy demand of storage systems and behavior at subzero temperatures, better understanding of degradation of MEAs (Membrane Electrode Assemblies) in different applications, etc.).

Current status and trends of the fuel cell vehicle, in Villigen, Switzerland (Paul Scherrer Institute), 2009. The workshop findings were:
Representatives of automotive OEMs who attended reported significant progress in the development of fuel cell vehicles and hydrogen storage devices over recent years. The latest generation of fuel cell vehicles shows a remarkable improvement in terms of reliability, driving range, power density, durability, and cold-start capability. The investment by industry and various governments into this technology within the last 10 years is in the range of billions of euros.

The proof of concept phase has been reached, but costs are still very high (approximately USD $100,000 per car) due to the lack of economies of scale (production of a few units), among other reasons.

Summary of the discussion on Fuel Cell perspectives for the vehicle industry, research institutions, and public authorities:

- In Europe, the Fuel Cell and Hydrogen Joint Technology Initiative of the European Commission is creating a stable and long-term (10 years) oriented funding plan for fuel cell technology.
- Germany’s National Innovation Programme for Hydrogen and Fuel Cell Technology also has a long-term-oriented strategy with a total project budget of €1.4 billion over a period of ten years.

- The budget proposal for the U.S. Department of Energy's hydrogen program discussed in 2009 planned a significant reduction of funding from USD $200 million to USD $7O million. The influence of this decision on other countries' policies was discussed.

8.5 Further work

Task 13 has concluded. The implementation of fuel cells for electric vehicles may be included in the new IA-HEV Task 17, System Integration. Additionally, international cooperation in the field of fuel cells for transport applications will continue under the IEA Implementing Agreement for Advanced Fuel Cells in Annex 26, Fuel Cells for Transportation.

8.6 Contact details of the OA

Task 13 was coordinated by the Austrian Agency for Alternative Propulsion Systems (A3PS).

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9 Market deployment of electric vehicles: Lessons learned (Task 14)

Participants: Sweden, Switzerland, United States (USA)

9.1 Introduction

Several car-making nations have embraced electrification as a means to invigorate their car industries, pumping research and support funds towards industry to accelerate development and commercialization of plug-in hybrids (PHEVs) and EVs. Also, several automakers continued to feature electric drive vehicles in car shows, experimental programs, and announced market rollouts. Deployment programs are multiplying around the world.

Task 14 focused on new EV deployment efforts and explores whether these are including lessons from the past. For example, a past lesson was that much of the public infrastructure put in place during previous deployments was poorly used and difficult to maintain. However, many cities, OEMs, and infrastructure developers are proceeding to install public charging stations, and it is unclear whether these new plans apply the knowledge from the old. As a result, during 2010, the "Lessons Learned" Task held two final workshops in Paris and Berlin to discuss past and new deployments, following meetings in several other cities in the immediately preceding years.

9.2 Objectives

As efforts to manufacture and market EVs reformulate, this Annex was designed to capture and report important lessons learned in past and new deployments of electric vehicles. The goal was to develop practical advice for utilities, local governments, OEMs, small firms, regulators, and other parties involved in future deployments.

9.3 Working method

The work of this Annex relied upon at least three research components:

1. Workshops in former deployment areas (United States, Switzerland, Sweden, Japan, United Kingdom, France, and Germany) that brought together experts who have experience pertaining to the deployment of electric and hybrid vehicles. These experts offered a range of experiences and perspectives on the lessons they have learned in these deployments in the areas of manufacturing, distribution, sales, charging infrastructure, and market support from the utilities

and governments. This approach has yielded useful comparisons across these regions.
2. Additional interviews with important experts who could not attend workshops.
3. Review of literature and historical material from each deployment region, including other sources of interest. For example, surveys among EV and HEV users in fleet tests were evaluated.

During 2010 the main researchers from IA-HEV member countries in Task 14 were:

- Björn Budde, Systems Research, Austria.
- Sigrid Muntwyler, Muntwyler Energietechnik AG, Switzerland.
- Robin Haycock, Office of Low Emission Vehicles, United Kingdom.
- Danilo Santini, Argonne National Laboratory, USA.
- Kanehira Maruo, ETC Battery & FuelCells Sweden AB, Sweden.
- Tom Turrentine, Task 14 Operating Agent, University of California at Davis, USA.

Eleven workshops were held between October 2007 and April 2010 in France, Germany, Japan, Sweden, Switzerland, the UK, and USA. Box 9.1 presents an overview of the nine workshops that have been organized to date, and box 9.2 lists the participants in these workshops.

Box 9.1
Overview of IA-HEV Task 14 workshops

No.	Location	Date
1	Santa Cruz, California, USA.	October 3-4, 2007
2	Anaheim, California, USA.	December 5, 2007
3	Geneva, Switzerland.	March 10, 2008
4	Tokyo, Japan.	May 23, 2008
5	Tokyo, Japan.	May 26, 2008
6	Gothenburg, Sweden.	September 19, 2008
7	Stockholm, Sweden.	September 22, 2008
8	London, United Kingdom.	September 2009
9	Boston, Massachusetts, USA.	October 2009
10	Paris, France	April 2010
11	Berlin, Germany	April 2010

Box 9.2
Participants in IA-HEV Task 14 workshops

	Workshop Number										
Takafumi Anegawa, Tokyo Electric Power Company.					5						
Yoshitaka Asakura, Toyota.				4							
Yasuko Baba, Keio University.				4							
Tom Balon, MJ Bradley & Associates.									9	10	
James Barnes, US Department of Energy.	1	2	3								
John Batterbee, ETI.								8			
Jon Bentley, IBM.								8			
Joseph Berreta, PSA Peugeot-Citroën.			3							10	
Annalisa Bevins, CARB, presided over ZEV process in the 1990s.	1										
Cyriacus Bleijs, Electricité de France.			3								
Herve Borgoltz, DBT (Douaisienne de Basse Tension).										10	
Per Brannstrom, Grontmij AB.							7				
Björn Budde, Systems Research.				4	5	6	7	8	9		
Andrew Burke, University of California, Davis.				4							
Dave Buttery, Office for Low Emission Vehicles, UK.								8			
Tom Cackette, CARB, presided over ZEV process in the 1990s.	1										
Stefan Camenzind, ESORO.			3								
Craig Childers, veteran of the California ZEV regulatory process.		2									
Peter Cocron, Technical University Chemnitz.											11
Gérard Coquery, INRETS.											11
John Dabels, former head of marketing for the GM EV1 program.	1										
Ziad Dagher, Renault.										10	
Ingo Diefenbach, RWE.											11
Tien Duong, US Department of Energy.		2	3								
Bernhard Egger, A3PS.			3								
Robert Eriksson, Volvo Car Corporation.						6					
Sture Eriksson, Royal Institute of Technology, Stockholm.						6					
Ricardo Espinosa, Azure Dynamics.									9	10	
Robert Evans, Cenex.								8			
Mark Evers, TFL.								8			

Hans Folkesson, the Swedish Hybrid Vehicle Center.						6					
Yuichi Fujii, former president of Panasonic EV Energy.					5						
Masato Fukino, Nissan.				4							
Harold Garabedian, Evermont (formerly VT DEC).									9		
Bernt Gustafsson, Swedish Energy Agency.							7				
Robin Haycock, Office of Low Emission Vehicles, UK.								8	9	10	
Rusty Heffner, Booz Allen Hamilton.									9		
Roger Hey, E-ON.								8			
Torben Holm, DONG Energy, Denmark.								8			
Joergen Horstmann, consultant, Denmark.								8			
Tomohiko Ikeya, CRIEPI.				4							
Professor Ishitani, Keio University.				4							
Bengt Jacobson, Volvo Car Corporation.						6					
Maytom Jon, AMI.								8			
Marie-Loise Karlsson, Embassy of Sweden.				4	5						
Magnus Karlstrom, Hydrogen Sweden.						6					
Peter Kasche, Swedish Energy Agency.							7				
Kerry-Jane King, NYPA.									9		
Edward Kjaer, EV deployment veteran, Southern California Edison.		2									
Sigrid Kleindienst, Muntwyler Energietechnik AG, Task 14.	1	2	3	4	5	6	7	8	9	10	11
Joseph Krems, BMW.											11
Urban Kristiansson, Volvo Car Corporation.						6					
Ken Kurani, market research projects for the State of California.	1										
Greger Ledung, Swedish Energy Agency.							7				
Anders Lewald, Swedish Energy Agency.						6					
Stefan Liljemark, Vattenfall Power Consulting AB.							7				
Kanehira Maruo, ETC Battery & FuelCells Sweden AB, Task 14.	1	2	3	4	5	6	7	8	9	10	11
Akiteru Maruta, TECHNOVA.					5						
Arno Mathoy, Brusa Electronics.			3								
Brian McBeth, Daimler.											11
Andre Metzner, NOW GmbH/Roland Berger Automotive Division.											11
John Miles, Arup.								8			
Paul Miller, NESCAUM.									9		

Takeshi Miyamoto, Nissan.				4							
Urs Muntwyler, IA-HEV chairman.	1	2	3								
Ranbir Nota, Office for Low Emission Vehicles, UK.								8			
Mr. Ono, President & CEO Tokyo R&D.				4	5						
Michel Orville, DBT (Douaisienne de Basse Tension).										10	
Michel Parent, INRIA.										10	
Maxime Pasquier, ADEME.										10	
Marco Piffaretti, Managing Director, Protoscar.			3								
Hans Pohl, Vinnova.						6	7				
Joel Pointon, Sempra Energy.										10	11
Christoph Saafeld, Daimler.											11
Ichiro Sakai, Honda.									9		
Danilo Santini, Argonne National Laboratory.	1	2	3	4	5	6	7		9	10	11
Glenn Schmidt, BMW.											11
Max Schwalm, BMW.											11
Chelsea Sexton, a front lines EV1 sales person for GM.	1	2									
Joachim Skoogberg, Fortum Markets AB.							7				
Rosie Snashall, Department for Transport, UK.								8			
Matt Solomon, NESCAUM.									9		
Eva Sunnerstedts, Environment and Health Admin., Stockholm.							7				
Fujio Takimoto, Consultant & Representative Fuji Tech. Info Service.					5						
Dean Taylor, EV deployment veteran, Southern California Edison.		2									
Masahiko Teramoto, Nissan.				4							
Jonan Tollin, Vattenfall AB.							7				
Tom Turrentine, Operating Agent IA-HEV Task 14.	1	2	3	4	5	6	7	8	9	10	11
Jun Watanabe, Nissan Motor Manufacturing.								8			
Andreas Weber, Vattenfall.											11
Oliver Weinmann, Vattenfall.											11
James Worden, former owner of Solectria.									9		
Martijn van Walwijk, secretary IEA IA-HEV. Takehisa Yaegashi, Toyota.				4							
Sigvard Zetterstrom, Royal Institute of Technology, Stockholm.						6					

9.4
Results: Lessons learned

The workshops have resulted in the compilation of practical lessons for future deployments in the areas of how regulators can work best with OEMs, how local governments and utilities can best develop infrastructure and incentives for future EV deployments, and how state and OEM marketing can best introduce EVs to the public. In particular, these small workshops have resulted in candid and in-depth discussions.

The study contains many lessons and detailed discussions of past deployment efforts in several countries, which we are synthesizing into a report. We offer here the types of lessons learned in the workshops held during 2010 and before:

- Subsidies were required to promote use of EVs in France.
- It is difficult to transition from demonstration to commercialization; there is a lack of instruments to foster this stage.
- Low consumption ICE cars, hybrid vehicles and battery electric vehicles compete for many of the same customers.
- There is potential positive influence of new information technologies on the future development of electric vehicles and charging infrastructure.
- It is necessary to reduce the cost of batteries (high production volume needed)
- Infrastructure investment should be carefully focused. Limited, effectively located public charging is needed.
- Accurately predicting EV customer locations is desirable in order to plan public infrastructure.
- Cost-effective charging infrastructure at the dwelling is crucial; there are complications for multiple unit dwellings.
- Charging equipment standardization remains an issue.
- Charging times must be advantageous to electric utilities. Electric vehicles should charge up at off-peak hours, during the night; reinforcing existing daytime peaks or creating new peaks is to be avoided.
- The fuels and technologies used for electricity generation vary widely across nations and by time of day; net full fuel cycle carbon emissions therefore vary. Increasing renewable use can be technically enabled via battery storage, but is economically challenging.
- Many of today’s EVs can be fun to drive in the city and perform adequately even on limited access highways.

9.5
Further work

The final report remains to be completed. A continuation of some of this work may be addressed in Task 18, EV Ecosystems.

9.6
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10

Plug-in Hybrid Electric Vehicles (PHEV) (Task 15)

Participants: Canada, France, Germany, Sweden, United States (USA)

10.1 Introduction

By reducing fossil fuel use per mile of service delivered, sustainable transport leads to greater energy security and reduced greenhouse gas (GHG) emissions. Plug-in electric drive's ability to eliminate oil use has become increasingly attractive as oil prices have become more volatile in recent years. Among member countries to this Implementing Agreement, the transportation sector ranks high in national oil use and GHG emissions.

More than ever, low consumption of refined petroleum products per kilometer of operation is becoming a principal primary focus for powertrain product development, with reduced overall carbon emissions also a high priority. By implementing the positive synergism between electric drive and internal combustion, hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) enable sharply reduced fuel consumption. The plug-in hybrid electric vehicle concept is increasingly seen as an excellent, readily implementable powertrain for sustainable transportation.

Task History

Task 15 began its initial three-year phase in December 2007 to focus on the PHEV-related issues identified in the final report of IA-HEV Task 7 on hybrid electric vehicles, and those related items identified on renewable energies.

The Task 7 final report addressed issues such as modelling, simulation, life cycle analysis, fuel consumption and energy savings estimation, potential reduction of greenhouse gas emissions and fossil fuel dependency, battery cost, and lastly infrastructure. Items related to renewable energies for electricity production were also identified as important topics for further research, including the investigation of merits and costs from using grid electricity effectively in PHEVs (along with EVs). PHEVs can provide energy storage, for no-carbon electric energy sources such as wind and solar. Technological options include use of the stored wind or solar energy to provide transportation, or to return electricity to the grid for other uses – so called "vehicle-to-grid" (V2G) operation. Finally, there are also potential benefits of using plugged in PHEVs or EVs for a form of short term grid power management known as regulation.

Since 2007, the interest in PHEVs has dramatically increased. In 2010, virtually all of the major vehicle manufacturers are offering—or planning to offer soon—PHEVs for sale to the mass market. Though the broad PHEV technology offers great promise, many unanswered questions exist about details, such as which types of PHEVs are best in various applications; how widely will they be adopted; and how much will they actually enhance sustainability of transport? These questions merit investigation.

Task 15 changed Operating Agents (OA) in 2010 and has recently revised its work plan. Charles Thibodeau, of Natural Resources Canada, resigned as OA and Danilo Santini of Argonne National Laboratory in the U.S. took on the position. The main contributing factors for the changes to Task 15 were the oil price shock of 2008, subsequent world recession, and the increasing public interest and market developments in PHEVs. For Canada and other nations, the oil price increases actually led to substantial increases in demands on the time of country experts, as their governments demanded domestically-focused analyses of the implications of use of electric drive in powertrains in order to cope with high oil prices and oil price uncertainty. At the same time, IA-HEV member interest in PHEVs expanded, along with the policy changes needed to support widespread introduction and Task membership expanded.

Due to these factors, the level of interest in the four analytical subtasks of Task 15 increased and needed new structuring. Some subtasks deserved consideration for possible elevation to the Task level, while other subtasks were integrated into an existing Task. A proposed revised work plan reorganizes the original Task subtasks as outlined below:

1. Advanced battery technologies *(moved to Task 10, Electrochemical systems)*
2. PHEV components *(moved to the new Task 17, System integration)*
3. Policy issues and marketability *(retained by Task 15)*
4. Utilities and the grid *(workshop results documented, further work dropped, possible new Task focused on the topic under discussion)*
5. Task administration, communication and coordination *(retained by Task 15)*

Task 15 was originally scheduled to end the first three-year phase in 2011, but it has now extended this phase by a year. The Task is now scheduled to conclude in 2012. A revised work plan been completed and was presented for IA-HEV Executive Committee approval at its May 2011 meeting.

10.2 Objectives

According to the proposed new Task 15 work plan, the revised Task subtasks now are limited to:

1. Powertrain attributes and vehicle lifetime use costs
2. Policy issues and marketability
3. Group administration, communication, and coordination by the OA

Task 15 objectives are to:

- Find the best niche(s) for multiple PHEV technology options
- Evaluate competing vehicle technologies which operate in the same niche (high use rate) as PHEV: gasoline, diesel, EVs, compressed natural gas (CNG)
- Update PHEV analyses from closed Task 7
- Examine different default charge rates by continent
- Include advanced DI boosted gasoline, clean diesel, EV100
- Retain Extended Range Electric Vehicles (100+ kW)
- Retain PHEV derived from 40–60 kW (electric) HEV
- Add PHEVs derived from coming mild/micro HEVs (~20–25 kW)
- Refine analyses of oil use reduction; sustainability of alternative feedstocks; GHGs
- Focus: mass market new C-class personal vehicles; dedicated overnight parking spots; overnight charging; high daily vehicle use rates
- Evaluate infrastructure costs at the overnight parking spot only
- Consider costs and benefits of charge upgrades to allow multiple charges/ day

10.3 Working method

Operating Agent

The U.S. Department of Energy (DOE) will provide support of the Operating Agent (OA), Dr. Danilo J. Santini through the Energy Storage Program managed by David Howell within the Vehicle Technologies Program, which is within the DOE's Office of Energy Efficiency and Renewable Energy. The OA will organize at least two expert meetings in participating countries in North America and Europe, respectively. Additional meetings planned by country experts working on subtasks may be arranged, depending on the needs and desires of the country experts. The OA will endeavor to attend such meetings if possible, but he will not discourage separate meetings in his absence. Each meeting may include a technical visit to the participant's facilities and/or other interesting projects or events. This allows a participating country expert to illustrate research capabilities and supporting infrastructure in the field of plug-in hybrid electric vehicles and related technologies.

The OA will chair meetings, prepare agendas and minutes, and report to the IA-HEV Executive Committee. The OA will provide project management and coordination, to ensure that activities are implemented and objectives are achieved.

Sustask Leaders

A Subtask Leader or co-leaders will be designated for each of the subtasks. Aymeric Rousseau, U.S. country expert, and Francois Badin, French country expert, have agreed to co-lead Subtask 1. Subtask leaders or co-leaders for Subtask 2 will be recruited from participating country experts. The timing of the subtasks implies that Subtask 1 is the more urgent of the two Subtasks, since its outputs would be needed to complete Subtask 2 analyses.

10.4
Results

In 2010, the revision of the Task 15 work plan and the transition of the OA responsibilities from Canada to the U.S. were completed. The revised Task work plan was submitted for ExCo approval in a May 2010 meeting

From December 2007 through December 2009, three major activities have been concluded, the findings of which were very important for Task progression: a meeting on the world lithium supply, a session on the cold-temperature performance of PHEVs, and a workshop evaluating grid-connected vehicles in support of integration of wind into the grid.

1. World's Supply of Lithium

In December 2008, a meeting on the "World's Supply of Lithium," co-sponsored by this Implementing Agreement's Task 10 and Task 15 was conducted in Charlotte, NC, USA. The general conclusions indicate that lithium (Li) availability will not be an issue.

There could, however, be legitimate concern about reliance on other materials. Examples include cobalt and rare earths (neodymium and dysprosium for magnets and motors). Rare earths may require an order of magnitude increase in mine production in the next 10 to 12 years.

2. Cold Temperature Performance of Electric Drive Vehicles

In September 2009, during the PHEV Conference in Montreal, Canada, a special session on cold temperature performance of electric drive vehicles was hosted by Task 15's Battery Subtask Leader.

General conclusions are as follows:

- Extreme conditions, such as cold winters and hot-humid summers found in the interior of several major industrialized nations of the Northern Hemisphere, pose unusual challenges on the performance of batteries when compared to islands and coastal locations with less severe temperature fluctuations.

- For early personal PHEVs, using a combination of nickel metal hydride and retrofitted lithium-ion packs, average fuel and electricity consumption rose as temperature dropped.

- Efficiency of the battery dropped as temperature decreased, and time required to charge increased. However, a presentation for HEV urban buses using a nickel metal hydride pack showed no temperature penalties on average. The bus was driven many hours per day, making the cold start portion of the day small relative to the PHEV tests. This suggests that pre-heating when plugged in could be very effective in reducing the effects of cold starts for personal PHEVs.

- Very high temperature areas in the U.S. also cause losses of PHEV operating efficiency, and incomplete battery charging. However, for the range of ambient temperatures evaluated, the operating efficiency effects of extreme cold were considerably more dramatic than for extreme heat. However, an issue not addressed in the presentations is the effect of extreme temperatures on calendar life of battery packs.

- Battery packs need designs for salt-related intrusion problems from either road-salt used in cold-weather conditions or coastal water-related "salt-fog".

3. Grid-Connected Vehicles and Renewable Energy

In November 2009, an international workshop entitled "Grid Connected Vehicles and Renewable Energy Workshop – Exploring Synergies" was conducted in Frederica, Denmark. A final workshop report was issued and results were presented at the June 2010 meeting in London, UK.

The focus of this workshop was to better understand how different electricity systems from different regions and jurisdictions around the world will provide/acquire power to/from grid-connected vehicles and to learn from different approaches to better take advantage of the opportunities these vehicles present. Although sponsored by Task 15, the focus leaned towards pure electric vehicles rather than plug-in hybrid vehicles.

Potential spin-off: In November 2010, the Task proposal for Renewables and Vehicles received the third highest level of support among ten proposals at the 33^{rd} ExCo meeting in Shenzhen, China.

Findings and Outcomes:

Renewable energy supply - Those countries that have an above-average renewable energy capacity were considered more ready than others to supply "green" electricity to these vehicles; however, the implementation of "smart grid" systems was seen as essential to effectively manage these loads, particularly if these vehicles make up a significant portion of their total vehicle fleet.

Promotion of renewable energy through grid-connected vehicle energy use - Fuel switching reduces use of fossil fuels, contributes to price stabilization for vehicle operating costs, and minimizes the impact of oil price fluctuations. Life cycle costs to the consumer could be reduced if GHG credits and/or Renewable Energy Credits are provided and owned by the vehicle purchaser and user.

Marketing strategies for both vehicles and renewables - Public education with an emphasis on politicians and advocacy from related associations is needed. Charging strategies include the installation of public charging stations by utilities and encouraging night-time charging.

Regulatory/Policy options - Recommendations for vehicles include: maintain subsidies and tax rebates, consider building codes requiring inclusion of charging infrastructure, use smart meters, and codes and standards for vehicles. Renewable energy options for promotion are: the Renewable Portfolio Standard (RPS), Feed-in Tariffs (FIT), federal subsidies and tax incentives, and government renewable energy purchase and use.

10.5 Further work

The revised work plan narrows the scope of further work between the two subtasks: 1) Powertrain attributes and vehicle lifetime use costs and 2) Policy issues and marketability.

Subtask 1 – Powertrain Attributes and Vehicle Lifetime Use Costs

A goal of this study will be to compare marketability and oil use reduction cost effectiveness per kWh of the installed battery pack when grid-connected HEVs, PHEVs, and Extended Range EVs compete head-to-head in the marketplace with available models. The aim is to predict market share and fuel use reduction per year of operation. The ideal vehicles studied would include EVs, diesels, advanced gasoline, and perhaps CNG vehicles.

To the extent possible, this Subtask will evaluate each of the items named in the bullets below, with a sensitivity analysis across the items in parentheses.

- Glider, or the vehicle minus the powertrain (weight, rolling resistance, drag area, front-wheel drive (FWD) vs. rear-wheel drive (RWD))
- Electric machines [Permanent Magnet (PM) vs. induction]
- Drivetrains (parallel, split, extended-range EV)
- Transmission type (planetary, continuously variable transmission (CVT), auto manual, automatic)
- Chargers (Levels 1 & 2 AC; circuit upgrades, meters)
- Control & communication equipment (on &/or off PHEV)
- Fuel and electricity use in real vs. certification driving
- Thermal management, battery & electric machine
- Pack life management strategies, tendencies
- Maintenance and component replacement costs

Subtask 2 – Policy Issues and Marketability

Activities will focus on identifying policy issues which concern participating member governments, especially those related to effectiveness of use of resources (for example, miles of service obtained and oil use reduced per unit extracted or harvested) and greenhouse gas emissions (i.e.: CO_2, CH_4, N_2O). Policy issues will be separated into two groups: (1) vehicles and (2) local infrastructure (neighborhood distribution, inspection needs, circuit upgrade costs, metering costs, etc.). This subtask will use available market penetration models to examine financial policy effectiveness designed to alter initial cost or operating cost.

Subtask 2 activities will explore issues related to:

- Vehicle purchase & operations costs (leasing vs. owning)
- Purchaser's charge circuit & electric vehicle supply equipment (EVSE) costs (time and money)
- Niche marketing to various mass-market consumers
- Effects of taxes – road, registration, fuel, etc.
- Vehicle regulation impact on powertrains offered to consumers
- Oil supply crisis management via altered driving & charging
- Net petroleum use reduction – usual & in oil supply crises
- Full-fuel-cycle energy feedstock/resource use changes
- GHG reduction vs. hour/season of charging; electric generation technology and fuel; utility regulation options, effects
- Tailpipe vs. full fuel cycle emissions changes (incl. annual)
- Repair & maintenance "infrastructure" build out
- Safety codes, standards, regulations, training

10.6
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11

System integration & optimization of components for enhanced overall electric vehicle performance (Task 17)

Task members: Austria, Switzerland, and the United States

11.1 Introduction

Discussion of the challenges for the market introduction of electric-drive vehicles is often focused on performance, battery costs, and charging infrastructure deployment. However, the feasibility of electric drivetrains also depends on less visible features of these vehicles, specifically the integration and configuration of components. Significant work remains in optimizing the electronic systems of these vehicles, including the handling of interfaces such as system management and monitoring.

In recent years, electronic systems for operating and monitoring vehicles have substantially improved and have consequently gained importance in conventional transport systems. These improvements have increased the market prospects for electric drivetrains as well. However, further optimization is necessary for components and the concepts for overall system integration tuned for the specific requirements of different vehicle applications.

Improved power electronics make possible the operation control of increasingly complex component configurations. Also, the individual components (electric motors, batteries, supercapacitors, internal combustion engines, and fuel cells) have experienced rapid improvements that offer new options for their integration. For example, new possibilities might include combining different energy storage devices to achieve more effective storage strategies, or systems that add a fuel cell or a specifically optimized internal combustion engine to batteries in order to increase the driving range. Depending on the Task capacity, system integration topics considered could go beyond assembling the electric drivetrain to include aspects such as strategies to integrate the drivetrain into lightweight vehicles.

These new developments and the opportunities provided should be analyzed within Task 17. Results from other IA-HEV Annexes, such as Task 10 on electrochemical storage systems, Task 12 on heavy-duty hybrid vehicles, and Task 15 on plug-in hybrid vehicles should also be taken into account.

An additional Task effort should be to investigate the potential of these new system configurations with regards to the specific opportunities and challenges of different vehicle applications. Promising niche markets for these new vehicles (airport vehicles and plant operation vehicles, among others) should be evaluated.

11.2 Objectives

This Task will assess the progress in component developments and configurations to determine the potential for enhanced overall system performance. The impact on the following aspects of system performance will be analyzed:

- Improvement of energy efficiency (by thermal and electric energy management optimization), safer operation, and durability through better monitoring of components' operation
- Cost reduction (for example, through increased efficiency in operation and production, increased part commonality across different applications, and through the use of alternative materials)
- Weight and volume reduction through optimized assembly or configuration of the drivetrain
- Improved spatial arrangement of the drivetrain within the vehicle
- Optimization of the overall vehicle design adapted to the specific requirements and opportunities of electric vehicles for different applications and vehicle classes

11.3 Working method

Task 17 formally started in June 2010 at the IA-HEV Executive Committee meeting in London, UK. The first meeting for this Annex was held in combination with the conference on "Vehicle Integration and System Optimization" in November 2010 and organized by the Austrian Agency for Alternative Propulsion Systems (A3PS) in Vienna.

The activities in this Task consist predominantly of technology assessment studies and information dissemination. The organization of workshops with participation from industry, research organizations, and technology policy experts will provide an international basis for the exchange of information on relevant activities.

11.4 Next steps

The tasks will involve the monitoring and analysis of progress in component configuration and vehicle architecture for electric vehicles. Detailed topics are listed below.

- Analysis of existing component technologies, their development potential, and a cost assessment

- Overview of present component configurations of vehicles on the market
- Review of different OEMs' strategies and technologies for electric vehicles and follow-up of new prototypes
- Analysis of theoretical possible operation and configuration concepts with an assessment of their advantages and disadvantages (comparison/analysis of efficiency, performance, or price reduction along with design considerations depending on different applications for electric vehicles)

11.5 How to join

IA-HEV member countries have to confirm their participation by signing a notification of participation and by delegating a country expert for this Task. Non-member countries may participate on the basis of a special agreement (e.g., as sponsors), which has to be negotiated with the Operating Agent and confirmed by the Executive Committee of the Implementing Agreement.

11.6 Contact details of the OA

Task 17 is coordinated by the Austrian Agency for Alternative Propulsion Systems (A3PS). For further information regarding Task 17, please contact:

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12

Electric Vehicle Ecosystems (Task 18)

Current Participants: Austria, Germany, Portugal, Spain, United Kingdom, United States

12.1 Introduction

Task 18 (Electric Vehicle Ecosystems, or EV Ecosystems) will capture practical experience from cities, regions, and businesses that are pioneering advanced Plug-in Electric Vehicle (EV) pilot programs. The Task was approved on November 4th, 2010, at the 33rd IA-HEV Executive Committee meeting in Shenzhen, China.

The operation of thousands of EVs in cities will require changes to urban systems. This encompasses "hard infrastructure" such as recharging technologies, smart grids, and transport systems, along with "soft infrastructure," such as regulation, business models, skills, and community engagement. Blending this complex mix of technologies and services into the fabric of cities requires alignment between governments, municipal authorities, and other key stakeholders from the automotive manufacturing sector, energy companies, and technology suppliers.

The successful uptake of EVs by the market is by no means guaranteed. This Task aims to play an important role in mapping out the conditions required to support the market growth needed for mass adoption of EVs in cities.

12.2 Objectives

The overarching goal of this Task is to advance international policy and the design of EV urban ecosystems. A group of 10 to 20 leading cities, regions, and nations will be presented as international forerunners and engaged in the following processes:

1. **Roadmapping workshops** in leading cities will assemble experts from municipalities, regional authorities, governments and industry.
2. **First-cut roadmaps** tailored for each city will identify local priorities and challenges to support a plan of action for future opportunities.
3. **An International Roadmap** will establish a blueprint for provision of infrastructure for EVs. It will aggregate best practices from each of the cities and establish a consensus vision on emerging challenges and opportunities.
4. **A global community of pioneering cities** will connect international experts via an interactive web portal and a series of city congress meetings to facilitate

policy exchange and problem solving.

The outputs from each of the city roadmaps will be distilled into a single International Roadmap, which will share best practices and case studies on leading cities along with "100 Big Ideas" that have the potential to influence policy and system design.

12.3 Working method

Roadmapping Workshops

The main data collection activity will be a series of one-day roadmapping workshops in 10 to 20 participating cities. These workshops will have the following broad aims:

- To develop a first-cut "strategic landscape" including consideration of socio-economic drivers, market needs, science and resources, business opportunities, products, services, processes, systems, and technology.

- To identify priority areas and gaps in understanding in order to support local infrastructure programmes and inform national policy and system design.

In a city roadmapping workshop, 10 to 20 local experts will be assembled to share insights, ambitions, and visions, which will be promoted to an international audience of policymakers and industrialists. Using a facilitated process developed at the University of Cambridge, the workshops will produce the following key outputs:

- A "strategic landscape" providing commentary on emerging market, technology and operational trends.
- A ranked list of priority opportunities and challenges.
- Outline action plans to respond to emerging opportunities and challenges.
- A structured framework to enable knowledge sharing, benchmarking and exploration of gaps in understanding.

The approach for a workshopping session is outlined in Box 12.1. The main deliverable for each city workshop will be a report detailing all workshop outputs, including the first-cut strategic roadmaps. Each of the city roadmaps will later be integrated into a single International Roadmap that summarizes the key issues identified, best practices, and the emerging trends that are likely to impact the provision of future infrastructure.

Box 12.1
Summary of roadmapping process

1) Planning and preparation
Consult with the host city to define the scope, focus, and aims in more detail, define roadmap architecture parameters, develop workshop agenda, and required preparation. A briefing note will be prepared for participants, together with workshop facilitation materials.
2) Workshop agenda example
    - Introduction (background, aims, agenda, overview of roadmapping)
    - Strategic perspectives (presentations from key individuals, based on a predefined template)
    - Break
    - Strategic landscape (articulate vision, current position and strategic gap, capture additional views, identify & discuss areas of synergy)
    - Identify and prioritize strategic opportunities for roadmapping
    - Lunch
    - Strategic roadmaps and strategic opportunities (break into small groups):
        - Develop “narrative” strategic roadmaps for priority opportunities
        - Prepare for feedback
    - Way forward
        - Actions to take strategic opportunities forward
        - Actions to take roadmapping process forward
    - Review and close
3) Transcription of the data generated into a summary report.
4) Review consultation with the city to discuss ways of further developing the first-cut roadmap.

Web Portal and EV City Congress

Sharing information to advance urban transport systems using a web portal is the best method for instant delivery of worldwide information. The web portal will be designed to share information, and the web work plan will be developed in the spring of 2011. Additionally, up to four EV City Congress meetings are planned through 2013. Participants from multiple cities that are developing EV roadmaps will meet in person to share experiences and best practices. Face-to-face communication and focused interactions between roadmap participants strengthen the global EV network.

Task 18 Governance Structure

David Beeton (United Kingdom) and Thomas Turrentine (United States) are serving as the Operating Agents. Additionally, a Task 18 Steering Group is being established to approve amendments to the activities and the budget. David Howell, at the U.S. Department of Energy’s Vehicle Technologies Program, is the Steering Committee Chair and Luís Reis of INTELI in Portugal is the Steering Committee Co-chair.

12.4
Next steps

Task 18 is in its first year of operation. An initial Steering Group Committee meeting was held in early 2011, and the Task is currently developing a work plan. Anticipated results include the 10–20 city EV roadmaps, the web portal, and the City Pioneer Congress meetings. After the workshops are concluded, one International Roadmap for EV Ecosystems will be written with best practices and other relevant information.

12.5
Further work

The year 2011 will prove to be very busy for this new Task with three city roadmap workshops already scheduled. Locations confirmed: Newcastle, UK; Lisbon, Portugal; San Francisco, U.S., and Barcelona, Spain. More roadmapping workshops will be held as new members join.

Task 18 and Steering Group meetings will be held by teleconference and in conjunction with the biannual IA-HEV Executive Committee meetings.

12.6
How to participate

Task 18 is actively recruiting new partners. Each nation and city engaged in the project will receive focused support to advance local EV programs. Experts will connect with their international peers to exchange best practices, solve common problems, and create a tailored roadmap to support mass adoption of EVs in their cities. Participation in the project may be led by a city, a company that is active in pilot programs, or a national body that is shaping EV and infrastructure policy. Inherent flexibility for participation maximizes the potential benefits to participants and will broaden potential findings.

The Task will engage both established cities that are leading advanced pilots and emerging regions that are advancing ambitious plans for the introduction of EVs. Other organizations and businesses are also invited to contribute to the development of the roadmap, in particular, companies committed to advancing the introduction of EVs to cities and which are in a position to contribute experts or host workshops.

12.7
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13 Overview of hybrid and electric vehicles in 2010

Many countries which had seen automotive sales drop in 2008 and 2009 began to see growth again during 2010. In many cases, sales of hybrid electric vehicles (HEVs) increased along with the rebound in overall sales. However, in the U.S., HEVs decreased as a percentage of new car sales from 2009, partly due to some early purchase incentives phasing out.

However, the biggest EV-related news of the year was the successful rollout of the first production models of the Chevrolet Volt (a plug-in HEV, or PHEV) and Nissan Leaf (a battery electric vehicle, or BEV). Though fewer than 400 units total of these plug-in vehicles were delivered to U.S. customers by the end of 2010, these initial sales have garnered much publicity. Several other IA-HEV member countries were well underway with EV programs of varying scales (for example, Denmark, the Netherlands, Portugal, Spain and the United Kingdom) or preparing to launch programs.

One trend that held among both long-time and new IA-HEV members was that vehicle electrification grew as a national priority between 2009 and 2010. In many countries that had plans to promote EVs, these plans grew more concrete; and plans to launch plug-in EVs emerged in some countries which were only in the beginning stages of HEV sales in 2008 and 2009. As table 13.1 shows, with an estimated one million EVs on the road by the end of 2010, the future for hybrid and electric vehicles looks better than ever.

Fig. 13.1 The Nissan Leaf was selected as "World Car of the Year" by pre-eminent automotive journalists from Asia, Europe, and North America. (Photo courtesy of Nissan)

Table 13.1 Actual or estimated *(estimates in italic)* electric vehicle (EV) and hybrid electric vehicle (HEV) populations in IA-HEV member countries, per December 31st of each year that is shown. Though numbers for 2010 were not yet available in some countries, a total may be estimated by extrapolating from the previous year's total and sales trends.

Year	2007		2008		2009		2010	
Vehicle type	EV[1]	HEV	EV[1]	HEV	EV[1]	HEV	EV[1]	HEV
Austria	691	1,264	1,200	2,592	2,148	3,563	n.a.	n.a.
Belgium[2]	1,030	2,900	1,109	4,800	1,229	6,700	1,295	n.a.
Canada	21	25,783	29	45,703	41	59,541	n.a.	n.a.
Denmark	650	76	10,600	300	15,600	380	20,750	535
Finland	404	303	470	1,142	820	1,876	828	3,073
France	n.a.	15,000	n.a.	24,000	980	33,000	1,000	43,000
Germany	n.a.	n.a.	n.a.	n.a.	5,613	37,748	n.a.	n.a.
Italy	206,300	8,786	217,200	11,254	227,975	19,045	n.a.	n.a.
Netherlands	30,450	6,005	60,452	20,005	458,000	40,000	611,000	57,000
Portugal	n.a.	n.a.	n.a.	n.a.	300	n.a.	350	n.a.
Spain	n.a.	n.a.	n.a.	n.a.	10,698	14,000	10,698	21,190
Sweden	3,320	9,400	3,370	13,500	3,368	16,102	2,739	19,261
Switzerland[3]	23,400	7,762	39,000	11,140	n.a.	13,000	88,480	21,000
Turkey	n.a.	n.a.	n.a.	264	n.a.	n.a.	n.a.	400
UK	n.a.	n.a.	1,405	47,035	n.a.	n.a.	56,004	78,590
USA	55,730	1,012,111	56,901	1,324,497	57,185	1,614,768	58,000	1,888,978
Total IA-HEV	*322,000*	*1,090,000*	*400,000*	*1,500,000*	*850,000*	*1,800,000*	*1,000,000*	*2,250,000*

n.a. not available

1 Includes e-bikes and e-scooters.
2 EV data for Belgium are per August 1st of each year.
3 Swiss EV data does not include industrial and agricultural vehicles. The 2010 HEV figure is for September 2010.

14 Austria

14.1 Introduction

Electric mobility in Austria has been steadily gaining in importance over the last few years. Many initiatives, programs, and working groups were launched in 2009 and began implementation in 2010. Of note are the Electric Mobility Model Regions funded by the Climate and Energy Fund, and the Lighthouse Projects Initiative. These programs are described in detail in following sections.

Greenhouse gas (GHG) emissions reduction continues as a national priority with specific reduction targets for the transport sector. GHG emissions from the transport sector decreased by 0.9 million tons in 2009 compared to 2008 with a total of 21.7 million tons carbon dioxide equivalent emitted (CO_2) (see figure 14.1), yet the current values exceed the target of 19 million tons CO_2 eq. set for Austria by the Climate Strategy 2007 for the period 2008–2012 (see figure 14.2).

The goals set by the European Climate and Energy Package of 2009 requires that 10% of final energy consumption for transport is provided from renewable energy sources and GHG emissions from non-Emission Trading System sectors (road transport included) are reduced by 10% by 2020 with reference to 2005.

The National Energy Strategy of 2010 (Energiestrategie) identified several measures towards achieving these goals including a progressive introduction of electric mobility.

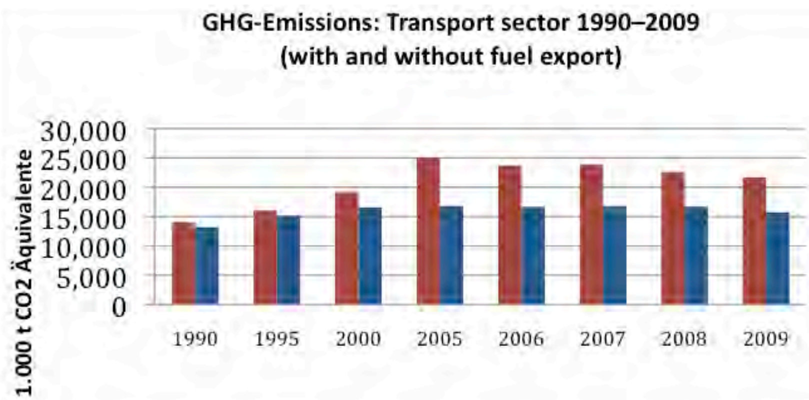


Fig. 14.1 Status of GHG emissions from the transport sector in Austria. The vertical axis is measured in units of “1,000 tons CO_2 equivalent.” (Source: Umweltbundesamt, or Environment Agency Austria.)

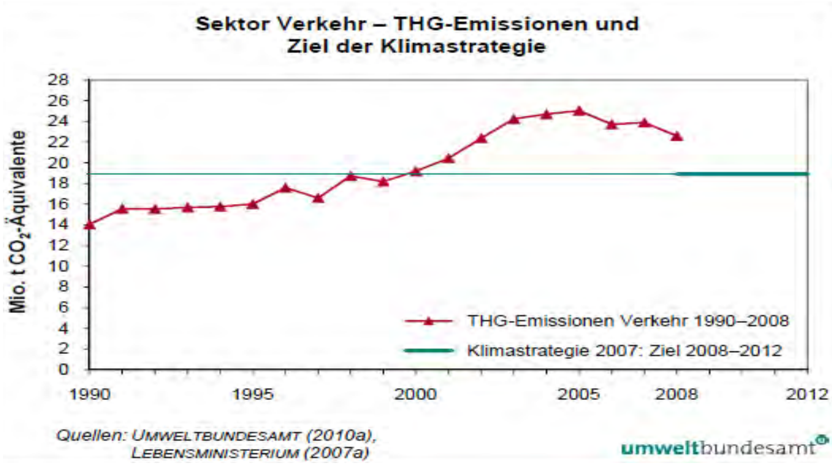


Fig. 14.2 GHG emissions from transport sector for the period 1990–2008 and Climate Strategy 2007 target value. The vertical axis is measured in units of "Million tons of CO_2 equivalent." (Source: Umweltbundesamt and Ministry of Agriculture, Forestry, Environment and Water Management.)

14.2 Policies and legislation

The goal set by the Austrian Energy Strategy is to reach 250,000 two-lane electric vehicles (including plug-in hybrids) in use by 2020 which would represent a 5% share of all registered passenger vehicles. Electric mobility will play an increasingly important role in Austria to achieve the larger goal of reducing CO_2.

SUBSIDIES

National subsidies are already implemented for electric vehicles. The purchase of electric vehicles is exempted from the NoVA tax which in Austria can add up to a maximum of 16%. Exclusively electrically-powered vehicles are also exempted from the motor-based insurance.

Current subsidies on the federal-state level through December 2010:

1. Vienna: The purchase of electric bicycles, mopeds, and motorcycles is subsidized with a maximum of 30% of the value or €300/vehicle
2. Lower Austria: The purchase of electric scooters is subsidized with a maximum of 20% of the vehicle value or €300/vehicle
3. Carinthia: Subsidy for the purchase of electric scooter of maximum €400 until December 31st, 2010.

Other policies are also providing support to vehicle electrification. In January 2011, an increase of the mineral oil tax became effective: for gasoline the increase is 0.04 €/L (increased by 9%) and for diesel 0.05 €/L (increased by 14%). A new bonus-malus (tax credit and tax penalty) system was introduced in July 2008 for the acquisition of new vehicles (NoVA - Normverbrauchsabgabe). A tax reduction of €300 is applied for vehicles with CO_2 emissions lower than 120 g/km. A further tax increase of the NoVA-Malus applies as of January 1st, 2011:

- Emissions over 160 g CO_2/km: 25€ tax increase for each additional gram of CO_2
- Emissions over 180 g CO_2/km: the incremental penalty increased from 25 to 50 €/g CO_2
- Emissions over 220 g CO_2/km: the incremental penalty increased from 25€/g CO_2 to 75 €/g CO_2

Current activities and governmental initiatives are the National Introduction Plan for Electric Mobility and the appointment of a coordination group in 2010 involving the Ministries of Economy, Transport, and Environment to support the electric mobility developments. The Ministerial group for electric mobility is assigned with the following tasks:

- Structured exchange of information and communication
- Coordination of strategies, goals, and measures implemented by each Ministry
- Maximization of synergies between these activities
- Joint formulation of a time plan for the implementation of the agreed measures

14.3 Research

The Federal Ministry of Transport, Innovation, and Technology (BMVIT) implemented the IV2S (Intelligent Transport Systems and Services) research program from 2002 to 2006. The IV2Splus program began in 2007 to build upon these activities and will continue through 2012. Other activities relevant to the development of electric mobility in Austria include the Lighthouse Projects Initiative (LTPI) launched in 2009, and the Electric Mobility Model Regions launched in 2008.

IV2Splus PROGRAM

IV2Splus focuses on expanding research, development and demonstration (RD&D) excellence particularly by leveraging established Austrian RD&D competencies and integrating on an international level industrial and academic research efforts. The structure of the IV2Splus strategy program is shown in figure 14.3; it covers projects from basic research to demonstration and pilot projects. The portion of IV2Splus most relevant to the goal of electromobility is the A3plus program line, while the I2V program and Ways2Go action line are more tangentially related through their general aim of adapting transportation systems to the evolving needs of Austrian society.

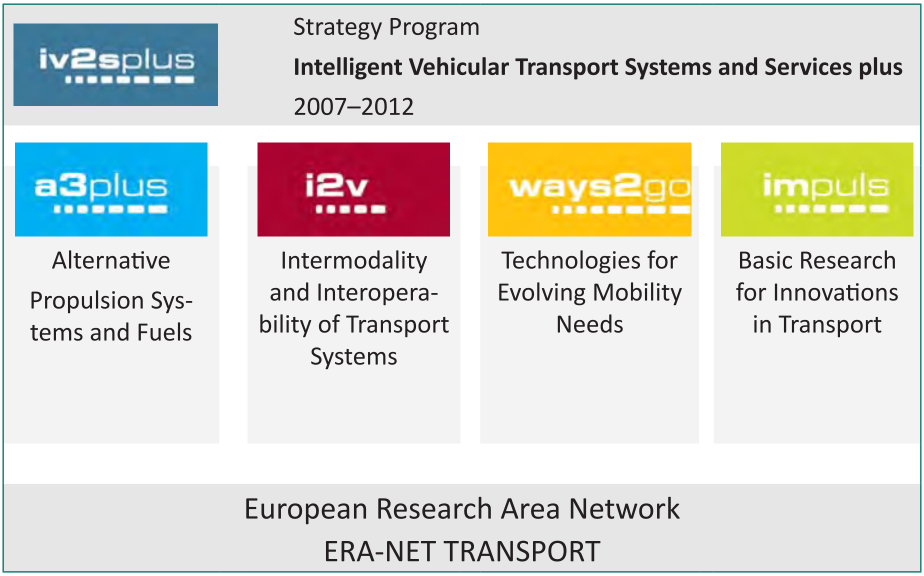


Fig. 14.3 Overview of Intelligent Vehicular Transport Systems and Services plus (IV2Splus) strategy program. (Logos © BMVIT.)

The A3plus program strives to make transportation of the future significantly more energy-efficient and environmentally friendly by promoting RD&D in innovative propulsion technologies and alternative fuels. The goal is to achieve reductions in the energy consumed by surface transport vehicles and to reduce emissions from this sector. The program also aims to develop such systems for rail and inland waterway transportation.

The A3plus program line is intended to support cooperative proposals involving industrial, university, and non-university research. These partnerships should strengthen the innovativeness and competitiveness of the Austrian drivetrain technology industry.

Calls for proposals for research projects are scheduled annually over the time frame of the IV2Splus program. The funding budget assigned for the 2010 call was €5 Million.

The core areas of this program are:

1. Alternative propulsion systems for road, rail, and waterways
   - Scope: Drive systems and drivetrains for road transport, rail transport, and inland waterway transport, including electric drive for surface transport
   - Objectives: Increased motor efficiency and overall energy efficiency (including energy recuperation), reduction of emissions
2. Automotive electronics for energy-efficient control and management of system operation
   - Scope: Power electronics, energy management, energy efficiency optimization of subsystems, monitoring and sensor systems, bidirectional energy conversion
3. Innovative storage concepts
   - Scope: Tanks for liquids and gases, electrochemical and electrostatic storage, storage of kinetic energy
4. Alternative fuels
   - Scope: Liquid and gaseous (bio-)fuels or fuel combinations
5. Development of required infrastructure (recharging/filling stations) for alternative propulsion systems
   - Objectives: Evaluate the possibility of using existing distribution networks and the flexible use of this infrastructure for various alternative energy carriers, achieve a reduction of comparable costs for a homogeneous area coverage

LIGHTHOUSE PROJECTS INITIATIVE AND ELECTRIC MOBILITY MODEL REGIONS

Also relevant for electric mobility research activities in Austria are the funding programs of the Klima- und Energiefonds (Climate and Energy Fund) covering the Lighthouse Projects Initiative with a total budget for 2010 of 19 M€ and the Electric Mobility Model Regions with a total budget for 2010 of 3.5 M€. These programs fund the demonstration of new technologies in the area of electric mobility. They cover the demonstration and implementation of large-scale proposals including the required infrastructure facilities and involve developers, producers, downstream operators, and future users.

The Electric Mobility Model Regions anticipates the implementation of an integrative mobility concept that should include the installation of the necessary charging infrastructure supplied with renewable energy, the procurement and integration of electric vehicles in the regional transport system (public and commercial passenger transport, transport of goods and bicycles), and the analysis of the data obtained from the operation within the model region.

The Lighthouse Project Initiative funds demonstration projects in the field of electric mobility for technologies which are still not market-ready, whereas the Model Regions program provides a framework for market-ready technologies to be tested within new business models and to increase public awareness. Despite their differences, synergies will take place between these two programs. For example, it is recommended that a group of partners applying for funding within the model regions program include stakeholders who also applied for funding within the Lighthouse Projects Initiative.

14.4 Industry

The automotive sector is key for the Austrian economy. Employing approximately 175,000 people in more than 700 enterprises (mostly suppliers), this sector is one of the top five in Austria in terms of number of employees and turnover.

Relevant industrial stakeholders in the sector of hybrid and electric vehicles in Austria include the companies Magna E-Car Systems, AVL, KTM Power Sports AG, Infineon Technologies Austria, and ATB Technologies GmbH.

MAGNA E-CAR SYSTEMS

At the end of August 2010, the automotive supplier Magna International established a partnership with the Stronach Group to continue to pursue opportunities in the vehicle electrification business. It created a new product group, Magna E-Car Systems, which will work closely with other groups, including Austria-based Magna Steyr.

This partnership covers relevant products and services including modules, and components for hybrid and electric vehicles, including cells and battery packs, charging stations, powertrain control modules, electric-drive motors, generators, inverters, converters, and onboard chargers. The capabilities and services that Magna E-Car Systems offers range from R&D activities and engineering, to the integration and production of hybrid and electric vehicles.

AVL LIST

AVL is the world's largest privately-owned company for development of drive systems with combustion engines. AVL works with automobile manufacturers towards the goal of producing more efficient vehicles and reducing CO_2 emissions.

Activities in the field of hybrid and electric vehicles include the optimization of the battery and system development in order to reduce the demand on batteries.

The implementation of the AVL Pure Range Extender makes it possible to extend the range of electric vehicles and to reduce both battery size and costs. The AVL Pure Range Extender uses a generator that can generate electricity, if required, and equips electric vehicles with a range equal to that of conventional vehicles. A concept vehicle implementing this system is shown in figure 14.4.

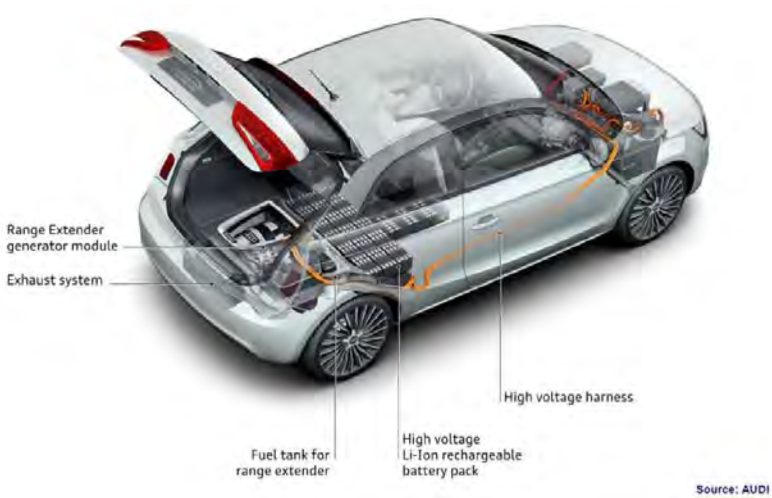


Fig. 14.4 Audi A1 E-Tron concept vehicle with AVL Range Extender in the form of a Wankel Motor. (Source: Audi.)

KTM POWER SPORTS AG

KTM Power Sports AG, one of the world's leading suppliers of motorsport vehicles, is a division of the KTM Group. KTM is the second largest motorcycle supplier in Europe and a global market leader in the off-road motorcycle sector.

KTM presented the prototype of a zero-emission motorcycle in 2008, which was a significant development for the future of Enduro sports (long-range, off-road motorcycle racing) by providing a clear direction for further development of motorcycle technology. This completely new drive concept, developed in cooperation with AIT (Austrian Institute of Technology) based in Vienna, will go into series production in the near future (see figure 14.5). The KTM development department is currently working on several concepts for three- and four-wheel electric vehicles for urban mobility.

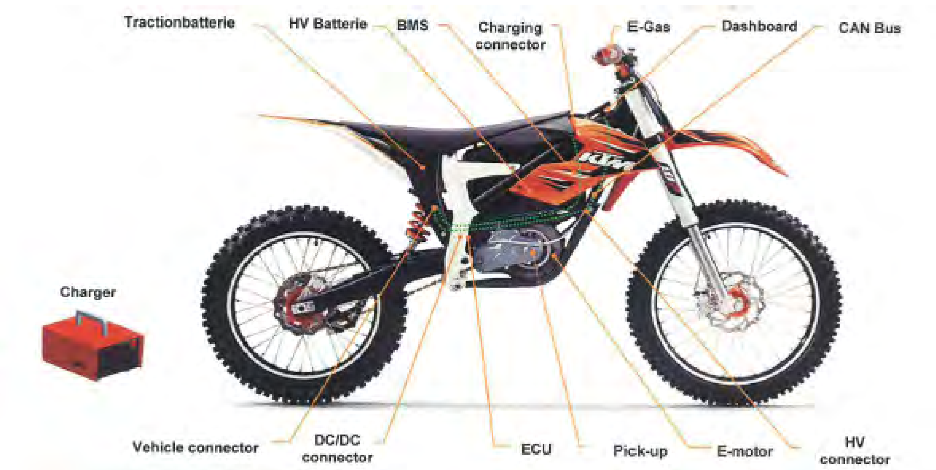


Fig. 14.5 KTM ZEMC, zero-emission motorcycle (Source: KTM.)

INFINEON TECHNOLOGIES AUSTRIA

Infineon Technologies supplies the automotive industry and is a globally-operated company whose semiconductor and system solutions address the increasing market requirements for applications regarding energy efficiency, communications, and safety. The product portfolio comprises discrete components, power semiconductors, microcontrollers, sensors as well as high-power modules and is suitable for all electric drivetrain architectures.

ATB TECHNOLOGIES GmbH

ATB is a leading European manufacturer of electrical motors and drive systems. Their competencies are in the development, calculation, design, and manufacture of customized special motors and drive systems.

14.5 Charging infrastructure and vehicle deployments

The federal Ministry of Transport, Innovation, and Technology (BMVIT) is responsible for planning, financing, and establishing infrastructure for e-mobility. The Electric Mobility Model Regions Program aims for the progressive installation of charging infrastructure, the supply of renewable energy, and the development of new business and mobility models. Other initiatives are also contributing to the further development of the charging infrastructure. An overview of charging points already in operation in Austria can be found online at http://www.e-tankstellen-finder.at/.

CURRENT DEVELOPMENT HIGHLIGHTS

- Companies in the energy industry have either started pilot projects or launched cooperation to develop and establish charging stations.
- Telekom-Austria, a telecommunication company and operator of public phone boxes that are no longer in use or demand, has started to extend public phone boxes with e-charging facilities. The plan included the conversion of at least 30 phone booths by the end of 2010 (see figure 14.6). The charging point can be activated via SMS, RFID chip or a "Just-Plug" Chip developed by Everynear under the framework of the Lighthouse Project Initiative. The charging points are suitable for both single-lane and two-lane vehicles.
- Supermarket retail chains, such as REWE and Spar, are starting to establish charging infrastructure by utilizing their current network of stores.

Fig. 14.6 Charging point from an adapted phone booth in Maria Taferl (Lower Austria) (Source: Everynear).

ELECTRIC MOBILITY MODEL REGIONS

Five model regions are being developed since the 2008 program launch:

- Rheintal - Vlotte (Vorarlberg)
- Salzburg
- Vienna
- Graz
- Eisenstadt

Rheintal - Vlotte (Vorarlberg)

In 2008, Vorarlberg was awarded funding to begin the first e-mobility model region in Austria (www.vlotte.at). It is subsidized with €4.7 M by Austria's Climate and Energy Fund for phase one and €551,000 for phase two beginning in 2010. The further expansion of charging stations is currently limited by the availability of electric cars.

Instead of purchasing an electric car, the customer gets a "mobility card" for approximately €350 a month (exact price depends on vehicle type). The mobility card includes, apart from the car lease, maintenance costs of the electric parts, a free pass for the Vorarlberg public transit system, and free charging at public charging stations. After four years the car can be purchased by the customer for a residual value of 25% of the initial purchase price. A key in the park-and-charge system gives access to all park-and-charge stations in Switzerland, Austria, and Germany along with additional benefits. See box 14.1 for a summary of the goals and achievements of the two phases of the VLOTTE project.

BOX 14.1 VLOTTE
PROJECT GOALS AND PHASES

Goals of VLOTTE project

- Introduce e-Mobility to public by including various stakeholders
- Setup of service and e-charging infrastructure
- Extension of renewable energy sources

Phase one (2008–2010)

- Increased public awareness
- 75 e-cars are on the road
- 32 Charging stations have been built
- 150,000 km have been driven

Phase two (2010–onward)

- Introduction of mobility hubs with rental stations for different vehicle types ranging from electric bicycles to two-lane vehicles
- Development of car sharing plans for company- vehicle fleets
- Use of electric vehicles in the tourism sector

Salzburg

The three-year target for this region is 2,000 electric vehicles that will include 1,000 passenger cars. The vehicles are leased under a subscription and returned after a certain period of time. Currently 300 clients have subscribed using a card that allows free recharging of the vehicles at any of the charging points installed by the consortium. These charging stations are exclusively supplied with renewable energy.

Vienna

Hundreds of charging stations in place and electric vehicles on the road by 2012 are planned to be supported by funding of €1.3 M. The "E-mobility on demand" concept for this model region consists of the integration of electric vehicles into company and car sharing fleets. A "mobility card" specific for this model region is expected to shift demand from private vehicles to public transport and E-car sharing service.

Graz

Graz will be also focus on the optimization of the regional transport system and the integration of 500 electric two-lane and 2000 single-lane vehicles from 2011–2013 with a funding of €1.6 M. The installation of 140 charging stations with 950 charging points is planned. The additional energy demand will be partially supplied with new photovoltaic units. In total, a yearly saving in CO_2 emissions of approximately 1000 tons is expected (source: http://www.graz.at/cms/beitrag/10156096/2767074/).

Additional activities by the Graz city council include a subsidy of €1,500 for electric vehicles for taxis or social and delivery services. Vehicles for driving schools are eligible for up to €1,000. The "Municipal Energy Concept Graz 2020" includes a section for electric mobility and sets a target of 15% of new registrations for electric vehicles by the year 2020.

Eisenstadt

The concept for the model region in Eisenstadt foresees the shift of taxi services to electric vehicles as well as the implementation of E-car sharing and E-carpooling business models. This project was approved for 2011–2013 and is funded with €560,000.

OTHER ELECTRIC MOBILITY INITIATIVES

Europe's first transnational electric mobility project will connect the two cities of Vienna, Austria and Bratislava, Slovakia. In the program for Slovakian-Austrian trans-border cooperation 2007–2013, the concept of the consortium consisting of Energy Centre Bratislava, EVN, Wien Energie and Zapadoslovenska energetika, headed by the Austrian electricity company VERBUND, has successfully convinced the EU sponsoring agency. Between 2011 and 2013, the partners will invest more than one million Euro in the twin city region.

The objective is to demonstrate the operational ability of the overall system of electric mobility. This means that, in the project, there will be a selection of users of electric vehicles who will have the possibility of charging their electric vehicles on either side of the border. For this purpose, charging stations will be installed at select public and semi-public places (for example, customer parking lots at shopping malls) for both fast and regular charging. A focus of the project is the demonstration of the user-friendliness of electric vehicles in daily traffic. This also includes the trans-border availability of services, no matter what the country of residence of the e-mobility customer.

In addition, the future-oriented project is the first joint venture between Austrian and Slovakian energy providers. The project is sponsored by the Austrian Federal Ministry of Economy (BMWFJ) and all relevant regional government authorities, such as the city councils of Bratislava and Vienna, as well as the provincial governments of Bratislava and Lower Austria.

14.6
On the road

The following section gives an overview of the (still) slow but steady increase in the fleet numbers for hybrid and electric vehicles in Austria as well as a description of the vehicles currently available for the consumers or expected in the near future.

Table 14.1 shows the growth in the number of HEVs and EVs in the fleet as of the end of 2009. Table 14.2 focuses on passenger cars only. As mentioned in section 14.2, national subsidies are already implemented for electric vehicles. The number of electric vehicles available for purchase in Austria has been growing, with a list of the models as of July 2010 in table 14.3.

Table 14.1 The distribution of the Austrian hybrid and electric vehicle fleet as of December 31, 2009.

	PER DECEMBER 31, 2009		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs and HEVs)**
Bicycles (no driver license, L1e)	1,627	-	305,042
Motorbikes (L3e)	129	3	158,745
Passenger vehicles (M1)	223	3,559	4,359,944
Buses (M2/M3)	106	-	9,599
Trucks (N)	46	1	370,907
Industrial vehicles	17	-	16,422
Total	**2,148**	**3,563**	**5,220,659**

Table 14.2 Austria's fleet distribution by drivetrain

Fleet distribution by drive train (passenger cars) as of December 31, 2009		
Drive train	Total	New registrations 2010
Gasoline [1]	1,972,352	159,740
Diesel	2,381,906	167,130
Electric	223	112
LPG	1	
Natural gas	1,105	171
Bivalent Gasoline/LPG	56	
Bivalent Gasoline/Natural Gas	742	30
Hybrid Gasoline/Electric	3,559	223
Total	**4,359,944**	**327,406**
Source: Statistik Austria, Kraftfahrzeuge, Kfz-Bestand. - 1) Includes Gasoline/Ethanol (E85).		

Table 14.3 Electric vehicles available in Austria as of July 2010

Electric vehicles available in Austria - status July 2010 Passenger cars and commercial vehicles				
	Model	**Power (kW)**	**Range (km)**	**Price (€)**
REVA	REVA i	6	80	from € 13.700
	NXR City	13	80	from € 19.900
	NXR Intercity	25	160	from € 30.900
NF	Nano	3	90	from € 18.500
EcoCraft	EcoCarrier ES	15	75	from € 26.770
Fiat	Fiorino Electric	15	120	from € 48.500
	Doblo Electric	15	120	from € 62.000
	Scudo Electric	30	100	from € 82.000
	Ducato Electric	n.a.	n.a.	n.a.
	500	8	110-130	from 30.500 *
	Panda Electric	8	100	from € 31.000 *
Mercedes	Sprinter	30	120	from € 99.000
Piaggio	Porter	10,5	110	from € 19.790
Renault	Trafic	30	70	from € 85.000
	Master	30	130	from € 88.000
	Kangoo	n.a.	110	from € 33.000 *
Tazzari	Zero	15	140	from € 19.990
Think	City	n.a.	120-180	n.a.
Tesla	Roadster	n.a.	250-400	n.a.
Mazda	Mazda 2	n.a.	130	from € 33.000
Electric Motorcycles				
Vectrix	VX-1	7	45-60	€ 9.990
Source: ÖAMTC * (before taxes)				

14.7 Outlook

The Energy Strategy for Austria was finalized in 2010. It identifies the introduction of electric mobility supplied with renewable energy sources as highly relevant in order to reach the 10% share of renewable energy for transport by 2020 as required by the EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources as well as the reduction of the GHG emissions from this sector.

A report published in 2010 by the Environment Agency Austria (Umweltbundesamt) analyzes different scenarios for the market introduction of electric vehicles up to 2020 (see figures 14.7 and 14.8). Figure 14.7 shows the growth of the number of plug-in vehicles under the most favorable political and economic conditions, which would result in more than 200,000 such vehicles in 2020 out of a fleet of more than 5 million. On the other hand, if policies continue along the current lines, then the total number of plug-in vehicles in 2020 is projected to be less 64,000.

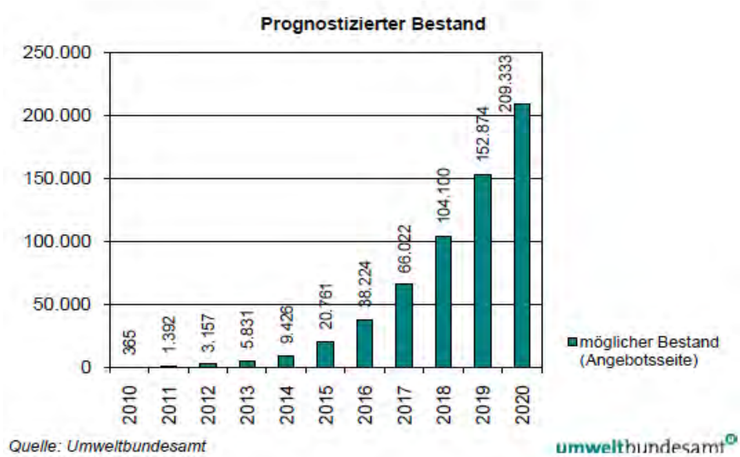


Fig. 14.7 Development of electric vehicles fleet (BEVs and PHEVs) for the period 2010–2020: scenario developed assuming ideal political and economic conditions. (Source: Umweltbundesamt 2010)

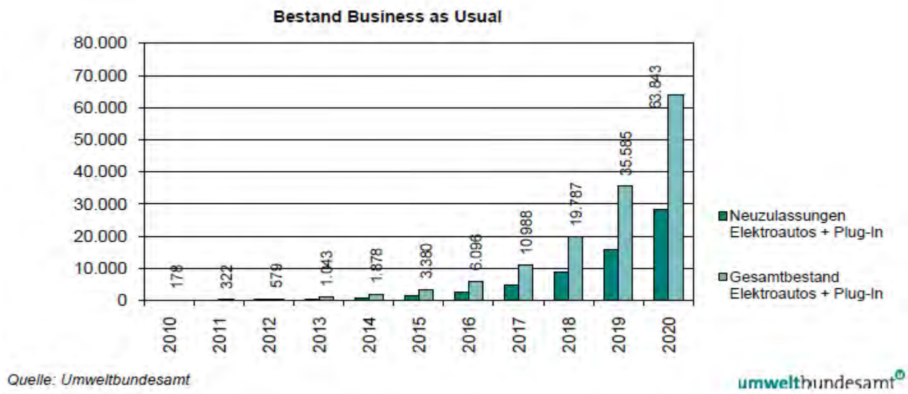


Fig. 14.8 Development of electric vehicles fleet (BEVs and PHEVs) for the period 2010–2020: scenario under business-as-usual conditions. Dark columns: new registrations. Light columns: total number of vehicles. (Source: Umweltbundesamt 2010)

The measures foreseen in the National Energy Strategy from 2011 on for the promotion of electric mobility are the following:

- Coordination activities by involved Ministries, regional authorities, and companies for the preparation of a roadmap for Austria
- Increased support for model regions and further development of subsidies for the exchange of communal and business fleet vehicles as a first step towards market introduction
- Development of innovative business models and application areas through the introduction of market regulations for the production and use of electricity and charging infrastructure
- Specific benefits for electric vehicle users regarding infrastructure and traffic management
- Introduction of attractive infrastructure and services for the use of electric mobility in multi-modal passenger transport (car sharing, electric taxis, small buses)
- Fiscal incentives for the acquisition of electric vehicles
- Information, public awareness measures, and expansion of the educational and training capacities for skilled labor

The financial means required for these measures will be provided by national funding, energy suppliers, and the automotive industry. The required funding is based on the current price difference between conventional and electric vehicles resulting in an estimated forecast of €500 million needed until 2020.

15 Belgium

15.1 Introduction

The automotive sector has always been one of the most important industrial sectors in Belgium. In 2008, the turnover of the automotive sector was €15.9 billion and 81,661 people were employed at the nation's assembly plants and suppliers. But as in many other West European countries, the local automotive sector is under severe pressure. The local automotive industry needs a fundamental transformation to be able to tackle future challenges of a potential rise in oil prices and European requirements to reduce carbon dioxide (CO_2) emissions, and hybrid and electric vehicles can play an important role.

Immediate actions are needed from all stakeholders to support this transformation of the local auto industry: government, industry, interest groups, the education sector, and the research community. Synergies between the mobility and the energy sector also need to be fully exploited. This is the only way to enable a substantial rollout of electric vehicles and infrastructure in Belgium. In 2010, some important initiatives have been taken at the federal and regional level to start up this process.

On the federal level, the *Belgian Platform on Electric Vehicles* was organized in 2010 to inform and bring together all relevant stakeholders from the electric mobility value chain. The platform will also prepare Belgium's master plan for electric mobility, which is projected to be ready at the end of 2011. The official logo of the platform is shown in figure 15.1.

Fig. 15.1 Belgian Platform on Electric Vehicles logo.

On the regional level, the Flemish government launched a dedicated call for establishing a *Living Labs Electric Vehicles* program to facilitate and accelerate the innovation and adoption of electric vehicles in the Flemish region. The call was launched in late 2010 and aims to set up a structured real-life environment in which innovations can be tested by representative end users in their own living and working environments. The call initiated much industrial activity. More than 200 companies and organizations were involved in the preparation of 22 platform proposals that have been submitted and of which 6 platforms have been selected for the next phase of evaluation. Final decision on approval is expected in the second half of 2011.

15.2 Policies and legislation

In 2010, federal and regional governments took further actions to support the introduction of hybrid and electric vehicles in Belgium. Special tax rules have been set up to stimulate the business and residential markets to choose more environmentally friendly vehicles.

Business market

The company car tax is based on CO_2 emissions, with the deductibility of expenses related to car usage having most recently been changed to range between 50% and 120% of the purchase cost. The 120% deductibility is meant to stimulate the use of pure electric vehicles, and the company is also allowed to write off the investment over a period of two years. Also, the extra legal advantages for the user of the company car will now be based on the level of CO_2 emissions of the car.

Residential market

Tax incentives are granted to private persons purchasing a car based on CO_2 emissions per kilometer. The incentives consist of a reduction on the invoice price by the following amounts:

- Cars emitting less than 105 g CO_2/km: 15% of the purchase price, with a maximum of €4,540
- Cars emitting between 105 and 115 g CO_2/km: 3% of the purchase price, with a maximum of €850
- For diesel vehicles (< 130 g CO_2/km) and with a diesel particulate filter (< 5 mg CO_2/km): a bonus of €210

Extra incentives were added to stimulate the introduction of pure electric vehicles. A distinction has been made among motorcycles, quadricycles, and passenger cars. Without going into too much detail, these are the general rules:

- Incentive not directly on the invoice, but via taxes
- For two- and three-wheelers: 15% of the purchase price, with a maximum of €2,770
- For quadricycles: 15% of the purchase price, with a maximum of €4,540

- For passenger cars: 30% of the purchase price, with a maximum of €9,000

Other

Several systems exist to define the environmental-friendliness of vehicles, including fuel type, CO_2 emission level, or homologation legislation (e.g., EURO-4). However, these approaches are not sufficient to describe the complete impact on the environment. For this reason, the Flemish Institute for technological research (VITO) and other partners, including the Vrije Universiteit Brussel, have developed the Ecoscore methodology. With this methodology, climate change counts for 50% of the final score, health effects for 20%, impact on ecosystems for 20%, and noise for 10%. The pollutants considered are CO_2, CH_4, N_2O, CO, NMVOS, PM_{10}, NO_X, and SO_2. The environmental evaluation permits the combination of different effects in one indicator. The methodology is based on a well-to-wheel analysis. The Belgian government is evaluating how this methodology could be incorporated in the regulations, but at this point it is being used as an objective information source to compare the environmental-friendliness of different vehicles. More information on how car models rate according to this system can be found at www.ecoscore.be.

15.3 Research

The following key organizations (including research institutes, universities and other platforms) are involved in Belgian research on hybrid and electric vehicles: VITO, Katholieke Universiteit Leuven (K.U.Leuven), Vrije Universiteit Brussel (VUB), University of Ghent, Flanders' DRIVE, the Limburg Catholic University College (LCUC, or in Flemish KHLim), and the electric vehicle not-for-profit organization AVERE, together with its Belgian arm, ASBE.

VITO

VITO is a leading independent European research and consulting center developing sustainable technologies in energy, environment, materials, and remote sensing. VITO's 600 highly qualified employees cooperate with sector federations, universities, European research institutes, and business communities. The budget of 2010 was €95 million, of which more than half was from contract research.

VITO's energy unit has a strong link with sustainable transport engaging hybrid and electric vehicles. VITO performs research on different areas in this field, from improving the energy efficiency of the vehicle itself (e.g., via brake energy recuperation) up to the integration aspects of plug-in and electric vehicles in the electricity network of today and tomorrow. This is depicted in figure 15.2.

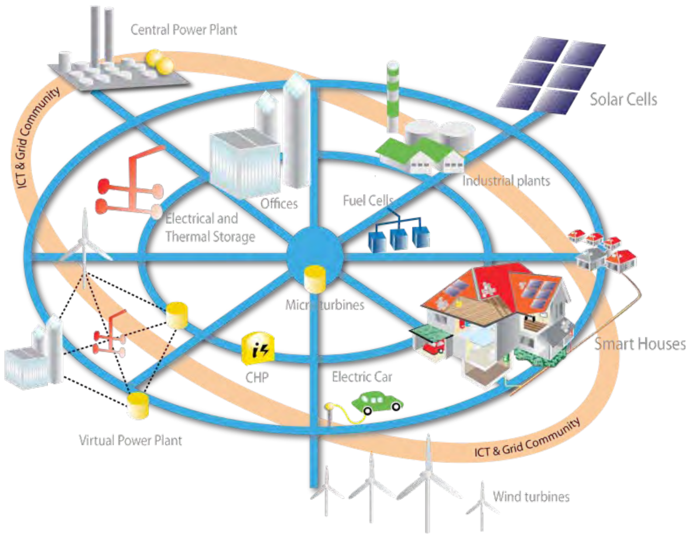


Fig. 15.2 Plug-in hybrid and electric vehicles and smart grids: A perfect match. (Image courtesy of VITO.)

Smart grids offer a solution for electric vehicles: hybrid and electric vehicles can easily charge their batteries with (ideally) green electricity via the grid at moments that are advantageous for the network as well as the user, in an approach known as intelligent charging. A smart grid relies on the integration of power electronics, intelligent communication structures, and control algorithms, which are some of the VITO research areas. VITO has an extensive smart grid test infrastructure at its disposal that combines a thermal-technical and electrical lab with battery test infrastructure and a test bench for hybrid vehicles.

VITO is also working on the energy efficiency of the vehicle itself. VITO has developed an energy storage system for use in hybrid diesel-electric city buses, shown in figure 15.3.

Fig. 15.3 Hybrid buses using ultracapacitors for brake-energy recovery (inset). (Photo courtesy of Van Hool.)

The energy storage system is used to store the regenerated braking energy, which later gets used when the bus starts to accelerate, or when the bus needs some additional energy under certain driving conditions. By using ultracapacitors as the basic storage cell, this process of storing and releasing energy can be repeated very frequently for a long time. A control system manages the complete storage system and communicates the status of the system to the drivetrain controller. Hybrid buses equipped with this storage system consume up to 25% less fuel than similar diesel buses and are less noisy. VITO has transferred this technology to a spin-off company, Bluways, for the further commercialization of energy storage systems in different types of heavy-duty hybrid vehicles.

Other research projects at VITO related to hybrid and electric vehicles include ESTO, Trans2House and EVCITY.

The ESTO project seeks breakthroughs in energy storage technologies such as lithium-ion battery cells and packs and battery management systems. Partners in this effort include the major players in Flemish automotive research and development (R&D), several of which are described further below: Flanders' DRIVE, Emrol, PEC, PsiControl, Punch Powertrain, Triphase, Umicore, VDL Jonckheere, VITO, and VUB.

Trans2House, performed by VUB, VITO and ABEA, is short for "Transition pathways to efficient (electrified) transport for households" and is studying how to develop driving forces and shift the social, cultural, technological, economic and political barriers to household energy consumption reduction, with transport a major portion of the study.

EVCITY is one of the innovation projects within the EIT KIC InnoEnergy (www.innoenergy-initiative.com) and is focusing on the business and service models to support the rollout of electric vehicles in cities.

K.U.Leuven

At the K.U.Leuven (Katholieke Universiteit Leuven), the ESAT-ELECTA group performs research on the production, transmission, distribution, and rational use of electrical energy, including work related to electric and hybrid vehicles in the field of power electronics, electric drivetrains, and grid integration of plug-in vehicles, including solving potential bottlenecks by smart charging methods.

Vrije Universiteit Brussel

The Department of Electrical Engineering and Energy Technology (ETEC) of the VUB Faculty of Engineering Sciences established an R&D program on electric, hybrid and fuel cell vehicles in 1974, making it the premier electric vehicle research facility in Belgium. ETEC's work mainly emphasizes the characterization, testing and demonstration of electric, hybrid and fuel cell vehicles and their components, such as electric drives and batteries. ETEC is also very active in participating in several European projects in the field of electric, hybrid, and fuel cell vehicles.

ETEC works closely together with the MOSI-t team at the VUB, which focuses on application of socio-economic evaluation methods in the field of transport and logistics. Both teams work together under the umbrella of the MOBI research group. The multidisciplinary group results in a scientific expertise in which technical, social, and economical aspects of development and deployment of electrified vehicles are taken into account.

Limburg Catholic University College

The Limburg Catholic University College (LCUC, or in Flemish KHLim) has built a "green" charging station powered by photovoltaic panels of 10 kWp. The charging station contains different brands of charging points. The charging station is integrated in a microgrid of 200 kVA. In one current project, 22 electric scooters from Chinese company, Haoren, are equipped with a tracking system to analyze how KHLim students use these e-scooters.

Flanders' DRIVE

Flanders' DRIVE is the competence center established in 2001 to support the Flemish automotive industry in their research activities in different technological domains like manufacturing, lightweight materials, clean powertrains, and active safety. Flanders' DRIVE has about 170 active members and organizes collaborative research projects with them, including the ESTO project mentioned above in the VITO section.

Green Propulsion

Green Propulsion was founded in 2001 as a spinoff of the University of Liege. It has since become an independent specialist in increasingly cleaner vehicle technologies. In the field of plug-in hybrids, in particular, Green Propulsion is without a doubt one of the leading independent R&D centers in Europe, with no fewer than seven topologies and innovative management strategies to its credit.

Green Propulsion mainly concentrates on the development of three prototype hybrid vehicles:

- A plug-in hybrid, 12-m urban bus equipped with the Automixte® combined series-parallel technology, which is now at its approval phase after the completion of its development
- A plug-in hybrid, estate car combining electric predominance and CNG, which is now as well at its approval phase after the completion of its development. Discussions about a pilot production of 200 similar units have started.
- The plug-in hybrid Imperia GP roadster, whose first prototype was presented at the Brussels Motor Show and chassis n°2 is now equipped with the PowerHybrid® motorization.

AVERE and ASBE

AVERE and ASBE, the Belgian chapter of AVERE, are non-profit associations, founded in 1978 under the aegis of the European Community, as a European network of industrial manufacturers and suppliers for electric vehicles. The Association's goal is to promote the use of battery, hybrid and fuel cell electric vehicles, and to rationalize the efforts of its member companies in the scientific and technological developments. ASBE restarted in 2009 and brings together a mix of new EV-entrepreneurs together with scientists and industry. ASBE also took the initiative to show the location of the charging points installed in Belgium on their website.

15.4 Industry

Despite the closure of the Opel plant in late 2010, Belgium still hosts several car assembly plants: Ford Genk, Audi Brussels, and Volvo Cars Gent. Toyota Motor Europe conducts business in Belgium that includes its European headquarters, logistics centers, and its technical R&D center for Europe. Besides the car OEMs, Belgium also hosts manufacturers of other types of vehicles, like bus and coach makers Van Hool, VDL Jonckheere, and a Volvo truck assembly plant. An important part of the vehicle industry is in the local supplier base of about 300 companies, including companies like Punch Powertrain.

Here we describe some of these companies' activities in Belgium with a particular focus on those related to hybrid and electric vehicles.

Toyota Motor Europe

Toyota Motor Europe is active at different locations in Belgium and employs more than 3,000 people in the country. More than 386,900 Toyota cars pass through Zeebrugge each year to points across Europe. In 2008, the sales of Toyota cars in Belgium amounted to 28,363 units, which represent a total vehicle sales market share of 4.3%.

Toyota is well-established in the area of hybrid vehicles with its Prius, and recently Toyota Motor Europe has been involved in the European road trials with the plug-in hybrid version of the Prius (or PHV, in Toyota's abbreviation), and is expected to begin sales in 2012.

Volvo Cars

"DRIVe Towards Zero" is Volvo Cars' vision for developing cars entirely free from harmful exhaust emissions and environment-impacting carbon dioxide. Volvo Cars is therefore working on three different fields:

- Optimizing the efficiency of traditional combustion engines
- Alternative fuels
- Hybrid and pure electric cars

In early 2009, Volvo Cars introduced microhybrid technology—a start/stop function that switches off the combustion engine whenever the car comes to a standstill. In 2012, Volvo will launch the V60 Plug-in Hybrid which can be recharged via a regular household electric socket. The Volvo V60 Plug-in Hybrid is both an electric car with a range of up to 50 kilometers and also a high-efficiency hybrid with carbon dioxide emissions averaging just 49 g/km.

Fig. 15.4 Volvo C30. (Photo courtesy of Volvo Cars.)

There are still many challenges to face with dedicated battery-powered cars in terms of range, cost, and safety. Volvo Cars will continue to carry out comprehensive field tests during 2011 with Volvo C30s that are equipped for dedicated battery power (see figure 15.4). At the end of the field tests, the results will be evaluated and a decision will be taken on possible market introduction.

Imperia Automobiles

Imperia Automobiles was founded in 2009 as a spin-off from independent research center Green Propulsion, described in the Research section. It will produce and sell the Imperia GP (figure 15.5) plug-in hybrid vehicle, developed by Green Propulsion as well as its PowerHybrid® motorization.

Fig. 15.5 Imperia GP. (Photo courtesy of Imperia.)

The assembly plant is nearing the end of construction. Production of the Imperia GP, starting in 2011, is expected to reach 200 units per year.

Van Hool

Belgian company Van Hool manufactures approximately 1,600 buses and coaches, and as many as 4,000 commercial vehicles annually, of which 80% are exported worldwide. With a workforce of over 4,100 employees, Van Hool is a major bus manufacturer in Europe, offering a complete range of buses for public transport for international markets, ranging from a 9-m midi bus to a 25-m double-articulated-low-floor bus. Many public transportation companies are investing in environment-friendly vehicles at the moment, and Van Hool is very active in developing fuel cell buses and hybrid buses.

Punch Powertrain

Punch Powertrain started as a supplier of pushbelt continuously variable transmissions (CVT), but is also developing hybrid powertrains for passenger cars based on the VT2 CVT. Its efforts to develop a solution that would reduce fuel consumption while being cost-competitive and easily integrated into a vehicle have yielded a hybrid transmission based on many existing parts that are already produced in large volumes at low cost. For the other hybrid powertrain subsystems, Punch Powertrain also made less obvious choices. The motor technology developed is Switched Reluctance (SR) and for the battery system Punch Powertrain looked for suppliers of battery packs with $LiFePO_4$ cells.

Fig 15.6 Powertrain being integrated into demonstrator vehicle. (Photo Courtesy of Punch Powertrain.)

In the spring of 2009 Punch demonstrated its new hybrid powertrain for the first time with a Smart ForFour vehicle as the carrier, showing that the powertrain fits into a small, compact car (figure 15.6). The car was driven as an electric vehicle in initial tests. Although intended as an HEV motor, its EV performance is excellent. The vehicle is agile, motor noise is more than acceptable, and its torque is ripple-free. Next, the powertrain control was modified for hybrid operation. The quality of the demonstrator has resulted in a first customer for the hybrid powertrain.

Further research on the hybrid powertrain revealed that the base configuration developed for charge sustaining operation can also be used for plug-in and range extender applications. The latter part of this research was presented at the 25th World Electric Vehicle Symposium in November 2010 in Shenzhen, China. This allows Punch Powertrain to offer a complete range of powertrains from conventional to full EV (see below) with all hybrid options in between.

The excellent performance of the electric motor inspired Punch Powertrain to convert another Smart ForFour to EV. A large 15 kWh battery pack was sourced to provide an EV-range of 80 to 100 km depending on the vehicle use. The vehicle has been in use for battery tests as well as electric motor assessment since November 2009. Its performance is excellent for city traffic and good enough for rural and motorway traffic. In 2010 Punch Powertrain converted a Ford Transit Van to an EV. For this vehicle, more power is required, so they developed a transmission that can take either one or two electric motors (see figure 15.7). This vehicle has been presented for a demonstration fleet of 50 vehicles to be built in 2011.

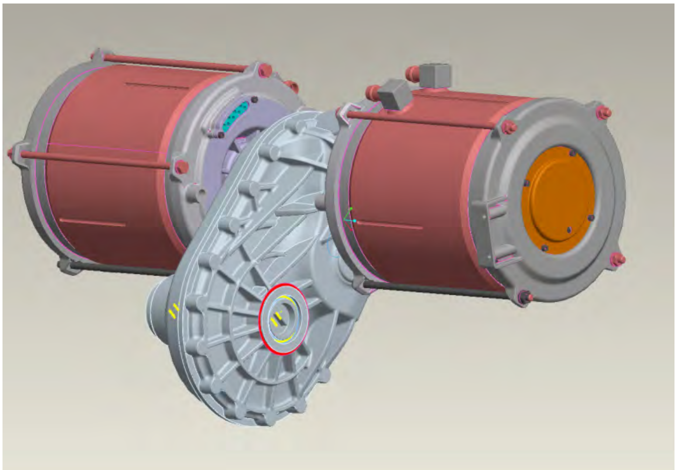


Fig 15.7 Dual Motor EV-Powertrain. (Photo Courtesy of Punch Powertrain.)

Volvo Trucks

In June 2011 the first series of about 100 hybrid trucks was expected to be produced in the Volvo Trucks plant in Ghent, Belgium. The first mass-produced hybrid trucks (see figure 15.8) will be used primarily for distribution applications and garbage collection in urban environments. The hybrid technique is particularly appropriate for operating cycles involving repeated stops and starts, and a period of intensive field testing has shown that fuel savings of more than 30% can be achieved.

Fig. 15.8 Volvo FE Hybrid. (Photo courtesy of Volvo Trucks.)

Bluways

Bluways, a spin-off company from VITO, is a manufacturer and supplier of energy storage systems and hybrid-electric drive system products for heavy duty applications. The integrated drive systems and components are on board in over 300 heavy duty vehicles in revenue service, with over 13 million operational fleet miles accumulated and counting. The fully integrated electric drive systems provide unprecedented reductions in harmful emissions, increased fuel economy, and quieter operation. These products are in its portfolio:

- Fully integrated gasoline hybrid, diesel hybrid, and zero emission hydrogen fuel cell drive systems for heavy duty vehicles
- Patented ultracapacitor and battery energy storage systems and modules for hybrid buses, waste trucks, cranes and others
- Power electronics for hybrid and electric system energy management
- Fully electric vehicle accessories for improved fuel economy and reduced emissions
- Proprietary hybrid control system software
- Hybrid electric and zero emission fleet support services

Fig. 15.9 Hydrogen fuel cell buses for London. (Photo courtesy of Bluways.)

As an example of its capabilities and product offering, Bluways is supplying eight hydrogen fuel cell buses to Transport for London in the UK to operate on the RV1 route through central London (see figure 15.9). The buses will be showcased in the 2012 summer Olympics. Five buses are now in service with three more to be introduced before the end of 2011. The contract with London includes vehicle support and provisions to supply additional vehicles. These buses are 12m in length, with a hybrid electric drive that includes regenerative braking, ultracapacitor energy storage, a 75-kW hydrogen fuel cell, and 45 kg of on-board hydrogen storage giving a range in excess of 500 km.

15.5
Charging infrastructure and vehicle deployments

Charging infrastructure is a crucial part to support the rollout of electric vehicles. Important choices have to be made on a city, regional, and country level about the required number, location (home-parking vs. public) and type of charging infrastructure (slow vs. fast, conductive vs. inductive vs. swapping). Many aspects need to be considered to make these decisions, such as user acceptance, user comfort, safety, standardization, and costs.

Making such decisions requires the involvement of all stakeholders: federal, regional and local governments, industry from different sectors (automotive, energy, mobility), academia, and regulators—and of course the users of the electric vehicles. Therefore, initiatives like the *Belgian Platform on Electric Vehicles* and the call for *Living Labs Electric Vehicles* in the Flemish region (both described in the introduction) are very valuable for accelerating this process. The call for *Living Labs Electric Vehicles* will certainly speed up the rollout of more public charging infrastructure in Flanders. The suppliers of charging infrastructure also play an important role in the new innovation platform, *Smart Grids Flanders*, which brings together the stakeholders to develop the future electricity grid in Flanders. One working group is dedicated to ‘grid connected vehicles’ and is taking up the challenge to develop innovative charging solutions.

Fig. 15.10 Charging point designs from various suppliers on the Belgian market.

However, to date private companies have launched the most initiatives to roll out charging infrastructure in parking areas located on their own premises. A few hundred charging points have been installed by a variety of suppliers for clients such as LeasePlan, McDonalds, VinciPark, Eandis, K.U.Leuven, KHLim, and Toyota Motors Europe (see figure 15.10). As mentioned in the preceding section, ASBE has taken the initiative to show the location of those charging stations on a website at www.asbe.be/en/locations (see figure 15.11).

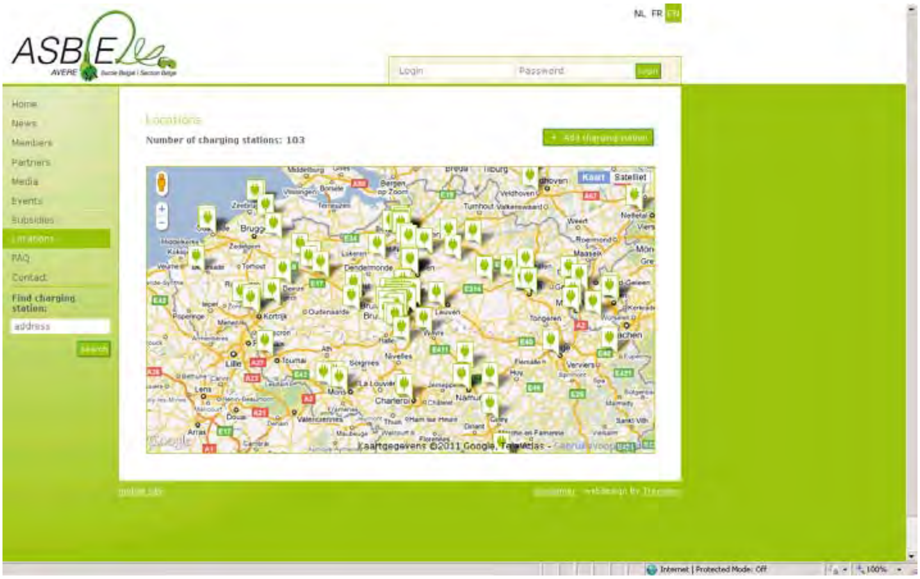


Fig. 15.11 Overview of the location of charging stations in Belgium. (Source : ASBE - www.asbe.be/en/locations.)

Most charging infrastructure in Belgium is currently located on privately owned or semi-public areas, but the first initiatives on public charging infrastructure began in 2010. Total Belgium took the initiative to invest in charging infrastructure at 12 of their service stations, where the user can choose the type of charge with different charging prices (see figure 15.12).

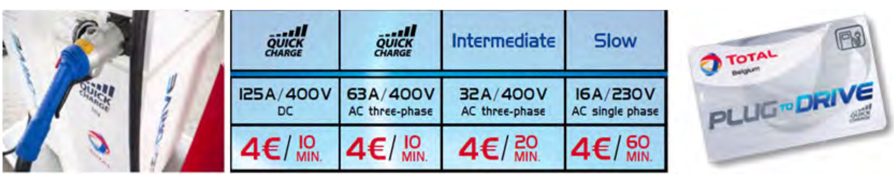


Fig. 15.12 Charging station, interface, and membership card for Total Belgium‘s Plug to Drive network. (Image courtesy of Total Belgium.)

Commercial charging station suppliers indicate their awareness of the benefits of linking the charging station to renewable energy sources and talk about “green from well-to-wheel” solutions.

In addition to the available solutions for charging electric vehicles today (conductive charging by using a cable), research is ongoing to study alternatives such as inductive charging. A research project is being conducted at Flanders' DRIVE to study the possibilities of inductive charging while being parked and while driving.

Car-sharing companies like Cambio and public transport companies like NMBS railway have launched initiatives to integrate electric mobility more fluently into the whole mobility chain. These efforts are seen as valuable because such new mobility concepts are part of the complete solution to tackle the mobility challenges of the future: energy consumption, oil independence, emission levels, and traffic jams.

15.6 On the road

At this moment, the passenger car market in Belgium is still dominated by diesel vehicles. Belgium has one of the highest market shares of diesel passenger cars in Europe. Although we can see the growth of smaller and more environmentally friendly vehicles on the market, the share of hybrid and electric vehicles is still limited, as shown in tables 15.1 and 15.2.

Table 15.1 Number of new passenger cars sold in Belgium and average fuel consumption, 2002 through 2009. (Data © VITO.)

		2002	2003	2004	2005	2006	2007	2008	2009
Number of vehicles	Gasoline	154	135	143	128	133	94	113	119
(x 1,000)	Diesel	288	303	342	351	392	430	422	368
	Total	442	438	485	479	525	524	536	488
Average fuel consumption	Gasoline	7.10	7.00	6.90	6.70	6.60	6.60	6.40	
	Diesel	5.80	5.80	5.70	5.60	5.60	5.60	5.50	
(liters/100 km)	Total	6.25	6.17	6.05	5.89	5.85	5.78	5.69	

Table 15.2 Hybrid car sales in Belgium. (Data © VITO).

Make	Model	2004	2005	2006	2007	2008	2009
Honda	Civic	5	3	86	149	132	46
Honda	Insight	0	0	0	0	0	479
Lexus	GS 450h	0	0	47	101	73	20
Lexus	RX 400h	0	106	283	264	246	130
Lexus	RX 450h	0	0	0	0	0	160
Lexus	LS600h & LS600hL	0	0	0	0	47	6
Mercedes	S400 Hybrid	0	0	0	0	0	22
Toyota	Prius	126	362	486	778	1399	1045
	Total	131	471	902	1292	1897	1908
Total car market		484,757	480,088	526,141	526,141	539,485	490,878
Share of Hybrids		0.03%	0.10%	0.17%	0.25%	0.35%	0.39%

In addition to hybrid passenger cars, pure electric passenger cars are appearing on Belgian roads again (mainly the Tesla Roadster). The official number of registered electric passenger cars in 2010 is still very modest, but it is growing, as shown in table 15.3.

Table 15.3 Characteristics and population of the Belgian motorized vehicle fleet per August 1, 2006–2010.

	2006	2007	2008	2009	August 1, 2010	
Vehicle type	EV fleet	EV fleet	EV fleet	EV fleet	EV fleet	Total fleet
Motorized bicycle (no driver licence)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Motorbike	8	10	20	39	71	418,915
Passenger vehicle	13	8	10	10	36	5,276,283
Multipurpose pass. vehicle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Bus	21	19	19	19	3	16,226
Truck	62	51	56	62	68	737,510
Industrial vehicle	886	942	1,004	1,099	1,117	240,131
Total	**990**	**1,030**	**1,109**	**1,229**	**1,295**	**6,689,065**

Source: FOD Economie - http://statbel.fgov.be/nl/modules/publications/statistiques/verkeer_vervoer/evolution_du_parc_de_vehicules_2010.jsp.

n.a. not available

The definitions of the different vehicle categories can be found in section E of this report, chapter "Vehicle categories."

Finally, we can also see some movement in heavy-duty hybrid vehicles like trucks and buses. Public transport in particular has increased its fleet of hybrid buses since 2009. In Brussels and Genk, the first full-electric buses have been put in service, and in other cities (Brugge, Gent, Leuven, etc.) De Lijn has been rolling out an extra fleet of 79 hybrid buses. At the moment hybrid buses already make up 3.5% of their total bus fleet.

15.7 Outlook

In 2010, some important initiatives concerning electric mobility in Belgium were taken on the federal and regional level.

On the federal level, the *Belgian Platform on Electric Vehicles* was set up to inform and bring together all relevant stakeholders from the electric mobility value chain. The platform will also prepare Belgium's future master plan for electric mobility, which will be completed at the end of 2011.

On the regional level, the Flemish government launched a dedicated call for establishing the program *Living Labs Electric Vehicles* to facilitate and accelerate the innovation and adoption of electric vehicles in the Flemish region. The call was launched in late 2010 with the aim of setting up a structured real-life environment in which innovations can be tested by representative end users in their own living and working environment. The *Living Labs Electric Vehicles* will run for 3 years and are expected to give an extra boost to develop, test, and implement new products and services on e-mobility.

16 Canada

16.1 Introduction

In 2008, transportation accounted for over one-quarter (approximately 27%) of Canada's total greenhouse gas (GHG) emissions, with cars and light trucks accounting for about 12%. The Government of Canada is committed to reducing Canada's total GHG emissions by 17% from 2005 levels by 2020. Canada is also committed to the goal of having 90% of Canada's electricity provided by non-emitting sources such as hydro, nuclear, clean coal or wind power by 2020.

Canada's electricity supply mix is one of the cleanest and most renewable in the world. Hydroelectricity, the largest renewable energy source in Canada, accounts for approximately 60% of Canada's electricity generation, making Canada the world's second largest producer of hydro power. Along with energy sources such as nuclear, biomass, wind, and solar, clean energy contributes approximately 75% of Canada's total electricity mix. As a result, the opportunity to reduce greenhouse gas emissions by electrifying the transportation system is significant.

16.2 Policies and legislation

New vehicles sold in Canada are required to meet national emissions and safety standards administered by the Federal Government. Although most of Canada's federal regulations for motor vehicles generally do not distinguish hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and electric vehicles (EVs) from conventional vehicles, national policies continue to move towards increasingly stringent GHG emissions standards that could encourage growing use of such vehicles. At the provincial level, some provinces have started to address PHEVs and EVs in their policies. Québec, Ontario, and British Columbia have announced a variety of goals and plans to support the introduction of these vehicles.

FEDERAL

Emissions Standards

Because of the rising concern about the impact of GHG emissions, vehicle fuel consumption has become an issue of importance for governments. Over the past 30 years, Canada has had a voluntary policy for improving the fuel consumption of cars and light trucks. Despite some improvements in fuel consumption and emission-control technology that have resulted from adherence to these voluntary policies, the total fuel consumed and GHG emissions have still risen substantially over the last two decades.

In response to this increase, in 2005 the Canadian automotive industry signed a memorandum of understanding (MOU) to reduce GHG emissions from cars and light trucks by 5.3 million metric tons in 2010. As part of this MOU, a report was released in the fall of 2010 indicating that the Canadian automotive industry surpassed the first interim goal set out in the MOU, having reduced annual GHG emissions by over 3 million metric tons in 2007.

In October 2010, the Minister of the Environment announced new regulations that establish progressively more stringent GHG emission standards for new passenger automobiles and light trucks for the 2011–2016 model years. Through the implementation of the proposed standards, it is anticipated that the average GHG emission performance of the 2016 Canadian fleet of new cars and light trucks would match the average level of 155 g CO_2/km (250 g CO_2/mile) that has been projected for the United States (U.S.). As a result of the regulations, it is projected that the average GHG emission performance of new vehicles for the 2016 model year will be about 25% lower than the vehicles that were sold in Canada in 2008. Given that these stringent GHG emissions regulations were finalized in October 2010, the voluntary GHG MOU was terminated. Canada's national emissions regulations are established under the authority of the Canadian Environmental Protection Act and administered by Environment Canada (www.ec.gc.ca/CEPARegistry/regulations).

Because of Canada's geopolitical links with the U. S., all the above-mentioned standards and regulations are being continually developed with the intent of achieving full harmonization, both to ease the burden on the automotive industry and to facilitate trade and product availability. Canada also participates in the United Nations Economic Commission for Europe (UNECE) world forum for the creation of global technical regulations.

Safety Standards

Canada's Motor Vehicle Safety Act (MVSA), administered by Transport Canada, regulates the manufacture and import of motor vehicles and motor vehicle equipment in order to reduce the risk of death, injury, and damage to property and the environment (see www.tc.gc.ca/eng/acts-regulations/acts-1993c16.htm).

In Canada, electric passenger vehicles must meet the safety standards required by the MVSA that apply to all passenger cars. Electric low-speed vehicles (LSVs), however, do not have the same legal status as a passenger car, and are not required to meet the same strict safety standards. Specific requirements for low-speed vehicles are summarized in table 16.1, with the full specifications outlined in Technical Standards Document No. 500 of the Canadian Motor Vehicle Safety Standards (see www.tc.gc.ca/eng/acts-regulations/regulations-crc-c1038-sch-iv-500.htm). The Federal government does not have any statutory role in regulating road use; however, it provides advice and recommendations regarding vehicles and their usage to Canadians. While provinces and territories regulate public road use and vehicle and driver licensing, Transport Canada does not encourage the use of LSVs on public roads, since they are not required to provide the same level of safety as mainstream vehicles. The provinces of Québec, Ontario, Manitoba, and British Columbia have introduced legislation or pilot projects for the use of LSVs (see table 16.1).

In 2001, Transport Canada amended the Motor Vehicle Safety Regulations to allow the introduction of power-assisted bicycles in Canada. This amendment created a definition specifically for power-assisted bicycles and applied separate technical and safety requirements.

PROVINCIAL

Although Québec, Ontario and British Columbia are currently the most active provinces with respect to implementing initiatives to support the adoption of EVs, a number of provinces offer a variety of incentives for the purchase, lease, or use of HEVs, PHEVs and EVs. A summary of the various incentives by province is provided in table 16.2 below.

Québec

Québec wants to make it known that it is in favor of and possesses all the necessary assets for the deployment of EVs. With 97% of its electricity produced from renewable sources, the province is an ideal location for the deployment of EVs. In addition, Québec currently has enough electricity to satisfy the charging requirements of at least one million EVs and its electricity network is very reliable. It is also one of the regions in North America where the difference in cost between gasoline and electricity is most favorable for EVs.

The Government of Québec has set a target to reduce GHG emissions by 20% below 1990 levels, by the year 2020, and EVs can make a significant contribution toward achieving this target.

Table 16.1 Overview of most relevant federal and provincial legislations for various vehicle classes

Jurisdiction	Definition / Requirements
Electric Vehicles (EVs)	
Federal	▸ Any vehicle that uses batteries to power an electric motor, including electric passenger cars, multipurpose passenger vehicles, truck and buses ▸ Must meet the same MVSA safety standards as those that apply to all passenger cars ▸ Requirement for a series of crash tests to protect occupants from the hazards that are unique to EVs, such as electric shock, electrolyte spills from batteries, and the potential injury arising from the battery assembly entering the passenger compartment See www.tc.gc.ca/eng/mediaroom/releases-nat-2001-01_h146e-2219.htm
Low-Speed Vehicles (LSVs)	
Federal	▸ A vehicle designed for use primarily on streets and roads where access and the use of other classes of vehicles are controlled by law or agreement ▸ Travels on four wheels ▸ Is powered by an electric power train that is designed to allow the vehicle to attain a speed of 32 km/h but not more than 40 km/h in a distance of 1.6 km on a paved level surface ▸ Does not use fuel as on-board source of energy ▸ Has a gross vehicle weight rating of less than 1,361 kg ▸ No crash test requirements ▸ Shall be permanently marked with a slow-moving vehicle identification emblem as per specifications ▸ Shall be equipped with headlamps, front and rear turn signal lamps, tail lamps, stop lamps, reflex reflectors, an exterior mirror mounted on the driver's side of the vehicle and either an exterior mirror mounted on the passenger's side of the vehicle or an interior mirror, a parking brake, and a conforming windshield, vehicle identification number (VIN) and seat belt assembly ▸ Only the VIN, seatbelt assemblies and windshield components of the LSV requirements must meet performance standards. The other items are only required to be present and operational. ▸ On August 6, 2008, Transport Canada amended its regulations to add small trucks to the LSV class
Québec	▸ Effective July 17, 2008, implementation of a pilot allowing two electric LSV models, the Nemo and the ZENN, on its roads with speed limits up to a maximum of 50 km/h. ▸ The LSVs are subject to strict operating conditions under the pilot ▸ The LSVs must be equipped with defog/defrost and heating systems, 3-point seat belts, slow-moving vehicle signs, and proximity warning devices that emit intermittent noise when the vehicles are near pedestrians or bicyclists

Ontario	▸ Effective March 21, 2009, LSV pilot expanded to allow LSVs to be driven on Ontario roads with a posted speed limit of 50 km/h or less ▸ LSV pilots to run until December 31, 2014 ▸ Final recommendations will be made regarding if, and how, LSVs should be allowed to interact with mixed-vehicle traffic prior to the expiry of the pilot
Manitoba	▸ On June 12, 2008, Bill No. 15, which permits zero-emission and LSVs on highways, received Royal Assent and was proclaimed.
British Columbia	▸ On June 6, 2008, regulations were amended to allow LSVs on roads with a speed limit of 40 km/h or less and, where permitted by municipal by-law, any road between 40 and 50 km/h.
Power-Assisted Bicycles (PABs)	
Federal	▸ Electric bicycles propelled by either a combination of the cyclist and a motor or by the motor alone ▸ Maximum of three wheels ▸ One or more electric motor that can assist the cyclist up to a speed of 32 km/h and that do not exceed a total output of 500 watts ▸ An on/off switch or mechanism that prevents the motor from being engaged until the bicycle reaches a speed of three km/h See www.tc.gc.ca/eng/mediaroom/backgrounders-b01_050e-5416.htm
Prince Edward Island	▸ PABs are treated as mopeds and will need to pass inspection as a moped
Nova Scotia	▸ PABs are permitted on the road ▸ Operators are required to wear an approved bicycle helmet
Québec	▸ PABs are permitted on the road ▸ Operators must be 12 years old or older, and must wear a helmet if under the age of 18
Ontario	▸ Legal as of November 2005 ▸ PAB riders must follow the rules and regulations of regular bicycles, wear an approved bicycle helmet and be at least 16 years or older
Saskatchewan	▸ PABs are permitted on the road ▸ Requires at least a learner's driving license ▸ Operators must wear a helmet
Alberta	▸ Legal in Alberta since July 2009 ▸ No driver's license, insurance, or registration required ▸ Operators must be 12 years old or older, and are required to wear a motorcycle helmet
British Columbia	▸ No vehicle registration, licensing, or insurance required ▸ No driver's license required ▸ Operators must be at least 16 years old, and are required to wear a bicycle helmet

Québec wants to pave the way for EVs, and with its know-how in the field of electric cars and its clean electricity generation, they are in the best possible position for moving in this direction. On February 23, 2011, the Government announced a commitment to develop the new electric transportation industry and the use of EVs. The Government will present a plan:

- To support the electric vehicle products and parts manufacturing industry so that Québec becomes a worldwide force in this new sector;
- To prepare for the arrival of these vehicles, notably by development of vehicle-charging infrastructure;
- To support public transit companies in their bid to go electric;
- And to encourage Quebecers to choose electric and hybrid vehicles.

Ontario

Ontario's target is to become a world leader in building and driving electric cars. In July 2009, the provincial government announced a vision to have one out of every 20 vehicles driven in Ontario to be electrically powered by 2020. In support of this vision, Ontario implemented several incentives on July 1, 2010 (see table 16.2).

As of January 5, 2011, 14 incentive grants have been issued by the Ontario program along with 18 green vehicle license plates. The Ontario government will also lead the way in building consumer demand by purchasing EVs for the Ontario Public Service fleet. Its stated goal is that 20% of eligible new Ontario Public Service passenger vehicle purchases will be EVs by 2020.

Ontario is taking further steps to ensure that the environmental benefits of EVs are maximized. In November 2010, the Province launched its Long Term Energy Plan, which keeps its commitment to phase out coal-fired generation by 2014 and targets increasing its hydroelectric and renewable energy capacity to nearly 20,000 MW by 2018. This builds upon the province's 2009 Green Energy Act which transformed Ontario into a renewable energy leader through its best-in-class Feed-in-Tariff and its proactive position on smart grid implementation. Time-of-use pricing is actively being rolled out across the province for residential and small business customers. The availability of low off-peak prices for EV charging will further make EVs an attractive option in the province while mitigating potential grid impacts in the future.

British Columbia

The Renewable and Low Carbon Fuel Requirements Regulation (RLCFRR) will reduce British Columbia's (BC) reliance on non-renewable fuels, help reduce the environmental impact of transportation fuels, and contribute to a new, low-carbon economy. The RLCFRR provides a regulatory framework that enables the Province to set benchmarks for the amount of renewable fuel in B.C.'s transportation fuel blends, reduce the carbon intensity of transportation fuels, and meet its commitment to adopt a low-carbon fuel standard. This legislation further supports British Columbia's legislated target to lower provincial GHG emissions by 33% by 2020. The low carbon fuel requirement of the RLCFRR requires a 10% reduction of fuel intensity by 2020. Fuel suppliers are able to meet this intensity reduction target by trading credits with less carbon-intensive transportation fuel suppliers such as electricity suppliers to the transportation sector. As such, the RLCFRR is expected to help establish a market for low-carbon fuels and encourage investments by traditional fuel suppliers in electricity for transportation. The RLCFRR can be found at the following link: http://www.empr.gov.bc.ca/RET/RLCFRR/Pages/default.aspx.

The Clean Energy Act outlines sixteen energy objectives for B.C. Regulations developed under Sections 18 and 35 of the Clean Energy Act will facilitate utility investment in GHG emission reduction measures. Potential regulations may focus on programs to support the use of electricity in transportation, and the installation and operation of EV charging infrastructure. The Clean Energy Act can be found at the following link: http://www.leg.bc.ca/39th2nd/1st_read/gov17-1.htm.

The City of Vancouver has passed a bylaw that requires that 20% of parking stalls in multi-unit residential buildings and all new single family housing be plug-in EV ready. The Province is exploring options for a plug-in EV model regulation that other communities across the province would be able to adopt.

Table 16.2 Summary of provincial policy instruments for PHEVs and EVs

Province	Policy Instrument
Prince Edward Island	**Hybrid Vehicle Tax Refund** ▸ Provincial Sales Tax (PST) refund up to a maximum of $3000 on the purchase (or 12-month minimum lease) of a HEV
Québec	**Purchase/lease incentive for recognized energy-efficient vehicles** ▸ Refundable tax credit based on the environmental performance of the vehicle; varies from $3000 for a PHEV to $8000 for a full EV, and $4000 for a low-speed EV ▸ Effective from December 31, 2008 to January 1, 2016

Ontario	**Purchase/lease incentives** ▸ Rebates for PHEVs and battery electric vehicles (BEVs) acquired after July 1, 2010 ▸ Incentive is based on the vehicle's battery capacity and ranges from $5000 for a 4 kWh battery to $8500 for a 17 kWh battery ▸ The value of the incentive for leased vehicles is scaled to the term of the lease ▸ Conventional hybrids, low-speed EVs, off-road vehicles, PHEV conversions, electric motorcycles, e-bikes and vehicles with fewer than 4 wheels are not eligible for the incentive **Green vehicle license plates** ▸ Allow drivers to use less-congested High Occupancy Vehicle (HOV) lanes until June 30, 2015, even if there is only one person in the vehicle ▸ Access to future public charging facilities and parking at GO Transit lots
Manitoba	**Purchase/lease incentive** ▸ $2000 rebate on the lease or purchase of a HEV ▸ Program ended October 31, 2010
Saskatchewan	**Green Rebate Program** ▸ 20% rebate on basic annual insurance premiums and registration fees paid for all hybrid vehicles and qualifying fuel efficient vehicles ▸ 4-year program initiated in 2008
Alberta	**Green Trip Incentives Program** ▸ $2-billion Green Transit Incentives Program supports new and expanded public transit throughout Alberta, including the purchase of hybrid transit vehicles
British Columbia	**Purchase incentives** ▸ PST reductions as a function of vehicle technology and classification; program terminated with the introduction of the Harmonized Sales Tax (HST) in B.C. on July 1, 2010

16.3 Research

Canada has well-established ongoing federal research programs supporting more energy-efficient transportation, including PHEVs, EVs and fuel cell vehicles. In addition to Natural Resources Canada's long standing Program of Energy Research and Development, a number of short-term research, development, and demonstration (RD&D) programs also provide support for activities related to EVs. Each of these programs is briefly explained below.

Program of Energy Research and Development

The Program of Energy Research and Development (PERD) is a federal, interdepartmental program operated by Natural Resources Canada (NRCan). PERD funds research and development (R&D) designed to ensure a sustainable energy future for Canada in the best interests of both the economy and environment. It directly supports energy R&D conducted in Canada by the federal government and is concerned with all aspects of energy supply and use.

The Clean Transportation Systems Portfolio, under PERD, supports R&D in the five following program areas:

- Hydrogen and Fuel Cells
- Advanced Structural Materials for Next-Generation Vehicles
- Advanced Fuels and Technologies for Emissions Reduction
- Particles and Related Emissions
- Electric Mobility

The initial phase of the Electric Mobility Program concentrates on PHEVs and focuses its efforts on four activity areas: energy storage systems; electric drive components; powertrain optimization; and development of regulations for emissions and fuel efficiency.

Electric Mobility Program Highlights from 2010–2011:

The Electric Mobility (EM) Program brings together more than 30 principal investigators from five government departments to share results on 18 projects. The EM Program is focused on issues surrounding adoption of PHEVs in the Canadian marketplace. While most of the resources are directed at improving energy storage systems and developing measurement protocols and baseline data on energy efficiency and emissions, attention is also being directed to new materials that reduce the weight of electric drive components, and on developing and applying advanced powertrain modeling systems.

New electrolyte chemistries, electrode materials, and fabrication techniques are being investigated. Significant advances are being made in identifying and understanding new materials for Li-ion batteries that are safer, less expensive, and have higher energy and power densities. This is integral to the commercial success of PHEVs. Industry collaborators are developing new formats of cells and battery packs, and addressing cold-weather performance.

Recommended practices have been developed and published, through a Canada-US/government-industry task force (SAE J1711) for measuring exhaust emissions and fuel economy of HEVs, including PHEVs. The EM Program has a particularly valuable contribution to make through the cold- weather testing of EVs and PHEVs to ensure that the Canadian context of this promising, clean transportation mode is evaluated and addressed through technology, policy, and regulation.

The Clean Energy Fund

The Clean Energy Fund (CEF), part of the Government of Canada's Economic Action Plan, provides $795 million over five years for research and development and the demonstration of promising technologies, including large-scale carbon capture and storage (CCS) projects and renewable energy and clean energy systems demonstrations. Through the CEF, the Federal Government is supporting the following three projects which include an EV component.

- Utility-Scale Electricity Storage Demonstration Using New and Re-purposed Lithium Ion Automotive Batteries
- Interactive Smart Zone Demonstration in the City of Boucherville, Québec
- Community-Scale Solar Project of Colwood in British Columbia

Natural Sciences and Engineering Research Council (NSERC)

NSERC is a federal agency that supports university students in their advanced studies, promotes discovery research, and fosters innovation by encouraging Canadian companies to participate and invest in postsecondary research projects. NSERC investments in automotive research in 2009–10 totaled $24.7 million. The following are some of the automotive research activities NSERC funds.

Automotive Partnership Canada

Announced in April 2009, Automotive Partnership Canada (APC) is a five-year, $145 million initiative that supports collaborative, industry-driven R&D involving automotive companies, universities and government labs. This initiative is a partnership between five federal research and granting agencies under the Industry Canada umbrella. NSERC, one of the five federal granting agencies participating in APC, has committed $85 million to this initiative. Research projects approved to date will focus on reducing weight by using more plastic parts in engines, improving the efficiency of transmissions, advancing the state-of-the-art in longer-range EVs (e.g., thermal management system technology development), and boosting auto software productivity and quality.

AUTO21

AUTO21, a federal Network of Centres of Excellence, is helping to build a stronger, sustainable and globally competitive automotive sector in Canada. The network engages more than 200 researchers and more than 200 industry, government, and institutional partners from across Canada. Network projects explore issues that range from consumer education in the use of safety devices, to new or improved processes for design, materials and manufacturing, to advance fuel research. In 2009–10, the network benefited from $5.8 million in support from NSERC, the Canadian Institutes for Health Research, and the Social Sciences and Humanities Research Council.

ecoTECHNOLOGY for Vehicles Program (eTV)

Over the past four years (2007–2011), Transport Canada's *ecoTECHNOLOGY for Vehicles* program has worked in collaboration with governments, industry, and academics to test and evaluate the performance of advanced vehicle technologies in Canada, including battery electric, plug-in hybrid, fuel cell, clean diesel, and advanced gasoline vehicles. Test results are helping to inform the development of codes, standards, and regulations required to help introduce EVs in Canada in a safe and timely manner. For more information about the eTV program please visit: http://www.tc.gc.ca/eTV.

PROVINCIAL

Québec

The Province of Québec continues to be very active in the area of R&D for EVs, as demonstrated by the following initiatives:

- The *Fonds québecois de la recherché sur la nature et les technologies (FQRNT)*, a provincial research fund, awarded $1 million to four universities for research projects related to EVs.
- The *Programme d'aide au développement des technologies de l'énergie verte (PADTEV)*, a clean energy program, has a total budget of $8 million, and includes a research, development and demonstration component specific to EVs.

- The Hydro-Québec Research Institute (IREQ) conducts research aimed at discovering new materials to increase battery life and performance. Patents resulting from this research have been applied to ground transportation and energy storage. IREQ is developing a battery with longer life expectancy and faster recharge rates than current lithium-ion batteries.
- The Industrial Research Chair in Energy Storage and Conversion from the University of Montreal is working on perfecting energy storage materials to enable their production and application on a large scale.

- The *Institut du transport avancé du Québec (ITAQ)*, Québec's advanced transportation research institute, offers a number of specialized services to businesses and researchers. The institute conducts applied research specifically related to EVs. A $5.4 million investment has been allotted for the deployment of a new advanced transportation laboratory at ITAQ.

British Columbia

The Pacific Institute for Climate Solutions (PICS) was established in 2008 by the University of Victoria, in partnership with the University of British Columbia, Simon Fraser University, and the University of Northern British Columbia, with a $94.5 million endowment from the Province of B.C. PICS partners conduct ongoing research in areas related to climate change and energy. To date, PICS has issued one white paper on electric transportation (*Electrifying the B.C. Fleet*, November 2009), and is supporting a number of graduate research projects and internships in PHEVs and grid-aware charging infrastructure. For more information on PICS, please see: http://www.pics.uvic.ca/index.php.

The BC Institute of Technology (BCIT) is conducting testing and research in grid-aware charging technologies in support of the B.C. PHEV activities. This PHEV and charging infrastructure work is a component of BCIT's intelligent electricity microgrid system, the first such system in B.C., led by BCIT's Group for Advanced Information Technology. BC Hydro and BCIT are conducting a joint Distributed Power Connections Study at BCIT's AFRESH house, a component of the microgrid system at BCIT and a vehicle-to-grid ready facility.

16.4 Industry

The Canadian automotive industry produces light duty vehicles, which include cars, vans, and pickup trucks; heavy duty vehicles, which include trucks, transit buses, school buses, and military vehicles; and a wide range of parts, components, and systems used in vehicles of this nature. To complement its manufacturing activities, the industry boasts a well-developed vehicle dealer network, plus an aftermarket organization which has grown into a world-class distribution system and service provider.

The automotive industry is Canada's largest manufacturing sector, accounting for 10% of manufacturing gross domestic product (GDP) and 17% of manufacturing trade in 2009. The industry consists of 12 passenger/commercial vehicle assembly plants and more than 750 auto parts plants. It directly employs about 109,111 people in automotive assembly and component manufacturing. Manufacturing is clustered in central Canada, while distribution is spread across the country. Canadian heavy-truck manufacturing industry comprises two relatively low-volume assembly plants: one located in Ontario (Hino Motors Canada Ltd.), and the other located in Québec (PACCAR of Canada Ltd.). These two plants employed approximately 750 workers in 2010.

Canada's EV industry continues to grow as well. Canada has a strong EV industry network that spans many areas including battery development and manufacturing, power train and systems integration, clean electricity production, and mining. Electric Mobility Canada (EMC), a national membership-based not-for-profit organization dedicated exclusively to the promotion of electric mobility, has published a *Directory of Electric Mobility Resources Canada*, which is available for download on EMC's website (www.emc-mec.ca).

Canada's industry is active in planning for EVs. In March 2010, EMC released the full report of the Canadian Electric Vehicle Technology Roadmap (evTRM). The full report and the Executive Summary are available on EMC's website.

The following are a sample of EV-related industry developments in Canada in 2010.

Electrovaya

In March 2010, Electrovaya, a leading Canadian battery supplier, was selected by Chrysler as the battery supplier for the Dodge Ram PHEVs demonstration program. One hundred and forty Ram PHEVs will feature a 12kWh lithium ion battery from Electrovaya. In July 2010, Electrovaya received a $5 million contribution from Sustainable Development Technology Canada (SDTC) in support of battery development for PHEV applications. Also, in January 2011, Electrovaya was selected by a major U.S. utility company to provide a 1.5 MWh capacity Lithium Ion SuperPolymer® Battery Energy Storage System for grid storage applications.

Novex

In June 2010, Novex, an environmentally-conscience courier company, announced that they are halfway towards a goal of having all clean vehicles in their Vancouver-based fleet by 2015. The new electric trucks (see figure 16.1) have 80 kWh of 'hybrid' batteries, giving the trucks a range of 160 km between charges.

Fig. 16.1 Electric delivery truck (Photo courtesy of Novex Delivery Solutions)

Phostech Lithium Inc.

In July 2010, Sud-Chemie AG announced that it will build the world's largest plant for the production of lithium iron phosphate in Candiac, Québec (the site of its Canadian subsidiary Phostech Lithium Inc.). Commercial production for delivery will start in 2012 and reach a rate of 2,500 tons per year, which is enough to supply 50,000 EVs or up to 500,000 HEVs.

TM4

TM4, a Hydro-Québec subsidiary responsible for developing electric powertrains, has provided 100 electric motors to Miljø Innovasjon, a subsidiary of Tata Motors, for an electric car demonstration that is underway in Norway and England. TM4's latest generation of motors for the automobile industry, the TM4 MΦTIVE™ series (see figure 16.2), is the product of a decade of research and development efforts. Incorporating TM4's patented technologies, the motor has the best power-to-weight ratio in its class and industry-leading efficiency.

Fig. 16.2 TM4 MΦTIVE™ - Electric Powertrain (Photo courtesy of TM4 inc.)

Azure Dynamics Corp.

In January 2011, Azure Dynamics Corp. signed a contract with Purolator Courier Ltd., a Canadian logistics and delivery company, to supply 600 hybrid vans over the next three years. Azure integrates its HEV technology, which includes lithium ion batteries, into a Ford E450 chassis. During the same month, Azure received another order for 50 hybrid units from an undisclosed logistics firm.

Québec's Electric Bus

As part of Quebec's 2010–2011 budget, and an item in the Government of Quebec's Economic Action Plan, $30.3 million over three years was allocated to design and manufacture an entirely electric bus. This partnership will also be financed by industry experts who will match the government's funding and contribute $30.2 million to the project. This bus will be made of aluminum and composite materials. The private partners include Novabus (manufacturer of city buses), Alcoa (providing aluminum structures), TM4 (electric drivetrain), Giro (software solutions for public transit operations), Sigma Industries (aluminum and composite products), and Bathium (Batteries).

EV 2010 VÉ Conference & Trade Show—Vancouver, B.C.—September 13–16, 2010

The EV 2010 VÉ Conference & Trade Show was Canada's premier electric mobility event for 2010. It brought together representatives of the vehicle industry, including small companies, energy providers, fleet managers, government agencies, research centres, academia and others. The Conference Program was organized along four tracks: Vehicles Technologies, Infrastructure and Other Readiness Measures, Public Policies and Institutional Changes Required, and Commercialization and Environmental Impacts. The conference hosted over 350 delegates, 60 speakers, 25 exhibitors and several sponsors.

16.5
Charging infrastructure and vehicle deployments

Electricity Mix

Canada is already a world leader in the use of renewable energy. Canada's electricity supply mix is one of the cleanest and most renewable in the world. Figure 16.3 illustrates Canada's national electricity mix.

Source	MW.h	Percentage
Hydro	334,251,275	58.7%
Coal	94,334,455	16.6%
Nuclear	88,190,431	15.5%
Natural gas	37,357,022	6.6%
Petroleum	6,894,195	1.2%
Other	5,668,991	1.0%
Wind and Tidal	2,946,466	0.5%
Total	569,642,835	100.0%

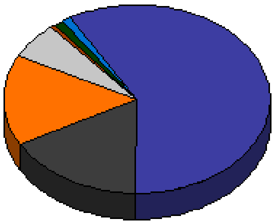


Fig. 16.3 Canada's National Electricity Mix, 2007. *(Source: Electric Power Generation, Transmission and Distribution Report - Statistics Canada.)*

By far, the largest source of electricity in Canada is hydro at almost 60%, with coal, nuclear, and natural gas adding significant portions to the mix. While hydro contributes significantly to Canada's electricity mix at the national level, the amount varies largely from province to province (see figure 16.4).

Québec

Since the signing of a MOU in June, 2010, the Government of Québec, Alliance Renault-Nissan, Hydro-Québec, the City of Montréal, Québec City and the *Agence de l'efficacité énergétique du Québec* have established a task force to plan the infrastructure of charging stations for EVs and to promote the use of EVs in Québec.

Later in June, Nissan and Communauto, a car sharing company, announced a commitment to add 50 Nissan LEAF EVs to its fleet in Fall 2011. This project will test the operation of charging stations within the framework of car sharing.

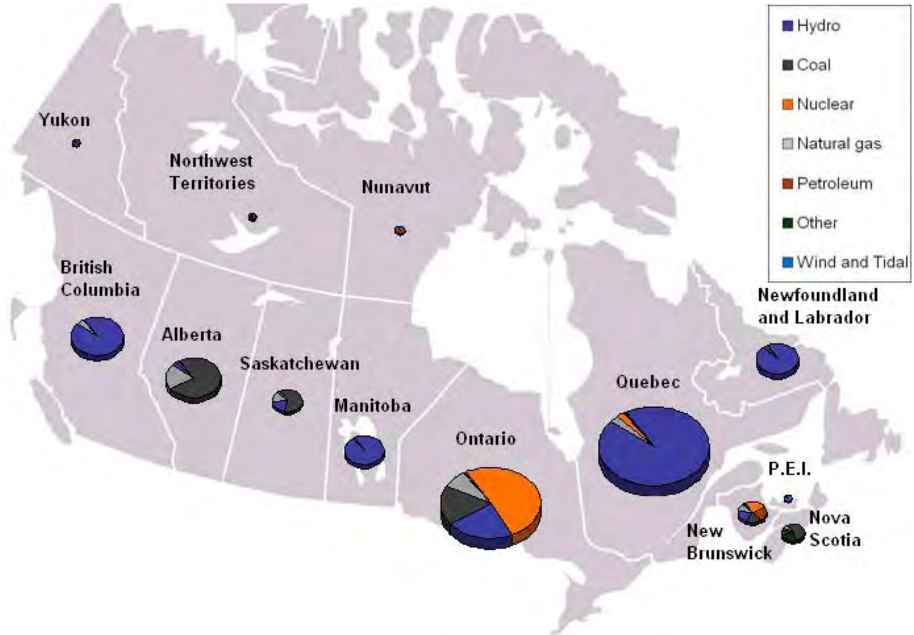


Fig. 16.4 Provincial Electricity Mix, 2007. *(Source: Electric Power Generation, Transmission and Distribution Report - Statistics Canada.)*

On July 14, 2010, Toyota's Québec partners welcomed the first Toyota Prius PHEV to Québec. Université Laval will spearhead Toyota's research project, which will benefit all of Québec.

The first phase of the largest testing program for EVs in Canada began in December 2010 with the commissioning of the first five Mitsubishi i-MiEVs, for a demonstration project in the City of Boucherville. It is expected that by mid-2011, about fifteen i-MiEVs will be made available to local businesses for integration into their fleets. At completion, fifty i-MiEVs will be used in this project, which will have an emphasis on assessing the performance of EVs under winter conditions. Hydro-Québec will instrument the Mitsubishi i-MiEVs to collect data on the volume and frequency of charging, as well as the behavior of the battery as a function of the temperature extremes that are unique to Québec's climate. The data collected will contribute to planning the charging infrastructure that will be necessary when EVs are mass-marketed in Québec.

On December 2, 2010, Hydro-Québec and Chevrolet Canada announced a new partnership by which Hydro-Québec will integrate 20 Chevrolet Volts into its fleet, starting in 2011. Hydro-Québec, the first company in Canada to acquire 20 EVs with extended range, intends to assess the vehicle's environmental benefits, specifically in terms of GHG reductions.

On December 7, 2010, le Centre Sheraton Montreal, the Sheraton Centre Toronto and Coulomb Technologies, in collaboration with Hydro-Québec in Québec, announced the installation of the first ChargePoint® networked EV charging stations at hotels within Canada. Hotel guests at the Sheraton Centre Toronto and Le Centre Sheraton travelling by EV will enjoy the ease of charging their vehicles downtown while staying at either hotel property. The two charging stations operational at each hotel will also be made available to residents and visitors of Toronto and Montreal. These installations make the Sheraton Centre Toronto and Le Centre Sheraton Montreal the first Canadian hotel properties to offer this service.

Ontario

Infrastructure for charging EVs will be built through a combination of private sector companies and Ontario's electricity utilities. The government will take the lead in supplying this infrastructure by ensuring recharging capacity is integrated into designated parking facilities owned by the Ontario government and GO Transit parking facilities for the public to use. Ontario is also working with the private sector and electricity organizations to develop business models for recharging facilities that will work within Ontario's regulated electricity market.

Pilot projects are also a crucial element of Ontario's EV activities. The Province, along with three other partners, has signed an agreement with Toyota Canada to obtain a PHEV model of the Toyota Prius in order to test vehicle and battery performance in real-world scenarios. Similarly, Ontario's local utilities are endeavoring to demonstrate EVs to better understand their impacts to the grid. Toronto Hydro will provide 15 electric drive versions of the Smart fortwo to selected customers for a four year period, while Burlington Hydro will also be adding a Rapid Electric Vehicle to its fleet as part of its *GridSmartCity* initiative.

British Columbia

B.C.'s Plug-In Electric Vehicle (PEV) Network coordinates plug-in EV activities in the province, including charging infrastructure roll-out and vehicle deployments. The Network is a multi-stakeholder group with representation from the provincial government, BC Hydro, local governments, industry, and academia. The Network is focusing market transformation efforts for electric transportation in five key areas: vehicle deployment, charging infrastructure, policy, outreach (education and awareness), and analysis.

BC Hydro has completed charging infrastructure guidelines for BC, an initiative commissioned by BC Hydro and sponsored by Natural Resources Canada, with the intent of facilitating consistent and safe deployment of charging infrastructure required for charging EVs at homes, businesses, and on public streets. These guidelines were created by the Electric Transportation Engineering Corporation. They provide an excellent reference for utilities facing the challenges of creating a comprehensive plan for the emerging electrical vehicle market. The Centre for Energy Advancement through Technological Innovation (CEATI) International is leading efforts to create a national guideline for Canada and is accepting comments and feedback on the guidelines developed for BC. The BC guidelines can be found on CEATI's website at www.ceati.com/ev.

Under the Pacific Coast Collaborative, B.C. is working with Pacific Coast States on the development of a Green Highway from B.C. to California that will include EV charging points. Part of this work includes working with the Pacific Coast States on the harmonization of charging infrastructure standards, the sharing of information on local charging infrastructure efforts, and collaboration on public outreach and awareness.

The PEV Network has designed a proposed Charging Infrastructure Project that will deploy up to 1000 grid-aware charging points throughout B.C., utilizing different charging types (Levels 1 and 2, and fast chargers) and different charging locations (at home, at work, on-the-go), with an emphasis on energy efficient charging. The project represents the implementation of the charging infrastructure guidelines with the objective of developing "best practices" for infrastructure deployment. The best practices will address stakeholder needs, including the following:

- A streamlined process for permitting and installation;
- Smart infrastructure designs that minimize the need for upstream infrastructure upgrades and encourage energy efficiency charging; and
- Insights into infrastructure deployment challenges and opportunities for informing policy development for government and the utility.
- The findings of the demonstration project will also help verify the guidelines and refine it into a more robust reference document.

Some local governments in B.C. are moving forward on deployments of charging infrastructure in support of the Charging Infrastructure Project. For example, the City of Vancouver is working with charging solution providers to demonstrate and test their technologies at public parking locations throughout Vancouver. In addition, the City of Colwood is working with developers and community members to deploy grid-aware charging technology as part of a broader smart grid / energy efficiency / clean energy project.

BC Hydro was the first utility in Canada to announce a deal with Mitsubishi Motors to take delivery and begin road testing the i-MiEV by the end of 2009. Two i-MiEVs have been in operation in the BC Hydro and City of Vancouver fleets for over one year. In 2010, the PEV Network agreed to work with Mitsubishi to expand the BC i-MiEV program and place up to an additional 50 i-MiEVs across the province.

On October 6, 2009, BC Hydro, the Province of B.C., Nissan, and the City of Vancouver announced a partnership that will see British Columbia become the initial launch point for Nissan's Canadian zero-emission transportation program. British Columbia is scheduled to be the first Canadian province to receive the Nissan Leaf EV in 2011, in advance of global distribution in 2012. Green Fleets BC, one of the PEV Network members, is currently working with Nissan to place the first Nissan Leafs in Canada in B.C. fleets in 2011.

On March 25, 2010, PEV Network members and Toyota announced a partnership to test and deploy the Toyota Prius PHEV in B.C. The vehicle is being shared between BC Hydro, the City of Vancouver, the Province of B.C., BCIT, and the University of Victoria for testing and demonstration purposes.

On December 8, 2010, BC Hydro signed a MOU with Chevrolet Canada to work with Chevrolet to help place 15 Chevrolet Volts into the fleets of B.C.-based organizations in 2011, with at least two of those vehicles being added to BC Hydro's own fleet.

The majority of British Columbia's energy supply is from clean energy sources. The Clean Energy Act establishes an objective to generate at least 93% of the electricity in British Columbia from clean or renewable resources. This, combined with grid-aware charging infrastructure, is expected to help ensure that clean electricity powers EVs in B.C.

16.6 On the road

The only vehicle data currently available in Canada are based on provincial vehicle registrations for light-duty passenger vehicles and light-duty trucks. The registered population totals of EVs and HEVs from 2004–2009, as of July each year, are shown in table 16.3.

Table 16.3 Light-duty vehicle registrations in Canada, as of July each year (Source: Desrosiers Automotive Consultants Inc.)

Type of fleet	2004	2005	2006	2007	2008	2009
EV fleet (a)	14	11	18	21	29	41
HEV fleet	2,939	6,053	13,253	25,783	45,703	59,541
Total fleet (b)	18,709,017	18,882,567	19,365,344	20,242,775	21,202,441	21,674,752

(a) The EV fleet includes registered light-duty passenger vehicles, light-duty trucks (up to 8500 lbs), and low-speed EVs.

(b) The total fleet numbers include all propulsion systems and fuels (gasoline, diesel, liquefied petroleum gas [LPG], natural gas, biofuels, etc.) for vehicles up to 10 000 lbs

16.7 Outlook

The Canadian government has not established an official goal regarding the deployment of EVs on Canada's roads. However, both industry and some provinces have publicly announced some specific objectives. The *Electric Vehicle Technology Roadmap for Canada*, which was developed by industry, has a vision of at least 500,000 highway-capable plug-in electric-drive vehicles on Canadian roads by 2018. The Province of Ontario has announced a vision to have one out of every 20 vehicles driven in Ontario to be electrically powered by 2020, and has stated a goal that 20% of eligible new Ontario Public Service passenger vehicle purchases will be EVs by 2020. On April 7, 2011, the Québec Government unveiled its *2011–20 Action Plan for Electric Vehicles*, in which they will invest $250 million on the deployment and use of EVs and the development of an industrial sector. The Action Plan set an ambitious target: by 2020, 25% of all new light passenger vehicle sales will be EVs (all-electric and rechargeable hybrids)—in other words, 118,000 EVs will be in use, representing 5% of Québec's total light-vehicle fleet. In addition, by 2030, the Québec Government anticipates that 1.2 million EVs will be travelling on Québec's roads that will represent 18% of the total number of light vehicles currently on the road.

A somewhat less optimistic picture is drawn from the results of a 2010 survey of Canadian new-car dealers. According to the 2010 *Trendsetter Survey* conducted by PricewaterhouseCoopers, DesRosiers Automotive Consultants, and Seguin Advisory Services, Canadian auto dealers were reported to be most optimistic about diesel-powered vehicles and believe that gasoline-electric hybrids will break through this decade and more than quadruple in sales. According to the survey, dealers predict that plug-in electric vehicles will not catch hold in the market this coming decade, predicting only 50,000 will be bought over the next 10 years.

In 2011, vehicle manufacturers will start marketing EVs in Canada. In most cases, OEMs have developed these vehicles with the expectation that Governments will support early adoption through incentive programs. These incentive programs make EVs more cost competitive with conventional vehicle prices, and encourage consumers to try out a new technology. While there is no Federal incentive program in Canada, a number of provinces offer a range of tax rebates or credits on the purchase of an EV. However, all government incentives will eventually disappear and vehicle manufacturers will need to offer EVs that will appeal to consumers with or without subsidies. Beyond cost, there are a number of other barriers to address for the uptake of EVs to succeed. Infrastructure and public acceptance will be key issues that will require government attention for the successful adoption of these vehicles. Only time will tell if consumers in Canada will purchase vehicles such as the Chevrolet Volt or the Nissan Leaf, but with the current trend of rising gasoline prices, coupled with government incentives, EVs are becoming a more attractive option for Canadian consumers.

17 Denmark

17.1 Introduction

In January 2007 the Danish government announced a new energy strategy aiming for a higher share of renewable energy in the Danish energy system. The long-term vision is energy independence from fossil fuels such as coal, oil, and natural gas.

The government's goal is to double the current share of renewable energy of 15% to at least 30% by 2025. As of 2010, biomass accounts for almost half of the use of renewable energy, and wind turbines produce slightly over 20% of the total electricity consumed. In 2025, 50% of the electricity consumed might be produced by wind turbines through expansion of the total capacity from 3,000 MW to about 6,000 MW.

This new energy strategy faces several challenges. A major one is to adapt the electricity system to manage a considerably higher share of intermittent electricity produced by wind turbines. Flexible timing for electricity consumption will be an important factor, and within this context, battery, plug-in hybrid, and fuel cell electric vehicles (EVs) have now been assigned important roles.

17.2 Policies and legislation

POLICIES

The national energy strategy has included the transportation sector since January 2007. In order to reduce oil dependency and carbon dioxide (CO_2) emissions from the transportation sector, the main strategy focus is to promote more energy-efficient vehicles and the use of biofuels. The Danish government has decided to prioritize the development of second-generation biofuels produced mainly from agricultural waste products.

In August 2007, the Danish Energy Agency published an alternative-fuels report for the transportation sector. One of the report's conclusions states that in the long term, battery electric vehicles (EVs) have the potential for both the highest energy efficiency and important advantages for the local environment, such as no local emissions and a very low noise level. The electricity storage capability of the batteries has the interesting potential to optimize the integration of intermittent renewable energy from wind power and other sources into the electricity system. In the fall of 2010 a revision and update of the report began, and a new report is expected based on current data using an enhanced calculation model with a projected publishing date in the summer of 2011.

In 2008 the government initiated the Energy Technology Development and Demonstration Programme (EUDP) to support development and demonstration of new energy technologies to realize the energy goals. During 2008 and 2009, hybrid electric vehicles (HEVs) and EVs were increasingly identified and cited in political and public discussions as an optimal and realistic answer to the challenges of the transportation sector. The energy sector especially has shown a high interest in plug-in hybrid (PHEVs) and EVs as important means to meet the challenge of integrating 50% of wind power into the electricity system. The energy sector has advocated for demonstration programs for EVs with advanced engineering.

Electricity and EV report

In April 2010, the Danish Energy Agency released a report on interplay between EVs and the electricity system. The analyses covered relations to transmission, distribution, and CO_2 reduction. A major conclusion was that intelligent charging is paramount. While intelligent charging can provide a very positive interaction of EVs with the electricity system—especially in the situation of a greater amount of fluctuating power (wind)—the situation rapidly turns into a disadvantage with demand for extra capacity (e.g., when charging the EVs at peak hours morning and evening).

Furthermore, a working group of different stakeholders chaired by the Energy Agency delivered a report to the Minister of Climate and Energy on framework conditions for the establishment of a network of public charging facilities. The report analyzes the need and costs for public EV charging poles and identifies three different models for options to support EVs in Denmark. The models suggest different degrees of public regulation, but the report does not recommend one system, so the choice is left for political decision.

Additionally, in 2008 two major new programs to promote EVs were started and continued to be active in 2010. These are the EV promotion program and the Centre for Green Transport, which will implement EV demonstration projects.

The Danish EV promotion program

In February 2008, almost all political parties in the Danish Parliament entered into a new Climate and Energy Agreement. As part of this agreement, the parties agreed to allocate 30 million DKK (€4 million) to promote demonstration programs for battery EVs, beginning in December 2008.

The purpose of the EV promotion program is to obtain data about users' experiences with EVs. Monitoring experiences will help identify practical barriers for the deployment of EVs in Denmark. All knowledge gathered about technical, organizational, economic, and environmental factors associated with using, operating, and maintaining EVs will be made available to the public. Another purpose of the EV promotion program is to analyze the potential for EVs to store excess electricity production from wind turbines through intelligent recharging.

Organizations and enterprises with vehicle fleets can receive subsidies for the acquisition of EVs and charging facilities when they participate in the program. Public authorities, as well as public and private enterprises and institutions, may apply.

All subsidized EVs are equipped with the same type of measuring instrument. This makes it possible to monitor usage of EVs in use. Data are gathered about daily driving patterns, including number of trips, trip length, and the duration and time of day when the EV is charged. Users can also apply for additional subsidies if they participate in additional data-gathering activities on the use of their EVs. Finally, subsidies are also available for cross-sector projects, such as analysis of collected EV data and reports on communication of experiences.

The program is being administered by the Danish Energy Agency. In spring 2009 support was granted totaling DKK 10 million (€1.3 million) for 17 projects for 49 EVs, which included cars, vans, minibuses, and trucks. In early 2010 about DKK 7 million (€940,000) was allocated, resulting in grants for 45 additional cars. In February 2011, DKK 11 million (€1.5 million) was allocated. The remaining DKK 5 million (€670,000) is scheduled for allocation in the beginning of 2012.

Danish Transport Authority, Centre for Green Transport

In the December 2008 political agreement for "A green transport policy," a total of DKK 284 million (€38 million) was allocated for initiatives to help reduce CO_2 emissions from the transportation sector. In April 2009, the Danish Transport Authority established the Centre for Green Transport to create the framework for a Danish center in the field of sustainable transport and to manage these initiatives. The Centre collaborates with stakeholders in the private and the public sectors and conducts ongoing test and demonstration projects about energy-efficient transport solutions in order to create synergy between the specific initiatives and the most recent research and knowledge.

Projects conducted by the Centre include a transport certification program for municipalities and companies, an energy-efficient driving campaign, and energy label-ing of light commercial vehicles. DDK 200 million (€28 million) has been allocated specifically for demonstration projects between 2010 and 2013 that promote environmentally aware and energy-efficient transport solutions, including test projects with alternative types of fuels, electric cars, electric buses, and electric trucks. The grants cover 20–30% of the projects' total budget, and the projects will operate for 2 or 3 years. Demonstration projects include the following:

- ChoosEV: 15 million DKK (€2 million) was granted for the ChoosEV project to field-test 300 mass-produced EVs.
- Hybrid buses: 4.8 million DKK (€640,000) was granted to field-test 4 hybrid buses.
- EV timeshare leasing: 1.7 million DKK (€230,000) was granted to gather experiences from leasing EVs on a timeshare basis.

LEGISLATION

Battery EVs and fuel cell vehicles are exempted from the registration tax and annual tax until the end of 2012. Additionally, the Government has announced an extension of the tax exemption until end of 2015.

There are no special tax rules for PHEVs. As part of the new Climate and Energy Agreement, it is stated that tax rules with the necessary incentives to allow the introduction and deployment of plug-in hybrid vehicles should be decided. A government tax committee is now overhauling the taxation system for cars and is expected to present proposals for a revised tax system, including the future taxation of EVs and PHEVs.

Current Danish registration tax for passenger cars is very high (180%) and is based on the value of the car. In August 2007, the tax rules for light vehicles (passenger cars and vans) were changed to promote the sales of more energy-efficient vehicles. New rules reduce the registration tax for gasoline cars that are more energy-efficient than 16 km/L (18 km/L for diesels) and have a higher tax for less energy-efficient cars. The reduction is 4,000 DKK for each km/L higher than 16 km/L, and the extra tax is 1,000 DDK for each km/L less than 16 km/L. These changes are having a considerable effect on the sales of passenger cars in Denmark. The share of small energy-efficient cars has increased considerably, especially for diesel cars.

The annual tax for the past several years has also been based on energy consumption and CO_2 emissions to promote the sales of energy-efficient and environmentally friendly cars.

There are no special incentives to purchase hybrid cars. Of course, the Toyota Prius benefits from the recent changes in the registration tax and a low annual tax, but the purchase price for the passenger version is still considered too high for most consumers. A new registration option for the Prius began in January 2008 that allows the Prius to be registered as a van (with front seats only), which qualifies this model for the lower tax rate on vans and thus reduces the price considerably. In 2008 and 2009, sales of the Prius increased significantly, but the absolute figures are still small.

17.3 Research

The main focus of Danish research in transportation technologies has been on biofuels and hydrogen and fuel cells. However, several activities and research projects were initiated in 2008 and 2009 to analyze the potential of intelligent charging systems and vehicle-to-grid (V2G) services for PHEVs and battery EVs. These activities are expected to expand considerably in the coming years.

Denmark has two world-leading companies—Novozymes and Danisco—that develop enzymes to produce bio fuels. In 2007, construction of a full-scale demonstration plant for second-generation bio ethanol using agricultural waste products began with support from EUDP. Inbicon, a subsidiary of DONG Energy, opened the new plant in November 2009. It is one of the largest full-scale production plants for second-generation bio ethanol in the world. The enzymes for production are delivered by Novozymes and Danisco, and the production of bio ethanol is distributed to the market by Statoil, which is the first company in Denmark to sell gasoline blended with bio ethanol.

Several hydrogen and fuel cell related transport projects over the years have been funded by the Danish Energy Agency. This has led to around 10 hydrogen refueling stations in operation in Denmark, of which two stations are for road vehicles such as cars. A new station will open in early 2011, and will be the first station in Denmark to provide 700-bar refueling that meets the international SAE J2601 standard on fast and safe refueling of hydrogen.

Transportation hydrogen-related efforts in Denmark are coordinated by the Hydrogen Link Denmark network and is part of the Scandinavian Hydrogen Highway Partnership (SHHP) that constitutes a transnational networking platform that catalyzes and coordinates collaboration between three national networking bodies—HyNor (Norway), Hydrogen Link (Denmark) and Hydrogen Sweden (Sweden). The SHHP aims to establish an early hydrogen refueling infrastructure. Furthermore, the collaboration consists of regional clusters involving major and small industries, research institutions and local/regional authorities. The SHHP main focus at present is to position and attract the expected 2015 market introduction of hydrogen powered fuel cell vehicles from the major car manufacturers for Scandinavia. Due to an attractive tax exemption on hydrogen cars in Denmark as well as Norway, the expected market price of vehicles in 2015 could be fully competitive with gasoline.

Fig. 17.1 Fuel cell vehicles from international manufacturers visit the Danish Parliament during UN COP15. (Photo courtesy of H2 Logic)

EDISON Project

In March 2009 the EDISON project for EVs and PHEVs began. The EDISON project is an international research venture partly publicly-funded through the research program FORSKEL, administered by the Danish transmission system operator Energinet.dk. The total budget is approximately 49 million DKK (€6.5 million), 33 million DKK of which come from FORSKEL. The consortium behind the project consists of IBM, Siemens, DTU/Risø, DONG Energy, Eurisco, Østkraft, and Dansk Energi.

The project objectives are to develop system solutions and technologies for EVs and PHEVs that will:

- Enable a sustainable, economic, and reliable energy system with substantial fluctuating renewable energy.
- Provide a technical platform for Danish demonstrations of EVs with emphasis on power system integration.
- Export globally applicable Danish expertise in distributed energy resources and operation of energy systems with high wind power penetration.

The EDISON project connects research institutions and major industry enterprises to cover all three stages: research through concept and technology development to demonstration. The main emphasis is on the two first stages: research, and concept and technology development. The project also includes proof-of-concept where the developed technologies will be tested by using EVs and charging stations installed in the grid on the island of Bornholm. This location was chosen for the pilot test because it offers an opportunity to show the interaction between wind turbines and EVs in an isolated system. After a successful proof-of-concept test, the consortium expects to be ready for a large-scale demonstration by the end of 2011.

Halfway through the project in 2010, important results were already being used for input in the upcoming standard ISO/IEC 15118 (V2G communication interface) along with suggested new logical nodes for the existing standard IEC 61850 (International Electrotechnical Standards, Communication networks and systems in substations).

Fostering of several similar projects throughout Europe has been one of the indirect project results, which has lead to an increased knowledge sharing between the power and automobile industries. For this reason, most EV manufacturers see the value of smart charging today. Although the initial focus of the EDISON project was on integrating renewables, investigations have shown that restrictions in the grid distribution must be addressed very early in the process of implementing EVs into the power system.

17.4 Industry

Denmark has no conventional car industry, but it houses many component suppliers. Denmark was one of the first countries to produce and market electric vehicles. Production of the small Ellert—which became the best-selling EV in the world—began in 1987, followed by the 1991 production of the KEWET El-Jet. To facilitate sales of these vehicles in Denmark, EVs were exempted from registration tax and the annual car tax based on weight. However, both manufacturers have ceased production in Denmark, but improved versions of these vehicles are currently produced in Germany and Norway.

In 2008 and 2009, the new interest in electric drive vehicles in Denmark has to a large extent focused on the potential for using electricity from renewable sources in transportation and on the role of the vehicles in adapting the electrical system to manage a higher share of intermittent electricity produced from wind turbines.

The Danish Electric Vehicle Alliance

The Danish Electric Vehicle Alliance was established as a trade association under the Danish Energy Association in November 2009. The main objective of the Alliance is to represent the interests of member companies in matters regarding authorities, politicians, and organizations, both nationally and internationally. The Danish Electric Vehicle Alliance represents 55 companies with a direct commercial interest in the introduction of EVs in Denmark, including energy companies, suppliers of components for the charging infrastructure, charging operators, and suppliers of EVs.

17.5 Charging infrastructure and vehicle deployments

Two major companies, Better Place and ChoosEV, are established in the field of charging infrastructure and vehicle deployment in Denmark.

Better Place Denmark

In 2009, Better Place and DONG Energy closed a joint agreement investing about 100 million Euros in a nationwide Danish infrastructure for electric cars to pave the way for Denmark to adopt EVs on a larger scale.

Better Place is developing and deploying EV services, systems, and infrastructure. The company cooperates with automakers, battery suppliers, energy companies, and the public sector to create a compelling solution, which is also scalable for global implementation.

Subscribers and guests get access to a network of charge spots, battery switch stations, and systems. The aim is to provide EVs with the known mobility of the conventional car that is combined with an optimized driving experience with minimum environmental impact and cost. To make the purchase of an EV more feasible for consumers, Better Place owns the expensive batteries and offers them as part of the subscription, thus eliminating a significant additional cost for the car owner and making the EV price competitive compared to the conventional car. Better Place will offer different subscription plans including a given number of kilometers per month as well as a battery and access to battery switching when necessary.

Recharging the battery will usually take place at a charge spot since few driving trips in Denmark exceed 100 km. For longer trips exceeding the current range limit for a fully charged battery (160 km), Better Place subscribers can switch the depleted battery with a recharged one in less than five minutes at a battery switch station. The Better Place infrastructure is compatible with and open to all modern EVs—with or without the battery switch technology.

The Better Place solution addresses the climate challenges of transportation through intelligent charging at charge spots. Most cars are parked 22 hours a day on average. Better Place is planning to manage charging during times when renewable energy is supplying the electricity grid, while taking into account the specific driving needs of the car as well as reducing the stress on the local grid.

Better Place Denmark also continued to create partnerships with Danish municipalities in 2010. By the end of the year, 34 agreements covering almost 50% of the Danish population were completed. Additionally, preparations for a Better Place Centre conducting test drives and education on future EV transportation for both consumers and international stakeholders also began in 2010.

Better Place will launch its infrastructure of charge spots and battery switch stations in late 2011. This coincides with the launch of the Renault Fluence Z.E. (see figure 17.2) into the Danish market. The Fluence is the first EV with a switchable battery produced with the battery switch technology in mind.

Fig. 17.2 The Renault Fluence Z.E. at a redesigned public charging post. (Photo courtesy of Better Place Denmark)

The construction of Europe's first battery switch station was initiated in Copenhagen in autumn 2010. The design of the station follows the concept illustrated in figure 17.3. The station will be fully operational in mid-2011, and after an initial test period it will become part of the Better Place network. Fifteen or twenty stations are planned to be deployed in 2011 in various locations along the highways securing full mobility across almost the country including all big cities. In 2012 more stations will follow to secure coverage also in the more remote areas, therefore creating a nation-wide network with full mobility for EVs with battery switch. This network of battery switch stations using an advanced robotic system to replace the depleted battery with a fully charged one is expected to solve the range anxiety problem of EVs.

Fig. 17.3 Battery switch station outline. (Photo courtesy of Better Place Denmark)

Charge spots are installations at home, at work, or in public spaces that charge the EV using a cable between the vehicle and the charge spot. For the most part, EVs will charge at the charge spot installed at the driver's private address.

Central to the network is the network operating center liaising between the individual EV elements: car, charge spots, and battery switch stations while simultaneously managing their connection to the Danish national grid. The network operating center is staffed around the clock and provides important information about the usage of charge spots and battery switch stations. Through the connection to the Danish electricity grid, the network operating center is essential in providing intelligent charging to ensure charging is optimized during periods when the electricity supply is from a large share of renewable.

EVs are connected wirelessly to the network operating center. This communication allows the network to let the charge spot either begin or delay the charging process while taking into account factors such as driving needs, the share of renewables in the national grid, and the pressure on the local grid.

The network operating center will also be able to guide the EV towards the nearest battery switch station when a fresh battery is needed. Through wireless communication with the EV, the network operating center and in-car software can plan the next battery switch and guide the EV towards a battery switch station ensuring the correct battery type is prepared and ready to be switched. The switch takes less than five minutes and includes cleaning of the undercarriage before the battery is removed and replaced. The depleted battery will be stored and recharged at the station.

Also in 2010, Better Place signed a letter of intent with China's largest independent automaker, Chery Automobile, to work on developing an electric model with a switchable battery, and the company is in dialogue with large parts of the automotive industry to establish more partnerships concerning battery switch technology. There were a number of significant international partnerships solidified for Better Place, starting with a US$ 350 million investment led by HSBC in the beginning of the year—one of the largest cleantech investments ever to be made. In September, Better Place, and GE revealed a partnership based on four pillars including development of standards based technology, a pilot battery financing program for the first 10,000 batteries in the Danish and Israeli markets, electrification of car fleets, and a consumer awareness program.

ChoosEV

ChoosEV was established in November 2009, with the two utilities Syd Energi and SEAS-NVE and the car rental company Sixt as owners. The purpose of ChoosEV is to lease and maintain EVs (including PHEVs) and to establish an infrastructure of charging facilities throughout the country.

In summary, ChoosEV offers these options for infrastructure:

- Leases all types of EVs available for sale on the market.
- Provides and maintains charging facilities. The initial version of the charging facility will be capable of controlling the charging period to optimize the use of renewable energy in the grid.
- Offers tools to analyze driving patterns in an existing fleet to determine which vehicles could be replaced by EVs.
- Participates in national and international development projects related to EVs and infrastructure

Since very few EVs were on the market in 2010, ChoosEV decided to start with the sales and leasing of a converted Citröen C1. About 50 cars were converted by a company in Denmark. The range of the vehicle is about 100 km. Users who need a longer range have the option of renting a gasoline or diesel car at a special rate.

During 2010, ChoosEV planned and initiated an EV test and demonstration program called *TestEnElbil* (Test an EV), which may be the largest such program in Europe (see figure 17.4). In cooperation with 30 local authorities, 300 EVs during a period of 2 years will be put at the disposal of 2,400 families for a period of 3 months each. During the project period user experiences and data based on a total mileage of about 6 million kilometers and about 300,000 battery charges will be collected for research and analysis.

Fig. 17.4 EVs ready for the *TestEnElbil* project in the city of Aalborg. (Photo courtesy of ChoosEV.)

The project started in October 2010 and will run until 2013. In the first part of the project, the EVs will mainly be Mitsubishi i MiEV, Citroën C-Zero, or Peugeot Ion, but later in 2011 the Nissan Leaf is expected to be available.

To support the general use of EVs in Denmark ChoosEV is planning to establish an intelligent charging infrastructure consisting of private charging modules (see figure 17.5), semi-public slow charging, and semi-public quick charging facilities. In 2011, 300 semi-public slow charging and 6 quick charging facilities (ChadeMo) are planned. Additionally, 300 private charging modules are part of the *TestEnElbil* project.

Fig. 17.5 Intelligent private charging module. (Photo courtesy of ChoosEV.)

The project is financed by ChoosEV, local and national sponsors and has been supported by the Centre for Green Transport and the Danish EV promotion Programme.

17.6 On the road

The total number of passenger cars in Denmark has passed 2.1 million and is slightly increasing. However, the number of EVs has been slightly decreasing and was estimated at 200 at the end of 2008. The cars were mainly the French Citroën Saxo, Berlingo Électrique, and the Danish Kewet El-Jet. For several years, there were no sales of new EVs, and some EVs were taken out of service as a result of technical issues, such as problems with batteries or electrical equipment. Many EVs that were originally bought and owned by companies and public authorities have since been sold for private use or have been exported.

In 2009 and 2010, however, sales of EVs were resurrected, to a large extent as a result of the Danish EV promotion program. In 2010, 71 new EVs were sold, and the total EV fleet by the end of the year was 368, as shown in table 17.1. About 350 City-El vehicles and a similar number of new electric scooters are also in use. With 5 million unmotorized bicycles in use, the Danish average more than one bicycle per person. However, electric bikes are still not selling in large numbers, even though their quality improved in 2009 and 2010. Most new e-bikes are now equipped with lithium-ion batteries.

Table 17.1 Characteristics and population of the Danish motorized vehicle fleet per December 31, 2008 and 2009. Estimates are in italics

	DECEMBER 31, 2009			DECEMBER 31, 2010		
Vehicle type	EV fleet	HEV fleet	Total fleet	EV fleet	HEV fleet	Total fleet
Motorized bicycle (no driver license)	15,000	0	n.a.	20,000	0	n.a.
Motorbike (a)	350	0	200,000	650	0	200,000
Passenger vehicle	292	325	2,100,000	368	470	2,160,000
Multipurpose pass. vehicle	0	55	25,000	0	65	25,000(b)
Bus	n.a.	0	15,000	11	0	15,000
Truck	n.a.	0	50,000	15	0	50,000
Industrial vehicle	n.a.	0	n.a.	n.a.	0	n.a.
Total	**15,600**	**380**	**2,390,000**	**20,750**	**535**	**2,450,000**

n.a. *Not available*

Motorbikes include City-el.

Not including vans. Many MPV's and SUV's are registered as vans in Denmark.

17.7 Outlook

From 2001 to 2006, EVs were not considered a realistic possibility for future road transportation in Denmark. However, the market success of hybrid vehicles and the new concept of plug-in hybrid vehicles have changed public opinion. In light of the new Danish target stating that 50% of the electricity consumption in 2025 should come from wind power, the combination of PHEVs and renewable energy from wind is seen as a very strong solution to some of the future challenges in the electricity and transportation sectors.

Demonstration projects with PHEVs and development of V2G technologies will be in focus in the coming years. Better Place Denmark's full-scale introduction of battery EVs is expected to start in late 2011 and the demonstration and test activities of ChoosEV have already started and will include more that 300 new EV's in 2011. However, the expectations for growth of the numbers of HEVs, PHEVs, and EVs in Denmark are very difficult to define based on the following factors:

- Battery EVs and fuel cell vehicles are exempted from registration tax and annual tax until the end of 2015, but there are no special incentives to purchase hybrid cars.
- A government tax committee is overhauling the taxation system for cars and is expected to present proposals for a revised tax system, including the future taxation of EVs and PHEVs.
- There is considerable political and public interest in EV's in Denmark. However, their sales are still very limited because the available EVs on the market are currently very few, they and are not competitively priced when compared to conventional gasoline and diesel cars, and their range is limited.
- The current sales of EVs are mainly for demonstration and test projects supported with government and other incentives.
- Considerable investments in infrastructure for PHEVs and EVs are planned. It may help the introduction of EVs and PHEVs, but only to a limited extent. EVs and PHEVs can easily be charged using existing standard plugs already widely available in Denmark.

18 European Union

18.1 Introduction

The European Union (EU) encompasses 27 member countries with a population of nearly half a billion citizens and the world's largest GDP of $14.43 trillion. As a single entity, the EU ranks second and third in the world in the consumption of oil and electricity, respectively. While it produces all of its electricity domestically, it is the second largest importer of oil.

The EU started as an economic agreement between six countries in 1951. The EU is not a federation like the United States, but it is much more than a free-trade association. The countries that make up the EU (its "member states") remain independent sovereign nations, but they pool their sovereignty in specific areas in order to gain a strength and world influence none of them could have on their own. In practice, the member states delegate some of their decision-making powers to shared institutions they have created, so that decisions on specific matters of joint interest can be made democratically at the European level.

Twelve of the member countries of the IA-HEV are also members of the EU. These are: Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. In addition to the regulations and other actions of the individual nations, policies created at the European level also affect these countries. The EU framework facilitates the communication between countries for issues such as standardization across national boundaries, and it supports joint research efforts.

EU interest in hybrid and electric vehicles, and in particular in vehicles having a significant zero emission range compatible with average urban trips, has grown in recent years due to a series of reasons, which sometimes reflect specific policies outlined in recent documents. The initial stress on renewable fuels as a significant part of the effort to control carbon dioxide (CO_2) emissions from road transport has been supplemented by the inclusion of electricity from renewable energy sources in the directive on the promotion of the use of energy from renewable sources, which was adopted on 2009.

Air quality is certainly a reason to support the application of these vehicles in many EU urban areas. The availability of untapped electricity production capacity from low-carbon sources in many member states, particular in non-peak times, is a further incentive. Energy policy plays a significant role, both to reduce dependence on imported oil and refined derivatives and to pave the way to its long-term replacement. Finally, the importance of the automotive industry in EU's industrial fabric and its relevance for high quality jobs, trade and innovation requires that these advanced vehicles are kept in focus to guarantee that the European vehicle and component industry maintains its leadership in the future.

18.2 Policies and legislation

The European Commission does not currently have regulations or incentives that encourage the uptake of hybrid and electric vehicles specifically, but some current and forthcoming regulations do address issues of greenhouse gas (GHG) emissions, safety, and standardization which may have the impact of encouraging the adoption of green vehicle technologies. Additionally, the EU is considering measures to stimulate the demand side, such as guidelines on financial incentives and revising taxation frameworks. Developments in the latter area might be a cornerstone of future energy taxation across the EU, with proposals linking it to energy content and CO_2 emissions. Electrical energy would not be directly affected, since it would fall under another mechanism (the CO_2 emissions trading scheme), but in the medium term all sources would be treated on an equal footing across Europe. Also, recent regulations mandating a minimum use of 20% from renewable energies (which includes both biofuels and electrical energy) will most likely be beneficial to EVs. The EU Renewable Energy Directive, in fact, mandates a 20% share of renewable energy sources in energy consumption by 2020, with a 10% binding minimum target for transport sector.

Another tool to facilitate the adoption of clean vehicles is Directive 2009/33/EC on public procurement of clean and energy efficient vehicles, which requires that energy and environmental impacts of the operation of vehicles over their whole lifetime are taken into account in all public purchases of road transport vehicles. The transposition of the Directive into national legislation will be facilitated by the Clean Vehicles Portal (www.cleanvehicle.eu). This portal offers EU-wide information about existing procurement rules and incentive schemes for clean vehicles, market shares, and access to Europe's largest vehicle database with individual data-output and calculations for each Member State in the EU.

Adopted on 28 April 2010, the Communication from the Commission "A European strategy on clean and energy efficient vehicles" sets out a strategy for encouraging the development and uptake of clean and energy efficient ("green") heavy- (buses and trucks) and light-duty vehicles (cars and vans) as well as two- and three-wheelers and quadricycles. It sets out medium- to long-term objectives to promote a new industrial approach, based on clean and energy-efficient vehicles that will boost the competitiveness of the European industry and will provide new jobs and support restructuring. At the same time, the proper functioning of the internal market shall be preserved. It comprises some 40 actions in the fields on regulation, standards, demand-side measures, research as well as actions on the international stage and tackling the social dimension of the industrial change. This strategy document may be found online at http://ec.europa.eu/enterprise/sectors/automotive/competitiveness-cars21/energy-efficient/communication_en.htm.

Regulations and standards

The most significant EU regulation impacting hybrid electric vehicles (HEVs), plug-in hybrid vehicles (PHEVs), and electric vehicles (EVs) is Regulation (EC) 443/2009, which came into force in April 2009. This legislation mandates the reduction of CO_2 emissions from motor vehicles, specifying a fleet average of 120 g/km CO_2 phasing in at 65% of new car fleets in 2012 and going to 100% by 2015. Implementing measures to this regulation are already being discussed.

Also, following the recent agreement to create CO_2 standards for light commercial vehicles, the EU plans to review the steps by which the 2020 target for reducing CO_2 emissions from light commercial vehicles can be achieved. Furthermore, initial steps towards establishing CO_2 standards for heavy-duty vehicles are also being taken.

Smaller vehicles have not been neglected. A new type-approval framework for two- and three-wheelers and quadricycles is now in the approval process, overhauling the whole regulation by rationalizing it from 15 to just 5 regulations. This will ensure increased coherence of the EU approach, streamlining type approval procedures and increasing the ambition on environmental performance. The proposal foresees significant adaptation to the latest and anticipated near-future vehicle construction and propulsion technology. Also, it will increase the level of functional safety, opening the way to lighter yet safe EVs on European roads.

With the strategy on clean and energy efficient vehicles, the Commission is also creating a regulatory framework that supports full-size EVs by addressing issues related to safety, standardization, charging and/or refuelling infrastructure, recycling and reuse of batteries used in transportation, and raw materials necessary for their production.

On the safety side, the regulation UNECE (United Nations Economic Commission for Europe) 100 "Uniform Provisions Concerning the Approval of Battery Electric

Vehicles With Regard to Specific Requirements for the Construction, Functional Safety and Hydrogen Emission" requiring shock protection has been incorporated into European law. This way requirements and test procedures for electrical safety have been harmonized between EU countries to simplify type approval (minimum technical and safety requirements) and reduce the administrative burden. The EU additionally revised other type-approval requirements in Directive 2007/46/EC "Establishing a Framework for the Approval of Motor Vehicles and their Trailers, and of Systems, Components and Separate Technical Units Intended for Such Vehicles," by including the mandatory application of certain UNECE regulations on crash safety, in order to cover risks specific to electric powertrain vehicles.

In terms of standardization, the EU is working to establish Europe-wide harmonization between the electricity supply point (charging point) and EVs, so that these will be interoperable across the member states. The European Committee for Standardization (CEN), European Committee for Electrotechnical Standardization (CENELEC), and European Telecommunications Standards Institute (ETSI) have been mandated to agree on an EV charging standard, paying attention to smart-charging, safety, data transfer and electromagnetic compatibility requirements. The standard will take into account new and international developments to ensure as broad of a scope as possible. In addition, a joint focus group has been established to issue a report assessing European needs to help ensure that international standards fulfil them.

An Informal Group on Rechargeable Energy Storage Systems has also been established by UNECE Working Party 29 in order to develop safety requirements for batteries in electric vehicles. Such requirements will probably be incorporated in UNECE Regulation 34, which is also included in the list of UNECE Regulations whose application will be mandatory for the purpose of EU type-approval of motor vehicles and their components. They will address the functional, mechanical, chemical, and electrical safety aspects of batteries.

Incentives

The EU has agreed upon some demand-side measures that could stimulate uptake of green vehicles by consumers in the member states. It is seeking measures that will produce the greatest economic performance, while making sure that any benefit to industry is in line with existing State Aid Rules. The EU is also in the process of revising its Energy Tax Directive 2003/96/EC to create standards for CO_2 taxation, rationalizing existing taxes on a variety of energy sources by linking them both to energy content and CO_2 emissions so as to avoid distortions between different types of fossil fuels.

In this context, the demand-side pillar of the European Green Cars Initiative is worth mentioning, where, among others, the European Commission provided guidelines on national vehicle scrapping schemes, which have been the tool of choice for market support during the economic crisis. Scrapping incentives were enacted in 13 member states of the EU during 2009. The scrapping schemes have been remarkably successful, although it is important to note that some of the impacts derived may have been uniquely beneficial to the specific situation of the global financial and economic crisis of 2008/9. Scrapping schemes also provided a mechanism for accelerating the renewal of the European car park, potentially generating environmental improvements and benefits for road safety. The similar approach of guidelines is prepared for the financial incentives for clean and energy efficient vehicles.

Other policies relevant to HEVs, PHEVs, and EVs

The White Paper on European Transport Policy laid out the sustainable development strategy for the EU for the years between 2001 and 2010. Adopted by the European Council in Gothenburg in June 2001, the paper proposes 60 courses of action to make the European transport system more effective. The paper calls for flexibility in transportation modes, updating railways and water transportation and the control of air transport growth.

In 2010, the CARS 21 (Competitive Automotive Regulatory System for the 21st century) High-Level Group comprising Commission, Member States, regions, industry and other stakeholders was relaunched to make recommendations for short-, medium-, and long-term public policy for the European automotive industry. The goal of this group is to come up with recommendations that ensure competitiveness of the automotive industry and its sustainable development at the same time. The Group will deliver its Interim Report in October 2011 and its Final report in 2012.

The European Union is also concerned with supporting industries for electric vehicles. The EU has developed a project to evaluate the impact of EVs on the electricity supply system and power grid. The European Investment Bank is developing lending policies to help the EU emerge as a leader in the development of EV infrastructure. It is also engaged in the development of recycling, reusing and transportation policies for batteries as well as regulations and policies for raw materials related to the whole EV industry.

18.3 Research

The European Union has gradually been growing its funding of research since the early forays in this area, after having funded steel and nuclear research within the first Communities (CECA and EURATOM) which were part of the initial Community structure. The objective of this funding, has been to leverage the synergies existing between national competencies and to grow a truly European research area, in which researchers could move freely and gradually build an integrated Europe of science and technology. This EU funding is complementary to the much higher national and private funding, particularly in large industrial sectors such as automotive,

While research and demonstration on hybrid and electric vehicles and their components has been funded in many previous projects across several Framework Programs, the European Green Cars Initiative (EGCI) created a specific instrument to support, among other, specific research on these technologies. The EGCI, announced on November 26, 2008, is one of the Public Private Partnerships created in the framework of the European Economic Recovery Plan in response to the world crisis. The EGCI was created to support the research and development of technologies and infrastructures to tackle global warming by funding work in areas such as vehicle technologies to use renewable and clean energy sources, safety, and traffic fluidity. The Initiative focuses on vehicle electrification but also includes trucks and logistics in its scope.

The EGCI is supported by an Industrial Advisory Group (IAG) that cooperates with the European Commission in shaping the research program. In 2010 the IAG released three technology roadmaps which are at the base of the work programs of the actual calls for proposals. The European Commission launched its first set of calls for proposals related to the EGCI on July 31, 2009, which focused on fully electric vehicle technologies. Thirty projects were selected for funding with a total budget of €108 million. The initiative was articulated over five “Calls”: the DG RTD Surface Transport call, the Joint Call on Electrochemical Storage, the DG INFSO Main Call and the DG TREN Main Call. The areas of research include: Highly Energy-Efficient ICT Components and Solutions, Sustainable Automotive Electrochemical Storage Applications, Power Dense and Cheap Electric Motors, Efficient Auxiliaries, Compact Range Extender Engines, Battery Integration and Exchange, Innovative Architectures and Vehicle Technologies, a large demonstration project and Education and Training. Several of the programs are currently running and the remainder will be underway by early 2011. A second funding opportunity announcement (FOA) was announced on July 20th, 2010, which opened further research topics on trucks and logistics research, while keeping a major focus on EVs. In this area, topics on safety, thermal management and innovative light-duty vehicles architectures, as well as battery manufacturing and ICT for battery and onboard systems management, were opened for proposals.

18.4 Industry

The European Union with its industrial policy as well as trade, research, social, and other policies can influence the industries, including the automotive, in its member nations. In addition to the regulations and incentives that steer the European automotive industry towards greater efficiency, the EU also has the ability to aid its member nations through its financial tools.

The European Investment Bank (EIB) has added to the European movement toward energy efficiency while helping overcome the crisis by supporting many programs. The EIB made a major contribution to the European Green Cars Initiative (EGCI) by pledging €4 billion (and actually delivering even more) through a dedicated financial instrument: the European Clean Transport Facility (ECFT). This helped fund research for the development and innovation of more fuel-efficient and eco-friendly vehicles as well as aircraft, rail and ship efficiency. In addition, loans for projects targeting at greening transport have been provided by another EIB instrument, the Risk-Sharing Financial Facility (RSFF).

In the period between December 2008 and July 2010, the EIB provided €6.7 billion in loans for the automotive industry. Since then, lending has grown to €11.3 billion and is primarily used to fund OEM and supplier development of powertrain efficiency and emissions projects. Loans are predicted to reach €4.6 billion for all of 2010, with €2.8 billion going towards the ECFT.

18.5 Charging infrastructure and vehicle deployments

The EU is not directly involved in projects to install charging infrastructure or to deploy EVs, although it is engaged in activities to harmonize standards for various aspects that would be elements of such infrastructure. See section 18.2 Policies and Legislation: Regulation. However, in order to gain first-hand experience from vehicle deployment, large demonstration projects will be funded. See section 18.3 Research.

18.6 Outlook

Several EU Member States have set ambitious targets in terms of number of vehicles and infrastructure. At the EU level no similar targets were set, whereas the activities concern creating the right conditions for the deployment of these technologies by the policies defined above.

Whereas the current sales of vehicles with alternative power-trains can still be qualified as a niche market, the manufacturers' rollout plans and the regional initiatives prepare the ground for a rapid market penetration in the next years. The nascent market and business opportunities related to manufacturing, repair and maintenance, and broader mobility solutions is bound to provide for the job creation and prosperity for the European economy in line with Europe 2020 strategy.

With regard to the influence of policies on the market penetration rate of the H/EVs, it will be interesting to look at the implications of reaching the 2020 target of a 95 g/km fleet average on sales for passenger cars (and the corresponding regulations for other vehicles which will be gradually be defined) as well as the long-term (2030) perspective for these targets. It is expected that these targets can provide a significant push for the introduction of electrification in powertrains; the same is true for air quality regulations, which in the future will be mainly concerned with the elaboration of a strategy on limiting real life emissions, be it based on new test cycles or a PEMS (portable emissions measurement systems) approach, or both.

Another important ingredient for the success of H/EVs—and in particular for EVs, needing a precise awareness of conditions and charging infrastructure availability along their route, as well as convenience in the use of this infrastructure—is the application of the Directive on the framework for the deployment of Intelligent Transport Systems(ITS); it should ensure the compatibility, interoperability, and continuity for the deployment and operational use of ITS applications.

As far as research is concerned, the funding of research activities under the European Green Cars Initiative (EGCI) will continue till 2013 and will be based on the relevant roadmaps defined by the IAG. In the longer term, the direction will be defined by Horizon 2020, the next Framework Programme for Research and Innovation, which is currently under preparation. It is very likely that the model established with the EGCI will be kept as a reference.

Market development will be supported with actions to improve coordination and the overall effectiveness of measures taken by of Member States in the area of vehicle taxation in order to promote “green” vehicles. In addition, various projects will have a positive impact on the market development, which aim at a better understanding of consumer expectations and buying behaviours, as well as testing different information tools to compare clean and energy efficient cars with conventional ones.

Aside from local initiatives at city level, infrastructure funding will be more and more linked to the establishment of the European transport network under the Trans-European Transport Networks (TEN-T) initiative, with support for electricity, hydrogen, and other alternative fuels along these main axes. In a wider sense, electric infrastructure will also be adapted and upgraded in the framework of the Strategic Energy Technology (SET) Plan, which will generalise the use of smart grids and look also at the possibilities of vehicle-to-grid (V2G), at least for the longer term.

The workforce has to be prepared for the changes that will come with the gradual electrification of the fleet; therefore, a European Automotive Skills Council will be established. The training, retraining and upskilling of the workers will continue with the financial support of the European Social Fund and, in case of restructuring, of the European Globalization and Adjustment Fund.

19 Finland

19.1 Introduction

Sustainability is most often defined as the "means meeting the needs of the present without compromising the ability of future generations to meet their own needs". Finland has been on the sustainability track for decades and is now increasing its efforts.

Finland is located on the periphery of Europe and transport distances within the country are long. In many cases, more energy is used in logistics than in manufacturing. Primary energy supply in Finland is diverse with five different fuels contributing more than 10% each to total supply. Domestic production is largely based on renewable sources with significant nuclear energy production. Imports consist mainly of oil, gas and solid fuels, with the Russian Federation being a major supplier for all three fuels. Electricity generation is also diverse in terms of fuels used, with renewable energy contributing the largest share and natural gas exhibiting the largest increase in recent years. The most important renewable sources of energy in Finland include bioenergy—wood and wood-based fuels in particular—as well as hydropower, wind power, and ground-source heat.

In 2010 the Finnish economy returned to a growth track, and GDP rose on estimate by 3.2%. New car sales are a good indicator of consumers' confidence in the overall economy. Between 2008 and 2009, sales of new personal cars fell from 139,535 vehicles to 90,568 vehicles. Then, in 2010, sales rebounded to 111,968 vehicles—a partial recovery towards the 2008 sales figures.

HYBRID ELECTRIC VEHICLES

The number of hybrid electric vehicles (HEVs) on the road in Finland is still relatively small at roughly 3,000 registered vehicles, but this figure is increasing due to carbon dioxide-based (CO_2-based) taxation of cars and consumers' growing desire to appear "green". Consumer confidence has been boosted by the successful results for HEVs (Toyota's Prius and Auris, Honda's CR-Z) in the most recent "Winter Test" conducted by car magazine Tekniikan Maailma, which may have significant impact for future sales. The Winter Test annual series began in 1980 using laboratory and on-the-road tests specifically for cars in the colder, Nordic climates that pose unique challenges for EV technology. The Toyota hybrid Auris rated well in performance, fuel consumption, cold-start emissions, and passenger compartment (cabin) heating performance. The cabin-heating performance is a particularly important issue for customers in Nordic climates. These results represent a victory for HEVs in Finland, as hybrid and electric vehicles have generally been considered to have weak cabin-heating performance, and the positive test results are considered to be from a reliable source.

EVS AND PHEVS

Electric and plug-in-hybrid electric vehicles (EVs and PHEVs) are still a niche market in Finland, with fewer than 100 registered. According to the existing policy provisions, there will be no direct government incentives for electric cars in the future. All low-emission technologies are supported with taxation. However, the new “Systems for electric vehicles” research program, launched at the end of 2010 by Tekes, the Finnish Funding Agency for Technology and Innovation, will most probably include a fleet test and demonstration project with a few hundred electric cars. This is also known as the EVE program, and further details can be found in section 19.3 on research. Additionally, an EV test fleet of 500 vehicles will be launched in the Helsinki Metropolitan area in 2011–2012. Over 40 public and private parties are supporting the project with the goal of building a world-class innovation cluster for businesses related to electric vehicles, intelligent traffic systems, and smart grids in Finland.

19.2 Policies and legislation

As a member of the European Union (EU), Finland is committed to EU environmental targets and the Kyoto Protocol. The main targets are to reduce national greenhouse gas (GHG) emissions to the same level as 1990 and ensure that 38% of the total produced energy comes from renewable sources by 2020. Transport causes about 20% of Finland’s GHG emissions. Of the substances known as traditional emissions, such as NOx, sulfur dioxide, and others, transport accounts for 20–60%, depending on the compounds.

For road traffic, the accepted targets for 2020 average CO_2 emissions of new cars should be 95 g/km, a reduction from the current average emissions levels of 150.1 g/km for new cars sold between January and May 2010. An average new-car GHG emissions level of 120 g/km should be reached in 2012, as shown in Figure 19.1. Finland aims to achieve these targets by improving vehicle technologies and increasing the use of biofuels. Beginning in 2010, the standard 95 octane gasoline has been 95E10 with 10% ethanol.

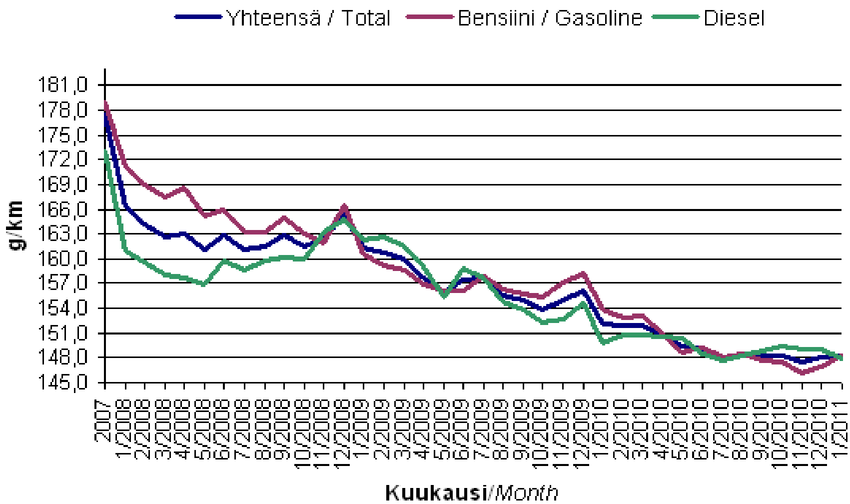


Fig. 19.1 Average CO_2 emissions of new passenger cars in Finland, 2007–2010.

Climate strategy ILPO

In 2009 the Ministry of Transport presented its climate strategy “ILPO” (from the acronym of the program name in Finnish) for the year 2020 to realize these CO_2 target reductions from road traffic. The strategy assumes that biofuels will make up 20% of the energy sources in transport in Finland in 2020. Biofuels are considered to be carbon-neutral when calculating the CO_2 emissions from transport.

In addition to the implementation of biofuels, ILPO calls for a 2.8-million-ton reduction in CO_2 emissions (around 20%) for transport as compared to the business-as-usual scenario. Some 80% of the additional reductions are expected to come from the replacement of the passenger car fleet with more energy-efficient vehicles. No specific targets for hybrids or electric vehicles have been set.

In 2010 the first ILPO follow-up study was presented. ILPO stipulates a fleet replacement rate of 7% per year, or about 150,000 new vehicles annually. Although car sales increased slightly from 2009, only around 112,000 new cars were sold in 2010. New measures to stimulate fleet replacement at the higher rate specified by ILPO with low-emission vehicles will be needed.

Energy tax

A new taxation plan for energy was presented in 2010 and is effective as of January 1, 2011. For transportation fuels, tax levels are now based on energy content, CO_2 emissions, and the impact on local air quality. The new CO_2 component is based on a life-cycle approach to emissions, rather than on combustion gas emissions only. The new system will favor the best biofuels as well as electric vehicles with reduced taxes (see figure 19.2).

The new vehicle annual tax ranges between 20 €/year (for vehicles with emissions at 66 g CO_2/km or less) and 605.90 €/year (for vehicles with emissions at 400 g CO_2/km or more). Between those two values the tax varies linearly with emissions.

Vehicle purchase tax

The vehicle purchase tax was reformed in 2008 to become based on CO_2 emissions and has had a positive effect on reducing the average emissions of new passenger cars, as seen in Figure 19.1. However, towards the end of 2010 the rate of decrease in CO_2 emissions appears to have slowed down.

The vehicle purchase tax ranges between 12% of the retail price (for vehicles with emissions at 60 g CO_2/km or less) and 48.8% of the retail price (for vehicles with emissions at 360 g CO_2/km or more), with the tax varying linearly between these values according to a formula.

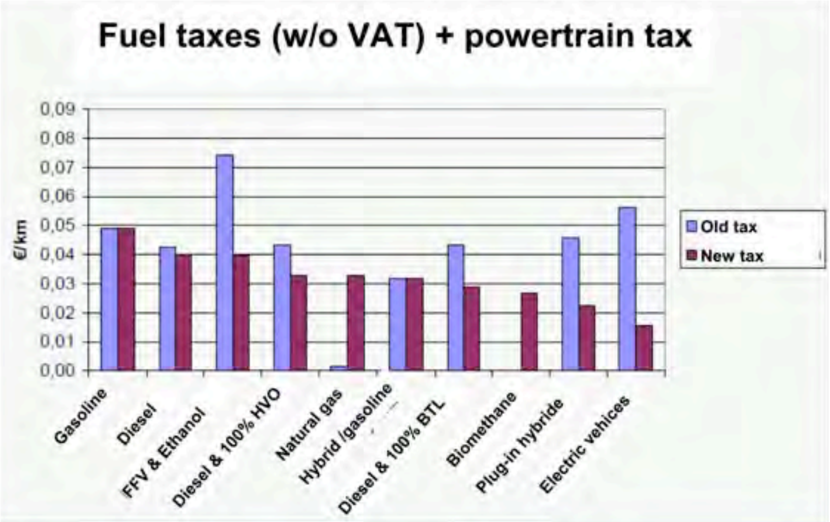


Fig. 19.2 Energy taxation: taxes before and after January 1, 2011. Calculated as accumulated taxes per vehicle kilometer. (Source: Jyrki Katainen, www.vm.fi.)

Biofuels and electric vehicles

Since January 1, 2008, a national law has required fuel distributors to provide biofuels to the market. A mandate was deemed more cost-effective than a system based on incentives. The national target states that 2% of all vehicle fuels should be biofuels in 2008, growing to 4% in 2009 and 2010. The biofuels obligation law was amended in December 2010 and is progressive: biofuels must make up a 6% share of energy for transport from 2011 through 2014, followed by a linear increase from 8% in 2015 to 20% in 2020. The preamble states that the 20% obligation in 2020 will predominantly be met by fuels eligible for double-counting according to the EU Directive 2009/28/EC.

For all of the EU nations, Directive 2009/28/EC sets a minimum requirement of 10% of renewable energy (biofuels and renewable electricity) in transport by 2020. In the case of Finland, due to the progressive biofuels obligation law, electric vehicles will not be needed to meet the 2020 requirement for renewable energy in transport. Currently, no “acceleration plan” is in place for electric vehicles.

19.3 Research

EVE (Electric Vehicle Systems Program)

In August 2009 the Ministry of Employment and the Economy published a task force memorandum entitled “Electric Vehicles in Finland”. This memorandum focused on new business opportunities arising from electric vehicles, electric working machinery, and related components. Following up on the recommendations in the memorandum, Tekes, the Finnish Funding Agency for Technology and Innovation, started the Electric Vehicle Systems Program (EVE). The program will run from 2011 to 2015 with a total budget of €80 million, with slightly less than half the funding from Tekes and the remainder from private sources.

The program will enable the creation of large test platforms for pilot and demonstration projects related to electric vehicles and electric working machinery. The objective is research and demonstration of the functionality and performance of components, subsystems, and complete electric vehicles, in both technical economic terms. The demonstrations will also cover related systems and services for charging infrastructure and new service concepts related to electric vehicles.

Electric vehicles study

In 2010, the Ministry of Transport and Communications contracted with VTT Technical Research Centre of Finland to evaluate the future of electric vehicles in Finland in the transport and climate policy context. VTT Research Professor Nils-Olof Nylund authored the report. Findings from the study were presented in early 2011. At the end of the report, recommendations are given for various actions and measures and the order for implementation. It also states that Finland should strive to have some 2,000 electric vehicles in service as soon as possible, and that the Finnish government should support these vehicles financially as part of a research/demonstration project.

Study highlights

- EVs will not contribute much towards fulfilling the 2020 targets in energy and climate policy due to the use of biofuels. However, the situation will change markedly by 2030 and especially by 2050.

- Even if the EV market may still be modest in 2020, it is time to begin considering factors to support the rollout of EVs, including, for example, addressing EV battery charging systems in construction and building regulations.

- Public charging infrastructure is needed in order to provide all motorists' equal opportunity and access to EVs. However, as driving distances in Finland are quite long, plug-in hybrids may prove to be a more practical and cost-effective solution than pure battery-only EVs, which are more suited to short-distance driving in the urban environment.

- Electricity generation capacity does not limit the growth of EV park (total number of EVs in Finland), but when the vehicle numbers exceed a critical threshold of penetration within local areas, the timing of the charging must be carefully controlled. Otherwise, EV charging increases the need for peak power and raises grid load.

- The average carbon intensity of the electricity supply is quite low, and therefore the implementation of EVs will eventually reduce CO2 emissions from transport.

- From the point of view of transport policy and cost-effectiveness, it is not justified to immediately take measures to maximize EV market penetration, because the price of electric vehicles is expected to decrease and overall performance to improve over time.

- However, there is a need to launch demonstrations that are extensive enough to obtain statistically valid feedback information about EVs and their associated subsystems. This is in congruence with the objectives of the EVE program of Tekes.

19.4 Industry

The car industry in Finland is small. Valmet Automotive is the only passenger car manufacturer in the country. It has historically acted as a contract manufacturer, but during the past few years it has raised its profile by purchasing the cabriolet (soft-top convertible) business operations of Karman and a small part of the Norwegian electric car company Th!nk. Valmet Automotive now manufactures the plug-in vehicles Th!nk City, Fisker Karma, and a BEV golf-car Garia. In 2010 Valmet produced 1000 Th!nks. The first Fisker Karmas began to emerge from the production line in the summer of 2011.

Non-road mobile machinery industry

In contrast to the relatively small car industry, the manufacturing of non-road mobile machinery (NRMM) is a large and important business in Finland. Non-road mobile machinery includes machines targeted for specific tasks in off-road conditions that mainly move on wheels or tracks. Traditionally, NRMMs are categorized by the application area in the following categories:

- Construction machines or earth-moving machines, including all types of loaders, dumpers, excavators, land rollers, bulldozers
- Goods transport or material handling equipment, including forklifts, automated guided vehicles (AGVs), mobile cranes, rubber-tired gantry (RTG) cranes for stacking shipping containers, and straddle carriers
- Municipal or janitorial machines, including different types of gardening and cleaning machines that are often targeted for on-road operations
- Agricultural and forestry machines such as tractors.

NRMMs are mainly powered by diesel engines with high fuel consumption and emissions. Manufacturers are actively developing electric and hybrid electric solutions in order to decrease NRMM fuel consumption and emissions. The biggest Finnish machine manufacturers (or Finnish subsidiaries of international companies) are presented in table 19.1. Valmet Automotive is also included for reference with 2010 sales figures improved over 2009, but lagging behind 2007–2008 sales.

Table 19.1 Finnish mobile machinery manufacturers

Company	Business area(s) in Finland	Sales 2010 (M€)	Note
Valmet Automotive	*Car manufacturing*	*84*	*Included as a comparison to show scale of Finnish NRMM industry*
Sandvik Mining and Construction	Underground mine loaders and dumpers, drill rigs	4,270	EVs in product range
Cargotec	Terminal machines (for container handling in harbours) and forklifts	2,575	BEVs, EVs and HEVs in product range
Metso Minerals	Mobile crushers and conveyors	2,457	~ 1/3 of this comes from mobile machines (editor's estimate)
Konecranes	Terminal machines and industrial cranes	1,546	BEVs and EVs in product range
Valtra	Agricultural tractors	1,030	part of Agco-group
Patria Land Systems	Armoured vehicles	540 (2009)	
Ponsse	Forest harvesters and forwarders	262	
JohnDeere Forestry	Forest harvesters and forwarders	256	Part of JohnDeere
Agco Sisu Power	Diesel engines for NRMM, 44 – 367 kW	167 (2009)	GenSet systems available 12-1800 kW
Bronto Skylift	truck mounted hydraulic platforms	114 (2009)	Mainly on-road vehicles
Rocla	Forklifts and AGVs	94	All machines are BEVs
Normet	Underground mining vehicles	90 (2009)	
Avant Tecno	Multipurpose loaders	52	
Mantsinen	Special material handling machines	36	

Electric drive industry

Finland has a large electric drive industry, where the biggest players are ABB and Vacon. Neither has products for mobile applications, except for rail vehicles. However, both companies are intensively following the development in mobile applications, especially in the area of NRMMs.

Battery manufacturing

European Batteries is ramping up the biggest lithium-ion battery (for automotive use) factory in the EU. European Batteries develops and manufactures large, rechargeable lithium-ion-based prismatic cells and battery systems.

The new production facility in Varkaus, Finland began operations in the spring of 2010. Focusing on the latest lithium-ion technology, the plant aims to reach an annual production capacity of 300 MWh by the year 2012.

It should also be noted here that Keliber Oy, located in Finland, has one of Europe's largest deposits of lithium spodumene mineral, from which the lithium for batteries can be extracted. Keliber has concessions and permits to start mining operations and plans to be the first producer of lithium carbonate in Europe.

Automotive suppliers

Additionally there are small companies focused on mobile machinery applications. MSc Electronics has a product range of power electronics and energy storage converters. Visedo sells power electronics, motors, and generators. Hybria offers power management software and engineering services for electric power trains.

19.5 Charging infrastructure and vehicle deployments

Energy supply

The energy mix in Finland varies with the consumption, but on average roughly 35–40% is produced from fossil fuels and peat, 30% from nuclear, and 30–35% from renewable sources (water, biofuels and wind). The average CO_2 emission per kWh for the electricity produced is approximately 175 g CO_2/kWh. Emissions vary widely during the year, mainly depending on the overall consumption and availability of hydro power. Peak power is produced with fossil fuels. On the other hand, most of the continuously used fossil power plants are used for heat production. CO_2 emissions of electricity production are presented in figure 19.3.

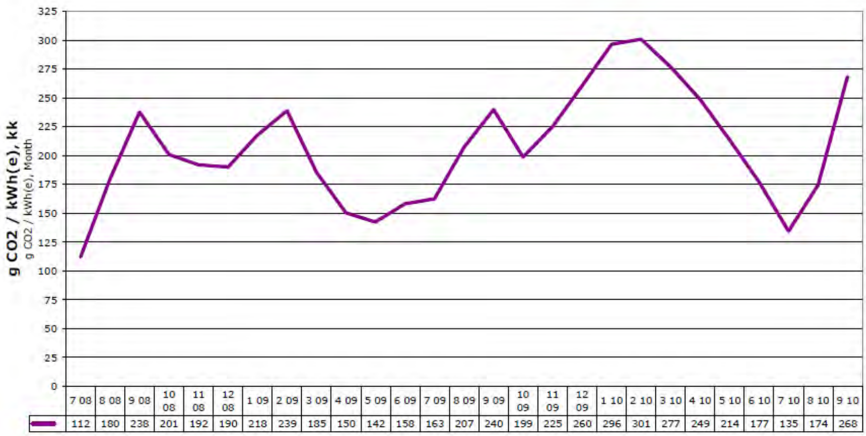


Fig. 19.3 CO_2 emissions of the electricity production per month, July 2008– September 2010

Assuming that an electric vehicle consumes ~0.3 kWh/km, the emissions would be 60 g CO_2/km when the average of new cars is ~150g CO_2/km (2010).

Current energy production is sufficient to handle the power needed for electric vehicles. For example, one million EVs (40% of the total vehicle fleet) would require 4 TWh per year, which is less than 5% of the annual electricity consumption in 2010 (87.5 TWh). Energy consumption by industry is high. Finland is the world's northernmost industrialized nation, and the Nordic climate increases the energy needs for household heating, saunas, and boilers. As a result, the existing transmission system can easily adapt for the electricity needed for electric car charging. It is estimated that implementing up to 500,000 EVs would be very easy, with only minimal changes in the low-voltage electrical distribution network and house installations.

Infrastructure and Block Heaters

Finland has two levels of existing charging infrastructure on its streets. There are very few charging stations targeted for electric cars. The rough amounts are 20–30 slow charging stations (220V/16A), with a few fast charging stations (400V/250A). The number of specific charging stations will increase in coming years due to new demonstration projects bringing up to 500 electric cars into the Helsinki area.

There are 1.5 million block heaters commonly used to preheat cars due to cold Nordic temperatures that with certain modifications would be able to charge EVs. A block heater is an element which is installed inside the motor block in order to warm up the cooling water and thereby the whole motor before starting.

Timing the EV charge requires balancing with the electrical load. Without any monitoring and control of EV charging, the cars could increase the peak power of distribution networks up to three times as much compared with the present load level on a medium-voltage feeder. However, using an intelligent charging system would adjust charging times to a low-electricity-load period.

Fig. 19.4 "Block heater pole" and a view from a car park of a row house condominium. There are typically standard "2-hour" timers at block heater poles. The starting time is selected by the user, but the heating time is fixed for two hours from the start.

If block heaters are used as charging stations, they can also gather interesting data on plug-in cars. It is recommended that a block heater be used when the temperature is less than +5°C. Block heater supplies have lockable boxes with two standard electrical sockets. Typically, each socket is equipped with its own fuse or breaker and a 24-hour timer that allows two hours of continuous heating time per session. These boxes are mounted either on a wall or a pole (Figure 19.4).

The power of a block heater element is typically roughly 500W. However, today many block heater systems are equipped with an "inside-socket" which allows an additional electric heater to also preheat the cabin. The power of these cabin heaters is typically 500–2,000 W. In the "old" installations dating to before 1985, the supply sockets were dimensioned for 10A (240V AC) and later for 16A sockets. During renovations, block heater supply sockets are typically updated to 16A/sockets. These supplies, providing total power over 3kW, are sufficient for overnight charging of electric cars. However, there are some limitations in the use of block heaters for EV charging.

Limitations of Block Heaters in Car parks

One technical limitation arises from the installation of block heater supplies in large car parks. Even though the individual supplies can deliver continuous 16A current, they are often wired in groups preventing simultaneous use with maximum power.

However, the number of plug-in cars will not increase rapidly, and thus only a few supply sockets will be occupied by an EV. In order to prevent too many EVs drawing power off of the same line, it would be simple to advise drivers of EVs to spread out their locations so that each may draw maximum power. Existing timers are a minor problem; they can be replaced or removed easily.

Billing for EV Charging

A bigger obstacle for using block heaters for charging will be the billing, especially in the early phases of EV use. In housing corporations, the block heaters are typically within the corporation-owned electrical network, and the energy usage is billed to the owner or tenant in the overall housing corporation charge or fee. In some cases the car park has a separate rent. In both cases the single electricity supply is not measured, but instead the expenses are divided equally among the residents. The car park energy used between non-heating and fully heating is 0 vs. 2h x 2.5 kW=5 kWh/day. In Finland the average temperature for six months remains below +5°C, which is the standard limit to use heating blocks. In the worst-case scenario, the heater is used daily, which means 180 x 5 kWh = 900 kWh per year are used. With the existing retail price of electricity at €0.10 per kWh, the resident who uses the heater daily gets a benefit of 90€/year compared with the resident who is not using a block heater.

Today, Finnish consumers accept that residents who do not use the block heaters are effectively subsidizing the residents who do use block heaters when they all pay the standardized monthly housing corporation fee. However, in the case of an EV which is charging with 22.5 kWh/day (including the heating) every day of the year, the difference between the two types of consumer would jump to 821€/year. This additional cost would probably not be accepted by non-EV owners in the housing corporation. Thus, either increasing the housing corporation charge for EV owners or introducing supply-specific metering of electricity consumption would be relatively easy solutions to implement.

Advantages of using block heaters for EV charging

This Nordic-wide “human laboratory test” using block heater systems has a public perception advantage. People are educated to plug in their cars on a daily basis. This habit increases a car owner’s ability to easily adapt to the introduction of PHEVs and EVs and daily charging. The block heaters are accepted as a part of landscape in parking areas or at residences. Additionally, they are considered safe to use and are rarely vandalized.

Deployments

In January 2011, the Helsinki Metropolitan Area hosted an event for the launch of a new program to put 500 electric cars on the road from 2011–2012. There were over 40 signatory parties on the program's "expression of will", among them four cities of Helsinki Metropolitan area, Aalto University, and companies such as Nokia Siemens Networks and Fortum. Signatory parties formed a steering group for the cluster venture led by Nokia Siemens Networks.

The aim of the gathered parties is to build a world-class innovation cluster for businesses related to electric vehicles, intelligent traffic systems, and smart grids in Finland. Preliminary estimates indicate the cluster could generate as much as 10 billion Euros worth of new business. To make the cluster effective, large anchor companies—those operating in energy, utility or related service business— are needed. Their risk-taking and investing capabilities will enable the participation of innovative start-ups and SMEs.

A large Finnish vehicle importer and one of the companies involved, Veho Group, has already conducted negotiations with its principals to secure the availability of the needed electric vehicles whose global production is still very limited. The first cars of the test fleet will arrive in Finland this spring at which point Veho Group will provide an opportunity to try them out.

Initially the test fleet cars will be offered to companies and various organizations. The aim of the fleet is to collect crucial information about the performance of electric vehicles in northern conditions. Several slow-charging and fast-charging stations in the capital area will be installed.

19.6
On the road

At the end of 2010, the total number of vehicles had grown by 4.0% and that of automobiles by 3.8% from the year-end situation of 2009. There were 2,877,484 registered passenger cars in Finland. The stock of passenger cars grew by 3.6% during the year. The biggest relative increases in numbers of registrations were recorded for mopeds (up by 8.4 %) and trucks weighing more than 3,500 kg (5.3 %). These data, complied by Statistics Finland, are based on the Vehicular and Driver Data Register of the Finnish Transport Safety Agency (Trafi) and the vehicle register of Ålands Motorfordonsbyrå. Data from mid-2010 are presented in table 19.2.

Table 19.2 Fleet data presentation categories for 2010, as of the middle of the year. (Source: Finnish Transport Safety Agency (Trafi).)

			PER JUNE 30, 2010	
Vehicle type	**EV fleet**	**PHEV fleet**	**HEV Fleet**	**Total fleet (incl. EVs and HEVs)**
Bicycles (no driver license)	500[1]	0		3,050,000[2]
Mopeds	250			200,000
Motorbikes	2			221,590[3]
Passenger vehicles (including multipurpose passenger vehicles)	76	9	3,073	2,816,265
Buses				13,293
Trucks				449,173
Industrial vehicles (mostly agricultural tractors)				417,410
Total	**828**	**9**	**3,073**	**6,967,695**

Note: the total fleet numbers include all propulsion systems and fuels, so include gasoline, diesel, LPG, natural gas, biofuels, etc.

1 estimate

2 estimate

3 estimate

19.7 Outlook

EVs are on their way in Finland with cautious optimism for growth. The strong environmental culture and willingness to accept new technologies are strong motivators for improved transport options. The government policies are tied to GHG reduction targets and currently do not favor or subsidize EVs. Overall targets for GHG reduction can be met currently with the use of biofuels which are in ready supply from Finland's forests. However, EVs will increasingly become necessary in the coming decades to achieve GHG reductions. Charging infrastructure using intelligent charging is needed to inspire consumer confidence in adopting EVs or PHEVs.

As the world's most industrialized northern nation, Finland's many businesses for key-technologies related to EVs are readily developing. They represent ideal opportunities to participate in the burgeoning worldwide EV industry. The Valmet and European **B**atteries factories are two prime examples. Finland also possesses skilled knowledge in power electronics and information technology needed to develop intelligent charging technology. Additionally, Keliber Oy will supply lithium needed for lithium-ion battery production. Finland is in the beginning stages of the EV transport with a promising road ahead.

20 France

20.1 Introduction

In 2009, French Ecology and Transport Minister Jean-Louis Borloo unveiled a 14-point plan to promote the development of hybrid and electric vehicles. The overall goal of the French government is to place two million electric cars (EVs) on the road by 2020. Car manufacturers PSA Peugeot, Citroën, and Renault have pledged to produce and deliver 70,000 plug-in electric vehicles (PEV) by 2015, while a group of companies including Electricite de France, SNCF, Air France, France Télécom, and La Poste have committed to an initial purchase order of 50,000 electric vehicles. Those purchasing a vehicle with carbon dioxide emissions (CO_2) of 60 g/km or less will receive a €5,000 government grant through 2012.

This plan has specific implications for energy storage and charging infrastructure requirements. For instance, Renault's investing in the construction of a lithium-ion production facility that will have the capacity to produce 100,000 batteries per year for Renault's battery electric vehicle (BEV). Thirteen municipalities, among them Bordeaux, Nice, Paris, Rouen, Strasbourg, and Nancy, will deploy public battery recharging infrastructure. The government has also announced an investment plan to support public infrastructure. An estimated one million public and private battery-charging stations will be built by 2015 under the plan.

Research designed to identify secondary markets for batteries through recycling or reuse is also being conducted. Additionally, a joint venture formed by Renault and the French Atomic Energy Commission will address advanced research, manufacturing, and recycling of electric vehicle batteries.

At this stage there are pilot programs for PEVs and related infrastructure. The intent is for local communities to match or contribute funds for the infrastructure investment needed. The State is investigating options for how local authorities can contribute financing.

Environmental legislation has been adopted by the National Assembly. This legislation, Grenelle II, assigns responsibility for infrastructure construction to local and regional authorities, and requires charging points at new construction areas.

These combined efforts impact the French automotive industry because it promotes the feasibility of EV adoption.

20.2
Policies and legislation

The major policies and laws pertaining to hybrid and electric vehicles in France relate to tax incentives and building charging infrastructure. The Grenelle II legislation, adopted in July 2010 addresses a number of environmental topics, including EV charging.

Tax incentives

The French Government designed an annual eco-label for the average CO_2 emissions of passenger cars on new vehicles with a bonus-malus (tax-deduction/tax-penalty) system that favors low-CO_2 emission vehicles. The national plan establishes tax deductions (bonus) and tax penalties (malus) for new vehicle purchases on the basis of their tank-to-wheel CO_2 emissions. The plan applies to new cars sold on the French market since January 2008, and because the tax deductions are balanced by the tax penalties, no government financing is needed. In 2009 the plan set a new bonus of €5,000 for new cars and light commercial vehicles emitting less than 60g CO_2/km, which automatically covers all electric vehicles. The bonus applies until 2012 for the first 100,000 low-carbon vehicles purchased.

A progressive company-car tax is also based on CO_2 emissions. Tax rates vary from €2 for each gram emitted for cars emitting 100g/km of CO_2 or less and up to €19 for each gram emitted for cars emitting more than 250 g/km of CO_2.

Charging infrastructure

In 2010, the government formed a charging infrastructure working group to coordinate installation of a standardized national charging network for PHEVs and battery-powered BEVs. The strategy foresees inclusion of the following provisions: local governments will be empowered to install public charging infrastructure; a quota of parking areas in work places and shopping areas will be reserved for electric vehicles and charging spots; builders of collective residences must install charging facilities at parking places upon request of the inhabitants; local governments will be obligated to equip public-parking areas with charging facilities.

20.3
Research

There is a long-term vision for the electrification of transportation supported by the French clean energy supply that can satisfy more than 80% of electricity needs through nuclear generation. The emphasis is on State programs that foster research and development (R&D) in the EV sector. Certain counties where the State has funded infrastructure for EV charging are showcased by the government. The Renault-Nissan Alliance and the utility Electricite de France (EDF) are currently field-testing 100 battery-powered vehicles and related infrastructure.

There are also broader R&D programs specifically for lithium-based battery technology. France's lithium-ion patent landscape is led by Saft. Automotive manufacturers, such as Renault, are involved in several partnerships with other battery makers and are in the process of developing new technology.

Despite France's notable global presence in the lithium-ion industry, in reviewing a total of 29,946 patents with an assignee country listed, only 273 of these patents are French. While 42 patents are assigned to Saft, 40% of the French patents in this space are assigned to research institutions (Centre National de la Recherche Scientifique has 49 patents; Commissariat à l'Energie Atomique et aux Energies Alternatives has 22; Centre National d'Etudes Spatiales has 15). Alcatel-Lucent, a leader in fixed, mobile, and converged broadband networking, is also a significant patent holder with a total of 42 patents assigned.

In 2009 the French government dedicated €120 million for research, development, and demonstration (RD&D) projects on low-carbon vehicles and charging infrastructure over 2008–2012.

ADEME (the French Environment and Energy Management Agency) received funding in 2008 under the French Grenelle Environmental Forum. This funding exhibits the abilities of French companies and State laboratories to produce automotive technology that contributes to the goal of CO_2 emission reduction in response to climate change issues. In 2010 the program Investissements d'Avenir ("Investments for the Future") was created under the National Loan plan. This research is designed to go beyond demonstration by providing companies with the support they need to pilot new technology into the experimental phase and validate it prior to commercialization.

ADEME has been selected for several projects under the "Investments for the Future" program. Projects aimed at developing future vehicles include €1 billion for research into road, rail, and marine vehicles. ADEME will also study carbon-free energy sources, the "circular economy" of commercialized waste sorting and recovery, and smart grid. The substantial funding levels for RD&D will be applied to convert results from the research demonstrator fund into projects and products that will promote green, sustainable growth in France and abroad.

20.4 Industry

Industry is moving forward

In 2009 the global automobile industry suffered its worst economic crisis since its beginning more than a century ago, calling into question all the fundamental aspects of this sector. One of today's challenges is to ensure industry transitions to provide new mobility services. France is developing the EV industry by focusing on all the pieces of the puzzle: "energy research, battery production, adequate battery range, optimal energy consumption, charging points, local government investment, EV models, and finally, road and grid infrastructure."

Public authorities must adopt and support the development and industrial production of plug-in vehicles. Recently adopted measures and public incentives are a step in this direction. They are unprecedented in scope, particularly for the necessary, successful deployment of plug-in vehicles and charging infrastructure development. Progress is afoot: Car manufacturers PSA Peugeot, Citroën, and Renault have pledged to produce and deliver 70,000 PEVs by 2015, while a group of companies including Electricite de France, SNCF, Air France, France Télécom, and La Poste have committed to an initial purchase order of 50,000 electric vehicles.

Going beyond accompanying measures, the entire regulatory system must be modified to ensure that private investment is profitable. New mobility solutions will have to be proposed and put into place in the different spheres of plug-in vehicle deployment (businesses, homes, and public spaces).

The situation in France is favorable for a full-fledged, low-carbon vehicle industry that includes plug-in vehicles because of the high percentage of nuclear and hydro power energy sources that emit low CO_2 emissions. France also benefits from the recent efforts taken by auto makers in the production of plug-in vehicles in all segments of the value chain: electric powertrains, charging equipment, batteries, and services.

In addition to the "Electric Vehicles" plan, France is starting a whole new industry beginning with vehicle batteries. Renault, the CEA (French Atomic Energy and Alternative Energies Commission), and Nissan are currently building a factory in Flins, 30 miles outside of Paris, with the capacity to produce 100,000 to 350,000 batteries annually. French firm Saft, a world leader in production of high-tech batteries, founded a joint venture with United States equipment manufacturer Johnson Controls in 2006, and since 2009 its French factory in Nersac (Poitou-Charentes) has been providing power supplies for foreign automakers that produce vehicles such as the Mercedes S-Class hybrid and the BMW 7 Series ActiveHybrid.

Meanwhile, the EV Plug Alliance created in March 2010 by Schneider Electric, Legrand, and Scame is working towards a standardized plug and socket solution. Not to be outdone, equipment manufacturers Valeo, Michelin, Leroy Somer, GKN, Johnson Controls-Saft, and Leoni joined forces in June 2009 in a consortium to develop an integrated product range of electric vehicles.

Automotive manufacturers (Renault, PSA, Bolloré, etc.) are planning to launch their first electric vehicles at the end of 2010 and their first rechargeable hybrids by the end of 2012. Spurred on by this bustle of activity, BMW has chosen France as a platform for trials of its new electric Mini.

PSA Peugeot Citroën

PSA Peugeot Citroën has already sold more than 10,000 electric vehicles. The Group is building on this expertise to develop hybrid vehicles. Studies are focused on two types of hybridization.

In city driving, vehicles are in a standstill position with the engine running around 30% of the time. On the basis of this observation, PSA Peugeot Citroën introduced a first level of hybridization, the Stop & Start system (STT), on vehicles such as the Citroën C2 and C3 (figure 20.1). This technology cuts the engine and restarts it again in a split second, reducing fuel consumption in the city by up to 15%. This technology has begun to be rolled out on a large-scale basis in the Peugeot and Citroën model ranges from 2010.

Fig. 20.1 Logo for the C2 Stop & Start. (Photo supplied by PSA Peugeot Citroën.)

The Group will go further in 2011 with HYbrid4 technology. This new diesel hybrid architecture optimizes the diesel hybrid powertrain and also boasts an all-new four-wheel drive mode, bringing more value for the additional cost of the hybrid. HYbrid4 technology combines a 2-litre HDi diesel engine fitted with a particulate filter (DPFS) and a high-voltage Stop & Start system, together with an electric motor on the rear axle, a power inverter, high-voltage batteries, and a dedicated electronic control unit. Transmission is via an automated manual gearbox.

Average fuel consumption for a mid-sized crossover vehicle equipped with HYbrid4, like the Peugeot Prologue, will be roughly 4.1 L/100 km (diesel), with CO_2 emissions at a low 109 g/km, equivalent to those of a Peugeot 107. This figure is remarkable for a vehicle of this size, 25% lower than that of a similar vehicle equipped with a petrol hybrid powertrain.

PSA will also sell a PSA-badged iMiev in Europe, continuing its partnership with Mitsubishi. This vehicle will use batteries from the Mitsubishi-GS Yuasa joint venture.

Renault-Nissan

Renault aims to become the first full-line manufacturer to market zero-emission vehicles accessible to the greatest number in 2011. The Renault-Nissan Alliance is developing a complete range of 100% electric powertrains, as showed in figure 20.2 below, with power ratings of between 15kW (20hp) and 100kW (140hp). Additionally, the battery production plant in Flins which Renault, the CEA, and Nissan-NEC are launching is expected to support Renault's EV Zoe in 2012.

Fig. 20.2 Renault PEV product line: the Twizy, Zoé, Fluence ZE, and Kangoo ZE. (Source: Renault)

For Renault, the electric vehicle is the real long-term solution to today's environmental and noise pollution issues. Technological innovations now make it possible to mass-market an electric vehicle at reasonable cost. Renault's electric vehicles will retail at the same price as equivalent diesel models (without the battery, which will be rented). Several BEV models expected to enter the market within the next couple of years are depicted in figure 20.2. Changes in vehicle use make electric cars ideal for the majority of trips, with 87% of Europeans currently driving less than 60 km a day.

New electric vehicles

- Especially designed for professionals, Kangoo Express Z.E. (zero emission) will become available in 2011. Pre-tax prices in Europe will start from €20,000 (before available tax incentives). Pre-tax prices in France will start from €15,000, once the €5,000 eco-subsidy is deducted. Monthly subscriptions covering battery rental will be available from €72.
- The family sedan Fluence Z.E. will be launched first in Israel (2011) and then in other countries. Prices in Europe will start at approximately €26,000 (depending on the local VAT rate). Prices in France will start from €21,300, with the €5,000 tax incentive deducted. Customers will also subscribe to a monthly lease starting from €79 (including VAT) to cover the battery.
- In November 2011, the new urban vehicle Twizy will become available in two versions (5-kW or 15-kW motor). The ultra-compact footprint of Renault Twizy (length: 2.32m, width: 1.19m, height: 1.46m)delivers all the fundamentals associated with any car, namely four wheels, a steering wheel and pedals, plus an enveloping body for two occupants sitting in tandem, one behind the other.
- By mid-2012 a zero-emission city car will be launched. Measuring less than four meters long and with five seats, it will be ideal for commuting.
- Beyond 2012 Renault will continue to extend its electric car range to cover all market segments.
- Renault will also bring customers access to innovative services making electric vehicle use easier and to advanced battery technology currently under development by the Renault-Nissan Alliance.

Renault is currently working on a number of fronts in preparation for the launch of its range of zero-emission vehicles:

- In R&D, a €4 billion investment has been made on electric cars as part of the Renault-Nissan Alliance.
- Renault is cooperating with governments on infrastructure development and purchase incentives.
- Partnerships are being formed with mobility operators worldwide.
- Additionally, Renault SA is making battery technology a key business, to be described in a later subsection, "Other French battery manufacturing."

Johnson Controls-Saft

As mentioned in the introduction and research sections, France is home to Saft, the world's leading manufacturer of primary lithium batteries with expertise in developing and qualifying customized integrated lithium-ion battery systems. In order to capitalize on the expanding market for hybrid and electric vehicles, in 2006 Saft entered into a joint venture with Johnson Controls, a top-ranking U.S. supplier to the automobile industry, to form Johnson Controls-Saft Advanced Power Solutions.

In 2007, Johnson Controls-Saft Advanced Power Solutions built a new production line in Nersac, France, which was the first plant in the world to produce lithium-ion batteries for electric and hybrid vehicles. Johnson Controls-Saft Advanced Power Solutions batteries are currently used in the Mercedes S400 series and the BMW 7 Series: the company's batteries will also be used in Ford's first plug-in hybrid electric vehicle, which will be available in 2012. In a further boost, in 2009 Johnson Controls-Saft Advanced Power Solutions was selected by the U.S. Department of Energy to manufacture lithium-ion batteries and components in a new plant in the state of Michigan. The U.S. federal government will invest $299 million in this plant and production is expected to commence in 2012. Even as Saft appears to be making inroads in the North-American market, Johnson Controls-Saft Advanced Power Solutions is actively working on a strategy for China in order to capitalize on that fast-growing market.

Other French battery manufacturing

Renault SA is making battery technology a core business and is currently developing lithium-ion batteries for electric vehicles. In addition to the battery factory currently under construction by the Renault-Nissan Alliance, CEA, and FSI, Renault SA is already producing lithium-ion batteries through Automotive Energy Supply Corp, a joint venture between Nissan Motor Co. Ltd. and NEC Tokin Corp. Additionally, the joint venture Renault Samsung Motors Inc. is working with SK Energy Co. Ltd. and SB LiMotive Co. Ltd to develop lithium-ion batteries in South Korea.

The lithium-ion industry in France has also recently witnessed the acquisition of Societe de Vehicles Electriques (SVE) by Dow Kokam, a joint venture between Dow Chemical Company and Townsend Kokam. SVE, which develops high-performance battery and energy management systems and is a wholly-owned subsidiary of the France-based Groupe Industriel Marcel Dassault (Dassault), thus becomes a French subsidiary of Dow Kokam and Dassault becomes a shareholder.

A subsidiary of the Bolloré Group, BatScap, develops and commercializes lithium batteries and supercapacitors. The Bolloré Group has two joint ventures in place: one with Italy's Pininfarina and one with France's Gruau Group, allowing for BatScap products to be used in both lines of vehicles.

Electric powertrains (Valeo)

Vehicles driven by electric powertrains developed by Valeo and Leroy Somer — including the Citroën AX, Saxo and Berlingo, Peugeot 106 and Partner, and Renault Kangoo — have already covered more than 1 billion kilometers.

Valeo, with its partners Leroy Somer and GKN, is developing a line of second-generation powertrains at affordable prices. Its goal is for the cost of the electric motor as a whole, including the inverter, charger, voltage converter, and reduction gear, to eventually become equivalent to that of the gasoline-driven powertrain (engine, gearbox, and differential), which it aims to replace. The overall cost represents a major factor if second-generation rechargeable electric and hybrid cars are to be available for mass distribution at economically viable prices and without providing governmental subsidies for buyers.

To become a leading global player in the electric powertrain market, Valeo has signed development agreements with major industrial partners. In addition to Valeo, this consortium also includes some of the leading equipment suppliers in their fields, such as Leroy-Somer, Johnson Controls-Saft, GKN, Michelin, and Leoni.

20.5
Charging infrastructure and vehicle deployments

The development of plug-in vehicles in France is seen as a symbolic step towards more environmentally-friendly transport to achieve national goals. The government has also announced an investment plan to support public infrastructure. An estimated one million public and private battery-charging stations will be built by 2015 under the plan.

One of the keys to success for these vehicles is to establish user confidence in their driving range and safety. Reliable charging infrastructure that is backed by a national installation strategy is required to ensure sufficient driving range. France is planning to deploy this infrastructure in all sectors of daily life, in particular for the following groups:

- **Enterprises:** Charging infrastructure will be installed for captive fleets of plug-in vehicles, such as corporate fleets. The possibility of "plug-in benefits" will be considered, such as allowing employees to recharge their personal or company cars at their place of work with low or no cost. Added power demand for charging would be managed.
- **Public domain:** Plug-in vehicles and charging infrastructure will also be

deployed in public areas, such as roadways and public parking garages. Suitable options for use are being developed, such as shared vehicles and vehicles on demand.

- **Residential sector:** Plug-in vehicles and charging infrastructure will be made available to individual users, with or without vehicle ownership.

Charging infrastructure to meet national environmental goals

Experimental research will be conducted to anticipate the long-term evolution for charging infrastructure deployment. Current charging infrastructure deployment contributes to the larger environmental goals elaborated at the Grenelle conference described in section 20.1 above. Thirteen municipalities, among them Bordeaux, Nice, Paris, Rouen, Strasbourg, and Nancy, will deploy public battery recharging infrastructure.

At this stage there are pilot programs for PEVs and related infrastructure. The intent is for local communities to match or contribute funds for the infrastructure investment needed. The State is investigating options for how local governments can contribute financing.

The long-term objective is to be compatible with the Factor 4 goal of the Energy Policy bill (Program d'Orientation de la Politique energétique française, or POPE) enacted in France in 2005 to reduce French greenhouse gas emissions by 75% from their 1990 level by 2050.

Factors for consideration

- Electric vehicle power ratings and consumption
- Using energy resources that generate low or zero greenhouse gas emissions to supply electricity to the future electric vehicle fleet. After 2030, energy sources that generate greenhouse gases will have to be coupled with systems to capture CO_2 and store it underground
- Life-cycle analysis of the electric vehicle chain, covering all environmental impacts

Challenges and opportunities

1. The first challenge relates to taking advantage of favorable industry conditions and the energy ecosystem highlighted below.
    - The situation in France is favorable for a full-fledged low-carbon vehicle industry, which includes plug-in vehicles, because nuclear and hydro power provide most of the electricity supply in France.
    - The French economy also benefits from the new efforts taken by automakers

and OEMs in the production of plug-in vehicles throughout all segments of the value chain: electric powertrains, charging equipment, batteries, and services.
- The major industrial challenge is to build a complete and viable industry that integrates every link of the value chain. Various roadblocks and bottlenecks must be cleared away, such as those that affect charging infrastructure.

2. The second challenge is building a "public service electricity supply for mobility" to instill public confidence.
   - When totally implemented, publicly available charging stations in parking lots, garages, or along roadways may represent only 10% of outlets and 5% of total use. However, their presence reassures users that they will have access to charging facilities even when they are away from their familiar routes. The public charging stations constitute a token of reliability for the entire system that is indispensable to break down the lack of confidence towards plug-in vehicles among end users.
   - This regulation, these investments, and the commitment of public authorities influence purchasers' decisions to buy or lease plug-in vehicles and also guarantee better insertion of these vehicles in society.
3. Finally, the third challenge is to consider and plan for the constraints of electricity distribution networks. Massive deployment of plug-in vehicles and the associated charging infrastructure will generate additional electricity demand with consequences. Some points to consider are the following:
   - The average CO_2 amount per kWh of electricity (depending on the type of power generation, nuclear, hydroelectric, thermal, etc.)
   - The architecture, management, and operation of electricity distribution networks
   - Peak load management, especially for fast charging
   - Local reinforcement of the power grid

The extent of these impacts will be determined by decisions made by industry, equipment suppliers, public authorities, and energy producers in regard to these points: technological options used, such as slow or fast charging and regulation of other aspects, such as electricity pricing that encourages slow recharging during off-peak hours.

French strategic roadmap

The French strategic roadmap being put in place to tackle those challenges can evolve over the long term depending on several key parameters. These key parameters, including standards, the integration of the market system, and infrastructure supply and demand, will significantly inflect charging infrastructure deployment options.

1. **Standards**
   The question of standardization arises at both national and European levels. In the near term, the charging methods of vehicles will probably vary, and charging installations will differ from one place to the next.
   However, in the future, standards will be needed for the various components of the plug-in vehicle/charging infrastructure "ecosystem" in order to facilitate interoperability, safety, cost-competitive infrastructure, and management of electricity demand. Ultimately this involves elaborating a French plan within European and world standardization bodies.

2. **Entire market-system integration**
   The second parameter focuses on the nature and long-term viability of the economic and business models that will govern the entire charging infrastructure ecosystem. This includes plug-in vehicles, batteries, and also the installation and operation of infrastructure and associated services.

   Market penetration of plug-in vehicles will vary depending on purchase price, operating costs, and resale value. Initial adoption will be supplemented by mechanisms, such as subsidies, investment aids, and low-cost loans.

   But in the long term, only a regulatory framework and/or viable business models will ensure plug-in vehicle success. It is up to the actors in the production chain (equipment makers, electricity suppliers and distributors, vehicle manufacturers, providers of related services) and to public authorities to foster business models that will make plug-in vehicles financially viable for consumers. Challenges include changing the financing model for vehicles, batteries, and infrastructure, and how to use batteries once they can no longer power a plug-in vehicle.

3. **Match infrastructure supply with demand**
   The third parameter identified is the level and type of interaction between vehicles, users, and the charging infrastructure to match supply with demand. Understanding the surrounding ecosystem, in particular the availability of charging infrastructure, will to a large extent determine how massively plug-in vehicles can be deployed.

   These needs are determined by actual vehicle performance along with the types of use and economic models adopted. For example, there is a contradiction between seeking a greater driving range for electric vehicles and the intention to massively deploy charging infrastructure. Achieving a balance between these interactions is a key parameter to include in the strategy for deployment of charging infrastructure.

Furthermore, this is a dynamic equilibrium. To date no operator has been able to develop an economically profitable activity anywhere in the world, given the prohibitive cost of charging infrastructure (system manufacturing and installation costs). The time frame for a return on investment (ROI) on these investments is several decades and incompatible with industry needs for shorter timeframe for ROI.

A strong commitment from the State until 2020 is needed to ensure the equilibrium of this ecosystem. Leading up to 2050, new economically and industrially viable business models must take over without State intervention. This scenario relies on developing new economical charging infrastructure that is compatible with all types of plug-in vehicles.

Infrastructure outlook

The situation in 2050 will be determined by the choices made through 2020. Public policy measures implemented in the period 2010–2020 will influence the extent of infrastructure deployment at homes, places of work, and public parking areas. When analyzing the emergence and long-term deployment of plug-in vehicles, two major categories of bottlenecks can be identified which are rather different in nature: technological obstacles, along with socioeconomic and organizational roadblocks. Considering these bottlenecks, France has identified high-priority research areas that are grouped in three categories: environmental, technological, and thirdly organizational and socioeconomic research. The "Investments for the Future" program is being used to tackle these bottlenecks and align with the long-term vision for electromobility in France. Two calls for expressions of interest are being launched to support experimentations and deployment for charging infrastructure. At the experimental stage, research demonstrators establish a bridge for technologies between the purely research phase and industrial implementation. Financing of infrastructure deployment can then be spent wisely and will benefit from the data collected at the experimental stage.

20.6
On the road

With neither BEVs nor PHEVs available for purchase in France in 2010, only the number of HEV sales has been tracked. According to AVEM, the number of HEVs sold in France in 2010 is 9,443, a slight increase over the 9,399 HEVs sold in 2009 and 9,137 in 2008. Together with the 6,411 HEVs known to be registered in France in 2006 and an estimate of 9,000 HEVs sold in 2007, the total number of HEVs in France comes to around 43,000. HEV market penetration is below 0.5% of the 2,251,669 new vehicles sold in France in 2010. Honda has recently grown more successful in France, with 1,937 HEVs sold in 2010. However, the number of Toyota Prius HEVs sold in France in 2010 has strongly decreased from previous years. Table 20.1 has the current figures for auto sales.

Table 20.1 Total number of electric vehicles in France's hybrid and electric vehicle fleet. (Source: Frost & Sullivan; Global electric vehicles market forecast database)

	PER DECEMBER 31, 2010		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs and HEVs)**
Bicycles (no driver license)			
Motorbikes			
Passenger vehicles	184	*43,000*	
Multipurpose passenger vehicles			
Buses			
Trucks	796		
Industrial vehicles			
Total	**980**	***43,000***	***39,000,000***

Note: *the total fleet numbers include all propulsion systems and fuels, so include gasoline, diesel, LPG, natural gas, biofuels, etc.*

20.7 Outlook

Forecasts for the EV market range from highly optimistic to deeply pessimistic. One of the most optimistic surveys claims that 25% of vehicles sold in France in 2020 will be electric and 50% in 2050. On the other hand, studies show that the European market for electric vehicles will represent a mere 250,000 cars in 2015. These divergent views result because of the difficulty in making reliable predictions in view of complex relations among the multitude of parameters involved.

The French auto industry is following three different trends or directions.

1. **Revised mobility constructs**
   The emergence of a new market segment with production of city and urban-area vehicles with the appropriate automobile and four-wheeled cycle regulations. The size, design, and engines of these vehicles would be entirely revamped to correspond to the mobility needs and driving range of consumers in cities and urban areas and to environmental criteria for local pollution, noise, and occupation of space.

2. **Car sharing**
   Vehicles that could be specifically adapted for service-delivery options; for example, autolib rentals modeled after the Velib (bicycle rental program in Paris).

3. **Lighter vehicles**
   Reduced energy needs can be realized due to much lighter vehicles with 50% vehicle-weight reductions. These reductions will be obtained by the development and use of new materials along with the rethinking of vehicle design rules that make it possible to incorporate new materials and reduce vehicle drag (aerodynamic architecture, rolling contact). The growing use of electric powertrains in hybrid and electric vehicles allows design concepts that can be entirely revised, leading to improvements in these areas.

21 Germany

21.1 Introduction

Interest in electric mobility in Germany arises in response to the global megatrends that influence many other IA-HEV members, namely, global warming and reduction of CO_2 emissions; limited global fossil fuel resources; the increase in renewable energy resources; and the growth of emerging markets for products made in Germany and elsewhere.

As a result, electric vehicles (EVs) are on the rise in Germany for the following reasons.

- The European Union (EU) CO_2 emission target of 120 g/km starting in 2012 is particularly challenging for German OEMs that sell a high share of large, premium cars in the EU. Therefore, electrification of the powertrain is an important lever to lower CO_2 emissions.
- The increasing share of renewable energy resources in Germany, which will grow even faster in case of an accelerated nuclear power phase-out as was announced in spring 2011, also supports EVs as a "greener" form of transport.
- Grid integration of electric cars can balance peaks in power demand.
- EVs can help to secure the future competitiveness of German industry, as one out of seven jobs in Germany is either directly or indirectly associated with the automotive industry. German OEMs produced 12.6 million cars in 2010, 75% of which were made for export.

21.2 Policies and legislation

In May 2010, the German Federal Government initiated the National Platform for Electromobility (NPE), a nationwide initiative with representatives from industry, science, politics, and unions to support the development of electric vehicles and their charging infrastructure, commonly called "electromobility" in Europe. The objective of NPE is to position Germany as a lead supplier and lead market for electromobility. As a specific milestone, the government plans to deploy 1 million electric vehicles on German roads by the year 2020.

To reach this goal, the latest NPE report from May 2011 proposed the following incentives for drivers of EVs:

- Free usage of bus/taxi lanes in cities or introduction of special EV driving lanes
- Privileged parking spaces for EVs
- Interchangeable license plates for the first and second car, offering the option of sharing a single insurance policy between several cars, which would encourage owners of both EVs and internal combustion engine (ICE) vehicles to take short trips with EVs and longer trips with conventional ICEs with only one license plate
- Compensation for higher EV purchase prices in company car taxation (usually this is 1% of the purchase price, but for EVs this tax would be reduced by €500 per kWh of battery size)
- Special depreciation of 50% in the first year for commercially used EVs (instead of regular steady depreciation over 6 years)
- Loans with reduced interest rate for EV purchase provided by state-owned KfW bank (e.g., €30,000 over 4 years at an effective interest rate of 2.5%)
- Direct tax incentives, depending on battery size (€100–150/kWh over 4 years)

The NPE report emphasizes that governmental incentives are required to reduce the total cost of ownership (TCO) gap of €4,000–9000 between EVs and conventional cars. The required budget to implement the measures mentioned above is estimated to amount to €220 million from 2012 to 2014. Without additional incentives, only 0.45 million EVs (out of the 1 million target) are forecasted for 2020 in Germany.

However, to date the German government has not decided to implement any new incentives for EV buyers. Today the only monetary incentive for holders of a battery electric vehicle (BEV) is the motor vehicle tax exemption for a period of 5 years with savings of approximately €50 per year. However, other measures are still in discussion.

21.3 Research

The general funding strategy of the German government is diversified and focuses on various key areas of electromobility. As depicted in Fig. 21.1, an analysis of 67 selected projects in the first half of 2010 shows that German research funding had a strong focus on the electric vehicle and the powertrain, while projects concerning information and communication technologies and battery, cell, or field research were in the minority. (The areas of field research and society include work on charging infrastructure or other services related to electromobility.)

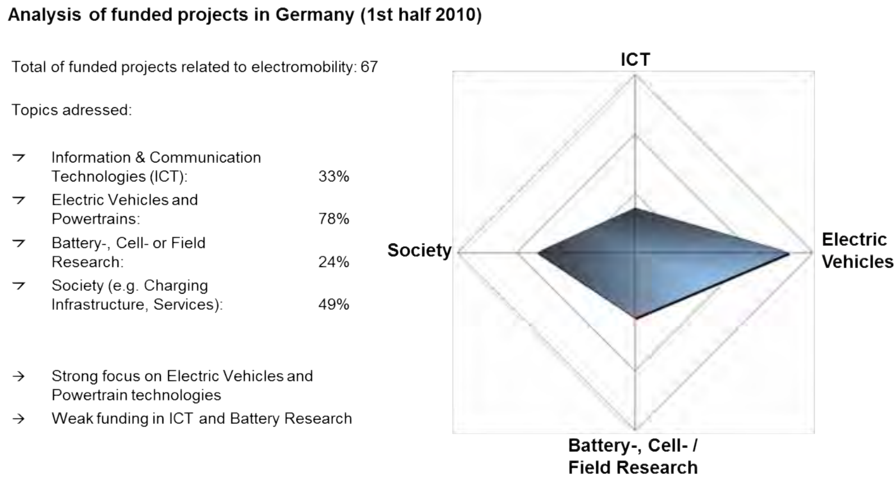


Fig. 21.1 Analysis of funded projects related to electromobility in Germany as of the first half of 2010. *(Source: Wegweiser Elektromobilität, 2010, p. 66.)*

The German economic stimulus package ("Konjunkturpaket II", implemented in January 2009) is a joint initiative of the Federal Ministry of Economics and Technology, the Ministry of Education and Research, the Ministry of Transport, Building and Urban Development as well as the Ministry for Environment, Nature Conservation and Nuclear Safety. With a total value of €500 million, this package is the largest federal support program concerning electromobility. As shown in Fig. 21.2, the stimulus package contributes significantly to the whole value chain of electromobility, starting from raw materials, components, cells, and batteries through to the overall system, its implementation, and utilization. Furthermore, funding aims to support pure R&D (technology-oriented) projects as well as projects close to the market. The goal of the program is to combine short-term economic effects (focus on 2009 and 2010) with a long-term strengthening of the competitiveness of Germany.

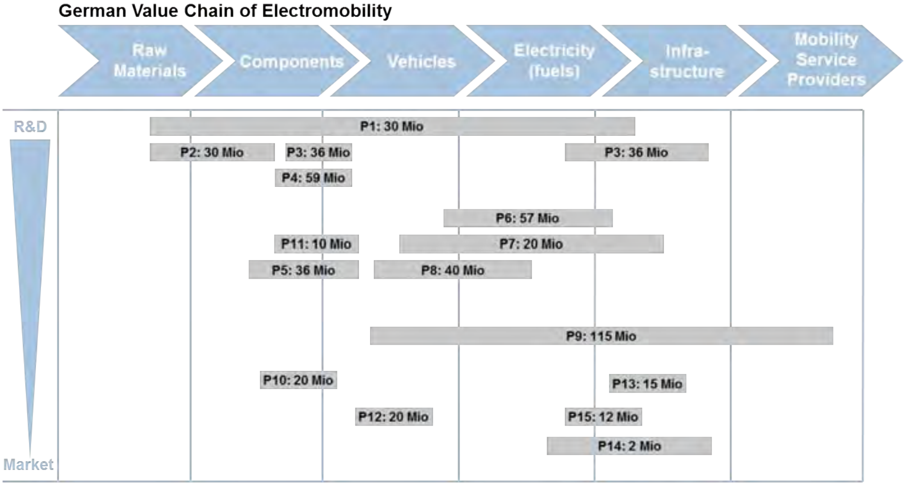


Fig. 21.2 Diagram showing the distribution of Germany's 15 national research programs relating to electromobility. The horizontal axis is the value chain, and the vertical axis shows the level of technology readiness. *(Source: Auszug aus dem Bericht an den Haushaltausschuss Konjunkturpaket II, Ziffer 9 Fokus „Elektromobilität", 2009, p. 8.)*

The economic stimulus package comprises the following 15 individual topics to be funded:

1. Setting up a competency network for electromobility systems research aimed at bundling the Fraunhofer Society's competencies in electromobility and making this available to the motor-vehicle manufacturing industry (€30 million)
2. Establishing applied research priorities in electrochemistry with the focus on electromobility and battery technology at universities and non-academic research institutions (€30 million)
3. Energy research through a new funding initiative, "Key Elements in the Electricity Industry for Electromobility: Storage, Grids, Integration," with the focus on electricity storage units, future electricity supply grids, concepts for grid integration and fuel cells (€36 million)
4. Developing production technologies for lithium-ion cells and systems (€59 million)
5. Transport research: prompt implementation of current project proposals (e.g., components and systems for braking energy recovery, optimizing the powertrain, on-board electricity generation for range extension, use of waste motor heat for producing electric energy, relevant aspects of standardization), scientific preparations and monitoring of field tests (electric car, hybrid refuse collection

vehicle) (€36 million)

6. ICT for Electromobility and Smart Grids, Renewable Energies and Electromobility (€57 million)
7. Field tests on electromobility in car traffic (€20 million)
8. Fleet test on electromobility in commercial traffic (€40 million)
9. Electromobility in the public domain - integrated mobility schemes in a limited number of selected pilot regions (€115 million)
10. Battery testing center for cells, batteries, systems, and crash behavior (€20 million)
11. Research and development for a pilot plant to recycle lithium-ion traction batteries (€10 million)
12. Hybrid buses for ecological local public passenger transport (€20 million)
13. Installing 25 pilot hydrogen fuel stations (€15 million)
14. Pilot project, Mobile with Biomethane (€2 million)
15. Erecting a pilot synthesis plant for the production of high-quality synthetic fuels (€12 million)

The biggest program, on electromobility in the public domain (€115 million) aims to set up and analyze new mobility concepts in selected pilot regions. Therefore, an integrated approach with focus on different key topics is chosen:

- Inclusion of manufacturers, users, service providers, and infrastructure operators as well as local stakeholders (local authority districts, etc.)
- Investigation of the specific mobility behavior when using electric vehicles under everyday terms
- Analysis of passenger cars, utility vehicles, public transport, and bikes
- Integration of different carriers
- Mobility services like car-sharing etc.
- New business models
- Regional links to the value chain of electromobility or to market preparation and development
- Consideration of different requirements (“subsidiarity”)
- Use of the creativity of regional initiatives
- Consideration of urban planning and town planning aspects

21.4 Industry

Automakers

All German automakers develop and test electric vehicles. So far, all companies have introduced (full) hybrid electric vehicles (HEVs) into their portfolios. However, as of 2010, no all-electric vehicle (or BEV, battery-electric vehicle) has been available for the mass market.

Daimler AG in Stuttgart pushes the electrification process in all technology directions. Plug-in hybrid electric vehicles (PHEVs), extended-range electric vehicles (EREVs), BEVs, as well as fuel cell vehicles (FCVs) are under development. Current test fleets are based on the Smart ED (BEV), the E-Cell (BEV), the E-Cell-Plus (EREV), and the F-Cell (FCV). The batteries for these vehicles are supplied by several joint ventures or subsidiaries. Daimler has established alliances with Tesla Motors (mainly supplying batteries for the Smart ED), the Chinese automaker BYD, and Deutsche Accumotive, a joint venture with the German chemical company Evonik. Daimler plans on producing its batteries in Germany through this subsidiary. Regarding fuel cell vehicles, Daimler shows the most activities of all German automakers. In early 2011, three FCVs completed a world tour, trying to emphasize the suitability of fuel cell technology for daily use. Together with Bosch, Daimler has founded a joint venture for the production of electric motors.

BMW is developing the Megacity Vehicle (MCV) as the first mass-produced BEV with a carbon fibre chassis (CFC) chassis, which is scheduled to enter the mass market in 2013. Currently, BMW is involved in a fleet test with the Mini E and the 1 series ActiveE (both BEVs). BMW has joined a strategic cooperation with SB Li-Motive (a joint company of Samsung and Bosch) for the production of lithium-ion batteries.

Volkswagen is building up its EV competencies mainly in-house, for example, in the e-motor plant in Kassel. VW has announced several PHEV and BEV models by 2013, including the Golf blue-e-motion and the E-Up!. Audi is following a top-down introduction of hybrid models. Currently, hybrids are available for the A8 and Q-models. Audi's all-electric vehicles focus on sports cars and small vehicles. Mass market introductions of BEVs are scheduled for 2012 (R8 e-tron) and 2013 (A3 e-tron). Audi has presented a range-extender concept for the A1 model based on a rotary (Wankel) engine.

Suppliers

The German automotive supplier industry offers a broad portfolio of technologies for electrified vehicle concepts, covering all aspects of the car. Overall, 924 companies with 289,000 employees are directly supplying the automotive industry. Additionally, 2,250 companies with around 700,000 employees are indirectly involved in the industry. The two biggest players are Bosch and Continental.

Bosch produces systems and components for all levels of hybridization. Ranked the second largest automotive supplier in the world, Bosch invests €400 million per year into electromobility-related technologies. Overall, Bosch has around 800 engineers dedicated to the cause of hybrid and electric vehicles. The product range covers e-motors (in part in cooperation with Daimler), batteries (through a joint venture with Samsung via SB LiMotive), software, e-bikes (in-house production since 2011), chargers, and inverters. Until 2013, Bosch is involved in 20 series-projects for 12 different OEMs.

Continental is ranked the third largest automotive supplier in the world. With a focus on hybrids, Continental is an integrated supplier of key components for the electric drivetrain. Its product range includes e-motors, batteries, software, power electronics, as well as gears and couplings. Continental produced the first lithium-ion battery for a series hybrid, the Mercedes S-400H.

21.5
Charging infrastructure and vehicle deployments

In 2009 the federal government started eight electromobility model regions across Germany in Berlin/Potsdam, Hamburg, Bremen/Oldenburg, Rhein-Ruhr, Sachsen, Rhein-Main, Stuttgart, and Munich. The objective of the model regions is the connection of application-oriented research with customer-focused everyday use of electric vehicles. By the end of 2011, 1,100 charging stations should be installed and 2,350 electric vehicles should be the road. Table 21.1 summarizes the current status of implementation across these model regions.

Table 21.1 Figures for electric vehicles and charging infrastructure implemented as of May 2011 at eight model regions around Germany. Achieved counts are shown in brackets. (Source: NOW GmbH.)

	Berlin / Potsdam	Bremen / Oldenburg	Hamburg	München	Rhein-Main	Rhein-Ruhr	Sachsen	Stuttgart
BEVs Total: 700 (330)	190 (53)	74 (13)	100 (86)	60	50 (22)	110 (26)	32	89
Electric motorcycles and scooters Total: 1400 (510)	10	25			471 (59)	140	38	710 (500)
Hybrid electric busses Total: 60 (30)		25		2 (2)	5 (1)	21	20	5 (5)
Utility vehicles Total: 140 (73)	5	3			11 (8)	30		50
Charging points	500 (90)	150 (160)	100 (100)	187 (150)	100 (95)	300 (340)	141 (139)	n.a. (490*)

* 200 are only for pedelecs

Within the model regions, electromobility is developed and assessed with different focuses by a large number of players. The following aspects are taken into account:

- Integration of different modes of transportation: passenger cars, commercial vehicles, motorbikes, buses, and trains
- Involvement of local and regional players with the existing technology and value-add potential in terms of electromobility
- Inclusion of several stakeholders, e.g., manufacturer, developer, user, service provider, and utilities
- Cross-linking of different applications and use-cases, e.g., intermodal transportation and mobility services like car sharing
- Assessment and integration of electromobility in private and commercial mobility patterns
- Installation of charging infrastructure with open, non-discrimination access
- Development and analysis of new business models

The programme budget of €115 million is split across the eight model regions in 220 projects. The funding from the Konjukturpaket II (stimulus package) will be terminated by the end of year 2011. The continuation of the model regions in so-called pilot regions or showcases (proposed by the NPE) is currently in discussion.

21.6
On the road

The numbers of hybrid and electric vehicles on German roads as of the start of 2010 are shown graphically in figure 21.3 below. These quantities are also listed numerically in table 21.2. All figures are based on registration counts.

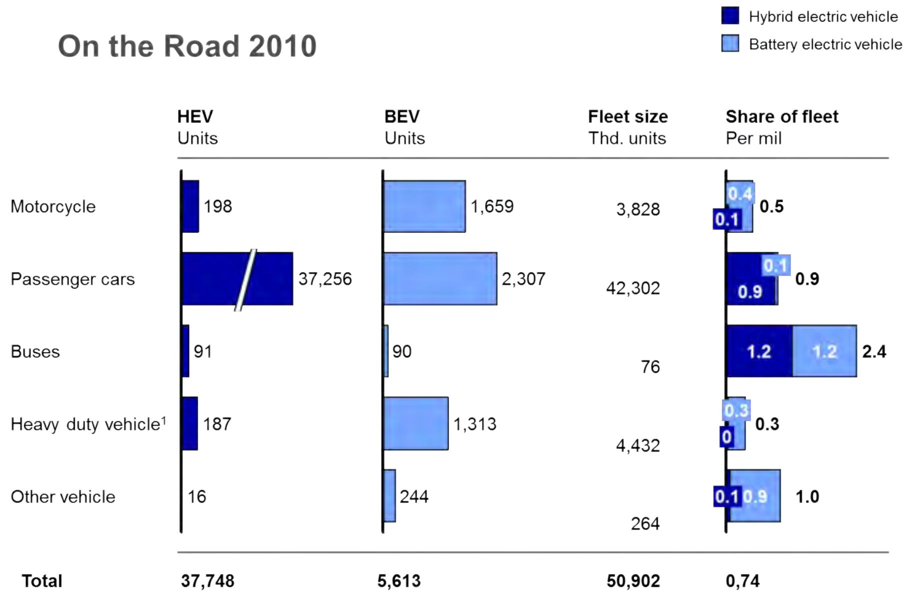


Fig. 21.3 Population of the German motorized vehicle fleet as of January 1, 2010. (Source: Kraftfahrt Bundesamt, annual report 2010.)

Table 21.2 Population of the German motorized vehicle fleet as of January 1, 2010. (Source: Kraftfahrt Bundesamt, annual report 2010.)

	Per January 1, 2010		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs and HEVs)**
Motorcycle	1,659	198	3,828,000
Passenger cars	2,307	37,256	42,302,000
Buses	90	91	76,000
Heavy duty vehicle*	1,313	187	4,432,000
Other vehicles	244	16	264,000
Total	**5,613**	**37,748**	**50,902,000**

* including semi-trailer trucks

21.7 Outlook

The German government aims at establishing Germany as both a lead supplier and lead market for electromobility by 2020 and therefore has heavily increased public funding for identified key topics. The funded projects of the Economic Stimulus Programme will allow research institutes as well as industry to significantly build up and connect know-how in the field of electromobility while at the same time preparing for market penetration.

In the market escalation phase through 2016, the focus of German R&D funding, automotive OEMs, and suppliers will remain on field tests, demonstration, and serial mass production of lithium-ion batteries as well as PHEVs, BEVs, and FCVs. In terms of infrastructure, efforts have to be put into the development of appropriate ways of charging and grid integration of EVs, with advanced energy transmission systems and renewable energy sources in mind. Both financial and non-financial incentives will help to overcome the total cost of ownership gap, by helping the public to become familiar with new mobility concepts and making EVs attractive.

22 Italy

22.1 Introduction

In 2010 the continuation of the international economic crisis, in the absence of car subsidy measures, has compressed the overall vehicle market in Italy, while confirming that its energy system strongly depends on imported oil. At the same time, renewable energy is increasing through the national "Conto Energia," a strong subsidy plan that supports the construction of power plants and distributed generation from renewable energy sources, mostly photovoltaic (PV) and wind generators. The overall energy consumption in Italy remains nearly the same as in 2009. However, renewable energy sources have now reached a share of 2% of the total energy supply, almost 3 times their share in 2008. The overall number of PV plants in the national electricity grid has more than tripled in 2010 (with about 54,000 new plants) with respect to 2008, reaching the value of 144,800 plants at the end of January 2011 and overall installed power of 2,903 MW.

On the other hand, the shrinking consumption of fossil fuels is having a beneficial effect by decreasing greenhouse gas (GHG) emissions. Italy looks likely to achieve the national target of reducing CO_2 emissions by 6.5% from 1990 levels by 2012, with preliminary reduction results already announced in the range of 6.4–6.8%. Consequently, more ambitious targets for GHG reduction by 2020 are being discussed at the European Union level, to move from the planned 20% decrease up to a more challenging 30% reduction for the same reference year of 2020.

The introduction of EVs and HEVs in Italy is driven by a series of temporary environmental control actions and the increasing share of renewable energy sources within an increasingly diverse energy mix. Examples of environmental control actions include pedestrian-only areas and alternative methods for delivering goods. Also, in recent years, major urban areas have been forced to strongly limit the use of private cars. For example, Milan has introduced a pollution charge to be paid by private drivers to enter a defined city zone. Rome has created a green zone, where selected categories of private cars periodically are not allowed to enter (clean cars, such as EVs and HEVs, are exceptions to this rule).

The central government, regulatory bodies, and local authorities (regional and municipal) are proposing and discussing new legislation, regulations, and supporting measures to significantly reduce the environmental and energy impact of the transport sector, which still accounts for about 27% of the overall end use of energy and about 30% of the overall GHG emissions. In addition, the transport sector is the major contributor to the deterioration of air quality in urban areas, where most trips are carried out.

22.2 Policies and legislation

In 2010 the persistent economic situation convinced the central government to stop the incentives from 2009 that supported the vehicle market and, in particular, the substitution of more polluting cars and commercial vans with cleaner vehicles, including EVs and HEVs. (There is no specific attention to PHEVs in the Italian initiatives, because these are still included in the HEV category). After an initial debate with industry and different trade and labour associations, the central government instead committed financial resources to support renewable energy plant installations, because of the strong commitment of Italy in reaching the overall European Union targets established for 2020 on energy efficiency, renewable energy share, and GHG reduction.

However, there have been different types of initiatives to support the introduction of EVs and HEVs: legislation, regulations, standards, promotions, and demonstrations. Most of these initiatives are the result of a growing interest by electric utilities in analyzing market prospects and the potential impact of EVs on the electricity grid. There have been some ongoing and prospective legislative initiatives to support research and the introduction of EVs and HEVs involving several ministries (Economic Development, Environment, Research, and Transport) and the parliament. Some dedicated standards for HEVs and related components (e.g., rechargeable lithium battery applications and supercapacitors) also have been initiated by the national standard-setting bodies as part of an international effort promoted by the International Organization for Standardization (ISO) and the International Electrochemical Commission (IEC).

Legislation

Two proposed laws to support the uptake of HEVs and EVs were prepared in 2009 and 2010 and are currently being examined. The first proposed law (n. 2844: *Measures to favor the development of mobility by using vehicles without* CO_2 *emissions*) was aimed at subsidizing purchase of these vehicles through installing vehicle battery charging infrastructure and other specific incentives. These incentives included zero property tax on the HEVs and EVs, lower taxes on electricity, free circulation in restricted urban areas, and free parking in reserved parking lots. A small tax on plastic bottles is proposed to cover the financial needs for all the initiatives.

The second proposed law (n. 3553: *Measure for the realization of infrastructure aimed at assisting the broad introduction of EVs*) is a policy and strategy document stating general rules for integrating charging infrastructure for EVs into any governmental and regional strategy addressing the health impact of noxious emissions and diversification of energy sources. This approach would also support pursuing European Union targets for atmospheric emissions and clean vehicle introductions. Furthermore, the possible introduction of EV charging infrastructure must be considered in various types of initiatives: renewal of roads, research and innovation, promotion of industrial sectors, and innovation in buildings. The law proposal also includes the governmental preparation of a National EV Infrastructure Plan that would create the conditions and possible funding schemes for various installations of charging points.

Regulation

In 2010, the Italian Authority for Electrical Energy and Gas (AEEG) enacted regulatory simplifications and a general analysis of the problems related to the introduction of EVs and their relation to the electricity grid. The first regulatory action has been the removal of restrictions on private sector introductions of dedicated electrical meters for charging EVs. Furthermore, the early EV market will be helped through new regulations for experimental demonstrations aimed at verifying business models and various EV and infrastructure technologies. A set of general rules has been defined for the services of transmission, dispatch, distribution, and electrical energy measurement for each EV charging point. These rules will be applied in 6 pilot demonstration projects to run during 2011, pending agreement between AEEG and service providers.

Standardization

The increasing commitment and interest of the large industrial sector in EVs can be measured by the growth in standardization activities for various technologies: vehicles, lithium batteries, and charging stations. Different standardization bodies have been active during 2010 in supporting international standard development, such as CUNA for the vehicle and battery module and systems at ISO level, and the Italian Electrotechnical standardization body CEI for the battery cell and charging stations at CENELEC and IEC level.

Apart from some international standards in advanced preparation stage (not discussed here), there have also been attempts to propose temporary solutions to the lack of current international standards. In particular, CIVES (the Italian EV Association, an internal committee of CEI) has organized workshops and participates in the analysis of infrastructure needs and charging limitations. The experimental standard CEI 312-1 *Safety requirements for charging stations for electric road vehicles* was introduced in 2010 to support the start of some demonstration projects and to assure adequate safety in using charging stations.

Financial initiatives

The international and national economic crisis impacted national clean vehicle initiatives more than those in regions, provinces, and many municipalities. These local governments were able to support clean vehicles through European, national, and industrial funding for projects supporting the environment and energy diversification. Major metropolitan areas (e.g., Rome, Milan, Turin, Genoa, and Florence) defined plans in which cleaner vehicles could play a significant role. The financial support for the purchase of EVs and the creation of dedicated charging infrastructures have been proposed in a variety of municipalities, often in conjunction with the definition of promotional and protective measures to limit or ban the circulation of more polluting vehicles.

22.3 Research

During 2010, Italy remained strongly involved in EU-level research projects on EVs, HEVs, and fuel cell vehicles (FCVs). Many Italian research organizations and industries have been involved in such European projects dealing with research and demonstration of these electrically-propelled vehicles and related technologies: HCV, HELIOS, Hi-CEPS, Zero Regio, and many others. The EU Framework Program 7 (FP7) has concentrated on various EV and HEV-related activities, including the evaluation of the impact on the electricity grid. A specific public-private partnership named “Green Cars” has been assisting short- and longer-term research activities at the EU level on electrically propelled vehicles.

In national programs, the research programs and projects with a major focus on EVs and HEV technologies and applications continued, while fuel cell vehicle R&D activity was substantially reduced. EV and HEV research and demonstration (R&D) activities remained part of some national programs, which only partially address EVs and HEVs. The programs INDUSTRY 2015 and “Research for the Electrical System” include some activity on electric mobility. There has also been an effort to develop a national roadmap for research and development needs for electrical mobility.

Various entities in Italy conducting research into electric-drive and fuel cell vehicles include academia, research organizations, component and vehicle manufacturers and assemblers, electric utilities, and large fleet users. Among others, relevant research activities are carried out by ENEA, the National Council of Research (CNR), various universities (e.g., Bologna, Camerino, Genoa, Milan, Rome, Turin, and others), and industry (e.g., FIAT, IVECO, Ansaldo Electric Drives, Breda Menarini, Piaggio, Eldor, Micro-vett, FIAMM, FAAM, Magneti Marelli, and STMicroelectronics).

Italian Electrified Mobility Technological Platform

A National Platform for the Electric Mobility was started in 2010 with the participation of about 100 stakeholders (industries, research organizations, and academia) with the scope of elaborating a strategy and long-term actions. The Italian Electrified Mobility Platform aims to proactively define the innovation needs for effective urban mobility, to help Italian industry provide new products and national infrastructures, and to coordinate European national efforts. The plan would be implemented over the next 5 to 10 years.

INDUSTRY 2015 Project in Sustainable Mobility

The INDUSTRY 2015 project launched in 2008 to fund industrial innovations and reached fully operational status in 2010. At the end of 2010, 29 projects involving a variety of technologies in the transport sector were finally approved and granted with a total budget in excess of €450 million, of which about €180 million came from public funding. The topics of individual three-year projects include the electrification of vehicles of different sizes, ranging from 2-wheeled vehicles up to public transport buses.

LIVE

The LIVE project is coordinated by IVECO, one of the largest European manufacturers of heavy-duty vehicles and commercial vans. The project involves the development of light-duty transport vehicles with different drivetrains, including one with a hybrid configuration. The total budget is close to €31 million.

Zerofilobus

This project, coordinated by Breda Menarini, aims at developing and validating an innovative approach to public buses, integrating them into a complete transport system. Electric buses are charged at stations during each temporary stop using fast storage systems (supercapacitors or high-power batteries). The total budget is close to €12 million.

MUSS

The MUSS project, coordinated by Piaggio, one of the leading manufacturers of scooters and motorbikes, aims at clean and safe small vehicles, also using electric and hybrid drivetrains. The total budget is close to €21 million.

22.4 Industry

In 2010, the cancellation of public subsidies for cleaner cars exerted a significant negative impact upon the Italian EV and HEV industry, which was mostly mitigated by the opening of other European markets. The large Italian car maker FIAT has not yet defined a specific industrial strategy on EVs and HEVs, despite its involvement in Chrysler. However, the periodic survey of the Italian Electric Road Vehicle Association (CIVES) confirmed that around 50 producers, assemblers, and importers are able to manufacture or supply HEVs and EVs. Most of these companies are small and medium enterprises, but large foreign companies such as Toyota, Honda, Renault, Daimler-Smart, and Peugeot are also bringing HEVs to the Italian market, while EVs will be sold after preliminary demonstration projects. Heavy-duty vehicle manufacturers (Breda Menarini, Piaggio, Cacciamali, and IVECO) continued to work with new projects or improving products by introducing various innovations such as a hybrid drivetrain to increase energy efficiency and reduce emissions.

The automotive industry still exceeds 5% of the national GDP. In Italy, there are about 3,500 enterprises in the automotive sector, employing about 1.2 million direct and indirect workers. The automotive industry invests more than €2 billion in R&D per year.

EVs and HEVs available for purchase in Italy cover the full spectrum of categories, including power-assisted bikes, scooters (with two, three, or four wheels), light- and heavy-duty pure electric and hybrid buses, and electric boats. Hundreds of EV and HEV models are now available on the market. Retail prices range from a few hundred euros for power-assisted bikes to hundreds of thousands of euros for hybrid buses. An EV still costs about two or three times more than a conventional vehicle while HEVs have much less of a price differential.

The components industries have become more active with new commitments on advanced batteries and charging stations, while the producers of power electronics, complete electric and hybrid drivetrains, and electric motors are improving their products.

In 2010, several Italian companies presented new EV- and HEV-related products and concepts and improved products already on the market.

Fiat Research Centre

Fiat Auto and its Research centre (CRF) unveiled or announced two new vehicle concepts. In the first concept, Alfa Romeo MiTo fuel cell vehicles (Figure 22.1) will be tested in the *H2moves Scandinavia* project. This project is part of the EU European Fuel Cells and Hydrogen Joint Undertaking Program, aimed at establishing hydrogen refueling stations and commercial hydrogen cars by 2015.

Fig. 22.1 Alfa Romeo MiTo fuel cell vehicle. (Photo supplied by ENEA (from website)).

This vehicle uses a Nuvera Fuel Cell stack combined with a compact Li-ion traction battery pack to supply power to the electric motor; this allows the vehicle to reach a top speed of 150 km/h (93 mph) and to accelerate from 0 to 100 kilometers in 10 sec, with hydrogen consumption of 3.2 L diesel equivalent/100 km (74 mpg US) and a range of 450 km (280 miles) in NEDC (New European Driving Cycle), thanks to 700 bar H_2 tanks.

Also, an electric version of the FIAT 500 (Figure 22.2) was showcased at the Detroit auto show in January 2010. This car is expected to be produced and commercialized through Chrysler in 2012 in the U.S. The technical specifications and costs are not yet available.

Fig. 22.2 FIAT 500 Electric with its electric drive. (Photo supplied by ENEA (from website)).

Pininfarina

The famous car design and vehicle producer company developed a new concept EV in 2010, following its previous agreement with Batscap (of French group Bollorè) for the construction and commercialization of an electric passenger car named Blue-car. The new car, named Nido EV (Figure 22.3), is a small-size city car, with two seats and a rear-axle permanent magnets electric motor.

Figure 22.3 Pininfarina Nido EV. (Photo supplied by ENEA (from website)).

The prototype was equipped with a Zebra Z5 (sodium-nickel chloride) battery, offering a high level of safety and reliability. The full range for single charge was 120 km with a top speed of 140 km/h (electronically limited), while the acceleration was an acceptable 6.7 seconds to reach 60 km/h.

FIAMM FZ Sonick

At the beginning of 2010, the Italian battery company FIAMM created a joint venture with the Swiss MES DEA to further develop and market the Zebra Battery, a technology owned by the Swiss company. The new company was called FZ Sonick, which addresses stationary and mobile applications, as demonstrated by the Pininfarina Nido EV prototype. Figure 22.4 shows the Zebra battery designed for mobile applications.

Fig. 22.4 FZ Sonick Zebra battery. (Photo supplied by ENEA (from website)).

22.5 Charging infrastructure and vehicle deployments

Italy is seeing a growing number of initiatives to develop and promote the introduction of infrastructure for EVs. The activities in this field can be divided into three types, excluding the normative and regulatory efforts already described:

- Development of new plugs, sockets, and charging stations.
- Financial support for private and public initiatives to create local infrastructure.
- Pilot and demonstration projects to validate electric infrastructure technologies, business models, logistics, and the interaction with EVs.

DEVELOPMENT OF NEW PLUGS, SOCKETS AND CHARGING STATIONS

In 2010 the Italian manufacturer Scame, which produces electric sockets and plugs, participated in the creation of a European association for charging infrastructure. EV Plug Alliance was founded by various European producers of plugs and sockets, like Legrand, Scame and Schneider Electric. The association aims to promote a label that will guarantee conformity of the connection with the IEC (International Electrotechnical Commission) draft standard. EV Plug Alliance proposes a connecting solution with sockets and plugs having the highest safety level thanks to shutters preventing any accidental contact with live parts (figure 22.5). This device, which is imposed by regulation in many European countries, guarantees totally safe usage at home as well as in public areas. Also, there are at least four companies in Italy now supplying complete charging stations.

Fig. 22.5 Scame Type 3 Plug. (Photo supplied by ENEA (from website)).

Scame

Scame Parre S.p.A. has been one of the first companies to design and produce a complete set of connectors for EVs and charging stations for public and home uses. The series LIBERA has been the parent technology, based on a high safe design and protection engineering, of the present plug proposed by the EV Plug Alliance. Figure 22.6 shows the various plugs and sockets, largely applied in most recent EVs in Italy. Figure 22.7 gives a pictorial view of the public application of LIBERA sockets.

Fig. 22.6 SCAME plugs and sockets used in EVs recently introduced in Italy. (Photo supplied by ENEA (from website)).

Fig. 22.7 Illustration of LIBERA sockets in public charging stations. (Photo supplied by ENEA (from website)).

ENEL

ENEL, the largest electric utility in Italy, is strongly committed in analyzing the technological and market implications of the use of EVs. Through its subsidiary ENEL Sole, the company has designed and produced its own charging station (figure 22.8), initially named Sunflower (*Girasole,* in Italian).

Fig. 22.8 ENEL Sole charging station. (Photo supplied by ENEA (from website)).

ENEL has developed an advanced charging system that comes in two formats for different uses:

- Home Station, aimed at charging the EV from home electricity meters in garages and private lots.
- Public Station, with the charging points located in public roads, selected in agreement with local authorities.

The charging system is equipped with personalized electronics and an individual card to allow for customer recognition and remote control of charging and payment activities.

Other products

Other intelligent charging stations are also on the market, including the GIGIEFFE charging station, another charging station produced by Progetti, and Pininfarina's solar charging station for the Nido EV (figure 22.9).

Fig. 22.9 Pininfarina solar charging station. (Photo supplied by ENEA (from website)).

Financial promotion to support private and public initiatives to create local infrastructures

In Italy, apart from the proposed laws under discussion within the central government, there have been many local initiatives to create EV charging infrastructure. More than 1,500 charging points are estimated to have been already built or are under construction in Italy. Known projects include 400 charging points (home and public) to be built in Milan, Pisa, and Rome as part of the E-Mobility Project (better described in the next paragraph). Another 270 charging points will be installed in Brescia and Milan as part of the E-Moving Project. Rome already has 96 charging points at 11 stations. Florence has a network of about 130 charging points and growing. Parma has approved a plan to install 300 charging points in the city by 2015. Bologna has 60 charging stations, Genoa has about 24 sites, and many charging points and stations have been installed or are planned in other towns.

Table 22.1 Examples of charging networks in Italy. (Source: ENEA.)

City/Project	Number of vehicles	Number of Charging points	Aim of infrastructure
Milano	-----	400+	Various
Brescia		70	Real world study
Bari		(100)	Smart City EU project
Florence		500+ since 1997	EV promotion
Imola	70	Undefined yet	EV promotion – Mi Muovo Elettrico
Modena	70	Undefined yet	EV promotion – Mi Muovo Elettrico
Pisa	many	50	EV , infrastructure and business model testing
Reggio Emilia/ REZIPE	322+	100	EV promotion – Mi Muovo Elettrico
Roma	many	200+	Various
Sesto Fiorentino	0	3	Service to citizens, test intelligent charging system

Pilot and demonstration projects

Italy has seen some success stories of EVs and HEVs in public fleets over the past decade thanks to large public subsidies introduced by various ministries. An exemplary case is the Municipality of Reggio Emilia that fully electrified its fleet of around 400 EVs that carry out a variety of services in the center city. This project earned a great deal of recognition from its citizens and the national and international EV community.

However, more recently electric utilities and the large car manufacturers have become interested in the business opportunities offered by EVs and HEVs. Therefore, there is increased need to better analyze the level of maturity of EV and HEV technology and to test in real-world conditions how well these vehicles can integrate into the transport system and electricity network. Both technical issues (charging mode, plug standards, safety aspects) and non-technical issues (business models for the charging service, tariffs to be applied, and the implied regulatory aspects) need to be tested.

For such reasons, three large EV deployment projects been running or started in 2010. The EU Zero Regio project finished during the year. The E-Mobility Project involves both ENEL, the largest Italian electric utility, and Daimler, which worked together to install a large charging infrastructure and an adequate fleet in three cities of different size and traffic conditions. Finally, the project E-Moving is another collaboration between an electric utility, A2A, and a car maker, Renault that also demonstrates charging infrastructure and EVs in two cities of different size.

Zero Regio

This EU project tested hydrogen fueling stations and FCEV in Frankfurt and in Mantova. In this city a multi-fuel station was first approved and then installed (figure 22.10) for fuelling three Panda Hydrogen vehicles (figure 22.11).

Fig. 22.10 Hydrogen refueling station in Mantova with PV power plants. (Photo supplied by ENEA (from website)).

Despite a large number of problems related to the homologation and circulation permission experienced by the project, the final results have been extremely interesting:

- The total distance traveled by the demonstration cars was about 33,000 km.
- The overall H_2 consumption was 352 kg.
- The average fuel consumption was about 1 kg H_2 per 100 km.
- The three vehicles ran for 880 hours without any technical problem or accident.

Fig. 22.11 FIAT Panda Hydrogen of Lombardy Region for the Zero Regio project. (Photo supplied by ENEA (from website)).

E-Mobility

The E-Mobility project is based on collaboration between ENEL and Daimler (Smart). ENEL has built up more than 400 charging points in three Italian cities (Milan, Pisa, and Rome) and Daimler has made 100 EV Smart cars available for rental, equally shared among the three cities. Drivers selected to test the cars will pay a monthly rental fee (€450) for the Smart and a monthly flat rate (€25) for any electricity consumption during charging. Figure 22.12 depicts a sample charging point and EV.

Fig. 22.12 E-Mobility in Rome. (Photo supplied by ENEA (from website)).

E-Moving

The E-Moving project sees the collaboration between A2A, an electric utility based in Lombardy Region, and Renault, supplying EVs. A2A plans to build 270 charging points in two Italian cities (Brescia and Milan), and Renault will supply 60 EVs of various types (passenger cars and vans). The 200 charging points in Milan will be partially public (64) and partially private (136), while the other 70 charging points will be installed in Brescia. Figure 22.13 sketches the charging point map in Milan, and figure 22.14 shows a Renault that will operate in Milan.

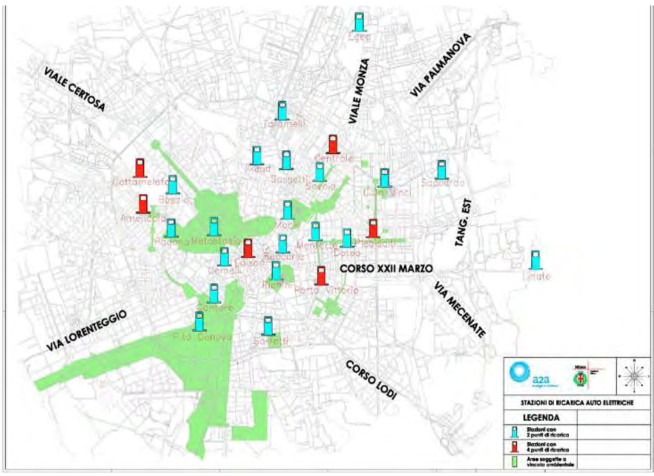


Fig. 22.13 Charging points in Milan for the E-Moving project. (Photo supplied by ENEA (from website)).

Fig. 22.14 A Renault EV in Milan. (Photo supplied by ENEA (from website)).

22.6
On the road

As stated in earlier sections, the overall vehicle market in 2010 experienced a decline because of the economic crisis and the cancellation of the incentive policy from 2009. The overall passenger car market declined about 9%. Consequently, the purchase of cleaner passenger cars (LPG, NG, EV, and HEV) also decreased from 22% of new purchases in 2009 to less than 18%. In particular, the purchase of small EVs (power-assisted bikes, mainly) was supported by local authorities' initiatives. Still, the overall figures for EV and HEV sales declined for the first time. Figure 22.15 presents the yearly sales of EV and HEV passenger cars in recent years, while Table 22.2 provides statistical data on the vehicle fleets in Italy.

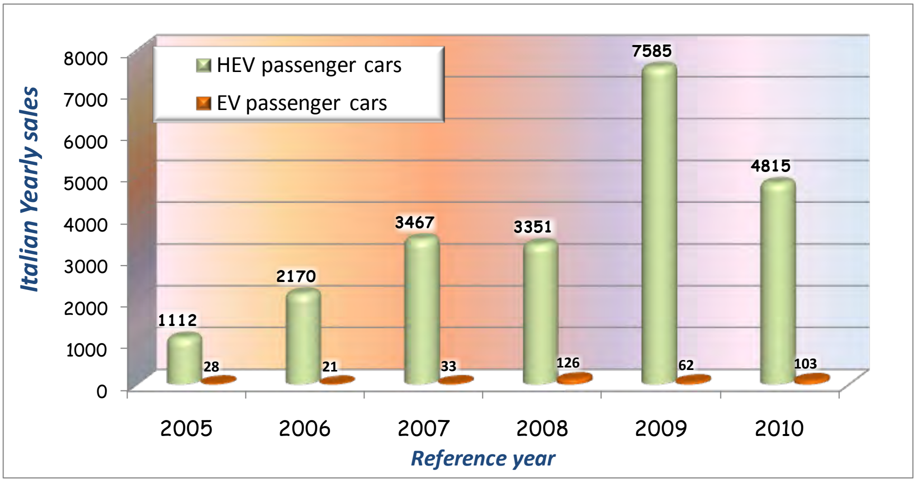


Fig. 22.15 EV and HEV passenger car sales in Italy in recent years. (Photo supplied by ENEA (from website)).

Table 22.2 Characteristics and population of the Italian motorized vehicle fleet per December 31, 2009.

	Per 31 December 2009		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs and HEVs)**
Motorized bicycles (no driver license)	177,573*		177,573*
Motorbikes	40,400		9,518,098**
Passenger vehicles	332	18,785	36,371,790
Multipurpose passenger vehicles	8,700		639,428
Buses	950	260	98,724
Trucks			3,944,782
Industrial vehicles			862,345***
Total	**227,975**	**19,045**	**51,612,740**

Note: the total fleet numbers include all propulsion systems and fuels, so include gasoline, diesel, LPG, natural gas, biofuels, etc.

* The number only refers to electrically-assisted bikes with an electric motor up to 250 W.

** Motorbikes include motorized mopeds and scooters with an engine cylinder volume up to 50 cm^3.

***In 2009, some special categories (mostly special extension and trailers for trucks) have been eliminated by the statistics, thus reducing previous numbers by about 50%.

The CIVES estimates at the end of 2009 showed an increase in the total number of EVs and HEVs on Italian roads compared with the 2008 figure (about 247,000 versus 217,000 vehicles). However, the market share of HEV passenger cars remained negligible in Italy compared with other countries. Large EVs and HEVs were still purchased mostly by fleet users, such as public service utilities. For the 2-wheel vehicle categories, the situation remained unstable, with a further reduction in mopeds/scooters sales of about 15%.

22.7 Outlook

In Italy, the overall perception of the progress of the EV and HEV market is generally more positive and favorable than in recent years, largely because of the variety of initiatives that have been taking place in 2010. The lack of an overall political strategy for cleaner vehicles, such as clear numerical targets for the number of HEVs and EVs to be on the road by a specific date, remains mostly motivated by the worldwide economic situation. On the other hand, the government is considering important legislative measures and is formally committed by the European Union targets for CO_2 emission reductions and increased use of alternative fuels.

A plan has been also elaborated and proposed by CIVES, the Italian EV association, in order to assist the central and local governments with realistic figures and estimation. The plan contains recommendations and suggestions to substantially modify current auto taxation and credits, in order to include better incentives and motivations for the purchase of EVs and PHEVs (not simply HEVs). CIVES would link these purchases to CO_2 and polluting emissions. This “neutral cost” plan shows that with an intelligent taxation and subsidy policy, it would be possible for Italy to reach the target of 100,000 EV passenger cars and 30,000 EV commercial vans by 2015. CIVES believes that the required budget for a funding scheme could be funded by conventional and innovative taxes.

Other positive signals for HEVs, PHEVs, and EVs in Italy include the initiatives supporting organized charging infrastructure and experimental pilot demonstrations, together with the announcements of new vehicles ready for the market. The control of urban air quality and the reduction of CO_2 emissions remain two clear objectives of the national policy, in which zero- or low-emission vehicles can play a significant role. This is particularly significant as an increasing share of electrical energy is produced by renewable energy sources. These are also expectations that some support measures, such as INDUSTRY 2015, will start yielding results in next few years.

In conclusion, the market for EVs and HEVs (and even PHEVs) is estimated to grow slightly in the short to medium term, and then more significantly when more vehicles and new batteries become available after 2012. In the event of a faster recovery of the economy, growth in sales could be enhanced due to:

- The financial support of local and central governments.
- The introduction of more severe emission standards, as well as new directives and laws for renewing car fleets, which will require improved vehicle drivetrains and fuels.
- The consolidation and confirmation of a set of non-technical and non-financial measures by local authorities to limit private car use in urban areas, including restricted circulation areas for polluting vehicles, free parking for clean cars, no access tolls for clean cars, free recharging stations, and enlarged recharging infrastructures.

23 The Netherlands

23.1 Introduction

"Progress" is the word that best characterizes the 2010 developments in the Netherlands. The introduction of battery electric vehicles (BEVs or EVs) and plug-in hybrid electric vehicles (PHEVs) is underway because of the concentrated efforts by all stakeholders. Fuel cell electric vehicle (FCEV) development and introduction is on a more modest curve. The upward trend for BEV/PHEV is due to increased political attention and developments in the automotive field that make it possible to "stop talking and start driving".

The Dutch government firmly supports sustainable mobility, and especially in economically difficult periods it makes a strong point of keeping the country's economy moving. This vision for mobility can only be realized by approaching economic, social, environmental, and climate issues simultaneously. Although vehicle production in the Netherlands is rather moderate and the vehicle-related research and development (R&D) activity is even more restricted, there is an important and promising components industry.

The Dutch Government has ongoing policies and legislation for reducing carbon dioxide (CO_2) and nitrogen oxide (NO_x) emissions and improving air quality. CO_2 reduction targets recently changed to reduce the national target to correspond with the European Union (EU)-level of 20 % reduction in 2020 vs. 1990, instead of an earlier 30 % reduction target.

The objectives for the transport sector are (1) to encourage consumers and research institutes to devote more attention to improving the efficiency of transportation systems and practices and (2) facilitate the hybridization of vehicles for use. Aware of the many initiatives in the Netherlands and other countries, the government reviews the ideas of electricity providers, manufacturers, and local authorities to promote the introduction of electric mobility. Initiatives from the market, threatened by possible restrictions and other uncertainties, should be facilitated. Electric mobility has possibilities for success, but only with the joint cooperation between the market, NGOs, social institutions, knowledge centers, and a wide range of authorities.

23.2
Policies and legislation

Action Plan for Electric Driving

The national Action Plan for Electric Driving was launched in mid-2009. The central objective of this leading plan is to make the Netherlands a guide and international laboratory for electric driving in 2009–2011. The plan's implementation is based on past learning experience and can lead to wide-scale market introduction. The central government's monetary contribution will total up to 65 M€.

Additionally, the central government supports efforts by market parties, social organizations, and local and regional authorities resulting in a much larger overall funding that multiplies the initial government investment. The government expects the combined contributions will stimulate around 500 M€ in expenditures for electric driving. The central government's contribution consists of three main parts.

1. The establishment of a Formula-E team with a robust and authoritative chairperson and members from all industries who are indispensable for the successful introduction and roll-out of electric driving. The team's primary task is to spur market development and remove obstacles.

2. Initiating the following activities in 2009–2011: (a) practical testing and demonstration projects; (b) acting as a launching customer; (c) charging, energy, and other infrastructure; (d) research, development, and production of electric vehicles and/or components; (e) formation of consortiums and coalitions; and (f) ancillary (mostly fiscal) policy.

3. A market introduction facilitated, coordinated, and phased-in by the Formula-E team plan based on the central government Action Plan and other pertinent studies.

The government envisions four program stages linked to anticipated market development phases in the period 2009–2020, as shown in table 23.1.

Table 23.1 The Netherlands national government's anticipated development of the market for electric vehicles during the next 10+ years.

Period	Market development	Expected number of EVs	Program stage
2009–2011	Laboratories	<100 to <1000	Program start-up
2012–2015	Scale-up	15,000 to 20,000	Program implementation
2015–2020	Continued roll-out	200,000	Program consolidation
After 2020	Mature market	1,000,000 cars in 2025	Program scaled down

Results of the National Action Plan for Electric Driving at the end of 2010

The Formula E-team was established on March 17, 2010.

- Formal cooperation between government, companies, and institutions to enforce breakthroughs in E-driving is occurring.

A successful subsidy plan for hybrid and electric driving is underway.

- Nine projects have been granted, in total about 10 M€, that will be finished by the end of 2012.

Conditional tender (bulk vehicle purchase) has been facilitated.

- National government prepares for participating in the Dutch Consortium for the Tender of Electric Cars (DC-TEC) to acquire about 400 E-vehicles for the national government fleet. In order to tender a commercially interesting amount of electric cars, more than 30 Dutch companies have bundled their demands in a purchasing consortium, the Dutch Consortium for the Tender of Electric Cars (DC-TEC). This joint initiative will start an international tender, or call for bids, for the supply of four different E-vehicle classes. A charitable foundation, DC-TEC, was established in May 2010 to run the tender according to EU public procurement rules. The costs of the tender are divided between the participants in proportion to the indicated number of vehicles each wishes to purchase. The consortium plans to purchase about 3,000 EVs with the tender scheduled for 2011.

A standard plug has been selected.

- The most important stakeholders have unanimously selected as the standard plug the same plug that was chosen by Germany and Sweden.

Universal access to charging stations is completed.

- As agreed by the various suppliers of charging stations in September 2010, one type of charging pass can be used at all charging stations in the Netherlands.

Encouraging research by the Dutch automotive sector through funding has been accomplished.

- About 18.5 M€ has been assigned to 15 projects.

Fiscal policies are in force.
At present applicable to EVs:

- Exemption from additional purchase tax on new passenger cars and motor cycles until 2018
- Exemption from road tax until 2018
- Exemption from income tax surcharge for lease cars until 2014
- Fiscal grants for companies that invest in EV for commercial transport (the grants account for a net profit of maximum 19%)
- Fiscal grants for companies that invest in charging stations

The supply of EVs for the Dutch market is being established.

- The Formula-E team has spoken successfully with many large manufacturers to promote the Dutch approach regarding electric mobility. It is expected that about 4000 EVs will be available for the 2011 Dutch market.

Information is being shared.

- Additionally, working groups have instructed the mechanics in HEV/EV vehicle technology and a training course for first responders. Both these are possible sources for IEA-coordinated activities for international exchange in 2011.
- A digital platform has been installed for communities and their services to share efficient access to the experience and knowledge developing throughout the country.
- A special remark should be made about the monitor that has been installed as a national tool for identifying and solving all types of problems that will arise during the transition towards electric mobility.

Complementary policies

Government-supported transport programs focus on the principal environmental policy objectives of reducing CO_2 emissions and improving air quality. EVs are one important aspect for transport, while other programs support the production of biofuels for transportation and investment in filling stations for alternative fuels, such as compressed natural gas (CNG).

There are also dedicated communication programs sponsored by the Dutch Government to promote the concept of “eco-driving” for drivers of all vehicle types. The principles that underlie this fuel-efficient driving behavior are incorporated in a training course required to earn a car operator's license. Fuel economy can be improved by 10–20 %, mostly by behavioral measures at an initially low program cost. Eco-driving can play a role in extending the range of EVs as well.

Legislation

Special tax rules are in place for EVs and hybrid vehicles. EVs are exempt from the yearly road tax. Since mid-2006, hybrid vehicles have qualified for a substantial bonus/registration tax reduction to encourage their sales. The bonus is dependent on the energy efficiency label of the car which reflects the fuel economy of the car (i.e., for the highest fuel-economy label A: €5,000; label B: €2,500). Conventional cars that are very energy-efficient can also earn a registration tax reduction depending on their CO_2 emissions in grams per km. FCEVs follow the EV ruling.

For leased cars, an income tax measure makes EVs and HEVs attractive. A normal tariff of 20% of the new car value that is added to the yearly income tax is lowered to 0% for zero-emission vehicles or 14% for low-CO_2 vehicles like many hybrids. Although tax regulations usually are subject to change, these privileges will be effective until 2018.

The effort to improve air quality in cities has led to the introduction of "environmental zones" in urban areas with specific entry rules. Some of the largest cities in the Netherlands have already designated environmental zones with more stringent entry rules for vehicles on the basis of their emission characteristics. Greater restrictions are imposed on vehicles not classified as "environmentally friendly".

23.3 Research

The Netherlands has several automotive and energy research institutes.

- TNO Industry and Technology – Automotive
- Technical Universities of Delft and Eindhoven
- Technical College, Automotive Division, Arnhem
- D-incert (Dutch innovation centre for electric road transport), Delft
- ECN (Energy Research Centre), Petten

The Automotive Technology Centre (ATC) is a cluster organization that stimulates technological innovation and cooperation. Its mission is to strengthen the international technology and business position of the Dutch automotive sector: members are mostly from the industry, and the organization is supported by several authorities.

Most automotive research institutes are located near Eindhoven in the southeast, which has easy access to the areas associated with the automotive industry in nearby Aachen, Germany, and the institutes in Belgium.

High Tech Automotive Systems (HTAS) Program

The HTAS is a market-driven program organized and directed by the Dutch automotive industry and empowered by the Department of Economic Affairs, Agriculture, and Innovation. Its goals are to focus automotive innovation on areas that match the strengths and ambitions of the Dutch automotive sector and to identify future opportunities and challenges in the international automotive industry. Key focus areas are vehicle efficiency and driving guidance. The HTAS Program was established in 2007 to run for 5 years. At the end of 2009 a research plan for Electric Vehicle Technology was added.

Dutch Action Plan for Electric Driving: Demonstration and R&D projects

As described in the policy section, the national government unveiled an Action Plan for Electric Driving in mid-2009. Included in this plan are demonstration and R&D projects. For the demonstration projects, the national government developed a subsidy program with a budget of 10 M€ in the first quarter of 2010. The objectives of the program are testing the technologies of the vehicles in real-world transport, learning about how these vehicles will be used, demonstration of the transportation possibilities of electric vehicles, and business case development.

Nine demonstration projects were awarded subsidy grants. The projects started in 2010 and should conclude by the end of 2012. The projects entail testing BEVs and PHEVs in a number of applications, as listed below:

- 7 BEVs for supermarket supply and urban freight distribution (Arnhem-Nijmegen area)
- 15 BEVs in a goods delivery transport system in Amsterdam
- 25 BEVs and PHEVs in a car-sharing system (top-4 cities)
- 40 BEVs for grocery deliveries in urban area (Amsterdam)
- 20 BEVs and 50 charging points for taxi's (Utrecht – see figure 23.1)
- 75 BEVs and PHEVs for company car use (passenger cars and light vans, Rotterdam area; 30 of which subsidized)
- 8 BEVs for garbage collection (Schiphol Airport and city centers)
- 26 BEVs and PHEVs and 40 charging points for tourist area (island of Texel)
- 15 BEVs and PHEVs for carpooling and car sharing (The Hague)

Fig. 23.1 Four of the ten-car fleet of Mitsubishi i MiEV's ready for use at their introduction in Utrecht. (Photo courtesy of Utrecht Municipality)

Ten R&D projects with a subsidized content of 14.7 M€ were awarded for developing applications related to electric mobility. These include:

- Development of navigation equipment for electric vehicles
- Development of a prototype PHEV garbage collection truck
- Development of parts for the driveline of electric vehicles
- Development of a system for calculating the cost per km and the residual value of batteries for electric vehicles
- Development of a small range extender for PHEVs
- System analysis of electric power flow to the wheels of heavy-duty vehicles
- Development of a lightweight wheel suspension with a wheel hub electric motor
- Development of a modular platform for hybrid and electric vehicles, including heavy-duty and distribution vans
- Development of a continuously variable transmission (CVT) for heavy-duty electric and hybrid vehicles
- System analysis of the electrification of heavy-duty vehicles

A new series of R&D projects was launched in 2010 with a national contribution of 3.5 M€:

- FCEV zero-emission small-size low-floor bus
- Development of an electric hub-engine
- Zero-emission full-size bus (‘Phileas’)
- Drivetrain innovation for EVs
- Safety and standardization of EV batteries

Another element of the action plan is the development of a program for the support of demonstration projects with vehicles running on hydrogen. This program has a budget of 5 M€, but has had a slow start because the targeted international vehicle suppliers were not ready to send their products to the Netherlands. The subsidy plan will probably re-open under adjusted conditions in 2011. In the meantime, the manufacturers have shown new interest in participating in ”Living Labs”, testing situations in which a near-real use of vehicles can be simulated. The labs are used to test the functionality of the vehicles under “all-day conditions”, and demonstrate the new technology to a broad spectrum of (potentially) relevant parties at the same time.

All programs mentioned are executed by the Netherlands (NL) Agency, which is part of the Department of Economic Affairs, Agriculture, and Innovation. NL Agency executes programs on innovation, sustainability, and international business and co-operation for various departments within the national government.

Dutch innovation is not only supported by national plans, but also relies on support from other regions or from international plans. Two interesting examples in the automotive fuel cell application for buses are the HyMove project (for the Arnhem-Nijmegen region) and the Waterstofnet project, in the Flanders/Noord-Brabant/Zeeland (Belgium/the Netherlands) region.

23.4 Industry

Dutch industry in the EV/HEV field, including potential parties, consists of:

- DAF Trucks N.V. (trucks, subsidiary of PACCAR, Inc.)
- VDL (Van de Leegte) Bus B.V. (public transport buses and touring cars)
- APTS BV, subsidiary of VDL, manufacturer of Phileas hybrid buses
- NedCar car assembly factory, owned by Mitsubishi
- Spijkstaal, EV-manufacturer (see figure 23.2)
- Various manufacturers of automotive components except batteries
- AGV (All Green Vehicles)
- ECE (E-cars Europe), import company of various electric vehicles

- E-traction (electric hub engines)
- Epyon (AC/DC fast charging infrastructure)
- NedStack (PEM fuel cell stacks)
- HyGear (Hydrogen generators and on-site gas processing equipment)
- Silent Motor Comp. (fuel cell systems)
- Various others, focusing on FC buses, trucks or conversions (“integrators”)
- Duracar (small BEV truck-concept that was sold to Chinese Sino EV Tech during 2010)

Next to these first-line businesses, a number of specialized consultants are working in the field, such as Appm, The New Motion, EV consultant Ronald Berger, and the consultancy DHV (the latter partly contributed to this report). The new mobility concepts also pave the way for new supporting organizations that procure cars, charging points, service and battery-monitoring businesses.

Fig. 23.2 “Binky,” small full-electric garbage collecting truck by Spijkstaal. (Photo courtesy of Spijkstaal.)

23.5
Charging infrastructure and vehicle deployments

E-laad Foundation plans for 10,000 charging stations

In 2010, local initiatives in electric charging infrastructure achieved great progress. The Foundation of E-laad ("E-load") was initiated by the cooperating regional electricity grid operators of the Netherlands and should be seen as a temporary implementation organization. All costs of the charging points (budget 25 M€) are covered by the cooperating grid managers. The objective is to establish 10,000 charging points in total for public spaces comprising 2,000 charging spots requested by municipalities (one charging point per 10,000 inhabitants) and 8,000 charging spots requested by EV drivers (through a dealer organization).

Municipalities and provinces are the natural partners of the grid managers because they hold a large part of the electrical shares and own public space. Research has shown that only 30% of the households in the Netherlands are able to park at their own premises and install charging infrastructure, and only 1/3 of these households are willing to use their space for this purpose. In other words, 90% of households need a charging point in a public space. If there is the possibility of installing a charging point in a private space, no public point will be installed. Although end-users can request a charging station, the municipality decides whether the end-user qualifies, and where the charging station will be placed to ensure the quality of the network. Municipalities need to develop local policy and directions regarding the establishment of charging points, and many are currently reviewing charging plans and options.

Status as of December 2010:

- 400 charging points have been established.
- 243 charging point requests are being processed. A municipality must formally approve a charging location, which takes about 9 weeks to process.

As an example of the prospering Dutch charging infrastructure, power supplier ENECO announced a plan to build a network of 750 charging points, and Essent, owned by German electrical utility RWE, is working on a similar plan. These suppliers are responding to the national, regional, and local incentives as mentioned above.

At the moment, slower charging points are standard while fast-charging facilities are the exception. On May 20th, 2010, the first public fast-charging point was opened in Leeuwarden. Essent proudly claimed it to be Europe's first, adding it would certainly help in standardizing charging points on a European scale.

International standardization remains as a weak point for fast charging and for slower, normal charging: European authorities can be heard saying it will be left to the marketplace. An interesting aspect of the charging development is the fact that the mineral oil companies seem to care about charging speed. The Leeuwarden facility as seen in Figure 23.3, was built in cooperation with Tamoil, a Dutch supplier, who possibly learned from fast-charging examples in France, Belgium and other countries.

Fig. 23.3 Epyon public fast-charging point put into operation in Leeuwarden in May 2010 by the president of the Formula E-team, HRH Prince Maurits van Oranje and Alderwoman Mrs. Diks. (Photo courtesy Drive4Electric.)

Local action plans for electric mobility

E-laad assists communities with local action plans for electromobility using other Dutch mobility plans as examples. They reflect the policy and activities to make electric mobility accepted and welcomed into the streets of communities wishing to participate in the new EV era. User groups are formed from the start. This section summarizes the efforts of four local leaders.

1. **Amsterdam**

   "Amsterdam Elektrisch" is the local action plan on electric mobility began in April 2009 with firm objectives and goals in place for 2010–2040, as listed in table 23.2. Policies and measures have been confirmed in the work plan through 2015 that will be evaluated each year.

Table 23.2 General objectives for EV adoption in Amsterdam.

2009–2012	200 charging stations, 200 electric vehicles
2015	10,000 vehicles (or 5% emissions-free kilometres driven in the city)
2020	40,000 vehicles (or 20% emissions-free kilometres driven in the city)
2040	200,000 vehicles (or 100% emissions-free kilometres driven in the city)

Electric vehicles may be either EV or PHEV, and include range-extenders using biofuels or hydrogen. Present measures define the EV as being able to drive a minimum of 60 kilometres purely on electricity.

This vision of sustainable mobility won Amsterdam the AVERE E-Visionary Award for electric cities in 2010. The award was presented during EVS 25 in Shenzhen, China.

2. ’s Hertogenbosch

The local action plan for sustainable mobility in the city of ’s Hertogenbosch was expected to be approved at the beginning of 2011. A major part of the plan is devoted to electric driving, with its electric mobility objectives listed in Table 23.3. Policies and measures to introduce and increase the use of battery-electric vehicles in ’s Hertogenbosch are in place for 2011–2014. In total about 2 M€ is reserved for electric driving.

Table 23.3 ‘s Hertogenbosch electric mobility objectives.

2011–2020	Minimum of 10% of ‘s Hertogenbosch vehicles are electric, based on a regional objective of 200,000 EVs in the province of Noord-Brabant. No objectives have been formulated regarding charging points. The number of charging points is expected to grow with the number of EVs initiated by private parties and located mostly in private premises, such as driveways, parking garages, and company parking lots.

Electric vehicles may be either EV or PHEV, including range extenders preferably on biofuels.

3. Rotterdam

”Stroomstoot” (“Electric pulse”) is the local action plan for electric mobility in Rotterdam that began in September 2009. Policies and measures to introduce and increase the use of battery electric vehicles in Rotterdam have been set for 2009–2014, as shown in table 23.4. In total, about 2 M€ is already reserved for partial implementation of measures for 2009–2011. For the remaining measures, to be implemented in 2011–2014, an extra budget of about 15 M€ has been planned.

Table 23.4 Rotterdam general objectives for electric mobility.

2009–2014	Minimum of 1,000 electric vehicles in the region of Rotterdam, 25% of the municipality fleet should consist of EVs, which would total 350. Minimum of 1,250 charging points (1,000 for non-municipal use) 1–3 fast charging points (dependent on market developments)
2025	Minimum of 200,000 electric vehicles in the region of Rotterdam (15% of national objective of 1.3 million EVs in the Netherlands by 2025) 100% electric local public transport kilometres driven

Electric vehicles may be either EV or PHEV, and include range-extenders using biofuels or hydrogen.

4. Utrecht

The local Action Plan on Air Quality Utrecht (ALU) began in 2009, with EV-related targets as described in table 23.5. The plan has been launched to meet air quality targets by 2015. ALU sustainable mobility has a transport mix that addresses clean buses (hybrids and electric), clean city distribution (electric and environmental zoning), electrification of the municipal car fleet, and mobility management of freight transport. Utrecht wants to reduce traffic in the inner city by 30% by 2030. The ALU will result in about 7 to 8% less traffic. Additional measures under the program "Utrecht Bereikbaar" (Accessible Utrecht) emphasize public transport and bicycling as the first transport options and clean cars as the second, less desirable option.

Table 23.5 Utrecht objectives for EVs.

2009–2011	Minimum of 200 electric vehicles in the city of Utrecht Minimum of 300 charging stations Minimum of 5 municipal EVs
2014	Minimum of 5,000 electric vehicles in the city of Utrecht 300-1000 charging stations Minimum of 60 municipal EVs

Electric vehicles may be either EV or PHEV, and include range-extenders using biofuels or hydrogen.

Additional national plans

The Province of Noord-Brabant makes available a budget of 10 M€ for the development of electric mobility. This area is ideally located because it hosts the majority of Dutch automotive businesses and R&D institutions. Energy suppliers in Noord-Brabant are especially capable of joining the program with the opportunity to provide sustainable energy.

As a part of a sustainable mobility program, the coastal Province of Friesland will support the acquisition of 10,000 electric vehicles, including scooters. Also, as the center of Dutch water sports, province transport options include nautical transport applications that may be influenced by the electrification of road transport.

Various international plans

Dutch and North Rhine-Westphalia (NRW, Germany) authorities are developing an idea for a cross-border "Living Lab" in NRW and its Dutch neighboring areas. Benefits should be spread along automotive industry, engineering, safety, and infrastructure topics.

The Netherlands participates in Electromobility$^+$, a contribution of 13 European countries and regions to the European Green Cars Initiative. The initiative aims at the creation of long-lasting conditions for the development of electric mobility in Europe by 2025. Within Electromobility$^+$ the involved national and regional authorities bring together 20 M€ of public funding.

Hydrogen

On the hydrogen scene, charging points and vehicle deployment projects are still limited in number. In December 2010 the first Dutch public hydrogen supply facility was opened in Arnhem. The city is also the center of Dutch R&D on fuel cells, FCEVs, and decentralized hydrogen production facilities.

23.6
On the road

The vehicle park (in-use population) in the Netherlands is shown in Table 23.6. Car density is one car per 2.3 inhabitants.

Table 23.6 Characteristics and population of the Dutch motorized vehicle fleet as of December 31, 2009 and 2010 (in cooperation with RDC and VWE; figures partly estimated).

	December 31, 2009			December 31, 2010		
Vehicle Type	**EV Fleet**	**HEV Fleet**	**Total Fleet**	**EV Fleet**	**HEV Fleet**	**Total Fleet**
Motorized bicycle (no drivers licence)	458,000	0	18,500,000	611,000	0	18,600,000
Motorbike	0	0	668,000	0	0	680,000
Passenger vehicle	50	40,000	7,775,000	238	57,000	8,003,000
Multipurpose passenger vehicle	Included in passenger vehicle totals					
Bus[1]	50	30	11,600	64	41	11,600
Truck, van and minibus[2]	30	0	1,100,000	63	0	1,120,000
Industrial vehicle	n.a.	n.a.	n.a.	2	1	n.a.
Total (round figures)	**458,000**	**40,000**	**28,055,000**	**611,000**	**57,000**	**28,415,000**

n.a.= not available

1 EV Bus figures include 40 trolleybuses in Arnhem

2 The numbers include trucks, vans and minibuses. Minibuses are vehicles that carry up to nine people, with a gross vehicle weight up to 3.5 tons. In Dutch statistics, this category cannot be separated from vans up to 3.5 tons. Their estimated number as of December 31, 2009, is 875,000 and 900,000 as of December 31, 2010.

Definitions of vehicles in Section E of this report, chapter on Vehicle Categories.
Hydrogen vehicles include 1 Passenger vehicle, 2 Trucks and vans, 1 Bus as per December 31, 2010

Hybrid cars have been commercially available in the Netherlands from 2004 when the Toyota Prius II was introduced. Toyota, Lexus, and Honda are the main players in the market for hybrid cars. Sales figures continuously increase each year, especially for the lease-market. These cars benefit from purchase and road tax relief with income tax reductions as described earlier.

Until 2009 the average annual sales volume of cars in the Netherlands was about 500,000 units. The 2009 drop in sales by 22% was nearly compensated for by an increase in 2010 (480,000 units). In 2010, sales share of hybrids was about 7%—up once more from the previous year. By the end of 2010, one of every 200 passenger cars was a hybrid.

The interesting news in 2010 was the public's great enthusiasm for second-hand hybrids. Lease companies (the biggest group of first owners) feared the average consumer would not find the hybrids attractive enough because part of the tax exemption was not applicable to private owners. While flooding the second-hand market with large numbers of four-year-old ex-lease hybrids, lease companies found to their surprise that the Dutch public welcomed all of them. This means lease-tariffs for new hybrids can be kept relatively low, making them even more appealing when offered as company cars.

The passenger car population was up slightly in 2010, following increased new-car sales over the crisis year 2009. There is a strong tendency, driven by tax measures, for cars to be lighter, smaller, and more fuel-efficient, which continued in 2010. This will help the introduction of BEVs because they fit this market need, especially for the new Nissan Leaf.

About 400 BEVs are in service, mainly passenger cars and utility vehicles (i.e., EVs that require a license plate to be used on public roads). Barriers to greater sales and use of electric cars begin with their availability, purchase price, limited driving range, and the lack of available service support. The number of passenger cars increased a full 100%, totalling over 200 registrations by the end of 2010. The lease market was responsible for approximately 50% and private owners for approximately 15% of this increase. The top three manufacturers Th!nk, Volkswagen Golf, and Daihatsu Syrion accounted for 70 % of the market.

Electric bicycles are bestsellers in the Netherlands and the sales of electric mopeds are taking off. Charging points for bicycle batteries are readily available at restaurants in tourist areas, bicycle parking facilities, and in more places. Charging reliability builds consumer confidence and affects the market growth. Public appreciation has increased because modern electric bicycles perform significantly better than their “ancestors” of 5 to 10 years ago.

The Netherlands is a bike-friendly country with about 18 million bicycles that is more than the number of inhabitants. Various makes and models of electric bicycles are available, primarily the power-assist type (i.e., electric assistance is supplied only when the rider is pedalling). They are allowed to travel at a maximum speed of 25 km/h. Their share of the total bicycle market was about 10 % in 2010 and is rising. Quality brands lead in sales with an average price tag of about €1,900 which makes them popular with retailers and stimulates a robust electric bicycle market.

Hybrid buses and commercial transport vehicles are not widely available for sale in the Netherlands. As such, their numbers are negligible in the current truck and bus stock. This will certainly change in the coming years since foreign manufacturers know the Netherlands will invest in any condition favorable to the new line of electric and hybrid products with the ”Living Labs” program for electric and hybrid vehicles pushing this market. Industry, of course, is making progress in developing the vehicles. The prototype HEV DAF distribution truck was announced last year, and DAF will introduce the LF hybrid distribution truck on the British, Dutch, German, French, Belgian, and Czech markets in 2011 (see figure 23.4). Its range to travel on batteries only will be around 2 kilometres, sufficient for use in most environmental zones.

Fig. 23.4 DAF LF hybrid distribution truck. (Photo courtesy of DAF.)

In the hydrogen and fuel cell area, progress is being made although a number of vehicles still remain in the prototype or drawing board phase. The scale of the operations is a concern to the national government, and companies are incited to look for partnership opportunities with national or international companies with a solid background to support R&D over a longer period. Other firms in the component area currently have found a firm position in the international marketplace.

23.7 Outlook

Current trends

The introduction of new hybrid cars in the Dutch market is continuing. Toyota, Lexus, and Honda dominate the hybrid market, but serious competition from European manufacturers will emerge in the coming years. Vehicle types and engines will vary. For example, micro-hybrids have already been introduced and are gaining in popularity. This vehicle type represents brake-energy recuperation and start/stop systems, helping the vehicles to achieve extremely low fuel consumption along with related tax benefits for owners. It remains to be seen whether the standardized test procedures used will represent everyday use.

Plug-in hybrids were not yet on sale in 2010, but the first sale is projected for 2011. By 2015, a vast variety of hybrid cars can be expected to be for sale. Hybrid goods vehicles (i.e., delivery vans and trucks) are emerging from the prototype stage, while hybrid buses are generally in the very early development phase, with some demonstration projects under way.

Compatibility of HEVs and EVs with the country's objectives

Every day, 2.5 million cars with an average occupancy rate of 1.15 persons per car (i.e., nearly single-person occupancy) commute over Dutch roads. At the end of 2007, the Dutch Government issued a white paper that articulates policies to promote a clean environment and energy efficiency within all sectors of society. For the transportation sector, these policies address (1) the need for consistent regulations within the European Union, (2) the need to encourage demand for clean and fuel-efficient vehicles, and (3) the need to promote innovation in demonstration projects. The use of hybrid and electric vehicles, both cars and goods vehicles (i.e., light-duty goods delivery vans and heavy-duty distribution trucks and buses) is also compatible with clean-air policies from recent years. Especially in urban areas, the call for zero-emission and noise-reduced vehicles have led to measures which now focus on clean fossil fuel vehicles, but should also be interpreted as a welcome to the EV, HEV, and FCEV. These policies are strongly backed and facilitated by the national government, although recent Dutch economic austerity measures may impact the funds available to reach these goals.

Public opinion

Society in general is moving toward "green" behavior and consumption patterns. This trend also applies to how people move. The use of public transport is increasing. Sales of smaller cars are also increasing—and this trend is not solely the result of governmental fiscal measures. The trend affects the average curb weight of cars, which decreased from 1,125 kg in 2006 to about 1,000 kg in 2009. These developments positively affect the future prospects for HEVs and EVs. As explained before, numbers are still marginal, even for the popular hybrids. As is the case with other products, a sustained support of "green" cars is needed to improve transport options to reach national environmental goals.

Government plans and policies

As previously mentioned, the market for hybrid and electric vehicles in the Netherlands depends mainly on the supply of these vehicles from manufacturers outside the country. However, this market can be influenced by specific policies of the Dutch government, such as fiscal measures and entry rules for urban areas (i.e., environmental zones in cities). Research, development, and demonstration plans have triggered research projects, and plans for the 2009–2015 time period are in place.

The government established a program in 2010 to support demonstration projects that focus on BEVs and PHEVs in specific transportation applications. These projects will provide information to determine and evaluate how these vehicles operate in practice.

In brief, the core figures related to the government plans and policies are as follows:

- Optimistic scenario: 1,000,000 EV/HEV/PHEV in 2020 (ca. 8% of total, ca. 50% market share in new car sales)
- Realistic scenario as followed by Dutch government: 200,000 EV/HEV/PHEV in 2020
- Optimistic scenario: 5,000,000 EV/HEV/PHEV in 2030 (ca. 30% of total).

The market for the FCEV has not been predicted yet. This depends on developments in other countries (with Germany as the closest market example) and by pushing the FCEV application to become a serious transport alternative by 2015. Dutch strategy is to follow the FCEV market closely and take measures that both support and take advantage of measures in surrounding countries.

Core technologies

The Netherlands does not have a national car manufacturer. DAF Trucks (a United Statesbased PACCAR company) is the only truck manufacturer with the capacity to develop products, produce components, and assemble vehicles. The country does have universities and a few research institutes with R&D capabilities. These resources are used by vehicle manufacturers throughout the world. In an institutional sense, the HTAS Program will play a major role in the future development of core technologies. Charging infrastructure can be another strong point of Dutch industry. In the FCEV case, strong business cases should be developed to create long-term success based on the innovative, original products conceived by smaller but highly innovative companies.

Market developments

DC-TEC

As described in the Policy and Legislation section, over two dozen Dutch companies and authorities so far have bundled their demands in a purchasing consortium, the Dutch Consortium for the Tender of Electric Cars (DC-TEC).

The goals of the consortium reach beyond the mere procurement of EVs with these activities:

- Creation and fulfilment of initial demand for successful development of the electric vehicle market in the Netherlands by reducing the barriers for businesses in electrifying their fleets
- Dissemination of knowledge about electric vehicles
- Creation of operational boundary conditions that meet the threshold levels of conventional internal combustion engine technology
- Encouraging manufacturers to step up the development of electric drivetrains

DC-TEC is open to public and private companies established in the Netherlands that are willing to purchase at least 10 EVs. The project aims for participation from large, front-runner companies that manage the environmental impact for operations. They must understand the merits and potential drawbacks of E-vehicles, have the capability to adapt their logistical concepts, and install charging points along with other infrastructure needs. In doing so, the risk factor is minimized.

Other developments

In another new development, Amsterdam has signed a letter of intention with Nissan, in order to have 1,000 EVs in operation by the end of 2011. More market developments have been described earlier in this report. The Dutch market is open with a large front-running group of buyers, but the numbers will still remain relatively low. By offering an inviting infrastructure, market development could nevertheless keep pace with other European countries. This also applies for hybrid trucks, EV passenger cars, PHEVs and other EVs. In 2011 plans will be made to ensure a similar approach for FCEVs.

Infrastructure for PHEVs

The increased use of the electrical grid for plug-in charging of PHEV batteries is becoming more technically feasible, but some issues must still be resolved. These issues relate to the dependency of the battery capacity to provide a greater all-electric range (AER), technical and infrastructural limits, the safety of connections, and the impacts of PHEV electrical demand on electricity production and utilities. Because the mean commuting distance in the Netherlands is less than 20 km one-way, the PHEV represents a good fit to meet Dutch transportation needs. Thus, a PHEV (40) (i.e., a PHEV with an AER of 40 km) would supply enough electric power for most commuting and short trips in a city.

By the end of 2010, no PHEVs were on the market in the Netherlands. The outlook for the PHEV category is very positive in the short term. High battery cost and AER limitations prohibit a massive rollout of BEVs in the near term. Although BEVs did not play a major role in national policy plans in earlier years, they may account for up to 40–50 % in sales by 2020. A separate approach for infrastructure has yet to be defined.

Energy and environmental impacts

Even though fuel prices have risen rapidly over the last 3 years, the average annual number of kilometres travelled by a vehicle has also continued to increase slightly (for a private car powered by gasoline, to about 10,500 km; for the average of all private cars powered by all fuels to 13,800 km). Since the penetration of hybrid cars into the total market will be slow during the next five years, the beneficial energy and environmental impacts will be limited during this period. Nevertheless, HEVs and PHEVs will have a substantial positive impact on local air quality in urban areas. The hybridization of delivery vehicles (i.e., distribution vans and trucks) and public transport buses will also positively impact air quality in cities. Substantial product development and improved production capability are needed before EVs establish a dominant market position and have a large energy and environmental impact.

24 Portugal

24.1 Introduction

Portugal is pursuing an integrated strategy for electric vehicles (EVs) to ensure they are a viable transportation option in major cities by the end of 2011. In the recent past, the energy supply has comprised fossil-fuel imports of coal, natural gas, or oil. However, the energy supply is changing—as of 2009, Portugal is producing 43%, or approaching one-half, of its energy from domestic renewable sources such as hydro, wind, and solar power. As a result of this increased reliance upon domestic renewable energy, the nation is interested in converting its transportation system entirely into electricity-powered vehicles. Portugal currently has about 2,500 hybrid electric vehicles (HEVs) on the road, but the national policy focus has switched to pure EVs.

Electric mobility represents a crucial opportunity for future sustainability in Portugal. Increased use of EVs powered by domestic renewable energy results in reduced carbon dioxide (CO_2) emissions and other air and noise pollution. EVs will also lessen the country's dependence on imported fossil fuels and lead to improved trade balances.

In early 2008, the Portuguese Government launched a national Program for Electric Mobility, aimed at creating an innovative electric mobility system that includes intelligent electric grid management. As a result, MOBI.E (from the phrase *Mobilidade Eléctrica*) was created as an innovative electric mobility model and technology and is the first charging network in the world with national coverage. The MOBI.E electric mobility model, developed by INTELI, a Portuguese think tank, is a fully integrated and totally interoperable system. The Portuguese Government and MOBI.E partners believe a global strategy and an electric mobility action plan are needed, and Portugal is poised to share its experiences. Transnational approaches for electric mobility should be designed with a special focus on the vehicle users that ensures full compatibility and interoperability.

The MOBI.E smart integration between mobility and energy systems will result in using vehicles as a "decentralized mega-battery" that can store excess renewable energy for return to the grid during periods of high electricity demand and charge the vehicle batteries during periods of low demand when the electric grid is supplied by renewable energy. With a single card, a user may charge the battery of any electric vehicle at any charging point around the country with electricity supplied by any retailer.

A public network with national coverage (1,350 charging points in the 25 main cities and roads), is being implemented, thus allowing electric vehicle users the ability to travel throughout the country without range anxiety. The network will be complemented in a demand-driven approach by private operators, which will contribute to build a wider and more comprehensive network for streets, public car parks, shopping centers, service stations, hotels, airports and private garages, as depicted in Fig. 24.1.

Fig. 24.1 MOBI.E charging stations offer flexible solutions for users. (Source:MOBI.E and the Office for Electric Mobility (GAMEP).)

24.2
Policies and legislation

MOBI.E Electric Mobility Model

MOBI.E is based on an open-access, fully interoperable system that is able to integrate different players of the service value chain. MOBI.E enables the integration of several electric mobility electricity retailers and charging service operators into one single system, thus stimulating competition. The central management system, with a dedicated layer for full compatibility, makes it possible to integrate any charging equipment from any manufacturer and to connect to multiple systems from third parties. Hence, MOBI.E allows any user to charge any vehicle in any location without any worries for technical compatibility, by using a single subscription service and authentication mechanism.

The MOBI.E model has led to the creation of three new types of electric-mobility entities:

Electric Mobility Operator: *the physical interface.* The Operator is the entity that operates the charging points, making the charging service available to vehicle users/ customers through the different Electricity Retailers. The Operators are remunerated according to the electricity that runs through the infrastructure maintained by them.

The Electricity Retailer: *the arena for competition.* The Electricity Retailers are the entities supplying and selling electricity (through the charging points managed by the Operators). And this is where the market is open to competition. In order to differentiate from its competitors, every Retailer can set different electricity tariffs and enable access to associated services, such as the payment of car sharing, car parking, public transportation, and other services that may be integrated with the MOBI.E system. Every EV user may have a contract with any Retailer (or more than one).

The Managing Authority: *a clearing house.* At the top of the system, there is a Managing Authority for the Operation of the Electric Mobility Network. This entity is responsible for the management of energy and financial flows from electric mobility network operations. The Managing Authority is thus a platform for the integrated management of electric mobility, available to all Operators, Electricity Retailers, and Users.

In practical terms, the MOBI.E electric mobility model, as implemented in Portugal, sets the business relations between the different stakeholders. The relationship of these entities to one another is shown in Fig. 24.2. Below is an example of a transaction in this system.

- The EV user pays a total fee to the electricity Retailer for three parts: electricity, charging service, and MOBI.E central system costs.
- The electricity Retailers pay the electric mobility Operators for the use of the charging point. There is a ceiling currently set by Government legislation for the maximum charging service fee to be paid (€0.03 to €0.07 per kWh for normal charging; €0.20 per kWh for fast charging). Electricity is to be offered at a non-regulated market price.
- All fees received by the managing authority for system access and usage (paid by the Electricity Retailers and Electric Mobility Operators) are regulated by the ERSE (the Energy Services Regulatory Authority).

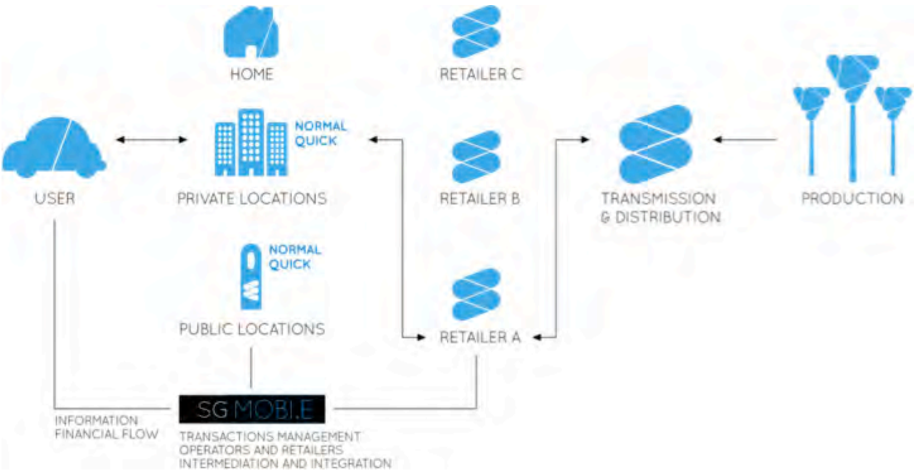


Fig. 24.2 The Portuguese electromobility value chain. The Electric Mobility Operators are represented by the list of sites where charging points are located (home, private locations, and public locations). The Electricity Retailers interact with the Operators through the Managing Authority, shown as SG MOBI.E. (Source: MOBI.E.)

Further details about current progress in implementing MOBI.E will be discussed in section 24.5 below.

Complementary legislation and incentives

The support to implementing a national mobility network based on the MOBI.E model is the country's key policy initiative relating to electric vehicles. Under the coordination of the Office for Electric Mobility (GAMEP), established within the Portuguese Ministry of Economy with direct connection to the Prime Minister's Office, a specific legislative package establishing a well-defined, yet flexible, framework for electric mobility was introduced in April 2010, based on MOBI.E. The legislation package is designed to ensure full integration and transparency resulting in low barriers to entry for business-stakeholders with a clear picture of the return-on-investment to attract private investors. The legislative framework defines actors and roles, high-level specifications, and a comprehensive set of incentives for vehicle purchase and operation, circulation and parking, infrastructure installation, and the main structure for market regulation.

In addition, several direct and indirect incentives for EVs have been enacted. According to the Portuguese electric mobility legislation, an electric vehicle is defined as any vehicle that can be plugged into the electric grid. However, all direct and indirect incentives as outlined in box 24.1 are solely restricted to fully electric vehicles

(PHEVs are not included) in order to coherently maximize the measures' effectiveness and impact.

BOX 24.1
INCENTIVES TARGETING EVS IN PORTUGAL

- Exemption of EVs from ISV (Vehicle Acquisition Tax) and IUC (Circulation Tax)
- Consumer incentives for EV acquisition up to a maximum of €6,500 to apply to the first 5,000 electric vehicles sold until the end of 2012
- Corporate tax deduction for fleets that include EVs
- Mandatory installation of electric mobility charging infrastructure in the parking areas of new buildings, starting in 2010
- Special EV access to priority lanes and exclusive circulation areas
- Preferential parking areas for EVs in urban centers
- Annual renewal of State and municipalities' fleets with 20% of EVs, from 2011 onwards
- Financing of pilot network infrastructure

As a result from the Portuguese Electric Mobility Program, the country is today a natural environment for the development and testing of electric mobility-related systems and technologies.

The following factors can be used to support the perceived economic importance of electromobility in Portugal:

- In order to implement renewables and green policy, leadership included both small- and medium- enterprise (SME) along with large corporations with diverse energy knowledge into the electricity value chain (see figure 24.1).
- The experienced and multinational automotive cluster sees electric mobility as a defining moment for its growth and development in the face of recent competition from the eastern European countries.
- A young, talented and entrepreneurial information and communication technology (ICT) community that has the required skills and creativity to overcome the challenges from the paradigm shift in mobility.

The exploding world economic and sovereign debt crises have put Portugal under severe market pressure that could, at least in theory, endanger the transition from internal combustion engine (ICE) vehicles to electric vehicles. However, the momentum has been created, and the government role has been mainly one of leadership and coordination of the myriads of market-driven international collaboration projects that are largely perceived as self-sustainable.

24.3 Research

At the research level, interest from the academic community is building following the country's strong push for electric mobility. The main research focus in Portugal has been on the development of an intelligent and integrated infrastructure to support the deployment and evolution of the current national network for electromobility. The technological solution was the result of significant investments in research and development (R&D) and engineering by Portuguese companies and R&D organizations from a wide range of technological areas and industrial sectors: automotive, electric and electronics systems, ICT, and energy. The technical solution includes all the operational, security and safety specifications, leading to the full integration of all information and energy flows and financial transactions.

The development of new generation mobility solutions—with MOBI.CAR and MOBI.BIKE as two leading examples—contributes to a fully integrated electromobility solution. In particular, the consortium now leading the implementation phase, comprising companies and research centers such as EFACEC in the integrated and differentiated electromechanical and electronic systems business; the IT company Novabase and Critical Software (IT systems and solutions); the innovation center INTELI; and the Centre for Excellence and Innovation in the Auto Industry (CEIIA), began in late 2008 from a research project that originated the MOBI.E innovative concept and technology.

Fig. 24.3 The MOBI.E Intelligence Center in Maia in northern Portugal manages the EV charging network in real-time. (Source: MOBI.E)

Mobility Intelligence Center

Based in Maia, the Mobility Intelligence Center is the MOBI.E network monitoring center. Here, charging network managers have real-time access to all their charging stations, always being informed of which are in use and which are available, daily and monthly charging averages, as well as the quantity of power supplied. This center is promoted by INTELI and was established with the following objectives:

- To become the core of the integrated platform that will operate and monitor the Portuguese electric mobility system (MOBI.E) both in business and network management, providing technical support to the managing authority
- To be a space for real-time electric mobility demonstrations, where it is possible to interact with and implement add-on solutions to the MOBI.E platform that are available to the technological partners
- To be a support platform for research, development, and innovation (RDI) initiatives towards the development of solutions, products and services for electric mobility
- To provide certification and homologation for equipment and systems to ensure technical compatibility and interoperability within the MOBI.E system.

E2 Research Net

One other very important research-fostering initiative has been the launch of the Sustainable Energy Systems & Electric Mobility Research Platform and Network (E2 Research Net) which integrates research teams across the entire Massachusetts Institute of Technology (MIT)–Portugal educational and research joint venture with goals for new research and advanced training in systems of electric mobility and renewable sources. It brings together industry, academia, and government agencies building on recent initiatives in Portugal to implement various forms of electric mobility. The ultimate goal is to provide new solutions and systems for markets worldwide, making use of emerging competencies and knowledge from test-beds currently under development. Entities involved include the University of Minho, Faculty of Engineering at the University of Porto, Instituto Superior Técnico, MIT-Portugal, EFACEC, CEIIA, Simoldes, INTELI, Novabase, and others.

In addition to the research projects in the paragraphs above, Portugal has many other research projects underway as seen table 24.1. The entire research network brings together diverse technical areas. Soon it will be a formal electromobility cluster with advanced knowledge in mobility, energy and ICT systems.

Table 24.1 Summary of main research initiatives related to electromobility.

Project Name	Short Description / Objectives	Main Entities Involved (in Portugal)
MOBI.E Pilot Project	Research project for the full development of a large-scale national demonstrator with the following components: normal charging solutions, fast charging solutions, home charging solutions, and a complex ICT platform for the full network management both from an energy and business perspective.	INTELI, EFACEC, Critical Software, Novabase, CEIIA
MOBILES	To create ICT-based solutions to support electric mobility, in particular mobile-based applications with navigation systems for support	NDrive, FEUP, INTELI, CEIIA and INESC-Porto
MERGE	Development of a management and control concept that will facilitate the actual transition from conventional to electric vehicles; adoption of an evaluation suite of tools based on methods and programs enhanced to model, analyze, and optimize electric networks where EV and their charging infrastructures are going to be integrated	INESC-Porto, among other international partners
Green Islands Azores Project	MIT-Portugal flagship research project developing new energy planning tools to assist the local government and people in identifying strategies to meet their energy needs with indigenous energy resources, namely through smart energy networks; smart-end uses; renewables resource dynamics; and sustainable mobility applications.	MIT-Portugal community
MOBI.CAR	Flagship project within the competitiveness pole for the mobility industries, which aims to fully engineer and design a light electric vehicle that embodies the green car revolution	CEIIA, VN Automóveis
TICE.MOBILIDADE	Flagship project within the competitiveness pole for ICT, which aims to explore new solutions for urban transport through the use of ICT in an ecological and energy efficient perspective	ICT Competitiveness pole companies
MOBI.BIKE	To conceive and develop a complete solution (infrastructure + charging point + bike) integrated within the MOBI.E system. Further integration with the urban transport management so as to increase capillarity. To identify and develop new opportunities for the national industry in terms of engineering design, materials and structures and urban mobility services	CEIIA, Abimota

24.4 Industry

Electric vehicles will be available to the market in 2011 through a public-private partnership between Portugal and automaker Renault-Nissan Alliance that began in 2008. In July 2009, Renault-Nissan built upon its commitment to Portugal by announcing that it would build a new €250 million (US$ 355 million) plant in the city of Aveiro to produce 60,000 lithium-ion batteries a year for electric cars.

In spite of not having a national car manufacturer, the Portuguese automotive cluster has attracted quite a good number of leading companies as well as supplies and component firms. Five of the six main component suppliers in the world are present in Portugal. Leading industry players such as Volkswagen (VW) and Opel, and all the numerous suppliers and component firms such as Visteon, Delphi Automotive systems, Robert Bosch, Faurecia, Lear and Johnson Controls are present in Portugal.

Automotive production

Car brands manufactured include Volkswagen, Seat, Citroen, Peugeot, Mitsubishi, Toyota and Isuzu. Roughly 97% of all vehicles assembled were destined for exports. Automotive production amounted to 126,015 vehicles in 2009 from five assembly plants with the vehicle type presented in figure 24.4:

1. VW Autoeuropa (1,307 M€ in sales with 86,008 vehicles),
2. Peugeot Citroen (269.2 M€ in sales with 34,520 vehicles),
3. Mitsubishi Fuso Truck Europe (2,850 vehicles),
4. Toyota Caetano (1,967 vehicles), and
5. VN Automóveis (670 vehicles).

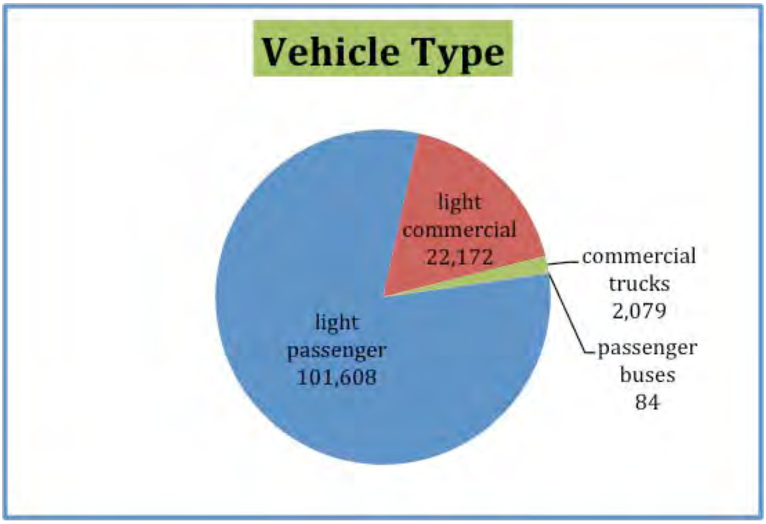


Fig. 24.4 Automotive production in Portugal during 2009 by vehicle type.

Auto component industry

There is a very strong and multidisciplinary auto component industry in Portugal whose main areas of production are electric and electronic components (29.3% of total industry production/sales or turnover), metalomechanics (31.8%), polymers and composites (19.5%), textiles (11.6%), assembly (3.6%) and moulding (3%). Summary industry figures are presented in table 24.2.

In terms of the relative position within the auto component industry supply chain and its weight on industry production, 55% is generated from Tier 1 suppliers, 25.2% from Tier 2 suppliers, 7.0% from Tier 3 suppliers, and 12.8% from aftermarket.

Geographically speaking, 22.2% of auto component industry sales come from Germany, 21% from Portugal, 18.3% from Spain, and 16.2% from France, while the remaining countries include United Kingdom, Belgium, United States, Italy, Sweden, and Austria, among others.

Table 24.2 Automotive component sector industry statistics for 2009. (Source: AFIA – Portuguese Association of Automotive Suppliers.)

Number of Companies	180
Sales	€5,116,000,000
Sales (% GDP)	3%
Exports (% Sales)	79%
Employment (number)	39,600
Employment (%)	4.7%

The automotive sector is forward-looking and benefits from several important ongoing R&D initiatives and support programs. The Centre for Excellence and Innovation in the Auto Industry (CEIIA) was created to support the development of technical knowledge and strategic competencies of companies active in the sector and to identify potential business, technological, and financial synergies amongst industry players. This organization is also one of the main driving forces behind the electrification of the auto industry in Portugal, while also playing a defining role in the engineering development and design of the charging stations being installed.

In particular, within the newly created Competitiveness and Technology Pole for the Mobility Industries, which CEIIA coordinates, an industrial electric mobility cluster is currently well underway involving some of the major industrial companies in Portugal in order to develop products and solutions around electric mobility, as outlined in the table 24.3.

Table 24.3 Top industrial areas in the Portuguese electromobility cluster.

Products	Short Description	Main Companies Involved
Electric Bus	Development of electric bus	CaetanoBUS
Electric Bicycles	Development of electric bicycles and scooters for urban use and bikesharing solutions	CEIIA, Abimota (National Association for Two-Wheel Vehicles Industry)
Light Electric Vehicles	Development of LEV (L7 homologation) for both passenger and commercial use	CEIIA, VN Automóveis
EV Charging Systems	Development of EV charging solutions: indoors / outdoors, normal / fast, 4-wheel / 2-wheel vehicles	CEIIA, Efacec, Siemens, MagnumCAP
IT Systems	Development of IT platforms for electromobility network communication, management and services	Novabase, Critical Software
Smart Grids	Development of fully intelligent electric networks bridging together many applications: electric mobility, intelligent homes, efficient companies, public spaces and distributed generation	EDP, Efacec, INESC-P, Logica, Janz

24.5 Charging infrastructure and vehicle deployments

Portugal's electric mobility program is widely known as MOBI.E, and much of the structure of this program was explained in section 24.2. Here we will discuss the progress in its implementation, as well as that of related projects.

Developed via the MOBI.CAR program, Portugal's 100% electric Mobicar will start to be assembled in 2011 and will roll out in 2012. With a range on a single charge of 120 km (74 miles) and a top speed of 100 kmph (62 mph), the three-seater compact vehicle is being developed at the CEIIA in Porto, in collaboration with Spain's CTAG, among other entities, companies and universities.

The initial phase of MOBI.E includes both building a nationwide recharging infrastructure and growing the domestic market for EVs, which will begin commercial sales in Portugal in 2011. The MOBI.E consortium took delivery of nine Nissan LEAFs in December 2010, becoming the first commercial customer in Europe of the world's first mass-market 100% electric vehicle. The keys to the cars were handed over to the CEOs of the nine companies belonging to the MOBI.E consortium in a ceremony in Lisbon. Nissan also presented a set of keys to the Portuguese government who receives one Nissan LEAF on loan for test-drive purposes. Prime Minister

José Sócrates accepted the keys on behalf of the government. Portugal was the first country in Europe to establish a direct electric vehicle partnership with the Renault-Nissan Alliance in November 2008, signing an agreement to build a widespread re-charging network at Portugal and to promote the benefits of zero emission mobility.

Fig. 24.5 MOBI.E vehicle electrification project includes installing charging stations in 25 municipalities and along main highways in its pilot phase (shown on the Portugal country map at left) as well as developing its own 80-km range battery-electric vehicle Mobicar, primarily aimed at the export market. (Source: MOBI.E.)

In June 2008, Prime Minister Jose Socrates unveiled plans for a nationwide pilot network of 1,350 recharging stations (1,300 normal and 50 fast chargers) for EVs spread across 25 cities by June 2011 (see figure 24.5). The first MOBI.E charging point was inaugurated on June 29th, 2010 in Lisbon, the capital city where nearly half of the charging stations will be installed. A total of 320 charging stations were installed in the MOBI.E network in 2010. Additionally, in order to reach the entire Portuguese territory, the Regional Electric Mobility Programs for Madeira and Azores have already been launched, acknowledging the importance of the MOBI.E approach as an enabler for the Green Islands vision.

The initial phase for MOBI.E is publicly funded, but one of the program goals is for private business development using renewable energy sources to expand the network. This network will gradually grow with the involvement of private partners, some of which have already joined the network. A wide and comprehensive network is underway, including charging points along streets and in public car parks, shopping centers, service stations, hotels, airports, and private garages. Legislation has defined that it is mandatory for all publicly accessible charging stations (either in private or public sites) to be operated by Charging Point Operators (see section 24.2), which in turn must have them connected in real time to the central MOBI.E system. The MOBI.E charging network then includes different charging profiles, according to developing technologies and standards. Currently, there are two predominant types of charging stations:

- Normal charging stations: At home, for fleets, on-street and off-street parking, and
- Fast charging stations: on main roads and highways, in service stations and other strategic urban locations.

The charging infrastructure is expanding, and there has been much enthusiasm from the majority of the municipalities beyond Lisbon to participate. In order to achieve network coherence, national authorities require each municipality to submit its local electromobility strategic plan. This plan includes a medium- to long-term vision, including proposed locations for EV charging stations for all types of electric vehicles, as well as public transportation integration at both the local and regional level.

Public infrastructure is important as a decisive and enabling success factor for electric mobility, but one main focus will be at the domestic level to maximize nighttime, off-peak charging that involves the following building modifications:

- Gradual renovation and rewiring of existing residential buildings to accommodate the increase in power requirements with the adoption of electric vehicles, and
- Mandatory pre-wiring of parking spaces for all new buildings for electric mobility purposes.

Table 24.4 Summary of charging infrastructure technical characteristics.

	Public Infrastructure		Private/Domestic Infrastructure		
	Mode	Plug		Mode	Plug
2-wheel vehicles	1	IEC-60309 up to 16 A, schuko up to 10 A	Charging Power less than 2.5 kW	1/2	IEC-60309 up to 16 A, schuko up to 10 A
4-wheel vehicles	3	IEC-62196 Type 2 up to 63 A	Charging Power more than 2.5 kW	3	IEC-62196 Type 2 or fixed cable up to 63 A

Charging Technical Aspects

The Portuguese government has taken an official position concerning the standards for use in the electromobility infrastructure. Table 24.4 summarizes the recently proposed infrastructure technical configuration to be included in the legislation. As the table suggests, different needs and requirements associated with two-wheel and four-wheel vehicles both in technological terms and in their role in the urban mobility systems have led to the development of specific solutions for the associated charging infrastructures, all of which are fully integrated into the MOBI.E system.

The reference charging concept developed by MOBI.E partners for street charging is based on a highly flexible and modular solution: one central station capable of managing several satellite stations, which concentrates authentication, management, and communication in one single unit with a set of satellite stations (plugs). As of 2011, each satellite station is equipped with one IEC 60309 single phase 16A socket in each output (the central station can also have outputs) allowing for EV charging in mode 1 or 2 (mode 3 upgrade is underway). The central station makes use of a 3G/GPRS communication system in order to communicate with the central management system, while users provide authentication through a CALYPSO card. Standards are an important aspect for interoperability. The current standards and national legislation followed by Portugal are as follows:

- ISO 14443 standard for authentication
- IEC 61851 IEC for charging modes
- IEC 62196 for plugs
- Low Voltage Directive 2006/95/CE
- Electromagnetic Compatibility Directive 2004/108/CE and IEC 61000 CHAdeMO protocol for DC fast-charging applications

The mix of energy sources expected for EV charging is dependent on the user's choice of retailer and the available type of electrical energy supply. Some retailers will guarantee 100% clean electricity such as Energias de Portugal (EDP) Commercial Verde, which offers a similar product for the domestic user. One example for the type of supply and associated vehicle emissions is from December 2010 where the electricity mix provided by the main reseller, EDP Serviço Universal (regulated), is as follows: 34.4% wind, 21.1% hydro, 13.1% natural gas, 11% coal, among other sources. The corresponding emissions are around 225 g CO_2/kWh or approximately 45 g CO_2 eq./100km for an EV.

However, one of the most important features and strengths of the MOBI.E platform is the real-time monitoring of electromobility impact at all levels. The platform will know the precise mix of the electricity being consumed at the individual level and for all users and communities in the MOBI.E network. Table 24.5 presents additional services to be offered to the multiple MOBI.E network stakeholders.

Table 24.5 Examples of services offered to the MOBI.E network stakeholders.

For Users	For Charging Operators	For Electricity Resellers
• Multi-platform access • Charging station location and availability • Charging station reservation • Car battery status • Mobility management and historical track • Aggregation of Value Added Services (parking...)	• Information on network status • Remote management of charging stations • Financial settlement service for Value Added Services (parking, etc.) • Pre-paid / post-paid billing capability for Value Added Services • Integration with third party loyalty programs	• Metering information • CRM platform (clients, contracts, tariffs, helpdesk) • Pre-paid / post-paid billing capability • Loyalty programs • Financial settlement service for base and Value Added Services

24.6 On the road

From a national perspective, taxes on the Portuguese automotive market represent roughly 20% of the total state tax income. Over the past five years, annual car sales have maintained an approximately constant rate of around 250,000 units (272,761 in 2010). The lowest year for sales with 203,760 units was in 2009. The strong increase in 2010 is mainly a result of the government program for end-of-life vehicles. The total number of all vehicles in Portugal is represented in table 24.6.

In terms of energy efficiency, Portugal has become the first country to meet European Union fuel-efficiency goals for cars, which set a target for cutting average emissions from new cars to 130 grams of CO_2 per km by 2015. In fact, average car emissions in Portugal's new car market were 127.4 grams of CO_2/km in 2010, the lowest in the European Union.

Table 24.6 Portugal's vehicle fleet numbers by type for 2009 and passenger vehicles for 2010.

Vehicle type	Total vehicle fleet (including HEVs, PHEVs, and EVs)	EVs	PHEVs	HEVs	Date of vehicle fleet information
Bicycle (no driver license)					2009
Motorbike	199,270	261			2009
Passenger vehicle	445,7000	71			2010
Multipurpose passenger vehicle	120,4000				2009
Bus	15,500	3			2009
Truck	133,000				2009
Industrial vehicle	195,000				2009

As a consequence of the direct incentive for EV acquisition of €5,000 for the first 5,000 vehicles (exclusively for individual private users), and the strong disincentive of ICE-based vehicles in favor of EVs for company fleets, it is expected that the number of EV cars on the road by the end of 2012 will be over 10,000 units. In absolute terms, two-wheelers will also be one of the main drivers for EV adoption in Portugal with the deployment of specific charging solutions in specific locations. PHEV vehicles are expected to be available in the market in the latter half of 2011 with the arrival of the Opel Ampera and Chevrolet Volt.

24.7 Outlook

The government estimates that Portugal could have roughly 200,000 EVs on the roads by 2020, with approximately 25,000 public charging stations in its network. In best-case scenarios, these figures will hopefully be amplified by a continuously strong interest from public authorities and private companies, as well as the necessary technological breakthroughs that are predicted. Portugal's major electricity operator and business group EDP estimates that the recharging market could be worth up to €2 billion (US$ 2.8 billion) in 2020. From an environmental perspective, electric mobility will account for roughly 700 kton of avoided CO_2 emissions in the year

2020, in addition to over 300 M€ in energy-import savings.

Portuguese culture traditionally has supported innovative technologies and new business models. Due to this progressive culture, rapid acceptance is anticipated as different electric vehicles are launched in the market and customer expectations are met. In terms of public opinion, surveys have shown that there is still a general lack of knowledge on the subject of EVs in spite of the interest and curiosity exhibited by the general population. According to recent studies, although 75% of the general population is still unaware of what an electric vehicle represents, more than 50% of the people surveyed have the intention to purchase an EV in the near future and acknowledge the inevitability of the shift towards greener technologies and behaviors in mobility and transport.

The current EV technology clearly delivers the required performance in terms of average daily distance travelled in the main urban areas of the country. The PHEV will also play a vital role as an intermediate technological alternative, which seems to bring an almost ideal compromise for current auto users. In order to attain effectiveness (and due to limitation of resources), the focus has been on fully electric vehicles rather than PHEVs or hybrid electric vehicles, because these intermediate solutions (even if more expensive than current ICE-based technologies) already presented a sustainable business case without the need for further government incentives.
In fact, current legislation has devised a tax-based strategy in which ICE-based vehicles will be gradually disincentivized, with particular impact at the corporate tax level, thus indirectly supporting EV adoption. Myriads of companies have shown interest in adhering to the electromobility movement motivated for economic benefits, for social responsibility, for an improved sustainability rating, and above all for the promise of the multiple innovative business models that can be created all around a smart grid for electromobility. Additionally, the ability to quantify avoided CO_2 emissions or energy consumption into "White Certificates" (energy efficiency standards) and "Green Certificates" (renewable energy standards) that are traded and have monetary value will need to be determined for EVs.

Beginning with the electric vehicle, Portugal is taking the opportunity to revolutionize its own urban mobility model with profound impact both at the individual and public transportation level due to the adoption of intelligent ICT-based technologies that enable true seamless integration and the creation of value-added services focused on the user needs.

Starting with the setup of a unique legislation package that defines all the system architecture both at the business and technical level, Portugal clearly advocates for the fast and formal adoption of common standards for vehicles, charging infrastructure, and communication business protocols. With the foreseen success of diverse electromobility models, common platforms will be required in order to ensure transnational interoperability in terms of vehicles and systems.

In summary, even if the national outlook for electric vehicles is severely dependent on the country's ability to successfully overcome its short-term financial difficulties for achieving sustained economic growth, electromobility is perceived as a strategic sector in order to leverage for medium-term economic success of the country.

25 Spain

25.1 Introduction

The Spanish government continues to work toward its goal of putting one million hybrid and electric vehicles on the nation's roads by 2014. This includes a target of 250,000 battery electric vehicles and plug-in hybrid electric vehicles (BEVs and PHEVs), corresponding to about 1% of the total Spanish auto fleet. This ambitious goal shows the firm commitment of Spain to promote alternative fuel vehicles, in particular hybrid and electric vehicles.

A major impetus for these efforts is to reduce Spain's heavy reliance on foreign energy supplies. At present Spain relies on external sources for 77% of its energy, with oil consumption accounting for almost half of the country's total energy usage in 2009. The transportation sector used 38.8% of total energy consumed in 2009—the most of any sector—and it consumed 65% of oil imports. Within the transportation sector, road transport accounts for fully 80% of the energy consumed, with virtually all of this energy coming from oil.

This strong reliance upon road transport has led to an unbalanced situation in this sector, with negative impacts on Spanish energy independence and efficiency as well as on the national transportation infrastructure. It also contributes to Spain's greenhouse gas emissions, with just over a quarter of Spain's CO_2 emissions (25.5% in 2009) produced by the transportation sector.

If all the vehicles on Spanish roads were electrically driven, national oil imports could be cut by half—helping Spain reduce its trade deficit by 25%—and it would also help the country to realize emission reductions of 81 million metric tons of CO_2 (MMT-CO_2) per year, or about 18% below 2007 levels. This translates into 1,000 million Euros (1,000 M€) per year in CO_2 emissions rights.

One notable fact is that 53.2% of all the electricity produced in Spain in 2010 was free of CO_2, with renewable energy sources accounting for a 32.6% of the total. In this way, a widespread implementation of EVs that would require overnight charging could even increase the portion of renewable energy sources in the Spanish electricity generation mix, especially in wind energy. Due to its geographical location on the Iberian Peninsula, Spain is practically energy isolated, so it is currently common practice to stop wind generation plants at night in order to match the reduced electricity demand.

25.2 Policies and legislation

Spain's policies to promote HEVs, PHEVs, and BEVs have been developed within the framework of its national commitments to meet international goals. In December 2003 the country's parliament approved the Spanish Strategy for Energy Savings and Efficiency 2004–2012 (or E4, as it is more frequently referred to). E4 is a policy strategy that seeks to reduce energy consumption in accordance with Spain's international agreements while working toward the goal of a secure energy supply and maintaining a competitive economy.

Two Action Plans (one for the period 2005–2007 and another for the period 2008–2012) have been implemented under E4. These Action Plans define relevant measures, key stakeholders, and budgets for improving the energy efficiency of different sectors. E4 also covers a large percentage of the objectives for CO_2 reductions in Spain's National Plan for GHG Emissions. For the transportation sector, up to 9,087 ktoe (kilo-tonnes oil-equivalent) of energy consumption could be reduced by adopting the most stringent measures in these plans compared to the business-as-usual scenario. Promotion of alternative fuels and vehicle technologies (LPG, natural gas, HEV, PHEV, BEV, hydrogen and fuel cells) represents a key action line in this strategy. E4 has been complemented by the Activation Plan on Energy Efficiency and Savings 2008–2011 that enhanced the former's objectives through various initiatives including the MOVELE project (discussed below).

A further major specific "Integral Plan for the promotion of electric vehicles" was presented by the Spanish government in April 2010. This plan includes an "Integrated Strategy for EVs 2010–2014" promotion in Spain, and its two action plans (2010–2012 and 2012–2014) define specific actions to develop their respective budgets and responsibilities in both periods. The Integrated Strategy sets the goal of putting one million hybrid and electric vehicles on Spain's roads, with 250,000 of this total to be BEVs and PHEVs.

The section below discusses in more detail the E4's three strategic programmes related to the introduction and widespread deployment of hybrid and electric vehicles. The purpose of two of these efforts is to facilitate fleet renewal through the establishment of incentives for the acquisition of alternative vehicles, including hybrid and electric technologies. The third effort supports the acquisition of BEVs and PHEVs (exclusively) and involves a demonstration project for EV charging infrastructure, the MOVELE Project. After these programmes, the Integrated Strategy for EVs promotion in Spain approved in April 2010 is discussed.

Agreements between IDAE and Regional Administrative Governments

The first E4 strategic effort involves sets of agreements between the national government's Institute for Diversification and Saving of Energy (IDAE) and Spanish regional administrative governments to support actions that improve energy efficiency in various sectors. The budget for these actions is supported by IDAE and the regional governments in a 77%–23% split. These programmes started in 2005 and are renewed each year with an assigned budget and planned actions to carry out in each region. Regional governments are responsible for implementing these measures in collaboration with IDAE.

In the transportation sector, the agreements are intended to support the acquisition of hybrid and electric vehicles and the establishment of electric charging stations for both vehicle fleets and for vehicles belonging to members of the Spanish public. "Fleet renewal" is the key measure used for both categories.

The efforts here are designed to support the acquisition of alternative vehicles based on fuel type (e.g., natural gas, LPG, hybrid, battery electric, hydrogen and fuel cell) and vehicle type (e.g., motorbikes, quadricycles, cars, buses and trucks). Incentives are offered to a wide range of beneficiaries including public and private transport fleets, companies, and individual citizens, and are available also for financial arrangements including leasing and renting. The categories and amounts are listed in Table 25.1.

Table 25.1 HEV and EV incentives provided by IDAE and Spanish regional governments.

Vehicle Types (both private and industrial)	Hybrid & Electric Vehicle Incentives (applicable to both public and private sectors)
Motorbikes	Maximum of €750 for motorbikes above 4 kW
Passenger vehicles (M1), commercial vehicles (N1), and quadricycles (L7e)	Up to 15% of market price, with a maximum of €7,000
Full hybrid	Up to a maximum of €2,300, for HEVs with voluntary pure electric traction and CO_2 emissions below 110 g CO_2/km in 2011
Mild hybrid	Up to a maximum of €2,000, for HEVs without voluntary pure electric traction and CO_2 emissions below 110 g CO_2/km in 2011
PHEV and BEV	Up to a maximum of €7,000, with a minimum electric range of 20 km (12 miles) for PHEVs.
Buses and trucks	Up to 15% of market prices, with a maximum of €50,000

The results of this fleet renewal programme through 2010 are tabulated in Table 25.2 and show how HEVs and EVs have begun to penetrate fleets at increasing rates.

Table 25.2 Results of E4 fleet renewal programme, 2006–2010.

Results of E4 Fleet Renewal Programme, 2006 through 2010		
Year	**Types of vehicles**	**Totals**
2006	Total vehicles renewed (GLP, Natural Gas, HEV, BEV, Fuel Cell) **Hybrid vehicles**	142 **137**
2007	Total vehicles (cars, motorcycles, and industrial) renewed **Total hybrid and electric vehicles**	1,070 **963**
2008*	Total vehicles (cars, motorcycles, and industrial) renewed **Total hybrid and electric vehicles**	3,151 **2,062**
2009*	Total vehicles (cars, motorcycles, and industrial) renewed **Total hybrid and electric vehicles**	3,065 **2,957**
2010*	Total vehicles (cars, motorcycles, and industrial) renewed **Total hybrid and electric vehicles**	3,776 **3,480**
TOTAL 2006–2010	Total vehicles renewed **Total hybrid and electric vehicles for 2006–2010**	11,204 **9,599**

(*): 2008–2010 years show provisional results

Note: The table above shows that fully 85% of the total renewed fleet consists of HEVs and BEVs. Furthermore, the overwhelming majority of these were hybrids (not explicitly shown in the above table). For example, of the 3,480 HEVs and BEVs in 2010, all but 29 were HEVs.

Strategic Support Plans in the Transportation Sector

The second theme in the E4 framework is a series of strategic support plans for different sectors. These strategic plans involve projects concerning at least three different regional administrations, with investments above 1 M€ and to develop in several years. Proposals are annually solicited from all sectors including transportation. Total funding available for this effort for 2011 (beginning in March) is €120 million. This amount is the same as was budgeted in both 2009 and 2010 and double the €60 million in 2008. The four-year total of this funding is €420 million.

Transportation sector projects include support for the acquisition of HEVs, PHEVs, and BEVs through incentives aimed at large operations with a high amount of car renewal. These efforts are mostly channelled by vehicle leasing and renting companies.

Some noteworthy examples relating to buses include the Electrobus I (2009–2012) and Electrobus II (2010–2013) projects that support the acquisition of hybrid buses and the transformation of conventional buses into hybrid ones. In the Electrobus II case, the hybrid buses use CNG technology exclusively. These projects are focused on the transport consortiums in the major Spanish cities Madrid, Barcelona, and Valencia. Another example is the ALSA project (2010–2013) supporting the acquisition of HEV and PHEV buses by ALSA Company, which focuses on coach services providing passenger road transport.

The objectives and budgets for these strategic support projects for vehicle fleet renewal programs are shown in Table 25.3.

Table 25.3 Objectives and budgets of strategic projects/fleet renewal programs.

Results, Objectives, and Budgets of Strategic Projects Fleet Renewal Programs			
Project period	Types of vehicles	Total investment committed	Total vehicle renewal
2008–2012	Renewed cars will include around 400 LPG/CNG vehicles and 1,800 HEVs/BEVs 7 renting/leasing companies participating	36 M€ IDAE support: 4.2 M€	2,200 (1,800 are HEVs/BEVs)
2009–2012	All renewed vehicles will be HEVs 7 renting/leasing companies participating	22 M€ IDAE support: 2.6 M€	1,382
2010–2013	Renewed cars include 899 HEVs and 42 BEVs 10 renting/leasing companies participating	11 M€ IDAE support: 1.45 M€	1,171
Bus projects			
2009–2012	Electrobus I project, including hybrid transformations and hybrid buses (subtotals below)	33.3 M€ IDAE support: 9.3 M€	179
2010–2013	Electrobus II project, including hybrid-CNG transformations, hybrid-CNG buses, BEV buses, and charging points	23.8 M€ IDAE support: 5.1 M€	122
2010–2013	ALSA project, including series hybrid buses, parallel hybrid buses, and BEV buses	26.5 M€ IDAE support: 4 M€	57

Provisional cumulative results of the E4 strategic supporting line for hybrid and electric vehicle renewal are shown in Table 25.4 below.

Table 25.4 Hybrid and electric vehicle renewals under E4 strategic support, 2008–2010.

Strategic projects supporting line: Vehicles renewed 2008–2010					
Hybrids			Gas*	BEV	TOTAL
Full hybrid	Mild Hybrid	All hybrids			
777	122	899	230	42	1,171

*Includes both CNG and LPG vehicles.

MOVELE Demonstration Project EVs and Infrastructure

The third relevant effort oriented to promote electric mobility in the frame of E4 is the MOVELE project (from “MOVilidad ELEctrica”), implemented through the Activation Plan on Energy Efficiency and Savings 2008–2011 that supported the E4 framework’s objectives through various initiatives. One of these initiatives was this major electric vehicle demonstration project in three of Spain’s major cities and financial support for the acquisition of PHEVs and BEVs at the national level.

The MOVELE pilot project, funded with €10 million, is intended to demonstrate the technical and economic viability of electric vehicles. It represents a first step toward electric mobility in Spain as well as a starting point for achieving the Spanish goal of 250,000 BEVs and PHEVs on the road by 2014. MOVELE aimed to put 2,000 PHEVs and BEVs on the road by the end of 2010 and to install a total of 546 charging stations, with 280 in Madrid, 191 in Barcelona, and 75 in Seville. An update on the status of the MOVELE charging stations is given in Section 25.5.

MOVELE establishes public incentives for the acquisition of PHEVs and BEVs up to between 15 and 20% of their market prices (depending on the technical specifications of the vehicles) as shown in Table 25.5.

Table 25.5 MOVELE incentives for purchasing PHEVs and BEVs by vehicle category

Vehicle Category	Maximum support	
(According to European Commission Directives 2002/24/EC and 2001/116/EC)	Up to 20%	Up to 15%
Motorbikes (L3e)	€1,200	€750
Heavy Quadricycles (L7e)	€3,500	€2,000
Cars and vans (M1& N1)	€7,000	€5,000
Microbus (M2) and duty vehicles < 6,500 kg (N2)	€20,000	€15,000

These vehicles were sold among 119 project-recognized sale points. As of the end of the project in March 2011, 1,530 vehicles had been acquired with an average support of €2,843. Figure 25.1 below shows that motorbikes and vans (acquired by both public and private fleets) are selling the most of all vehicle categories.

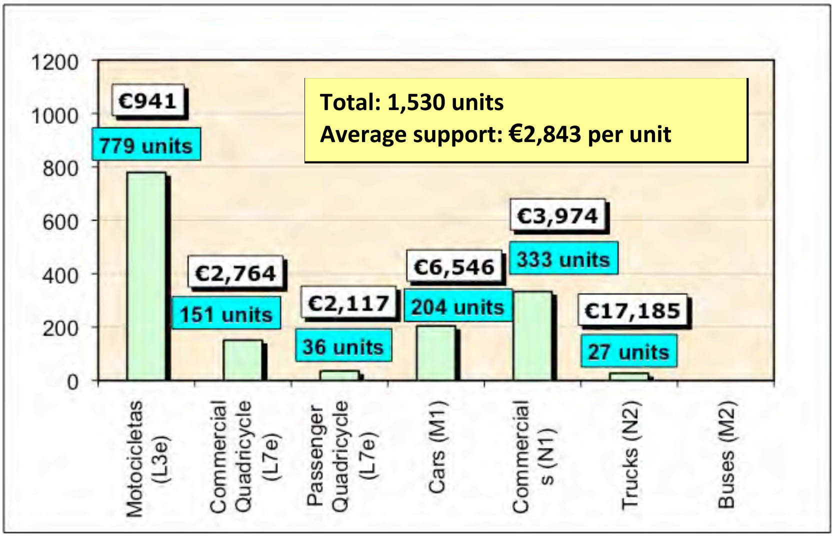
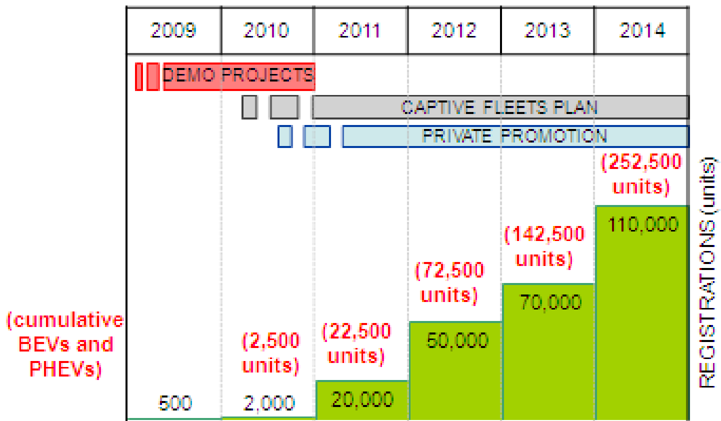


Figure 25.1 Units in each category of vehicle sold in MOVELE program and average financial support per unit, as of March 31, 2011.

Integrated Strategy for Electric Vehicles Promotion in Spain 2010–2014

A further major development relating to BEVs and PHEVs policy occurred in April 2010 when the Spanish government presented the "Integrated Plan for the promotion of electric vehicles." This plan was developed in the context of the Spanish Sustainable Development Strategy (SSDS).

This plan includes the Integrated Strategy for Electric Vehicles promotion 2010–2014 and its Action Plans (2010–2012 and 2012–2014). The Integrated Strategy sets the goal of putting 250,000 electric vehicles (BEVs and PHEVs) on Spain's roads, which could be recharged at 343,510 charging points throughout Spain. The plan envisions the rollout of the plug-in electric vehicles occurring according to the timetable set forth in Figure 25.2.



	2009	2010	2011	2012	2013	2014
MOVELE project		2,000	-	-	-	-
Fleets	-	-	18,000	45,000	60,000	90,000
Private Owners	-	-	2,000	5,000	10,000	20,000

Figure 25.2 Integrated Strategy for 250,000 BEVs & PHEVs in Spain by 2014.

Key Integrated Strategy Efforts and Related Action Plans

The Integrated Strategy relies on four strategic efforts with Action Plans for 2010–2012 and 2012–2014:

1. Promotion of demand for PHEVs and BEVs.
2. Promotion of the HEV and EV industry including research and development (R&D).
3. Promotion of charging infrastructure and energy demand management.
4. Cross-cutting actions to promote PHEVs and BEVs (referred to as horizontal programmes).

The objective of the first Action Plan (2010–2012) is to develop a social, technical and knowledge framework for the implementation of hybrid and electric vehicles in Spain. Another objective it set forth was 70,000 PHEVs and BEVs in Spain, including 63,000 in fleets and 7,000 among private citizens, with 108,850 charging points established by 2012.

To accomplish these goals, a budget of €531 million is to be applied to 15 key measures related to these four strategic efforts. The Department of Industry, Commerce and Tourism in collaboration with other Departments of the Spanish Government are working on the implementation of those 15 measures. The plan includes a 25% subsidy for the purchase price of an electric car up to a maximum amount of €6,000.

A partial list of these key measures includes:

- Support for the purchase and use of BEVs and PHEVs of more than 25% of market prices, to put 20,000 of these vehicles on the road in 2011 (budget: €72 million) and another 50,000 in 2012 (budget: €144 million).
- Identification and promotion of demand for BEVs and PHEVs in private and public urban vehicle fleets, which could potentially introduce 60,000 of these vehicles to fleets through 2014.
- Completion of a guide to educate urban mobility managers on the benefits of EVs. This guide is available to download (in Spanish language only) from the website www.movele.es.
- Special public distinction for town councils with special commitment with electric mobility: "City with Electric Mobility distinction".
- Building on current plans to build up the industry surrounding BEVs and PHEVs, amounting to €63 million in 2011 and another €63 million in 2012.
- Supporting R&D related to BEVs and PHEVs, amounting to €77.9 million in 2011 and another €77.9 million in 2012.
- Supporting communication technologies related EVs, amounting to €15.7 million in 2011 and another €15.7 million in 2012.
- Developing voluntary agreements with utility companies on issues related to electric vehicle tariffs and incentives for electric vehicle users and to develop solutions for charging infrastructure.
- Creation of a special reduced tariff ("tarifa supervalle") for nighttime recharging from 1 a.m. to 7 a.m. (Royal Decree 647/2011, 9th May).
- Installation of smart meters so that consumers can use the reduced tariffs.
- Establishment of a legal framework for recharging services that included creation in April 2010 of a "manager of charging" (Royal Decree Law 6/2010, 9th April). Rights, duties, procedures and other technical specifications of this figure were legally defined and developed in the later Royal Decree 647/2011, 9th May.
- Various programs for overcoming identified barriers for BEV/PHEV use; standardization of charging infrastructure, vehicle components, and related

technical procedures.

- Development of professional training programs for those involved in various electric vehicle processes such as manufacturing, maintenance, recycling, and safety.

As part of the Integral Strategy Action Plans, Spain will consider European guidelines on the standardization of EVs in both infrastructure and vehicle components. To this end, IDAE is participating in the 18-month long European Grid for Vehicles (G4V) project that began in January 2010. Participants in G4V are conducting analyses on the likely impact of a mass introduction of BEVs and PHEVs on European's electrical grids. The purpose is to develop recommendations to the EU on needed R&D for grid infrastructure, investment tax credit (ITC) protocols, and policies for the mass introduction of BEVs and PHEVs.

Other Initiatives under consideration to support EVs

The Spanish Government is participating in the ongoing Electric Vehicles Initiative (EVI) of the Clean Energy Ministerial (CEM). The EVI provides a forum for global cooperation on the development and deployment of electric vehicles. Participating countries agreed to share information about EVs, and to launch pilot city programmes to promote electric vehicles demonstrations in urban areas.

As complementary work, within the framework of MOVELE project, IDAE has developed a report on technical recommendations for the deployment of public recharging networks for EVs. This report was requested by policy makers of town councils and regions who are involved in the deployment of EV infrastructure in order to achieve interoperability of their systems with other systems placed in different areas or cities.

25.3 Research

As discussed in section 25.2, the Integrated Strategy 2010–2012 Action Plan seeks to develop various frameworks including a technical one for the implementation of electric vehicles in Spain. As part of this effort, the plan establishes public support for related R&D activities. This includes the identification and analysis of key technologies and increase of support as needed. The Spanish "Innovation Plan" of 2010 supports this effort with a 77.9 M€ budget in 2011.

As noted in last year's report, Spain participates in the EU's European Green Car Initiative (EGCI). This involves public-private partnerships to bolster innovation in the automotive sector and sustain its focus on environmental progress. A working group has summarized in a report the Spanish contributions, interests, and needs for the EGCI. The group has emphasized three major avenues of research: heavy-duty vehicles, electrification of urban and road transport, and logistics and co-modality (the use of different modes of transportation on their own and in combination with the aim of obtaining an optimal and sustainable utilization of resources).

On the Spanish national level, one of the most active entities in the R&D arena is the Centre for Industrial Technological Development (CDTI), a public company founded in 1977 and supervised by the Ministry of Science and Innovation. CDTI supports the development of new products, services, and standards in many areas, including mobility. The working group representing Spain for the EGCI is from the CDTI. The Ministry of Science and Innovation also supports Spanish technology platforms in many areas including that of transport. Finally, IDAE is implementing the MOVELE Project, the EV pilot project described in the Policies and Legislation section of this chapter.

Vehicle development efforts are also underway in the private sector. Spanish automaker SEAT is developing a Leon Twin-Drive prototype PHEV in its Technical Centre in Barcelona. SEAT presented the concept for the new car to the Ministry of Industry in January 2009, with the goal of introducing a car in 2014. As of February 2011, SEAT has signed an agreement with Madrid City Council for the loan of two León Twin Drive Ecomotive plug-in hybrid vehicles, which have a range in electric mode of up to 50 km. SEAT also unveiled the IBE 2.0—a concept car with an electric-only motor—at the last Paris Motor Show.

SEAT also heads Cenit Verde, a project initiated by the Spanish Ministry of Science and Innovation that brings together 15 companies as well as 14 universities and technological centers, to develop the necessary technologies and components for hybrid and electric cars.

25.4 Industry

Spain is currently the 8th largest vehicle producer in the world, the 3rd largest European manufacturer of cars and the largest manufacturer of light commercial vehicles in Europe.

Spain's automotive industry continued to recover in 2010 following nearly a year and a half of decline as a result of the severe global economic slump of 2008– 2009. Figures from the Spanish car manufacturers association ANFAC show that overall car sales in 2010 climbed 3.1% from 952,772 to 982,015 (although this is still well below the 1,634,608 sold in 2006). Table 25.6 shows new car registrations (representing new car sales) in Spain from 2006–2010.

Table 25.6 New car registrations in Spain per year, 2006–2010.

Year	2006	2007	2008	2009	2010
Car registrations	1,634,608	1,614,835	1,161,176	952,772	982,015

But this is only part of the story, because the removal of government incentives, including the end of the Plan 2000E (discussed in section 25.2), contributed to a renewed sustained drop in car sales. By March 2011 sales had declined for nine months consecutively.

Nevertheless, the Spanish government continued to provide support in other areas in 2010, in particular, through implementation of automotive sector Competitiveness and Reindustrialising plans. In 2009, the Ministry of Industry Trade and Tourism gave 56 M€ towards electric vehicle manufacturing in Spain, along with automakers SEAT, Renault, Nissan and Peugeot investing 88 M€ in Spain's EV industry. The Ministry gave another 250 M€ for general strategic projects in the automotive sector in 2010. It also created a guarantee plan to facilitate financing for investments in the automotive sector that includes €1 billion (presented in the 2010 budget assigned to the Ministry of Industry to support projects and actions principally oriented to HEVs and EVs).

Working in tandem with the Integrated Strategy Action Plan 2010–2012, the Competitiveness and Reindustrialising plans set forth an objective that at least 80M€ should be provided to BEV and PHEV technologies in 2011 with 63M€ going toward new initiatives. In 2010 it provided 52.5 M€ for 18 projects.

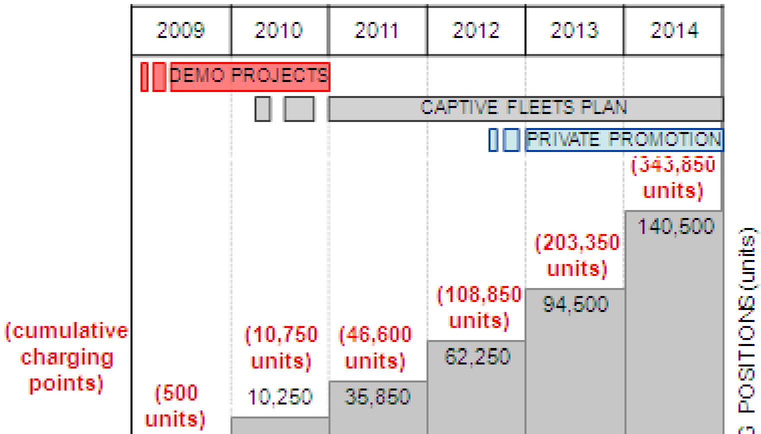
The following is a list of current production plans by manufacturers in Spain of electric and hybrid vehicles, including motorcycles and quadricycles. Fuel type and European vehicle classification are listed in parentheses:

- 20,000 units of the Renault Twizy (BEV, M1) by the end of 2011 at Renault's Valladolid facility.
- 2,000 units of the Mercedes Vito (BEV, N1) by the end of 2011 at the Mercedes-Benz Vitoria facility.
- Comarth's electric quadricycle (BEV, L7e) to be produced at the company's Murcia facility in 2011.
- Rieju's electric motorcycle (BEV, L3e) in Barcelona in 2011.
- Ford C-Max (HEV and REEV, M1) in Almusafes (Valencia) before 2013.

- Peugeot Partner and Citroën Berlingo (both BEV) in Vigo by the start of 2013.
- “Xerus” and “Intea” HEV buses by Tata Hispano (both have been produced at the company’s Zaragoza facility since 2010).

25.5
Charging infrastructure and vehicle deployments

Spanish government considers as a key matter the development of an adequate recharging infrastructure which supports the introduction and implementation of EVs. The objectives of recharging infrastructure are also considered in the Integrated Strategy to promote EVs and are shown in figure 25.3.



	2009	2010	2011	2012	2013	2014
Linked infra-structure		10,000	35,000	60,000	90,000	130,000
Energy charging services		250	850	2,250	4,500	10,500
Fast Charging services	-	-	10	20	40	90

Fig. 25.3 Integrated Strategy for EV charging infrastructure in Spain by 2014.

Figure 25.3 shows that most of the recharging infrastructure planned is oriented to linked infrastructure (that is, assigned to specific vehicles, as in the case of housing and fleet charging), but it is also necessary to deploy charging points for public use on streets and public parking lots, petrol stations, etc. A small number of fast charging points are under consideration in order to reduce range anxiety and for sporadic use.

The charging infrastructure for battery-only and plug-in hybrid electric vehicles in Spain is presently supported by the following projects and programmes:

MOVELE Project

This project was discussed in Sec. 25.2. In seeking to demonstrate the technical and economic viability of plug-in hybrid and electric vehicles, the project aims to have 546 charging stations installed in March 2012, with 280 in Madrid, 191 in Barcelona, and 75 in Seville.

Agreements between IDAE and Regional Administrations

These agreements were discussed in section 25.2. In collaboration with regional governments, IDAE is supporting the deployment of EV charging infrastructure during 2011 and 2012, which includes two main lines of activity. These lines include deploying charging points for EVs in private or restricted use and for public use.

Infrastructure for electric vehicles in private or restricted use (linked infrastructure)

The following incentives are in effect for different uses:

- Parking lots in private sector companies. Table 25.7 shows maximum estimated eligible costs and public supporting per item:

Table 25.7 IDAE support for charging points in parking lots of private sector companies.

Subject of investment	Maximum eligible cost	Support (€)
Complete installation of a charging point (< 40 kW power)	€4,000	Up to 30% of eligible costs with a maximum of €1,200.
Complete installation of a charging point (> 40 kW power)	€50,000	Up to 30% of eligible costs with a maximum of €15,000.
Central system for control and management of the recharging points.	€50,000	Up to 30% of eligible costs with a maximum of €15,000.

- Blocks of flats and single-family housing. This measure promotes the deployment of charging points in blocks of flats and single-family housing through public supporting for the installation needed. Smart meters are not considered for public support. Only wiring and related installation equipment (from the meter box to the charging point) are included. Public support will cover 40% of the installation with a maximum of €200 per charging point per parking lot.

Infrastructure for electric vehicles in public use

Two initiatives are considered:

- Promoting the installation of single charging points in public services centres (e.g., malls, fuel stations, etc.). These charging points may be independent and not involved in a charging network. Again, only wiring and related installation equipment from the charging points are considered. Smart meters are not included.
- Promoting the installation of charging networks by town councils and charging services companies. Charging networks must include at least 10 charging points open to public use, with a suggested ratio of one charging point per 5,000 inhabitants connected by a central managing system.

Costs and support are as follows in Table 25.8 for both initiatives:

Table 25.8 IDAE support for public charging point installations.

Subject of investment	Maximum elegible cost (€)	Support (€)
(*)Complete installation of a "covered" charging point (recharging power <40 kW)	€4,000	Up to 40% of eligible costs with a maximum of €1,600
(*)Complete installation of "on street" charging point (recharging power <40 kW)	€50,000	Up to 40% of eligible costs with maximum of €2,600
(*)Complete installation of a charging point (recharging power >40 kW)	€50,000	Up to 40% of eligible costs with maximum of €20,000
Battery swapping station	€60,000	Up to 40% of eligible costs with maximum of €24,000
Centralised control system for the management of the charging points	€50,000	Up to 40% of eligible costs with maximum of €20,000
Marketing and Communication campaign (recharging networks)	€6,000	€6,000

(*): The installation of wiring from the final box meter and the connection system (recharger) is supported.

Strategic support plan

In this program (discussed in section 25.2), charging infrastructure for the "Electrobus II" includes 25 charging points for those deployed in the transport consortia of Barcelona and Madrid. This includes 20 charging points in Barcelona and five in Madrid by late 2013 at estimated cost of €12,000 and public support of €2,400 per recharging point.

As of May 2011, the status of electric vehicle infrastructure deployment in Spain for public use is shown in Table 25.9 and Figure 25.4.

Table 25.9 Numbers of public-use charging points in Spain.

Spanish Public-use Charging Points	
Cities	59
Stations	210
Total charging points	517
By Type	
Single-phase charging points	465
Three-phase charging points	52

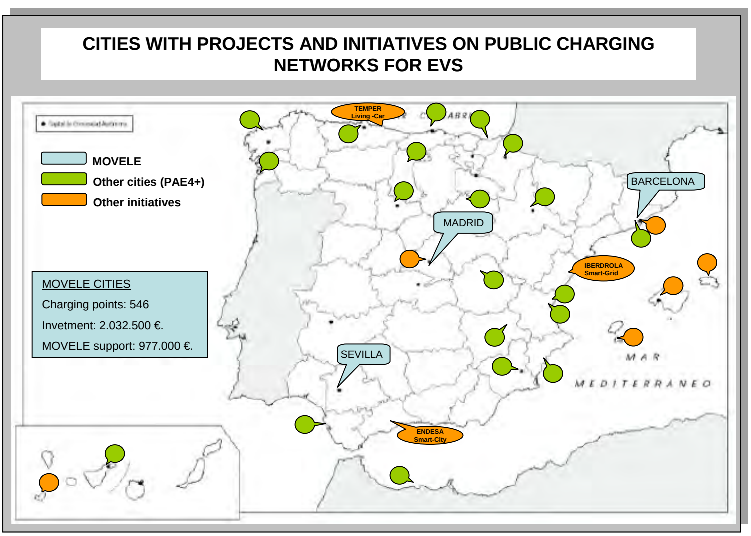


Figure 25.4 Public-use charging networks with more than 10 charging points as of May 2011.

25.6
On the road

Spain currently has approximately 10,700 electric vehicles and 21,190 hybrid electric vehicles out of about 45 million vehicles on the road (including 15 million bicycles). However, this includes about 10,000 electric bicycles that do not require a driver's license. The electric vehicle figure drops to approximately 1,000 when bicycles are excluded.

If bicycles are excluded, then there are approximately 22,000 BEVs and HEVs on Spain's roads out of a vehicle fleet size of about 30 million. The plan to boost the number of plug-in electric vehicles (BEVs and PHEVs) to 250,000 by 2014 will give these a market penetration of approximately 1%. Table 25.10 shows the hybrid and electric vehicle fleet numbers through late 2010 including bicycles.

Table 25.10 Hybrid and electric vehicle fleet numbers in Spain at the end of 2010.

	PER 31 DECEMBER 2010		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs and HEVs)**
Bicycles (no driver license)	<10,000	0	15,000,000 aprox.
Motorbikes (>4 kW)	435	0	2,500,819
Passenger vehicles	147	21,190	22,145,364
Multipurpose passenger vehicles	370	0	2,364,471
Buses	20	0	62,196
Trucks (between 3.500 and 6.500 kg)	23	0	2,290,942
Industrial vehicles	0	0	213,366
Total	**10,698**	**21,190**	**44,577,158**

Table 25.11 shows hybrid electric vehicles acquisition during the year 2010 based on car registration data.

Table 25.11 New hybrid vehicle registrations in Spain in 2010.

Hybrid vehicles registrations in 2010		
	2010	% hybrids
TOYOTA PRIUS	4,676	65.0%
TOYOTA AURIS 1.8 HSD 5P	917	12.8%
LEXUS GS 450 H	64	0.9%
LEXUS LS 600	21	0.3%
LEXUS RX 400 H	19	0.3%
LEXUS RX 450 H	672	9.3%
HONDA INSIGHT	455	6.3%
HONDA CR-Z	244	3.4%
HONDA CIVIC 4P 1.3 IMA	17	0.2%
MERCEDES S 400 HYBRID 4P	2	0.0%
MERCEDES S 400 HYBRID CORTO 4P	17	0.2%
B.M.W. X6 4.4 ACTIVEHYBRID	25	0.3%
B.M.W. ACTIVEHYBRID 7 4.4 4P	4	0.1%
B.M.W. ACTIVEHYBRID 7L 4.4 4P	5	0.1%
VOLKSWAGEN TOUAREG 3.0 HYBRID	10	0.1%
PORSCHE CAYENNE S HYBRID	42	0.6%
Total Hybrids	**7,190**	**100.0%**
Total Market (Spain)	**989,576**	
% Hybrids	**0.7%**	

Tables 25.10 and 25.11 show that the number of HEVs on the road in Spain increased by slightly more than 50% during 2010, rising from 14,000 to 21,190.

The steady growth in hybrid electric vehicle purchases in Spain is being sustained through a comprehensive set of incentives and changes in consumer preferences thanks to increased concern over fuel efficiency and environmental matters.

25.7 Outlook

Putting it all together provides a roadmap of how hybrid and electric vehicles will gain widespread use in Spain in the coming years. Table 25.12 shows the short, medium, and long-term scenarios for Spain's H&EV market.

Table 25.12 New hybrid vehicle registrations in Spain in 2010.

Initiatives_	Vehicles Target	At the end of
Short term: MOVELE	2,000	2010
Medium term: Spanish Strategy to Impulse Electric Vehicles (2010–2014)	250,000	2014
Long term: Renewable Energy Sources Di-rective	2,500,000	2020

In the short term, the MOVELE Project is a key demonstration programme designed to prove the viability of PHEVs and BEVs with a target of 2,000 vehicles on the road by early 2011. It also supports installation of basic charging infrastructure.

In the medium term, through the Integrated Strategy to promote EVs, Spain has established the goal of reaching 250,000 PHEVs, and BEVs on the road by 2014. The Integrated Strategy is supported by other national initiatives and efforts. There is also an objective of the Spanish government of 750,000 conventional hybrid vehicles by 2014.

In the long term, the objectives for the introduction of EVs/PHEVs were recently defined according the 2009/28/CE Directive, which establishes a target of 10% of introduction of renewable energies for all the energy consumed by the transportation sector.

In order for Spain to achieve this, the National Plan for Renewable Energies 2011–2020 (PANER) establishes the introduction of renewable energies through 8% of biofuels, and 2% of electricity of the total final energy consumption. Of this 2% as applied to the transportation sector, 0.5% is assigned to railways and the other 1.5% is assigned to PHEVs/BEVs in the road transport according to the following proportions by 2020:

- 80% of PHEV (2,000,000 vehicles)
- 20% of BEV (500,000 vehicles)

If these efforts are successful, the total number of BEVs and PHEVs on Spain's roads by 2020 will reach 2.5 million. This would represent around 10% of the current Spanish fleet.

26 Sweden

26.1 Introduction

During 2010, automotive sales in Sweden recovered from the decline of 2009. Also, during 2010 "eco cars" (cars eligible for governmental subsidy, including hybrid and electric vehicles) continued to gain market share. The Swedish market for personal cars increased by 35% (compared to a 16% decrease in 2009) and that for light trucks increased by 38% in the past year. However, for heavy trucks the result was a further drop of 13%, which came on top of a 28% drop in sales in 2009.

The sales share of private cars that are eco vehicles continued its increase from 38% to 40%. This might show the Swedish public's great interest in climate change, but economic reasons such as high oil prices and vehicle purchase subsidies might also play a part. This year ethanol vehicles (E85) lost the position as the best-selling powertrain. In 2010, eco vehicles with efficient conventional powertrains with maximum emissions of 120 g CO_2/km accounted for 62% of all sales of eco vehicles. Table 26.1 shows 2008, 2009, and 2010 eco vehicle sales shares by vehicle type.

Table 26.1 Relative sales shares (in %) for "green" vehicles in Sweden.

Category	2007	2008	2009	2010
E85 (ethanol)	65	68	49	30
Max 120 g CO_2/km, gasoline	14	13	16	15
Max 120 g CO_2/km, diesel	12	13	24	47
Hybrids	6	4	3	2
Gas	3	2	8	6
Total	100	100	100	100
Eco share of total private car sales	**18**	**33**	**38**	**40**

26.2
Policies and legislation

Over the past decade, Sweden has put into place policies that reduce certain taxes and fees on eco cars including hybrids (HEVs), plug-in hybrids (PHEVs), and electric vehicles (EVs). Currently, the national government is considering additional measures to further encourage the uptake of these vehicles. Among other policies, a demonstration program will run from 2011 through 2014 with the purpose to investigate the use pattern and infrastructure need that is associated with PHEVs and EVs.

Taxation

From 1 January 2011, vehicle taxes are based on several factors including weight, fuel, and CO_2 emissions.

Rules for public purchasing of vehicles

Since 1 January 2005, the requirement governing the public purchase and leasing of vehicles for public authority fleets is that at least 85% of the total number of cars purchased or leased by a public authority during a calendar year should be eco vehicles. In 2006, the National Road Administration published a definition of the types of vehicles that qualify as eco vehicles in accordance with the requirements of the ordinance. This is described in the following subsection.

Grants for eco vehicles

Any private individual who bought a new eco car between 1 April 2007 and 30 June 2009 received an "eco car subsidy" of SEK 10,000 = US$ 1,100. After 30 June 2009, the subsidy was replaced by a 5-year exemption from vehicle tax that differs from vehicle to vehicle but is averages about US$ 300 per year. The criteria for an eco car tax exemption are:

- The fuel consumption of an alternative fuel vehicle (flexible fuel, bi-fuel, and/or electric) must be below the energy equivalent of 9.2 L of gasoline, 9.7 m^3 of natural gas (CNG), or 37 kWh of electric energy per 100 km.
- An alternative fuel vehicle must run predominantly on alternative fuels as opposed to fossil fuels.
- A vehicle run on fossil fuels can be called an eco car if the carbon dioxide emissions are below 120 g/km. In order to meet this requirement, the fuel consumption per 100 km must be below 4.5 L for diesel or 5.0 L for gasoline. (Note that this consumption restriction is due to the carbon dioxide requirement.)
- In addition, for vehicles with diesel engines, emissions of particulate matter must be below 5 mg/km. In practice, this means that vehicles that run on

diesel must be equipped with a particulate filter to be classified as eco cars.

Other incentives can reward drivers of hybrid, electric, and other eco vehicles. Some local authorities have reduced parking charges for eco vehicles; the rules vary from one local authority to another.

A congestion-charging scheme (i.e., tax charged during times of traffic congestion) has been in effect in central Stockholm since the summer of 2007. The congestion tax is imposed on Swedish-registered vehicles driving into and out of the Stockholm inner city zone on weekdays (Monday through Friday) between 6.30 a.m. and 6.29 p.m. Each passage into or out of the inner city zone costs SEK 10, 15 or 20 (about US$ 1 to 2), depending on the time of day. This policy benefits PHEVs and EVs as there is no taxation on vehicles equipped with the technology to run either completely or partially on (1) electricity or a gas other than LPG or (2) a fuel blend that consists predominantly of alcohol.

26.3 Research

The major research programme in Sweden called the Vehicle Strategic Research and Innovation programme (FFI) continues to provide grant support to projects in the PHEV and EV area. In addition, private industry continued with research and other initiatives to help bring more hybrid and electric vehicles to Sweden's roads during the coming decade.

There were four national research programmes dealing with issues related to electric, hybrid, or fuel cell vehicles active during 2010. The programmes are closely linked in order to benefit from common tasks and overall synergies among them. They also share in monitoring and analyzing business intelligence. In brief, these are:

- **The Vehicle Strategic Research and Innovation programme (FFI)** started on 1 January 2009, following a previous three-year effort of advanced research into HEVs, EVs, and FCVs named the Green Vehicle Programme. The FFI programme is a cooperative effort between the Government and the Swedish automotive industry. The programme is financing common research efforts, innovation, and development activities mostly in the overall theme areas Climate and Environment, and Safety, respectively. The project is managed by Vinnova (Swedish Agency for Innovation Systems), the Swedish Energy Agency, and the National Road Administration. It comprises five subprogrammes: Sustainable production technology, Vehicle development, Transport efficiency, Vehicle and traffic safety, and Energy and environment.

The venture includes R&D operations valued at approximately SEK 1 billion per year (approximately US$ 140 million per year), of which public funds amount to SEK 450 million per year (approximately US$ 65 million).

- **Energy Systems in Road Vehicles**, administered by the Swedish Energy Agency, involves several research projects dealing with batteries, fuel cells, and other vehicle components that use electricity as a means of improving energy efficiency. The programme entered its third phase in 2007 and ran until the end of 2010 with an additional budget of about US$ 12 million. US$ 7 million of these are devoted to hybrid vehicles and fuel cells. Under the programme to date, several PhD students have been trained in the field of hybrid vehicles and fuel cells, and a number of patents for new types of hybrid drive lines have been granted. This programme now concentrates on hybrid vehicles, especially their drive systems, battery technology, diesel reformers for fuel cells, and the architecture of hybrid systems. This program continues under the name "Energy-efficient road vehicles" for the period 2011–2014 with an annual budget of US$ 2.9 million.

- The aim of the **Swedish Hybrid Vehicle Centre (SHC)** is to establish an internationally competitive centre of excellence for HEV technology by facilitating education and research to meet industrial and societal needs in this area and by forming a natural framework for co-operation between industry and academia. Participating in the centre are AB Volvo, Scania CV AB, Saab Automobile AB/GM Powertrain AB, Volvo Car Corporation AB, BAE Systems Hägglunds AB, Chalmers University of Technology, Lund University, and the Royal Institute of Technology. The Centre started in July 2006, and the budget for the first period, 2007 to 2010, is about US$ 11 million. The centre has been evaluated during 2010 and is recommended to be continued for another four-year period.

- The **Environmental Vehicle Development Programme** started in June 2007 and ran through 2010. Its total budget from the Swedish Government is about US$ 29 million, and it is administered by the Swedish Energy Agency. The programme covers hybrids, engines for alternate fuels, and lightweight and fuel-efficient engines. It includes co-operative projects between the United States (U.S. Department of Energy, Mack Trucks) and Sweden (Swedish Energy Agency, AB Volvo).

26.4 Industry

Sweden's economy is very dependent on its automotive industry. The sector employs over 100,000 people, which includes 1,000 or so automotive subcontractors.

After two years of difficult market conditions, the expectations for sales in 2010 were very low. However the Swedish economy performed better than many other major European economies, and new sales of passenger cars increased compared to previous year nearly reaching 2008 levels. However, heavy truck sales did not have the same good recovery.

In the beginning of 2010, Saab Automobile was purchased by the Dutch company Spyker Cars and Volvo Car Corporation was bought by Chinese company Zhejiang Geely Holding Group. Completing the sales of these two iconic Swedish brands has resolved the uncertainty that had resulted from the mounting layoffs and losses of previous years. Although the future will look different for the two companies, the new ownership should be positive for the Swedish supplier base.

The major manufacturers Volvo AB, Volvo Cars, Saab Automobile, and Scania all have presented electric and/or hybrid concept vehicles. As the hybrid vehicle portion of the automotive sector has become more commercial, data on R&D activities have become proprietary and impossible to obtain from the companies.

All through 2009, interest in electric and hybrid vehicles has been high. Industry has taken the role as the main driving force behind the continuing discussions on several R&D programmes and is showing great interest in building upon these efforts, for example, in the case of FFI and SHC as well as the demonstration projects for EVs. Previously the state had led these initiatives.

Industry-funded research efforts include an ongoing project in which Volvo Cars, ETC Battery and Fuel Cells AB, and electric power producer Vattenfall are demonstrating three Volvo PHEVs in practical use. Volvo also have announced the launch of the PHEV V60 model in 2012. Examples of subcontractors and small companies that are engaged in the fields of electric vehicles, fuel cells, and/or hybrid vehicle development are listed in box 26.1.

BOX 26.1 SUBCONTRACTORS AND SMALL COMPANIES IN THE FIELDS OF ELECTRIC VEHICLES, FUEL CELLS AND/OR HYBRID VEHICLES DEVELOPMENT	
Company	**Activity**
ETC, Battery and Fuel Cells AB	Development and sale of batteries for hybrid vehicles: primarily nickel metal hydride, and various activities in the fuel cell sector.
Alelion Batteries AB	High-performance batteries and power electronics.
LiFeSiZE AB	Up-scaled production and sale of low-cost Fe-based cathode materials for EV/HEV Li-ion batteries, especially Li_2FeSiO_4.
Effpower	Development and sale of bipolar lead acid batteries for hybrid vehicles.
Cell Impact AB	Development and sale of bipolar plates for PEM fuel cells.
Morphic Technology AB	Development of production technology for PEM fuel cells.
Cellkraft AB	Development of systems for PEM fuel cells.
Opcon Autorotor AB	Air supply systems for PEM fuel cells.
Woxna Graphite AB	Graphite for fuel cells.
Outocumpo Stainless AB	Stainless steels for fuel cells.
Powercell	Development and commercialization of fuel cell auxiliary power unit (APU) for heavy-duty truck applications.
Actia Nordic AB	Power electronics for electric and hybrid vehicles.
Transic	Development of silicon carbide power electronics.
Bevi	Electric machines.
Danaher	Hybrid electric drivetrains.
Calix	Development of charging technology for electric vehicles.
ABB	Total systems provider of electric machines and components.
Electroengine in Sweden AB	After-market conversion to electric drive.
Vehiconomics	Development of small commuter and city vehicles.

26.5
Charging infrastructure and vehicle deployments

In 2009 the Swedish Energy Agency supported two projects where a total of 150 battery electric vehicles will be demonstrated. One project will test the Volvo C30 EV in 2011 (figure 26.1). The other concerns 100 Saab 9-3 EVs during 2010 and 2011. The Energy Agency got directions from the government to include questions regarding infrastructure and user acceptance in a new demonstration program that will run for four years.

Fig. 26.1 Volvo Cars C30 Battery Electric Car (50 cars will be demonstrated in 2011)

The major Swedish power companies began working together in 2008 in a joint initiative promoting EVs and PHEVs. The goal is to bring 600,000 vehicles to the market by 2020. One ongoing subproject involves converting ten Toyota Priuses to PHEVs and field-testing them.

In contrast to the utilities' goal, the Swedish Energy Agency has recently revised its previous prediction of 85,000 EVs in 2020 to 18,000. This suggests that the initial expectations of the EV market may be somewhat optimistic.

26.6
On the road

In total, there were almost 4.9 million private cars and heavy vehicles on the road in Sweden at the end of 2010 (see also table 26.2). About 51% of newly registered private cars had diesel engines. In January 2011, there were 362,000 eco cars in Sweden, an increase from 279,000 eco cars at the start of 2010. As described earlier, the market share of eco cars has increased from 13% in 2006, to 18% in 2007, 33% in 2008, 38% in 2009 and to 40% in 2010.

Table 26.2 Characteristics and population of the Swedish motorized vehicle fleet per December 31, 2009 and 2010. Estimates are in *italics*.

	DECEMBER 31, 2010		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet**
Motorized bicycle (no driver licence)	2,300		258,402
Motorbike	111		492,209
Passenger vehicle	191	19,249	4,336,125
Multipurpose pass. vehicle	n.a.	n.a.	n.a.
Bus	4	2	13,873
Truck	133	10	526,440
Industrial vehicle	n.a.	n.a.	n.a.
Total	**2,739**	**19,261**	***5,627,049***

n.a. not available

The definitions of the different vehicle categories can be found in section E of this report, chapter "Vehicle categories."

26.7 Outlook

In Sweden, the long dominance of ethanol vehicles has now given way to other eco vehicles such as efficient small diesel and gasoline engines. The trend might have been affected by the opinions of different NGOs that question whether using ethanol fuel is a good way to reduce carbon dioxide emissions from the transport sector. Questions were raised on the fuel production methods used for ethanol and their effects, especially the effects on food prices and CO_2 emissions. A possible future use of ethanol is to mix it with gasoline in lower percentages (10 %).

With all these options to consider, choosing the technology for energy-efficient cars is becoming even more interesting than before. The EU directive Regulation CE/443, adopted by the European Union in April 2009, promotes this effort further with its tougher rules on carbon dioxide emissions for vehicle producers. The Swedish vehicle industry is therefore now very focused on technologies that increase fuel efficiency in order to comply with the new emission rules as well as satisfying the increasing customer demand for more fuel-efficient vehicles. The research focus from the industry has been to make the ICE more efficient, and governmental funding has promoted further efforts in the field of batteries and EV. In the future, plug-in hybrids, pure electric vehicles, and perhaps fuel cell vehicles will be seen as viable alternatives, although one big challenge will be the development of batteries that will operate in the harsh climate of the Nordic winter.

27 Switzerland

27.1 Introduction

Efforts to develop clean vehicle technologies in Switzerland are embedded in actions to reduce energy consumption and carbon dioxide (CO_2) emissions in the transportation sector. As a result of Switzerland's near total reliance on nuclear and hydropower for power generation (about 40% nuclear and 60% hydropower) and because of improvements in industry and construction, the transportation sector is responsible for about 40% of CO_2 emissions in Switzerland (air traffic included). Furthermore, transport-related emissions continue to increase. Seeking to counter this trend, the Swiss government has proposed to limit emissions of new vehicles to 130 grams CO_2 per kilometer by 2015. This is in keeping with the European Union's standard issued in 2009. Discussions of a "2,000 W-society" or 1 ton CO_2 per capita society that were initiated by the Swiss academic world are being extended to mobility, and a "minergie"-car (coming from a blend of "minimum" and "energie") has been proposed based on efficiency standards in the construction field.

Current efforts are actually not the first time that Switzerland attempted a major foray into the electric vehicle market. In the 1990s, Switzerland was a trendsetter in the development and market deployment of electric vehicles. Those efforts were spurred by the solarmobile race known as the "Tour de Sol," held annually from 1985 through 1993. This race resulted in hundreds of prototypes of lightweight electric vehicles (Fig. 27.1) and smoothed the way for highly specialized companies that are still leaders in the development of components and lightweight materials. To encourage this emerging industry, the Swiss Federal Office of Energy enabled a field test in which the questions around the market introduction of electric vehicles have been investigated. The six-year-project in Mendrisio (1996–2001) enabled a unique in-depth analysis of what constitutes a properly functioning EV market, including user preferences, best applications, and environmental impact.

Looking back, though, it seems that Switzerland was too early with these extraordinary EV initiatives. At the end of the Mendrisio project, all car manufacturers stopped their electric vehicle production, and only a few small companies produced niche products like the Swiss development TWIKE that is still available (Fig. 27.2). However, although the electric vehicle market dried up, nevertheless around 2,500 electric vehicles were running on Swiss roads at the end of the Mendrisio project.

Fig. 27.1 Ahead of its time: lightweight electric vehicles participating in the solarmobile race “Tour de Sol” in 1991. (Photo: Solarcenter Muntwyler.)

Fig 27.2 A meeting of Swiss lightweight electric vehicle TWIKE owners in Gelterkinden, Switzerland, in 1989. More than 1,500 units have been produced. (Photo: Solarcenter Muntwyler.)

27.2
Policies and legislation

As a result of the mixed results of the country's previous forays into vehicle electrification, Swiss policy is now hesitant to promote electric vehicles actively. The government is also expressly not taking a leading role in the development of a public charging infrastructure (see Section 27.5). Swiss government policy efforts instead focus on developing framework conditions. This has the benefit of avoiding preferential treatment for any specific technology.

In most of Switzerland's Cantons, electric and hybrid vehicles profit from a reduction or even exemption from vehicle taxes. At the federal level there is discussion about a bonus-malus ("good-bad") system concerning vehicle import taxes dependent upon CO_2 emissions. The government also expects that the parliamentary acceptance of a bill that will limit CO_2 emissions to 130 g/km for new cars starting in 2015 will likely encourage at least some adoption of hybrid and electric vehicles. Moreover, the high penalties levied on car importers for surpassing the 130 g CO_2/km emissions threshold is expected to incentivize domestic car importers to import clean vehicles, particularly battery electric models, in order to offset higher CO_2 emissions of ICE car models in the fleet.

The Swiss federal government delegates the role of distributing information on hybrid and electric vehicles to the non-governmental agency Eco Mobile with the organizations e'mobile and NewRide (promoting electric two-wheelers) as partners. Currently, the Swiss Touring Club (TCS), a traditional motorists' association, also gets government support to act as an information platform on electric mobility.

In summary, the Swiss government believes that the introduction of electric vehicles should be driven by market forces, and that its role is primarily that of a facilitator of information for a network of stakeholders, and as the guarantor of a legal and fiscal system that favors ecologically sustainable applications.

27.3
Research

In the last year a fundamental debate has arisen between proponents of the "clean internal combustion engine (ICE)" and proponents of EVs at the technical universities concerning the ecological "footprint" of battery electric cars. Despite this, all researchers agree that vehicle weight plays the decisive role. An electric vehicle of the same weight as a conventional car shows few advantages in terms of CO_2 emissions compared with an efficient diesel car due to the bad life cycle assessment of the batteries. But compared to a diesel car of the same weight, the potential of a lightweight electric vehicle is enormous. Figure 27.3 below shows the "CO_2" balance of various kinds of EVs with diesel cars given in kilograms CO_2 per passenger-kilometer (pkm).

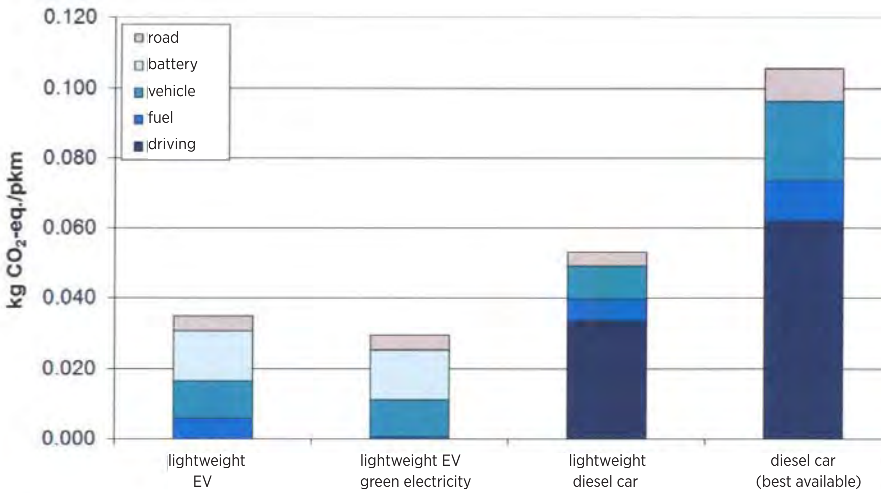


Fig 27.3 Lightweight electric vehicles show the best results in a CO_2 balance. (Source: eco-services 2011.)

Other research at the Paul Scherrer Institute includes efforts to develop marketable fuel cells for the use in cars. Belenos Clean Power, a co-operative effort between the Paul Scherrer Institute and the Swatch affiliate Belenos, has been awarded the 2011 "Watt d'Or" award by the Swiss Federal Office of Energy (SFOE) for this applied research.

The issue of vehicle-to-grid opportunities is leading to increased research into smart grids, a topic popular with proponents of new renewable energy technologies. A working group under the SFOE umbrella has started to focus on the question of the effects of widespread use of electric vehicles on the Swiss grid. Participants in this working group have pointed noted that base load loses its importance as additional peak load becomes available from new renewable energies. This suggests that electric vehicles should be recharged during daylight hours to level out these peaks. The issue of charging infrastructure is discussed in more detail in Section 27.5.

Swiss company Battery Consult, the maker of the sodium nickel chloride "ZEBRA" battery, is establishing a new research centre that it expects to be operative in late 2011. This battery type is used in several battery electric vehicle models (e.g. the Smart electric drive).

27.4 Industry

Swiss banking and financial services giant Credit Suisse (CS) recently launched a new index for hybrid and electric vehicles for professional investors. The Credit Suisse Electric Vehicle Index tracks 32 businesses in the fields of energy storage, suppliers and materials, vehicle manufacturers, infrastructure and services. This can be interpreted as a sign that the EV business is regarded by key financial players such as CS as a sustainable market opportunity. CS reasons this by the co-operation between renowned European car companies and newer Chinese companies, such as Daimler partnering with BYD, and their stated commitment to develop electric and plug-in hybrid vehicles. CS also analyzes potential investments in battery companies (e.g., SAFT and Panasonic) and grid operators.

Within Switzerland, small specialized companies have excellent opportunities in the electric and plug-in hybrid vehicle market niche. These include the ZEBRA battery maker Battery Consult, H&EV component makers such as BRUSA Elektronic AG and ESORO, and pedelec manufacturers.

These specialized companies still show their know-how in high-efficiency electric vehicle prototypes. In January 2011, the magazine *auto-illustrierte* named Marco Piffaretti of Protoscar as the “carmaker of the year” for his commitment to promoting electric vehicles and designing appealing prototypes (figure 27.4).

Fig. 27.4 Lampo II electric prototype by Protoscar/Brusa. (Photo: Protoscar)

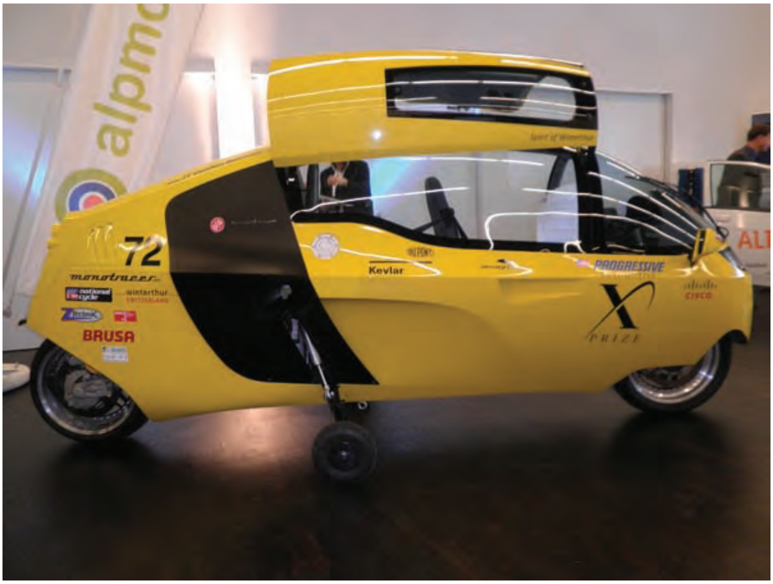


Fig. 27.5 Peraves X-Tracer, winner of the Automotive X-Prize in the Alternative Class-Tandem category. (Photo: Solarcenter Muntwyler.)

Another Swiss company, Peraves, won Progressive Automotive's famous Automotive X-Prize in the "Alternative Tandem Class" category in September 2010 for improvements to its X-Tracer (figure 27.5).

The electric version of the Peraves Zerotracer with propulsion system by BRUSA Elektronic is scheduled to be available in the course of 2011.

The startup Mindset (founded in 2007) has announced that it will start the production of its prototype (figure 27.6). The German special vehicle maker Xenatec Group will manufacture the car while the drive train is produced by BRUSA. The original rollout was planned in mid-2009 but has been delayed with production now expected to begin in fall 2011.

The young company SwissCleanDrive, with the help of the SFOE, has developed a kit for converting a convention ICE vehicle into a plug-in hybrid electric vehicle. The kit comprises a 39-kW AC motor, controller, and a charger that is attached to the axle not driven by the IC engine. The electric drive is completed by a 4-to-6 kWh / 400 V lithium iron phosphate ($LiFePO_4$) battery that allows a 20–30 km range in electric mode. Using a switch, the driver can choose pure electric, hybrid, or regular ICE modes. The hybrid mode features the ICE working on the front axles and the electric motor working on the rear axle with the result being a 4x4 drive. The kit is currently available for the FIAT Cinquecento (figure 27.7); kits for other car models are being developed.

Fig. 27.6 Mindset prototype. (Photo: TWIKE.)

Fig. 27.7 SwissCleanDrive Fiat 500 converted to a plug-in hybrid car. (Photo: Solarcenter Muntwyler.)

27.5 Charging infrastructure and vehicle deployment

The Swiss government expressly does not see a role for itself in supporting the development of a charging infrastructure for plug-in hybrid and electric vehicles. As a result, the utilities in some respects have taken over the role as active promoters of electric vehicles. This happens in the context of the discussions about reducing CO_2, in particular the topic of how to supply electricity for EV operations. It is in this context that plans for renewable energies and the need for smart grids to avoid grid instabilities are being discussed by utility companies and project promoters.

Public charging infrastructure has been most actively promoted by the Electric Vehicle Club Switzerland, a private association of electric vehicle users. The system they have is simple: payment of an annual contribution that includes overhead and electricity costs gives an EV user access to the 120 so-called “park & charge” charging stations (figure 27.8). Moreover, 32 of the stations enable “accelerated” or quick charging by providing 32 A/230–400 V outlets. In addition, private citizens (mostly EV users themselves) and certain companies put their sockets at the disposal of charging subscribers. This adds up to a total of more than 650 listed charging points across Switzerland that can be looked up online at www.lemnet.ch. For the most part, the local utilities do not charge for the amount of electricity drawn from these park & charge stations.

New charging points are installed as soon as a public or private institution confirms its interest. These are mainly located at hospitals, schools and universities, railway stations and airports, shopping centres, but also include corporations (e.g., ABB). This ensures that public charging infrastructure is available at sites where it is really needed. As a consequence of this experience, there is no big discussion in Switzerland about the “chicken-and-egg problem” of whether there should be a dense charging infrastructure network before or after people are willing to shift to the use of electric vehicles.

Fig. 27.8 Park & charge facility at the railway station in Thun. (Photo: Solarcenter Muntwyle)

Most of the utilities that currently set up pilot infrastructure networks—in most of the cases as part of the park & charge system—use conventional CEE-approved industry plugs and outlets (figure 27.9). According to utility industry representatives, this is the safest and cheapest solution until international standards for charging connectors are implemented. The installation of expensive public charging points could jeopardize the advantage of the cheap electricity "fuel" and, by extension, the low operating costs for electric vehicles. In addition, utilities do not see investments in public charging infrastructure as a business development issue. Rather, up through now it has been handled as a service for the (future) customer.

Fig. 27.9 Typical outlets for 16 A (blue) and 32 A (red) using CEE industry plugs and sockets. (Photo courtesy of EKZ.)

Fig. 27.10 TEXX fast-charging freeway facility service station Grauholz. (Photo: Solarcenter Muntwyler.)

However, there are also interest groups that envision a largely electrified car fleet that can also be used for long-distance travelling. The private company TEXX, founded in 2009, started to install charging points at freeway service stations along the north-south Basel–Chiasso transit route (Fig. 27.10). These charging points are now sponsored by local power companies and TEXX is convinced that an "electric mobility service" will become a profitable business.

An ongoing dispute in charging infrastructure is about which party is responsible for managing the complexity of the charging electronics. Most Swiss utilities are convinced that the consumer—i.e., the electric vehicle user—can be more flexible and already has sufficient intelligence on board (telematic systems, GPS). In their opinion, it seems that the danger of redundancies will occur in case the automotive industry and the providers of the charging infrastructure do not agree on a technically sustainable and cost-effective solution.

The additional electricity consumption of 720,000 EVs and PHEVs, a figure that would correspond to 15% of the overall Swiss car fleet, is estimated at just 2% of today's total consumption of electricity in Switzerland. However, load levelling is still seen as necessary. Both because of cost reasons and conditions of the grid operators, the power of on-board chargers likely will not exceed typical values. Swiss experts believe that it will be limited at 11 kW per vehicle.

Swiss importers of the new electric vehicle models such as the Mitsubishi i MiEV, the Nissan Leaf and others, are not enthusiastic about marketing models that offer an electric vehicle purchase with separate battery leasing contracts. According to them, this does not correspond with the need of the customers to have one contract and warranty for a fully functioning car. This seems to be in line with the visions of EV manufacturer representatives. However, a solution of Swiss electricity suppliers is to set up new networks of "electric mobility operators" that care for the acquisition of the electric vehicle as well as the "energy supply"—the package of battery together with the electricity needed for the contracted period. This means that parallel or even different structures of electric vehicle distribution channels can emerge.

27.6 On the road

Swiss media have discovered the topic of electric mobility. Many recent reports on EVs are based on driving experiences, either by reporters or by early adopters, especially of the Tesla Roadster, the Mitsubishi i MiEV or Nissan Leaf.

Few showcases are successfully communicating a positive picture of electric vehicles. One such positive example was the project Alpmobil that organized rentals of 60 THINK EVs to tourists in a Swiss alpine region received a remarkably positive response from tourists and the press. It also won the Sustainability Award 2010 of the German tourism magazine *Travel One*. A second example was the sale of 50 Tesla Roadsters in Switzerland that prompted Tesla to open a shop in Zurich. The biggest Swiss food store chain MIGROS has begun its own EV business called "m-way". Migros sells THINK City EVs as well as an electric scooter model, and it also offers leasing schemes to help with the cost (figure 27.12).

Fig. 27.11 THINK of the "m-way". (Photo: Solarcenter Muntwyler.)

Switzerland is a highly successful market for assisted e-bikes and pedelecs. More than 85,000 e-bikes are currently on the Swiss roads, and 7% of all bicycles sold in 2010 have an electric drive. There are several reasons for this: Swiss cities are small and well-linked internally and with their nearby surroundings. Distances between places are short and people commute rather than drive private cars to work.

The promotion agency NewRide has successfully established a network among city authorities, bike dealers, and utilities to share publicity from information campaigns and support such as small local subsidies for the purchase of pedelecs. Swiss companies have also developed the new category of high-speed pedelecs combining human power with that of the electric motor and successfully brought them to the market, where the sales figures have doubled every year and achieved a market share of 11.2% of all new bikes sold in 2010.The market is still open for new products that address the smartphone generation in style and design above all (Fig. 27.12).

In 2011, changes in categorizing pedelecs are planned: high-speed e-bikes achieving more than 25 km/h speed will be regarded as motor bikes requiring a driver's licence. The main reason for this change is so that the local authorities can monitor of the rate of accidents in which pedelecs are involved, which have not been tracked thus far.

Fig. 27.12 The pedelec Stromer by Thömus, with a removable lithium-ion battery pack. (Photo courtesy of Thömus)

Electric scooters have been less successful in Switzerland so far. They are more expensive than the conventional ones and do not show the same advantages for scooter riders that e-bikes have over conventional bicycles: they are not faster and are not cheaper to operate than ICE scooter models. Therefore it is argued by transport specialists that all vehicles less than 125 cc/m^3 should be electric by law. Swiss Post meanwhile has 1,000 Oxygen Cargo Scooters in operation for postal deliveries.

There are a few new players in the field of EV marketing in Switzerland. As noted already, the country's biggest retailer chain Migros has started sales and leasing schemes of electric vehicles under the label "m-way". Currently, THINK and five electric scooter models are offered. Also, a few cities have expressed their interest in promoting electric vehicles. Although toll systems like the congestion charge in London do not seem likely to be implemented (one such proposal by the City of Zurich was rejected a few years ago), other measures such as preferred parking, the use of bus lanes, and public investments in charging infrastructure are being discussed. The Office of Energy and Environment in the City of Basel sponsors EV sharing schemes for companies and private individuals. Twenty electric Renault Twingos are available in this four-year-long project starting in 2011.

As of 2010, several electric vehicle models were available in Switzerland. The company Kamoo converts gasoline cars to electric drive and currently sells conversion models of the Renault TWINGO and small FIAT models. They have also announced that they will offer home charging systems. In 2010, it took orders for 80 EV conversions, and 60 of them were delivered before the end of the year. The THINK City is only delivered in procurement schemes, but the cars can now be ordered by individual customers at the Migros "m-way". Quadricycles such as the Italian Tazzari Zero, Aixam Mega e City, Bellier Opale, Reva and MyCar from Monaco can be bought from various small importers, but they are only sold in small numbers. A case in point was in 2010 when 10 Tazzaris were sold, significantly fewer than the 50 Tesla Roadsters sold in the same period.

For 2011, the new EV generation such as the Mitsubishi i MiEV (of which more than 100 pre-orders are reported), Peugeot Ion, Citroën C-ZERO, Opel Ampera, Nissan Leaf and Renault Fluence have been announced. Prices are in a range of CHF 46,000 (US$ 50,600) for the i MiEV and 55,900 (US$ 61,500) for the Ampera. However, ongoing availability of these models is not guaranteed, as representatives of the "new" EV manufacturers complain that the Swiss market is too heterogeneous, as it comprises three language areas with relevant cultural differences, and that the Swiss government is not willing to support their efforts.

The sales of hybrid models continue to grow, although less strongly than in previous years. Table 27.1 reports the data on the Swiss car park as of September 2010, which shows that there are now 18,000 HEVs on Swiss roads, an increase of more than 60% since the end of 2008. It is expected that the new hybrid models (e.g., the Prius III, especially the family version, or the Toyota Auris) will provide additional stimulus to the market.

Table 27.1 Hybrid and electric vehicle fleet numbers in Switzerland as of September 2010. Estimates are in *italics.*

Vehicle type	per September 2010			
	EV fleet	HEV fleet	Total fleet	Remarks
Motorized bicycle (no driver license)	>85,000		4,300,000 50,000 mopeds included	High-speed E-bikes are licensed as mopeds, plus this total includes 450 Segways
Motorbike	2,100		650,000	Includes lightweight three-wheelers
Passenger vehicle	1,000	18,000	4,400,000	
Multipurpose passenger vehicle	350			Special vehicles in the car-free resorts
Bus	30	30	350,000 including agricultural vehicles	
Truck				
Total	**88,480**	**21,000**	**9,700,000**	

27.7 Outlook

As discussed in this chapter, the development in Switzerland is being driven at present in large measure by non-government stakeholders, above all the utilities, EV importers, and the interested public. New players, like the leading retail business chain Migros, are starting new business models for marketing electric vehicles. It is these actors that will set the electric vehicle market in motion.

28 Turkey

28.1 Introduction

The automotive industry in Turkey is quite large, with OSD, the Automotive Manufacturers Association, representing 15 manufacturers, stating that in 2010 the automotive industry was the largest country export sector at 15.3%. Total production was 1,095,000 units, with a 26% increase in 2010. Yet while the automotive industry is strong, the Turkish hybrid and electric vehicle market is in a beginning phase. The Honda Civic hybrid electric vehicle (HEV) is the first commercial hybrid being offered for sale in the automotive market, with Toyota following their lead. During the last year, Renault announced production of the Fluence Z.E. electric vehicle (EV) with a projected market date of 2011. In July 2010 TOFAŞ, a joint venture of FIAT Auto, introduced the prototype of the Doblo EV, the first battery electric vehicle designed and developed for serial production in Turkey. Also, Turkish bus manufacturers Temsa and Otokar announced the addition of a hybrid bus to their portfolios.

In anticipation of future sales in coming years, some companies, such as Mitsubishi with the i-Miev and Nissan with its Leaf, are introducing their HEVs and EVs to consumers on their websites. Electric two-wheelers have been on the market for the last few years with a small market share.

In the year 2009, 19.8% of the total energy consumption of Turkey was attributable to transportation, and 83.6% of that figure was from road transportation. Awareness of environmental issues and clean vehicles is increasing in Turkish industries, research and development (R&D) organizations, and society as a whole. Turkish policies and legislation are encouraging reductions in greenhouse gas (GHG) emissions and improved air quality.

28.2 Policies and legislation

Turkey has several legal and policy instruments to support the "greening" of transportation, which could help encourage the use of hybrids and EVs when they become more common in the country.

As a candidate for membership in the European Union (EU), Turkey aims to fully cohere with EU legislation. For this purpose, several new items of legislation were published, and many studies are underway to help prepare new regulations and legislation designed to reduce GHG emissions and improve air quality. Turkish emission standards for all gasoline and light- and heavy-duty diesel vehicles have matched the Euro IV standards since 1 January 2009, according to emission legislation 70/220/AT and 88/77/AT-2005/55/AT.

In January 2009, a regulation to inform consumers about the fuel economy and carbon dioxide (CO_2) emissions of new passenger vehicles was implemented. The government now requires dealers of new passenger cars to provide potential buyers with useful information about the vehicle fuel consumption and CO_2 emissions in order to help consumers choose vehicles with low fuel consumption. This information must be displayed on the car's label, on posters and other promotional materials, and in specific guides. The vehicle's official specific CO_2 emission class, as specified in table 28.1, must also be given.

Table 28.1 Official specific CO_2 emission classes for vehicles. The CO_2 emission values are given in grams emitted per km of travel.

Official specific CO_2 emission class	Official specific CO_2 emission
A	< 100 g CO_2/km
B	101–125 g CO_2/km
C	126–150 g CO_2/km
D	151–175 g CO_2/km
E	176–200 g CO_2/km
F	201–225 g CO_2/km
G	> 225 g CO_2/km

Two types of taxation measures are imposed on vehicles in Turkey. The first one is a tax on an initial new vehicle sale; the second type is an annual vehicle tax, which is paid yearly and based on the engine cylinder volume and the age of the vehicle. The annual tax is lower for smaller engines and older vehicles. For buses, the annual tax is independent of the engine type or size, but rather depends on the vehicle's seating capacity and age. Studies are underway to prepare new tax regulations that will be based on vehicle emission rates.

However, with the new vehicle sale tax regulation, the special consumption tax on EVs when they are purchased is lower than that for conventional vehicles. The vehicle sale tax reduction only includes battery electric vehicles and battery electric motorbikes and excludes HEVs, plug-in electric vehicles (PHEVs). Also, only passenger vehicles and motorbikes are included in the vehicle sale special consumption tax reduction; light duty trucks, trucks, buses, etc., are excluded. Table 28.2 shows the vehicle sale special consumption tax categories for the initial new passenger vehicle and motorbike sales. This new incentive available in Turkey is expected to impact only electric vehicle sales out of HEVs, PHEVs, and EVs.

Table 28.2 Special consumption tax classification categories on an initial new vehicle sale

	Conventional		Electric Only	
	Engine Cylinder Volume (cm^3)	Special Consumption Tax (%)	Electric Motor Power (kW)	Special Consumption Tax (%)
PASSENGER VEHICLE	<1600	37	<85	3
	1600-2000	60	85-120	7
	>2000	84	>120	15
MOTORBIKE	<250	8	<20	3
	>250	37	>20	37

Turkey is reassessing its energy portfolio in response to its current dependence on imported natural gas. The Ministry of Energy and Natural Sources released a strategic document regarding energy efficiency, including in transportation. In addition to this, Ministry of Industry and Trade released an Automotive Industry Strategy Document and Action Plan for implementation between 2011 and 2014. The topics below are mentioned in both ministerial documents, several of which would impact the incentives for purchasing hybrid and electric vehicles when they become more widely available in Turkey.

According to the strategic documents, the specific fuel consumption of domestically produced vehicles will be reduced. Vehicle efficiency standards will be upgraded, public transport systems will be expanded, and advanced traffic signal systems will be installed. It is expected that new laws will be written according to the goals of the strategic document. Legislation arrangements for the following measures will be included:

- To increase the use of alternative energy vehicles in accordance with the vision of Turkey regarding climate change, automotive and subcomponent manufacturing companies will be encouraged with initiatives to design and manufacture the main parts of the alternative vehicles such as electric motors, batteries, control systems, and other vehicle components.
- Public awareness studies will be conducted to increase the usage of green vehicles.
- Vehicle energy efficiency labels will be applied, and efficient vehicles will be allowed to use parking lots, cross bridges, and travel on highways with

discounts on tolls or even free of charge.

- Green vehicles will be the preferred purchase of new governmental fleets.
- Tax regulations will be revised to encourage the usage of low-CO_2-emitting vehicles (hybrid, electric, others).
- Electric vehicle charging infrastructure and filling stations for CNG vehicles will be implemented.
- Energy efficiency courses will be given in driver training.
- Rail and sea transport will be encouraged.
- Urban transport routes will be planned according to fuel consumption values.
- Bicycle routes will be arranged where local topography is suitable.
- The use of vehicles with small engine volumes, low emission levels, hybrid vehicles, cellulosic ethanol, and synthetic fuel that can be produced from domestic biomass resources will be encouraged with tax incentives.
- With the new regulation, vehicles (buses and trucks) that have been used more than 25 years are encouraged to be taken out of use.

28.3 Research

In the last decade, the Turkish Government has significantly increased the amount of financial resources allocated for research and development (R&D). The automotive industry is an important industrial sector for the country, and automotive-related research is part of the vision of its R&D program. Research topics relevant to HEVs and EVs along with electric drivetrain technology subcomponents are naturally a part of automotive R&D. With the growth of the HEV market, a synergy between scientific and industrial interests was inevitable, leading to the development of joint projects. The following organizations are involved in hybrid and electric vehicle technologies: TÜBITAK MRC Energy Institute, OTAM, Istanbul Technical University Mechatronics Education and Research Center, and Okan University Transportation Technologies and Intelligent Automotive Systems Application and Research Center.

The National Automotive Technology Platform (OTEP) began in 2008 and is the program for industry, trade organizations, universities, research institutions, and the public sector to jointly determine a vision for the Turkish automotive industry and identify strategic research areas (SRAs) to be addressed to realize this vision. Precompetitive R&D projects based on these SRAs will be proposed and awarded at the national scale. Activities will be chosen to create an awareness of Turkey's vision and goals across all European technology platforms. The vision and the SRAs will be reviewed and possibly realigned on an annual basis.
The vision of OTEP is "to make Turkish automotive industry R&D and innovation infrastructure competitive in the international arena," and the vision for the Turkish

automotive industry was stated as follows: "To authentically develop and implement technologies of high added value for meeting the global transportation requirements and expectations in order to obtain a globally sustainable and competitive automotive industry which provides innovative, environmentalist, efficient and contemporary transportation systems and platform solutions."

At the first stage, preparation of the documents for the "Turkish Automotive Industry Vision and Strategic Research Program for 2023" was initiated by the working groups created within the platform. Four working groups were established in order to determine the vision and build the strategic research plan for mobility, transportation and infrastructure, environment, energy and resources, safety, and lastly, design and production systems.

In addition to these four working groups, an "Electrical Vehicles" working group was established. This group has been working to generate new ideas in the following areas: projects regarding electrical vehicles; collecting information about the products on the market; the market estimates for electrical vehicles from various sources; electrical vehicle technologies, including the present state-of-the-art and anticipated future directions; power supply technology, engine technology and the outstanding companies/research centers in these fields; analysis on the state of the electrical vehicles in terms of performance and environmental pollution; and lastly, the state of affairs in Turkey regarding the above mentioned issues together with possible suggestions.

TÜBITAK MRC Energy Institute

The Scientific and Technological Research Council of Turkey (TÜBITAK) was founded in Ankara in 1963. Its aim is to develop, promote, plan, and coordinate R&D activities in fields consistent with the priorities for Turkey's development. The scientific and technological R&D activities of TÜBITAK are conducted through its research institutes. Of these, the Marmara Research Center (MRC) in Gebze, founded 1972, is the oldest and largest. The MRC Energy Institute's vehicle technology research emphasizes the following areas.

- Vehicle technologies: system integration of HEV powertrains; modeling and simulation of EV and HEV technologies and HEV control systems; and rapid prototyping of control systems, electrical energy storage systems and battery technologies, and electric machines and drives for traction applications.
- Power electronics technologies: circuit designs; programming, control, and signal processing; power system simulation and analysis; and network analysis.
- Advanced energy technologies: fuel cell technologies, e.g., proton exchange

membrane (PEM) fuel cells and direct sodium borohydride fuel cells (DSB-HFCs); hydrogen production and storage; and combustion, gasification, and gas cleaning systems.

- Fuel technologies: analyses of solid fuels, e.g., lignite, coke, and petrocoke; analyses of liquid fuels—especially gasoline, diesel, biodiesel, and fuel oil, according to international standards; and production of biodiesel.

TÜBITAK MRC Energy Institute has several completed and ongoing projects that address EVs and HEVs and their subcomponents. Examples are (a) ELIT-1 series HEV design and development, (b) Ford Otosan light-duty commercial HEV (FO-HEV) development, (c) electric motor driver design and development, (d) HEV battery development, (e) emission reduction in transportation, (f) electric energy storage technologies, and (g) sodium borohydride fuel cell vehicle (fig. 28.1) projects.

Fig. 28.1 TUBITAK MRC Energy Institute sodium borohydride fuel cell vehicle prototype. (Photo courtesy of TÜBITAK MRC Energy Institute.)

At the MRC Energy Institute, a Hybrid & Electric Vehicle Technologies Excellence Center is being planned for research projects and testing of HEVs, EVs, and their components. This project is supported by the Turkish State Planning Organization (DPT) and will be ready to serve the automotive industry in 2011. The test equipment for the center includes a two-axle chassis dynamometer, an electric motor dynamometer, battery test systems, an engine dynamometer, and an emission measurement system. The center will also include various laboratories: labs for electronic control units and other subcomponents, an electric motor design lab, a hardware-in-the-loop lab, an automotive electronic control lab, an advanced vehicle simulation techniques lab, and a mechanical design lab.

OTAM - Automotive Technology Research and Development Center

OTAM was established in 2004 in partnership with the Automotive Manufacturers Organization (OSD), TÜBITAK, and Istanbul Technical University (ITU). OTAM's overall goals are to carry out R&D on pre- and post-production efforts by the automotive industry and to act as a bridge between academia and local automotive companies in order to improve resource usage and technology exchange. OTAM was incorporated in 2006 when the Association of Automotive Parts and Components Manufacturers (TAYSAD) joined Uludag Automotive Exporting Union (UIB). This union provided the robust support and funding needed to establish a new platform for advanced projects.

OTAM operates and maintains state-of-the-art laboratories in the ITU Department of Mechanical Engineering's Automotive Division. These labs were revived and improved in recent projects supported by DPT and the European Union. Experts in various areas of automotive research and qualified engineers trained in ITU's undergraduate and graduate programs work together here under the same umbrella. Recent R&D projects with the local automotive industry in Turkey took advantage of ITU facilities, including the automotive acoustics laboratory (with silent chassis and engine dynamometers), vehicle durability and performance laboratory (with a four-poster shaker), vehicle emissions laboratory (for passenger cars and commercial vehicles), and engine emissions laboratory (for testing against current exhaust emission regulations).

Istanbul Technical University Mechatronics Education and Research Center

The Mechatronics Education and Research Center (MERC) was founded at the Maslak Campus of Istanbul Technical University (ITU) in 2008. MERC offers theoretical and applied studies to many students from a large number of technical departments including mechanical engineering and electrical and electronics engineering. Projects relating to automotive technologies are underway, including a hybrid vehicle project, an electric minibus project, and unmanned land vehicles projects. The hybrid vehicle project includes studies on fuel efficiency, energy management, power electronics, vehicle control, and hybrid vehicle design.

Fig. 28.2 ITU-MERC electric minibus prototype. (Courtesy of ITU-MERC.)

An electric minibus prototype was announced in October 2010 (see Fig. 28.2). The electric minibus can travel a minimum distance of 120 km with a maximum speed of 150 km/h at full load with 50-kW batteries. It also achieves a speed up to 75 km/h in 11 seconds. The vehicle gross weight is 3000 kg including batteries with a carrying capacity of 20 people up to a maximum weight of 4500 kg. Charging time for the minibus's battery is 3–4 hours in slow charge mode, and it has a service life of 3,000 charge-discharge cycles. It has a water-cooled electric motor, and vehicle control is achieved by the on-board vehicle computer rather than by a gearbox.

Okan University Transportation Technologies and Intelligent Automotive Systems Application and Research Center (TTIS)

Okan University Transportation Technologies and Intelligent Automotive Systems Application and Research Center (TTIS) aims to develop the academic and technical knowledge required by the Turkish automotive industry, the automotive supplies industry, and the public by conducting foresight studies on the following topics: future transportation systems and vehicles that run on clean energy; intelligent vehicles; intelligent transportation systems; unmanned vehicles; robots and robot groups along with their modeling, simulation, design and realization. Okan University TTIS performs and contributes to research and development in the areas of intelligent vehicles, intelligent transportation systems, vehicle-to-vehicle and vehicle-to-infrastructure communication, advanced automotive technologies, electric transportation technologies, fuel cells, vehicle technologies that use renewable energy, and finally, development and application of complicated simulation and virtual environments.

28.4 Industry

When the Turkish automotive industry was established prior to the 1960s, its objective was mainly to produce vehicles to replace foreign import of vehicles. The industry began to grow with the establishment of Tofas A.S. and Oyak Renault A.S. in 1970. The supply industry also began to develop in connection with the establishment of the main automotive industry. Since the 1990s, it has qualified as an export-oriented, competitive industry.

OSD, the Automotive Manufacturers Association, represents the 15 manufacturers in Turkey: Anadolu Isuzu, B.M.C., Ford Otosan, Hattat, Honda Türkiye, Hyundai Assan, Karsan, M.A.N. Türkiye, Mercedes Benz Türk, Otokar, Oyak Renault, Temsa Global, TOFAŞ, Toyota, and Türk Traktör. As stated in the chapter introduction, according to OSD's annual report, in 2010 the automotive industry was Turkey's largest export sector at 15.3%. The total production was 1,095,000 units in 2010, representing a 26% increase over the number of vehicles manufactured in 2009.

TAYSAD, established in 1978, represents the Turkish automotive supplier industry. With 287 members, TAYSAD represents 65% of the output of the automotive supplier industry and 70% of the industry's exports. Of TAYSAD's members, 80% operate in the Marmara region, 12% in the Aegean region, and 8% in other regions of Turkey. The TAYSAD members employ a total of 80,000 people, and when the suppliers of TAYSAD members are included, the total number of employees reaches about 125,000. The main product groups manufactured by TAYSAD members operating in the motor vehicle manufacturing industry can be classified as complete engines and engine parts, power trains, brake systems and parts, hydraulic and pneumatic spare parts, suspension parts, safety spare parts, foam and rubber parts, chassis parts and spare parts, forged and cast parts, electrical equipment and illumination systems, batteries, automobile glass, and seats.

The Turkish automotive industry's awareness and interest in HEVs and EVs has been increasing with some companies in the prototype phase and other companies in the serial-manufacturing phase. Research projects on system components are being carried out by several companies and research institutions. Industry interest has concentrated on battery, electric motor, and fuel cell technologies along with emissions and vehicle system integration.

TOFAŞ, a joint venture of Koc Holding and FIAT Auto, is located in Bursa, Turkey, and in 2010 it introduced the Doblo EV. The factory produces more than 300,000 passenger cars and light-class vehicles per year. TOFAŞ's R&D Center employs more than 350 experts and specialists. In 2009, the company concluded the development of FIAT Doblo, with all commercial and industrial rights belonging to TOFAŞ. Sales of the Doblo launched in 2010, and the vehicle was awarded with the International Van of The Year 2011 award at the 2010 IAA Commercial Vehicle Show in Hanover, Germany.

Fig. 28.3 FIAT Doblo EV – The first battery electric vehicle designed and developed for serial production in Turkey. (Photo courtesy of TOFAŞ.)

In November 2009, TOFAŞ started developing the all-electric version of the vehicle, Doblo EV (Fig. 28.3). The development process was conducted at TOFAŞ and announced by FIAT as "the first electric vehicle designed and developed for mass production in Turkey". The first prototype was introduced at the 1 Millionth Doblo ceremony in July 2010, receiving positive comments from Minister of Industry and Trade of Turkey and the media pundits.

The Doblo EV has the same size and cargo capacity (750kg) as the original internal combustion engine (ICE) version. It also has a limited maximum speed of 110km/h and a seamless fast acceleration of 0 to 100km/h in 9.6 seconds, with the help of the two mode 75/105-kW, 180/320-Nm electric machine and a single gear. The running range is 150km, with a 21-kWh lithium-ion battery pack with a 10-year/300,000-km lifespan. It is possible to charge the batteries in 7 hours with a simple 220V/16A plug, or else fast-charge the battery in 45 minutes with a DC high voltage charger. The vehicle also employs regenerative braking to recuperate energy.

Fig. 28.4 Renault Fluence Z.E. Electric Vehicle

Fluence Z.E (Fig 28.4) production has begun at Oyak Renault Bursa Plant. It is expected that the EV version of Fluence will be sold in September 2011. The electric version of Fluence uses the same chassis as the conventional one with an extension of 13 cm. The charging inputs are both located at the right and left side of the vehicle. The vehicle has a synchronous electric motor with 70 kW peak power at 11,000 rpm and 226 Nm maximum torque with 160 kg motor weight. The lithium-ion battery has a capacity of 22 kWh and weighs 250 kg. The vehicle has a range of 185 km, with the limited maximum speed of 135 km/h. It will be possible to charge the battery of Renault Fluence Z.E. in one of three ways: 1) via a household mains supply (10A or 16A, 220V), which will fully charge the battery in between six and eight hours; 2) at fast-charge stations using a 32A/400V supply which enables the battery to be charged in approximately 30 minutes; and 3) using a QuickDrop battery switch system that will enable the Renault Fluence Z.E.'s battery to be swapped in approximately three minutes at battery exchange stations.

Fig. 28.5 TEMSA Avenue Hybrid bus. (Photo courtesy of TEMSA.)

Turkish bus manufacturing company TEMSA offers the Avenue Hybrid (figure 28.5) in their city bus portfolio. The 12-m bus has a series hybrid powertrain with two asynchronous electric motors on one axle, a permanent magnet generator, and an ultracapacitor as electric energy storage system. The reductions in fuel consumption and emissions can reach 30% when compared to an ICE. With wide-ranging options for capacitor and engine size and capacity, this series hybrid bus offer great flexibility and are even adaptable for use in zero-emission zones.

Otokar has a concept hybrid urban bus, Doruk 160LE Hibra, based on Otokar's Doruk LE Series in the heavy-duty segment. When compared to conventional fossil fuel–powered buses, Doruk also presents better emission and fuel consumption figures over an ICE.

28.5 Charging infrastructure and vehicle deployments

During the past year Turkey has seen some new developments towards the introduction of charging infrastructure and pilot electric vehicle fleet programs.

İstanbul Enerji, an association of İstanbul Metropolitan Municipality, is taking the lead role of organizing the related parties to assess the possibilities for electric vehicle deployment in metropolitan cities, including charging stations and municipality services. The project, Charging Infrastructure for Electric Vehicles, began in 2010. The project focus includes the following topics: vehicle technologies, battery technologies, charging stations, grid technologies, and standardization and regulations.

Driver/user profiles, charging station points, and feasibility studies are underway during the initial project phase. Regulation studies related to charging infrastructure for implementation such as subcontracts and payment systems have been discussed with the Ministry of Industry and Trade and Energy Market Regulation Board. Additionally, charging station technologies, payment technologies, and electric grid infrastructure topics have been under discussion with universities, electric companies, and municipality service providers. İstanbul Enerji, along with the other two İstanbul Metropolitan Municipality associations, BELBİM (related to the information technologies) and İSPARK (related to the car parking services) have been planning to install the required infrastructure for charging the electric vehicles in İstanbul. The first demonstration charging stations are planned for the parking lots and the social facilities of the municipality (see Fig. 28.6).

Fig. 28.6 The first few planned stations are marked with the orange flags on the online traffic map of İstanbul. Drivers will also be able to check the availability status of the charging stations from mobile phones to choose a charging station that is not in use.

The Renault Fluence Z.E. electric vehicle is projected to be sold in 2011. Renault has been working on three charging options, as described in the previous section: to charge the vehicle via a household mains supply, to charge at fast charge stations using a high power supply, and the QuickDrop battery switch system to swap the electric vehicle's battery in approximately three minutes using existing vehicle sales/service points locations. In order to increase the usage of the EVs, Renault has signed contracts with city municipalities like Istanbul, Ankara, and Gaziantep to install the charging stations.

Ankara Metropolitan Municipality has also announced that it will acquire a fleet of 100 electric vehicles within the coming year. Initially, the charging stations will be located at the municipality buildings. The next step will be to install charging stations at different locations of Ankara.

Standardization efforts are ongoing for the advanced energy and alternative fuel vehicles. Last year the regulation for the production of motor vehicles was renewed that included hybrid vehicles, hybrid electric vehicles, and battery electric vehicles. The required types of approvals have been described for the alteration of motor vehicles to hybrid and electric vehicles. The battery charger should be compatible with 2006/95/EC. The standards and the regulations are being modified to include the requirements for electric vehicles.

The electric energy grid load and mix of energy sources is another important aspect for EV charging. Since 2002, strong and stable economic growth together with rising social wealth has led to a substantial increase in energy consumption. From 2002 to 2008, electricity consumption increased by 49%. However, since the last quarter of 2008, when the global economic crisis started to profoundly affect the Turkish economy, a deceleration in economic activities combined with an increase in energy prices caused the demand for energy to decrease. After a previous 2001 crisis, the second and largest drop in electricity demand in the last 30 years was observed in 2009. The most recent statistics revealed economic activities are on a positive incline, and thus the electricity consumption increased by 7.9% in 2010. In 2009, 19.8% of the total energy consumption of Turkey was attributable to transportation, and 83.6% of that was from road transportation. Statistics for 2009 show that Turkey's electricity was generated 49.3% from natural gas, 28.6% from coal, 18.5% from hydro sources, and 0.8% from wind.

28.6
On the road

The number of vehicles on the road in Turkey is increasing. Although the total fleet of vehicles on the road is about 15 million, there are only a few HEVs among them (The Honda Civic hybrid and Toyota Prius). The number of road vehicles presented in Table 28.4 is based on figures published by the Turkish Statistical Institute.

Table 28.4 Number of vehicles on the road in Turkey from 2005 through 2010. (Source: Turkish Statistical Institute.)

	2005	2006	2007	2008	2009	2010
Passenger vehicle	5,772,745	6,140,992	6,472,156	6,796,629	7,093,964	7,544,871
Minibus	338,539	357,523	372,601	383,548	384,053	386,973
Bus	163,390	175,949	189,128	199,934	201,033	208,510
Light-duty truck	1,475,057	1,695,624	1,890,459	2,066,007	2,204,951	2,399,038
Truck	676,929	709,535	729,202	744,217	727,302	726,359
Motorbike	1,441,066	1,822,831	2,003,492	2,181,383	2,303,261	2,389,488
Tractor	1,247,767	1,290,679	1,327,334	1,358,577	1,368,032	1,404,872
Others	30,333	34,260	38,573	35,100	34,104	35,492
Total	**11,145,826**	**12,227,393**	**13,022,945**	**13,765,395**	**14,316,700**	**15,095,603**

Passenger vehicle: Vehicle with a designated maximum seating capacity of 8.
Minibus: Vehicle with a designated seating capacity of 9 to 15.
Bus: Vehicle with a designated seating capacity of 16 or more.

Light-duty truck: Vehicle designated for the transportation of equipment with a maximum gross vehicle mass of 3, 500 kg.
Truck: Vehicle designated for the transportation of equipment with a gross vehicle mass of more than 3, 500 kg.
Motorbike: Vehicle designated to travel with no more than three wheels contacting the ground.
Tractor: Agricultural vehicle not used for commercial transportation.
Others: Vehicles designated for the transportation of passengers or equipment, such as an ambulance, fire fighting vehicle, towing truck, and hearse.

Most passenger cars in Turkey were previously fueled by gasoline, but now the proportions of diesel and liquefied petroleum gas (LPG) passenger vehicles are increasing due to the lower cost of diesel and LPG when compared to gasoline. The population of road vehicles by fuel type based on Turkish Statistical Institute data is presented in table 28.5. Sales of electric two-wheelers have recently begun, but the number of these vehicles on the road is still small. Table 28.6 profiles the makeup of the Turkish in-use fleet as of the end of 2010.

Table 28.5 Types of fuel used by motor vehicles in Turkey from 2005 through 2009. (Source: Turkish Statistical Institute.)

	2005	2006	2007	2008	2009
Gasoline vehicle	5,606,321	5,935,725	5,980,516	5,952,,746	5,887,559
Diesel vehicle	3,836,399	4,372,042	4,850,837	5,323,478	5,654,350
LPG vehicle	1,298,830	1,569,951	1,880,023	2,276,283	2,592,695
Unknown	404,276	349,675	311,569	212,888	182,096
Total	*11,145,826*	*12,227,393*	*13,022,945*	*13,765,395*	*14,316,700*

Table 28.6 Characteristics and population of the Turkish motorized vehicle fleet as of December 31, 2010.

	December 31, 2010		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet**
Motorized bicycle (no driver license)	n.a.	n.a.	n.a.
Motorbike	n.a.	n.a.	2,389,488
Passenger vehicle	n.a.	400[a]	7,544,871
Multipurpose pass. vehicle	n.a.	n.a.	n.a.
Bus [b]	n.a.	n.a.	595,483
Truck	n.a.	n.a.	3,125,397
Industrial vehicle	n.a.	n.a.	1,440,364
Total	**n.a.**	**400**	**15,095,603**

n.a.: not available
(a) estimate
(b) Includes minibuses.
The definitions of the different vehicle categories can be found in section E of this report, “Vehicle categories.”

28.7 Outlook

The outlook is positive for hybrid and electric vehicles in Turkey over the next decade due to interest from the automotive companies in introducing these vehicles, the declaration of government spokesmen, and the strategy documents and action plans of the various Turkish ministries.

As mentioned previously, the hybrid vehicle market in Turkey is just beginning. The Honda hybrids and Toyota hybrids are on the market. In 2010, the electric vehicle market has begun to attract manufacturers and consumers due to the "special consumption" tax reduction announcement for battery electric vehicles. In 2011, the Renault Fluence Z.E. electric vehicle will enter the market supplied by the serial production at a plant in Bursa, Turkey, and the Doblo EV by TOFAŞ is anticipated within the next couple of years. Other hybrid and electric models such as the Mitsubishi iMiev and Nissan Leaf are promoting consumer awareness of their products in advance of their introduction to the Turkish market.

The National Automotive Technology Platform that includes a broad spectrum of stakeholders is determining a vision for the Turkish automotive industry. Turkey aims to fully cohere with European Union legislation including in the areas of transport and reductions for CO_2. On the national level, Turkey has new vehicle legislation and is also conducting many studies to prepare new regulations and legislation to reduce GHG emissions and improve air quality.

Turkey's current situation and short-term policies indicate that the number of R&D projects related to electric vehicles, hybrid vehicles, fuel cells, energy storage, and alternative fuels will continue to increase. More hybrids, electric vehicles and low-CO_2-emitting vehicles will no doubt be seen in the market and on the roads in the coming years because of greater awareness about clean vehicles and the environment.

29 United Kingdom

29.1 Introduction

The new United Kingdom Coalition Government of Prime Minister David Cameron has moved quickly to affirm its commitment to the decarbonization of road transport originally outlined in the May 2010 "Our Programme for Government." That document outlined the government's plans for a national recharging network for electric (EVs) and plug-in hybrid electric vehicles (PHEVs), measures to encourage "green growth," and the creation of a green investment bank. The British transport sector in particular is one where significant CO_2 reductions could be realized. In 2009, the most recent year for which final numbers are available, road transport accounted for almost 24% of UK carbon dioxide emissions and the transport sector overall accounted for about 22% of UK greenhouse gas emissions.

The Coalition Government has announced provisions for over £400 million in measures to promote the update of ultra-low carbon vehicle technologies including the Plug-In Car Grant for the purchase of qualifying cars (as detailed in Section 29.2) and continued support for the Plugged-In Places recharging infrastructure plan. Significantly, the grant program was confirmed in July 2010, two months before the completion of the government's comprehensive spending review. Most recently, in May 2011, the government formally accepted the recommendations in the Committee on Climate Change's Fourth Carbon Budget issued in December 2010. The report states that progress in decarbonizing surface transport must begin now to meet carbon reduction goals for the 2020s. It also states that this will require additional government support to lower the cost of electric vehicles as well as investment in charging infrastructure. In particular, the Committee concluded that £800 million in total government support would be needed under its "Extended Ambition" scenario whereby 5% of the total UK car fleet and 16% of all new cars on UK roads in 2020 consist of electric and plug-in hybrids. It cautioned that a five-year delay would raise this cost to £5 billion.

The Coalition Government's plans in many ways represent a continuation of the efforts to develop ultra-low carbon vehicles announced by the previous government. It was in late October 2006 the landmark *Stern Review on the Economics of Climate Change* was released, setting out the economic case for climate change including on the part of the UK.

The strategy for shifting to ultra-low carbon vehicles in the UK was announced in April 2009 when the Secretary of State for Transport and the Secretary of State for Business, Enterprise and Regulatory Reform jointly announced the vision document *Ultra-Low Carbon Vehicles in the UK* outlining a comprehensive package of measures totalling £400 million to accelerate the transition to ultra-low carbon vehicles. This document represented the collective strategy of the Department for Transport (DfT); the Department for Business, Enterprise and Regulatory Reform (BERR); and the Department for Innovation, Universities and Skills (DIUS) and included £400 million in measures. (BERR and DIUS were subsequently merged into the new Department for Business, Innovation and Skills (BIS).) Fully £250 million was to come from DfT, with most of that used to be used for consumer incentives (i.e., the Plug-In Car Grant) and infrastructure development (i.e., the Plugged-In-Places initiative).

The main efforts are being carried out through the Office for Low Emission Vehicles (OLEV). OLEV was established in November 2009 as a cross-government effort to manage the programmatic and regulatory efforts to decarbonize UK road transport. This includes development of ultra-low emission vehicles through research, development, and demonstration efforts, as well as promoting consumer uptake of such cars. OLEV is also charged with improving fuel economy of conventional vehicles. OLEV includes staff and personnel from DfT, BIS, and also the Department of Energy and Climate Change (DECC).

29.2 Policies and legislation

The UK Coalition Government is committed to put in place the necessary policies to facilitate the decarbonization of the road transport sector. This commitment is within the context of a more austere overall fiscal strategy that is intended to improve the country's finances. In particular, the Spending Review undertaken by the Chancellor of the Exchequer and presented to Parliament in October 2010 states that all UK government departments except health and overseas aid will experience an average budget cut of 19% over the next four years. Despite these cuts, the UK Government announced a package of around £400m for ultra-low emission vehicles to support their green growth and environmental aspirations. The amount was broadly the same as the amount committed by the previous administration.

DfT Business Plan 2011–2015: Decarbonizing Transport

It is against this background that the UK's Department for Transport (DfT) produced a four-year *Business Plan 2011–2015* that details the priorities, structural reform plans, expenditures, and efforts at increasing public transparency and accountability.

The current plan (most recently updated in May 2011) covers the period 2011–2015, but the intention is for it to be updated annually. This plan outlines the UK Government's five structural reform transport priorities which include a commitment to tackle carbon and roadway congestion. As part of this priority, DfT states that it will "support the early market for electric and other ultra-low emission vehicles, promote the more effective use of strategic roads by addressing the causes of congestion, and continue to improve road safety."

In addition, the plan outlines five specific actions that will be necessary to achieve the stated goals. While four are related primarily to reducing road congestion, the action relevant with respect to decarbonizing transport calls for the promotion of electric and other ultra-low emission vehicles and mandating a national recharging network. Within this action are five additional ones listed as follows:

1. Develop a nationwide strategy to promote the installation of electric vehicle infrastructure, including a decision on whether to use an energy Regulated Asset Base and/or changes to planning/building regulations.
2. Support the Plugged-In Places pilots programme to encourage the establishment of electric vehicle recharging infrastructure across the UK and inform the development of the electric vehicle infrastructure strategy.
3. Push for early European Union (EU) adoption of electric vehicle infrastructure standards.
4. Consolidate existing support mechanisms for low and ultra-low emission vehicle research and development.
5. Promote consumer uptake of ultra-low emission vehicles.

As part of the Plugged-In Places effort, DfT plans to run a bidding process for the second round of funding and to release those funds to successful bidders. Additional information on the Plugged-In Places initiative is discussed below.

Plug-In Car Grant

Approximately 22% of UK domestic carbon emissions are from the transport sector, almost all of which is road transport. To meet UK carbon reduction targets, this sector needs to be decarbonized. A key element of this decarbonization will be the move to ultra-low carbon vehicles, including both electric and plug-in hybrid ones. These vehicles will initially be more expensive than conventional cars due to low production volumes and high battery cost. To help encourage consumer uptake of such vehicles until the technology improves and prices fall, the UK Government has created a subsidy programme called the Plug-In Car Grant. The purpose of this consumer grant programme is to enable the purchase of ultra-low carbon vehicles which would otherwise have been unaffordable. The consumer should also benefit from lower running costs over the lifetime of the vehicle.

Under the Plug-In Car Grant program, qualifying ultra-low emission cars will receive a grant of 25% toward the cost of the vehicle up to a maximum of £5,000. The subsidy has been designed to help make the "whole-life costs" of a qualifying car comparable to a conventional internal combustion engine vehicle, and it is intended to be "technology neutral" in which any car regardless of fuel propulsion system is potentially eligible provided it has tailpipe CO_2 emissions no higher than 75 g per km. Thus, it includes electric and plug-in hybrids as well as hydrogen-fuelled vehicles. While the Plug-In Car Grant had its policy origin under the previous Labour government, it is noteworthy that the Coalition Government's Secretary of State for Transport Philip Hammond himself confirmed the subsidy and its amount a full two months before its government-wide Spending Review was completed.

The Plug-In Car Grant programme opened to consumers on 1 January 2011, and as of 30 June 2011, 680 cars had been ordered through it. The prices listed on the program's website at http://www.dft.gov.uk/pgr/sustainable/olev/grant1/ reflect the cost after the grant has been applied and include the 20% value-added tax (VAT). These include £23,990 for the Mitsubishi i MiEV, £25,990 for the Nissan Leaf, and £28,995 for the Vauxhall Ampera.

The grant programme will be reviewed at regular intervals to confirm that there continues to be a strategic case for such subsidy and, if so, to ensure the subsidy is set at an appropriate level. The first such review is scheduled for April 2012.

Plugged-In Places

The Plugged-In-Places (PIP) initiative was originally announced in 2009 and was intended to support the development and consumer uptake of ultra-low carbon vehicles by creating electric car hubs in six key British cities or hubs with the installation of charging points in various locations. PIP represents a major effort in establishing a charging infrastructure in the UK, and therefore it is discussed in more detail in Sec. 29.5.

Other National Measures

In addition to the aspirations above, electric vehicles in the UK also benefit from a range of other support at both national and local level. These measures are summarized in table 29.1.

Table 29.1 National and local measures that support PHEVs and EVs in the United Kingdom

National Measures	Electric Vehicles
Vehicle Excise Duty (UK's Circulation tax)	Exempt (as tailpipe emissions < 100 g CO_2/km)
Company Car Tax	Employees and employers exempt from income and national insurance contributions
Van Benefit Charge	Employees and employers exempt from income and national insurance contributions
Fuel Benefit Charge	Exempt (N/A)
Enhanced capital allowances	100% first-year allowance: business can relieve entire cost of an electric car or van against taxable profits in the year of acquisition
Local Measures	
London congestion charge	100% discount
Parking charges	Some local authorities provide exemptions or a reduced charge for electric cars.

29.3 Research

A number of research, development, and demonstration (RD&D) initiatives, activities, and projects are underway in the UK to advance ultra-low carbon vehicles including electric and plug-in hybrid cars. Among the most notable UK government efforts are the Technology Strategy Board's Low Carbon Vehicles Innovative Platform and its component pieces, including the Integrated Delivery Programme (IDP) and Ultra Low Carbon Vehicle Demonstrator project. Other RD&D activities include those related to (1) growth opportunities in the UK automotive supply chain, in particular low carbon technologies; (2) demonstration projects of hydrogen and fuel cell-powered vehicles; and (3) consolidation of support mechanisms for low and ultra-low carbon vehicles (as called for in the DfT Business Plan). Finally, three government departments are working collaboratively to produce a new Roadmap to the Green Economy scheduled for release in mid-2011. It will focus in particular on transforming the automotive sector.

Low Carbon Vehicles Innovation Platform: IDP and ULCV Demonstrator

The Low Carbon Vehicles Innovation Platform was launched in September 2007 by the Technology Strategy Board (TSB), a non-departmental entity of the UK Government that is funded by BIS and other departments. The purpose is to promote UK-based research and development in low carbon vehicle technologies and strengthen the domestic supply chain link. The key piece of the innovative platform is the

Integrated Delivery Programme (IDP), a government and industry co-funded effort that is intended to coordinate UK low carbon vehicle activity from initial strategic research through industry-led collaborative research and development and demonstration projects. IDP intends to release £120 million in grants with that amount to be matched by industry for an overall total approaching £250 million. Among those funding the IDP are the Engineering and Physical Sciences Research Council (EPSRC), BIS and the Department for Transport's OLEV, as well as regional development agencies such as the Advantage West Midlands and One North East.

The Integrated Delivery Programme features:

- A strategic programme of university-based research targeted towards future technologies for which there are good prospects of commercialization in the long term.
- An industry-led advisory panel to help shape the technological direction and priorities for the programme. This panel is to be composed of representatives of leading elements of the UK automotive industry and low-carbon vehicle technology developers, as well as relevant academic experts.
- Flexible rolling opportunities for industry to seek support for high-quality collaborative research and development proposals which take technology through to system or vehicle concept readiness.
- Funding to support trialling and demonstration of particularly innovative lower-carbon vehicle options.

The IDP features distinct competitions throughout the life of the programme, with the subject of these competitions based on strategic research and development needs as advised by the industry-focused Advisory Panel (which is distinct from the managing Funder's Panel). To date there have been six competitions as shown in figure 29.1, with the first five funded at £110 million and the sixth intended to be funded at £9 million.

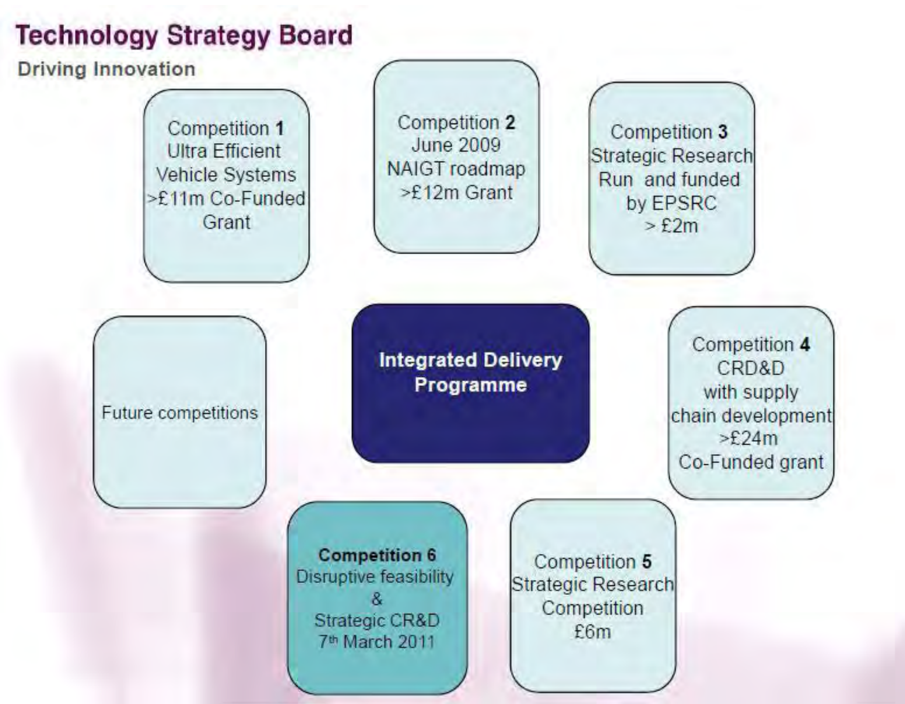


Fig. 29.1 The six components of the Integrated Delivery Programme. (Graphic courtesy of TSB.)

Most recently, Competition 6 focused on both on collaborative R&D for achieving significant cuts in CO_2 emissions in low-carbon vehicles, including energy storage and management systems, lightweight vehicles and power train structures, and power electronics; and on feasibility studies targeting disruptive technologies. Applications were accepted from companies, academic institutions, and individuals through 20 April 2011.

IDP represents the largest of the components of Low Carbon Vehicles platform. Another component includes the Ultra Low Carbon Vehicle (ULCV) Demonstrator, which sought to put at least 250 vehicles on UK roads with tailpipe emissions of 50 g CO_2/km or less as well as a significant zero emissions range. At present, over 300 such vehicles including electric, plug-in hybrids, and hydrogen-fuelled are being trialled across the country. An additional 201 all-electric and low-carbon vans are being trialled in 21 public sector fleets through the Low Carbon Vehicle Public Procurement Programme. Figure 29.2 shows both the IDP and ULCV Demonstrator projects in the context of the larger Low Carbon Vehicles Innovation Platform.

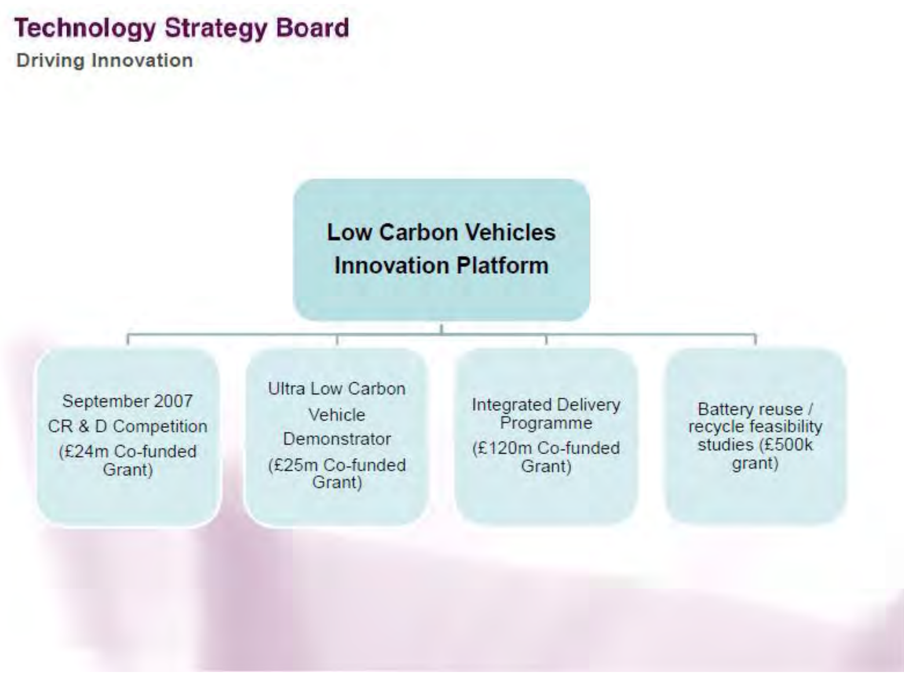


Fig. 29.2 Components of the Low Carbon Vehicles Innovation Platform. (Graphic courtesy of TSB.)

UK Automotive Supply Chain

Other RD&D activities are those related to the UK automotive sector and its associated supply chain, especially those having to do with ultra-low carbon technologies. This is an area of concern for the Automotive Council UK, an organization created in 2009 to promote UK-based manufacturers and technologies, to strengthen the supply chain, and to position the UK as a leader in developing ultra-low carbon technologies. The organization consists of a Supply Chain Group and Technology Group and is co-chaired by Vince Cable, Secretary of State for Business, Innovation and Skills (BIS), and Richard Parry-Jones, former CTO of Ford Motor Company. In March 2011, the Automotive Council UK issued a report *Growing the Automotive Supply Chain: The Road Forward* identifying key findings and growth opportunities for the UK automotive supply chain. This supply chain covers a wide range of interior and exterior vehicles parts, including those where key low carbon technologies are applicable. The opportunities were assembled into a “UK sourcing roadmap” (see Figure 29.3).

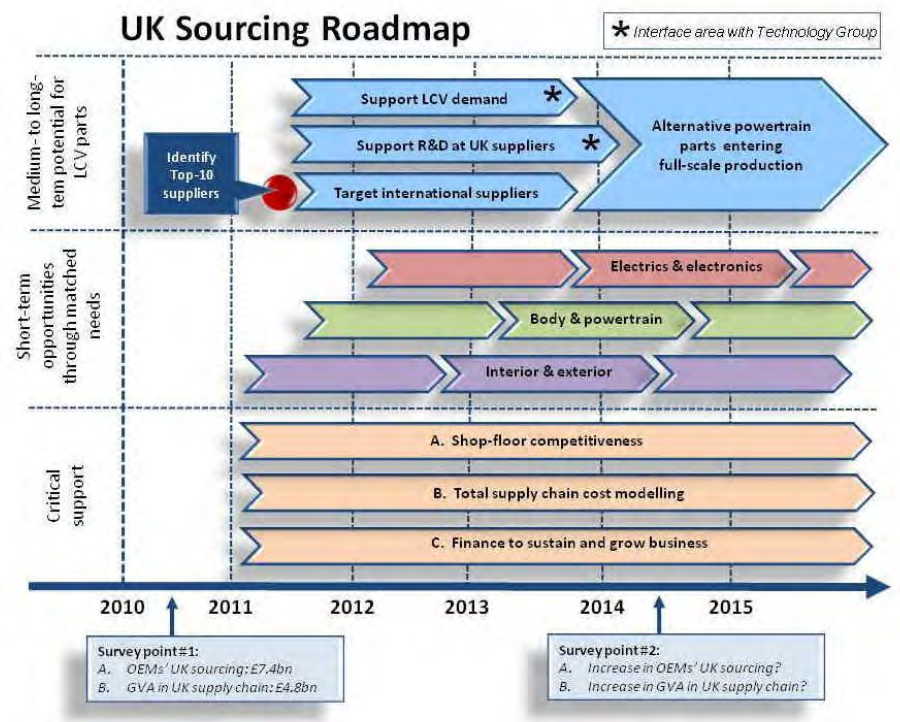


Figure 29.3 UK Sourcing Roadmap from the report *Growing the Automotive Supply Chain: The Road Forward (2011).*

The report in particular focused on the question of how to encourage the "Top 10" suppliers of low-carbon electric powertrain components to commence operations in the UK, including makers of batteries, motors, and inverters. While the report concluded that UK suppliers are currently not well-positioned in this area based on surveys, over time this situation will change as a result of the development of a "portfolio of powertrain architectures" and the novel components these will require.

DfT Business Plan and R&D

Part of the Department for Transport (DfT) Business Plan (see Sec. 29.2) is a commitment to review and consolidate existing support mechanisms for low and ultra-low emission vehicle research and development. This review is scheduled for completion by summer 2011. As part of this effort, extensive discussions are underway with industry and stakeholders to feed into this review, including a workshop with industry leaders from across the automotive supply chain to identify the industry's priorities for R&D and their preferred delivery mechanism for Government support.

Roadmap to a Green Economy

Finally, three government departments—the Department for Business, Skills and Innovation (BIS), the Department of Energy and Climate Change (DECC) and the Department for Environment, Food and Rural Affairs (Defra)—are working collaboratively to produce a new *Roadmap to the Green Economy* scheduled for release during 2011. It will focus in particular on transforming the automotive sector. OLEV staff are working closely with the BIS Automotive Unit to develop the case study demonstrating what industry and government are doing to enable the sector to be a key element of a future green economy.

29.4 Industry

The UK automotive industry

The UK automotive sector has two distinct parts: the manufacture of vehicles and components, and the motor trade (including retail, distribution and aftermarket services). More than 40 companies manufacture vehicles in the UK, ranging from global volume car makers and van, truck, and bus builders, to specialist niche players. Currently none of the vehicles manufactured in the UK is a hybrid or electric vehicle, but the sector was boosted with the March 2010 announcement that Nissan would be manufacturing the Leaf electric car at their Sunderland plant from 2013 with planned production of 50,000 cars annually.

The automotive manufacturing industry in the UK is characterized by significant foreign direct investment and high exports, equivalent to 13% of the UK's exports of goods. Overall, automotive manufacturing provides 156,000 direct jobs, including 60,000 in vehicle-making, and contributes some £6.5 billion value-added to the UK economy (4.9% of the total for the whole UK manufacturing sector). The UK accounts for some 2.4% of worldwide vehicle output and 8.7% of European assembly, ranking it fourth in Europe and twelfth globally. The companies based in the UK operate in Europe's third biggest automotive market, with UK customers in 2010 accounting for the purchase of more than 2 million new cars, equivalent to 15% of European vehicle registrations.

The industry includes 2,400 component manufacturers in the UK, ranging from the global players to small and medium-sized businesses. Together they contribute £4.7 billion in added value and employ around 82,000 people. The components sector exports over £5 billion worth of goods annually, 75% destined for Europe.

The UK is home to the dedicated facilities of vehicle manufacturers, such as those at Ford's engineering centres at Dunton, Gaydon and Whitley, and Nissan's R&D centre at Cranfield. In addition, renowned names such as Lotus Engineering, MAHLE, MEL, Millbrook, MIRA, mi Technology, Perkins, Pi Technology, Prodrive, Ricardo, RLE, Roush, TRW Conekt, TWI and Zytek are also active in the UK. Many of these companies are also part of the supply chain for hybrid and electric vehicles.

Scrappage Incentive Scheme of 2009

The global recession had a significant impact on the UK automotive sector, with car and LCV production down 33.5% to 1.075 million units in 2009. However, in reaction to the decline in demand for new vehicles the UK government initiated the Scrappage Incentive Scheme on 18 May 2009. The scheme gave a £2,000 incentive to those trading in a vehicle over 10 years old when purchasing a new vehicle. It was a great success and far more influential than most imagined, driving a major increase in vehicle demand while helping to reduce the average CO_2 emissions of the road fleet. The scheme saw a downsizing of the vehicle market, with strong sales in the mini and supermini segments. As a result of the Scrappage Incentive Scheme, combined with a global upturn in the market, volumes of unit production recovered to nearly 1.4 million in 2010.

The recession reduced jobs dependent upon the automotive sector by 10%, although this was in part due to a restructuring to accommodate the overcapacity which had been created across Europe. Fortunately, the majority of volume manufacturers and suppliers were able to cover the reduced demand through shortened working hours and increased plant down time, and some have already been able to return to full production.

The UK Automotive Council

As noted in Sec. 29.3, the UK Automotive Council was established in December 2009 as a key recommendation of the industry-led New Automotive Innovation and Growth Team (NAIGT) in response to a UK government request to industry to take the automotive sector forward and ensure its strength and contribution to the UK economy and employment. The Automotive Council, along with its Technology and Supply Chain Working Groups, are working to create a transformed business environment for the automotive industry in the UK, to provide a more compelling investment proposition for related industries.

A technology roadmap for low and ultra-low carbon vehicles and fuels was developed through the Automotive Council and unanimously agreed to by the UK automotive industry. This has been produced concurrent with a review of the automotive technologies in which the UK has an established expertise, including high-tech internal combustion engines, energy storage and management, lightweight vehicles and powertrains, electric machines, low-cost power electronics, and intelligent transportation systems.

Many of the areas of identified UK expertise cross-cut both the low and ultra-low carbon sectors, and are driven by the strong automotive heritage. The industry is working hard to develop and consolidate the UK capabilities in these technologies to encourage the formation of a flourishing early market for ultra-low carbon vehicles, while working hard to develop a stronger and more competitive automotive supply chain.

29.5 Charging infrastructure and vehicle deployments

The Plugged-In-Places (PIP) initiative represents a significant effort at establishing an electric vehicle charging infrastructure in the more densely populated parts of the United Kingdom. The ongoing PIP efforts mark a continuation and expansion of those begun under the previous government. PIP was originally announced in 2009 and its purpose was to create a charging infrastructure in three to six key British cities or hubs with thousands of charging points in order to spur the development and consumer uptake of ultra-low carbon vehicles. The first three such hubs were announced in February 2010, including London, Milton Keynes, and the Northeast region. Approximately £8 million is allocated for the installation of more than 11,000 charging points over a three year period.

In December 2010 Transport Secretary Hammond announced both continued funding for these three first-round projects as well as five additional second-round PIP hubs. They will receive matched funding to install electric vehicle recharging infrastructure in Northern Ireland, Central Scotland, Greater Manchester, the Midlands, and the East of England. These five new projects will join the three existing ones, with all eight PIP projects to receive funding through the end of March 2013.
The PIP programme expects the eight projects to install an additional 8,900 charging points during years two and three. This will take the PIP programme total to 9,700. Charging infrastructure will be installed in homes, at workplaces, on street, and in private and public car parks. The projects will be testing a variety of business and operating models and different technological approaches. The resulting insights will be used to inform the developing UK national strategy for infrastructure roll out.

On 30 June 2010, the OLEV team released a strategy for promoting the rollout of recharging infrastructure for electric and plug-in hybrid vehicles, *Making the Connection: The Plug-In Vehicle Infrastructure Strategy*. This publication is available for download at http://www.dft.gov.uk/publications/plug-in-vehicle-infrastructure-strategy.

The Committee on Climate Change (CCC) in its Fourth Carbon Budget stated that while a 100-mile charging range means the vast majority of trips could be done on a single charge, there is still “a very limited charging infrastructure in place”. The report said that a charging infrastructure must include the following:

- Off-street home charging, which would be an option for up to 75% of car owners
- On-street home charging
- Workplace charging
- Charging in public places (e.g., supermarket or public car parks)
- Battery exchanges where an empty battery is exchanged for a fully charged one

The CCC, which are independent advisors to the UK Government, also concluded that a charging infrastructure to support 1.7 million cars in 2020 (representing the Extended Ambition scenario of 5% of the total UK car fleet being electric or plug-in hybrids, though the UK has not stated an absolute number as a target) could be achieved at a cost of a few hundred million pounds, but that this could rise to £1.4 billion “depending on the level of sophistication of charging meters”. The group also concluded that this money would have to come at least in part from the Government.

29.6 On the road

As of December 2010, the UK had the following number of EVs, PHEVs, and HEVs on the road as shown in Table 29.2.

Table 29.2 Hybrid and electric vehicle fleet numbers in the UK at the end of 2010.

Vehicle Type	Total vehicle fleet (including EVs, PHEVs, and HEVs)	EVs	PHEVs	HEVs
Motorbike	1,350,999	1,372	0	1
Passenger vehicle	29,495,975	1,478	20	78,496
Multipurpose passenger vehicle	101,912	7	0	0
Bus	77,784	69	0	0
Truck	501,725	978	0	0
Light Goods	3,323,786	3,857	0	38
Tricycles	15,452	43	0	0
Other	580,303	48,200	0	35
Total	**35,447,936**	**56,004**	**20**	**78,570**

Note: the total fleet numbers include all propulsion systems and fuels.

29.7 Outlook

The UK Government's policy framework aims to both stimulate and accommodate the expected substantial growth in plug-in vehicles in the UK in the next few years. The UK expects to see tens of thousands of plug-in vehicles on its roads, with manufacturers bringing increasing numbers of models to market. Early purchasers are expected to be fleet or business users and consumers in urban and suburban locations. It is the owners in these segments of the market who are most likely to reap the full environmental and cost-of-ownership benefits of plug-in vehicles. The UK market will expand its reach as consumer and business acceptance continues to grow. The majority of charging will happen at home or "back at base", with further charging opportunities provided at key locations. The majority of public recharging infrastructure will be provided through the Plugged-In Places Programme, which will provide key Information such as how consumers use infrastructure and the impact of plug-in vehicles on the grid. Commercial business models for public charging will begin to emerge, supported by forward-thinking enterprise and local initiatives.

30 United States

30.1 Introduction

The United States, through the U.S. Department of Energy (DOE), actively supports the research, development, and deployment (RD&D) of innovative vehicle technologies. DOE supports R&D on more energy-efficient and environmentally friendly highway transportation technologies at the national laboratories and also works through industry partnerships to develop and deploy advanced transportation technologies. Government-industry partnerships for the advancement of high-efficiency vehicles envision affordable full-function cars and trucks, reduced oil imports, and less emissions. For example, DOE's Clean Cities Program supports public-private partnerships that would deploy alternative fuel vehicles (AFVs) and build supporting infrastructure.

30.2 Policies and legislation

FEDERAL

The Federal government policies and legislations are designed to directly or indirectly promote the U.S. market for electric drive vehicles (EDVs), which include hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs), the last two of which are together referred to as plug-in electric vehicles (PEVs). In his State of the Union address in January 2011, President Obama called for putting one million electric vehicles on the road by 2015, affirming and highlighting a goal aimed at building leadership in technologies that can reduce U.S. dependence on oil. EDVs represent a key pathway for reducing petroleum dependence and providing other associated benefits. Accordingly, a new effort has been proposed to support advanced technology vehicle adoption through improvements to tax credits in current law, investments in R&D and competitive programs to encourage communities to invest in infrastructure supporting these vehicles.

With increases in the Corporate Average Fuel Economy (CAFE) standards, vehicle manufacturers are required to increase fuel economy through 2016, with further increases beyond 2016 under consideration. On March 30, 2009, the National Highway Traffic Safety Administration (NHTSA) published the final rule raising CAFE standards by 30% for both cars and light trucks. These new standards will encourage the expanded market entry of electric drive technologies.

In recent years there have been a number of federal and state policy initiatives to encourage the introduction and sales of EDVs. Industry can achieve its planned production with the support of policies that encourage investment in manufacturing facilities, enable technology demonstration and deployment, and provide incentives to promote adoption and drive consumer demand.

Manufacturing Investments

Through the American Recovery and Reinvestment Act of 2009, the United States made a significant investment to build its domestic manufacturing capacity in advanced lithium-ion battery technology. This investment includes:

- $2.4 billion in loans to help companies build three of the world's first BEV factories in Tennessee, Delaware, and California.
- $2 billion in grants to support 30 factories that produce batteries, battery materials and components, motors, and other EDV components. Companies are cost-sharing the funding.

Deployment, Demonstration, and Outreach

Recovery Act funds are also supporting the largest-ever coordinated demonstration of PEVs, including nearly 13,000 vehicles and more than 22,000 electric charging points in more than 20 cities across the country. Companies are matching the funding of this $400 million public investment. More details about these efforts are in Section 30.5.

Incentives

The Recovery Act established tax credits for purchasing electric vehicles (between $2,500 and $7,500 per vehicle, depending on the battery capacity) and conversion kits to retrofit conventionally powered vehicles with electric vehicle capability ($4,000 per vehicle, maximum). The President has also proposed transforming the existing $7,500 PEV tax credit into an immediate rebate at the dealership. Additional information on the long-term Federal activities in developing solutions to replace less energy-efficient transportation technologies with more efficient counterparts like EDVs, including support for improved fuel economy standards, the setting of safety standards for new transportation technologies, setting more favorable emission standards, etc., has been discussed in the U.S. chapter of this report in prior years.
Some of the 2010 highlights of Federal activities in this area related to EDVs are listed as follows:

- U.S. updated its automobile fuel-economy standards by about 30%, raising them from 27.3 mpg to an average of 35.5 mpg for 2016-model cars and light trucks.
- U.S. provided about $16.5 billion in loans by mid-2011 to automakers,

suppliers, and manufacturers of batteries and storage technology to help produce more fuel-efficient U.S. vehicles under the Advanced Technology Vehicles Manufacturing program.

Other Federal activities in this area related to fuel economy and efficiency, if not EDVs, include:

- U.S. DOE awarded several grants to automakers for developing more energy-efficient technologies: $14.5 million to Chrysler Group (to develop a flexible combustion system for its minivan platform), $15 million to Ford (to achieve a 25% fuel-economy improvement for a gasoline engine), and $7.7 million to General Motors (GM, to improve the fuel economy of a 2010 Malibu by 25%).
- The U.S. Environmental Protection Agency (EPA) revised regulations to enable the sale of higher ethanol content gasoline, E-15, containing 15% ethanol, up from the current 10% limit, for vehicles built between 2001 and 2006. Previous regulations had allowed the use of E-15 only in vehicles built in 2007 or later.

STATE

As shown in Table 30.1, at least 47 U.S. states and the District of Columbia maintain regulations promoting HEV usage, including high occupancy vehicle (HOV), parking, or registration privileges; waived emissions inspection; tax credits, rebates, or grants; and preferential purchase directives, promotion directives, or mandates. The overwhelming majority of states (40 out of 47) provide tax benefits or rebates of one kind or other. In addition, thirteen other states (Connecticut, Florida, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington) and the District of Columbia have attempted to adopt California-like clean air standards, which would require automakers to reduce greenhouse-gas emissions for their vehicles by 30% before 2016. Several others are actively pursuing or considering adoption, including Colorado, Florida, Illinois, Iowa, Minnesota, Montana, North Carolina, and Utah.

Table 30.1 2010 Status of U.S. State-level Incentives for Hybrid Electric Vehicles.[1]

Type of Incentive	States
HOV, Parking, or Registration Privileges	Arizona, California, Colorado, DC, Florida, Georgia, Hawaii, Iowa, Maryland, Minnesota, Nebraska, New Jersey, Ohio, Tennessee, and Virginia
Emissions Benefits	Alaska, Arkansas, California, Connecticut, Florida, Michigan, Missouri, Nevada, Oregon, and Washington
Tax Credits, Rebates, or Grants	DC and all states (except for Alaska, Connecticut, Kansas, Kentucky, Minnesota, Mississippi, and Ohio)
Purchase Directives, Promotion Directives, or Mandates	DC and all states (except for Arkansas, Colorado, Florida, Georgia, Maryland, Michigan, Nebraska, Pennsylvania, and Virginia)
[1]Source: *http://www.afdc.energy.gov/afdc/fuels/electricity_laws.html*	

30.3 Research

DOE supports a broad portfolio of EDV battery R&D that spans basic research to applied development. Three main offices within DOE manage battery research programs. First, the Office of Science supports fundamental basic energy research on enabling materials through the Energy Frontiers Research Centers. Second, the Applied Research Projects Agency - Energy (ARPA-E) conducts transformational research on revolutionary, "game-changing" energy storage technologies. Third, the Vehicle Technologies Program (VTP) within the Office of Energy Efficiency and Renewable Energy (EERE) manages a research portfolio that is focused on battery module development and demonstration of advanced batteries to enable a large market penetration of EDVs. These programs at the DOE provide funding for relevant research by the national laboratories and by private industry through government-industry partnerships.

Enabling technologies for EDVs include advanced energy storage technologies, vehicle systems, lightweight materials, advanced power electronics, and fuel cells, which are individually discussed below. Additional information related to any of those technologies can be obtained from their latest Annual Progress Reports posted at the DOE Vehicle Technologies Program resources website (link to be posted at www.ieahev.org).

Advanced Energy Storage Technologies: An important step for the electrification of the nation's personal transportation is the development of more cost-effective, long lasting, and abuse-tolerant Li-ion batteries. For successful commercialization of EDVs, their battery system must meet several requirements simultaneously. For BEVs, a battery system must be high-energy. HEVs instead require a high-power

system. PHEVs and EREVs require both high energy and high power. Finally, all EDV battery systems demand rechargeability, long life, safety, and low cost.
To reach the required goals, DOE funds three primary battery research areas. First, the developer program assesses, benchmarks, and develops advanced batteries for vehicles. This R&D work is done at the national labs in close collaboration with the industry through the United States Advanced Battery Consortium (USABC). Second, the applied battery research program provides near-term assistance to high-power battery developers to overcome the barriers associated with lithium-ion batteries for vehicles, mainly calendar life, abuse tolerance, low-temperature performance, and cost. Finally, the focused fundamental research program investigates the next generation of battery technologies for vehicle applications.

Vehicle Systems Research: This activity provides support and guidance for many cutting-edge automotive and commercial vehicle technologies under development, including those for EDVs. Research is focused on understanding and improving the way the various new components and systems of future automobiles and commercial vehicles will function in a vehicle to improve fuel efficiency. It also supports development of advanced automotive accessories and the reduction of parasitic losses (e.g., aerodynamic drag, thermal management, friction and wear, and rolling resistance).

Lightweight Materials: The reduction of vehicle mass through the use of improved design, lightweight materials, and new manufacturing techniques, is key to meeting fuel economy targets for commercially viable EDVs. The DOE Lightweight Materials technology area focuses on the development and validation of advanced lightweight material technologies to significantly reduce automotive vehicle body and chassis weight without compromising other attributes. It pursues research in areas of cost reduction, manufacturability, design data and test methodologies, joining, and recycling and repair. Priority lightweight materials include aluminum, magnesium, titanium, and carbon fiber composites.

Advanced Power Electronics and Electrical Machines: This research activity develops new technologies for power electronics and electric machinery which include motors, inverters/converters, sensors, control systems, and other interface electronics. It is divided into power electronics, electric motors/generators, and thermal control and integration sub-activities. A primary research focus is on the thermal control of inverters and motors with advanced cooling technologies. All of these developments are key to EDVs.

Fuel Cells: The DOE EERE Fuel Cell Technologies program (FCT) leads RD&D efforts to enable the widespread commercialization of fuel cells across several application areas. The Program addresses the full range of barriers facing the development and deployment of fuel cell technologies by integrating basic and applied research, technology development and demonstration, and other supporting activities.

30.4 Industry

During the 1990s, a number of battery electric vehicles became available to U.S. consumers, a story which has been described in previous IA-HEV reports. The automakers Chrysler, Ford, General Motors (GM), Honda, Nissan, and Toyota all produced limited numbers of BEVs on lease to customers for several years. Some impetus for such vehicles then came from the California Air Resources Board's zero-emissions vehicle mandate, which was then successfully challenged in court in the early part of the last decade. As a result, the manufacture of BEVs for consumers stopped. However, there has been a resurgence of interest in BEVs, and some manufacturers have started working on newer generations of these cars. Also, over the past few years, HEVs have entered the U.S. market in significant numbers, crossing cumulative figures of one million sold back in 2007 and two million in 2011. However, total HEV sales have remained at below 3% of all light-duty vehicle sales. A current and frequently updated list of EDVs available or becoming available in the U.S. in the near term may be found on the website www.electricdrive.org.

The following information summarizes the 2010 U.S. industry highlights for EDVs:

General Motors (GM)

- GM said it will build 15,000 Chevrolet Volts by the end of 2011, increasing to 60,000 cars in 2012, and to as many as 120,000 cars in 2013. It expects to have several different variants of the Volt, including a multi-purpose vehicle (MPV). A PHEV version of the Cadillac SRX luxury crossover also is likely by 2012 or 2013.
- GM named SPX Corporation of Charlotte, NC as its sole Volt fast-charge installer.
- GM sent six Chevrolet Volts on a 3,400-mile cross-country tour to demonstrate their extended-range capability. The drive was called the "Volt Unplugged" tour.
- GM said it plans to introduce mild hybrid technology (called eAssist) in its 2012 Buick LaCrosse sedan. The technology integrates a small electric motor with a 182-hp, 2.4-liter four-cylinder engine to boost acceleration and cut fuel use.

- GM announced that it would hire 1,000 engineers and researchers over the next two years to work on vehicle electrification at engineering centers in Michigan.
- GM said it is developing an electric motor which is 25% smaller and 20% more powerful than motors in current Two Mode hybrid full-sized trucks, debuting in 2013 trucks and subsequently in cars. GM will build them at White Marsh, MD.

Ford

- Ford, working with Coulomb Technologies, will provide 2,000 charging stations for home installation to buyers of Ford Transit Connect and an additional 2,600 stations for commercial and public street-side use, in nine U.S. geographical locations. This will use funding from the Electric Vehicle Deployment Act.
- Ford's 2011 Lincoln MKZ Hybrid went on sale in 2010 at prices equal to the gasoline-powered MKZ. Lincoln boasted of being the first automaker to offer luxury customers a premium hybrid vehicle with a manufacturer's suggested retail price (MSRP) that matches that of its conventional gasoline-fueled sibling.
- Ford said it plans to introduce five new BEVs through 2012, including a Ford Transit Connect BEV, a Ford Focus BEV, two HEVs with next-generation batteries and a PHEV (the C-Max Energi, shown in figure 30.1). Johnson Controls-Saft's lithium-ion battery technology will be used.
- Ford will sell its "Auto Start-Stop" system (currently available for some European models) in some 2012 North American cars and light trucks.
- Ford said it will offer HEV and PHEV versions of its C-Max small minivan in 2013.

Fig. 30.1 The Ford C-MAX Energi PHEV will be introduced to the U.S. market in 2012. (Photo courtesy of Ford Motor Co.)

Toyota

- Toyota announced a U.S. entry-level luxury CT 200h compact HEV for 2011–2012.
- Toyota announced it plans to add six HEV models globally. Toyota would use lithium-ion batteries in HEVs to debut in the near future in Japan. However, nickel metal-hydride (NiMH) packs will remain the mainstay of its hybrid fleet including on the Prius.
- Toyota will launch a Prius PHEV by 2011–12. It plans a four-model Prius family including the Prius PHEV, a Prius PHEV variant with up to 13 miles range, a Prius V wagon, and a vehicle based on the Prius C Concept with high fuel economy.
- Toyota plans to buy some of its lithium-ion battery packs from Sanyo Electric Co. Also, its joint venture with Panasonic (named Primearth EV) will produce lithium-ion batteries for its PHEV (and NiMH batteries for other Prius models).

Nissan

- Nissan's all-electric Leaf, a 5-passenger sedan, debuted in five U.S. markets in December 2010. Its lithium-ion battery pack and 80-kW electric motor promise up to 100 miles per full charge. Production in Smyrna, Tennessee, is scheduled to begin in late 2012. Nissan will produce 200,000 lithium-ion batteries and 150,000 EVs yearly at its TN plant, partially funded by a low-interest DOE loan.
- Nissan plans a smart-phone application for the Leaf, which will link to a global data center to provide support and information for drivers. The application could also be used to initiate charging remotely or to locate nearby charging stations.
- The Nissan Altima hybrid, currently distributed in nine U.S. states, will not have a 2012 model. In 2013 its current NiMH battery electrical system will be replaced by an in-house hybrid system using a lithium-ion battery. Nissan's first HEV to use that system will be an Infiniti M (M35h) to be sold later in 2011. The lithium-ion battery would be made by Automotive Energy Supply Corp., a joint venture between Nissan and NEC Corp., which also makes batteries for the Nissan Leaf electric vehicle.

Tesla

- Tesla Motors and Toyota signed an agreement to start developing an electric version of the RAV4 compact SUV to go on sale in 2012.
- Tesla Motors reportedly earned $12 million by selling Zero Emission Ve-

hicle credits earned from the sale of its EVs in California (under that state's Zero Emission Vehicle program).

- Panasonic Corp. said it invested $30 million in Tesla Motors, obtaining a 2% stake.
- A Tesla Model S prototype made an appearance at the 2010 Detroit Auto Show, where it was announced that deliveries would begin in mid-2012 (see figure 30.2).

Fig. 30.2 The Tesla Motors Model S BEV will be introduced to the U.S. market in 2012. (Photo courtesy of Tesla Motors)

BMW

- BMW announced it will introduce its Megacity EV in 2013, with a 96-cell lithium-ion power pack, a carbon fiber body, an interior safety shell, and aluminum components. BMW and the SGL Group announced plans to build a $100 million manufacturing plant in Washington state to supply ultra-light-weight carbon fiber-reinforced plastics parts for that vehicle.
- BMW AG, Audi, Mercedes-Benz, Nissan, and Infiniti are all looking into developing sound effects for their otherwise nearly silent BEVs to improve safety.

Smart USA

- Smart USA started to lease to corporations 250 electric "ForTwo" BEVs, with a battery system designed by Tesla Motors. It expects volume sales to begin in 2012.

Daimler

- Daimler said it will offer hybrid versions of its Mercedes vehicles in the U.S. about six months after their launch in Europe (the C- and E-class full hybrids will be launched in Europe before 2013, and the S-class plug-in hybrid will be launched in 2014). The next-generation Mercedes-Benz C-Class is expected to debut at the end of 2013 and hybrid technology is expected to be used on almost every model (see figure 30.3).

Fig. 30.3 The Mercedes C-Class HEV will be introduced to the U.S. market in 2013. (Photo courtesy of Mercedes-Benz.)

Chrysler

- Chrysler plans to offer a gasoline-electric hybrid version of its 300 sedan in 2013.
- Chrysler initiated a project with the EPA to develop a minivan hybrid that would store energy in a compressed air tank. This is an example of hydraulic

hybrid technology, currently used in delivery vans, garbage trucks and other commercial vehicles that make frequent stops.

Mitsubishi

- Mitsubishi will sell in the U.S. a larger version of its i MiEV BEV in fall 2011.
- Mitsubishi will launch a PHEV SUV in 2013.

GE

- GE said it will buy 25,000 electric vehicles, almost half from GM, by 2015, and BEVs will make up at least half of its car fleet and leased vehicles.
- GE plans to open two “experience centers” to promote BEVs to fleets operators.

Fisker

- Fisker displayed its Karma PHEV with a 50-mile all-electric range. Production began in the summer of 2011, with delivery of the first vehicles in late July.
- Fisker plans to export more than 50,000 BEVs annually, using an idled GM plant in Wilmington, DE, as an export hub.

Other manufacturers

- A123Systems opened a 291,000-square-foot lithium-ion battery plant near Detroit to manufacture lithium-ion battery systems for all-electric delivery vehicles, signing battery supply agreements with Fisker, Navistar, and the Navistar-Modec BEV Alliance.
- A123Systems won a contract from Shanghai Auto Industry Corp. to supply lithium-ion batteries for a 2012-model BEV and will initially build cells in Livonia, MI.
- Capacitor maker Kemet Corp. won a $31.7 million contract with DOE-NETL to develop technology for EDVs and other alternative-energy products.
- Hitachi announced plans to manufacture its third-generation lithium-ion batteries for GM.
- Dow Kokam broke ground on the first phase of an 800,000-square-foot lithium-ion cell manufacturing plant near the Dow Chemical complex in Midland, MI.
- Honda displayed its Fit EV concept car at the Los Angeles Auto Show in November 2010 (see figure 30.4). Stanford University, Google Inc. and the

city of Torrance, CA, are each testing a single battery-powered Fit for evaluation purposes during 2011, so that Honda can incorporate feedback before the Fit BEV is launched in 2012.

- Kia introduced its first production HEV, a 2011 Optima, at the New York auto show. U.S. sales of the hybrid were expected to begin in mid-2011.
- Hyundai demonstrated its Sonata Hybrid, which uses a 72-cell manganese-spinel lithium polymer battery pack which is claimed to have a 300,000-mile life and only a 10% loss in performance over life. It expects the vehicle to account for 5 to 7% of its U.S. Sonata sales.
- Audi will sell in 2012 an electric-powered version of its R8 model (a derivative of its convertible Spyder model) under the e-tron subbrand. Audi will initially produce only 1,000 of these BEVs.
- VW announced that it plans to produce the XL1, a two-seat PHEV concept car, within two years in Europe, to be followed by introduction into the U.S..
- A coalition consisting of manufacturers (Nissan, Toyota, Fuji Heavy Industries, and Mitsubishi), Tokyo Electric Power, and the Japanese government was formed to promote the adoption of the fast-charging technology used in the Leaf as a world standard.
- OnStar unveiled a smart-phone application (for BlackBerry, iPhone and Droid platforms) to help drivers remotely monitor their Volts and control battery charging.

Fig. 30.4 The Honda Fit BEV will be introduced to the U.S. market in 2012. (Photo courtesy of Honda.)

30.5
Charging infrastructure and vehicle deployments

As mentioned in Section 30.2, Recovery Act funds are also supporting the largest-ever coordinated demonstration of PEVs, including nearly 13,000 vehicles and more than 22,000 electric charging points in more than 20 cities across the U.S. While the majority of the vehicle chargers are 240-V AC chargers, another 350 are DC fast-charging points (500-V DC). Companies are matching this $400 million public investment.

This effort includes data collection projects that will provide important and detailed real-world operational data on vehicle usage, time-of-use and charging patterns, and potential impacts on our nation's electrical grid. The demonstrations will document lessons learned that help streamline infrastructure permitting processes and make data available that can alleviate consumer uncertainty and help transition PEVs from clusters of early adopters to national, mainstream use. DOE is also working with local leaders to encourage PEV adoption and drive consumer demand. Through a new competitive program, seed funding will help communities across the country with regulatory streamlining, infrastructure investments, vehicle fleet conversions, deployment of PEV incentives, partnerships with major employers/retailers, and workforce training.

In the future, it is expected that much of the public effort of deploying electric vehicles and their infrastructure will happen through the Clean Cities program managed by the DOE. Clean Cities is a voluntary, locally-based government/industry partnership established in 1993 in response to the Energy Policy Act (EPAct) of 1992. The mission of Clean Cities is the deployment of alternative fuel vehicles by encouraging and supporting local and state government decisions to adopt practices that advance the energy, economic, and environmental security of the U.S. Though most of the vehicles promoted Clean Cities run on alternative fuels, there is an increased emphasis on the deployment of light, medium, and heavy duty electric drive vehicles.

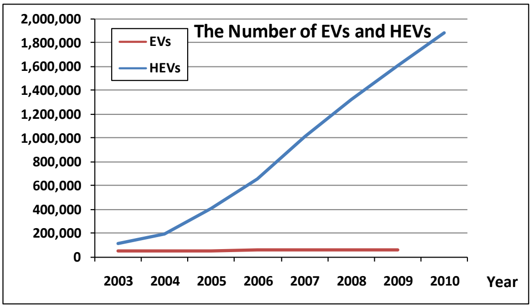
30.6
On the road

Compared to its total inventory of nearly 250 million light vehicles, the U.S. has a relatively small, but growing, number of HEVs. Table 30.2 lists the number of BEV and HEV sales in the U.S. over the past few years. Note that this is sales data only, as national annual vehicle registrations are not available.

The U.S. population of BEVs has remained stable due to the paucity of new personal mobility BEVs after their initial introduction from the mid-1990s through the early years of the last decade. However, as discussed in more detail the next section, this situation is expected to change, and the BEV population is likely to grow again as new technologies enter the market. Sales of the 2011 Chevy Volt extended range EV and 2011 Nissan Leaf BEV began in late 2010, though the number of these vehicles delivered before January 1, 2011, was only a few hundred. This information on the sales for the newest EV technologies is tracked in table 30.3.

Table 30.2 Numbers of EVs and HEVs in the U.S.

Year	BEVs [1]	HEVs[2]
1995	2,860	NA
1996	3,280	NA
1997	4,453	NA
1998	5,243	NA
1999	6,964	17
2000	11,834	9,367
2001	17,847	29,649
2002	33,047	65,691
2003	47,485	113,257
2004	49,536	197,490
2005	51,398	407,201
2006	53,526	659,837
2007	55,730	1,012,111
2008	56,901	1,324,497
2009	57,185	1,614,768
2010	N/A	1,888,978



[1] *EV data for 2005–2009 reported by Energy Information Administration (EIA), The Transportation Energy Data Book, Edition 30, Table 6.1.*

[2] *HEV data obtained from the DOE website for alternative fuel data center (*http://www.afdc.energy.gov/afdc/data/docs/hev_sales.xls*) (as retrieved on May 5, 2011) accumulated over the years*

Table 30.3 Numbers of new-technology EVs, HEVs, and the overall fleet in the U.S.

Type of fleet	2006	2007	2008	2009	2010
EV fleet [1]	0	0	0	0	345
HEV fleet [2]	659,837	1,012,111	1,324,497	1,614,768	1,888,978
Overall sales[1]	16,518,686	16,114,815	13,212,467	10,409,897	11,590,274
Overall fleet total[3]	244,643,000	248,701,000	250,239,000	248,460,000	N/A

[1]*Sales data are compiled from J.D. Power, EDTA, Hybrid Dashboard, and Green Car Congress since deliveries of the Chevrolet Volt and Nissan Leaf launched in late 2010. Does not include data on Tesla Roadsters sold beginning in 2008.*
[2]*HEV data obtained from the DOE website for alternative fuel data center (*http://www.afdc.energy.gov/afdc/data/docs/hev_sales.xls*) (as retrieved on May 5, 2011) based on cumulative sales.*
[3]*Energy Information Administration (EIA) Transportation Data Book, Edition 30 (http://cta.ornl.gov/datal).*

30.7 Outlook

Current trends for HEV sales

Although HEV sales have grown overall during the last several years, they have also been hit by the overall new car market declines since 2008. The annual sales figures in 2010 remained below 300,000, coming to about 2.4% of the total light-duty vehicle sales in the U.S. It is not clear when the HEV percentage of light-duty vehicles (which rose rapidly in the past decade from nearly zero to about 3%) will regain its upward trend. Also, a number of HEVs entering the market in 2009 and 2010 were in the higher price ranges, as can be seen in table 30.4. The average price of an HEV has been increasing during the past five years, mostly due to the introduction of more luxury hybrids, but the average incremental price, or the price differential between the HEV and its non-hybrid counterpart, has not been rising.

There are varying projections on the future market shares of HEVs and EVs in the U.S., and on how quickly those shares would be reached. Some analysts have made optimistic projections about the future market penetration of HEVs. Boulder-based Pike Research issued a report that projects 4 million fleet hybrids on streets worldwide by 2015. The report entitled “Hybrid Electric Vehicles for Fleet Markets” reviews market trends that can contribute to a 16% growth in fleet hybrid ownership in the near term. It projected hybrid fleet sales of 830,000 in 2015, citing the need for businesses, universities and government agencies to reduce fuel costs and emissions for this potential hybrid vehicle explosion. North America would be the most likely site for growth, experiencing annual increases of 8% to 2015. Pike Research attributes some of this growth to a projected 10% growth in hybrid bus sales and

Table 30.4 Recent HEV Sales in the U.S. by manufacturer, 2006–2010.

Make	Model(s)	Sales (by year)[a]				
		2006	2007	2008	2009	2010
Ford	Ford Fusion hybrid, Ford Escape hybrid, Mercury Milan hybrid, Mercury Mariner hybrid, and Lincoln MKZ	23,323	25,108	19,502	33,502	35,496
Honda	Civic hybrid, Accord hybrid, Insight hybrid, and CR-Z	37,571	35,980	31,493	35,691	33,547
Lexus	RX400h, 600h, 250h, and GS	21,945	19,873	16,785	21,890	26,216
Nissan	Altima hybrid	--	8,388	8,819	9,357	6,710
Toyota	Camry hybrid, Highlander hybrid, and Prius	169,797	257,750	224,287	173,655	162,971
GM	Cadillac Escalade, Chevy Tahoe, Chevy Malibu, Chevy Silverado, GMC Yukon, GMC Sierra, Saturn Aura, and Saturn VUE	--	5,175	11,454	16,134	6,759
Mercedes	S400, and ML450	--	--	--	--	1,428
BMW	X6, and ActiveHybrid7	--	--	--	--	307
Chrysler	Chrysler Aspen, and Dodge Durango	--	--	46	42	--
Mazda	Tribute	--	--	--	--	570
Porsche	Cayenne	--	--	--	--	206
Total U.S. HEV Sales		252,636	352,274	312,386	290,271	274,210
Total U.S. Light Duty Vehicle Sales		16,518,686	16,114,815	13,212,467	10,440,180	11,557,696
HEV Sales (% of light duty vehicles)		1.5%	2.2%	2.4%	2.8%	2.4%

[a] Totals for each manufacturer were calculated by summing model-specific sales data published at the DOE website for alternative fuel data center (http://www.afdc.energy.gov/afdc/data/docs/hev_sales.xls) (as retrieved on May 5, 2011)

comparable sales of hybrid trucks and commercial vehicles. The U.S. could become the largest market for fleet hybrids by 2015. However, the picture for EV market penetration by 2020 is more uncertain, as a number of market reports offer a range of figures that depend on factors such as predictions for the prices of oil and lithium-ion batteries.

Projections from the Energy Information Administration (EIA)

The U.S. Energy Information Administration (EIA) released its *Annual Energy Outlook 2011* which examines light-duty alternative fuel vehicle (AFV) sales over the years 2010–2035. It predicts that AFVs could reach a nearly 30% market share by 2030 (see Table 30.5) and flex-fuel, at about 20%, will continue to dominate the AFV market. According to this model, the U.S. will see an increase in EDVs—together accounting for nearly 8% of the total light-duty vehicle sales—under its reference case, which assumes a 2.7% annual growth rate and a constant world oil price (in 2009 dollars).

Table 30.5 Alternative fuel light-duty vehicle sales projections in the U.S.

Sales (Thousands)	2010	2015	2020	2025	2030	2035
Flex-Fuel	1,221.6	3,461.2	3,288.5	3,435.2	3,579.0	3,784.6
EV	0.1	48.2	67.3	109.7	138.0	175.0
PHEV	0.0	57.6	132.5	261.2	384.5	461.5
HEV	275.2	594.8	682.7	823.1	951.4	1,018.7
Gaseous	7.4	10.9	10.8	11.8	12.7	13.2
Fuel Cell	0.0	2.9	5.9	7.1	8.1	8.9
Sales (%)						
Flex-Fuel	11.3%	21.4%	20.7%	20.0%	19.3%	19.5%
EV	0.0%	0.3%	0.4%	0.6%	0.7%	0.9%
PHEV	0.0%	0.4%	0.8%	1.5%	2.1%	2.4%
HEV	2.5%	3.7%	4.3%	4.8%	5.1%	5.2%
Gaseous	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Fuel Cell	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	13.9%	25.8%	26.4%	27.0%	27.4%	28.1%

*Source: Annual Energy Outlook 2011, Table 57: Light-Duty Vehicle Sales by Technology Type - United States – United States (*http://www.eia.doe.gov/forecasts/aeo/sector_transportation.cfm*)*

Projections for BEVs Based on Manufacturer Announcements

Over the past few years, interest in BEVs in the U.S. auto industry has surged, with manufacturers beginning to introduce new generations of BEVs. The production capacity of BEV models announced to enter the U.S. market through 2015 could be sufficient to achieve the stated Administration goal of one million EVs by 2015. Table 30.6 shows the EVs expected to enter the U.S. commercial market over the next few years, including yearly production capacity, based on manufacturer announcements and media reports. Because certain other major potential BEV manufacturers (e.g., Chrysler, BYD, Coda, Honda, Mitsubishi, Hyundai, Toyota, Volkswagen and Volvo) are not included in this table, the actual production could even be higher.

Table 30.6 Estimated U.S. supply of electric vehicles from 2011 through 2015.

Manufacturer and Model	2011	2012	2013	2014	2015	Total
Fisker Karma PHEV	1,000	5,000	10,000	10,000	10,000	36,000
Fisker Nina PHEV		5,000	40,000	75,000	75,000	195,000
Ford Focus EV		10,000	20,000	20,000	20,000	70,000
Ford Transit Connect EV	400	800	1,000	1,000	1,000	4,200
GM Chevrolet Volt	15,000	120,000	120,000	120,000	120,000	495,000
Navistar eStar EV (truck)	200	800	1,000	1,000	1,000	4,000
Nissan LEAF EV	25,000	25,000	50,000	100,000	100,000	300,000
Smith Electric Vehicles Newton EV (truck)	1,000	1,000	1,000	1,000	1,000	5,000
Tesla Motors Model S EV		5,000	10,000	20,000	20,000	55,000
Tesla Motors Roadster EV	1,000					1,000
Think City EV	2,000	5,000	10,000	20,000	20,000	57,000
Cumulative Total						1,222,200

Source: One Million Electric Vehicles by 2015: February 2011 Status Report, U.S. DOE Press Release 02/08/11 (www.energy.gov/media/1_Million_Electric_Vehicle_Report_Final.pdf)

31 Developments in selected IA-HEV non-member countries

The IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) continues to attract countries outside of the agreement to attend its meetings. In 2010, IA-HEV welcomed the European Commission, Germany, Ireland, New Zealand, Portugal, and South Africa as observers at its ExCo meetings. As in years past, some observers have since committed to become members of IA-HEV; hence, the European Commission, Germany, and Portugal now have their own country chapters.

This year we will look at developments in China, Japan, Norway, the Republic of Korea (or South Korea), and South Africa.

31.1 China

China continued to expand its lead as the world's largest automotive sales market in 2010. After surpassing the U.S. vehicle market in annual number of new vehicles sold in 2009 for the first time ever, China further widened its lead in 2010 as the number of new cars sold reached 18.1 million versus 11.6 million in the United States. Annual vehicle sales in China increased 32% in 2010 on top of the 46% increase in 2009, meaning 2010 sales figures were nearly double (93% higher) 2008 levels. There were 199 million vehicles on the road in China as of September 2010 (compared to approximately 256 million in the United States). Driving this tremendous increase in vehicle sales was a combination of very strong economic growth (10.3% real GDP growth in 2010 on top of 9.1% growth in 2009) and extensions of two important government incentive programs. One program is intended to encourage rural area vehicle and motorcycle ownership, and a second one is a trade-in program intended to foster the purchase of energy-efficient vehicles. Yet even with these huge growth figures, private vehicle ownership is quite low in China with approximately 205 million drivers or 16% of the country's total population.

The Chinese government also continued to provide strong support for the hybrid and electric vehicle market this past year, including an announcement in August 2010 of an unprecedented US$ 15 billion in state-funded investments into hybrid and electric vehicle (H&EV) research, development, and deployment. That announcement was made by the powerful State-Owned Assets Supervision and Administration Commission (SASAC) of the State Council, which oversees 125 large state-owned enterprises (SOEs). The SASAC also said that 16 of the SOEs had formed the Association of the Electric Vehicle Industry, including all the key sector players. Among them are three major oil companies, two electrical grid operators, and two major automakers (the China FAW Group and Dongfeng Motor Corp). Li Rongrong, SASAC Chairman at the time of the announcement, said the purpose of the alliance was to speed up development of electric vehicles, fuel cells, and charging systems, as well as in setting unified standards. The plan also calls for the production of 500,000 energy-efficient vehicles (which would include H&EVs) annually for each of three years beginning in 2011. It also stated that more-efficient, "new-energy" vehicles could soon account for 5% of the passenger car sales in China. As of 2010, the category of new-energy vehicles included plug-in electric vehicles, but not hybrid electric or fuel cell vehicles.

China's Minister of Science and Technology Wan Gang said in October 2010 that 8.5 billion RMB (US$1.29 billion) in capital investments have been made in the H&EV industry since the start in 2009 of a pilot program to promote energy-efficient and new-energy vehicles in 25 Chinese cities, which is co-sponsored by his ministry.

China also provided support for the development of the needed charging infrastructure through demonstration projects and other efforts. In February 2011, the State Grid Corporation of China announced that in 2010 a total of 87 standardized charging or switching stations, 5,179 chargers and 7,031 AC charging poles were put into operation across China, the largest amount of charging equipment of any nation in the world. The State Grid has further plans to build an additional 2,351 charging or switching stations (also called charge and replacement power stations) and 220,000 charging spots across China as part of the 12th Five-Year Plan that runs from 2011–2015.

In addition to these announcements, China showcased H&EV technologies in 2010 at the Shanghai Expo where approximately 1,300 pure electric, hybrid, super condenser, and fuel cell vehicles were on display to millions of visitors during the event's six-month run. (A great number of hybrid, plug-in electric, and fuel cell vehicles were also on display at the exhibition component of the weeklong 25th World Battery, Hybrid and Fuel Cell Electric Vehicle Symposium and Exhibition held in Shenzhen in early November.) Shanghai is one of five cities in China with pilot programs underway that provide consumers subsidies of up to 60,000 RMB (approximately US$ 9,130) toward the purchase of hybrid and electric vehicles. Ai Baojun, Shanghai Deputy Mayor, said his city's goal is to have 20,000 new-energy vehicles on the road by 2012. He also said the Shanghai Automotive Industry Corp. (SAIC) plans to launch the PHEV Roewe 550 sedan by 2012 with a production capacity of 100,000 by the end of that year. The all-electric Roewe is still under development.

In other industry developments, BYD Automobile Co. announced in March 2010 that it had entered into a "comprehensive technology partnership "with Daimler AG for the development of EVs in the Chinese market. This followed its May 2009 agreement with Volkswagen to cooperate in the area of hybrid and electric vehicles powered by lithium-ion batteries.

Despite this central government support and industry developments, sales of hybrid and electric vehicles in China are not yet close to reaching the stated sales goals and still account for only a minuscule fraction of the overall domestic Chinese vehicle market. In spite of a government subsidy program in five cities, electric cars have not gained acceptance among Chinese customers, with only 10,000 vehicles sold from mid-2010 to mid-2011, and only about one hundred purchased by individuals. The Chang'an Automobile Group has halted production of its Jiexun hybrid electric vehicle—one of the first mass produced HEVs in China—following very poor sales that were well below 1,000-unit annual production levels that it had originally planned.

Other H&EV models also fared poorly. BYD sold only 54 of its E6 all-electric vehicles and 290 of its F3DM hybrid electric vehicles in the first 10 months of 2010. Even the globally successful Toyota Prius has only sold 4,000 units in China over a three-year period. It is a familiar set of factors to blame in China as in other countries for the poor H&EV sales: high costs, need for charging infrastructure, and lack of consumer confidence in the new technology. Cost is a particular issue in China: the Jiexun HEV was priced between 139,800 RMB ($21,265) and 149,800 RMB ($22,787), which is about three times the average annual per capita income (around $7,400 in 2010).

In the case of charging infrastructure, China at present has so few EVs on the road that the problem has actually been one of a premature rush to construction with many locally high-profile groundbreaking ceremonies in cities around the country, according to local reports. Oftentimes these ceremonies are not followed through to completion, and when they are completed, there are simply too few EVs. The result has been idle charging stations.

Additionally, the experience of the first EV taxi fleet in China has been a rocky one and suggestive of what other companies and individuals may face. Located in Shenzhen, Pengcheng Electric Vehicle Taxi Company is a joint venture between BYD and the Shenzhen Bus Group. The company has encountered a series of difficulties that include high vehicle price (nearly 300,000 RMB or US$45,600 per taxi, several times what a normal taxi costs); limited number of charging stands that require a costly staggering process for vehicle charging that severely limits the number of shifts per day to one or two; expensive maintenance and repair for such specialized vehicles; and the expense of the charging infrastructure itself. Given these issues, the only way for Pengcheng to realize a profit is through government support and product improvements.

While H&EV sales remain very low, the Chinese government is still strongly committed to significant expansion of the domestic H&EV market. The draft version of the 12th Fifth Year Plan approved by the Central Committee in October 2010 reportedly sets a target of 1 million electric vehicles and 10 million kWh worth of battery production by 2015 with an eye toward modularization of batteries and a halving of their costs. Under the plan, the Ministry of Finance will invest 738 million RMB (US$ 112 million) in 74 identified EV "core" projects. Also in October 2010, China's Minister of Science and Technology Wan Gang said the country's annual electric vehicle production capacity would reach 1 million units by 2020.

There are other policies that the Chinese government could undertake to hasten a large-scale shift toward hybrid and electric vehicles. Already in many Chinese cities, including Shanghai, the authorities limit the number of cars that can be on the road at given times to combat traffic congestion and air pollution.

Looking farther ahead, the question is whether China will have a competitive edge over other nations in the hybrid and electric vehicle market including the U.S. A recent report by the global giant consulting firm Accenture concluded that China could lead the H&EV race because it will be able to deploy new technologies more quickly. The 2011 report entitled The United States and China: The Race to Disruptive Transport Technologies concludes that a combination of factors including government backing of the EV industry, large domestic lithium supplies, and the existing advanced battery manufacturing capabilities will give China a competitive edge.

However, others disagree with this assessment. In a recent speech, Dr. Eric D. Isaacs, Director of Argonne National Laboratory in the U.S., cited a study by Dr. Ralph Brodd, Director of the Kentucky-Argonne National Battery Manufacturing Research & Development Center comparing battery manufacturing costs in the U.S. and China. Brodd found that since cost of materials are the same in both countries and since so much of the manufacturing process is automated, the U.S. is actually at a competitive advantage because its electricity costs are only about half what they are in China.

31.2
Japan

In a period of just a few years Japan has become the powerhouse of hybrid and electric vehicles, with Japanese drivers and automakers having embraced this technology and commercialized it with an ever-expanding array of commercially available models led by Toyota. A strong package of government incentive programs enacted in May 2009 was a major catalyst for these developments. These incentives were collectively known as the Green Vehicle Purchasing Promotion Measures and were extended beyond their initial one year beginning in spring 2009 for an additional 6 months, well into 2010.

Among the measures enacted as related to H&EVs was a suspension of the acquisition and tonnage taxes. The combined savings totaled ¥103,500 (US$ 1,278) per vehicle. In addition, purchase subsidies were offered for consumers, varying by type of vehicle purchased. Subsidies were ¥100,000 (US$ 1,235) for a standard or small car and ¥50,000 (US$ 617) for a mini-vehicle, if a consumer was replacing an older vehicle. In the non-replacement case, consumers could qualify for either ¥250,000 (US$ 3,086) or ¥125,000 (US$ 1,543).

The result was a hybrid sales boom from spring 2009 into fall 2010. The third-generation Toyota Prius dominated the domestic Japanese H&EV market in 2010. Of the 4,212,267 passenger car sales in Japan in 2010, a total of 315,669 or 7.5% were Toyota Prius models. Prius sales alone accounted for about 22% of the 1,415,439 new passenger cars Toyota sold in Japan in 2010. The 2010 sales figure was nearly double that for 2009 sales, and cumulatively the total number of Prius vehicles sold reached 2 million in August 2010. Waiting times to purchase a Prius in Japan reached 6 months. This Prius model cost ¥2.05 million (US$ 25,300) before incentives. Toyota has also introduced a variety of other hybrid versions of its Estima, Alphard, Camry, and Crown, as well as various Lexus lines. The total number of hybrids sold by Toyota globally has surpassed the 3-million mark.

Toyota also has plans in 2011 to unveil its new Prius plug-in hybrid electric vehicle (PHEV). Unlike the standard Prius, the new one can maintain speeds of 100km/h (62mph) and cover 13 miles in electric mode before the car reverts to the conventional hybrid function. The batteries can be charged in about 3 hours from a standard 110-volt outlet. Toyota is trying to price the vehicle in the "hybrid sweet spot" between US$ 15,000 and US$ 27,000.

Honda is also offering an expanding set of hybrid gasoline-electric vehicles. In October 2008 the company introduced a hybrid version of the Honda Fit. In 2010 the

Honda Fit ranked second in sales in Japan, behind only the Prius, with 185,439 units sold. By January 2011 the Fit overtook Prius for the top monthly sales spot with another 14,873 sold, and half were the hybrid version. Other Honda hybrids include the Civic Hybrid, the CR-Z, and the (new) Insight.

Thanks in large measure to such a rapid pace of hybrid car purchases Japan actually recorded its first increase in total new vehicle (car, truck, and bus) sales in 2010 in 7 years with a 7.5% increase over 2009.

Developments in Japan Electric Vehicles Market

While the lion's share of this growth has been in hybrid gasoline-electric passenger cars, the electric vehicle market showed signs of revving up in Japan in 2010. This includes Mitsubishi and Nissan offering new all-battery EVs and other companies such as Mazda and the maker of Subaru gearing up to make EVs.

Mitsubishi Motors Corporation's all-battery i-MiEV went on sale in May 2009, and by late November 2010 production reached 5,000 vehicles with fully 3,000 sold in Japan by the previous month. The i-MiEV has a top speed of 130 km/hr (80 mph), and a driving range of up to 160 km (100 miles) per full charge. Charging times vary widely depending on input voltage and current and can vary from 13 hours to as little as 25 minutes with quick-charging capabilities. The lithium-ion batteries used in the i-MiEV are produced by Lithium Energy Japan, a joint venture between GS Yuasa and Mitsubishi. The original cost of the i-MiEV in 2009 was ¥4.59 million (US$ 56,700), but this was cut to ¥3.98 million in April 2010 (US$ 49,136). Finally, after the full package of incentives, it was available to consumers for approximately ¥2.8 million (US$ 34,570).

Mitsubishi has also announced plans to debut eight new H&EV models by fiscal year 2015 including hybrid (HEV), plug-in hybrid (PHEV), and all-battery electric (BEV) vehicles.

Nissan's much-anticipated all-electric Leaf vehicle finally went on sale in the U.S. and Japan in December 2010, and by the end of February 2011 there were 3,484 sales in Japan and another 173 in the U.S., giving a cumulative total of 3,657. Eager consumers preordered so many that by September 2010 Nissan had a waiting list of 20,000 worldwide, and the company stopped taking preorders until it could catch up on the backlog. The Leaf price in Japan was set at ¥3.76 million (US$ 46,420) which dropped to ¥2.99 million (US$ 36,914) after incentives. The Leaf has a top cruising speed of 145 km/h (90 mph). Estimates for the Leaf range from as much as 222 km (138 miles) under ideal cruising conditions to as little as 76 km (47 miles), with a nominal range of about 160 km (100 miles).

Both Fuji Heavy Industries (FHI), maker of the Subaru, and Mazda have plans to introduce electric cars. Among these is Subaru's R1e, an electric car version of its R1. It is a 2-seater "micro-car," with a top speed of 100 km/h (62 mph) and a range of 80 km (50 miles). The lithium-ion batteries can be "quick charged" to 80% capacity in only 15 minutes and to fully-charged in 8 hours. FHI also has been testing the Subaru Plug-In Stella concept car that combines the R1e electrical system with the Subaru Stella. Mazda has plans to introduce a plug-in electric subcompact vehicle called the Demio or Mazda2.

The Japanese government also continues to fund advanced battery research and development. The New Energy and Industrial Development Organization (NEDO), an incorporated administrative agency of the Japanese government, started the Research and Development Initiative for Scientific Innovation of New Generation Batteries (RISING) in fiscal year 2009 with funding through 2015. In addition, in May 2010, NEDO published Battery RM2010, a roadmap for lithium-ion battery R&D.

Better Place Demonstration Project and Other Efforts

In other 2010 developments, Better Place, a clean tech venture capital company promoting electric vehicle infrastructure worldwide, and the Japanese government's Agency for Natural Resources and Energy (ANRE) within the Ministry of Economy, Trade and Industry (METI) launched and then extended a switchable-battery electric vehicle (EV) taxi pilot project in Tokyo. The project was intended to demonstrate the feasibility of battery switching for taxis to have an instant, zero-emissions range extension. During the first three months of the project, the taxies traveled 40,311 kilometers (approx. 25,000 miles) carrying 3,020 passengers and swapped batteries 2,122 times in an average of just 59.1 seconds per swap.

2011 Outlook

Despite the strong sales and H&EV market enthusiasm of the past two years, the situation in Japan going into 2011 was already much more uncertain. Toyota's sales of its Prius had fallen dramatically with the expiration of the various incentives last September. Then on March 11, 2011 a massive 9.0-earthquake and tsunami struck parts of Japan, followed by the partial meltdown of some of the units at the six-reactor Fukushima I nuclear power station. In addition to the human toll, the economic consequences of this multi-pronged disaster are likely to be severe. Already this has included supply chain disruptions and temporary shutdowns of much of the country's automobile manufacturing due to intermittent electricity and water supplies. Toyota announced that it is delaying the launch of its new Prius minivan in Japan that had been scheduled for April and the company said there could be some delays in the scheduled July 2011 launch in the U.S. market. By late March 2011 overall automobile production levels in Japan were still far below normal and one auto analyst estimated that overall global vehicle output may be cut by 30% or 100,000 vehicles per day for an unspecified period of time in the spring of 2011. The scope and scale of the disasters that struck Japan have created tremendous uncertainty for the remainder of the year.

31.3 Norway

A unique combination of factors has enabled Norway to take a leading role in the development of a domestic electric vehicle market. On the one hand, Norway has very large oil and natural gas resources that have made it the 9th largest petroleum and second largest natural gas exporting nation in the world. Around 30% of its revenue is derived from the petroleum sector. On the other hand, Norway's mountainous terrain and climate give it very large hydroelectric capabilities. Virtually all of Norway's electricity comes from hydropower.

Norway also has a relatively small and largely urban population that possesses a strong environmental sensibility that facilitates acceptance of elevated levels of taxation on gasoline. These include both a sales tax and a CO_2 tax. Gasoline prices in mid-2010 in the capital Oslo averaged around 11 NOK per liter (US$ 7.41 per gallon, or $1.96 per liter).

This combination of factors has made it easy for the country to undertake efforts to wean its automotive market off petroleum and instead build up a clean energy transportation sector. The Norwegian government has undertaken a number of incentives to expand the clean transportation sector and spur the growth of plug-in EVs. Among the incentives that the Norwegian government is using to encourage EVs are:

- Exemption from non-recurring vehicle taxes based on weight, engine power, and emissions (typically 75–80%)
- Exemption from sales tax (25%)
- Exemption from annual road tax
- Free parking in public spaces
- Permission to use bus and taxi lanes
- Exemption from tolls on roads
- Exemption from taxation on company cars

The Norwegian government also created the program called Transnova to fund transportation projects designed to reduce energy usage, including through the establishment of electric vehicle charging infrastructure. Transnova was established in 2008 as a three-year program that can be extended if deemed successful. Administered within the Norwegian Public Roads Administration, it was funded at a level of 50 million NOK (US$ 8.8 million) in 2009 and 2010 and 72 million NOK (US$12.7 million) in 2011. To date, Transnova has helped fund the establishment of over 2,000 new charging stations across Norway.

Norway has a rather well-developed road vehicle battery charging infrastructure that includes clusters and a "corridor" between Trondheim and Sundsvall (in Sweden). While charging clusters are important (given Norway's population distribution), charging corridors also may have a role in Norway given certain of its special characteristics. These include long distances and low population density outside the cities, as well as cold and snowy winter weather with resulting adverse road conditions that would otherwise reduce driving ranges between each recharging.

The result of all of these incentives and programs is a rather well-developed all-battery electric vehicle market. By late 2010 there were approximately 3,400 all-battery EVs on the road in Norway out of approximately 2.7 million vehicles, including 2.2 million private vehicles. Updated figures may be found at http://www.gronnbil.no/elbilkartet.

Among the two most notable brands are the City by THINK and the Buddy by Pure Mobility (formerly known as Elbil Norge AS). Collectively, these two Norway-based companies account for as much as two-thirds of the EVs sold in the Norwegian market. Other current and planned players in the Norwegian hybrid and electric vehicle markets are Mahindra Reva Electric Vehicles, Tata Motors, Citroën, Peugeot, Mitsubishi, and Toyota.

The City is manufactured by THINK Global and is advertised as a zero-emissions pure battery EV that can travel at speeds up to 110 km/hour (approximately 70 mph) and has a range of up to 160 kilometers (100 miles) on a single charge. The City is well-established both in Norway and across the European market. It was the first EV to be given a pan-European highway safety certification ("homologation") for a standard M1 category vehicle (i.e., passenger car) under the European Commission (EC) Whole Vehicle Type-Approval (WVTA) system. The City is available in both 2 and 2+2 person configurations. Valmet Automotive manufacturers the City at its facility in Finland under an agreement reached in August 2009 with THINK.

On October 11, 2010, THINK celebrated the manufacture of the 2,500th City at the Finnish facility. Through October 2010, the City fleet (or "parc") has travelled a combined estimated 56 million kilometres (35 million miles). The THINK City starting price is 224,000 NOK (US$ 36,900) for the 2-seater and 244,000 NOK (US$ 43,100) for the 4-seater before any incentives.

The Buddy is manufactured by Pure Mobility at its production facility in Oslo. The Buddy is actually a subsequent incarnation of the older Kewet electric vehicle and in fact was originally called the Kewet Buddy. At its 2009 formal debut it was dubbed the Metro Buddy but the term “Metro” was later dropped. Concerning driving characteristics, the Buddy can reach top speeds between 80 and 90 km/hour (50 to 56 mph) and has a driving range of 100 to 150 km (62 to 93 miles) on a single charge of the lithium-ion battery. Full recharging time takes 6 to 8 hours.

The Buddy is among the least expensive electric vehicles in Norway, with a pre-incentive purchase price of 124,900 NOK (US$ 22,100), although other models range up to 187,000 NOK (US$ 33,100). However, the Buddy has price competition from India’s Mahindra Reva Electric Vehicles Pvt. Ltd. (formerly Reva Electric Car Co.). The company sells the REVA L-ion electric car that is similar to its older REVAi except it has lithium-ion batteries. The REVA L-ion has about the same driving characteristics as the Buddy except it is less expensive owing to the absence of certain amenities. As of late 2007, it retailed in Norway for 91,000 NOK (US$ 16,000), which wasn’t just the least expensive EV in Norway but was among the cheapest of any type of cars sold there. Both the Buddy and Reva are officially classified as electric four-wheeled motorcycles and both are most practical for city driving. Both carry only three people (including the driver).

Another player in the Norwegian EV market is the Mitsubishi i MiEV, a five-door hatchback that is itself an electric car version of the 660cc “i” mini-car. As of early 2011 this was the fastest selling model in the Norwegian market, with over 600 on order and 200 already delivered. Two repackaged versions of the i MiEV that exist in the larger European market are the Citroën C-ZERO and Peugeot iOn.

Norway continues to develop its charging infrastructure. This includes the fast-charging infrastructure that is sometimes referred to as “CHAdeMO,” an abbreviation of “Charge de Move” or “Charge for Moving.” The CHAdeMO players are focused on a 50-kW standardized protocol, although this is not yet an official grid-standard. In the case of Norway where power generation is highly localized, there is a need for an overarching model or framework for connecting charging stations to electric utility companies.

31.4 Republic of Korea (South Korea)

The year 2010 was a busy and eventful one in South Korea's hybrid and electric vehicle market. The country's first mass-produced all-battery electric vehicle, the BlueOn, was introduced by Hyundai Motor Company in September. Both Hyundai and its collaborative partner Kia Motors Company continued their larger emphasis on the hybrid electric vehicle segment of the H&EV market with future models slated to join current ones. The South Korean government also unveiled in December 2010 specific numerical targets as part of a "green car roadmap" (see special subsection below) for alternative fuel vehicles including battery electric, hybrid, fuel cell electric, and clean diesel models. This roadmap was in line with the government's intention of South Korea becoming the world's fourth largest EV market by 2015. It is part of a larger set of initiatives and activities including those announced in 2009 to foster the development of the country's green car industry. On the lithium-ion battery production side, intense competition in pursuit of current and expected future EV market share rages between the South Korean firms Samsung and LG Chem and Japan's Panasonic. The result is oversupply and steadily dropping prices – a situation likely to persist through 2011.

Commercial Developments

Hyundai Motor Company formally unveiled the BlueOn in early September 2010, South Korea's first mass-produced battery-only electric vehicle. The BlueOn is based on Hyundai's prototype i10 Electric unveiled a year earlier at the Frankfurt Auto Show 2009. The BlueOn is a compact car (just 12 feet or 3.66 m long) with a 16.4 kWh lithium-ion polymer ("LiPoly") battery that powers a 61-kilowatt motor. The BlueOn has a top speed of 130 km/hr (about 80 mph), can accelerate from 0 to 100 km/hr (0 to 60 mph) in 13.1 seconds, and has a driving range of 140 km (about 87 miles) per charge. The recharge time is 6 hours at 220 V, but it can be recharged in as little as 25 minutes with a high-voltage (380 Volt) quick charger. Hyundai spent KRW 40 billion (US$ 36.8 billion) to develop the car, and it plans to manufacture 2,500 units by late 2012. In the meantime, Hyundai is providing 30 BlueOn vehicles to various Korean government organizations as test fleets.

Hyundai's Sonata Hybrid ended up being delayed from its anticipated late 2010 release in the U.S. market. The Sonata Hybrid will compete in the mid-sized hybrid market including with the Toyota Camry Hybrid and the Ford Fusion Hybrid with a fuel economy of 36 miles per gallon (6.53 liters per 100 km) city and 40 miles per gallon (5.88 liters per 100 km) highway. The engine includes a 1.4 kWh LiPoly battery pack that weighs less than a comparable lithium-ion battery pack, allowing for more cargo room and also making it the lightest mid-size hybrid vehicle. The Sonata is expected to retail at approximately US$ 26,000 in the U.S. market.

Hyundai and its collaborative partner Kia Motors Corporation have both also been active in developing other hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs) for the internal South Korean market. These include two HEVs launched in 2009, Hyundai's first-ever hybrid, the Elantra LPI and Kia's Forte LPI. The Elantra was powered by liquefied petroleum gas (LPG) and uses lithium polymer batteries, and it was marketed as the Avante LPI in the domestic South Korean market. Kia also is scheduled to release the Kia Optima Hybrid in 2011. The Optima Hybrid is a slightly smaller and less expensive version of the Hyundai Sonata Hybrid with the same drive train. Its launch was similarly delayed over modifications to the switch that would allow modifications to the car's noisemaking device.

Looking ahead, Hyundai is planning a new "Prius-fighter" hybrid-only model in addition to the Hyundai Blue Will plug-in hybrid vehicle planned for the U.S. market in the next few years. This hybrid-only will not be a derivative of a previous model and while no date has been set, it will have fuel economy targets in excess of 40 miles per gallon. Meanwhile, Kia introduced still more prototype hybrid and all-battery electric cars in 2010 and 2011. These include the Kia Ray Plug-In Hybrid (modeled on the Forte) unveiled at the 2010 Chicago Auto Show and the Kia Naimo electric vehicle at the Seoul Motor Show in March 2011 (the Naimo was the third such electric prototype to be introduced in the past year).

Yet another South Korean EV manufacturer is CT&T, maker of low-speed electric vehicles including the e-Zone "neighborhood electric vehicle" (NEV) in addition to the c-Zone electric golf carts the company makes. Founded by a group of former Hyundai employees, CT&T introduced NEVs into South Korea in 2008. NEVs have a top speed of 60 km/hr, and a new law that took effect in South Korea on March 30, 2010, allows them to operate on designated roadways throughout the country. The government hopes this will help spur its efforts to expand EV penetration into the domestic market (discussed in more detail below), although challenges remain such as low speeds, safety concerns, and charging infrastructure. The Seoul Metropolitan Government received 35 NEVs on a trial basis to go to fire departments, patrol officers, and parking enforcement. CT&T announced in July 2010 that it would open a final North America assembly production plant in South Carolina.

Green Car Roadmap

While its auto industry has been busy developing new hybrid and electric vehicle lines, the government of South Korea has announced ambitious plans that include numerical targets for the development of alternative fuel vehicles such as EVs, HEVs, fuel cells EVs (FCEVs), and clean diesel vehicles (CDVs). Collectively, these make up the "green cars" covered by this "green car roadmap."

The government has previously announced its intention of making South Korea the fourth –largest manufacturer of alternative fuel vehicles, including electric and hybrids. But in December 2010 it unveiled specific targets. These targets include achieving by 2015:

- 1.2 million "green cars" annual production, with 900,000 for export;
- Green cars will make up a 21% domestic vehicle market share;
- KRW 3.1 trillion (US$ 2.9 billion) in investment in additional domestic auto industry investment between 2011 and 2015 into achieving the green car roadmap objectives, or more than double the KRW 1.3 trillion (US$ 1.2 billion) invested between 2006 and 2010.

The government is seeking mass production of PHEVs by 2012 and both FCEVs and clean-diesel buses by 2015. The green car roadmap and the targets associated with it are part of a larger set of initiatives to foster the green car industry. Other initiatives include fostering the development of necessary components and supplies to build many vehicles and an expansion of the battery charging infrastructure. As part of its efforts, the government has plans for 1.35 million EV charging points to be built around the country by 2020.

The December 2010 targets built on announcements from 2009 that included introduction of tax incentives of up to KRW 20 million (US$ 18,400) for EV purchasers starting in 2012, plans to build charging stations, provide KRW 400 billion (US$ 368.3 million) on R&D into advanced batteries, and the creation of the On Line Electric Vehicle (OLEV) system by the Korea Advanced Institute of Science and Technology (KAIST) in which EVs are charged inductively by electrical cables embedded in roadways.

Advanced Battery Production: Battle for Market Share

South Korea and Japan account for approximately three-quarters of global lithium-ion battery production. LG Chem Ltd and Samsung SDI, Inc. are among the largest South Korean manufacturers of such batteries. These two companies and their Japanese counterpart Panasonic Corp., now the parent of Sanyo Electric, are generally acknowledged as the top three lithium-ion battery makers in the world and are in intense competition with each other to grab as much market share as possible. Their mass production of so many batteries has contributed to a global supply glut – with steadily falling prices.

This glut is likely to become even more pronounced in the coming years. In April 2010, LG Chem formally opened what it said is now the world's largest EV battery plant in South Korea. The Ochang facility reportedly has an annual production capacity to supply 100,000 EVs. LG Chem also has plans for two additional facilities. The company now supplies batteries for GM, Hyundai, Ford, Renault, and Volvo and it is seeking additional contracts with Japanese automakers. It is also developing its "second generation" of advanced batteries.

31.5 South Africa

South Africa has a history of experimentation with electric vehicles (EVs). The South African National Energy Research Institute (SANERI) worked on EV projects in both the 1980s and 1990s. One of the earlier prototypes was a lead-acid battery-powered electric bus that was developed to enable quiet transportation through a game reserve. More recently, South Africa has undertaken several initiatives to create a more efficient transportation system.

In the last few years, legislation has been put into place to help motivate the country towards improved energy efficiency. In 2007 the government issued a "Biofuels Strategy" which requires 2% penetration of biofuels in their national liquid fuel supply by 2012 (approx. 400 million liters/yr). New passenger cars will be taxed based on their certified CO_2 emissions beginning in September 2010. Consumers will be charged 75 Rand (roughly 7.5 Euros) for every gram of CO_2 emitted per kilometer in excess of 120 g CO_2/km. These taxes initially only apply to passenger cars but will extend to commercial vehicles once emission standards have been set for the sector.

The Department of Energy's South African Energy Development Institute (SANEDI) strives to bridge the gap between R&D and demonstration and implementation of new green technology. SANEDI was formed in part to implement the "Green Transportation Programme," which encompasses several initiatives for the advancement of efficient technology in the transportation industry. The program aims to demonstrate alternative fuels and propulsion systems for private and public transportation with a focus on education and involvement with EV stakeholders. They plan to develop and propose incentives to help bring EVs to South Africa as well as motivate consumers to own and operate them. The program also calls for development of charging infrastructure, and building capacity for the EV sector. It is anticipated that through a combination of state, donor and private sector funding that key projects can be accelerated, leading to faster deployment and consequently more jobs and local manufacturing opportunities.

"The Green Transportation Demonstration Project," which showcases alternative fuels and propulsion systems to the public, is establishing a "Green Transport Centre" in Midrand. The centre will be used primarily for exhibitions and demonstrations of

EVs and their technologies for the purpose of educating and training for the public. The facility will also provide services such as testing, evaluation, research, development, support and maintenance as well as conversions of vehicles to electric or natural gas power.

SANEDI is also developing an “Integrated Mass Transit Model”. The model is made up of several “nodes” (bus stops, stations) and “sections” (the route between nodes). The purpose is to discover the method of delivering people to their destinations in as little time as possible, while keeping costs and energy consumption low. In addition, the model tests the benefits of using several different energy sources to power the system. The “Bus Rapid Transit Propulsion Research and Concept” is investigating alternative propulsion technologies for the design of a road-based mass transit vehicle that could be a possible transportation solution for this model.

The private sector is also making some advancement in the realm of EVs. A small startup called GridCars (Pty) Ltd. is trying a car-sharing approach. Instead of being purchased, the vehicles will be rented by the consumer as needed. This allows the consumer to supplement public transportation with personal mobility for situations when public transportation would be less than ideal, at the same time as being less costly than ownership of the vehicle. The EVs, which are based on three-wheelers developed by the University of South Australia, will only be charged using solar or off-peak electricity.

For those South Africans who would rather own an EV, the company Optimal Energy is developing a car named Joule. Africa’s first production EV will be mass-produced in 2013 and will be available for purchase in mid-2014. Optimal Energy has not yet set a price for the vehicle as it anticipates reductions in the cost of batteries and other technologies. They intend to lease the batteries to customers as a way of lowering initial costs, putting the burden of any complications that arise due to the batteries on the company instead of the customer.

32

Matching electric vehicle deployment and charging infrastructure

IA-HEV outlook for hybrid and electric vehicles - 2011

Electric vehicles have no tailpipe emissions, and when powered by renewable electricity they contribute to reducing anthropogenic CO_2 emissions and fossil fuel consumption. Therefore they have gained the interest of authorities at national, regional, and city levels as a means to achieve environmental objectives for the transport sector. Authorities in many countries have set targets for electric vehicle numbers in future years and created programs for electric vehicle deployment. Car manufacturers also recognize the potential of electric vehicles, and they have recently started producing battery electric vehicles such as the Mitsubishi i MiEV, Nissan Leaf, Peugeot iOn and Tesla Roadster, and plug-in hybrid electric vehicles such as the Chevrolet Volt and the Fisker Karma. Most other car manufacturers have announced plans to introduce electric vehicles in the coming years as well. Besides authorities and car manufacturers, many other stakeholders are involved in the deployment of electric vehicles and in building up the infra-structure that is necessary to charge the vehicle batteries. Figure 32.1 presents an overview and it also shows the different factors that play a role in the large-scale deployment of electric vehicles.

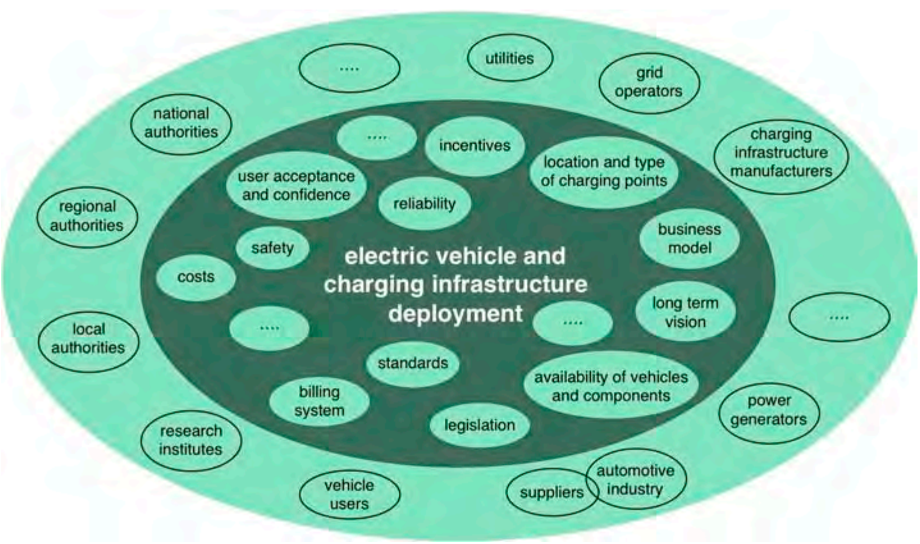


Fig. 32.1 Many stakeholders and factors influence the deployment of electric vehicles and building up the infrastructure to charge the vehicle batteries. (Stakeholders are shown in the outside ring and factors are shown in the center.)

The promises of electric vehicles have made many people and organizations eager to bring electric vehicles on the road. The enthusiasm has reached such a level that some people are now speaking of “electric vehicle hype”, suggesting that electric vehicles cannot live up to these expectations. And indeed, the first bottlenecks for electric vehicle availability can be observed. Worldwide electric vehicle production is still small and far from meeting today’s demand. The Danish aim to use electric cars running on wind power, but they have not been able to substantially expand their electric vehicle fleet the last few years. Another example is that the Vlotte project to make Voralberg in Western Austria an e-mobility model region has delayed expanding the number of charging stations because there are insufficient electric cars available.

And how about the longer term? When looking at just a few of the objectives for electric vehicle fleet numbers in IA-HEV member countries (see table 32.1), it is easy to imagine that the total worldwide objective might be tens of millions of electric vehicles on the road in 2020. Will the automotive and component industry be able to deliver these quantities by then? An IA-HEV workshop in December 2008 has shown that lithium supply for the vehicle batteries may be expected to be able to keep up with demand, but many other questions remain open. One question is related to the electric components that are necessary to build an electric car. Will it be possible to make components available in sufficient quantities? Another growing market sector shows that ramping up the supply chain is not always easy: in 2010 there was a shortage of components for power electronics in the photovoltaic industry, which limited the amount of solar panels that could be installed. Policy makers and decision takers need to take all of these kinds of issues into consideration when planning electric vehicle deployment.

Table 32.1 Examples of objectives for electric vehicle numbers on the roads in a few IA-HEV member countries and Germany.

Objectives for all electric and chargeable hybrid electric vehicle numbers on the road in 2020	
Canada	
Québec	118,000
Germany	1,000,000
Netherlands	
Amsterdam	40,000
Noord-Brabant	200,000
Portugal (estimate)	200,000
Spain	2,500,000

The infrastructure to charge large numbers of electric vehicle batteries—especially in public areas—is in its infancy, and therefore authorities on all levels are establishing programs to support the construction of this infrastructure. Today, many believe that a widespread presence of public charging points, including fast charging, is necessary to deal with range anxiety of vehicle users, which they consider one of the major hurdles for large-scale deployment of electric vehicles. On the other hand, results from various IA-HEV Tasks have shown that electric vehicle pioneers and participants in electric vehicle demonstration projects adapt their mobility behaviour to the performance of the vehicle. They mostly charge the vehicle batteries at home, and public charging points are rarely used. The drivers also indicated that they wanted a charging infrastructure that would help them reach their destination. By doing so,they expressed a range desire instead of a range anxiety.

However, it is still unclear what the future vehicle and charging infrastructure requirements will be when there would be an electric vehicle mass market and the general public would be using electric vehicles on a large scale. So entities that want to start installing charging infrastructure today still have questions about the number of charging points that are necessary, the location of these points (at home, at the workplace, in public parking areas, etc.), and whether slow charging would be sufficient or if a number of fast charging points will also be required. It is therefore necessary to experiment and to learn along the way. Exchanging experiences at an international level considerably enhances this learning process.

The bottlenecks that are mentioned above show that it is important to carefully balance the construction of a charging infrastructure with the amount of electric vehicles that could be made available over time, to avoid investments in infrastructure that will be insufficiently used during its first years of operation. Therefore, besides the role of the vehicle users, the dialogue with the automotive and suppliers industries is a crucial element in setting up programs and projects for the introduction of electric vehicles (figure 32.2). Some regions and cities have started this dialogue, but others still have questions regarding the supply of vehicles and the associated charging infrastructure that needs to be put in place. IA-HEV Task 18 “EV ecosystems” offers a platform for those setting up electric vehicle deployment programs to exchange practices and experiences, and it includes discussing these issues.

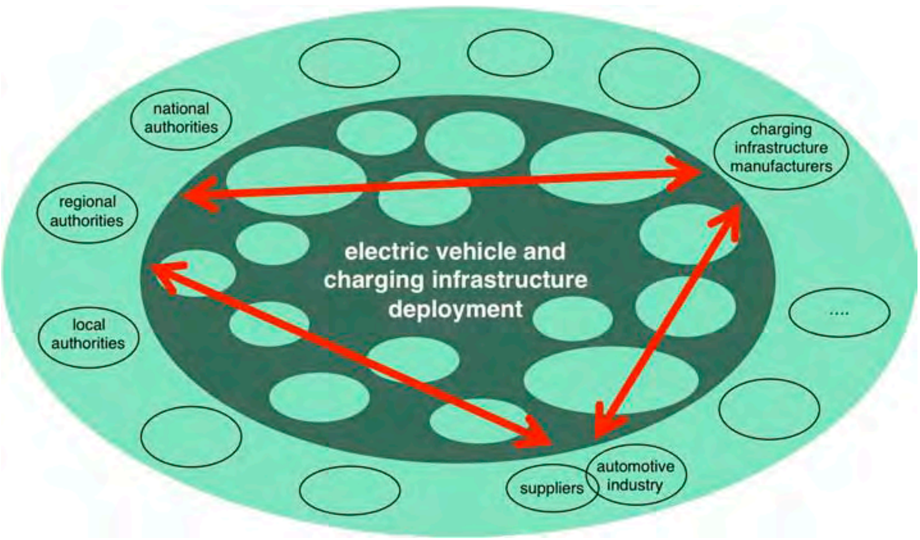


Fig. 2 Within all the factors that play a role, the dialogue between authorities, the automotive industry and its suppliers, and manufacturers of charging infrastructure is a crucial element in optimizing the timing of investments for large-scale electric vehicle deployment.

In summary, it can be observed that building a large-scale electric vehicle fleet and its associated charging infrastructure is a major endeavor in which many stakeholders play a role and with many factors that have to be taken into account (figure 32.1). In this complex environment the dialogue between authorities planning electric vehicle deployment and those who will have to deliver the vehicles and the charging infrastructure is a crucial element. The wishes of ambitious planners must be balanced with the realities of product development and the time that is required to build sufficient production capacity, to guarantee appropriate levels of investments over time. This will contribute to a sustained deployment of electric vehicles, which are destined to play a role in meeting environmental objectives and increasing the sustainability of road transport.

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Vehicle Categories

In the "On the road" sections of the country chapters on Austria, Denmark, Finland, Italy, the Netherlands, Spain, Sweden, Switzerland, Turkey, and the UK, fleet numbers of motorized road vehicles are presented in a standardized table as much as possible. The definitions of the vehicle categories that are used in these tables are given below.

VEHICLE	DESCRIPTION
Motorized bicycle (no driver licence)	Two-wheeled motorized (internal combustion engine or electric motor) vehicle with an appearance similar to a conventional bicycle or moped.
Motorbike	Vehicle designated to travel with not more than three wheels contacting with the ground.
Passenger vehicle	Vehicle with a designated seating capacity of 10 or less, except Multipurpose passenger vehicle.
Multipurpose passenger vehicle	Vehicle with a designated seating capacity of 10 or less that is constructed either on a truck chassis or with special features for occasional off-road operation.
Bus	Vehicle with a designated seating capacity greater than 10.
Truck	Vehicle designed primarily for the transportation of property or equipment.
Industrial vehicle	Garbage truck, concrete mixer, etc., including mobile machinery like forklift trucks, wheel loaders and agricultural equipment.

Conversion Factors

This chapter presents conversion factors for quantities that are relevant for hybrid and electric road vehicles, such as kilometers per hour and miles per hour for vehicle speed, and miles per gallon and litres per 100 km for fuel consumption. The International System of Units (SI - Système International) gives the base units for these quantities, and therefore the relevant SI units are presented first. The actual conversion factors can be found in the second section of this chapter.

BASE UNITS

Table 1 Selection of SI base units.

QUANTITY	UNIT	SYMBOL
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A

Table 2 Selection of SI prefixes.

PREFIX	SYMBOL	VALUE	
Kilo	k	1 000	Thousand
Mega	M	1 000 000	Million
Giga	G	1 000 000 000	Billion

Table 3 Selection of derived units.

QUANTITY	UNIT	SYMBOL	
Energy	Joule	J	1 J = N•m
Force	Newton	N	1 N = 1 kg•m/s^2
Power	Watt	W	1 W = 1 J/s
Pressure	bar	bar	1 bar = 10^5 N/m^2
Time	hour	h	1 hour = 3600 s
Volume	litre	L	1 litre = 0.001 m^3

SELECTED CONVERSION FACTORS

Table 4 Mass, dimensions, and speed.

QUANTITY	UNIT	SYMBOL	CONVERSION	REVERSE CONVERSION
Mass	pound (US)	lb	1 lb = 0.45359 kg	1 kg = 2.2046 lb
Length	inch	in	1 inch = 0.0254 m	1 m = 39.3701 inch
Length	foot	ft	1 ft = 0.3048 m	1 m = 3.2808 ft
Length	mile	mile	1 mile = 1.60934 km	1 km = 0.62137 mile
Volume	barrel (petroleum)	bbl	1 bbl = 159 l	--
Volume	gallon	gal (UK)	1 gal (UK) = 4.54609 L	1 L = 0.21997 gal (UK)
Volume	gallon	gal (US)	1 gal (US) = 3.78541 L	1 L = 0.26417 gal (US)
Speed	miles per hour	mph	1 mph = 1.609 km/h	1 km/h = 0.621 mph

Table 5 Energy and power.

QUANTITY	UNIT	SYMBOL	CONVERSION	REVERSE CONVERSION
Energy	British thermal unit	Btu	1 Btu = 1055.06 J	1 J = 0.0009478 Btu
Energy	kilowatt-hour	kWh	1 kWh = $3.6 \cdot 10^6$ J	1 J = $277.8 \cdot 10^{-6}$ kWh
Power	horse power	hp	1 hp = 745.70 W	1 W = 0.001341 hp
Pressure	pound-force per square inch	psi	1 psi = 0.0689 bar	1 bar = 14.5037 psi
Torque	pound-foot	lb-ft	1 lb-ft = 1.35582 Nm	1 Nm = 0.73756 lb-ft

Table 6 Fuel consumption.

x mile/gal (UK)	↔	282.48/*x* l/100 km
x l/100 km	↔	282.48/*x* mile/gal (UK)
x mile/gal (US)	↔	235.21/*x* l/100 km
x l/100 km	↔	235.21/*x* mile/gal (US)

Table 7 Comparison of energy carriers.

ENERGY CARRIER	UNIT	ENERGY CONTENT
Battery	Stored energy, expressed in kWh	1 kWh = 3.6 MJ
Diesel fuel	Calorific value, based on volume	34.9 - 36.1 MJ/l
Gasoline (petrol)	Calorific value, based on volume	30.7 - 33.7 MJ/l

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[3] Walwijk, M. van; M. Bückmann; W.P. Troelstra; P.A.J. Achten. Distribution and use. Volume 2 of the Automotive Fuels Survey, published by IEA/AFIS (Automotive Fuels Information Service), on behalf of the IEA Implementing Agreement on Advanced Motor Fuels. Breda, the Netherlands. December 1996.

Glossary

This glossary of terms related to hybrid and electric vehicles also includes information on the "competition" to the electric drive, because plug-in hybrid electric vehicles illustrate the many ways that electric and conventional drives may be combined, including multiple fuel possibilities for the conventional drive.

Advanced Technology Partial Zero Emission Vehicle (AT-PZEV)

As defined by the California Air Resources Board in a regulatory incentive system, a vehicle that uses electric drive components that should ultimately help industry introduce ZEVs such as EVs or FCVs.

All-electric range (AER)

This is a term used by CARB which has legal meaning related to a requirement that a PHEV be able to operate electrically until a specified set of conditions is no longer met. Within CARB regulations as of 2007, a credit system within their LEV regulations existed for PHEVs with 10 (16) or more miles (km) of AER.

Ampere

The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} Newton per meter of length. The ampere unit is symbolized by "A".

Ampere-hour capacity

The quantity of electric charge measured in ampere-hours (Ah) that may be delivered by a cell or battery under specified conditions. One ampere-hour is the electric charge transferred by a steady current of one ampere for one hour. In EV applications, typical conditions involve a specific ambient temperature and a discharge time of 1 or 3 hours: in these cases the capacity is expressed as C_1 or C_3 (see also "Rated capacity", "Installed capacity", "Energy capacity").

Ampere-hour efficiency

The ratio of the output of a secondary cell or battery, measured in ampere-hours, to the input required to restore the initial state of charge, under specified conditions (also coulombic efficiency). It is not dependent on the change of voltage during charge and discharge.

Battery cell

A primary cell delivers electric current as the result of an electrochemical reaction that is not efficiently reversible, so the cell cannot be recharged efficiently. A secondary cell is an electrolytic cell for generating electric energy, in which the cell, after being discharged, may be restored to a charged condition by sending a current through it in the direction opposite to that of the discharging current.

Battery module

A group of interconnected electrochemical cells in a series and/or parallel arrangement, physically contained in an enclosure as a single unit, constituting a direct-current voltage source used to store electrical energy as chemical energy (charge) and to later convert chemical energy directly into electric energy (discharge). Electrochemical cells are electrically interconnected in an appropriate series/parallel arrangement to provide the module's required operating voltage and current levels. In common usage, the term "battery" is often also applied to a single cell. However, use of "battery cell" is recommended when discussing a single cell.

Battery pack

A completely functional system that includes battery modules, battery support systems, and battery-specific controls. It may also be a combination of one or more battery modules, possibly with an added cooling system, and very likely with an added control system. A battery pack is the final assembly used to store and discharge electrical energy in a HEV, PHEV, or EV.

Battery round-trip efficiency

The ratio of the electrical output of a secondary cell, battery module, or battery pack on discharge to the electrical input required to restore it to the initial state of charge under specified conditions.

Battery Electric Vehicle (BEV)

See electric vehicle (EV).

Battery State Of Charge (SOC)

The available capacity in a battery expressed as a percentage of rated nominal capacity.

C rate

Discharge or charge current, in amperes, expressed in multiples of the rated capacity. For example, the $C_5/20$ discharge current for a battery rated at the 5-h discharge rate is derived as follows: C_5 (in Ah) divided by 20 gives the current (in A). As a cell's capacity is not the same at all discharge rates and usually increases with decreasing rate, a cell which discharges at the $C_5/20$ rate will run longer than 20 h.

Capacitance

The ratio of the charge on one of the conductors of a capacitor (there being an equal and opposite charge on the other conductor) to the potential difference between the conductors. Capacitance is symbolized by “C”.

Capacitor

A device which consists essentially of two conductors (such as parallel metal plates) insulated from each other by a dielectric (an insulator that may be polarized by an applied electric field). As part of an electric circuit, a capacitor introduces the capability of storing electrical energy, blocks the flow of direct current, and permits the flow of alternating current to a degree dependent on the capacitor’s capacitance and the current frequency.

Certification fuel economy or fuel consumption

An estimate of fuel economy (or the inverse, consumption) developed for official purposes by means of specified test procedures including particular driving cycles. These estimates usually result in fuel economy values that exceed what consumers actually realize in everyday use. Fuel economy and fuel consumption may for example be expressed in l/100km (liters per 100 km), km/l, or mpg (miles per gallon).

Charge / charging

The conversion of electrical energy, provided in the form of current from an external source, into chemical energy within a cell or battery. The (electrical) charge is also a basic property of elementary particles of matter.

Charge / charging factor

The factor by which the amount of electricity delivered during discharge is multiplied to determine the minimum amount required by the battery to recover its fully charged state. Normally, it is higher than 1.0 for most batteries in order to account for the losses in discharging and charging processes.

Charge rate

The current at which a battery is charged (see C rate).

Charger

An energy converter for the electrical charging of a battery consisting of galvanic secondary elements.

Charge depletion (CD)

When a rechargeable electric energy storage system (RESS) on a PHEV, EV or extended-range EV is discharged.

Charge depletion in blended mode (CDB)

When a rechargeable electric energy storage system (RESS) on a PHEV or extended-range EV is discharged, but it is not the only power source moving the vehicle forward (blended mode). A separate fuel and energy conversion system works in tandem with the RESS to provide power and energy to move the vehicle as charge of the RESS is depleted. This mode of operation allows use of a much less powerful RESS than does CDE operation.

Charge depletion all electrically (CDE)

When a rechargeable electric energy storage system (RESS) on a PHEV, EV or extended-range EV is discharged, and continuously provides the only means of moving the vehicle forward (all-electric operation).

Charging equalizer

Device that equalizes the battery state of charge of all the modules in an EV during charging. Employing this measure ensures that the voltage of all the batteries will rise equally and that the battery with the smallest capacity is not overcharged.

Charging levels

Charging equipment is classified by the maximum amount of power in kilowatts provided to the battery. There are several levels of charging equipment. In North America, the standards are:

- AC Level 1, which is a 120-volt (V) alternating current (AC) plug. A full charge at Level 1 can take between 8 and 20 hours, depending on the battery capacity of the vehicle. Charging rate is approximately 1 kW.

- AC Level 2, which is a 240-volt AC plug and requires installation of home charging equipment. Level 2 charging can take between 3 and 8 hours, again depending on the battery capacity of the vehicle. Charging rates fall within a range of 3 kW to 20 kW.

- Direct Current (DC) fast charging, which is as high as 600 V, enables charging along heavy traffic corridors and at public stations. A DC fast charge can take less than 30 minutes to charge a battery to most of its capacity.

Coal-to-liquids (CTL)

Conversion of coal to a diesel-like fuel low in sulfur suitable for use in compression-ignition direct-injection (CIDI) ICEs. The process used for conversion is called Fischer-Tropsch chemistry.

Compression ignition (CI)

Ignition of a mixture of air and fuel in a cylinder of an ICE via heating by compression of the mixture. A name consistently used for ICEs that use this method of ignition is “diesel”.

Controller

An element that restricts the flow of electric power to or from an electric motor or battery pack (module, cell). One purpose is for controlling torque and/or power output. Another may be maintenance of battery life, and/or temperature control.

Controller, Three-phase

An electronic circuit for controlling the output frequency and power from a 3-phase inverter.

Conventional mechanical drivetrain

A mechanical system between the vehicle energy source and the road including engine, transmission, driveshaft, differential, axle shafts, final gearing and wheels. The engine is operated by internal combustion (ICE).

Conventional vehicle

A vehicle powered by a conventional mechanical drivetrain.

Current

The rate of transfer of electricity, meaning the amount of electric charge passing a point per unit time. The unit of measure is the ampere, which represents around 6.241×10^{18} electrons passing a given point each second.

Cut-off voltage

The cell or battery voltage at which the discharge is terminated. The cut-off voltage is specified by the cell manufacturer and is generally intended to limit the discharge rate.

Cycle

A sequence of a discharge followed by a charge, or alternatively a charge followed by a discharge, of a battery under specified conditions.

Cycle life

The number of cycles under specified conditions that are available from a secondary battery before it fails to meet specified criteria regarding performance.

Diesel fuel – conventional and low-sulfur

Diesel fuel is a refined petroleum product suitable for use in compression-ignition direct-injection (CIDI) engines. In recent years there has been a worldwide movement to reduce sulfur content of diesel fuel in order to improve the reliability of required emissions aftertreatment for vehicles using CIDI engines. The sulfur reduction also reduces emissions of SO_x, which in turn reduces sulfate particle matter in the atmosphere. Costs of diesel fuel have been driven up by the need to remove sulfur from a mix of crude oil that is increasing in average percent of sulfur.

Depth of Discharge (DOD)

The percentage of electricity (usually in ampere-hours) that has been discharged from a secondary cell or battery relative to its rated nominal fully charged capacity (see also “Ampere-hour efficiency”, “Voltage efficiency”, and “Watt-hour efficiency”).

Direct current motor / DC motor

An electric motor that is energized by direct current to provide torque. There are several classes of direct current motors.

Discharge

The direct conversion of the chemical energy of a cell or battery into electrical energy and withdrawal of the electrical energy into a load.

Discharge rate

The rate, usually expressed in amperes, at which electrical current is taken from a battery cell, module, or pack (see “C rate”).

Driving range

See “Range”.

E-bike / electric bicycle

With an E-bike, riding a bicycle is possible without pedaling. The motor output of an E-bike is activated and controlled by using a throttle or button. Human power and the electric motor are independent systems. This means that the throttle and pedals can be used at the same time or separately. This contrasts with a Pedelec, which requires that the throttle and pedals always be used at the same time. As a result, an E-bike is more or less used in the same way as a scooter or motorcycle rather than a bicycle. Swiss and Italian regulations define the maximum power that can be used for an E-bike. More power makes it an electric scooter.

Electric assist bike

See “E-bike”.

Electric bike

See “E-bike”.

Electric drive system

The electric equipment that serves to drive the vehicle. This includes (a) driving motor(s), final control element(s), and controllers and software (control strategy).

Electric drivetrain (including electric drive system)

The electromechanical system between the vehicle energy source and the road. It includes controllers, motors, transmission, driveshaft, differential, axle shafts, final gearing, and wheels.

Electric motorcycle

An electric vehicle usually with two wheels, designed to operate all-electrically, and capable of high speed, including ability to travel on high speed limited access highways and motorways. It is usually capable of carrying up to two passengers. Such vehicles have a relatively high power to weight ratio. In addition to greater capability on highways, these vehicles are also more capable of travel off-road on undulating terrain with steep slopes, than are electric scooters.

Electric scooter

See “E-scooter”.

Electric Vehicle (EV)

An EV is defined as “any autonomous road vehicle exclusively with an electric drive, and without any on-board electric generation capability” in this Agreement.

Electrochemical cell

The basic unit able to convert chemical energy directly into electric energy.

Energy capacity

The total number of watt-hours that can be withdrawn from a new cell or battery. The energy capacity of a given cell varies with temperature, rate, age, and cut-off voltage. This term is more common to system engineers than the battery industry, where the ampere-hour is the preferred unit and terminology.

Energy consumption

See “Fuel consumption”.

Energy density

The ratio of energy available from a cell or battery to its volume in liters (Wh/L). The mass energy density in battery and EV industry is normally called specific energy (see “Specific energy”).

Equalizing charge

An extended charge to ensure complete charging of all the cells in a battery.

Equivalent All Electric Range (EAER)

A legal term defined by CARB, in which a formula is used to translate the blended-mode charge-depleting (CDB) operations distance of a PHEV into an equivalent all-electric range.

E-scooter

Small electric sit-down or stand-up vehicles ranging from motorized kick boards to electric mini motorcycles. Differences between the two types of small electric scooters are as follows. With stand-up scooters, instead of pushing the scooter forward with one leg, the rider simply turns the throttle on the handlebar and rides electrically. A typical stand-up scooter is a little more than one meter long and weighs between 12 and 25 kg. In contrast, sit-down scooters are small electric vehicles with a seat and are used much the same way as gasoline-powered scooters. A throttle on the handlebar regulates the acceleration. Sit-down e-scooters are usually bigger and heavier than the stand-up types. The appearance and accessories vary from trendy and stylish products to more utilitarian models with large seats and a big shopping basket.

Ethanol (EtOH)

A chemical that may be used as a motor fuel, either "neat" (pure) or blended into refined petroleum products such as gasoline. When used as a fuel, it requires multiple revisions of engine controls and of materials used in the engine and emissions aftertreatment system. Generally, the higher the percentage of ethanol blended into gasoline, the more changes have to be made to the engine and exhaust system. It is possible to design a vehicle to use varying blends of gasoline and ethanol. Such vehicles are called "flexible-fuel vehicles" (FFVs). Brazil, the United States, and Sweden produce significant quantities of FFVs. The leading producers of ethanol in the world are the US, which produces this fuel from corn, and Brazil, which produces it from sugar cane. In the future, the US intends to expand production of ethanol by use of biomass other than corn. Production of vehicles capable of using ethanol costs hundreds of dollars per vehicle, in contrast to PHEVs and EVs, where the costs of conversion to electric drive are in the thousands.

Extended-range electric vehicle

Also known as a series PHEV, an extended-range electric vehicle is an "autonomous road vehicle" primarily using electric drive provided by a rechargeable electric energy storage system (RESS), but with an auxiliary on-board electrical energy generation unit and fuel supply used to extend the range of the vehicle once RESS electrical charge has been depleted.

E85, E20

Ethanol blended into gasoline is generally labelled according to the volume percentage of ethanol in the mixed fuel. Thus, E85 contains 85% ethanol by volume, while E20 contains 20% ethanol, and so forth. Generally the lowest percentage of gasoline in gasoline-ethanol blends is 15% (i.e., as found in E85). In E85 the gasoline-like hydrocarbons contribute to improved vehicle cold starting, flame luminosity to help fire-fighters if the fuel catches fire, and also acts as a denaturant (prevents human consumption of the ethanol).

Federal test procedure (FTP)

The US Environmental Protection Agency's (EPA) federal test procedure used to measure emissions, from which an estimate of city fuel economy is also constructed. The FTP involves running a complete urban dynamometer driving schedule (UDDS), starting with a cold start, turning the engine off for ten minutes, restarting warm and running the first 505 seconds of the UDDS again. The running time for the UDDS is 1372 seconds. The running time for the FTP is 1877 seconds (ignoring the ten minutes with engine off). The average weighted speed of the FTP is 34 km/h, while the average speed for the UDDS is 31 km/h. This test is conducted at ~ 24 degrees Celsius. For purposes of developing estimates of "on-road" fuel economy, accounting for starting in cold temperatures, the US EPA has recently developed the "Cold FTP", which is conducted at approximately -6.7 degrees Celsius.

Fuel cell

An electrochemical cell that converts chemical energy directly into electric energy, as the result of an electrochemical reaction between reactants continuously supplied, while the reaction products are continuously removed. The most common reactants are hydrogen (fuel) and oxygen (also from the air).

Fuel cell vehicle (FCV)

A vehicle with an electric powertrain that uses the fuel cell as a source of the electricity to provide electric drive. FCVs may also include an electric storage system (ESS) and be HEVs or PHEVs. However, an ESS is not technically necessary in a FCV.

Fuel consumption

The energy consumed by a vehicle per unit distance (in km) and, sometimes, also per unit weight (in tons). It may be expressed as kWh/km and also kWh/(ton-km). For EVs and PHEVs the electrical energy counted, expressed in AC kWh, is from the plug (charger input). Usually developed from tests of vehicles when driven over a "driving cycle" (a speed versus time requirement), with a specified passenger and/or luggage load. Standardized methods of estimating fuel consumption of PHEVs have not yet been developed.

Fuel economy

Also referred to as fuel efficiency. For an EV it is the distance (in km) travelled per unit energy from the plug, in kWh. For an internal combustion engine vehicle it represents the distance travelled per liter of fuel. It is the reciprocal of the energy per unit distance (the reciprocal of fuel consumption). Usually developed from tests of vehicles when driven over a "driving cycle" (a speed versus time requirement), with a specified passenger and/or luggage load. Standardized methods of estimating fuel economy of PHEVs have not yet been developed.

Full HEV

A full HEV has the ability to operate all-electrically, generally at low average speeds. At high steady speeds such a HEV uses only the engine and mechanical drivetrain, with no electric assist. At intermediate average speeds with intermittent loads, both electric and mechanical drives frequently operate together. A PHEV can be developed based on a full HEV powertrain.

Gasoline – reformulated (RFG) and conventional

Gasoline is a refined petroleum product burned in spark ignition (SI) internal combustion engines. It comes in many types and grades, with formulations varying for purposes of octane rating and to influence evaporative and tailpipe emissions. In the US two very broad categories are "reformulated", which is a minority grade used in areas that need low emissions to improve air quality. The majority of gasoline in the US is "conventional".

Gas-to-hydrogen (GH2)

Conversion of (natural) gas to a synthesis gas (or syngas) containing hydrogen (H_2) and carbon monoxide (CO), followed by clean-up of the gas to produce pure H_2. The common process used is steam reforming.

Hourly battery rate

The discharge rate of a cell or battery expressed in terms of the length of time during which a fully charged cell or battery can be discharged at a specific current before reaching a specified cut-off voltage. The hour-rate = C/i, where C is the rated capacity and i is the specified discharge current. For EVs, a 3-hour or a 1-hour discharge is preferred.

Hybrid road vehicle

A hybrid road vehicle is one in which propulsion energy during specified operational missions is available from two or more kinds or types of energy stores, sources, or converters. At least one store or converter must be on-board.

Hybrid electric vehicle (HEV)

The 1990s definition of IA-HEV Annex I was "a hybrid electric vehicle (HEV) is a hybrid road vehicle in which at least one of the energy stores, sources or converters delivers electric energy". The International Society of Automotive Engineers (SAE) defines a hybrid as "a vehicle with two or more energy storage systems, both of which provide propulsion power, either together or independently". Normally, the energy converters in a HEV are a battery pack, an electric machine or machines, and internal combustion engine. However, fuel cells may be used instead of an internal combustion engine. In a hybrid, only one fuel ultimately provides motive power. One final definition is from the UN, which defines an HEV as "a vehicle that, for the purpose of mechanical propulsion, draws energy from both of the following on-vehicle sources of stored energy/power: a consumable fuel, and an electrical energy/power storage device (e.g.: battery, capacitor, flywheel/generator, etc.)."

Hybrid electric vehicle (HEV) – Parallel configuration

A parallel hybrid is a HEV in which both an electric machine and engine can provide final propulsion power together or independently.

Hybrid electric vehicle (HEV) – Series configuration

A series hybrid is a HEV in which only the electric machine can provide final propulsion power.

Hybrid vehicle

UN definition: A vehicle with at least two different energy converters and two different energy storage systems (on vehicle) for the purpose of vehicle propulsion.

Induction motor

An alternating-current motor in which the primary winding on one member (usually the stator) is connected to the power source, and the secondary winding on the other member (usually the rotor), carries only current induced by the magnetic field of the primary. The magnetic fields react against each other to produce a torque. One of the simplest, reliable, and cheapest motors made.

Inductive charging

The use of magnetic coupling devices instead of standard plugs in charging stations. This technology was actively pursued for EVs in the 1990s in the US.

Infrastructure

Every part of the system except the vehicle itself that is necessary for its use. For PHEVs or EVs the infrastructure includes available fuel (electricity), power plants, transmission lines, distribution lines, access to parts, maintenance and service facilities, and an acceptable trade-in and resale market.

Installed capacity

The total number of ampere-hours that can be withdrawn from a new battery cell, module, or pack when discharged to the system-specified cut-off voltage at the HEV, PHEV, or EV design rate and temperature (i.e., discharge at the specified maximum DOD).

Internal combustion engine (ICE)

The historically most common means of converting fuel energy to mechanical power in conventional road vehicles. Air and fuel are compressed in cylinders and ignited intermittently. The resulting expansion of hot gases in the cylinders creates a reciprocal motion that is transferred to wheels via a driveshaft or shafts.

Kilowatt-hour (kWh)

One thousand (1000) watt-hours of energy, which also equals 1.341 horsepower-hours (or 1.35962 CVh).

Lithium ion (Li-ion)

The term “lithium-ion” refers to a family of battery chemistries. Li-ion chemistries commonly used today have come down significantly in cost and have increased gravimetric and volumetric energy density over the last 15 years, with progress accelerating in the last few years. Li-ion has nearly completely supplanted nickel-metal hydride (NiMH) batteries in consumer electronics. NiMH remains the chemistry of choice in HEVs, but is anticipated that it will be replaced by emerging Li-ion chemistries. Because it has already attained significantly higher gravimetric and volumetric energy densities than NiMH in consumer cells and is improving further with new chemistries, Li-ion is seen as the coming enabling technology for PHEVs, in addition to being a solid competitor to replace NiMH in HEVs.

Low emissions vehicle (LEV)

A vehicle with tailpipe emissions below a specified level, as determined by regulations and test procedures specified by CARB.

Maintenance-free battery

A secondary battery, which during its service needs no maintenance, provided specified operating conditions are fulfilled.

Mild HEV

A HEV that has a less powerful electric machine and battery pack than a full hybrid. According to the Netherlands Organisation for Applied Scientific Research (TNO), a mild HEV cannot operate all-electrically. Electric assist always works together with the internal combustion engine.

Motor, electric machine, generator

A motor is a label for an electric machine that most frequently converts electric energy into mechanical energy by utilising forces produced by magnetic fields on current-carrying conductors. Most electric machines can operate either as a motor or generator. When operating as a generator, the electric machine converts mechanical energy into electrical energy. In HEVs, PHEVs, and EVs, electric machines operate both in motoring and generating modes.

Neighborhood Electric Vehicle (NEV)

A vehicle defined in US Federal Regulations. NEVs are low-speed electric vehicles that have a maximum speed of 25 mph and can only be driven on roads with a maximum speed of 35 mph. Such vehicles have a much less stringent set of safety requirements than do other US light-duty vehicles.

Nickel cadmium (NiCd)

Nickel cadmium was a common battery chemistry used in many EVs of the 1990s as well as in consumer electronics. It is no longer in common use because of restrictions put on hazardous substances, which include cadmium.

Nickel-metal hydride (NiMH)

Nickel metal hydride was a common commercial battery chemistry in the 1990s for consumer electronics. In the late 1990s it became the battery of choice for HEVs. It has higher gravimetric and volumetric energy density than nickel cadmium (NiCd), but lower than those for lithium-ion chemistries.

Nitrogen oxides (NO_x)

NO_2 and/or NO – "criteria pollutants" whose emissions from the tailpipe and concentration in the air is regulated. NO_x reacts in sunlight and high temperatures with reactive organic gases (ROG) to form ozone, a regulated pollutant of general concern. NO_x also reacts with ammonia to form the particulate matter (PM) ammonium nitrate. Total PM, by mass per unit volume of air, is also regulated.

Nominal capacity

The total number of ampere-hours that can be withdrawn from a new cell or battery for a specified set of operating conditions including discharge rate (for EV, usually C_1 or C_3), temperature, initial state of charge, age, and cut-off voltage.

Nominal voltage

The characteristic operating voltage or rated voltage of a cell, battery, or connecting device.

Normal charging

Also called slow or standard charge. The most common type and location for charging of a PHEV or EV battery pack necessary to attain the state of maximum charge of electric energy.

On-road (or "in use") fuel economy (or consumption)

Official certification test fuel economy (consumption) values typically exceed (underestimate) actual values experienced by vehicle drivers. To varying degrees, nations that have been involved with the IA have conducted research to determine actual "on-road" fuel economy (consumption). The US has adopted a method to estimate, and publish for consumers, estimates of on-road fuel consumption that use five different driving cycles. The official US certification fuel economy rating system uses only two different driving cycles. Europe has conducted studies on this topic, but has not yet developed an "on-road" rating system for consumers.

Opportunity charging

The use of a charger during periods of EV or PHEV inactivity to increase the charge of a partially discharged battery pack.

Overcharge

The forcing of current through a cell after all the active material has been converted to the charged state. In other words, charging is continued after 100% state of charge (SOC) is achieved.

Parallel battery pack

Term used to describe the interconnection of battery cells and/or modules in which all the like terminals are connected together.

Parallel HEV

A HEV in which the engine can provide mechanical power and the battery electrical power simultaneously to drive the wheels.

Partial zero emission vehicle (PZEV)

A category defined in the regulatory structure of the California Air Resources Board (CARB). From CARB's perspective, the vehicle has some of the desirable emissions characteristics of a ZEV, but not all.

Particulate matter (PM)

A mix of chemicals in particulate form, emerging from the tailpipe of a vehicle or within air. Both tailpipe PM and PM concentrations in ambient air are regulated in most advanced nations. PM emissions historically have consistently been far higher from diesel (compression ignition) engines than from petrol (spark ignition) engines.

Peak power (in kW)

Peak power attainable from a battery, electric machine, engine, or other part in the drive system used to accelerate a vehicle. For a battery this is based on short current pulse (per 10 seconds or less) at no less than a specified voltage at a given depth of discharge (DOD). For an electric machine, the limiting factor is heating of insulation of copper windings. Peak power of an engine is generally related to mechanical capabilities of metal parts at peak allowable revolutions per minute, also affected by heat. Generally, continuous power ratings are well below peak power ratings.

Pedelec

Pedelec stands for "pedal electric cycle". While pedaling the rider gets additional power from the electric drive system. The control of the motor output of a pedelec is linked to the rider's pedaling contribution by means of a movement or power sensor. In other words, the electric motor is activated as soon as the rider starts to pedal, and it is deactivated as soon as the rider stops pedaling.

Plug-in hybrid electric vehicle (PHEV)

A HEV with a battery pack with a relatively large amount of kWh of storage capability, with an ability to charge the battery by plugging a vehicle cable into the electricity grid. This allows more than two fuels to be used to provide the propulsion energy.

PHEVxk

A plug-in hybrid electric vehicle with “x” miles or kilometers of estimated charge depletion all electrically (CDE) range (also known as all-electric range, or AER). In this glossary, we suggest adding a small letter “k” to denote when the “x” values are in kilometres, or an “m” to denote when those values are in miles.

Power

The rate at which energy is released. For an EV, it determines acceleration capability. Power is generally measured in kilowatts.

Power density (volumetric)

The ratio of the power available from a battery to its volume in liters (W/L). The mass power density in battery and EV industry is normally called specific power (see “Specific power”) or gravimetric power density.

Range

The maximum distance travelled by a vehicle, under specified conditions, before the “fuel tanks” need to be recharged. For a pure EV, it is the maximum distance travelled by a vehicle under specified conditions before the batteries need to be recharged. For a PHEV it will be the maximum distance achievable after emptying both the battery pack and fuel tank. For a conventional vehicle or HEV it will be the maximum distance achievable after emptying the fuel tank.

Rated capacity

The battery cell manufacturer’s estimate of the total number of ampere-hours that can be withdrawn from a new cell for a specified discharge rate (for EV cells usually C_1 or C_3), temperature, and cut-off voltage.

Reactive organic gases (ROG)

These are emissions from the tailpipe as well as evaporation of fuel from vehicles. Consistent with the name, they are problematic because they react in air with other gases (NO_x in particular) to form ambient air pollution, primarily ozone. Generally, both the emissions of ROG from vehicles and ozone in the air are regulated.

Rechargeable electric energy storage system (RESS)

Battery packs, flywheels, and ultracapacitors are examples of systems that could be repeatedly charged from the grid, with the charge later discharged in order to power an electric machine to move a vehicle.

Regenerative braking

A means of recharging the battery by using energy produced by braking the EV. With normal friction brakes, a certain amount of energy is lost in the form of heat created by friction from braking. With regenerative braking, the electric machines act as generators. They reduce the braking energy lost by returning it to the battery, resulting in improved range.

Self-discharge

The loss of useful electricity previously stored in a battery cell due to internal chemical action (local action).

Series HEV

A series hybrid is a HEV in which only the electric machine can provide final propulsion power.

Smart charging

The use of computerized charging devices that constantly monitor the battery so that charging is at the optimum rate and the battery life is prolonged.

Spark ignition (SI)

Ignition of a mixture of air and fuel in the cylinders of an internal combustion engine via an electric spark.

Specific energy, or gravimetric energy density (of a battery)

The energy density of a battery expressed in watt-hours per kilogram.

Specific power, or gravimetric power density (of a battery)

The rate at which a battery can dispense power measured in watts per kilogram.

Start-stop

The lowest level of electrification of a powertrain, involving a slightly larger (higher kW) electric machine and battery than for starting alone, providing an ability to stop the engine when the vehicle is stopped and save fuel that would have been consumed at engine idle.

Start-stop + regeneration (and electric launch)

This technology package can also be called "minimal" or "soft" hybridization. According to the International Society of Automotive Engineers (SAE), a hybrid must provide propulsion power. If a start-stop system includes regeneration and electric launch, it is a hybrid, according to the SAE definition. If it does not, it is not a hybrid.

State of charge (SOC)

See "Battery state of charge".

Sulfur oxides (SOx)

Sulfur oxides are a "criteria pollutant" whose concentration in the air is regulated. Sulfur content of fuel is usually regulated, both in order to reduce conversion of fuel sulfur to SO_x from the tailpipe, and also to increase the reliability and functionality of vehicle emissions control systems. SO_x mass per unit volume concentrations are regulated. SO_x also reacts with ammonia to form the particulate matter (PM) ammonium sulfate. Total PM, by mass per unit volume of air, is also regulated.

Super ultra low emissions vehicle (SULEV)

For a given type of vehicle, the lowest "non zero" emissions rating under the CARB LEV emissions regulations.

Type 0 (as defined by CARB)

Utility EV with less than a 50 mile range.

Type I (as defined by CARB)

City EV with a range of 50 miles to 75 miles.

Type I.5 (as defined by CARB)

City EV with a range of 75 miles to less than 100 miles.

Type II (as defined by CARB)

Full function EV with a range of 100 or more miles.

Type III (as defined by CARB)

ZEV with a range of 100 or more miles, plus fast refuelling.

Type IV (as defined by CARB)

ZEV with a range of 200 or more miles, plus fast refuelling.

ULEV II

Ultra Low Emissions Vehicle after 1998 CARB regulation revisions.

Useable capacity

The number of ampere-hours (or kilowatt-hours) that can be withdrawn from a battery pack installed in a PHEV, taking into account decisions on control strategy designed to extend battery pack life or achieve vehicle performance goals (refers to a minimum power level). Useable capacity is a smaller number than nominal capacity.

Volt

A unit of potential difference or electromotive force in the International System units, equal to the potential difference between two points for which one Coulomb of electricity will do 1 Joule of work in going from one point to the other. The volt unit is symbolised by "V".

Voltage efficiency

The ratio of the average voltage during discharge to the average voltage during recharge under specified conditions of charge and discharge.

Watt-hour efficiency

The ratio of the watt-hours delivered on discharge of a battery to the watt-hours needed to restore it to its original state under specified conditions of charge and discharge.

Watt-hours per kilometer

Energy consumption per kilometer at a particular speed and condition of driving. It is a convenient overall measure of a vehicle's energy efficiency. Watt-hour efficiency = Ampere-hour efficiency x voltage efficiency.

Zero emission vehicle (ZEV)

A vehicle that has no regulated emissions from the tailpipe. Under California Air Resources Board (CARB) regulations, either an EV or a FCV is also a ZEV.

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Abbreviations

A	Ampere
AC	Alternating Current
ACEA	European Automobile Manufacturers Association
ACT	Accelerated Technology (IEA)
ADEME	Agency for Environment and Energy Management (France)
AEI	Advanced Energy Initiative (USA)
AER	All-Electric Range
AFV	Alternative Fuel Vehicle
AGV	Automatic Guided Vehicle
Ah	Ampere-hour
AHFI	Austrian Hydrogen and Fuel cell Initiative
AIM	Asynchronous Induction Machine
AIST	National Institute of Advanced Industrial Science and Technology (Japan)
ALABC	Advanced Lead-Acid Battery Consortium
ALM	Automotive Lightweight Materials
ANL	Argonne National Laboratory (USA)
ANR	Agence Nationale de la Recherche (France)
ANVAR	Agence Nationale de Valorisation de la Recherche (France)
APRF	Advanced Powertrain Research Facility (at ANL)
APSC	Austrian Alternative Propulsion Systems Council
APU	Auxiliary Power Unit
ASBE	Belgian Electric Vehicles Association
AT-PZEV	Advanced Technology Partial Zero Emission Vehicle
AVEM	Avenir du Véhicule Electrique Méditerranéen (France)
AVERE	European Association for Battery, Hybrid and Fuel Cell Electric Vehicles
A3	Austrian Advanced Automotive technology R&D programme
A3PS	Austrian Agency for Alternative Propulsion Systems
BC	British Columbia
BES	Basic Energy Sciences
BEV	Battery Electric Vehicle
BMVIT	Federal Ministry for Transport, Innovation and Technology (Austria)
BTL	Biomass-to-liquid (fuel)
CAC	Criteria Air Contaminants
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board

cc	cubic centimetre
CCFA	Comité des Constructeurs Français d'Automobiles
CCS	CO2 Capture and Storage
CD	Charge Depletion
CDB	Charge Depletion - Blended mode
CDE	Charge Depletion - all Electric operation
CEI	Italian Electrotechnical Commission
CEIIA	Centre for Excellence and Innovation in the Auto Industry (Portugal)
CEM	Clean Energy Ministerial
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CERT	Committee on Energy Research and Technology (IEA)
CFC	Carbon fiber chassis
CHF	Swiss Franc
CHP	Combined Heat and Power (generation)
CH4	Methane
CIDI	Compression Ignition Direct Injection
CITELEC	Association of European Cities interested in Electric Vehicles
CIVES	Italian Electric Road Vehicle Association
CMVSS	Canada Motor Vehicle Safety Standards
CNG	Compressed Natural Gas
CNR	National Research Council (Italy)
CO	Carbon monoxide
Co.	Company
Corp.	Corporation
CO2	Carbon dioxide
CRF	Fiat Research Center (Italy)
CRIEPI	Central Research Institute of Electric Power Industry (Japan)
CTL	Coal-to-liquid (fuel)
CUTE	Clean Urban Transport for Europe
CVT	Continuous Variable Transmission
DC	Direct Current
DfT	Department for Transport (United Kingdom)
DLR	Germany's national research institute for aeronautics, space, transportation and energy (Germany)
DKK	Danish Crown
DME	Dimethyl ether
DOD	Depth Of Discharge
DOE	Department of Energy (USA)
DOT	Department of Transportation (USA)

DPF	Diesel Particulate Filter
DPT	State Planning Organization (Turkey)
DSBHFC	Direct Sodium Borohydride Fuel Cell
EAER	Equivalent All-Electric Range
EC	European Commission
ECFT	European Clean Transport Facility
ECN	Energy research Centre of the Netherlands
ECU	Electronic Control Unit
EDF	Electricité de France
EDTA	Electric Drive Transportation Association
EET	European Ele-Drive Transportation Conference
EEV	Enhanced Environmentally friendly Vehicle (Europe)
EGCI	European Green Cars Initiative (European Union)
EIA	Energy Information Administration (USA)
EM	Electric Motor
EM	Expert Meeting
EMPA	Institute for Material Sciences and Technology Development (Switzerland)
EMU	Electrified Motive Unit
ENEA	Italian National Agency for New Technologies, Energy and the Environment
EPA	Environmental Protection Agency
EPACT	Energy Policy Act (USA)
EPE	European Power Electronics and Drives Association
EPRI	Electric Power Research Institute (USA)
EREV	Extended-Range Electric Vehicle
ESS	Electric Storage System
ESS	Energy Storage System
ETEC	Department of Electrical Engineering and Energy Technology (VUB)
ETH	Eidgenössische Technische Hochschule Zürich (Swiss Federal Institute of Technology Zürich)
ETO	Office of Energy Technology and R&D (IEA)
EtOH	Ethanol
EU	European Union
EUDP	Energy Technology Development and Demonstration Programme (Denmark)
EURO-x	European emission standard, level x
EUWP	End-Use Working Party (IEA)
EV	Electric Vehicle
EVI	Electric Vehicles Initiative of the Clean Energy Ministerial
E.V.A.	Austrian Energy Agency
EVS	Electric Vehicle Symposium

EVT	Electrical Variable Transmission
evTRM	EV Technology Roadmap (Canada)
ExCo	Executive Committee
E85	Fuel blend of 85 vol-% ethanol and 15 vol-% gasoline
F	Farad
FC	Fuel Cell
FCEV	Fuel Cell Electric Vehicle
FCV	Fuel Cell Vehicle
FFI	Strategic Vehicle Research and Innovation Initiative (Sweden)
FFV	Flexibly Fuelled Vehicle or Fuel Flexible Vehicle
FH	Fachhochschule (University of applied sciences - Germany, Switzerland)
FISR	Special Integrative Fund for Research (Italy)
FMVSS	Federal Motor Vehicle Safety Standard (USA)
FP	European Framework Programme for research and technological development
FT	Fischer-Tropsch
FTP	Federal Test Procedure (USA)
FY	Fiscal Year
g CO_2/km	Grams of CO_2 per kilometre (emissions)
GAMEP	Office of Electric Mobility (Portugal)
GDP	Gross Domestic Product
GEM	Global Electric Motorcars
gge	gallon gasoline equivalent
GHG	Greenhouse Gas
GM	General Motors
GMC	General Motors Corporation
Gt	Gigaton (109 tons)
GTL	Gas-to-liquid (fuel)
GVW	Gross Vehicle Weight
G2V	Grid-to-Vehicle
h	hour
HCCI	Homogeneous Charge Compression Ignition
HECU	HEV Electronic Control Unit
HEV	Hybrid Electric Vehicle
HFCIT	Hydrogen, Fuel Cells and Infrastructure Technologies
HIL	Hardware-in-the-loop
HMI	Human Machine Interaction
HOV	High Occupancy Vehicle
hp	horsepower

HTAS	High Tech Automotive Systems (The Netherlands)
HTUF	Hybrid Truck User Forum (USA)
H2	Hydrogen
H&EV	Hybrid and Electric Vehicle
IA	Implementing Agreement (of the IEA)
IA-AFC	Implementing Agreement on Advanced Fuel Cells
IA-AMF	Implementing Agreement on Advanced Motor Fuels
IA-HEV	Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes
IAEA	International Atomic Energy Agency
IAMF	International Advanced Mobility Forum
ICE	Internal Combustion Engine
ICT	Information- and Communication Technology
IDAE	Institute for the Diversification and Saving of Energy (Spain)
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
IMA	Integrated Motor Assist™ (by Honda)
Inc.	Incorporated
INL	Idaho National Laboratory
INRETS	Institut National de Recherche sur les Transports et leur Sécurité (France)
IPCC	Intergovernmental Panel on Climate Change
IPHE	International Partnership for a Hydrogen Economy
IPT	Inductive Power Transfer
IRS	Internal Revenue Service (USA)
ISO	International Organization for Standardization
ITRI	Industrial Technology Research Institute (Taiwan)
ITS	Intelligent Transport System
ITU	Istanbul Technical University (Turkey)
IV2S	Intelligent Vehicular Transport Systems and Services research programme (Austria)
JARI	Japan Automobile Research Institute
JCS	Johnson Controls, Inc. and Saft joint venture
ktoe	kilotonnes equivalent
kWh	Kilowatt-hour
L	Liter
LCA	Life Cycle Analysis

LDV	Light-duty Vehicle
LEV	Light Electric Vehicle
LEV	Low Emissions Vehicle
Li	Lithium
LiP	Lithium Phosphate
LiP	Lithium Polymer
LLNL	Lawrence Livermore National Laboratory
LMP	Lithium Metal Polymer
LNG	Liquefied Natural Gas
LNT	Lean NOx Trap
LPG	Liquefied Petroleum Gas
LRT	Light Rail Transit
LSV	Low-speed Vehicle
MATT	Mobile Advanced Technology Testbed
MCFC	Molten Carbonate Fuel Cell
MEA	Membrane Electrode Assembly
Mg	Magnesium
MH	Metal Hydride
min	minute(s)
MOBI.E	Mobilidade Eléctrica (Portugal)
MOU	Memorandum of Understanding
mpg	miles per gallon
mph	miles per hour
MPV	Multi Purpose Vehicle
MRC	Marmara Research Center (TÜBITAK, Turkey)
MVSA	Motor Vehicle Safety Act (Canada)
NAC	National Automotive Center (USA)
NEDO	New Energy and Industrial Technology Development Organization
NEET	Networks of Expertise in Energy Technology (an IEA initiative)
NEV	Neighbourhood Electric Vehicle
NGO	Non Governmental Organization
NGV	Natural Gas Vehicle
NHTSA	National Highway Traffic Safety Administration (USA)
NiCd	Nickel Cadmium
NiMH	Nickel-Metal Hydride
NL	The Netherlands
NMVOS	Non-Methane Volatile Organic Substances
NPE	National Platform for Electromobility (Germany)
NOx	Nitrogen Oxides

NRC	National Research Council of Canada
NRCan	Natural Resources Canada
NREL	National Renewable Energy Laboratory (USA)
NZES	New Zealand Energy Strategy
N2O	Nitrous Oxide (not considered a NOx compound)
OA	Operating Agent
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OERD	Office of Energy Research and Development (NRCan)
ORNL	Oak Ridge National Laboratory (USA)
OSD	Automotive Manufacturers Association (Turkey)
OTAM	Automotive Technology Research and Development Center (Turkey)
P.A.	Power-Assisted
PCA	Peugeot Citroën Automobiles (France)
PCCI	Premixed Charge Compression Ignition
PEFC	Polymer Electrolyte Fuel Cell
PEFC	Proton Exchange Fuel Cell
PEM	Polymer Electrolyte Membrane
PEM	Proton Exchange Membrane
PERD	Program of Energy Research and Development (NRCan)
PHEV	Plug-in Hybrid Electric Vehicle
PHEVx	Plug-in Hybrid Electric Vehicle that has the ability to travel x miles on electric-only mode
PM	Particulate Matter
PMSM	Permanent Magnet Synchronous Motor
PM10	Particulate Matter, size < 10 mm (10-6 m)
ppm	parts per million
PR	Public Relations
PRC	People’s Republic of China
PSAT	Powertrain Systems Analysis Toolkit (ANL)
psi	pound-force per square inch
PSI	Paul Scherrer Institut (Switzerland)
PTO	Power Take Off
PV	Photovoltaic
PZEV	Partial Zero Emission Vehicle
RD&D	Research, Development and Demonstration
RD&D	Research, Development and Deployment
RDI	Research, Development, and Innovation

RESS	Rechargeable (electric) Energy Storage System
RFG	Reformulated Gasoline
RMB	Renminbi (the official currency of the People's Republic of China)
ROG	Reactive Organic Gases
RT	Real-time
R&D	Research and Development
SAE	Society of Automotive Engineers
SAM	Super Accumulator Module
SASAC	State-Owned Assets Supervision and Administration Commission (of the State Council of China)
SC	Sub-Committee
SCE	Southern California Edison
SCR	Selective Catalytic Reduction
SEAI	Sustainable Energy Authority of Ireland
SEK	Swedish Crown
SHC	Swedish Hybrid Vehicle Centre
SHHP	Scandinavian Hydrogen Highway Partnership
SI	Spark Ignition
SI	Système International (International System of Units)
SIDI	Spark Ignition Direct Injection
SMEs	Small and Medium Enterprises
SOC	State Of Charge (battery)
SOE	State-Owned Enterprise (in China)
SOFC	Solid Oxide Fuel Cell
SOH	State Of Health (battery)
SOx	Sulfur Oxides
SO2	Sulfur dioxide
SQAIM	Squirrel cage rotor Asynchronous Induction Machine
SRA	Strategic Research Area
SULEV	Super Ultra Low Emissions Vehicle
SUV	Sport Utility Vehicle
S.V.E.	Société des Véhicules Electriques (France)
SWEVA	Swedish Electric & Hybrid Vehicle Association
t	Ton(s) (1 t = 1,000 kg)
TC	Technical Committee
TCG	Transport Contact Group (IEA EUWP)
TEKES	Finnish Funding Agency for Technology and Innovation
TLVT	Technology Life Verification Test
TNO	The Netherlands Organisation for Applied Scientific Research TNO

TÜBİTAK	The Scientific and Technological Research Council of Turkey
UC	University of California
UDDS	Urban Dynamometer Driving Schedule (USA)
UK	United Kingdom
ULEV	Ultra Low Emissions Vehicle
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
U.S.	United States (of America)
USA	United States of America
USABC	United States Advanced Battery Consortium
USCAR	United States Council for Automotive Research
US$	U.S. dollar
V	Volt
VAT	Value-Added Tax
VITO	Flemish Institute for Technological Research (Belgium)
vol-%	Percentage based on volume
VRLA	Valve Regulated Lead Acid (battery)
VSP	Vehicle Simulation Programme (ETEC, VUB)
VSWB	Flemish Cooperative on Hydrogen and Fuels Cells (Belgium)
VTT	Programme Véhicules pour les Transports Terrestres (ANR, France)
VUB	Vrije Universiteit Brussel (Belgium)
VW	Volkswagen
V2G	Vehicle-to-Grid
WEVA	World Electric Vehicle Association
Wh	Watt-hour
WSC	World Solar Challenge (race for solar powered vehicles)
wt-%	Percentage based on weight
ZEV	Zero Emission Vehicle

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