IEA INTERNATIONAL ENERGY AGENCY

HYBRID & ELECTRIC VEHICLE IMPLEMENTING AGREEMENT

IA-HEV

Hybrid and Electric Vehicles

THE ELECTRIC DRIVE CAPTURES THE IMAGINATION

March 2012

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International Energy Agency

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

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Cover Photo: BMW i3 Concept, which is being developed as the first mass-produced battery electric vehicle with a carbon fiber chassis (CFC), scheduled to enter the market in 2013. (Photo courtesy of BMW Group.)
The Electric Drive Captures the Imagination.
Cover designer: Kizita Awuakye, New West Technologies, LLC

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 2011

Hybrid and Electric Vehicles
The Electric Drive Captures the Imagination

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Report structure

This report consists of four 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 Chairperson’s message in chapter 1 includes a summary of IA-HEV activities in 2011, 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.

Part B “IA-HEV Tasks” presents the results of the work that is performed by the task forces, called Tasks, working under this Agreement to conduct research into specific topics of particular relevance to hybrid and electric vehicles.

A general picture of hybrid and electric vehicles (H&EVs) around the globe is painted in part C, “H&EVs worldwide”. The first chapter (12) in this section gives the most recently available H&EV statistical information from all 17 member countries. More detailed information on H&EV activities in each IA-HEV member country is presented in chapters 13 through 29. Chapter 30 highlights H&EV issues in the key countries of East Asia which are not currently IA-HEV members. Also, developments occurring at the European level are described, as thirteen of the IA-HEV member countries are part of the European Union, and there are international research projects in which several of these countries participate.

Finally, Part D 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 Executive Committee and Task Operating Agents.

1 Chairperson's Message

WORKING TODAY TO BUILD A FUTURE WITH ELECTRIC TRANSPORT POWERED BY RENEWABLE ENERGY

There is a pressing need to accelerate the development of low-carbon energy technologies in order to address the global challenges of energy security, climate change, and economic growth. This became more apparent than ever before during 2011 as world events forced governments to reexamine their energy sources. Last year Japan suffered major disruptions in its electricity production due to the failure of the nuclear power plants in Fukushima that were damaged by the impact of the earthquake and tsunami. Within weeks, as the environmental-nuclear disaster was viewed worldwide, government leaders and citizens in other countries began to question the use of nuclear energy, even though it is a source of carbon dioxide (CO_2)-free electricity production. The leadership in my home country, Switzerland, has decided to phase out nuclear technology which contributes to 40% of total electricity production. A mix of renewable energy resources should fill this gap, especially hydropower and photovoltaic (PV) energy.

Renewable energy is safer than nuclear power, but it has implications for the electricity grid. How we manage the electricity grid will need to change in order to use renewable energy effectively, because renewables produce electricity intermittently. Smart grids are particularly important as they enable the use of low-carbon energy technologies, including electric vehicles, variable renewable energy sources, and demand response. Electric vehicles can play an interesting role in this new world of electricity management because electric drives offer carbon-free mobility through the use of renewable energy instead of fossil fuels with the added possibility of storing electricity in car batteries. Yet, the big question is: how long will this transition take?

THE ELECTRIC DRIVE MARKET SHOWS GROWTH

In 2011 vehicle manufacturers offered hybrid electric vehicles (HEVs) were offered for sale to the mass market in larger numbers than previously seen. Plug-in hybrid electric vehicles (PHEVs) were also introduced to a few initial markets. Sales have been less than originally projected, but this may be due to the slower-than-anticipated production and vehicle delivery to showrooms. Many manufacturers and governments are hoping the measures taken to promote sales will prevail in the marketplace in 2012. A free market with rigorous competition between car producers results is moving the electric drive forward. Many automakers now offer a broad range of hybrid drive solutions in all their car segments. Toyota appears to have capitalized on its status of being the first to widely market HEVs more than a decade ago. More and more car producers are offering 100% electric versions of conventional cars or developing special models that use the electric drive.

The global market for electric two-wheeled vehicles—e-bikes, e-scooters, and e-motorcycles—will continue to grow. There are multi-millions of electric two-wheelers on the road today. China is currently the largest marketplace for electric two-wheel vehicles followed by Western Europe. People increasingly accept electric two-wheel vehicles as reliable forms of transportation with many environmental benefits, especially in an urban setting. They also relieve urban traffic congestion. Since the cost of ownership of an e-motorcycle or e-scooter remains low enough to see payback on the vehicle within a year or two of purchase, the market is likely to remain strong in markets with high economic growth rates.

Our Implementing Agreement for Hybrid and Electric Vehicles (IA-HEV) outlook is optimistic. We believe that the electric drive will succeed in the marketplace after several unproductive attempts in the 1970s, 1980s, and 1990s. Now that plug-in electric vehicles have arrived, the dialogue about transportation and renewable energy usage must also now include the smart grid of the future. The changes that smart grids, renewable energy, and electric vehicles bring will affect many business areas, especially the power sector. This creates uncertainties for companies, people, and governments. Communications and discussion will be important to moderate this transition. We are participating in several multinational forums for electricity and transport described in more detail in a following section. IA-HEV can play an important role in these forums by creating balanced information for governmental decision makers, which is one of the goals of IA-HEV in its 4th phase (2009–2015).

MORE RENEWABLE ENERGY SOLVES A PROBLEM OF THE ELECTRIC DRIVE

Electricity produced by fossil fuels that is used to power electric vehicles produces high CO_2 emissions. Additionally, electricity produced by nuclear power plants has had a bad image within many environmental groups for more than a generation, which has dissuaded some within the "early adopter-buyer group" from purchasing electric vehicles. Combining the electric drive with renewable energy gives plug-in electric vehicles both good CO_2 figures and a good image. There will be new opportunities for businesses as more electric vehicles are driven. For example, car engine maintenance is reduced for electric vehicles when compared to the traditional internal combustion engine (ICE) vehicle. Clever car-related managers know that plug-in EVs need less service, which reduces the income of car dealers and garages. However, the dealer can compensate for this loss by producing renewable electricity, especially through PV. In this fashion, the new coalition between the electric drive and renewable energy will bring change to these traditional markets or may even create new market opportunities.

THE FUTURE EFFECTS

Many energy studies state that the technological breakthroughs needed to solve today's environmental problems will finally be realized 50 years from now. What is needed and possible—with continued work from scientists, policy makers, and the business market—are technological breakthroughs that will benefit today's society and also future generations. My generation will be a memory by 2050, but my current students at the Berne University of Applied Sciences will still be working almost 40 years from today. When the International Energy Agency announces that renewable energy will dominate the world in 2050, as they did at the International Solar Energy Society (ISES) Solar World Congress in Kassel, Germany, in September 2011, it is the students of today who will manage this process in the future by building on current achievements. For them, a renewable energy future is real.

Summary of IA-HEV activities during 2011

During 2011, IA-HEV continued to deliver results and launch new projects. We had two Executive Committee (ExCo) meetings, in Turkey (spring 2011) and Portugal (autumn 2011). In Turkey, we participated in a workshop with the local association of car producers and the national research laboratory TÜBITAK Marmara Research Center. IA-HEV member Turkey already manufactures more than one million vehicles a year, and the recent rapid growth of its automotive industry guarantees that the country will be an important player in the future car market. What's more, some EVs are already being produced in Turkey. TÜBITAK showed an impressive infrastructure for their research activities. In Lisbon, we received an interesting inside view of the MOBI.E market introduction program for electric vehicles and EV service providers that is being launched in IA-HEV member country Portugal, who joined our group in 2010.

CONCLUDED TASKS

Task 11, Electric Cycles, and Task 12, Heavy-duty Hybrid Vehicles, closed their Tasks in 2011 and compiled their results into final reports, which first go to the Task participating countries and then to the larger audience. More information on these Tasks can be found in their respective chapters in this Annual Report.

NEW TASKS

In 2010 the ExCo approved two new Tasks, and in 2011 we started two more Tasks:

- Task 19, Life Cycle Assessment of Electric Vehicles: This group will explore the options available for the sustainable manufacture and recycling of electric vehicles. Switzerland and the United States are the initial member countries participating in Task 19. The Operating Agent from Austria, Gerfried Jungmeier (Johanneum Research) welcomes additional countries to join the Task. Please read further details in Chapter 10.
- Task 20, Quick Charging Technology: This group will discuss impacts and potential standards for EV quick charging. The initial members of Task 20 are Spain and the United States. The Operating Agent from Spain, Ignacio Martin (CIRCE, the Research Centre for Energy Resources and Consumption) invites the participation of more countries and companies. Further details are included in Chapter 11.

STRONG INTEREST IN CURRENT AND NEW TASKS

As of winter 2012, IA-HEV is running eight Tasks and is preparing one new Task. Although starting a new Task takes a lot of work, we have seen increasing interest in running Tasks, with four new Tasks launched since 2010. The Tasks with no entrance fee are particularly popular with IA-HEV members: Task 1 (Information Exchange), Task 10 (Electrochemical Systems) and Task 15 (Plug-in Hybrid Electric Vehicles). Please read about the research, the results, and the future plans of the Tasks as described in chapters 3 through 11 and contribute to their work.

External collaborations

IA-HEV PARTICIPATES IN EVI

The Electric Vehicles Initiative (EVI) of the Clean Energy Ministerial is a forum for global cooperation on the development and deployment of electric vehicles. The International Energy Agency's (IEA) Paris headquarters office coordinates the data transfer work. The EVI member countries as of summer 2011 are China, Denmark, Finland, France, Germany, India, Japan, Portugal, South Africa, Spain, Sweden, the United Kingdom, and the United States (U.S.). EVI seeks to facilitate the global deployment of 20 million EVs, including plug-in hybrid electric vehicles and fuel cell vehicles, by 2020. IA-HEV is cooperating with EVI as an observer.

STRONGER COLLABORATION WITH THE OTHER IMPLEMENTING AGREEMENTS

Electricity Co-ordination Group

In 2011 the IEA started a new Electricity Co-ordination Group. This new group brings together all of the IEA Implementing Agreements dealing with the production and the use of electricity. Many of these Implementing Agreements see electric vehicles as an interesting possibility for matching the production of mainly renewable electricity with the electric vehicle charging. Additionally, in the spring of 2011 the IEA published a Smart Grid Roadmap that is available online at the IEA website with input from this group.

Transport Contact Group

Collaboration within the four IEA transport-related Implementing Agreements is better than ever through the Transport Contact Group (TCG) led by Nils-Olof Nylund, who is also the End Use Working Party (EUWP) deputy chair for transport. The TCG's role is vital, because currently the various Implementing Agreements target road transport by individual technologies and different fuels rather than addressing the overall goal of fulfilling certain transport tasks such as moving people and goods to their destinations as quickly and safely as possible while using the fewest resources.

Renewable Energy Technology Deployment

We have a fruitful collaboration with the Implementing Agreement Renewable Energy Technology Deployment (RETD, or IEA-RETD). The IEA-RETD is working on a study on renewable energy in the transport sector. This cost-shared activity is mainly an international study covering the most interesting mature technologies such as biofuels, fuel cells, and hybrid and electric vehicles. IA-HEV leadership contributed to the study and served on the advisory committee. The study will be ready in 2012, and it will cover important topics for IA-HEV.

In an interconnected world — as demonstrated by the Electricity Co-ordination Group, EVI, TCG, and collaboration between IA-HEV and IEA-RETD — it is crucial that we work together to meet all of the associated challenges of climate change, restructuring the automotive industry, and constraints on fossil fuels and other resources.

New member countries: Germany and Ireland

In 2011 two new members, Ireland and Germany, joined IA-HEV. We welcome their participation. Both countries rely on renewable energy sources for a high percentage of their electricity. Germany with its strong automotive industry and research institutions is now active in several Tasks. IA-HEV has also attracted interest from other countries including Australia, Israel, and South Africa and some Asian nations. The European Commission has also participated in our meetings.

IA-HEV has 17 members with a twenty-year history of multinational collaboration that can benefit new members. We hope that more countries will consider joining IA-HEV as they view the range of activities conducted in the group's Tasks covering timely topics such as quick charging (Task 20) and creating a roadmap for bringing EVs to cities (Task 18, EV Ecosystems). Membership in IA-HEV offers countries technology sharing and expertise to reach energy security and environmental goals through the use of hybrid and electric vehicles.

Word of thanks to the management team of our Implementing Agreement

In 2011, the Task 1 Operating Agent and her team undertook an extraordinary amount of work to implement a new approach to IA-HEV external communications. The new website www.ieahev.org is now in operation. You may go there to read about the latest developments from IA-HEV, its member countries, and also to subscribe to receive email news and updates. Additionally, they have restructured the content of this Annual Report to make it a lighter and more focused book. I thank especially Kristin Abkemeier and her New West Technologies for the U.S. Department of Energy colleagues Alison Mize and Kizita Awuakye for their efforts.

In 2011, Mr. Tali Trigg became our new IEA desk officer. Our Secretary-general Martijn van Walwijk is doing an excellent job in coordinating the IA-HEV administrative functions. I must thank all of our Task leaders and the members who continue to do an superb job of addressing vital issues for hybrid and electric vehicles through our international collaborations. Finally, I thank my colleagues from the Executive Committee for their ongoing commitment to make IA-HEV the best forum for sharing information to move hybrid and electric vehicles forward.

May our efforts during 2012 lead to further progress of the electric drivetrain in the market and in the lab.

February 2012
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 coordinate 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 – 2011

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.

The IEA is regularly called upon by G8 and G20 leaders to provide information and recommendations at their respective summits for energy polices. In June 2010, the G20 Toronto Summit Declaration noted with appreciation the report on energy subsidies from the IEA, the Organization of the Petroleum Exporting Countries (OPEC), the Organization for Economic Co-operation and Development (OECD), and the World Bank. It also called for the rationalization and phaseout over the medium term of inefficient fossil fuel subsidies that encourage wasteful consumption, taking into account vulnerable groups and their development needs. The leaders encouraged continued and full implementation of country-specific strategies and agreed to continue to review progress towards this commitment at upcoming summits.

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) coordinates 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 Coordinating Committee. In addition, expert groups have been established to advise on electric power technologies, research and development (R&D) priority setting and evaluation, and on oil and gas (figure 2.1).

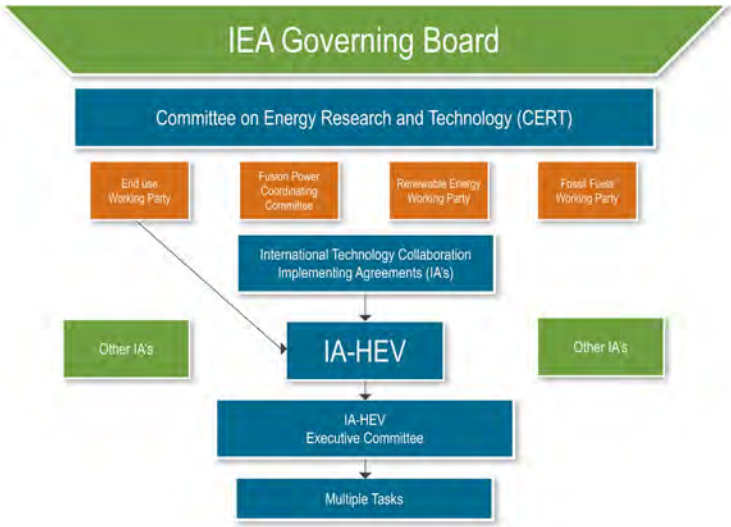

Fig. 2.1 The IEA energy technology network.

2.1.3 IEA Implementing Agreements

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 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.

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.

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.

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 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. The IEA Secretariat circulates the online 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 technology perspectives”, that presents updates on roadmaps for the technologies addressed by the Implementing Agreements. These reports can be downloaded free of charge from the internet at http://www.iea.org/techno/etp/index.asp. A new edition is expected to be released in June 2012.

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.

2.2 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 working on these vehicles. The IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes 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 17 active Contracting Parties (member countries) per July 2011 are Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, 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 2011 and in early 2012 are described in part B (chapters 3 through 11) 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 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 D of this report lists the most important publications of phase 2.

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, though Tasks 11 through 13 had closed by the end of 2011, and Task 14 and 15 are anticipated to issue their final reports during 2012. Therefore, specific details on each of these ongoing Tasks and their respective histories are collected in chapters 3 through 7 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 of the International Energy Agency, especially between the seven IAs with transportation as an item in their work programme through the Transport Contact Group.

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

- Information exchange (Task 1). The work includes: country reports, census data, technical data, behavioral 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 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 Tasks 11, 12, and 13 having rounded off activities by the end of 2011, and Tasks 14 and 15 expected to issue final reports during 2012.

Since 2010, the ExCo has approved four new projects: Task 17 on system integration and optimization of components for enhanced overall electric vehicle performance, Task 18 on "EV ecosystems," with an objective of mapping out the conditions required to support the market growth needed for mass adoption of EVs in cities. In November 2011, the ExCo agreed to support Task 19 on life cycle assessment of EVs, to explore the sustainable manufacture and recycling of these vehicles, and Task 20 on quick charging technology. Specific details on these new Tasks as well as the continuing Tasks that were operating during 2011 are collected in chapters 3 through 11 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
- 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
- Trolley buses
- Mobile machinery such as forklift 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

3 Information Exchange (Task 1)

Members: Any IA-HEV member may participate.

3.1 Introduction

Information exchange is at the core of IA-HEV's work, enabling members to share key insights, best practices, and to identify common research interests in the rapidly growing international hybrid and electric vehicle field. Task 1 began in the first phase of IA-HEV in 1993 and continues as the main forum and portal for announcing news and results to the broader International Energy Agency (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 3.1 below lists all phase 4 objectives, which include communication.

Box 3.1
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

3.2 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.

Information exchange focuses on these topics:

- Research and technology development
- Commercialization, marketing, and sales
- Regulation, standards, and policies
- Activities of IA-HEV Tasks

3.3 Working method

Experts from member countries serve as delegates at Task 1 meetings held every six months in conjunction with the IA-HEV Executive Committee meetings. Country delegates also write country-specific information for IA-HEV publications such as the country chapters in this annual report. Many country delegates also serve dual roles as the official Operating Agent for a specific Task. In this role, they may also represent IA-HEV to a public audience by presenting Task results at international conferences such as EVS (the Electrical Vehicle Symposium).

The Task 1 Operating Agent (OA) is responsible for coordinating and leading the semi-annual meetings, compiling the minutes of these meetings, maintaining the IA-HEV website, and editing and supervising the production of the newsletter and the Executive Committee (ExCo) annual report. The OA also acts as liaison to the other Task OAs, the ExCo Chair (together with the Secretary-general), and the International Energy Agency Desk Officer. Kristin Abkemeier serves as the Task 1 OA on behalf of The United States (U.S.) Department of Energy (DOE) Vehicle Technologies Program.

A significant component of the information exchange for the Task occurs at the experts' meetings where participants brief the attendees on relevant reports, facts, and statistics pertaining to hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and electric vehicles (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. The U.S. sponsors Task 1 and there is no cost for Task membership. Each country designates an agency or non-governmental organization as their Task 1 expert delegate. Frequently, guest experts are invited to 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.

3.4 Results

Thirty-two experts' meetings have been conducted since the inception of the IA-HEV in 1993. In 2011, two Task 1 meetings were held, the 2010 Annual Report was published, and an IA-HEV newsletter was issued. The Operating Agent along with a communications team at the U.S. DOE implemented a comprehensive new communication plan that included a redesigned website (www.ieahev.org) as shown in figure 3.1, a new e-newsletter, and the use of social media such as Facebook and Twitter.

Fig. 3.1 Home page of the new IA-HEV website (www.ieahev.org), which includes comprehensive information on hybrid and electric vehicles in all member countries, updates on activities of the Tasks, and links to national organizations working to promote vehicle electrification.

3.5 Further work

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.

The Task 1 expert meeting schedule will coordinate with future ExCo meeting schedule. The basic plan of the meeting is for country experts to report the latest developments in hybrid and electric vehicles in their respective countries using a thirty-minute presentation format followed by discussion. Every member country is not expected to present at each Task 1 meeting because of time constraints and the growing number of IA-HEV members.

The Task 1 OA welcomes suggestions for meeting, website, and newsletter topics from members.

3.6 Contact details of the Operating Agent

For further information, please contact the Operating Agent:

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4

Electrochemical Systems (Task 10)

Members: Any IA-HEV member may participate.

4.1 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.

4.2 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.

4.3 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.

4.4 Results

A Task 10 workshop on Battery Recycling (with an Emphasis on Lithium-ion Batteries) was held in Hoboken, Belgium (near Antwerp) on September 26–27, 2011. The location and time were chosen to allow the workshop to be held in conjunction with two European meetings on related topics, the 16th International Congress for Battery Recycling in Venice and Batteries 2011 in Cannes. The meeting was hosted by Umicore, a corporate group operating in the areas of materials science, chemistry, and metallurgy.

The need for the workshop was based on the fact that many groups are beginning to think about how the lithium-ion batteries used in hybrid and electric vehicles will be processed at the end of their useful lives. Though researchers are exploring the reuse of batteries in stationary applications after they are no longer suitable for use in vehicles, eventually the batteries will have to be recycled. As the growing fleet of electric-drive vehicles ages, the recycling of batteries will increasingly need to be addressed.

In order to allow for effective discussions, attendance at the workshop was limited. Invitations were sent to battery companies, vehicle manufacturers, companies in the recycling industry, and representatives of governments, national laboratories, and universities. More than 35 people participated in the workshop, with attendees from companies and organizations in Austria, Belgium, Finland, France, Germany, Netherlands, Sweden, the United Kingdom, and the U.S. Also, some Asian companies were represented by staff from their European divisions.

The meeting was organized to combine presentations from knowledgeable attendees with open discussions. As with other workshops sponsored by IA-HEV Task 10, the meeting was “off the record,” but almost all of the presentations given at the meeting were distributed to those who attended. Discussions are continuing through emails sent among the workshop participants.

Topics discussed related to various aspects of recycling:

- Regulations and requirements
- Perspectives of battery manufacturers
- Perspectives of vehicle OEMs
- Perspectives of recycling companies, including a tour of Umicore’s new battery recycling facility

Preliminary conclusions of the workshop included the following:

- Recycling of advanced vehicle batteries will occur.
- It is a challenge to plan now for an activity that will not occur for 15 years.
    - Battery developers are not yet designing for recycling.

    - Battery recyclers are only beginning to develop the technology for lithium-ion batteries.
- Communication among the various parts of the battery recycling industry is just developing.
- Possible recycling technologies and the maturity level of each are varied.
- The cost structure for lithium-ion recycling is still developing.

4.5 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.

4.6 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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5 Electric Cycles (Task 11)

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

5.1 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 5.1 and 5.2).

Fig. 5.1 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. 5.2 Full production of the Voltitude begins in 2012. This e-bike folds for easy storage and weighs around 50 pounds (23 kg). It is equipped with a 250-watt integrated motor powered by a 36-volt lithium-ion battery. (Photo courtesy of www.veloland.ch.)

5.2 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).

5.3 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 5.1.

Box 5.1 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 was the primary focus for Task 11 from mid-2010 through November 2011, when the Task was finally closed. From mid-2010 until early 2011, 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).

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."

On the behalf of AVERE, during 2011, Mr. Hannes Neupert (Germany), president of ExtraEnergy, carried out much of the work of completing the final report and disseminating information at electric cycle-related conferences.

Task 11 worked with partners to develop a handbook for bicycle policies for municipal decision makers to establish e-mobility in their communities. The partners included the organization ExtraEnergy and others working within the framework of the European Union (EU) project “Go Pedelec!”.

5.4 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.

5.5 Further work

The Task was closed at the IA-HEV Executive Committee meeting in November 2011 and will be rounded off with a handbook that Mr. Hannes Neupert of ExtraEnergy is writing for the EU project Go Pedelec!, scheduled to be distributed at several EV-related meetings during 2012, including the E-Bikes Forum in Barcelona, Spain; EVS 26 in Los Angeles, California, U.S.; and the Fully Charged 2012 International EV Summit in Dublin, Ireland.

5.6 Contact details of the Operating Agent

For further information regarding this Task, please contact the Operating Agent:

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Web:	www.ExtraEnergy.org

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

Members: Sweden, Switzerland, United States

6.1 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 explored whether these included 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.

6.2 Objectives

As efforts to manufacture and market EVs reformulate, this Task 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.

6.3 Working method

The work of this Task 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, in-

cluding 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 (U.K.).
- Danilo Santini, Argonne National Laboratory, United States (U.S.).
- Kanehira Maruo, ETC Battery & FuelCells Sweden AB, Sweden.
- Tom Turrentine, Task 14 Operating Agent, University of California at Davis, U.S.

Eleven workshops were held between October 2007 and April 2010 in France, Germany, Japan, Sweden, Switzerland, the U.K., and U.S. Box 6.1 presents an overview of the nine workshops that have been organized to date, and box 6.2 lists the participants in these workshops.

Box 6.1
Overview of IA-HEV Task 14 workshops

No.	Location	Date
1	Santa Cruz, California, U.S.	October 3-4, 2007
2	Anaheim, California, U.S.	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, U.K.	September 2009
9	Boston, Massachusetts, U.S.	October 2009
10	Paris, France	April 2010
11	Berlin, Germany	April 2010

Box 6.2 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, U.S. 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, U.K.								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, U.S. 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					

Box 6.2 Participants in IA-HEV Task 14 workshops *(continued)*

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, U.K.								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		

Box 6.2 Participants in IA-HEV Task 14 workshops *(continued)*											
Takeshi Miyamoto, Nissan.				4							
Urs Muntwyler, IA-HEV chairperson.	1	2	3								
Ranbir Nota, Office for Low Emission Vehicles, U.K.								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, U.K.								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, IA-HEV secretary-general.				4							
Takehisa Yaegashi, Toyota.				4							
Sigvard Zetterstrom, Royal Institute of Technology, Stockholm.						6					

6.4 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.

6.5 Further work

The final report will be completed during 2012 with the aim of publishing it through the International Energy Agency in order to maximize its distribution. Complete details on how to access this report will be available on the IA-HEV website, www.ieahev.org. A continuation of some of this work may be addressed in Task 18, EV Ecosystems.

6.6 Contact details of the Operating Agent

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7 Plug-in Hybrid Electric Vehicles (PHEVs) (Task 15)

Members: Canada, France, Germany, Sweden, United States (U.S.)

7.1 Introduction

Among member countries to this Implementing Agreement, the transportation sector ranks high in national oil use and greenhouse gas (GHG) emissions. Plug-in electric energy for transportation is seen as one way of reducing oil use, GHG emissions, and/or improving local air quality. By reducing oil use per mile of service delivered, using electricity from the grid leads to greater energy security. Plug-in electric drive's ability to eliminate oil use has become more attractive in recent years as (1) technical and economic feasibility have improved, (2) oil prices have increased significantly on average, and (3) oil prices have become more volatile. More recently, concerns about possible actual restrictions of supply have emerged.

Depending upon the mix of generation used, miles vehicle energy provided via the grid can modestly or dramatically reduce greenhouse gas (GHG) emissions. Improving knowledge about health damages from particulate matter has caused increased emphasis on eliminating tailpipe and "upstream" emissions caused by motor vehicles, driving up the costs of conventional powertrains.

Thus, 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, implementable powertrain supporting a long-run transition to more sustainable transportation.

Task History

A Task history may be found in last year's annual report. Two original goals of the Task were "spun-off" as the level of interest in various aspects of plug-in electric drive increased in recent years. After a period of intermittent activity, Task 10 (Electrochemical systems) held multiple workshops related to the original scope of work for Task 15. Work on components supporting electric drive was moved into the new Task 17, EV System Integration.

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 was completed and approved by the IA-HEV Executive Committee (ExCo) at its May 2011 meeting.

7.2 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 Operating Agent (OA)

Task 15 for 2011–2012 includes multiple country experts from Germany, France, and the U.S. One country expert from Switzerland hosted a November 18, 2011, experts' meeting in Switzerland. Both Germany and France have participating country experts from two research organizations, while the U.S. provides one expert and the OA, from one institution. France hosted two country expert meetings in 2011.

For subtask 1, country experts from France's Energies Nouvelles and the United States' Argonne National Laboratory Center for Transportation Research agreed to conduct joint vehicle simulation/modelling research on powertrain attributes for multiple types of plug-in hybrids, with varying amounts of electric drive power and energy, as well as different powertrain configurations. Country experts from the Institute of Vehicle Concepts at the German Aerospace Center and the Center for Transportation Research of Argonne National Laboratory agreed to collaborate on the topic of lifetime vehicle use costs, incorporating the vehicle and powertrain modelling results. One paper abstract on vehicle simulation, and one paper abstract on costs of ownership were submitted for consideration by the 26th Electric Vehicle Symposium (EVS 26), which is to be held in May 2012 in Los Angeles, California, U.S.

The general plan of the Task 15 team members is to produce EVS 26 papers that will each support the completion of the more extensive comprehensive report of the study.

Several Task 15 subtask 2 objectives, discussed in this section of last year's report, were presented in the work plan. During and between the 2011 country expert meetings, the objectives of subtask 2 of the work plan were reviewed for level of interest from, and support of, various country experts. During this review participants stated their level of interest in each topic.

Given the overall level of interest, the list of objectives that will be studied was narrowed, teams of topic participants were identified and managers selected. Remaining subtask 2 topics/objectives are:

1. Find the best niche(s) for multiple PHEV technology options
2. Evaluate vehicle purchase & operations costs; lease vs. own
3. Effects of taxes – road, registration, fuel, etc.
4. Vehicle regulation impact on powertrain choice
5. Infrastructure/charger attributes and costs
6. Choice of incremental vs. average for evaluation method
7. Net petroleum use reduction – usual & crisis
8. GHG reduction vs. hour/season of charging; generation type

A total of five abstracts were submitted by various country experts for consideration by EVS 26. Two of the five submitted abstracts involved cross-country collaboration between analysts of the Fraunhofer Institute for Systems and Innovation Research and Argonne National Laboratory. Analysts from these two institutions submitted a total of three other abstracts, each addressing subtask 2 topics.

7.3 Working method

Operating Agent

The U.S. Department of Energy (DOE) provides support of the Operating Agent (OA), Danilo Santini of Argonne National Laboratory, 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 and participating country experts met repeatedly in 2011 to develop a final detailed plan and put that plan into effect.

The OA chaired the meetings, prepared agendas and minutes, and reported to the IA-HEV Executive Committee. The OA has provided and will provide project management and coordination, to ensure that activities are implemented and objectives are achieved. Aymeric Rousseau of Argonne National Laboratory is the vice Operating Agent.

Subtask Leaders

Aymeric Rousseau, U.S. country expert, and Francois Badin, French country expert, co-lead subtask 1. Subtask leaders and/or co-leaders for subtask 2 topics/objectives have been recruited from other participating country experts. Bernd Propfe of the Institute of Vehicle Concepts at the German Aerospace Center, David Dallinger of the Fraunhofer Institute for Systems and Innovation Research, and Danilo Santini of Argonne National Laboratory are team leaders for various subtask 2 study topics/objectives.

7.4 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 were 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, North Carolina, U.S. 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, United Kingdom.

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 proposal for a Task on Renewables and Vehicles received the third highest level of support among ten proposals at the 33rd 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.

7.5 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

This study assesses 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 best market niches for large fuel use reduction per year of operation. The vehicles studied include EVs, diesels and advanced gasoline.

This subtask evaluates 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

Policy issues which concern participating country experts are addressed. Selected issues relate 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, $N2_O$). Policy issues addressed include (1) vehicle configuration incentives, (2) charging patterns and incentives for their modification, (3) local infrastructure needs (neighborhood distribution, inspection needs, circuit upgrade costs, metering costs, etc.), and (4) electric generation system operation and investment patterns. This subtask examines financial policy effectiveness designed to alter (or retain) initial costs or operating costs in support of market development.

7.6 Contact details of the Operating Agent

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8

System Integration for EVs (Task 17)

Members: Austria, Germany, Switzerland, and the United States (U.S.)

8.1 Introduction

The full title of Task 17 is “System integration and optimization of components for enhanced overall electric vehicle performance”. The motivation for creating this Task in 2010 was that discussions about the challenges for the market introduction of electric mobility often focus on the performance and cost of batteries, as well as the corresponding charging infrastructure.

However, other essential aspects should also be considered. Issues such as the optimized integration and configuration of components, including the handling of interfaces for system management and monitoring, are important because they could provide a significant contribution to the feasibility of electric drivetrains.

A system approach is therefore pursued in Task 17, which could be extended to vehicle architecture and materials. Depending on the capacities provided within this group, system integration could expand beyond the configuration of the drivetrain and thereby consider aspects such as the integration of the drivetrain into lightweight vehicles.

8.2 Objectives

Electronic systems involved in the operation and monitoring of vehicles have been the subject of substantial improvements during the past few years. Consequently, these systems not only have gained importance in conventional transport systems, but they also have improved the perspectives for electric drivetrains. Nevertheless, further optimization of these components and new concepts for their integration in the overall system tuned to the specific requirements of different vehicle applications are necessary.

Improved power electronics have resulted in new opportunities to control and steer the increasingly complex configurations of components. In addition, the components themselves, such as electric motors, batteries, super capacitors, internal combustion engines, and fuel cells, have undergone rapid improvements during the past few years, thus opening new options for their integration. These developments and the opportunities they provide are analyzed within Task 17.

The tasks include the assessment of the progress in component development and drivetrain configurations, as well as the analysis of the corresponding potential for enhanced overall system performance. The impacts on the following aspects of system performance will be analyzed:

- Improvement of energy efficiency (by thermal and electric energy management optimization), operation safety, and durability through better monitoring of component operation;
- Reduction of costs (for example, increased efficiency in operation and production and use of alternative materials);
- Reduction of weight and volume through optimized assembly of the drivetrain;
- Improved spatial arrangement of the drivetrain within the vehicle; and
- Optimization of the overall vehicle design adapted to the specific requirements and opportunities of electric vehicles for different applications and vehicle classes.

8.3 Working method

The activities in this Task predominantly consist of preparing a report on technology assessment and trends and providing opportunities for information exchange among the member countries through organized workshops. The workshop participants include industry representatives, researchers, and technology policy experts. These meetings provide a basis for the dissemination of information about relevant activities in an international context. Two expert meetings have taken place since the Task kick-off in November 2010.

The most recent workshop, in September 2011, addressed the topic of battery management systems. It was hosted by Argonne National Laboratory in the United States. The workshop provided the opportunity for participants to visit the testing facilities for batteries and vehicles at the Advanced Powertrain Research Facility. The discussion focused on current technology trends and the identification of aspects that require further research efforts, such as improved cell balancing, advanced battery models, highly scalable systems, and the possibility of supporting different cell chemistries within a single battery system.

8.4 Further work

The activities involve the monitoring and analysis of progress in component configuration and vehicle architecture relative to trends and strategies for electric vehicles. Key areas include:

- Analysis of existing component technologies, as well as their development potential and cost assessment.

- Overview of current component configurations of vehicles on the market.
- Review of different Original Equipment Manufacturers' (OEMs') strategies and technologies for electric vehicles and follow-up of new prototypes.
- Examination of theoretically possible operation and configuration concepts and assessment of their advantages and disadvantages, including comparison/analysis of efficiency, performance, and price reduction potential. Design considerations depend on the different applications for electric vehicles.

The scope of work has been focused to the participants' capabilities and fields of expertise. Based on the outcome of the Task meetings, two main areas were defined that correspond with the Task 17 final report structure:

- Section I on components will focus on battery management systems, electric motors, and range extenders.
- Section II will provide an overview of the current E/E (electrical and electronic) and vehicle configurations as well as performance assessment methods available involving simulation tools and testing procedures.

8.5 Contact details of the Operating Agent

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

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9 Electric Vehicle Ecosystems (Task 18)

Members: Austria, Germany, Portugal, Spain, United Kingdom (U.K.), and United States (U.S.)

9.1 Introduction

The focus of Task 18, Electric Vehicle Ecosystems (EV Ecosystems), is to shape a global vision for the infrastructure required to support mass adoption of plug-in electric vehicles (EVs) and to determine how this endeavor can create smarter cities. The Task aims to capture practical experience from cities, regions, and businesses that are pioneering advanced EV pilot programs and to investigate the markets, technologies, and business models relative to EVs that will operate in what we term "EV cities of the future". Task 18 was approved on November 4, 2010, at the 33rd IA-HEV Executive Committee meeting in Shenzhen, China.

An EV ecosystem defines the total system of infrastructure required to support the operation of EVs. This system includes interfaces with "hard infrastructure," such as recharging technologies, energy grids, buildings, and transport systems. It also requires the provision of "soft infrastructure," such as regulation, information and communication technologies (ICT), commercial services, skills, and community engagement programs. Blending this complex mix of technologies and services into the fabric of cities requires alignment among 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.

9.2 Objectives

The overarching goal of this Task is to advance international policy and the design of EV 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. ***Foresight workshops*** in leading cities will assemble experts from municipalities, regional authorities, governments, and industry to explore specific areas of opportunity.
2. ***An International Roadmap*** will be published toward the end of 2012. This International Roadmap will identify "100 big ideas" from around the world. It will

showcase pioneering projects and establish an expert view of the emerging challenges and opportunities in EV markets, technologies, and services.

3. ***A web portal of EV Cities and Ecosystems***, developed at the University of California, Davis, will provide a database of pioneering EV programs and connect international experts to facilitate policy exchange and problem solving.
4. ***Conferences of Pioneering EV Cities and Regions*** will convene the individuals who are shaping the future development and design of EV ecosystems.

9.3 Working method

Foresight workshops

The main data collection activity is a series of one-day foresight workshops. In each workshop, 10 to 20 experts will assemble to share insights, ambitions, and visions, which will be promoted in a summary report to an international audience of policymakers and industrialists. Each workshop will investigate a different priority area, such as business models, social change, fleets, and smart grids.

Web portal

Sharing information to advance urban transport systems by using a web portal is the best method for instant delivery of worldwide information. The web portal will be designed to share information.

World EV City conferences

Up to three International EV City Conferences are planned through 2013. Participants from multiple cities with pioneering EV programs will meet in person to share experiences and review best practices. Face-to-face communication and focused interactions among participants will strengthen the global EV network.

Alliances with global EV City projects and initiatives

Over the last 12 months, Task 18 has developed partnerships with a number of international EV projects focused on cities and regions. These collaborative working relationships will facilitate the sharing of data and resources, thereby connecting Task 18 participants into a more extensive global network. Collaborative partners include: The Clean Energy Ministerial's Electric Vehicle Initiative, the Clinton Climate Change Foundation's C40 Cities Program, the Rocky Mountain Institute's Project Get Ready, and the European Commission's Green eMotion Project.

Task 18 Governance Structure

David Beeton (U.K.) and Thomas Turrentine (U.S.) 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. Luís Reis, of INTELI in Portugal, is the Steering Committee Co-chair.

9.4 Next steps

Task 18 is in its second year of operation. Five foresight workshops have been held to date, as summarized in Table 9.1. Emerging results from the Task have been promoted at conferences in Belgium, China, Germany Turkey, South Africa, and the United Kingdom. In addition, the Operating Agents have undertaken fact-finding missions to the Denmark, Portugal, and Netherlands.

Table 9.1 Completed Task 18 Workshops.

Special Topic	Location
The Future of Recharging Infrastructure	Newcastle, U.K.
Intelligent Transport Systems for EVs	Newcastle, U.K.
Open Architectures and Payment Systems for EVs	London, U.K.
International Policies and Programmes to Support the Operation of EVs in Cities	Istanbul, Turkey
New Economic Opportunities and Business Models for EVs	Barcelona, Spain

The foresight workshops planned for 2012 are summarized in Table 9.2.

Table 9.2 Task 18 Workshops Planned for 2012.

Special Topic	Location
World Electric Vehicle Cities and Ecosystems Conference	Los Angeles, U.S.
How to Grow Markets for EVs and Manage Expectations	Vienna, Austria
EVs and Smart Grids	Vienna, Austria
Integrating EVs into Fleets	Berlin, Germany
Integrating EV Roadmaps	Paris, France

9.5 Further work

The year 2012 will prove to be very busy for Task 18. Four foresight workshops have been scheduled, as well as the first World EV Cities and Ecosystems Conference to be held in May, 2012, in Los Angeles, California. More workshops will be held in 2013 and as new members join.

To disseminate the emerging findings of Task 18, the Operating Agents will be present at conferences in Barcelona, Los Angeles, Edinburgh, Copenhagen, Newcastle, and Berlin. Additionally, a paper about Task 18 will be published as part of the proceedings of EVS 26 (the 26th Electric Vehicle Symposium).

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

9.6 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 and solve common problems. 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. The inherent flexibility for participation will maximize the potential benefits to participants and broaden the prospective findings.

The Task will engage established cities that are leading advanced pilots, as well as emerging regions that are devising ambitious plans for the introduction of EVs. Other organizations and businesses are also invited to participate in the development of the roadmap, particularly companies with a commitment to advancing the introduction of EVs to cities and in a position to contribute experts or host workshops.

9.7 Contact details of the Operating Agent

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10 Life Cycle Assessment of Electric Vehicles (Task 19)

Members: Switzerland, United States

10.1 Introduction

Task 19 has the full title of "Life cycle assessment of electric vehicles – From raw material resources to waste management of vehicles with an electric drivetrain." The Task will examine the environmental impacts of vehicles with an electric drivetrain based on life cycle analyses. The Task was approved on November 11, 2011, at the 35th IA-HEV Executive Committee meeting in Lisbon, Portugal, and plans to run through autumn 2014. The initial member countries are Switzerland and the U.S.

Electric vehicles have the potential to substitute for conventional vehicles to contribute to the sustainable development of the transportation sector worldwide, for example, in the reduction of greenhouse gas (GHG) and particle emissions. There is international consensus that the improvement of the sustainability of electric vehicles can only be analyzed on the basis of life cycle assessment (LCA), which includes an examination of the production, operation, and the end-of-life treatment of the vehicles. For example, about 90% of the GHG emissions of a vehicle running on renewable electricity from hydro power derive from the production and end-of-life treatment of the vehicle, and only 10% stems from vehicle operation. In addition, all environmental impacts must also include the whole value chain and—if relevant—interactions from recycling in the dismantling phase to the production phase, if recycled material is used to produce new vehicles (figure 10.1).

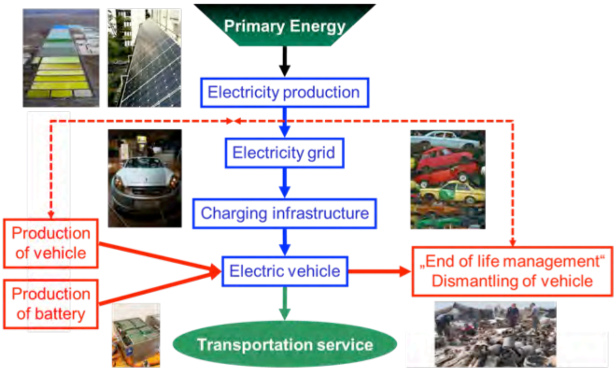

Fig. 10.1 Assessment of LCA aspects over the full value chain. The LCA includes three phases: production, operation, and end of life. The blue boxes are the elements of the operation phase of the electric vehicle. The red boxes are the production (at left) and dismantling phases (at right) of the vehicle, and the dotted arrow indicates possible recycling.

10.2 Objectives

Task 19 on the life cycle assessment (LCA) of electric vehicles has the objective of learning how electric drivetrain vehicles should be designed for optimal recyclability and minimal resource consumption. It also aims to promote the best available technologies and practices for managing the materials in EVs at the end of their useful life, when the vehicle is dismantled.

Based on the LCA activities in the member countries, the main goals of this Task are:

- Providing policy and decision makers with facts for decisions on EV-related issues
- Improving end-of-life management by identifying and promoting the best available technologies and practices
- Improving the design of vehicles and battery systems for optimal recyclability and minimal resource consumption
- Establishing a research platform for life cycle assessment including end-of-life management for EVs to augment the benefits and competitiveness of vehicles with an electric drive train.

The main topics to be addressed in the three-year working period are:

1. LCA methodology
2. Frequently asked questions on the environmental issues of EVs
3. Overview of international LCA studies
4. Parameters influencing the energy demand of EVs
5. LCA aspects of battery and vehicle production

6. Vehicle end-of-life management, e.g., recycling, or the reuse of batteries in stationary applications
7. LCA aspects of electricity production, distribution, and vehicle battery charging
8. Summarizing further R&D demand

Task 19 considers the following vehicles and propulsion systems:

- Propulsion systems:
  - Battery electric vehicle (BEV)
  - Hybrid electric vehicle (HEV)
  - Plug-in hybrid electric vehicle (PHEV)
  - Range extender vehicle (REV)
  - Hydrogen fuel cell electric vehicle (FCV) (including hydrogen production)
  - Diesel and natural gas vehicles using current and future technology
- Road vehicles:
  - Passenger cars
  - Light utility vehicles
  - Buses
  - Two-wheelers, e.g. motorcycles, electric bikes
  - Forklift trucks

10.3 Working method

The Task is a networking activity, which means that the experiences from the national projects are fed into the IA-HEV LCA Platform and discussed on an international level. Each participant contributes to the different topics in the Task based on a work sharing principle.

The individual work packages that are covered by the members from the participating organizations are as follows:

1. LCA methodology, e.g., setting of the system boundaries, modelling of recycling
2. Frequently asked questions
3. Overview of international studies on LCA of vehicles with an electric drivetrain
4. Influences on the energy demand of vehicles
5. LCA aspects of battery and vehicle production
6. End-of-life management, e.g., 2nd life of batteries in stationary applications
7. LCA aspects of electricity production, distribution, and charging infrastructure
8. Necessary and available data
9. Overview of key actors and stakeholders

10. R&D demand
11. Series of five workshops
    - I. Workshop I: “LCA methodology and case studies”
    - II. Workshop II: “LCA aspects of battery and vehicle production”
    - III. Workshop III: “End of life management”
    - IV. Workshop IV: “LCA aspects of electricity production and infrastructure”
    - V. Final event: “Results of Task 19”
12. Conclusions and outlook
13. Documentation: proceedings, reports, papers, notes, presentations
14. Management and operation of the Task

Other topics may be addressed, depending on the interests of the Task participants.

The most important networking activity in this LCA platform is the organization of the five workshops in different member countries aiming to involve the different stakeholders in the value chain of electric vehicles. 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.

10.4 Results

Members in this Task will compile information from existing LCA analyses in order to complete a fuller picture of approaches to resource usage, recycling, and disposal at end of life. This knowledge should help the industry and government to increase the benefits and competitiveness of vehicles with an electric drivetrain. An international “Research Platform for Life Cycle Assessment and End-of-Life Management for Electric Vehicles” will be established to augment the benefits and competitiveness of vehicles with an electric drivetrain.

10.5 Next steps

The initial meeting for Task 19 occurred at the 5th International Advanced Mobility Forum (IAMF 2012) at the Geneva Motor Show in early March 2012. At this meeting the places and dates of the first three workshops were arranged and the draft program for the first workshop was made.

10.6 Contact details of the Operating Agent

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.

Task 19 is coordinated by the JOANNEUM RESEARCH Forschungsgesellschaft mbH, a private research organization in Austria. For further information regarding Task 19, please contact the Operating Agent:

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11 Quick Charging Technology (Task 20)

Members: Spain, United States

11.1 Introduction

Task 20 will deal with quick charging technology. The Task was approved on November 11, 2011, at the 35th IA-HEV Executive Committee meeting in Lisbon, Portugal, and plans to run through the end of 2014.

Quick charging technology represents one of the most promising technologies for promoting plug-in electric vehicles (EVs) in order to help decarbonization of the transport sector. Quick charging technology will also contribute to innovative zero-emission drivetrain systems. Finally, quick charging opens a branch of possibilities to create economic opportunities as well as new challenges.

The implementation of charging infrastructure has gathered pace. CHAdeMO-type quick charging stations have increased to more than 1,000 globally, with 400 installed in 2011. For instance, in 2010, the EV Project was launched in the United States (U.S.) which is working towards deploying 14,000 level 2 and 400 DC quick charging stations across the nation by 2013. They are being deployed across 18 cities in six states and the District of Columbia.

Quick charging faces both technical and nontechnical challenges before it can become widespread. Some of the main technical issues include the impact on battery performance degradation over time, power grid stability and quality, the higher infrastructure costs, and the high average level of energy consumption that occurs during the first part of the EV battery charging process. Other challenges include improving public awareness of maintenance needs for public charging stations, and communicating the technical requirements and benefits of quick charging to help local governments and organizations negotiate administrative barriers to installing this technology.

In quick charging technology, the electric vehicle is connected to the main power grid through an external charger. Control and protection functions and the vehicle charging cable are installed permanently in the EV charging station.

Because the required charging energy is delivered by the power system, EV charging has an impact on the power system. This impact is dependent on the time, location, and power rating of charging. Passenger EVs are typically charged through the low-voltage (400/230 V) grid, due to the low power rating. For the quick chargers of greater than 40 kW, the chargers might be connected to a higher voltage level. As a result, planning for the power to supply the quick charging stations is necessary to allow for proper load management and avoid problems with the local electrical system.

In addition, there is still a lack of a quick charging infrastructure network in appropriate places and offering reasonable charging times. It is widely accepted that there is a growing need for widely distributed, publicly accessible charging stations, some of which support quick charging at higher voltages. Subject to the power handling of the car-charging electronics and battery chemistry, higher-power charging stations reduce charging time significantly. Public quick chargers are needed for long-distance trips. The EV drivers' anxiety is reduced when public quick chargers are available. However, the smart charging infrastructure may consist of a mix of different types of charging capabilities: single-phase charging stations (DC and 3-phase AC), and slow charging stations (single-phase AC).

The main difference between quick charging and normal charging lies in the additional service for the customer. Smart quick charging that could enable the exchange of information between the electrical system operator and the customer such as energy cost and the demand curve could also become important. Consequently, companies that provide a service or equipment to the e-mobility market, e.g., telecom or ICT (information and communications technology) industries that enable communication between the EV and the electricity grid, shall be also taken into consideration within the discussion.

Standards are also a key element for the full deployment of quick charging technology. Standards will help to ensure that drivers enjoy a convenient recharging solution that avoids a multiplicity of different cables and adaptors and/or retrofit costs for adapting to new charging systems. A standardized interface between the distribution grid and electric vehicles will ensure the required safety and security level for the consumer. A lack of interoperability between the different systems can cause some fear in the consumers, which can slow down the development of this market. Also, the different safety standards of the International Electrical Commission (IEC) must be considered (IEC 62196-3 Combo-1, IEC 62196-3 Combo-2, IEC 62196-2/3 Type 2, IEC 62196-3 CHAdeMO, IEC 62196-3 China).

All these challenges will be tackled in Task 20 through open discussion and exchange of ideas. Task 20 can provide promising suggestions and solutions to facilitate the full integration of quick charging technology in a multi-modal transport system.

11.2 Objectives

Task 20 on Quick Charging Technology aims to promote solutions and improvements that will enable a broad penetration of this technology. Through having objective discussions based on facts, and sharing knowledge about the development and trends for quick charging technologies, Task 20 participants will have access to very up-to-date information from car manufacturers, utilities (distribution system operators – DSOs), battery companies, government representatives, and equipment manufacturers. All participants will be able to take part of the discussions and provide input to standardization bodies such as CENELEC and SAE.

A special focus will be on:

- Minimizing the impact of quick charging on the grid and EV batteries
- Breaking down nontechnical barriers to installing quick charging
- Establishing common criteria for quick charging to enable correlations among potential standards in order to promote vehicle electrification across the globe.

The main topics to be addressed in the three-year working period are:

1. Current quick charging technology development trends worldwide
2. Outcomes from the latest quick charging pilot projects and the issues to be resolved
3. Lessons learned from past charging network deployment plans
4. Impact of quick charging on EV battery ageing and behavior
5. Different charging infrastructure options (e.g., specific charging stations that can charge one or many cars in private or public locations)
6. Relationship between the energy efficiency and the charge power of the charging station
7. Managing the trade-offs between the shortest time to a full charge and the charger cost
8. The need for quick chargers and public charging stations to counter range anxiety
9. Quick charging solutions that will help to popularize EVs
10. Issues in the relationship (technical and socioeconomic) between the EV and the grid, including power quality, tariffs, regulations, incentives, etc.
11. To analyze and propose the best technical solutions for interoperability and the optimum use of the electric infrastructure already in place
12. How emerging technologies (smart grids and EVs) can join efforts to accelerate their market penetration
13. The requirements and issues of quick charging technology for future smart grid promotion

14. Designing and ensuring convenient, safe, and secure handling for consumers
15. Future technology roadmap to help promote vehicle electrification

11.3 Working method

The Task is a networking activity. Each participant contributes to the different topics in the Task based on a work sharing principle (data, experiences, forecasts, etc.). All participants are welcomed to the workshops and provide inputs based on their background and forecasts.

Members will have access to the following information:

1. Different results coming from R&D and demonstration projects studying the impact of quick charging on the battery and the power quality
2. Overview of international studies on quick charging technology
3. Experiences and best practices from all other participants involved in the field
4. Final solutions and suggestions provided as a result of the task
5. The exchange of questions among the members of the Task and other relevant entities
6. Necessary and available data
7. Effect of the use of quick chargers on the energy demand of vehicles
8. Meetings with top experts in the area
9. Exchange of information related not only to the quick charging but also to any other matter of interest for those who take part of the meetings
10. Overview of key actors and stakeholders
11. Participation in a series of workshops:
    - 1st Workshop: Kick-off
    - 2nd Workshop: Quick charging for smart energy management
    - 3rd Workshop: Role of quick charging in the future powertrain. Discussing the requirement of quick charging to help promote vehicle electrification
    - 4rd Workshop: Smart energy management and barriers to overcome
12. Conclusions and outlook
13. Documentation: proceedings, reports, papers, notes, presentations

Several workshops will be organized in different member countries to serve as the main networking activity of this group. If possible, these workshops will be scheduled in proximity to other major EV-related meetings, with a view to involving as many different stakeholders in the value chain of electric vehicles as possible. Participants will come from industry, research organizations, and technology policy institutions around the world.

11.4 Results

Two intermediate reports and a final report will be produced. The reports will be restricted to the Task participants. Nevertheless, public versions summarizing these reports will be developed. The main outcomes will be:

- Advice will be given to the standardization bodies (CENELEC, SAE, etc.) according to their schedules.
- At least one paper per year will be generated, with the aim of publication in relevant international journals or presentation at conferences (e.g., EVI, or EVS 27).
- Participation in related events, as well as in other related IA-HEV tasks, for the dissemination of the Task conclusions and recommendations.
- Distribution of the public versions of the reports through existing channels (associations, technology platforms, federations, etc.).

Due to its clear links to other IA-HEV tasks, Task 20 will work closely with Task 1 (Information exchange) to share the latest information around quick charging technology, and Task 18 (EV Ecosystems) to share the latest updates about charging infrastructure development projects. As with Task 18, this Task will build upon the results from Task 14 (Lessons learned) which investigated past EV pilot projects that involved charging infrastructure.

The information collected and the consensus among the members of the task will contribute to the deployment of quick charging technology. This information should help standards bodies, industry, and government to realize the benefits and improve the competitiveness of vehicles with an electric drivetrain.

11.5 Next steps

The kick-off meeting takes place in May 2012 in conjunction with the 26th Electric Vehicle Symposium (EVS 26), in Los Angeles, California, U.S., as a starting point for further discussion. The goal of this first meeting is to gather lessons learned from the charging network plan and deployments in the past. This will be done by sharing past examples and addressing the issues to be solved; looking at current quick charging technology development trends worldwide; understanding the latest status of technology development and standardization discussion in China, Japan, Europe, and the U.S.; and identifying the latest pilot projects and their outcomes. Discussion will focus on how quick charging technology can contribute to EV deployment in its early phases. A follow-up meeting is anticipated for autumn 2012 to focus on several specific topics.

11.6 Contact details of the Operating Agent

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.

Task 20 is coordinated by Ignacio Martin, from CIRCE, Research Centre for Energy Resources and Consumption, a private research organization in Spain which has the aim of creating and developing innovative solutions and scientific/technical knowledge in the field of energy which it can then transfer to the business sector for commercialization.

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12 Overview of hybrid and electric vehicles in 2011

Mass-production plug-in hybrid electric vehicles (PHEVs) and electric vehicles (EVs) saw their first full year of sales to customers in several IA-HEV member countries during 2011. The latest sales figures available for these vehicles as well as hybrid electric vehicles (HEVs) are tallied in Table 12.1.

Table 12.1 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 2011 were not yet available in some countries, a total may be estimated by extrapolating from the previous year's total and sales trends.

Year	2008		2009		2010		2011	
Vehicle type	EV[1]	HEV	EV[1]	HEV	EV[1]	HEV	EV[1]	HEV
Austria	1,200	2,592	2,148	3,563	3,532	4,801	n.a.	n.a.
Belgium[2]	1,109	*4,800*	1,229	*6,700*	1,295	n.a.	n.a.	n.a.
Canada	29	45,703	41	59,541	n.a.	n.a.	n.a.	n.a.
Denmark	*10,600*	300	*15,600*	380	*20,750*	535	*26,510*	760
Finland	*470*	1,142	*820*	1,876	*828*	3,073	*837*	3,973
France	n.a.	*24,000*	980	*33,000*	*1,000*	*43,000*	*3,630*	*57,000*
Germany	n.a.	n.a.	n.a.	n.a.	5,613	37,748	n.a.	n.a.
Ireland	n.a.	n.a.	n.a.	n.a.	162	5,328	n.a.	n.a.
Italy	206,300	8,786	217,200	11,254	227,975	19,045	n.a.	n.a.
Netherlands	60,452	20,005	458,000	40,000	*611,000*	*57,000*	*800,000*	*72,000*
Portugal	n.a.	n.a.	*300*	n.a.	*350*	n.a.	*1,334*	n.a.
Spain	n.a.	n.a.	10,698	14,000	10,698	21,190	2,4903	32,888
Sweden	*3,370*	13,500	*3,368*	16,102	2,739	19,261	2,263	21,417
Switzerland[4]	*39,000*	11,140	n.a.	*13,000*	*88,480*	21,000	n.a.	n.a.
Turkey	n.a.	264	n.a.	n.a.	n.a.	400	*30*	*500*
U.K.	1,405	47,035	n.a.	n.a.	56,004	78,590	67,696[5]	99,007[5]
U.S.	56,901	1,324,497	57,185	1,614,768	*58,000*	1,888,978	18,108[6]	2,153,486
Total IA-HEV	*400,000*	*1,500,000*	*850,000*	*1,800,000*	*1,000,000*	*2,250,000*	*1,200,000*	*2,500,000*

n.a. not available
1 Includes e-bikes and e-scooters.
2 EV data for Belgium are per August 1st of each year.
3 Spain's 2011 count does not include electric bicycles, unlike previous years.
4 Swiss EV data does not include industrial and agricultural vehicles. The 2010 HEV figure is for September 2010.
5 The U.K. data are per September 30, 2011.
6 U.S. EV data now consider sales of new-model EVs and HEVs only, omitting legacy neighborhood electric vehicles. Also, Tesla Roadster and Fisker Karma sales are not included.

13 Austria

13.1 Introduction

A number of initiatives, programs, and working groups that focus on the introduction of electric mobility were launched recently in Austria. Of note are the Electric Mobility Model Regions Program and the Lighthouse Projects Initiative, both of which are funded by the Climate and Energy Fund.

The goals set in the European Climate and Energy Package (approved in December 2008) require that 10% of final energy consumption for transportation be provided from renewable energy sources and that greenhouse gas (GHG) emissions from sectors not in the Emission Trading System (which include the road transport sector) be reduced by 10% from the 2005 level.

The National Energy Strategy of 2010 (Energiestrategie) identified several measures to help achieve these goals, including the progressive introduction of electric mobility. The goal of the strategy is to have 250,000 two-axle electric vehicles (EVs) — including plug-in hybrid electric vehicles (PHEVs) — in use by 2020; this number would represent a 5% share of all registered passenger vehicles.

13.2 Policies and legislation

National subsidies for EVs are already being implemented. The purchase of EVs is exempted from the NoVA (Normverbrauchsabgabe) tax for new vehicle purchases; in Austria, this tax can increase a vehicle's price by a maximum of 16% (of the vehicle's value). Vehicles that are exclusively powered by electricity are also exempted from the motor-based insurance tax.

In addition to these incentives, insurance companies offer reductions of 10–20% in the cost of vehicle insurance for EVs, thereby reducing the overall cost of operating them.

Also, several subsidies at both the federal and regional levels are offered to purchase EVs. Examples include these:

- Vienna: The purchase of electric bicycles, mopeds, and motorcycles is subsidized by a maximum of 30% of the vehicle's value or € 300 (US$395) per vehicle. (This measure was planned to be funded until the end of 2011.)
- Lower Austria: The purchase of electric scooters and bicycles is subsidized by a maximum of 20% of the vehicle's value or € 300 (US$395) per vehicle. (This measure was also planned to be funded until the end of 2011.)

Moreover, other policies support the purchase of EVs and HEVs instead of conventional cars. In January 2011, taxes on gasoline/petrol increased by 9%, and taxes on diesel increased by 14%. In July 2008, a bonus-malus (credit and penalty) taxation system on purchases of new vehicles (NoVA) began, and since January 2011, a stepwise increase in the NoVA tax has been applied for each additional gram of CO2, as follows:

- Emissions over 160 g CO_2/km: Tax increase is € 25 (US$33)/g CO_2
- Emissions over 180 g CO_2/km: Tax increase is € 50 (US$66)/g CO_2
- Emissions over 220 g CO_2/km: Tax increase is € 75 (US$99)/g CO_2

This tax will be followed by a further tax increase for each additional gram of CO_2 that will be implemented starting in January 2013, as follows:

- Emissions over 150 g CO_2/km: Tax increase is € 25 (US$33)/g CO_2
- Emissions over 170 g CO_2/km: Tax increase is € 50 (US$66)/g CO_2
- Emissions over 210 g CO_2/km: Tax increase is € 75 (US$99)/g CO_2

13.3 Research

The Federal Ministry of Transport, Innovation, and Technology (BMVIT) has been running the IV2Splus (Intelligent Transport Systems and Services Plus) research program since 2007, and it will continue through 2012. Other activities relevant with regard to developing electric mobility in Austria include the Lighthouse Projects Initiative (LTPI) launched in 2009 and the Electric Mobility Model Regions Program launched in 2008.

IV2Splus PROGRAM

The IV2Splus strategy covers efforts from basic research to demonstration and pilot projects. The A3plus program line within IV2Splus is the most relevant with regard to electric mobility because it promotes research, development, and demonstration (RD&D) of innovative propulsion technologies and alternative fuels. A3plus supports cooperative proposals involving industrial, university, and nonuniversity research to increase the competitiveness of Austria’s automotive industry.

LIGHTHOUSE PROJECTS INITIATIVE AND ELECTRIC MOBILITY MODEL REGIONS PROGRAM

Further electric mobility research activities in Austria are conducted under the funding programs of the Klima- und Energiefonds (Climate and Energy Fund). These include the LTPI, which had a total budget of approximately € 6 million (US$7.9 million) in 2011, and the Electric Mobility Model Regions Program, with a 2011 budget of € 2.5 million (US$ 3.3 million). The objective of these programs is to demonstrate new technologies in the area of electric mobility. The programs cover the demonstration and implementation of large-scale proposals that can involve various required infrastructure facilities and people, including developers, producers, downstream operators, and future users.

The LTPI funds R&D and demonstration projects in the field of electric mobility for technologies that are still not ready for the market, whereas the Model Regions Program provides a framework for market-ready technologies to be tested within new business models and to increase public awareness.

13.4 Industry

The automotive sector is a key sector within 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 employment and turnover.

MAGNA STEYR AND MAGNA POWERTRAIN

- Magna Steyr and Magna Powertrain are companies of Magna International Inc., a leading global supplier of technologically advanced automotive components, systems, and modules.
- Their core competencies are vehicle integration, efficient processes, virtual engineering, and solutions for intelligent and safe vehicle design.
- Magna Steyr focuses on the development of ultra-light vehicles, preferably those operated by alternative fuels such as compressed natural gas (CNG) or hydrogen. Besides battery electric vehicles (BEVs), hydrogen is seen as a potential fuel for providing long-term technology solutions; thus, the integration of fuel cells and hydrogen tank systems in newly defined vehicle architectures is an increasingly relevant topic. Magna Steyr is working on providing solutions that address various hydrogen storage system challenges, as shown in figure 13.1.

Fig. 13.1 Magna Steyr hydrogen storage system (700 bar compressed gas). (Photo courtesy of Magna Steyr.)

AVL LIST GMBH

- AVL is the world's largest privately owned company for developing, simulating and testing powertrain technologies (hybrid, combustion engines, transmissions, electric drives, batteries, software) for passenger cars, trucks, and large engines.
- In the area of hybrid drivetrains, AVL recently presented its "e-fusion" power train (see figure 13.2), a seamlessly integrated modular system that enables significant reductions in weight, size, fuel consumption, and costs.
- Thanks to its modularity, the AVL e-fusion drive system covers the concepts of mild hybrid and plug-in hybrid as well as range extender and full electric drive. Depending on which concept is being applied, fuel consumption is between 1.2 and 3.7 litres per 100 km, according to the New European Driving Cycle (NEDC). The driving range for plug-in hybrids and range extenders is defined as 50 km, non-stop, in purely electric mode. The new system is suited for vehicle categories in the A and B segments and for entry-level engines in the C segment and offers a cost reduction of 14%–40% (without battery) as compared to conventional solutions.

Fig. 13.2 AVL e-fusion modular system for hybrid powertrains. (Photo courtesy of AVL List GmbH.)

KTM POWER SPORTS AG

KTM developed together with the Austrian Institute of Technology the Freeride E, a fully electric motorcycle (see figure 13.3). Soon to be available for customers, this motorcycle features a brushless, synchronous motor which delivers a peak power of up to 22 kW and 42 Nm of torque. A 300V battery provides 2.1 kWh of energy storage and battery swap is possible thanks to a special quick change system; full recharge is achieved within 90 minutes.

Fig. 13.3 KTM Freeride E zero-emissions motorcycle. (Photo courtesy of KTM Power Sports.)

INFINEON TECHNOLOGIES AUSTRIA

- This supplier of semiconductors and systems to the global automotive industry addresses challenges in the areas of energy efficiency, communications, and safety.

- Infineon's product portfolio comprises discrete components, power semiconductors, microcontrollers, and sensors as well as high-power modules 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.

13.5 Charging infrastructure

The Electric Mobility Model Regions Program aims for the progressive installation of a charging infrastructure, its corresponding supply from renewable energy sources, and the development of new business and mobility models.

Since the program's launch in 2008, five model regions are being developed: Rheintal–Vlotte (Vorarlberg), Salzburg, Vienna, Graz, and Eisenstadt. In 2008, Vorarlberg was awarded funding to become the first e-mobility model region in Austria (www.vlotte.at). It has been subsidized by Austria's Climate and Energy Fund with € 4.7 million (US$6.2 million) for phase one and € 551,000 (US$725,000) for phase two, which began in 2010.

Another relevant program is the Klima:aktiv mobil initiative, which was launched in 2004 by the Federal Ministry of Agriculture, Forestry, Environment and Water Management in the context of the Austrian Federal Climate Strategy. Klima:aktiv mobil supports measures that focus on mobility management, including alternative vehicles and renewable energy, intelligent multimodal mobility, eco-driving, cycling, walking, demand-oriented public transport, and the raising of public awareness.

Within this program, funds for "mobility management for commercial and public fleets" support different measures that target the reduction of CO_2 and pollutant emissions; they cover up to 30% of the total investment costs and up to 50% of operational costs and externally provided intangible services.

A special initiative within this program ("Sonderaktion E-Ladestation") will operate until July 2012, providing funds for the installation of charging stations, with the maximum number of stations being 50 per project and 1,000 in total. An overview of charging points already in operation in Austria through this and other initiatives can be found on line at www.e-tankstellen-finder.at/.

13.6 On the road and EV deployments

Table 13.1 Distribution of the Austrian EV and HEV fleet as of December 31, 2010.

	PER DECEMBER 31, 2010		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs and HEVs)**
Bicycles (L1e)	2,559	–	303,908
Motorbikes (L3e)	241	6	168,089
Light-duty vehicles (LDV) (L2e and L6e)	167	–	15,875
Passenger vehicles (M1)	353	4,792	4,441,027
Buses (M2/M3)	113	2	9,648
Trucks (N)	70	1	379,965
Industrial vehicles	29	–	16,766
Total	**3,532**	**4,801**	**6,091,881**

Table 13.2 New passenger vehicles registrations in 2011.

Passenger vehicles: New registrations by drivetrain, Jan.–Dec. 2011 (absolute, share in %, and change compared with Jan.–Dec. 2010 in %)					
	Passenger vehicles				**Change from 2010 (%)**
Drivetrain	**Jan.–Dec. 2011**	**Share (%)**	**Jan.–Dec. 2010**	**Share (%)**	
Gasoline[1]	159,027	44.7	159,740	48.6	–0.4
Diesel	194,721	54.7	167,130	50.9	16.5
Electric	631	0.2	112	0.0	463.4
Natural gas	262	0.1	171	0.1	53.2
Dual fuel: gasoline/LPG[2]	12	0.0	–	–	–
Dual fuel: gasoline/natural gas	82	0.1	162	0.0	12.3
Hybrid gasoline/electric	1,306	0.4	1,248	0.4	4.6
Hybrid diesel/electric	4	0.0	–	–	–
Total	356,145	100.0	328,563	100.0	8.4
Source: Statistik Austria (1) Includes gasoline/ethanol (E85). (2) LPG = liquefied petroleum gas.					

13.7 Outlook

In 2010, the government appointed a group composed of the Ministries of Economy, Transport, and the Environment to coordinate and support electric mobility developments. The ministerial group for electric mobility was 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 timed plan for implementing the agreed-upon measures

The outcome of this joint-ministerial effort will be the National Implementation Plan for Electric Mobility that is due to be published in 2012. It will cover the following topics: EVs, charging infrastructure, users (demands and requirements), preferential areas to start implementation, industrialization and the national economic policy, instruments for research, innovation and technology, energy systems and resources, integration of electric mobility in the transport system, environmental impacts, and laws and regulations to support innovation.

14 Belgium

14.1 Introduction

The automotive sector has always been one of the most important industrial sectors in Belgium. With a turnover of € 15.90 billion (US$22 billion), an export rate of more than 90% and 82,000 employees, it represents 10% of total Belgian exports and also 10% of the industrial employment in Belgium (figures from Agoria). Recent new initiatives are guiding the sector increasingly in the direction of electric mobility.

Fig. 14.1 Belgian Platform on Electric Vehicles logo.

On the federal level, the Belgian Platform on Electric Vehicles was created in 2010 to inform and bring together all relevant stakeholders from the electric mobility value chain. Several platform meetings were organized throughout 2010 and 2011. A Steering Group is preparing a "National Masterplan for Electric Mobility" in which sector federations and governments are working together to develop a stable framework to stimulate the introduction of electric vehicles. The policy document *Roadmap 2030 for the stimulation of electric mobility in Belgium* summarizes the key elements of the national Masterplan. (The Belgian Platform's logo appears in figure 14.1.)

Flemish Living Lab Electric Vehicles

On the regional level, the Flemish government launched the Living Lab Electric Vehicles program to facilitate and accelerate the innovation and adoption of electric vehicles in the Flemish region. A call for proposals was launched with the aim of setting up a structured real-life environment in which EV-related innovations can be tested by representative end users in their own living and working environments.

Five different platforms were approved in 2011 with a total funding of € 16.25 million (US$22.6 million) More than 70 companies, organizations, and research partners are working together.

An overview of the 5 platforms (2011–2014):

1. EVA (Electric Vehicles in Action): The platform, under the coordination of the company Eandis, will install charging infrastructure (more than 200 charging stations) spread out over 80% of the Flemish region (semi-public and public domain). Many municipalities are participating because of the significant impact on the public domain. A wide range of EVs (161 vehicles of different brands and types) will be monitored to study user behavior. Other topics to be studied include the geographical coverage needed for public charging stations, the impact on the grid, and methods for charging fees to the user.
2. EV TecLab: The platform, under the coordination of Punch Powertrain, is a consortium of ten Flemish companies and research institutions and will focus on new technologies for electric heavy-duty vehicles like vans (Ford Connects made by Punch Powertrain), trucks (made by E-Trucks) and buses (made by Van Hool). The vehicles will be used for freight and public transport in daily operation.
3. iMove: The platform, coordinated by Umicore, is a consortium of eighteen Flemish companies and research institutions. A large test population (in companies but also residential) will use 175 electric vehicles and 180 charging stations in daily use for three years. The innovation projects will focus on three main themes: renewable energy and smart grids, new battery and vehicle technology, and mobility behavior.
4. Olympus: The platform, coordinated by railway operator NMBS Holding, is a meeting place for the various players in the field of sustainable mobility, where information and knowledge in the field of travel behavior, green technology, and smart electricity grids are exchanged. NMBS Holding can be the engine of networked mobility, where different modes of transport (bicycle, car, public transport) seamlessly connect.
5. Volt-Air: The platform, coordinated by Siemens Belgium, aims to support innovations to integrate electric vehicles in company fleets and local micro-grids. It consists of three sublabs linked together through a common data platform for data exchange. There is the micro-grid lab on the Siemens site in Huizingen, focusing on smart micro-grids integrating EV and renewable energy sources. The EV lab at Volvo Cars Ghent consists of electric Volvo C30s fitted with equipment for logging technical data. Finally, the users' lab in Kortrijk consists of a pool of about 60 electric vehicles from Westlease to be used by local companies in their fleets for experimenting with new business models.

14.2 Policies and legislation

In 2011, federal and regional governments continued their actions to support the introduction of hybrid and electric vehicles in Belgium. Actions like the national Masterplan and the Flemish Living Lab Electric Vehicles will create an environment to accelerate the introduction, adoption, and innovation of electric mobility in Belgium.

Tax incentives were changed drastically at the end of 2011. The following tax incentives to stimulate the use of pure electric passenger cars still exist:

- Business market: 120% deductibility
- Residential market: 30% of the purchase price, with a maximum of € 9,190 (US$12,800, via taxes, not directly from invoice)

14.3 Research

E-mobility is changing the value chain in the automotive sector completely. Stakeholders from industry sectors (automotive, energy, mobility), governments, cities, sector federations, universities and research companies have to work together to look for the most valuable new concepts and innovations to support EVs.

The Flemish Living Lab Electric Vehicles is a good example of such a collaboration. The following research organizations play an active role in the 5 platforms:

- VUB (Vrije Universiteit Brussel): mobi.vub.ac.be
- Flanders' DRIVE: www.flandersdrive.be
- IBBT (Interdisciplinary Institute for Broadband Technology): www.ibbt.be
- UGent (University of Ghent): www.ugent.be
- VIM (Flanders Institute for Mobility): www.vim.be
- K.U.Leuven (University of Leuven): www.kuleuven.be
- LCUC (Limburg Catholic University College): www.khlim.be
- VITO (Flemish Institute for Technological Research): www.vito.be

These research partners will be responsible for supporting the industrial partners during the next 3 years on test population management, data logging, the definition of research projects, etc. One project completed in 2011 was a study by VUB to determine the market and environmental benefits potential of electric mobility in Flanders.

Other organizations involved in Belgian research on hybrid and electric vehicles are EhB (Erasmus University College), FUNDP (University of Namur), UlG (University of Liège), and Green Propulsion.

14.4 Industry

A new edition of the Agoria Automotive Directory is expected to be launched in May 2012. This directory will give an overview of the companies active in the Belgian vehicle industry. This year universities, colleges, competence centers and knowledge institutes will also be included in the Automotive Directory.

Car industry

Belgium hosts several car assembly plants: Ford Genk, Audi Brussels and Volvo Cars Gent. Toyota Motor Europe also has a strong presence in Belgium, including its European headquarters, logistics centers, and its technical R&D center for Europe.

A portion of the local automotive supplier base of about 300 companies is very active in the area of hybrid and electric vehicles. Imperia Automobiles, founded in 2009 as a spin-off from independent research center Green Propulsion, is planning to produce and sell a plug-in hybrid sport car called Imperia GP. Punch Powertrain started as a supplier of push belt continuously variable transmissions (CVT), but is also developing hybrid powertrains for passenger cars and building 50 full-electric Ford Connect vans in 2012.

Bus and coach industry

Belgium also hosts manufacturers of other types of vehicles, like bus and coach makers Van Hool and VDL Jonckheere. Both companies are active on diesel hybrid and fuel-cell hybrid buses.

Fig. 14.2 Full electric bus with contactless inductive power transfer. (Photo courtesy of Van Hool.)

Van Hool has announced a full electric solution for public transport by bus and is planning to introduce the first 3 full electric buses (as shown in figure 14.2) as part of the EV TecLab platform. Van Hool's 9-m E-bus will be charged at one or different bus stops by using the Bombardier Primove induction charging and can thus be operated continuously on a fixed line. The bus has an autonomous operating range of over 12 km and can carry up to 60 passengers.

Truck industry

Belgium hosts a truck assembly plant from Volvo Trucks. Since 2010, the plant in Ghent has been producing the first series of about 100 Volvo FE Hybrid trucks which will be primarily used for distribution applications and garbage collection in urban environments.

Fig. 14.3 A hydraulic hybrid truck for garbage collection made by MOL CY, pictured with company executives. (Photo courtesy of MOL CY.)

There have also been new developments on hydraulic hybrid trucks and full-electric trucks. MOL CY, through its division VDK Waste Systems, has been developing hydraulic hybrid trucks for garbage collection in the Brussels capitol region (as shown in figure 14.3). In this first pilot, two of those trucks will be evaluated on fuel consumption reduction. The hydraulic accumulators will recover energy normally lost during braking and first indications show a fuel consumption reduction of 30%.

Fig. 14.4 Full-electric truck. (Photo courtesy of E-Trucks Europe.)

E-Trucks Europe develops full electric drivetrains for heavy-duty applications to integrate them in new or retrofitted trucks (as shown in figure 14.4). Integrated in a mid-size truck up to 22 tons, this full electric vehicle has an autonomy range of about 250 km and can cover the full speed range from 0 to 90 km/h. This makes the E-Truck most suitable for urban application as there are garbage collection trucks, city delivery, transport of containers, and so on. In case a larger action range or more on-board energy is required, the E-Truck can be equipped with a hydrogen-driven range extender. The first prototype E-Truck is on the road today. Several others are being built for demonstration projects such as the Belgian EV TecLab during 2012.

14.5 Charging infrastructure

The Flemish Living Lab Electric Vehicles platforms will involve more than 600 charging points to be rolled out at public and semi-public locations. Most of these charging points will be implemented in 2012 and will offer charging capabilities for electric bikes, scooters and cars, as shown in figure 14.5.

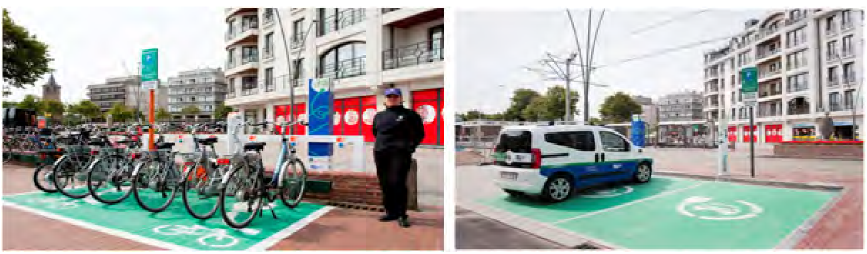


Figure 14.5 Public charging infrastructure. (Photo courtesy EVA Platform.)

In addition, the Belgian railway operator NMBS/SNCB foresees an investment in charging infrastructure on 34 railway station parking lots spread out over Belgium. At each location, 24 charging points will be installed for e-cars, e-scooters, and e-bikes (with 12, 6, and 6 points, respectively).

Most publicly accessible charging points in Belgium can be found on the ASBE website (www.asbe.be). At this moment, 177 locations are registered, but as mentioned above, many new charging points will be installed during 2012.

We also see increasing interest from charge infrastructure suppliers on products for home charging. In Belgium, statistics show that about two-thirds of all passenger cars theoretically have the possibility for off-street parking at night. A combination between home-charging, semi-public, and public charging (slow and fast) will alleviate users' "range anxiety".

Total Belgium has 12 fast-charging stations on strategic service stations in Belgium (Plug to Drive network). The charging stations offer four different ways of charging, from quick charging (AC and DC) to intermediate and slow charging.

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

14.6 On the road and EV deployments

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. In 2011, about 571,000 new cars were sold, of which 75% were diesel cars.

Although we can see a growth of smaller and more environmentally friendly vehicles on the market, the share of hybrid and electric vehicles is still below 0.5% of new car sales.

The official number of registered electric passenger cars in 2011 is still very modest: 263 new registered EVs in 2011 which brings the total number to 321 registered EV's (source: DIV). Almost 90% of the electric passenger cars are bought by companies.

Most of the electric vehicles, more than 1,000 in total, can be found in the light-duty and special vehicles segment (for example, forklifts and golfing carts).

Within public transport, we can see a further increase in the use of hybrid buses. At this moment about 80 buses, or 3.5% of the bus fleet of the Flemish Public Transport Operator "De Lijn" are hybrids. There is also an interest in full electric buses, but these will be first tested in limited numbers in 2012 in cities like Bruges.

An interesting trend in 2011 was the initiative to integrate electric vehicles in new mobility concepts. Companies like Cambio and Zen Car are using electric vehicles in their car-sharing concept. Zen Car has a network of Tazzari Zero electric cars and reserved parking places with charging poles in key locations in Brussels. As described earlier, the national railway company (NMBS/SNCB) has launched initiatives to integrate electric mobility more fluently into the whole mobility chain, by using electric bikes, scooters, cars and trains in shared and networked mobility concepts. These efforts are seen as very 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.

14.7 Outlook

In 2011, some important initiatives concerning electric mobility in Belgium were taken on the federal and regional level. It is obvious that electric mobility requires the involvement of many stakeholders and that a continuous effort is needed for success. Belgium's link with organizations like IA-HEV can help in making the right choices based on the "lessons learned" from other regions.

15 Canada

15.1 Introduction

The Government of Canada is committed to reducing Canada's total greenhouse gas (GHG) emissions by 17% from 2005 levels by 2020. The transportation sector is the largest single source of GHG emissions in Canada, accounting for approximately 28% of Canada's total GHG emissions, with light duty vehicles alone accounting for 12%. Combined with the fact that clean energy contributes approximately 75% of Canada's total electricity mix, electrifying the transportation system provides an opportunity to reduce Canada's GHG emissions.

15.2 Policies and legislation

New vehicles sold in Canada are required to meet national emissions and safety standards administered by the Federal Government. The *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* are the first regulated national GHG emission standards in Canadian history and will achieve significant and sustained GHG reductions. These regulations, which are aligned with those in the United States, took effect beginning with the 2011 model year, and will become more stringent over the 2011 to 2016 model years.

Once on the road, vehicles fall under provincial jurisdiction, and some provinces have started to address plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (EVs) in their policies. While Québec, Ontario, and British Columbia (B.C.) are currently the most proactive 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 hybrid electric vehicles (HEVs), PHEVs, and EVs. A summary of these incentives is provided in table 15.1. (Note that all currency amounts in this chapter are listed in Canadian dollars, which as of March 2012 are essentially equivalent to U.S. dollars.)

Table 15.1 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 $3,000 on the purchase (or 12-month minimum lease) of a HEV
Québec	**Rebate on purchase** ▸ As of January 1, 2012, point of sale rebate of up to $8,000 for purchasers of new rechargeable hybrid or electric vehicles **Subsidy for residential charging stations** ▸ As of January 1, 2012, subsidy of 50% of the eligible cost of purchasing and installing a 240-volt EV residential charging station, up to a maximum of $1,000 **Green license plate** ▸ The special plate with a pictogram used to identify an EV will ensure that only EVs use parking spots equipped with charging stations **Other** ▸ A call for tenders for the purchase of a least 400 EVs over the next year in a joint project with municipalities and the private sector ▸ Development plan for the charging infrastructure – le Circuit électrique ▸ Changes to the Québec building code for new buildings to require the wiring in new constructions to provide for the eventual installation of 240-volt charging stations A total of $50 million has been set aside for the vehicle rebate and residential charging programs.
Ontario	**Purchase/lease incentives** ▸ Incentive for eligible PHEVs and battery electric vehicles (BEVs) acquired after July 1, 2010 ▸ Incentive is based on the vehicle's battery capacity and ranges from $5,000 for a 4-kWh battery to $8,500 for a 17-kWh battery (prorated to term of lease for leased vehicles) **Green vehicle license plates** ▸ Allow solo drivers to use less-congested High Occupancy Vehicle (HOV) lanes until June 30, 2015 ▸ Access to future public charging facilities and parking at selected GO Transit lots 

Manitoba	**Manitoba's Electric Vehicle Road Map** ▸ The Province launched *Manitoba's Electric Vehicle Road Map* to help it adopt electric and hybrid vehicles, reduce dependence on fossil fuels, and take advantage of the economic opportunities of electric transportation
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, to end in 2012
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 	**Funding** Clean Energy Vehicle (CEV) Program started November 2011, as part of B.C.'s LiveSmart initiative, with three components: ▸ CEV for BCTM point of sale incentive program provides up to $5,000 off the sticker price for qualifying new battery electric, fuel cell electric, plug-in hybrid electric and compressed natural gas vehicles ▸ Residential Electric Vehicle Charging Station Rebate Program: Rebates of up to $500 per unit for eligible residential electric charging stations ▸ CEV Infrastructure Program: $6.3 million for charging infrastructure and fuelling infrastructure, including investments in upgrading hydrogen fuelling infrastructure and the delivery of a 1,000-point Charging Infrastructure Project, with community, private sector, non-government, academic and utility partners. **Supportive Regulatory Framework** The Renewable and Low Carbon Fuel Requirement Regulation requires a 10% reduction in transportation fuels by 2020, encouraging increased sales of electricity to the transportation sector. The *Clean Energy Act* allows government to approve, through regulation, utility prescribed undertakings that reduce emissions, including utility investments to increase the use of EVs and for the construction and operation of fuelling infrastructure. The City of Vancouver requires all new single-family homes and off-street bicycle storage rooms to have dedicated electric plug-in outlets and requires charging infrastructure for 20% of all parking stalls in new multi-unit residential buildings. The Province is exploring similar building regulations that communities could opt in to.

15.3 Research

Canada has well-established ongoing federal research programs supporting more energy-efficient transportation, including PHEVs, EVs, and fuel cell vehicles (FCVs). 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.

Table 15.2 Summary of R&D programs in Canada supporting PHEVs and EVs.

Program	Research relating to PHEVs, EVs, and fuel cell vehicles
Federal R&D efforts and funding support	
Program of Energy Research and Development	This federal, interdepartmental program operated by Natural Resources Canada supports R&D in advanced automotive technologies, including a program in electric mobility focusing on issues surrounding adoption of EVs in the Canadian marketplace. Project themes include energy storage systems; measurement protocols and testing for energy efficiency and emissions; lightweighting of electric drive components; advanced powertrain modeling; and cold-weather impacts.
ecoENERGY Innovation Initiative (ecoEII)	This new federal initiative, operated by Natural Resources Canada, will support RD&D projects in five strategic priority areas, including electrification of transportation.
Clean Energy Fund (CEF)	The Fund invests up to $146 million over five years to support renewable, clean energy and smart grid demonstrations, including three projects with an EV component.
Automotive Partnership Canada (APC)	This partnership between five federal research and granting agencies under the Industry Canada umbrella is a five-year, $145 million initiative supporting collaborative, industry-driven R&D. Recently approved projects include: ▸ Integrated, Intelligent Energy Management Systems for Hybrid Electric Vehicles ▸ Development of the Next Generation Heavy Duty (Bus) Fuel Cells with Enhanced Durability
AUTO21	A federal Network of Centres of Excellence engaging more than 200 researchers and more than 200 industry, government, and institutional partners from across Canada.
ecoTECHNOLOGY for Vehicles Program (eTV)	This Transport Canada program is a collaboration between governments, industry, and academia to test and evaluate the performance of advanced vehicle technologies, including PHEVs, BEVs, and FCVs.

(Table 15.2 continued)

Provincial-level R&D efforts and funding support	
Québec	▸ $30 million support for the development of two electric bus prototypes ▸ $36 million to support R&D and innovation in the EV sector ▸ $4 million investment to create a sectoral coalition for industrial research dedicated to EVs ▸ Creation of a Québec Cluster for EVs ▸ $30 million for EV investment projects undertaken by companies in Québec and subsidiaries of multinationals located in Québec ▸ $25 million to attract foreign investment in the EV sector Key research institutes include: ▸ The Hydro-Québec Research Institute (IREQ) – R&D aimed at discovering new materials to increase battery life and performance ▸ *Institut du transport avancé du Québec (ITAQ)* – conducts applied research specifically related to EVs ▸ Centre de technologies avancées BRP-Université de Sherbrooke.
Ontario	The Ontario government supports the production of EVs and components through investments such as: ▸ $16.7 million for Electrovaya of Mississauga (Ontario) to develop and manufacture lithium-ion batteries; ▸ $48.4 million for Magna International and Magna E-Car to develop advanced lightweighting technology, electrification of vehicle components and battery development; ▸ $2 million for Dana Canada to develop thermal management systems for hybrids and electric vehicles; ▸ $70.8 million to Toyota Motor Manufacturing of Canada on a spectrum of initiatives including production of the RAV4 EV.
British Columbia	The British Columbia government supports research and development in EVs through: ▸ $90 million endowment for The Pacific Institute for Climate Solutions (PICS) that supports a number of projects in PHEVs and grid-aware charging infrastructure. ▸ The Innovative Clean Energy Fund supports new pre-commercial technologies in the electricity, alternative energy, transportation and oil and gas sectors, as well as commercial technologies not yet used in B.C. Key research institutes with research programs and / or demonstration projects in the EV sector include the University of Victoria, the British Columbia Institute of Technology and the University of British Columbia.

15.4 Industry

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). Table 15.3 provides a sample of some key industry developments in the last year.

Table 15.3 Sample of key industry developments.

Auto Industry Developments
Mercedes-Benz: In March 2011, Mercedes-Benz announced that they will construct a Canadian Daimler plant in Burnaby, B.C. as the sole manufacturer of fuel cells for Mercedes-Benz F-Cells worldwide. This will be the world's first-ever large-scale production of fuel cells for passenger vehicles.
Bathium: In March 2011, Bathium Canada Inc. announced that their existing manufacturing plant in Boucherville, Quebec will be expanded through a $56 million total investment from the province of Quebec ($16 million) and Bathium Canada ($40 million). Over the next 5 years, the plant's annual production of lithium-metal-polymer batteries for EVs is expected to increase from 500 to 15,000 while employing an additional 245 workers to their existing 67 employees. These batteries are primarily designed for the Balloré Group's BlueCar, and a bus manufactured by Gruau in Germany, but can be used in other EVs.
Phostec Lithium: On April 8, 2011, the Government of Québec announced a $7.4 million grant for Phostech Lithium to establish the first lithium iron phosphate (LFP) battery commercial production facility in Candiac, Québec. Phostech Lithium, a subsidiary of the German firm Süd-Chemie AG, will invest $78 million in the new facility, which is slated to open in 2012 and will have an annual production capacity of 2,500 metric tons of LFP, enough to build around 50,000 EV batteries or up to 500,000 HEV batteries.
Electrovaya: Announced in June 2011, Electrovaya signed a contract to supply Chrysler with lithium-ion SuperPolymer® battery systems for 25 Town and Country minivans that will be part of a demonstration fleet of PHEVs that Chrysler Group LLC has developed in partnership with the United States Department of Energy.
Toyota: In August 2011, Toyota and Tesla Motors, Inc. confirmed that their jointly-developed RAV4 electric vehicle will be built at Toyota Motor Manufacturing Canada, Inc. (TMMC) in Woodstock, Ontario beginning in 2012. Tesla will supply the electric powertrain, which includes the battery, motor, gear box and power electronics for the RAV4 EV. Tesla will build the electric powertrains at its production facility in Palo Alto, California and then ship them to TMMC for final assembly into the vehicle. The RAV4 EV will be built at the Woodstock plant on the same line as the gasoline-powered RAV4. TMMC received a $71 million loan from the federal government and a matching grant from the government of Ontario, representing about 26% of the investment the company is making in its plants in Woodstock and Cambridge to finance production improvements and green initiatives.

(Table 15.3 continued)

Auto Industry Developments
Magna International Inc.: In August 2011, Magna International Inc. announced a $430 million R&D program for EV technology with an additional $48 million of funding from the Province of Ontario to help fund 19 projects over the next six years. The projects include developing concept electric cars, parts for hybrid vehicles, metallic components, alternative energy and ways to improve fuel efficiency.
GM Canada and Magna International Inc.: In November 2011, Magna E-Car Systems and GM Canada announced a joint demonstration project where a fleet of nine Chevrolet Equinox crossover vehicles were retrofitted with electronic components from Magna E-Car Systems, a division of Magna International Inc. Over the next two years, the 150-km range vehicles will be tested on the streets and highways in the greater Toronto area. The demonstration models are fitted with an electric motor generating up to 105 kW and a 33-kWh battery pack fitted into the undercarriage.
AddÉnergie Technologies: In February 2012, AddÉnergie Technologies of Québec was granted financial assistance in the form of a $200,000 repayable contribution from the Government of Canada to begin commercializing its charging stations for EVs and PHEVs in Canada, the United States and France. AddÉnergie Technologies is the only Canadian company to design and build charging stations for EVs.

15.5 Charging infrastructure

Table 15.4 Summary of EV charging infrastructure projects.

Province	Policy Instrument
Québec	▸ *The Electric Circuit*, a public charging network for plug-in EVs will be launched by Hydro-Québec and partners in spring 2012 (www.theelectriccircuit.com). It will initially consist of 120 240-V charging stations, with quick-charge stations also to be introduced later in 2012. ▸ In January 2012, Hydro-Québec published technical guidelines on the installation of EV charging stations, "*Bornes de recharge pour véhicules électriques – Guide technique d'installation*" (available in French only at www.hydroquebec.com/electrification-transport/pdf/guide-technique.pdf).
Ontario	▸ The Ontario government will provide public recharging in the future at selected GO Transit parking facilities. Ontario is also investigating the various business models for recharging facilities that could work within Ontario's regulated electricity market.
British Columbia	▸ B.C.'s *Electric Vehicle Charging Infrastructure Deployment Guidelines* are available, as of July 2009, at www.ceati.com/ev. ▸ In February 2012, the City of Vancouver launched its $800,000 "Charge and Go Vancouver" EV infrastructure trial that will install at least 67 Level I and Level II chargers for use at home, work and "on-the-go" by the end of 2013. ▸ The B.C. Charging Infrastructure Project will deploy up to 1,000 charging points throughout B.C. at different private and public locations, with an emphasis on energy efficient charging. The Project will include 30 DC fast chargers. See figure 15.1. ▸ B.C. has partnered with the Pacific Coast States under the Pacific Coast Collaborative to complete a "Green Highway" that will include charging infrastructure from B.C. to California.

Fig. 15.1 City of Vancouver and BC Hydro launch Vancouver charging network through the Easy Charge Pilot Project. (Photo courtesy of BC Hydro.)

15.6 On the road and EV deployments

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 as of July 2009 are shown in table 15.5.

Table 15.5 Light-duty vehicle registrations in Canada.

Vehicle type	Per July 2009		
	EV fleet	HEV fleet	Total fleet[b] (incl. EVs and HEVs)
Bicycles (no driver license)	n/a	n/a	n/a
Motorbikes(g)	n/a	n/a	594,866[f]
Passenger vehicles(a)(c)	41	59,541	21,674,752
Multipurpose passenger vehicles	n/a	n/a	n/a
Buses	249[d][e]	>900[d]	85,579[f]
Trucks	n/a	n/a	n/a
Industrial vehicles	n/a	n/a	n/a

(a) The EV fleet includes registered light-duty passenger vehicles, light-duty trucks (up to 10 000 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

(c) Source: Desrosiers Automotive Consultants Inc

(d) Represents urban transit only. Source: Canadian Urban Transit Association

(e) Streetcars

(f) Source: Statistics Canada

(g) Includes motorcycles and mopeds

Although recent activities in EV deployments in Canada have been limited, interest is growing as more vehicles become commercially available. Table 15.6 provides a sample of some of the deployment efforts that are taking place.

Table 15.6 Sample of EV deployment projects.

Province	EV Deployments
Québec	▸ In December 2011, Hydro-Québec delivered the last 10 of a total of 30 Mitsubishi i-MiEVs to local business partners. ▸ Communauto, the oldest carsharing service in North America, has integrated 25 Nissan Leafs into their vehicle fleet, with another 25 to be added in 2012.
Ontario	▸ 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. PowerStream has added two Nissan Leafs to its fleet and will use them as part of a smart charging pilot study.
British Columbia	▸ BC Hydro has partnered with several auto manufacturers, including Mitsubishi, Nissan, Toyota, and GM/Chevrolet, to conduct EV pilots and early commercial deployments. To date, over 100 vehicles have been deployed.

15.7 Outlook

The electric vehicle industry in Canada continues to be very active since the development of the *Electric Vehicle Technology Roadmap for Canada*, which was an industry-led initiative. The electrification of transportation has been identified as a priority for Canada and the federal government has a number of funding programs supporting developments in this area. In addition, provincial interest in the deployment of EVs continues to grow, with three key provinces announcing incentives and plans for deploying both EVs and charging infrastructure. However, only a limited number of EVs or PHEVs are currently available in Canada, making current uptake slow. Results of ongoing pilot projects that are studying the impact of Canadian winters on the performance of EVs and charging systems will provide insight on the readiness of these vehicles for the Canadian climate. Table 15.7 lists targets for the deployment of EVs that have been announced by industry and some provinces. Until OEMs increase their EV offerings in Canada, it is difficult to know if the targets can be reached.

Table 15.7 Targets for the deployment of EVs.

Organization/Province	EV Deployment Target
Industry – Electric Vehicle Technology Roadmap for Canada	▸ At least 500,000 highway-capable plug-in electric-drive vehicles on Canadian roads by 2018
Québec	▸ By 2020, 25% of all new light passenger vehicle sales will be EVs (all-electric and rechargeable hybrids)
Ontario	▸ One out of every 20 vehicles driven in Ontario to be electrically powered by 2020

16 Denmark

16.1 Introduction

The Danish government has set an ambitious goal to supply half of the electric power consumption from wind power in 2020. This implies a doubling of the current capacity from 3000 MW to 6000 MW, which is to be reached by adding 1800 MW from offshore wind farms and 1200 MW from land-based wind turbines. The aim is to phase out the use of coal for power generation by 2030. Furthermore, by 2035 all electric power and heat generation is to be covered by renewable resources, namely wind and biomass. A major challenge is adapting the electricity system to manage a 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.

16.2 Policies and legislation

POLICIES

An official Danish Energy Agency (DEA) report on the interaction of EVs with the electricity system has concluded that intelligent charging of EVs is paramount, but that charging the EVs at peak morning and evening hours can still be problematic. Furthermore, a working group of different stakeholders chaired by the DEA 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 identifies three different models for options to support EVs in Denmark involving different degrees of public regulation.

In 2008 two major new programs to promote EVs were started and continued to be active in 2011. These are the EV promotion program and the Centre for Green Transport, which implements EV demonstration projects.

The Danish EV promotion program

As part of a Climate and Energy Agreement from the Danish Parliament, the government allocated 35 million DKK (€ 4.5 million, US$6.3 million) to promote demonstration programs for battery EVs, to be administered by the DEA, beginning in December 2008.

In the demonstration programs, 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.

Through the end of 2010, total support totaling DKK 17 million (€ 2.3 million, US$3.2 million) was granted for 17 projects for 94 EVs, which included cars, vans, minibuses, and trucks. In February 2011, DKK 11 million (€ 1.5 million, US$2.1 million) was allocated. The remaining DKK 5 million(€ 670,000, US$930,000) is scheduled for allocation in the beginning of 2012.

Danish Transport Authority, Centre for Green Transport

In April 2009, the Danish Transport Authority established the Centre for Green Transport to collaborate with stakeholders in the private and the public sectors and conduct ongoing test and demonstration projects about energy-efficient transport solutions.

In the specific area of H&EVs, DKK 200 million (€28 million, US$39 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. Demonstration projects include the following:

- ChoosEV: 22 million DKK(€ 3 million, US$4.2 million) was granted for the ChoosEV project to field-test 300 mass-produced EVs.
- Hybrid buses: 4.8 million DKK (€ 640,000, US$890,000) was granted to field-test 4 hybrid buses in Copenhagen.
- EV car sharing: 1.7 million DKK (€ 230,000, US$320,000) was granted to gather experiences from EVs in a car sharing project in Copenhagen. Preliminary results show that the EVs have been used less than expected due to the limited range.
- Fuel cell electric vehicles (FCEVs): 1.7 million DKK (€ 230,000, US$320,000) was granted to field test of fuel cell EVs in Copenhagen.

In cooperation with the Danish Energy Agency, the Centre for Green Transport has established an information centre to exchange experiences on EVs between local communities in Denmark.

LEGISLATION

BEVs and FCEVs are exempted from the registration tax and annual tax until the end of 2015. There are no special tax rules for PHEVs. 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 (up to180%) and is based on the value of the car plus VAT. One way that this benefits HEVs is that the registration tax is reduced for gasoline cars that are more energy-efficient than 16 km/L (18 km/L for diesels), with 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.

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.

16.3 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 since 2008 to analyze the potential of intelligent charging systems and vehicle-to-grid (V2G) services for PHEVs and battery EVs.

HYDROGEN IN DENMARK

Hydrogen and fuel cell transport activities increased significantly during 2011 in Denmark and the other Scandinavian countries. In January 2011 the Nordic countries signed a collaboration agreement with the Korean car manufacturer Hyundai on preparing market introduction before 2015. This lead to the launching of the latest FCEV from Hyundai in May, the Tucson iX35, an SUV with a range of 500 km and a fuel economy of 25.5 km per gasoline equivalent liters.

In June 2011 the first 700-bar refueling station was opened, offering 3 minutes refueling in accordance with the international SAE J2601 standard that ensures a fast and uniform refueling of hydrogen to any FCEV at any hydrogen refueling station worldwide (see figure 16.1). The high pressure enables the Hyundai iX35 to travel cross-country over a range greater than 330 km while driving at highway speed.

Fig. 16.1 The 700-bar hydrogen station in Holstebro, Denmark enables refueling in 3 minutes. (Photo courtesy of H2 Logic.)

EDISON Project

The EDISON project is an international research venture partly publicly funded through the research program FORSKEL. 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.

A successful proof-of-concept on the island of Bornholm has demonstrated intelligent charging of EVs, using aggregators of electrical vehicles to provide the required balancing power for increasing the usage of wind power in the Danish electricity grid. The consortium has published several reports on the EDISON web-site, www.edison-net.dk, and presented its results at a scientific conference. Also, important results are already being used for input in the upcoming standard ISO/IEC 15118 (V2G communication interface).

Nordic Electric Vehicle Interoperability Centre (NEVIC)

NEVIC, established in 2011, is an independent test centre that has been established at DTU Electrical Engineering at Risø to ensure that the EVs can be charged on all charging posts regardless of car brand, EV service operator, distribution system operator (DSO), or power producer. This wide compatibility between technical components as well as operators is called interoperability. NEVIC will test the concept and collect experiences from the first EV operators.

16.4 Industry

Denmark has no conventional car industry, but it houses many component suppliers. The Danish Electric Vehicle Alliance was established as a trade association under the Danish Energy Association in November 2009. 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.

Denmark produced EVs in the 20th century, and now it appears it will do so again. ECOmove is an EV development company established in 2009 in Horsens, Denmark. The company is developing the flexible QBEAK EV which can seat up to six people or up to two square meters for cargo within a small outer size (see figure 16.2). The in-wheel motor system developed by ECOmove for 2-wheel or 4-wheel drive enables the large cabin space. Through ECOmove ultra-fast QPOWER charging, the QBEAK will be able to charge to 90% in 4 minutes over more than 12,000 charging cycles. The QBEAK is expected to begin sales in early 2013.

Fig. 16.2 The QBEAK EV from ECOmove has large cabin space despite outer dimensions of 3 meters by 1.75 meters, and can have a range of up to 300 km, based on the number of battery modules installed. (Photo courtesy of ECOmove.)

16.5 Charging infrastructure

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

Better Place Denmark

Better Place is an electric car operator developing and deploying EV services, systems, and infrastructure. The company cooperates with automakers, battery suppliers, energy companies, and the public sector. In the Better Place model, members get access to a network of charge spots, battery switch stations, and in-car software connecting the car to the network. The aim is to provide EVs with the known mobility of the conventional car combined with an optimized driving experience with minimum environmental impact and cost. 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 membership packages including a given number of kilometers per month as well as a battery and access to battery switching when necessary.

Better Place Denmark launched its nationwide infrastructure of charge spots and 16 battery switch stations in April 2012. This coincides with the Danish launch of the Renault Fluence Z.E. (see figure 16.3), which is designed to have a switchable battery. Europe's first battery switch station was inaugurated in June 2010 in Gladsaxe north of Copenhagen.

Fig. 16.3 The first Danish battery switch station in Gladsaxe north of Copenhagen. (Photo courtesy of Better Place Denmark.)

ChoosEV

ChoosEV is a major Danish electric mobility operator (EMO), owned by the utilities Syd Energi and SEAS-NVE. ChoosEV provides electric vehicles, charging stations, financing services, operation, advice, and environmental optimization in relation to electric vehicles and infrastructure. By promoting electric vehicles and ensuring that they are charged intelligently, ChoosEV is planning to play an important role in balancing the grid in developing smart grid solutions in regard to EVs.

During 2012 ChoosEV will establish more than 50 quick charge stations (ChaDeMo) nationwide in Denmark, which will make it possible to drive across the country in an EV (see figure 16.4). ChoosEV's infrastructure will also include private intelligent charging modules and hundreds of semi-public standard charging points.

Fig. 16.4 ChoosEV test vehicle and quick charge station (using the CHAdeMO protocol) developed in cooperation with Siemens. (Photo courtesy of ChoosEV.)

16.6 On the road and EV deployments

The total number of passenger cars in Denmark has passed 2.2 million and is slightly increasing. Since 2009, sales of EVs have grown, as a result of the Danish EV promotion program and other EV dissemination activities. In 2011 the number of EVs more than doubled to almost 900, as shown in table 16.1.

Table 16.1 Characteristics and population of the Danish motorized vehicle fleet per December 31, 2010 and 2011. Estimates are in italics.

	DECEMBER 31, 2010			DECEMBER 31, 2011		
Vehicle type	EV fleet	HEV fleet	Total fleet	EV fleet	HEV fleet	Total fleet
Motorized bicycle (no driver license)	*20,000*	0	n.a.	*25,000*	0	n.a.
Motorbike (a)	*650*	0	200,000	650	0	200,000
Passenger vehicle	368	470	2,160,000	845	695	2,200,000
Multipurpose pass. vehicle	0	65	25,000	0	65	25,000(b)
Bus	11	0	15,000	11	0	15,000
Truck	15	0	50,000	10	0	50,000
Industrial vehicle	n.a.	0	n.a.	n.a.	0	n.a.
Total	***21,000***	**535**	**2,390,000**	***26,510***	**760**	**2,490,000**

n.a. *Not available*
Motorbikes include City-el.
Not including vans. Many MPV's and SUV's are registered as vans in Denmark.

In 2010 ChoosEV initiated the large research project called Test-an-EV. ChoosEV has offered 300 electric vehicles to be tested by 2,400 Danish families for a period of two years. Each test driver will have the electric vehicle for a period of three months, while ChoosEV collects technical data from the cars about battery technology, driving patterns, and the electric vehicles' influence on the energy network. The project is supported by the Danish Energy Agency, the Danish Transport Authority, and private funding.

16.7 Outlook

Demonstration projects with FCEVs and PHEVs as well as development of V2G technologies will be in focus in the coming years. Better Place Denmark's full-scale introduction of battery EVs begins in April 2012 and the demonstration and test activities of ChoosEV will continue this year. Demonstration activities on hydrogen infrastructure for FCEVs is taking off in 2012 by introducing a network of three to five 700 bar refueling stations in the city of Copenhagen preparing for a market introduction of FCEV in 2015. However, the expectations for growth in the numbers of HEVs, FCEVs, PHEVs, and EVs in Denmark are very difficult to define based on the uncertainty about how taxes for H&EVs will be overhauled. Also, very few EVs are on the market and do not yet offer driving range and pricing that is competitive with conventional gasoline and diesel cars.

17 Finland

17.1 Introduction

Finland is located on the periphery of Europe, and transport distances within it, as well as to and from it, are long. The energy-intensiveness of its industries (pulp and paper, metal), its cold climate, and its long travel distances make the industrial, heating, and transportation sectors the biggest energy consumers in Finland. As a member of the European Union (EU), Finland is committed to EU environmental targets and the Kyoto Protocol. The main targets are to keep national greenhouse gas (GHG) emissions on the level they were at in 1990 during the period 2008–2012 and to ensure that 38% of the total produced energy comes from renewable sources by 2020. Since the transportation sector (air, water, and road traffic) causes about 20% of Finland's GHG emissions, it has an important role in cutting them.

17.2 Policies and legislation

With regard to road traffic, the accepted target for average CO_2 emissions from new cars sold in 2020 will be 95 g/km. This emission level represents a reduction from the current average level of 144.8 g/km for new cars sold in 2011. In 2015, the average new-car GHG emission level target will be 130 g/km. Beginning in 2010, 95E10 with 10% ethanol has been used as the standard 95 octane gasoline, which has helped decrease emissions. The common view is that electric vehicles (EVs) will not be needed before 2020. They do not yet have a significant role in cutting emissions, but after 2020, they will play an important role in the effort to reach the targets of going below 95 g/km emissions.

Because the Finnish car industry is very small, there will be no direct incentives for electric mobility in Finland in the near future. Finland's emission-based purchasing tax and yearly usage tax do, of course, promote low-emission vehicles, but the effect is relatively small when compared to the € 5,000 (US$6,200) purchase support given to buyers of low-emission cars by some other countries. Instead of supporting cars, practical efforts in Finland are focused on developing the infrastructure to be ready for the future march of EVs into the marketplace. The main focus is on the charging infrastructure, including using smart charging to avoid load peaks and preparing buildings for the additional electric load. It is extremely easy and inexpensive to make provisions for charging equipment by adding cables or cable pipes during building construction and renovation. Costs are remarkably higher when the equipment must be added to buildings that are already constructed.

Energy tax

The vehicle purchase tax was reformed in 2008 and the yearly usage tax was reformed in 2010 to be based on CO_2 emissions. These reforms helped reduce the average emissions of new passenger cars from 178 g/km in 2007 to 144.8 g/km in 2011.

A new taxation plan for energy was presented in 2010 and became effective at the start of 2011. For transportation fuels, tax levels are now based on energy content, CO_2 emissions, and the impact on local air quality. The new system reduces taxes on plug-in hybrid EVs (PHEVs) and battery EVs (BEVs) as well as many biofuels (figure 17.1).

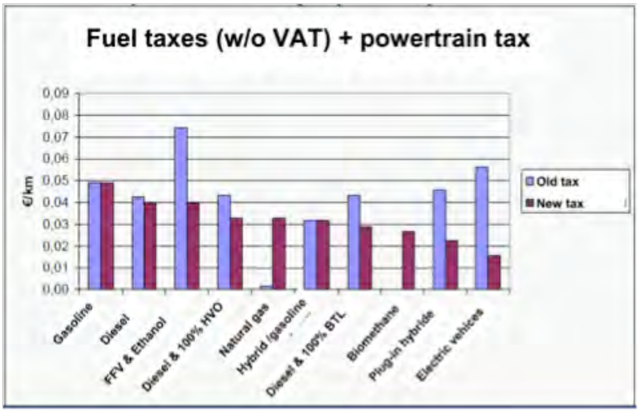


Fig. 17.1 Energy taxation: Taxes before and after January 1, 2011 (calculated as accumulated taxes per vehicle kilometer). (Source: Jyrki Katainen, www.vm.fi.)

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

17.3 Research

EVE (Electric Vehicle Systems Program)

Tekes, the Finnish Funding Agency for Technology and Innovation, started EVE as the result of a 2009 task force memorandum on EVs from the Ministry of Employment and the Economy. The program runs from 2011 to 2015 with a total budget of € 80 million (US$100 million). Slightly less than half of the funding is from Tekes, and the remainder is from private sources.

The program will enable the creation of large test platforms for pilot and demonstration projects related to EVs and electric machinery. The objective is to conduct research on and demonstrate the functionality and performance of EV components and subsystems and complete EVs, with regard to both their technical and economic benefits. In addition to the Tekes financing, the Ministry of Employment and the Economy is supporting the EV research infrastructure (including both EV fleets and the charging infrastructure) with investments amounting to € 10 million (US$12.5 million). The funding decisions for the first test platform and demonstration projects were published in December 2011, and the projects will start in 2012.

17.4 Industry

Valmet Automotive is the only passenger car manufacturer in Finland. It now manufactures the plug-in vehicles Th!nk City, Fisker Karma, and a BEV golf-car, Garia. The first Fisker Karmas began to emerge from the production line in the summer of 2011. Since then, more than 1,000 Karmas have been produced.

In contrast to the relatively small size of the car manufacturing industry in Finland, the manufacturing of nonroad mobile machinery (NRMM) is a large and important business there. NRMM includes machines that are targeted for specific tasks under off-road conditions, that move mainly on wheels or tracks, and that are used mostly in industrial or agricultural applications. NRMMs are usually powered by diesel engines with high fuel-consumption and emission levels. Manufacturers are actively developing electric and hybrid electric solutions in order to decrease NRMM fuel consumption and emissions.

European Batteries develops and manufactures large, rechargeable, lithium-ion-based prismatic cells and battery systems. It is ramping up the biggest lithium-ion battery factory in the EU for automotive applications in Finland. The new production facility, in Varkaus, began operating 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 2012.

17.5 Charging infrastructure

Finland is the world’s northernmost industrialized nation, and its Nordic climate has given the country an increased need for energy to run household heaters, saunas, and boilers. Its existing transmission system could be easily adapted to accommodate supplying the electricity needed to charge EVs. It is estimated that charging up to 500,000 EVs in Finland would be very easy, requiring 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. It has very few charging stations targeted for electric cars. Rough estimates indicate there are 20 to 30 slow charging stations (220V/16A) and a few fast charging stations (400V/250A). The number of specific charging stations will increase in coming years because new demonstration projects will bring up to 500 electric cars into the Helsinki area.

A block heater is an element that is installed inside a vehicle's motor block to warm up the cooling water and thereby the whole motor before starting. In Norway, there are 1.5 million of these block heaters commonly used to preheat cars in the cold temperatures (see figure 17.2). With certain modifications, they could be used to charge EVs.

Fig. 17.2 Block heater pole (left), and view from the car parking area of a row house condominium (right). Block heater poles typically have 2-hour timers; the starting time is selected by the user, and the heating time is fixed for 2 hours from the start.

Advantages of using block heaters for EV charging

Using the Nordic countries as a "laboratory test" for using block heater systems has an advantage when it comes to public perception. People there are accustomed to plugging 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 the landscape in parking areas or at residences. In addition, they are considered safe to use and are rarely vandalized.

17.6 On the road and EV deployments

At the end of 2011, there were 2,958,568 registered passenger cars in Finland. The stock of passenger cars grew by 2.8% during that year. A total of 126,123 new passenger cars were registered in 2011. Data from 2011 are presented in Table 17.1.

Table 17.1 Fleet data presentation categories for 2011. (Source: Finnish Transport Safety Agency, Trafi.)

	PER DECEMBER 31, 2011			
Vehicle type	**EV fleet**	**PHEV fleet**	**HEV Fleet**	**Total fleet (incl. EVs and HEVs)***
Bicycles (no driver license)	500**	0		3,050,000**
Mopeds	250**			277,187
Motorbikes	2			235,240
Passenger vehicles (including multipurpose passenger vehicles)	76	9	3,973	2,958,568
Buses				14,185
Trucks				484,172
Industrial vehicles (mostly agricultural tractors)				431,307
Total	**828**	**9**	**3,973**	**7,450,659**

* *Total fleet numbers include all propulsion systems and fuels (gasoline, diesel, liquefied petroleum gas, natural gas, biofuels, etc.)*
** *Estimates.*

17.7 Outlook

Finland's 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, the need to use EVs will increase in the coming decades in order to achieve GHG reductions. A charging infrastructure that uses intelligent charging is needed to promote consumer confidence about adopting EVs and PHEVs.

As the world's northernmost industrialized nation, Finland has many businesses involving key technologies related to EVs that would like to participate in the worldwide EV industry; Valmet and European Batteries are two prime examples.

18 France

18.1 Introduction

In 2009, former French sustainable development minister Jean-Louis Borloo launched a strategy aimed at fostering a domestic electric vehicle (EV) market. The government pledged € 1.5 billion (US$1.9 billion) to replace two million combustible engines with EVs and hybrids, and to build an EV recharge network comprising 400,000 public and four million private terminals by 2020. The funding, spread across a 14-point plan, was to be deployed from 2010–2015. One and a half years into the plan, significant progress has occurred.

In France, the year 2011 was marked by strong signals that highlight the introduction of the EV: the first commercialization of electric vehicles by major manufacturers, orders for EVs by the French government, and the widely publicized launch of Autolib in Paris, a fleet of 3,000 electric cars that customers can pick up and drop off at rental stands located around the city.

Despite this progress, the overall goal of the French government to place 2 million electric and hybrid vehicles in 2020 remains challenging. The proactive government action associated with the strategy of major manufacturers will guarantee the emergence of an EV market in France, but it is also important to unite all players of the EV ecosystem (automotive industry, utility operators, service providers, and local authorities) around concrete experiments that render EVs more appealing to drivers.

18.2 Policies and legislation

The major policies and laws pertaining to hybrid and electric vehicles in France relate to continuing tax incentives and building charging infrastructure.

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. Despite the economic crisis, the French government decided to maintain tax deductions (bonus) and tax penalties (malus) for new vehicle purchases on the basis of their tank-to-wheel CO_2 emissions. The plan continues to set a new bonus of € 5,000 (US$6,500) for new cars and light commercial vehicles emitting less than 60g CO_2/km, which automatically covers all electric vehicles.

Charging infrastructure

France's strategic vision to deploy nationwide charging infrastructure includes:

- Funding half of the cost for local governments that install public charging infrastructure;
- Reserving a quota of parking areas in work places and shopping areas for electric vehicles and charging spots;
- Requiring that builders of multi-unit residences must install charging facilities at parking places upon request of the inhabitants; and
- Requiring that local governments equip public parking areas with charging facilities.

18.3 Research

Before deploying a charging infrastructure, the French government estimated it was necessary to experiment with applying some key innovative technologies in pilot cities. This decision led to several funded projects, including:

- A project in Strasbourg where 100 Toyota Prius plug-in electric vehicles (PHEVs) were tested with 135 recharging spots.
- The "Projet CROME" is a cross-border field test of EVs in the Alsace region and neighboring parts of Germany; the vehicle fleet may use the charging stations of electrical utility company EnBW in Mannheim, Karlsruhe, and Stuttgart, and those of French electrical utility company EDF in Strasbourg.
- In the Yvelines department west of Paris, the fleet test SAVE (Seine Aval Véhicule Électrique) was started in April 2011 with a number of 200 charging stations.

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 (the French Environment and Energy Management Agency) has been selected for several projects under the "Investments for the Future" program. Projects aimed at developing future vehicles include € 1 billion (US$1.3 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 the smart grid.

18.4 Industry

Following from the “Electric Vehicles” plan, France is busy setting up a whole new industry.

In 2011, the French government asked car manufacturers PSA Peugeot Citroen and Renault to supply a total of 18,711 electric vehicles to government entities and corporations in the first portion of a collective order designed to support France’s nascent electric-vehicle industry. Renault is to supply nearly 16,000 plug-in electric versions of its Kangoo light van. The order for Peugeot Citroen is for more than 3,000 Peugeot Ions, full-electric city cars that are rebadged versions of Mitsubishi MiEV. This purchase commitment is key to fostering France’s EV market.

The initiative, led by La Poste, the French postal service involves a group of 20 large companies and various administrative bodies. So far, La Poste’s growing alternative energy fleet includes 270 electric cars, 8,000 electric bikes, 500 hybrid trucks, and 110 electric quad bikes.

PSA Peugeot Citroën

PSA Peugeot Citroën is building on its expertise to develop hybrid vehicles. Studies are focused on two types of hybridization.

PSA Peugeot Citroën introduced a first level of hybridization, the Stop & Start system (STT), on vehicles such as the Citroën C2 and C3. This technology cuts the engine and restarts it again in a split second, reducing fuel consumption in the city by up to 15%.

PSA Peugeot Citroën went further in 2011 with HYbrid4 technology. HYbrid4 optimizes the diesel hybrid powertrain and also boasts an all-new four-wheel drive mode, bringing more value to the additional cost of the hybrid. This technology can be applied to different range levels. But given its extra cost, it will be available initially on their distinctive and premium mid- and upper-range models. 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.

Renault-Nissan

Renault aims to become the first full-range car manufacturer to market zero-emission vehicles in use, available to the greatest number (see figure 18.1). Electric cars emit no CO_2 in use. The Renault-Nissan Alliance is developing a complete range of

100% electric powertrains with power ratings of between 15kW (20hp) and 100kW (140hp).

Fig. 18.1 Renault PEV product line: the Twizy, Fluence ZE, Kangoo ZE, and ZOE. (Source: Renault.)

Renault offers a full range of electric vehicles:

- Designed for professionals, the Kangoo Z.E. went on sale in October 2011, with prices starting at € 15,000 (US$19,544) (environmental subsidy deducted). Monthly subscriptions covering battery rental will start at € 72 (US$94) before value-added tax (VAT), including assistance.
- The family sedan Fluence Z.E. was first launched in Israel (November 2011) and then in other countries. Prices in Europe start at € 20,900 (US$27,231), depending on local tax incentives. Customers also subscribe to a monthly battery lease starting at € 82 (US$107) including VAT and assistance.
- Twizy, a new tandem type of urban vehicle, will be available in two versions (5 kW for drivers without a license, or 15 kW motor) with a price tag starting at € 6,990 (US$9,108) without a tax incentive.
- In 2012, ZOE, a zero-emission compact car measuring less than four meters long and with five seats, will be launched.

Saft

In 2011 Johnson Controls terminated its 5-year joint venture with French battery maker Saft by acquiring the latter's share for $145 million (€ 111 million) in cash. The agreement also includes an up-front royalty payment by the company to Saft in return for an expanded license to use certain Saft lithium-ion battery technology.

Johnson Controls will retain all assets of the joint venture, except the facility in Nersac, France, which will be transferred to Saft at the end of 2012.

The joint venture has production contracts with Daimler Mercedes S-Class hybrid, BMW 7-Series hybrid, Chery small sedan hybrid, Azure commercial delivery trucks hybrid Electric and Ford Motor's plug-in hybrid electric vehicle (used in section 18.3). It also has development contracts with Ford, General Motors, SAIC, Daimler and United States Advanced Battery Consortium. Upon completion of the transaction to acquire the share of the joint venture previously held by Saft, Johnson Controls began to honor the company's existing contractual agreements.

Autolib

In 2011, the Autolib EV hire pilot program launched in Paris with plans for 3,000 bubble-shaped Bolloré EVs stationed at 1,000 self-service hire points throughout Paris and Ile-de-France. The Mairie de Paris (Paris' administrative body) has invested around € 110 million (US$144 million).

18.5 Charging infrastructure

The government has announced an investment plan to support public charging infrastructure to be installed across the nation. An estimated one million public and private battery-charging stations will be built by 2015 under the plan. 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 EVs and related infrastructure. The intent is for local communities to match or contribute funds for the infrastructure investment needed.

In 2011, French Prime Minister François Fillon tasked Senator Louis Nègre with compiling a conceptual framework for EV network deployment. The information, compiled in a "Green Paper," was presented to France's respective transport and finance ministers, Nathalie Kosciusko-Morizet and Eric Besson, on April 28, 2011.

On the basis of this "Green Paper," France's environment agency ADEME has launched a call for expressions of interest (AMI) to regional authorities, OEMs, and electricity suppliers, among others. The objective of the AMI, which closes in 2013, is to supplement competitive solutions for building a nationwide EV network with standardized recharging facilities and generic pricing models.

18.6 On the road and EV deployments

According to data from the French Automobile Manufacturers Committee (CCFA), a total of 2,630 pure electric vehicles were registered as new vehicles in 2011 in France, along with 12,888 gasoline hybrids, and 401 diesel hybrids. The top EVs sold in France in 2011 are depicted in figure 18.2.

Fig. 18.2 Numbers of EVs sold in France with their respective market share (only the 10 most popular EVs sold presented). (Source: CCFA.)

A number of the EV deployments were mentioned in the Research and Industry sections of this chapter.

18.7 Outlook

The French auto industry is following three different trends or directions.

1. **Revised mobility constructs**
   A new market segment is emerging with the 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**
   EVs lend themselves to being specifically adapted for new service-delivery options; for example, Autolib short-term rentals are modeled after the Velib bicycle rental program in Paris.

3. **Lighter vehicles**
   Reduced energy consumption 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.

19 Germany

19.1 Introduction

The German Government attaches a high level of significance to the promotion of electric mobility. It is considered an important element of a climate-friendly energy and transportation policy. The German Government is convinced that electric vehicles (EVs) are a suitable way to enjoy mobility that is both environmentally friendly and future compliant. In 2009, the German Government adopted the National Development Plan for Electric Mobility which sets a target of one million EVs on the road in Germany by 2020. On May 3, 2010, the German chancellor convened a high-level meeting with leaders from industry and science as well as other key stakeholders, which resulted in the creation of a National Electromobility Initiative (NPE) and the adoption of a Joint Declaration. The NPE published its latest report in May 2011. In 2011 we saw the start of a considerable number of research projects, the presentation of several prototype cars by car manufacturers, and the outcome of various demonstration projects of electromobility in the eight model regions.

19.2 Policies and legislation

The German Federal Government is pursuing the objective of a sustainable transport policy. Transport should be made environmentally and climate friendly, socially responsible, and at the same time, economically efficient. The political objective is to have one million EVs and an additional 500,000 fuel-cell-powered vehicles registered and operating in Germany by 2020. In 40 years' time, urban transportation should be able to virtually do without fossil fuels.

Germany has set a greenhouse gas (GHG) emission reduction target of 40% by 2020 compared to 1990. Beyond 2020, the schedule foresees further reductions: 55% by 2030, 70% by 2040, and 80–95% by 2050 compared to 1990 levels. Road transport reached a share of about 15% of the total GHG emissions in 2010 in Germany, which represents a reduction of about 3% compared to 1990. Table 19.1 shows the progression of GHG emissions of road transport in Germany.

Table 19.1 GHG emissions of road transport in Germany from 1990 to 2010 in gigagrams (Gg $=10^9$ g).

	1990	1995	2000	2005	2006	2007	2008	2009	2010
CO_2, fossil	150,358	165,104	171,230	151,604	147,747	145,035	144,831	144,134	145,438
CH_4	52.1	32.9	20.6	12.2	11.0	9.8	8.5	7.8	7.4
N_2O	3.8	5.4	5.1	3.3	3.2	3.3	3.5	3.7	4.0

The national target for energy supply is as ambitious as the GHG emission reduction targets; by the middle of this century, power supply shall be met by at least 80% renewables compared to the 80% fossil energy carriers today. In 2011, the Federal Cabinet approved a legislative package for a nuclear phase out until 2022. Gross power generation from renewables in 2011 has reached a share of 20%, including sources like wind, hydro, solar, and biomass. In addition, by 2050, urban road transportation should be fueled predominantly by renewables.

The German Federal Government focuses on support of research for marketable products. Currently there are no additional incentives for EV buyers. However, battery electric vehicle (BEV) owners are exempt from the motor vehicle tax for a period of five years.

19.3 Research

The research strategy of the German Government is diversified and focuses on various key areas of electromobility. The German economic stimulus package ("Konjunkturpaket II", implemented in January 2009) is a joint initiative of the Federal Ministry of Economics and Technology (BMWi), the Ministry of Education and Research (BMBF), the Ministry of Transport, Building and Urban Development (BMVBS) and the Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) and ended in 2011. For 2012 and 2013, the German Government announced that it would support research and development (R&D) at the level of a further € 1 billion (US$1.39 billion). Table 19.2 shows the research programs and corresponding funding ministries.

A majority of research funds are targeted to industry-led development projects to ensure market-oriented research and development in this area. The research programs are organized as public/private partnerships where industry is typically funded by up to 50% of the eligible costs.

Table 19.2 Overview of 2011 calls for proposals of German national research programs related to electromobility.

Program	Funding ministries	Characteristic topics
▪Flexible technologies for series production of electric drives for vehicles	▪BMBF	▪Electric motors, mechatronic systems, contacting technologies power electronics, system integration
▪Energy efficient and safe electromobility (STROM2)	▪BMBF	▪Energy and thermo management ▪Safety concepts
▪ELEKTRO-POWER "Positioning of the new value chain"	▪BMWi	▪Integration of new value chains ▪Integration in and improvement of production lines
▪ICT for electromobility	▪BMWi	▪Smart car, smart grid, smart traffic ▪Architectures, concepts, plug&play ▪Integration in model regions
▪"Electromobility"	▪BMU	▪Field trails ▪Ecological aspects
▪Electromobility showcases	▪Federal government	▪Systems approach ▪Critical mass

21.4 Industry

Automakers

Currently, all German car manufacturers develop and test electric vehicles. To date, all companies have introduced (full) hybrid electric vehicles (HEVs) into their portfolios. Despite the initiated research programs, there has been no single all-electric vehicle that is available to the consumer mass market yet. Table 19.3 presents examples of major activities of German car manufacturers.

Table 19.3 Examples of major activities of German car manufacturers in the field of HEVs and EVs.

German OEM[1]	Characteristics
Daimler AG	• Current test fleets are based on the Smart ED (BEV)[2], the E-Cell (BEV), the E-Cell-Plus (EREV) , and the F-Cell (FCV)[4]. • 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 to produce its batteries in Germany through Evonik. • Has the most activities in fuel cell vehicles amongst all German automakers. • Joint venture with Bosch for the production of electric motors.
BMW	• Developing the i3 as the first mass-produced BEV with a carbon fiber chassis (CFC), scheduled to enter the market in 2013. See figure 19.1. • Involved in a fleet test with the Mini E and the 1 series ActiveE (both BEVs). • Strategic cooperation with SB LiMotive (a joint company of Samsung and Bosch) for the production of lithium-ion batteries.
Volkswagen	• 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, which are currently available for the A8 and Q-models. Audi's all-electric vehicles focus on sports cars and small vehicles. • Mass market introductions of Audi's 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.

[1] OEM: Original equipment manufacturer
[2] BEV: Battery electric vehicle
[3] EREV: Extended range electric vehicle
[4] FCV: Fuel cell vehicle

Fig. 19.1 The BMW i3 was unveiled at the 2011 Frankfurt Motor Show, and will be BMW's first zero-emissions mass-produced vehicle in 2013. (Photo courtesy of BMW Group.)

Suppliers

The German automotive supplier industry offers a broad portfolio of technologies for electrified vehicle concepts, covering all aspects of the car. Table 19.4 shows two representative examples of this industry.

Table 19.4 Examples of German suppliers' key activities in the fields of HEVs and EVs.

German Suppliers	Characteristics
Bosch	• Produces systems and components for all levels of hybridization. Invests €400 million (US$560 million) per year into electromobility-related technologies. • 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. • Involved in 20 series projects for 12 different OEMs through 2013.
Continental	• Integrated supplier of key components for the electric drivetrain, focusing on hybrids. • Product range includes e-motors, batteries, software, power electronics, as well as gears and couplings. • Produced the first lithium-ion battery for a series hybrid, the Mercedes S-400H.

19.5 Charging infrastructure

In 2009, the Federal Government started eight "electromobility model regions" across Germany: Berlin/Potsdam, Hamburg, Bremen/Oldenburg, Rhein-Ruhr, Sachsen, Rhein-Main, Stuttgart, and Munich. The objective of the model regions was the connection of application-oriented research with customer-focused daily use of electric vehicles. Table 19.5 shows the number of vehicles in each region at the end of 2011.

Table 19.5 Types of electric vehicles in the eight model regions around Germany at the end of the projects in 2011. (Source: NOW GmbH.)

Cars	Scooters	Hybrid electric buses	Utility vehicles	Pedelecs
881	693	59	243	600

The plan was for 1,100 charging stations to be installed and 2,350 electric vehicles to be on the road by the end of 2011. Table 19.6 summarizes the current status of implementation across these model regions, which shows that the anticipated plans have been exceeded.

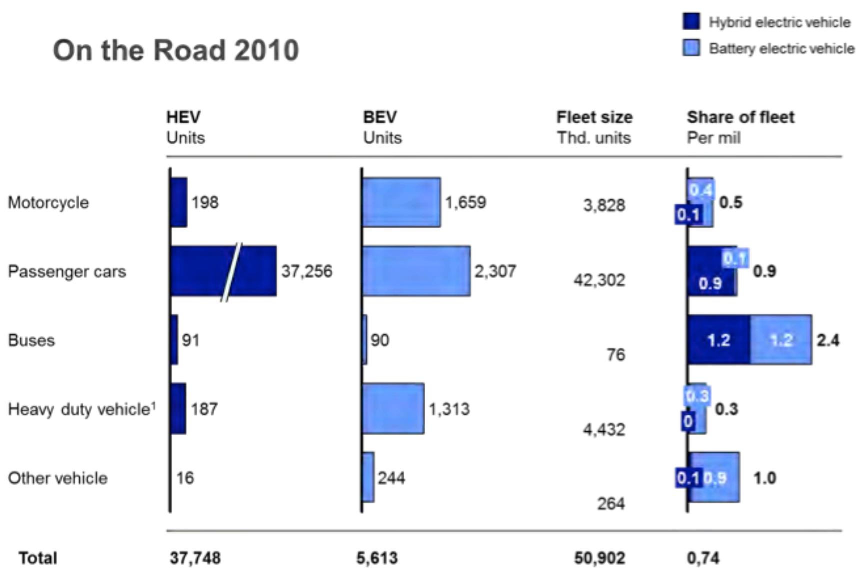
Table 19.6 Charging points installed in the eight model regions around Germany at the end of the project in 2011. (Source: NOW GmbH.)

Public	Semi-public	Private	Total
836	488	613	1937

The program budget of € 115 million (US$160 million) is split across the eight model regions in 220 projects. The funding from the Konjunkturpaket II (stimulus package) was terminated by the end of the year 2011. The continuation of the model regions in "showcases" (proposed by the NPE) is currently under discussion.

19.6 On the road and EV deployments

The numbers of hybrid and electric vehicles on German roads as of the start of 2011 are shown graphically in figure 19.2 below. These quantities are also listed numerically in table 19.7. All figures are based on registration counts.



[1] including semi-trailer trucks

Figure 19.2 Population of the German motorized vehicle fleet as of January 1, 2011. (Source: Kraftfahrt Bundesamt, annual report 2010.)

Table 19.7 Population of the German motorized vehicle fleet as of January 1, 2011. (Source: Kraftfahrt Bundesamt, annual report 2010.)

	Per January 1, 2011		
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

19.7 Outlook

In its 2011 report, NPE calls electromobility an opportunity as well as a challenge, for further enhancing Germany's position as a leading location for industry, science, and technology. Efforts to be undertaken are worthwhile; electromobility has a potential of creating about 30,000 additional jobs through 2020, according to NPE. The report also states that German industry is expected to invest around € 17 billion (US$24 billion) into electromobility R&D to prepare it for the market. NPE suggests three phases of support and market introduction in order to establish Germany as a leading market and to reach the target of one million electric cars on the roads by 2020:

1. **Preparatory stage, until 2014** — focus on R&D plus showcase projects,
2. **Ramp-up of market, until 2017** — focus on vehicles and infrastructure, and
3. **Start of mass market, until 2020** — roll-out with sustainable business models.

In 2012, many new results and real-world applications from on-going R&D and demonstration projects can be expected in Germany. The launch of new R&D and showcase projects is expected during the course of the year. There have been 23 applications received for showcase projects as of the beginning of 2012. Up to four showcases will be selected by the Government and launched in the first half of 2012.

20 Ireland

20.1 Introduction

The Republic of Ireland is a relatively small island country in area and has access to one of the best wind and ocean energy resources available in the world—the Atlantic Ocean. Although the country has no oil production, there are some natural gas resources. There is no significant motor manufacturing industry present in the country; therefore, Ireland's primary interest in promoting electric vehicles (EVs) is to capitalize on the environmental, energy efficiency, and renewable supply benefits the technology offers.

20.2 Policies and legislation

Highlights of policy- and legislation-related goals include the following:

- Ten percent (10%) of all passenger cars will be electric by 2020.
- The mandatory European Union (EU) Renewable Energy Supply Target (RES-T) legislation requires that 10% of all transport fuels will be renewable by 2020, which includes the gearing of renewable electricity content in EVs to reflect primary energy equivalence.
- A € 5,000 (US$6,609) grant for plug-in hybrid EVs (PHEVs) and battery EVs (BEVs) is currently available.
- Relief from paying the Vehicle Registration Tax is available in the amounts of € 5,000 (US$6,609) for BEVs and € 2,500 (US$3,305) for PHEVs.
- Accelerated Capital Allowances are available to companies purchasing EVs.
- A Charge Point Infrastructure program to install 1,500 on-street chargers and 30 fast chargers by the end of 2012 is under way.
- An EV Customer Billing and Information Technology (IT) system that interfaces with existing electricity market regulations is presently undergoing testing; it will enable customers to have access to all electricity suppliers.
- The parliament is currently considering new legislation that will enable Local Authorities to designate on-street parking spaces and charging point infrastructure as being for the exclusive use of electric vehicles.

20.3 Research

In December 2011, Ireland's Electric Vehicle 2050 Roadmap launch was attended by International Energy Agency (IEA) representatives, including Deputy Executive Director Richard Jones. The Roadmap indicated that the size of Ireland's passenger fleet could rise by 60% to 2.9 million vehicles. If it is assumed that 70% of Ireland's car stock is electric by 2050, the country's import of fossil fuels could drop by 50%, with resulting reductions in CO_2 of 80%.

This analysis excludes the use of biofuels, biomass, or natural gas–powered vehicles. The only renewable content is provided by accessible wind power.

The following list provides a selection of EV-related research activities currently under way in Ireland:

- **Aran Islands All-Electric Study and Trial**. The Sustainable Energy Authority of Ireland (SEAI) is currently investigating the opportunities offered by electrifying heat and transport loads by focusing on the Aran Islands in the west of the country (figure 20.1). The results of this work will be published in 2012, but early results indicate that fossil fuel imports to the islands could be reduced by 85%. Electrification of energy demand produces these benefits because EVs and heat pumps provide inherent energy efficiency gains. More significantly, however, their storage mechanisms enable enhanced utilization of wind and ocean power, resulting in a geared reduction of imported fossil fuels. A small trial of electric vehicles on the islands has confirmed energy cost savings of up to 80% for residents.
- **Electricity Supply Board (ESB) EV field trials** involve 15 Mitsubishi iMiEVs and three Nissan Leafs. In Phase 1, these were driven by ESB staff. Phase 2 (which starts in the first quarter of 2012) will involve members of the public in the trial. The iMiEVs are fitted with data loggers taking information from the vehicle Canbus, while the participant's home EV supply equipment (EVSE) circuit is fitted with a smart meter. In the case of the Leafs, the data are obtained from Nissan's "Car Wings" system. The vehicles are being tested in both private and commercial trials, including trials with a taxi company (figure 20.1).
- **The Charging Profile project** involves monitoring the electrical characteristics and charging profile of each type of vehicle and (separately) of each type of off-board (DC Fast Charger). Measurements include current, voltage, power, power factor, and resulting harmonics.
- **The Electric Power Research Institute (EPRI) Smart Grid project** is carried out in coordination with other utilities and EPRI. The Irish program involves four separate projects. One of these is focused on assessing the impact that an increasing number of electric vehicles will have on the distribution grid and measuring the point at which constraints emerge.
- In addition to this work, Irish companies and institutions are also partnering in the following projects across Europe:
  - **MERGE** (Mobile Energy Resources for Grids of electricity),
  - **FINSENY** (Future Internet for Smart Energy),
  - **Green eMotion**,
  - **MOBI Europe**,

- **Enevate**, and
- **Batterie** (an Atlantic Region of Europe project with 14 partners). Its aim is to explore the alternative fuel initiatives and their interoperability in the European Atlantic Region.

Fig. 20.1 Aran Islands EV Trial (left) and ESB Field Trials (right). Photos courtesy of SEAI (left) and ESB ecars (right).

20.4 Industry

A coordinated suite of IT systems is being developed by ESB ecars to support the EV charging market. The system includes an open architecture Charge Point Management system, which facilitates multiple suppliers of charge posts and market models (e.g., spot market, retail, landlord, etc.).

ESB ecars is working with Intel, SAP, Renault, and M2C (an Irish start-up) on developing a Smart Home charger. This is a “context aware” regime that learns and adapts to the customer’s lifestyle. Subject to the customer’s requirements and full override capability, it can control the charge based on inputs from wind generation (real or forecast), real-time electricity prices, electronic diary data on planned trips, weather, and battery state of charge.

A number of companies are already developing products for the emerging EV charging market. Some of these include portable chargers for emergency breakdown, test equipment for earth-loop impedance testing of Mode 3 installations, and apartment block charging systems, as well as a variety of public and home charging equipment.

20.5 Charging infrastructure

The following charging infrastructure was installed in the Republic of Ireland by the end of 2011 (figure 20.2):

- 100 home chargers (16A 230V AC Mode 3 dedicated circuit),
- 120 public chargers (32A 400V AC Mode 3), and
- 25 fast chargers (50kW DC CHAdeMO).

Although no AC fast chargers (63A 400V AC Mode 3) have been installed yet, it is expected that they will be installed when the first 3-phase car arrives—the Renault Zoe, which is expected in the fourth quarter of 2012.

In Northern Ireland, the eCar Project (which receives funding under the UK Plugged-In Places scheme) is installing 160 home chargers, 140 public chargers, and 5 DC fast chargers. Although contracts have been awarded, nothing had been installed as of the end of 2011. ESB ecars is on the project management team, and the one-charge-point management system will operate across both the Republic and Northern Ireland, allowing roaming with two different currencies. This project is one of the first to demonstrate cross-border functionality for EV infrastructure and payment mechanisms.

Fig. 20.2 Currently available charge points. (See http://www.esb.ie/electric-cars/electric-car-charging/electric-car-charge-point-map.jsp.)

20.6 On the road and EV deployments

Table 20.1 below indicates the number of EVs and HEVs registered in Ireland at the end of 2010. Since that time, a range of vehicle trials in 2011 has increased the number of electric vehicles by approximately 40 vehicles. In addition to this figure, the national Electric Vehicle grant program began in April 2011 with 43 electric vehicles registered in the country. These two programs yielded an estimated 83 new EVs registered in Ireland for 2011.

Table 20.1 Number of vehicles in Ireland at the end of 2010.

	PER DECEMBER 31, 2010		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs & HEVs)**
Bicycles (no driver's license)	n/a	n/a	n/a
Motorbikes	61	0	38,145
Passenger vehicles	44	5,325	1,952,522
Multipurpose passenger vehicles	26	2	308,215
Buses	0	1	9,935
Trucks	0	0	30,471
Industrial vehicles	31	0	77,099
Total	**162**	**5,328**	**2,416,387**

20.7 Outlook

As stated in Section 20.2, Ireland's target is to ensure that 10% of the vehicle fleet is electric by 2020. This aggressive goal equates to having approximately 220,000 BEVs and PHEVs registered in Ireland by this time. Achieving this stock target would mean that these types of vehicles must comprise 42% of all annual passenger car sales by that year.

In 2011, there were only two series production types of EVs available (from Nissan and Mitsubishi) that had full EU Whole Vehicle Type approval and were included in the grant awards program. In 2012, Renault and Citroen models are now available, with Peugeot, GM, and Toyota vehicles expected to arrive on the Irish market later in the year. This availability will greatly increase the amount of market activity and interest in EVs from consumers.

Legislation is currently passing through the Irish Parliament that will provide powers to local authorities to designate and reserve parking spaces exclusively for BEVs and PHEVs. It is expected that the majority of vehicle-charging infrastructure work will be completed by mid-2012, providing a high degree of confidence to potential EV customers.

To date, cooperation across all government departments and agencies has been good and has helped us reach this point. The economic recession, however, is limiting resources and funding in many areas. It is hoped that despite this set of circumstances, positive strides will continue to be made to the betterment of the EV market in Ireland.

21 Italy

21.1 Introduction

The introduction of electric vehicles (EVs) and hybrid EVs (HEVs) to Italy has been driven by a series of various environmental control actions and the increasing share of renewable energy sources within a substantially modified energy mix. Together, these actions and the energy mix aim to address common European Union targets of bringing about a large reduction in CO_2 emissions from the transport sector by 2020.

The central government, regulatory bodies, and local authorities (regional and municipal) are proposing and discussing new legislation, regulations, and supporting measures to help 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 overall greenhouse gas (GHG) emissions. In 2011, some dedicated initiatives to procure cleaner vehicles at the central government level were delayed by the international economic crisis.

21.2 Policies and legislation

Different types of initiatives are supporting the introduction of H&EVs (HEVs and EVs) into Italy, including legislation, regulations, standards, promotions, and demonstrations (Table 21.1).

Table 21.1 Summary of policy instruments regarding H&EVs currently in effect in Italy.

	Policy Instrument
Legislation	No legislation that specifically supports the uptake of EVs and HEVs is currently in place.
Regulation	The Italian Authority for Electrical Energy and Gas (AEEG) proposed new regulations to define rules for providing transmission, dispatch, distribution, and electrical energy measurement services for each EV charging point. These rules are under practical tests in six pilot demonstration projects that started in 2011.
Standardization	• CUNA (Commissione Tecnica di Unificazione nell'Autoveicolo) continued providing support to standards definition for EVs, HEVs, and battery modules and systems at the ISO (International Organization for Standardization) level. • The Italian electrotechnical standardization body (CEI) is for the battery cell and charging stations at the CENELEC (the European Committee for Electrotechnical Standardization) and International Electrotechnical Commission level.
Financial Incentives	Financial support for the purchase of EVs and the creation of dedicated charging infrastructure started in a variety of municipalities, often in conjunction with the definition of promotional and protective measures to limit or ban the circulation of additional polluting vehicles.

21.3 Research

During 2011, Italian organizations remained significantly involved in European Union (EU)-level research projects on EVs and HEVs, and, to a lesser extent, on fuel cell vehicles (FCVs). Many Italian research organizations and industries participated in research and demonstration projects of these electrically propelled vehicles and related technologies: HCVs, (hybrid heavy–duty vehicles, urban buses, and commercial vans); HELIOS, (comparison of different lithium-ion battery technologies for pure electric and plug-in HEVs); Hi-CEPS (different drivetrains for HEVs); Greenlion (eco-manufacturing processes for lithium-ion batteries); and Zero Regio (demonstration of small fleets of FCVs and related refuelling infrastructure in Germany and in Italy). The EU Framework Program 7 (FP7) has concentrated on various EV- and HEV-related activities, including evaluation of the impacts on the electricity grid.

In national programs, the research programs and projects with a major focus on EV and HEV technologies and applications continued, while FCV research and demonstration (R&D) activity was substantially reduced. EV and HEV R&D activities remained part of some national programs, which only partially address H&EVs. The national program “Research for the Electrical System” continued with increased focus and resources on electric mobility.

A not-for-profit legal organization was created at the end of 2011 as an offshoot of the National Platform for the Electric Mobility, which was started in 2010 to coordinate and implement a national research plan on electric mobility.

The INDUSTRY 2015 project, launched in 2008 with a public fund of about € 180 million (US$234 million) to promote industrial innovations, became operational in 2010. In 2011, the 29 projects receiving three-year grants produced their first (and interesting) results in different fields, with a clear focus on a variety of technologies in the transport sector, including the electrification of vehicles of different sizes, ranging from two-wheel vehicles up to public transport buses.

Projects funded in the private sector total more than € 60 million (US$78 million). The LIVE project, coordinated by heavy-duty vehicle maker IVECO, involves the development of light-duty transport vehicles with different drivetrains, including a hybrid version. The total budget is close to € 31 million (US$40.3 million). The € 12 million (US$15.6 million) Zerofilobus project, coordinated by heavy-duty vehicle manufacturer Breda Menarini, aims to create a public transport system wherein electric buses are charged at stations during each temporary stop using fast storage systems (supercapacitors or high-power batteries). Finally, the € 21 million (US$ 27.3

million) MUSS project, coordinated by Piaggio, one of the leading manufacturers of scooters and motorbikes, aims to develop clean and safe small vehicles by using electric and hybrid drivetrains.

21.4 Industry

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, even if the lack of public incentives, as has been the case in the last two years, has created serious problems. Heavy-duty vehicle manufacturers (Breda Menarini, Piaggio, Cacciamali, and IVECO) introduced innovations, such as a hybrid drivetrain, to some projects. Most carmakers, not Italian producers, announced commercialization plans for the end of the year and the beginning of 2012.

21.5 Charging infrastructure

Italy is seeing a growing number of initiatives aimed at developing and promoting 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, as discussed in the Research section.
- 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.

Through the action of local initiatives, more than 2,000 charging points are estimated to have been built already or are under construction in Italy. A partial list of projects may be found in Table 21.2 on the following page.

Table 21.2 Examples of charging networks in Italy. (Source: ENEA.)

City/ Project	Number of vehicles	Number of Charging points	Aim of infrastructure
Milano	-----	400+	Various, through E-Mobility and E-Moving Projects
Brescia		70	Real world study, through
Bari		(100)	E-Moving Project
Florence		500+ since 1997	Smart City EU Project
Imola	70	To be determined	EV promotion
Modena	70	To be determined	EV promotion – Mi Muovo Elettrico
Pisa	100+	50	EV, infrastructure, and business model testing, through E-Mobility Project
Reggio Emilia/ REZIPE	322+	100	EV promotion – Mi Muovo Elettrico
Roma	100+	200+	Various, including E-Mobility Project

The E-Mobility Project, involving both ENEL and Daimler, has increased the initial demonstration fleet from 100 to 140 EVs and was financially supported by the Italian Electric Energy and Gas Authority for experimentally demonstrating a specific business model for a large charging infrastructure. Similarly, the project E-Moving was also awarded a similar grant, a collaboration between an electric utility, A2A, and the carmaker Renault that also demonstrates a charging infrastructure and service for EVs in two cities of differing size.

21.6 On the road and EV deployments

Figure 21.1 shows sales of EVs and HEVs from 2005 through 2011. Table 21.3 shows characteristics and statistics about the Italian vehicle fleet as of December 31, 2010.

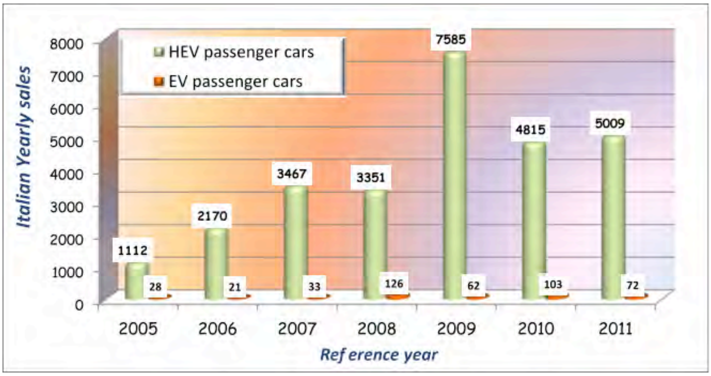


Fig. 21.1 EV and HEV passenger car sales in Italy in recent years. (Chart supplied by ENEA.)

Table 21.3 Characteristics and population of the Italian motorized vehicle fleet through December 31, 2010.

	Per December 31, 2010		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs and HEVs)**
Motorized bicycles (no driver's license)	180,000*		180,000*
Motorbikes	41,000		9,829,928**
Passenger vehicles	404	27,159	36,751,711
Multipurpose passenger vehicles	9,000		656,880
Buses	950	300	99,895
Trucks			3,983,502
Industrial vehicles			871,388***
Total	**231,354**	**27,459**	**52,373,304**

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 2010 showed an increase in the total number of H&EVs on Italian roads as compared with the 2009 figure (about 259,000 versus 247,000 vehicles). However, the market share of HEV passenger cars has remained negligible in Italy as compared with other countries, but simultaneously has been almost the only market to increase in 2011 in relation to the significant reduction of the overall market. Many H&EVs were still purchased mostly by fleet users, such as public service utilities. For the two-wheel vehicle categories, the situation remained critical, with a further reduction in sales of mopeds/scooters of more than 17%.

21.7 Outlook

The government is considering important legislative measures to support H&EVs and is formally committed by the European Union targets for CO_2 emissions reductions and increased use of alternative fuels. Other positive signals for H&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. These are also expectations that some support measures, such as INDUSTRY 2015, will start yielding results within the next few years. However, the international economic crisis in which Italy is strongly involved makes less clear and positive the outlook for the short term for a large increase in market share for H&EVs to occur, even considering the exceptional growth of electrical energy produced by renewable energy sources.

In conclusion, the market for H&EVs (and even plug-in HEVs) is estimated to grow more significantly when the economic situation becomes more stable and under control, with the prospect for more vehicles and new batteries becoming available after 2013–2014.

22 The Netherlands

22.1 Introduction

The Dutch government's vision for sustainable mobility can only be realized by simultaneously approaching economic, social, environmental, and climate issues. To this end, a second national Action Plan for Electric Driving 2011–2015 was implemented: Electric Mobility gets up to speed. Encouraging the electrification of transport should be continued to:

- Reinforce the economic position of the Netherlands,
- Help conserve the Netherlands' energy reserves, and
- Contribute to environmental goals.

The Dutch Government has ongoing policies and legislation for reducing carbon dioxide (CO_2) and nitrogen oxide (NOx) emissions and improving air quality. CO_2 reduction targets correspond with the European Union (EU) level of 20% reduction in 2020 vs. 1990.

22.2 Policies and legislation

Action Plan for Electric Driving

The central government contributed up to € 65 million (US$85 million) to support electric driving, which was implemented in 2009 by the first Action Plan. Additionally, the government welcomes efforts by market parties, social organizations, and local and regional authorities that will multiply the initial government investment. The government expects that the combined contributions will stimulate about € 500 million (US$655 million) in expenditures for electric driving.

Legislation and taxes

Special tax rules are in place for electric vehicles (EVs) and hybrid electric vehicles (HEVs). EVs are exempt from the registration tax and from the yearly road tax. Fuel cell electric vehicles (FCEVs) follow the same ruling.

For leased cars, an income tax measure makes EVs and HEVs attractive. A normal tariff of 25% of a leased car's value that is added to the yearly income tax is eliminated for zero-emission vehicles (less than 50 g CO_2 /km) or will be 14% or 20 % according to the fuel type and CO_2 emissions if the cars are fuel-efficient. Plug-in hybrid electric vehicles (PHEVs) will be treated as EVs. These privileges will be effective over a substantial period of time but criteria will be made tighter in coming years to keep pressure to improve emission performance

22.3 Research

The Netherlands has several automotive and energy research institutes, most of which 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. These include:

- 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 of the Netherlands), Petten

In 2011, the Dutch government launched a “Top Sector” policy as the new approach of stimulating industry, with automotive as a part of the Top Sector High Tech. A new program was launched, empowered by the Department of Economic Affairs, Agriculture, and Innovation, under the name of Automotive NL. This will act as a central platform for innovative action as a result of cooperation between industry, education, research, and policymaking partners.

For demonstration purposes, the government ran a subsidy program with a budget of €10 million (US$13 million) in the first quarter of 2010. Nine demonstration projects for testing a total of 231 battery electric vehicles (BEVs) and PHEVs in a number of applications have been running from 2010 to 2012. The results in 2011 indicated that the projects took off, except for the distribution-oriented projects, due to the poor supply of suitable distribution vehicles.

Since its start, the Action Plan granted about € 18.5 million (US$24 million) through a consortium of stakeholders facilitated by the government. The consortium also organized a “Battery Day”, with 300 participants from the Netherlands and abroad. The event coincided with the opening of the European Electric Mobility Center EEMC testing facility for EVs and batteries. Again the Action Plan was a main catalyst, contributing € 1.3 million (US$1.7 million) to the foundation. Another € 5 million (US$6.5 million) is being kept in reserve for future FCEV projects, possibly with an emphasis on hydrogen infrastructure.

Most programs are executed by NL Agency, which is part of the Department of Economic Affairs, Agriculture, and Innovation. The NL Agency executes programs on innovation, sustainability, and international business and cooperation for government organizations.

22.4 Industry

Dutch industry in the EV/HEV field, including potential parties, consists of:

- DAF Trucks N.V. (subsidiary of PACCAR, Inc.)
- APTS BV (subsidiary of VDL; manufacturer of Phileas hybrid buses)
- Spijkstaal (EV-manufacturer)
- B-Style & BUSiness BV (FCEV midibus) (see figure 22.1)
- Various manufacturers of automotive components
- Ecars Europe (importer and distributor of various electric vehicles)
- E-traction (electric hub engines)
- Epyon BV (AC/DC fast charging infrastructure; subsidiary of ABB Ltd, Switzerland)
- NedStack (PEM fuel cell stacks)
- SilentMotorCompany (integrated fuel cell units)
- HyGear (Hydrogen generators and on-site processing equipment)
- Various others, focusing on fuel cell (FC) buses, trucks or conversions ("integrators")

Next to these first-line businesses, a number of specialized consultants are working in the field. The new mobility concepts also pave the way for new supporting organizations such as those that procure cars, or those that provide charging points, services, and/or battery-monitoring businesses, or packages of these services.

Fig. 22.1 2011 Busworld Innovation Award winner: B-Style FCEV Midibus. (Photo courtesy of B-Style & BUSiness.)

22.5 Charging infrastructure

The former Action Plan for Electric Driving has helped to spur actions that relate to building a charging infrastructure in the Netherlands. It helped to have the most important stakeholders have a charging station plug standard that is the same as in Belgium, Denmark, Germany, and Sweden. Interoperability proceeded at both the national and international levels, with various suppliers of charging stations and energy agreeing upon a charging pass that can be used at all stations within the country, and in a small number of stations abroad; cross-border interoperability received more attention recently. Finally, fiscal grants have been created for companies that invest in charging stations.

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 (budgeted at € 25 million, or US$33 million) 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 and 8,000 charging spots requested by EV drivers (through a dealer organization). As of December 2011, a total of 1,000 charging points had been established. In the future, charging spots will be installed at a slower rate than in 2011.

Fig. 22.2 Charging facilities are becoming part of the scene in Amsterdam. (Photo courtesy of the NL Agency.)

Overall, a total of 2,525 charging points were installed across the Netherlands by the end of 2011, half of which are fully public, 600 are semi-public and 700 are private. The 2011 target of 1,000 non-private charging-points was well exceeded.

Fourteen quick-charging installations were also available, all public or semi-public. By the end of 2011, 459 quick-charging stations were commissioned for highway locations; thus, covering all main transport routes. All will be privately funded.

22.6 On the road and EV deployments

At the provincial level, Noord-Brabant has a budget of € 10 million (US$13 million) for the development of electric mobility. This province significantly hosts the majority of Dutch automotive businesses as well as research & development (R&D) institutions. Moreover, as a part of a sustainable mobility program, the Province of Friesland will support the acquisition of 10,000 electric vehicles, including scooters.

Internationally, 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. The first projects have started. Benefits should be spread among the automotive industry, engineering, safety, and infrastructure topics. The Netherlands also 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 million (US$ 26 million) of public funding. European countries such as Denmark, France, and Germany have been visited. Best practices have been exchanged and further cooperation between cities has been explored. Cooperation also is the keyword for participation in ENEVATE, Green e-motion, and EVI initiatives.

The starting guide for electric transport for municipalities has been made available in English, so others have access to the information too, and can make their own version if they wish. The guide can be downloaded from the IA-HEV Web site or requested from the NL Agency.

The vehicle park (in-use population) in the Netherlands is shown in Table 22.1. Car density is one car per 2.3 inhabitants.

Table 22.1 Characteristics and population of the Dutch motorized vehicle fleet as of December 31, 2010 and 2011 (in cooperation with RDC and VWE; figures partly estimated).

	December 31, 2010			December 31, 2011		
Vehicle Type	**EV Fleet**	**HEV Fleet**	**Total Fleet**	**EV Fleet**	**HEV Fleet**	**Total Fleet**
Motorized bicycle (no drivers licence)	611,000*	0	18,600,000***	800,000**	0	19,000,000***
Motorbike	0	0	680,000	96	1	690,000
Passenger vehicle	238	57,000	8,003,000	1,124	71,937	8,597,000
Multipurpose passenger vehicle	Included in passenger vehicle totals					
Bus[1]	64	41	11,600	91	40	12,000
Truck, van and minibus[2]	63	0	1,120,000	22/164	14/0	1,130,000
Industrial vehicle	2	1	n.a.	2	1	n.a.
Total (round figures)	**611,000**	**57,000**	**28,415,000**	**800,000**	**72,000**	**29,430,000**

* : includes 15,000 electric scooters (no driver's license needed)

**: includes 19,646 electric scooters (no driver's license needed)

***: including human powered bikes, reference to power assisted bikes included in EV fleet

n.a. = not available

Definitions of vehicles in Section D of this report, chapter on Vehicle Categories.

Hydrogen vehicles include 1 passenger car, 2 trucks and vans, 1 minibus and 1 bus as per December 31, 2011.

About 1,700 BEVs were in service as of December 2011, mainly passenger cars and utility vehicles (i.e., EVs that require a license plate to be used on public roads).

Electric bicycles took up 20% of the Dutch bicycle market in 2011. Various makes and models of electric bicycles are available, of which the power-assist type (assistance supplied only when the rider is pedaling) is the most popular. Public charging points for bicycle batteries are wide-spread. A number of municipalities are subsidizing the electric scooter in an attempt to replace sales of noisy and polluting internal combustion-engine versions.

Hybrid buses and commercial transport vehicles are not commercially available in the Netherlands. As such, their numbers are negligible in the current truck and bus stock. Industry is making progress in developing the vehicles, and the national Action Plan for Electric Driving offers fiscal grants for companies that invest in EVs for commercial transport. A HEV DAF truck was announced in 2010, and DAF is introducing this 12-ton LF hybrid distribution truck to select markets now. Under the "Truck for the Future" scheme, the purchase and exploitation of hybrid trucks on a project base has received incentives in 2011. Beneficiary distribution trucks are Mercedes Atego and Volvo FE hybrids, in two projects.

Green Deals

Green Deals are the "new style" governmental support, in which facilitating assistance replaces financial instruments. A wide range of stakeholders is working at electric vehicle roll-outs, aiming at 20,000 cars (in fleets) in 2015. This makes infrastructure investments attractive and should lead to 20,000 regular and 100 fast-charging points. Because of their large-scale base, the five Green Deals for electric transport can encompass public transport, city sanitation, and special personal transport as well as private transport of passengers and cargo.

Quota EV

By showing the zest of Dutch EV deployment to several major EV providers, the Netherlands is now ranking higher on manufacturers' shipping lists. For instance, this has led to the Dutch market ranking in second place for Opel Ampera supply, second only to the German home market.

EV Safety

The following results were reported by a working group that was tasked with creating guidelines about EV on safety issues in 2011:

- Established legal requirements for road approval of EVs and HEVs that are built in small series.
- Required certification of trained EV mechanics.
- Standardization of operating procedures for first responders and road patrolmen is in progress.
- A number of driving schools offer a one-hour EV driving lesson to every student.

22.7 Outlook

The introduction of new hybrid cars in the Dutch market is continuing. Especially in urban areas, the call for zero-emission and noise-reduced vehicles has led to measures which now focus on clean fossil fuel vehicles, but should also be interpreted as a welcome sign to all kinds of EVs. These policies are strongly backed and facilitated by the national and local governments, and their support will be sustained over a longer period of time. With EV sales figures approaching four-digits and HEV sales figures already in the five-digits, the next "news" will be the introduction of the PHEVs, in 2012. Because the mean commuting distance in the Netherlands is less than 20 km (12 miles) one-way, the PHEV represents a good answer to Dutch commuter transportation needs. Thus, a PHEV with an all-electric range of 40 km (25 miles) would supply enough electric energy for most commuting and short trips in cities in the Netherlands.

Government support in the meantime makes financial benefits for EVs, HEVs, and PHEVs converge towards the very fuel-efficient smaller petrol and diesel cars, narrowing the gap, but hopefully not reducing the attractiveness of the EV family of cars. A "realistic" scenario aims at 200,000 cars in the total park for 2020.

23 Portugal

23.1 Introduction

Portugal is pursuing an integrated strategy for electric vehicles (EVs) to ensure that they are a viable transportation option in its major cities. Portugal currently has approximately 2,500 hybrid electric vehicles (HEVs) on the road, but the national policy focus has switched to pure electric vehicles (EVs). A public network with national coverage, including 1,350 charging points in the 25 main cities and roads, is being implemented to allow EV users to have the ability to travel throughout the country.

23.2 Policies and legislation

MOBI.E Electric Mobility Model

MOBI.E

In early 2008, the Portuguese Government launched a national program for electric mobility, aimed at creating an innovative 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. It is the first charging network in the world that has national coverage. The MOBI.E electric mobility model, developed by INTELI, a Portuguese think tank, is a fully integrated and totally interoperable system.

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 a 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 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:

1. **Electric Mobility Operator**: ***the physical interface*** — These are the entities that operate the charging points, making the charging service available to vehicle users and/or customers through the different electricity retailers. The

Operators are remunerated according to the electricity that runs through the infrastructure maintained by them.

2. **Electricity Retailer**: ***the arena for competition*** — These are the entities supplying and selling electricity (through the charging points managed by Operators). Also, this is where the market is open to competition. To differentiate from its competitors, every Retailer can set different electricity tariffs and enable access to associated services. Every EV user may have a contract with any Retailer (one or more).

3. **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 managing energy and financial flows from the network operations. The Managing Authority is a platform for the integrated management of electric mobility that is available to all Operators, Electricity Retailers, and Users.

Complementary legislation and incentives

The support for implementing a national mobility network based on the MOBI.E model is Portugal's key policy initiative related to electric vehicles. Under the coordination of the Office for Electric Mobility (GAMEP), established within the Portuguese Ministry of Economy with a 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 participants and their 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 Portuguese legislation, an EV is defined as a vehicle that can be plugged into the grid. However, incentives as outlined in Box 23.1 are restricted to fully electric vehicles — plug-in hybrid electric vehicles (PHEVs) are not included — to maximize the measures' effectiveness and impact.

BOX 23.1
INCENTIVES TARGETING EVS IN PORTUGAL

- Exemption of EVs from vehicle acquisition tax and circulation tax
- Corporate tax deduction for fleets that include EVs
- Mandatory installation of electric mobility charging infrastructure in the parking areas of new buildings, from 2010
- Special EV access to priority lanes and exclusive circulation areas (defined at city level)
- Preferential parking areas for EVs in urban centers
- Annual renewal of state and municipal fleets with 20% of EVs, from 2011 onwards
- Financing of pilot network infrastructure

23.3 Research

The main research focus in Portugal has been on developing an intelligent and integrated infrastructure to support the deployment of the MOBI.E network. This is the result of significant investments in research and development (R&D) by Portuguese companies and R&D organizations from the automotive, electric and electronics systems, information and communication technologies (ICT), and energy sectors. The technology solution includes the full integration of all information and energy flows and financial transactions (see figure 23.1).

The technology solution was developed starting in 2010 by a consortium led by the innovation center INTELI, 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); and the Centre for Excellence and Innovation in the Auto Industry (CEIIA). A pilot test phase for the consortium will be extended through 2012.

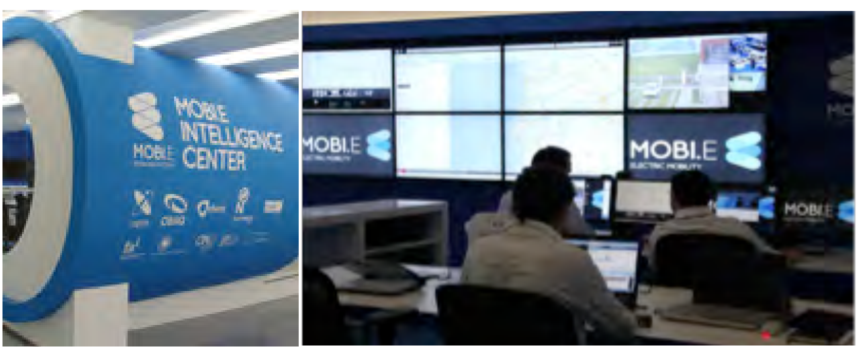


Fig. 23.1 The MOBI.E Intelligence Center in Maia in northern Portugal manages the EV charging network in real-time. (Source: MOBI.E)

Mobility Intelligence Center

A good example of the outcome of this research is the Mobility Intelligence Center, based in Maia, which is the MOBI.E network monitoring center. Here charging network managers and retailers have real-time access to all charging stations, with information about which are in use and which are available, daily and monthly charging averages, and power supplied.

Today, electric mobility is a core area for Portuguese R&D, and Portugal has many other research projects underway, as seen in Table 23.1. Among these, one of the first electric mobility demonstration projects in Europe, MOBI.Europe, aims at setting a framework for the standardization and openness of EV business and service approaches, integrating four electromobility initiatives in partner countries.

Table 23.1 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, fast, and home charging solutions and an ICT platform for full network management, both from an energy and a business perspective	INTELI, EFACEC, Critical Software, Novabase, CEIIA
MOBI.Europe	Pan-European research project focused on setting standard approaches for providing EV users with universal access to an interoperable charging infrastructure. The project will include the setup of energy-efficient mobility services through a seamless integration with transportation systems and with the EV ecosystem. It will establish the management interface between the EV infrastructure and the electric grid, benefiting from this information to create a more reliable and efficient end-to-end energy system.	INTELI, CEIIA, Critical Software
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 to electric vehicles; adoption of an evaluation suite of tools based on methods and programs enhanced to model, analyze, and optimize electric networks	INESC-Porto, among other international partners

Project Name	Short Description / Objectives	Main Entities Involved (in Portugal)
Green Islands Azores Project	Massachusetts Institute of Technology (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	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

23.4 Industry

In spite of not having a national car manufacturer, the Portuguese automotive cluster has attracted original equipment manufacturers (OEMs) as well as suppliers and component firms. Leading industry players such as Volkswagen (VW) and numerous suppliers such as Visteon, Delphi Automotive systems, Robert Bosch, Faurecia, Lear, and Johnson Controls are present in Portugal.

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 is a driving force 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 that are being installed. An industrial electric mobility cluster is well underway, involving some of the major industrial companies in Portugal that are developing products and solutions about electric mobility.

23.5 Charging infrastructure

Much of the structure of the MOBI.E program was explained in section 23.2. The initial phase of MOBI.E includes both building a nationwide recharging infrastructure and growing the domestic market for EVs, which began commercial sales in Portugal in 2011.

Fig. 23.2 MOBI.E vehicle electrification project includes installing charging stations in 25 municipalities and along main highways in its pilot phase as well as developing an 80-km range battery-electric vehicle, Mobicar, primarily aimed at the export market. (Source: MOBI.E)

Currently, there are two predominant types of charging stations:

- Normal charging stations: at home, for fleets, and on-street and off-street parking; and
- Fast charging stations: on main roads and highways, at service stations, and in strategic urban locations.

The nationwide pilot network included 976 recharging stations (968 normal and 8 fast chargers) for EVs spread across 25 cities as of the end of 2011.

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 (see figure 23.2). 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 locations) to be operated by charging point Operators (see section 23.2), who 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.

The charging infrastructure is expanding, with much enthusiasm from the majority of the municipalities. To achieve network coherence, national authorities require each municipality to submit to its local electromobility strategic plan.

23.6 On the road and EV deployments

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 total number of all vehicles in Portugal is represented in Table 23.2.

In terms of energy efficiency, Portugal has become the first country to meet European Union fuel-efficiency standards, which set a target for cutting average emissions from new cars to 130 g of CO_2/km by 2015. In fact, average car emissions in Portugal's new car market were 127.4 g of CO_2/km in 2010, the lowest in the European Union.

Table 23.2 Portugal's vehicle fleet.

Vehicle type	Total vehicle fleet including HEVs, PHEVs, and EVs (Total at end of 2010)	Number of EVs (Total at end of 2011)
Bicycle (no driver's license)	n.a.	n.a.
Motorbike	498,000	795
Quadricycles	n.a.	271
Passenger vehicle	4,515,500	233
Multipurpose passenger vehicle	n.a.	n.a.
Bus	15,600	22
Truck	1,337,000	13
Industrial vehicle	n.a.	n.a.

n.a.: Not available.

As a consequence of the direct incentive for EV acquisition of € 5,000 (US$6,600) for the first 5,000 vehicles (exclusively for individual private users), and the strong disincentive against internal combustion engine (ICE)-based vehicles in favor of EVs for company fleets, it is expected that the number of EVs on the road by the end of 2012 will be over 10,000 units. Two-wheelers will be one of the drivers for EV adoption with the deployment of specific charging solutions in some locations.

23.7 Outlook

The government estimates that Portugal could have roughly 200,000 EVs on the road 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, 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€ (US$396 million) in energy-import savings.

Starting with the setup of a unique legislation package that defines all the system architecture both at the business and technical levels, Portugal clearly advocates for the fast and formal adoption of common international standards for vehicles, charging infrastructure, and communication business protocols. Electromobility is perceived as a strategic sector to leverage for the medium-term economic success of the country.

24 Spain

24.1 Introduction

In 2011, Spain needed to import 74% of the total amount of primary energy it consumed. In this period, its specific budget for meeting its oil product needs (resulting from the commercial balance of crude and oil products) was close to € 40,000 million (US$52,800 million).

Spain's transportation sector especially depends on oil products; they account for 95.9% of its total energy consumption. Moreover, this sector accounts for about 65% of total oil product consumption in Spain. Thus, in order for the country to maintain a sustainable transport capability and economic growth, it needs to develop a national transportation energy efficiency program and to promote alternative technologies and alternative fuel vehicles.

Using electric vehicles (EVs) and hybrid EVs (HEVs) is a key way that Spain could improve energy efficiency, reduce CO_2 and pollutant emissions in metropolitan areas, and, in the case of plug-in HEVs (PHEVs) and battery EVs (BEVs), promote the use of indigenous sources of energy (35% of the electricity generated in Spain was produced from renewable sources in 2010).

Considering that Spain is already the second-largest car manufacturer in the European Union, and the largest manufacturer with regard to industrial vehicles, the country is also interested in promoting the industrialization of EVs and HEVs, along with their corresponding components, infrastructure, and recharging networks and systems.

24.2 Policies and legislation

Since 2003, Spain's policies to promote HEVs, PHEVs, and BEVs have been developed within the framework of its commitments to meet international goals. In consideration of these commitments, the *Spanish Strategy for Energy Savings and Efficiency 2004–2012* (E4) includes the promotion of alternative fuels and alternative vehicle technologies (liquefied petroleum gas [LPG], natural gas, HEV, PHEV, BEV, hydrogen, and fuel cells) as a key strategic line.

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 effort is designed to support the acquisition of alternative vehicles and focuses on certain fuel types and vehicle types. Incentives have been offered annually since the year 2006 to public and private transport fleets, companies, and individual citizens, and there are also incentives for financial arrangements, including leasing and renting. As a result of this fleet renewal program, at the end of 2010, almost 10,000 EVs and HEVs (about 85% of the total renewed fleet) had been renewed.

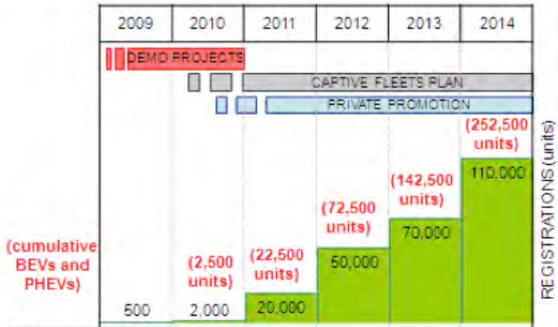
The second strategic effort in the E4 framework includes programs of incentives oriented to support “strategic projects”. These projects are submitted each year in response to a call for proposals made by IDAE. They must comply with the demand for an investment of more than € 1 million (US$1.32 million), a project length of 3 to 4 years, and the involvement of three or more regions of Spain. Strategic projects in the transport sector are mainly developed through vehicle leasing and renting companies and other vehicle fleets that acquire HEVs, PHEVs, and BEVs. Between 2008 and 2010, a total of 899 HEVs and 42 BEVs were renewed through this program. The last call for proposals was launched on May 8, 2011, and it had a total dedicated budget of € 120 million (US$158.4 million) for projects to be developed in the period 2011–2014.

Within the framework of E4, the third relevant program for promoting EVs is the “Movele” pilot demonstration project. Funded at € 10 million (US$13.2 million), this project supported the acquisition of 1,116 EVs between 2009 and early 2011 and the installation of 546 charging stations in the cities of Madrid, Barcelona, and Seville by March 2012.

In April 2010, Spain’s national government also presented the *Integral Plan for the Promotion of Electric Vehicles in Spain*, which includes an “Integrated Strategy for EV Promotion in Spain 2010–2014” and “Action Plan 2010–2012 (Plan Movele),” which establishes a budget, responsibilities, and objectives for the short term.

The Integrated Strategy for EV Promotion established an initial target of 70,000 EVs being on Spanish roads by the end of 2012 and 250,000 being there by 2014; these could be recharged at 343,510 charging points throughout Spain. This strategy envisions the rollout of PHEVs occurring according to the timetable set forth in Table 24.1. It includes four strategic efforts supported by 15 specific lines of action; further details can be found in the section on Spain at www.ieahev.org.

Table 24.1 Milestones in the Integrated strategy for EVs: BEVs and PHEVs on the road in Spain by 2014, per year.



	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

Incentives that support the acquisition of EVs as called for within the framework of the Movele plan were developed through appropriate legislation (Royal Decree [RD] 648/2011); they resulted in 1,205 EVs being acquired during 2011 with a total expenditure of € 3.62 million (US$4.72 million). These incentives were extended through the first half of December 2011 and from January 1 to November 30, 2012 through the additional legislation RD 1700/2011 and RD 417/2012 with a dedicated budget of € 10 million (US$13.2 million).

Table 24.2 shows the incentive levels of the different national programs that support the acquisition of HEVs and EVs in Spain, and Table 24.3 shows the number of EVs acquired within the framework of these programs.

Table 24.2 Support incentives for EVs acquisition at national scale in Spain.

Support Programs (National scale)	HEV <110 gCO2/km	PHEV, EREV, and BEV	Support level
IDAE-Regional Governments Agreements (E4)	Up to €2,300 (full hybrid) Up to €2,000 (mild hybrid)	Up to €7,000 (did not apply to BEVs in 2011)	15% of market prices
IDAE Strategic Projects (leasing/renting)	Up to €2,000 (full hybrid) Up to €1,800 (mild hybrid)	Up to €7,000	15% of market prices
MOVELE Pilot Demonstration Project (finished on 31st May, 2011)	–	Up to €5,000–€7,000	15-20 % of prices before taxes (according to technical performance of the vehicle)
MOVELE PLAN (RD 648/2011; RD 1700/2011 and RD 417/2012)	–	All-electric range: 15 km – 40 km: up to €2,000 40 km – 40 km: up to €4,000 > 90 km: up to €6,000	(*) 25% of prices before taxes (with battery) 35% of prices before taxes (without battery)

(*)Support levels increase up to 43.75% when multiple vehicles are purchased and are not subject to absolute limits.

Table 24.3 Results of national programs to support the acquisition of EVs as of December 31, 2011, showing number of vehicles acquired.

National Incentive Programs (results as of December 31, 2011)	EV acquisitions per category					TOTAL
	Motorbike	Quadricycle	Car	Commercial	Bus	
Agreements IDAE-CCAA (2006–2010; E4)	23	22	20	6	6	77
Strategic projects IDAE (2008–2011; E4)	0	5	7	36	0	48
MOVELE Pilot Project (2009–2011; E4)	511	145	140	320	0	1,116
Plan MOVELE (2011; RD 648 and RD 1700)	694	214	200	97	0	1,205
TOTAL	1,228	386	367	459	6	2,446

24.3 Research

Since 2009, the "Inno Plans" framework launched by the Ministry of Science and Innovation (MICINN) have supported seven projects related to EVs, with a total amount of € 13.8 million (US$18.2 million) dedicated to incentives in the following ways:

- Four projects are within the framework of supporting programs for collaborative activities between research entities and private companies (INNPACTO; SGECPP),
- One project is within the framework of supporting programs for technological centers (SGCTDE), and
- Two projects are within the framework of supporting programs for strategic projects (SGECCP).

As a result of changes in the new Spanish national government, research and development (R&D) promotion and supporting programs are now allocated within the new Ministry of Economy and Competitiveness.

24.4 Industry

Key action lines to promote the EV industry in Spain are the "Competitiveness Plan" and "Re-industrialization Plan". The objective of these plans, through appropriate calls for proposals, was to provide a dedicated budget of € 70 million (US$92.4 million) for specific projects related to EVs in 2011. Results for 2009 and 2010 and provisional results from November 2011 are shown in Table 24.4

Table 24.4 Provisional results from supporting programs for the industrialization of EVs.

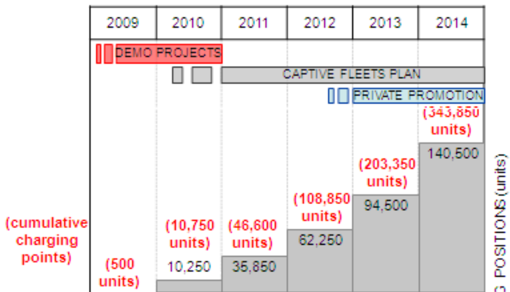
Parameter	2009	2010	2011
Number of projects (car industry)	155	144	141
Number of EV projects	5	13	23
Total expenditure for EV projects (millions of €)	30	39	30
Total expenditure for EV projects (millions of US$)	39.6	51.5	39.6
Budget ratio: EVs/car industry (%)	3.8	15.6	14

The promotion of information and communication technologies (ICT)-related EVs is considered within the framework of "Plan Avanza" through incentive programs and financing support. Twelve projects related to EVs were supported in the period 2009–2010; incentives amounted to a total of € 2.8 million (US$3.7 million).

24.5 Charging Infrastructure

The Spanish national government considers it a key matter to develop an adequate recharging infrastructure that supports the introduction and implementation of EVs. The recharging infrastructure objective is also considered in the "Integrated Strategy for EV Promotion," as shown in Table 24.5.

Table 24.5 Milestones in Spain's Integrated strategy for developing an EV charging infrastructure in Spain by 2014.



	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

This table shows that most of the recharging infrastructure planned is linked to specific vehicles, by being located at private houses or fleet operators. A small number of fast charging points are also being considered for public areas as well.

The charging infrastructure for BEVs and PHEVs in Spain is currently supported by the following relevant programs discussed here.

First, the objective of the Movele pilot demonstration project is to install a total of 546 public-use charging points in the cities of Madrid, Barcelona, and Seville by March 2012. At the end of 2011, 151 charging points had been installed.

Second, IDAE, in collaboration with regional governments, is supporting the deployment of an EV charging infrastructure during 2011 and 2012, which includes charging points for EVs in private or restricted use and for EVs in public use.

These national supporting programs for infrastructure deployment establish supporting levels of up to 40% of investment costs for public-use charging points and of up to 30% of investment costs for private-use charging points, fixing different maximum supporting amounts for each type of technology and each type of recharging infrastructure.

At the end of 2011, a total of 705 charging points were installed in 69 Spanish cities and were operative for public use.

Related to EV deployment, a new actor — "Manager of Recharging" — was created through the legislation (RD 647/2011, May 23). Entities registered as Manager of Recharging are allowed to commercialize recharging services for EV users. At the end of January 2012, three companies were officially registered as Manager of Recharging: IBIL Manager of Recharging S.A., EON Energy S.L., and Gas Natural Services SDG, S.A.

Under the same legal framework (RD 647/2011), a special tariff for recharging EVs during valley (as opposed to peak) hours was also created. This "supervalley tariff" affects the regulated part of the electricity tariff and is oriented to promote the recharging of EVs during valley hours, in order to use the electric system more efficiently.

Finally, it is expected that in the first half of 2012, legislation (a Royal Decree, which is not a law but rather modifies a law) on requirements and technical instructions for installing recharging infrastructure for EVs will be approved; it will affect new buildings and parking lots of private-use and public-use facilities.

24.6 On the road and EV deployments

Currently there are about 35,378 EVs and HEVs out of a vehicle fleet size of about 30 million on Spain's roads. The plan to boost the number of plug-ins (both BEVs and PHEVs) to 250,000 by 2014 will give these vehicles a market penetration of about 1%. Table 24.6 shows the EV and HEV fleet numbers, through late 2011.

Table 24.6 EV and HEV fleet numbers in Spain at the end of 2011.

	PER 31 DECEMBER 2011		
Vehicle type	EV fleet	HEV fleet	Total fleet
Motorbikes (>4 kW)	1,228	22	2,798,043
Cars	367	32,865	22,277,244
Commercials	459	0	2,314,595
Quadricycles/ special vehicles	386	0	459,117
Buses	27	1	62,358
Trucks (3,500–6,500 kg)	23	0	2,746,196
Total	**2,490**	**32,888**	**30,657,553**

With regard to the category "cars," it is worth pointing out that only in the year 2011 were a significant number of EVs and HEVs acquired in Spain (375 EVs plus 10,342 HEVs, for a total of 10,717 H&EVs) under the framework of the national incentive programs; this means that the market penetration of both technologies was 1.33% (808,059 new cars were registered in Spain during 2011).

24.7 Outlook

For the short term, Plan Movele has established an objective of 70,000 EVs in operation at the end of 2012.

For the medium term, the Integrated Strategy to Promote EVs in Spain has established an objective of having 250,000 PHEVs and BEVs on the road by 2014 and has also established measures to achieve this goal.

For the long term, the objectives for introducing EVs and PHEVs in the Spanish marketplace were recently defined according to the 2009/28/CE Directive of the European Commission, which establishes that renewable energy should constitute 11.5% of all the energy consumed by the transportation sector.

In order for Spain to achieve this last objective, the National Plan for Renewable Energies 2011–2020 (PANER) establishes that renewable energy sources should supply a portion of the final energy consumed by the nation's transportation sector. Specifically, 9.2% of energy for transport should come from biofuels and 2% should come from electricity (through railways and electric vehicles in road transport). This should imply the following fleet objectives by 2020:

- Total objective (for BEVs and PHEVs): 2,500,000 vehicles
- PHEV objective: 2,000,000 vehicles (80% of total objective)
- BEV objective: 500,000 vehicles (20% of total objective)

25 Sweden

25.1 Introduction

The Swedish government intends to gradually increase the energy efficiency of the transport system, break the system's dependence on fossil fuels, and thereby reduce climate impact. In 2030, Sweden should have a vehicle fleet that is independent of fossil fuels. Electromobility could be one important solution to fulfill this goal.

The Swedish vehicle industry is now very focused on technologies that increase fuel efficiency in order to comply with the new emission rules established by European Union (EU) directive Regulation CE/443 of 2009, as well as to satisfy the increasing customer demand for more fuel-efficient vehicles. The research focus of the industry has been on making the internal combustion engine more efficient, and governmental funding has promoted further efforts in the field of batteries and electric vehicles

25.2 Policies and legislation

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, according to a definition of vehicle types dating from 2006.

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). Since January 1, 2011, vehicle taxes have been based on several factors, including weight, fuel, and carbon dioxide (CO_2) emissions, all of which are advantageous for HEVs and EVs.

Since mid-2009, the purchase of an eco car has been rewarded by a 5-year exemption from vehicle taxes that averages about US$200 (€ 150) per year, depending upon the vehicle type. Eco car exemptions are defined by the fuel consumption, use of alternative fuels, and CO_2 emission levels (a vehicle run on fossil fuels can be called an eco car if the CO_2 emissions are below 120 g/km). In addition, vehicles with diesel engines must have emissions of particulate matter below 5 mg/km to qualify. In practice, this means that vehicles that run on diesel must be equipped with a particulate filter to be classified as eco cars.

The government has recently decided to introduce a "super-clean-car" rebate, starting on 1 January 2012, to stimulate the market introduction of passenger cars with very low emissions of CO_2—so-called super-clean cars. A super-clean car is defined as a car that does not emit more than 50g CO_2 per km in mixed driving. The total rebate will be approximately US$5,700 (€ 4,300).

Other incentives can reward drivers of PHEVs, EVs, 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. PHEVs and EVs are exempt, 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.

25.3 Research

Four national research programs dealing with issues related to EVs, HEVs, or fuel cell vehicles were active during 2011. The programs 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 programs are as follows:

- The fundamental objective of **demonstration programs for electric vehicles** is to create and convey the knowledge necessary to understand the methods, the technology and what incentives can practically be used in Sweden to facilitate a large-scale EV introduction. Activities include:
  - Demonstrating rechargeable vehicles and charging infrastructure in order to promote the electrification of the vehicle fleet;
  - Effectively identifying and possibly eliminating barriers to a large-scale introduction of EVs into the Swedish market; and
  - Establishing independent information channels on both research findings from the program and questions of general interest about the electrification of the vehicle fleet.

The total budget for years 2011 to 2015 is US$28 million (€ 21.5 million).

- **The Vehicle Strategic Research and Innovation program** was started in 2009 as a cooperative effort between the Government and the Swedish automotive industry. The program finances common research efforts, innovation, and development activities, mostly in the overall theme areas of (1) Climate and Environment and (2) Safety. The project is managed by Vinnova (Swedish Agency for Innovation Systems), the Swedish Energy Agency, and the National Road Administration. It comprises five subprograms: Sustainable

Production Technology, Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, and Energy and Environment. The venture includes research and development (R&D) operations valued at approximately SEK 1 billion per year (approximately US$140 million, € 105 million), of which public funds amount to SEK 450 million per year (approximately US$65 million, € 48 million). Electric roads whereby electric vehicles can obtain their energy while driving are a current research topic, as shown in figure 25.1.

Fig. 25.1 A concept picture from the Swedish company Svenska Elvägar that run one of three projects that the Swedish Energy Agency is financing about electric roads. The pantograph system connects to the overhead power line at vehicle speeds up to more than 80 km per hour. (Photo courtesy of Svenska Elvägar.)

- **Energy-efficient 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 program is a continuation of a previous program and now concentrates on hybrid vehicles, especially their drive systems, battery technology, diesel reformers for fuel cells, and the architecture of hybrid systems. The annual budget is US$2.9 million, € 2.2 million.

- The aim of the **Swedish Hybrid Vehicle Centre** is to establish an internationally competitive center 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 cooperation between industry and academia. Participating in the Centre are AB Volvo, Scania CV 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 annual budget is US$4.2 million, € 3.2 million.

25.4 Industry

Over 100,000 people are employed by Sweden's automotive sector, which includes 1,000 or so automotive subcontractors. Since 2010, the iconic Swedish brands Saab Automobile and Volvo Car Corporation have had owners in the Netherlands and China, respectively. In December 2011, the Saab Automobile manufacturer went bankrupt and the liquidator is now trying to sell the estate.

The major manufacturers Volvo AB, Volvo Cars, Saab Automobile, and Scania have all introduced electric and/or hybrid concept vehicles. As the hybrid vehicle portion of the automotive sector has become more commercialized, data on R&D activities have become proprietary and impossible to obtain from the companies.

Examples of subcontractors and small companies that are engaged in the fields of EVs, fuel cells, and/or hybrid vehicle development are listed in Table 25.1.

Table 25.1 Subcontractors and companies in the fields of EVs, fuel cells and/or hybrid vehicle 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	Upscaled production and sale of low-cost Fe-based cathode materials for EV/HEV Li-ion batteries, especially Li2FeSiO4.
Effpower	Development and sale of batteries for hybrid vehicles.
Nilar	Development and sale of nickel metal hydride battery power systems and batteries for hybrid vehicles.
Cellkraft AB	Development of systems for proton exchange membrane (PEM) fuel cells.
Powercell	Development and commercialization of fuel cell auxiliary power units for heavy-duty truck applications.
Actia Nordic AB	Power electronics for electric and hybrid vehicles.
Bevi	Electric machines.
Kollmorgen	Hybrid electric drivetrains.
Calix	Development of charging technology for EVs.
BAE Systems	Hybrid system for military and machinery vehicles.
BorgWarner	Electric rear axle for hybrid cars
Electroengine in Sweden AB	After-market conversion to electric drive.
Nimbell	Development of small commuter and city vehicles.
Clean Motion	Development of small commuter and city vehicles.
Vehiconomics	Development of small commuter and city vehicles.
Electroengine in Sweden AB	After-market conversion to electric drive.
Vehiconomics	Development of small commuter and city vehicles.

25.5 Charging infrastructure

The website www.uppladdning.nu lists about 280 charging sites for electric cars in Sweden. Approximately 65% of the Swedish population also has easy access to electrical outlets at home or at work through engine block heaters. (Please also see Chapter 17 on Finland for more discussion about engine block heater electric infrastructure in Nordic countries.)

25.6 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 25.2). 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 25.2 Characteristics and population of the Swedish motorized vehicle fleet on December 31, 2011. Estimates are in *italics*.

	DECEMBER 31, 2011		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet**
Motorized bicycle (no driver licence)	*1743*	0	234,737
Motorbike	35	0	485,000
Passenger vehicle	*366*	21,389	4,401,352
Multipurpose passenger vehicle	n.a.	n.a.	n.a.
Bus	4	2	13,947
Truck	*115*	26	548,272
Industrial vehicle	n.a.	n.a.	n.a.
Total	**2,263**	**21,417**	***5,683,308***

n.a. not available

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

Table 25.3 Relative sales shares (in %) for "green" vehicles in Sweden.

Category	2007	2009	2010	2011
E85 (ethanol)	65	49	30	13
Max 120 g CO2/km, gasoline	14	16	15	17
Max 120 g CO2/km, diesel	12	24	47	63
Hybrids/battery EV	6	3	2	2
Gas	3	8	6	5
Total	**100**	**100**	**100**	**100**
Eco share of total private car sales	**18**	**38**	**40**	**40**

The energy company Vattenfall and the City of Stockholm are working together to bring EVs and PHEVs to Sweden. The aim is to facilitate their market introduction and market expansion in Sweden. Together with purchasing group SKL Kommentus, they have carried out a coordinated procurement of EVs and PHEVs. Framework agreements with six suppliers have been signed and took effect on October 1, 2011. Funding of up to US$7,100 (€5,400) is available for the first 1000 EVs/PHEVs.

In 2009, the Swedish Energy Agency began supporting two projects for demonstrating a total of 150 battery EVs. One project started to test the Volvo C30 EV in 2011. The other was intended to test 70 Saab 9-3 EVs. The future of the Saab Automobile project is uncertain, however, after Saab's bankruptcy in December 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 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 23,000. This revision suggests that the initial expectations for the EV market may be somewhat optimistic.

25.7 Outlook

Choosing the technology for energy-efficient cars is becoming even more interesting than before because of the new EU directive Regulation CE/443, adopted by the European Union in April 2009, promotes this effort further with its tougher rules on CO_2 emissions for vehicle producers. In the future, PHEVs, battery EVs, and perhaps fuel cell vehicles will be seen as viable alternatives, although one big challenge will be the development of batteries that will operate with proper results in the harsh climate of the Nordic winter.

26 Switzerland

26.1 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. 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.

26.2 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 26.5). 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.

26.3 Research

Research at the Paul Scherrer Institute includes efforts to develop marketable fuel cells for the use in cars. Belenos Clean Power, a cooperative 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. The issue of charging infrastructure is discussed in more detail in Section 26.5.

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).

26.4 Industry

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 26.1).

Fig. 26.1 Lampo II electric prototype by Protoscar/Brusa. (Photo: Protoscar.)

The young company SwissCleanDrive, with the help of the SFOE, has developed a kit for converting a conventional internal combustion engine (ICE) vehicle into a plug-in hybrid electric vehicle. The kit is currently available for the FIAT Cinquecento (figure 26.2); kits for other car models are being developed.

Fig. 26.2 SwissCleanDrive Fiat 500 converted to a plug-in hybrid car. (Photo: Solarcenter Muntwyler.)

26.5 Charging infrastructure

Because the Swiss government expressly does not see a role for itself in supporting the development of a charging infrastructure, the utilities have taken over the role as active promoters of electric vehicles.

Public charging infrastructure has been most actively promoted by the Electric Vehicle Club Switzerland, a private association of electric vehicle users. According to its system, payment of an annual contribution gives an EV user access to the 120 “park & charge” charging stations (figure 26.3). Moreover, 32 of the stations enable quick charging by providing 32 A/230–400 V outlets. In addition, private citizens and certain companies offer their electrical sockets for charging for subscribers. This adds up to a total of more than 650 listed charging points across Switzerland, visible 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. Because of this network that grows according to need, 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. 26.3 Park & charge facility at the railway station in Thun. (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. These charging points are now sponsored by local power companies.

26.6 On the road and EV deployments

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. 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 (figure 26.4).

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. 26.4 The pedelec Stromer by Thömus, with a removable lithium-ion battery pack. (Photo: Thömus.)

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. The THINK City is only delivered in procurement schemes, but the cars can now be ordered by individual customers at the Migros "m-way".

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.

The sales of hybrid models continue to grow, although less strongly than in previous years. Table 26.1 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 26.1 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**	

26.7 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.

27 Turkey

27.1 Introduction

Despite the large automotive industry in Turkey, the Turkish hybrid and electric vehicle (H&EV) market is in a beginning phase. In 2010, 18.4% of the total energy consumption of Turkey was attributable to transportation and 87.6% of that figure was from road transportation. Awareness of environmental issues and clean vehicles is increasing in Turkish industries, in research and development (R&D) organizations, and in society as a whole. Turkish policies and legislation are encouraging reductions in greenhouse gas (GHG) emissions and improved air quality.

27.2 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. Turkey aims to fully cohere with European Union (EU) legislation. Turkish emission standards for all gasoline and light- and heavy-duty diesel vehicles have matched the Euro IV standards since January 1, 2009, according to emission legislation 70/220/AT and 88/77/AT-2005/55/AT.

Two types of taxation measures are imposed on vehicles in Turkey. The first one is a tax on an initial new vehicle purchase. The second type is an annual vehicle tax, which is paid yearly and is currently based on the engine cylinder volume and the age of the vehicle, not the emission rates.

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. It excludes HEVs and 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., maintain the same levels of taxation that were in place before 2011. Table 27.1 shows the vehicle sale special consumption tax categories for the initial new passenger vehicle and motorbike sales. Note that in 2011, the special consumption tax on passenger vehicles with engine cylinder volumes in the range 1600–2000 cm^3 has been increased from 60% to 80% of the purchase price, and those with engine cylinder volumes greater than 2000 cm^3 have seen this tax increase from 84% to 130%. This new incentive that has become available in Turkey is expected to impact only electric vehicle sales out of all H&EV types and only conventional vehicles with engine cylinder volumes below 1600 cm^3.

Table 27.1 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	80	85-120	7
	>2000	130	>120	15
MOTORBIKE	<250	8	<20	3
	>250	37	>20	37

According to strategic documents by the Ministry of Energy and Natural Resources regarding energy efficiency and by the Ministry of Science, Industry, and Technology on the automotive industry, several recommended actions would impact the incentives for purchasing hybrid and electric vehicles when they become more widely available in Turkey.

Recommendations that could lead to new legislation include reducing the specific fuel consumption of domestically produced vehicles, upgrading vehicle efficiency standards, expanding public transport systems, and implementing an EV charging infrastructure.

27.3 Research

Research topics relevant to HEVs and EVs along with electric drivetrain technology subcomponents are a part of the automotive R&D that is sponsored by the Turkish government. 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 Marmara Research Center (MRC) Energy Institute, OTAM (Automotive Technology Research and Development Center), Istanbul Technical University Mechatronics Education and Research Center, and Okan University Transportation Technologies and Intelligent Automotive Systems Application and Research Center.

TÜBITAK MRC Energy Institute

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.

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 Ministry of Development and is ready to serve the automotive industry.

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). In 2007, OTAM became a corporation with the shareholders ITU, OSD, the automotive industry trade group TAYSAD, and the Exporters' Association of the Automotive Industry (OIB). OTAM aims to serve as a center to carry out of pre-production research and development studies and product testing topics of the automotive industry and its suppliers, in cooperation with the university. OTAM has been studying projects on engine and vehicle emissions improvement, vehicle durability and performance, and automotive acoustics.

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 as well as electrical and electronics engineering. Projects relating to automotive technologies are underway, including a hybrid vehicle project, an electric minibus project, and some unmanned land vehicles projects. The hybrid vehicle project includes studies on fuel efficiency, energy management, power electronics, vehicle control, and hybrid vehicle design.

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) 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.

27.4 Industry

OSD, the Automotive Manufacturers Association, represents the 15 automobile 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 TürkTraktör. According to OSD's annual report, in 2011 the automotive industry was Turkey's largest export sector. Total production was 1,189,131 units in 2011, representing a 9% increase over the number of vehicles manufactured in Turkey in 2010.

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.

TOFAŞ, a joint venture of Koc Holding and FIAT Auto, is located in Bursa, Turkey. In November 2009, TOFAŞ started developing the all-electric version of the vehicle, Doblo EV (figure 27.1). The development process was conducted at TOFAŞ and announced by FIAT as "the first electric vehicle designed and developed for mass production in Turkey". In 2010 TOFAŞ introduced the Doblo EV.

Fig. 27.1 FIAT Doblo EV – The first battery electric vehicle designed and developed for serial production in Turkey. (Photo courtesy of TOFAŞ.)

Fluence Z.E. production has begun at the Oyak Renault Bursa Plant only. As of February 2012, more than 2,000 units of the vehicle have been exported. It is expected that the EV version of Fluence will be on the road in Turkey in 2012.

27.5 Charging infrastructure

During the past year, Turkey has seen some new developments toward the introduction of its charging infrastructure and pilot electric vehicle fleet programs.

İstanbul Enerji, an association of the İstanbul Metropolitan Municipality, 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.

The Renault Fluence Z.E. electric vehicle is projected to be sold in 2012. Renault has been working on three charging options; to charge the vehicle via a household mains supply, to charge at fast-charge stations using a high-power supply, and to use the QuickDrop battery switch to swap the electric vehicle's battery in approximately three minutes using existing vehicle sales and/or service point locations. To increase the usage of the EVs, Renault has signed contracts to install the charging stations with cities and municipalities like Istanbul, Ankara, Bursa, Kocaeli, and Gaziantep. It has been announced that Renault has received 160 electric vehicle orders from public authorities and will have at least 45 charging stations in these cities in 2012.

Ankara Metropolitan Municipality has also announced that it will acquire a fleet of 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.

Eşarj Electric Vehicle Charging Systems Inc., was started in 2008, and signed a strategic alliance and distributor agreement with Efacec Engenharia e Sistemas in 2010. Eşarj aims to contribute charging infrastructure studies in terms of technical, administrative, and legislation levels; supply different kinds of charging units; and to perform the installation of charging points in units requested by the customer to create a national network and operating system for the charging infrastructure. The company has 39 charging units at 20 charging points at the moment. The company has the goal of putting 2,000 charging units at 30 different cities in Turkey in the next 5 years. BD Otomotiv, based in Istanbul, is active in the distribution, production, and charging of electric vehicles. The company has a sales and service network throughout Turkey and some Eastern European countries, distributing BYD and Fisker branded cars. With respect to production, BD focuses on converting light commercial vehicles out of its Italian and Turkish assembly lines. The product range covers both van and combi type vehicles having a gross vehicle weight (GVW) between 1.5–3.5 tonnes. BD Otomotiv installs and retains the ownership of EV charging stations in top locations in Turkey to provide a charging service to its e-mobility customers. BD charging points can be managed centrally and monitored remotely with the smart charging capability to shift electricity consumption to non-peak hours. The company has 14 charging points in Istanbul at this time.

27.6 On the road and EV deployments

The number of vehicles on the road in Turkey is increasing. Although the total fleet of vehicles on the road is about 16 million, there are only a few EVs and HEVs among them, as shown in Table 27.2.

Table 27.2 Characteristics and population of the Turkish motorized vehicle fleet as of December 31, 2011.

	December 31, 2011		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet**
Motorized bicycle (no driver license)	n.a.	n.a.	n.a.
Motorbike	n.a.	n.a.	2,527,190
Passenger vehicle	*30*[(a)]	*500*[(a)]	8,113,111
Multipurpose pass. vehicle	n.a.	n.a.	n.a.
Bus [(b)]	n.a.	n.a.	609,341
Truck	n.a.	n.a.	3,339,562
Industrial vehicle	n.a.	n.a.	1,500,324
Total	***30***[(a)]	***500***[(a)]	**16,089,528**

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."

27.7 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 representatives, 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 2011, the electric vehicle market has begun to attract manufacturers and consumers due to the "special consumption" tax reduction announcement for battery electric vehicles. In 2012, EVs are expected to enter the 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 specifically in the areas of transport and reductions of 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.

28 United Kingdom

28.1 Introduction

The Coalition Government in the UK continue to make the road transport sector greener and more sustainable, with tougher emissions standards and support for new transport technologies. They recognize the reality that the car is central to people's modern-day lives. Motor vehicles are a vital socio-economic tool for thousands of businesses and millions of people. And, for many journeys, the car is, and will remain, the only practical and convenient travel choice.

Paradoxically, the very fact that the car plays such a fundamental role means that it has enormous decarbonizing potential. In order to realize that potential, an innovative blend of supportive Government policies and dynamic private enterprise is creating a green-motoring paradigm shift in the UK.

28.2 Policies and legislation

The UK Government has a comprehensive policy suite for the creation of an early market for ultra-low-carbon vehicles that encompasses support for infrastructure, vehicle purchase incentives, support for the supply chain, and a focused research, development and demonstration program. This policy package is supported by the provision of £400 million (US$627 million, € 478 million) of Government funding through 2015. These policies are coordinated by the cross-departmental Office for Low Emission Vehicles (OLEV), which draws on resources from the Departments for Transport, Business and Energy and Climate Change.

The £300 million (US$470 million, € 359 million) Plug-In Car Grant underwent its first review in 2011. As a result of this review, it was confirmed that the Grant, which provides 25% off the price of a qualifying car up to a maximum of £5,000 (US$7,800, € 6,000), will continue to 2015. In addition to this announcement, the similar Plug-In Van Grant was announced. Aimed at light truck (N1) vehicles that fulfill qualifying criteria, these grants will enable purchasers to receive 20% off the cost of a van up to a maximum of £8,000 (US$12,500, €9,500). The first eligible vans were announced on February 21, 2012.

The UK recognizes that there will be a portfolio of solutions for the decarbonization of road transport, which is why on January 18, 2012, UKH2Mobility was launched. The group brings together the Government and industrial participants from the utility, gas, infrastructure and global car manufacturing sectors. UKH2Mobility will evaluate the potential for hydrogen as a fuel for ultra-low-carbon vehicles in the UK before developing an action plan for an anticipated roll-out to consumers during the time period of 2014–15. It aims to:

- Analyze in detail the specific UK case for the introduction of hydrogen fuel cell electric vehicles as one of a number of solutions to decarbonize road transport and quantify the potential emissions benefits;
- Review the investments required to commercialize the technology, including refueling infrastructure; and
- Identify what is required to make the UK a leading global player in hydrogen fuel cell electric vehicle manufacturing, thereby paving the way for economic opportunities for the UK through the creation of new jobs and boosting of local economies.

The UK is also looking at improving the heavy-duty transportation sector. The third round of the Green Bus Fund was announced in 2011, which is a £68 million (US$106 million, € 81 million) fund supporting bus companies and local authorities in England to help them buy new low-carbon buses. Its main purpose is to support and hasten the introduction of hundreds of low-carbon buses across England. To date, 526 hybrid-electric and 16 all-electric buses have been purchased under the initiative. In addition, the Scottish Green Bus Fund provides opportunities to add eco-friendly vehicles to bus fleets. It will also help stimulate demand for green technology in Scotland.

For the truck sector, a new £8 million (US$12.5 million, € 9.6 million) green-truck fund was also announced in the autumn 2011 Budget statement. This fund will seed investment in low-emission heavy goods vehicles and their supporting infrastructure.

Fig. 28.1 A plug-in Prius in the heart of London, which would qualify for a 100% discount of the London congestion charge. (Photo courtesy of Toyota.)

In addition to the measures outlined above, the UK has put in place a range of fiscal and taxation measures with respect to electric vehicles, which are summarized in Table 28.1 below. Figure 28.1 depicts a plug-in electric vehicle that would merit reduced taxes and charges.

Table 28.1 Fiscal and other measures supporting electric vehicles in the UK as of March 21, 2012.

Fiscal and other measures supporting electric vehicles in the UK	
National Measures	**Electric Vehicles**
Vehicle Excise Duty (UK's Circulation Tax)	Exempt (for 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 (for tailpipe emissions < 100 g CO_2/km)
Parking charges	Some local authorities provide exemptions or a reduced charge for electric cars.

28.3 Research

In 2009, the automotive-industry-led New Automotive Innovation Growth Team (NAIGT) published An Independent Report on the Future of the Automotive Industry in the UK. This report defines NAIGT's 20-year vision for the automotive industry and contains recommendations for Government and industry to achieve it.

The Automotive Council was formed to move these recommendations forward; it also established five strategic areas for further study and R&D:

1. Improvements to internal combustion engines, for short-term road transport carbon reduction.
2. Energy storage and energy management, to support mid- to long-term low-carbon electric hybrid and fuel cell vehicles.
3. Lightweight vehicles and power train structures, to create lighter vehicles that consume less energy to move; applicable to all low-carbon vehicle materials, manufacturing and assembly methods.
4. Development of power electronics and electric machines - fundamental to electric and hybrid technology performance and efficiency.

5. Development of Intelligent Transport Systems and application to existing and new technologies - to improve travel efficiency and travel choices.

The Technology Strategy Board (TSB) is a non-Governmental organization sponsored and funded by Department for Business, Innovation and Skills (BIS). Other Government departments also fund specific programs and research priorities. The Low Carbon Vehicle Innovation Platform (LCVIP), launched in September 2007, was designed to deliver the Government's R&D funding on low-carbon vehicles. The platform is now running around 70 projects and has engaged with over 200 UK companies. The TSB LCVIP is run by setting up competitions to fund collaborative research and development. The competition criteria are set jointly with input from industry and Government (through the Automotive Council and TSB's Low Carbon Vehicle Steering Group). Project bids from industry are then assessed independently by a panel of automotive experts.

The latest competition scope for the Integrated Delivery Programme 7 was released in November 2011, with a budget of £25 million (US$39 million, € 30 million).

Phase 2 of the Low Carbon Vehicle Public Procurement Programme was launched in December 2011 with provision of grants to public sector organizations towards purchase of Ashwoods Automotive hybrid vans. The funding is for 500 vans and will be awarded on a first-come, first-served basis.

28.4 Industry

The UK automotive sector contributes about £10 billion (US$15.7 billion, € 12.6 billion) per year to the UK economy: the move to ultra-low-emission vehicles presents opportunities to support the economic recovery, green growth, and the creation of high-tech low-carbon jobs.

Cenex hosted its 4th annual Low Carbon Vehicle (LCV) event in September. The LCV event aims to promote a strong industry-led economic recovery by bringing together the key automotive industry stakeholders to showcase their capabilities in the field of low-carbon vehicles and fleet carbon reduction and by stimulating market demand through building fleet-operator and consumer awareness and confidence in accessible or near-market products for future procurement. LCV 2012 will be held on September 5–6, 2012, at Millbrook Proving Ground.

Also, the UK has a significant manufacturing presence in ultra-low-emission vehicles. The Nissan Leaf will be made in Sunderland starting in early 2013, with production growing to 50,000 vehicles per year. Nissan's battery plant will assemble lithium-ion battery packs for the Leaf on the same site, with production starting in 2012. Toyota's Auris Hybrid Synergy Drive has started production in the Burnaston plant in Derbyshire, which is the only plant outside of Japan to manufacture hybrid engines. Tata has begun assembling the Vista EV at the Crosspoint facility in Coventry, producing small numbers for sale in the UK starting in 2012. Allied Vehicles, Ashwoods, and Smiths also produce electric and hybrid commercial vehicles.

In November 2011, the new £9.8 million (US$15.3 million, € 11.8 million) Skills Academy for Sustainable Manufacturing and Innovation opened; it will be at the heart of skills and workforce development in this sector. The pioneering facility, developed by Gateshead College, will provide world-leading training to apprentices and people seeking emerging jobs created in the industry. The Academy is the first of its kind in the UK and will take trainees through all the essential elements of working with low-carbon vehicles.

OLEV has also forged links with the powered two-wheeler industry through its representative trade associations, the electric Motor Cycle Industry Association (eMCI) and the British Electric Bike Association.

28.5 Charging infrastructure

The UK recognizes that charging infrastructure is one of the key barriers to the wider acceptance of plug-in vehicles. The Department for Transport published Making the Connection: the Plug-In Vehicle Infrastructure Strategy on June 30, 2011. The strategy outlines support for plug-in vehicle infrastructure through the following measures:

- Ensuring plug-in vehicles are an attractive choice for the motorist, for example, by:
  - Ensuring that Britain's smart metering is implemented so that cars can charge when it is cheapest for the consumer;
  - Providing comprehensive information through a National Chargepoint Registry so when motorists need to use a public chargepoint they know where to find one;
  - Ensuring systems are in place so that an individual motorist can easily access chargepoints across the national network; and
  - Challenging industry to resolve, by the end of the year, a range of technical issues to allow the market to grow in the UK.
- Making it easier for private enterprise to provide recharging infrastructure

by removing regulatory barriers—e.g., establishing a Permitted Development Right for chargepoints so they no longer need planning permission. The Office of the Gas and Electricity Markets will consult this year on an exemption that makes it clear that chargepoint owners and operators can sell electricity via chargepoints at the market rate.

- Proposing the inclusion of policy on plug-in vehicle infrastructure in the National Planning Policy Framework, now out for consultation, to encourage local authorities to consider adopting policies to include plug-in vehicle recharging infrastructure in new domestic, workplace and retail developments.

OLEV are now working on delivering the strategy, and on November 11, 2011, the Office announced a project to develop UK's National Chargepoint Registry. POD Point, a UK-based chargepoint manufacturer, will be developing a publicly accessible database of chargepoints across the UK. Alongside this database, POD Point will also create a new system—the Central Whitelist—to make it easier for motorists to access each chargepoint without having to sign up to new schemes each time they charge in a different location. More details can be found at www.pod-point.com.

Fig. 28.2 A North East PIP charge point overlooked by Newcastle-Upon Tyne's iconic High Level Bridge. (Photo courtesy of Charge Your Car.)

The Plugged-In Places (PIP) scheme continues to be supported by the UK Government. PIP offers match-funding to local consortia of businesses and public sector partners to support the installation of a critical mass of electric vehicle recharging infrastructure in key locations across the UK. The Government is supporting eight PIPs in the East of England, Greater Manchester, London, the Midlands, Milton Keynes, the North East, Northern Ireland, and Scotland. Figure 28.2 depicts a North East PIP chargepoint. OLEV estimates that as of October 2011, the number of installed chargepoints in the UK is more than 2,500, of which 765 have been delivered through the PIPs and the remainder through investment by private sector organizations. Examples of the latter include the Chargemaster Polar Network, the Welcome Break and Ecotricity partnership, the Little Chef restaurant chain roll-out, and Nissan's rapid-charging network. Private sector organizations have commitments to deliver approximately 4,000 additional points across the UK by the end of 2012.

28.6 On the road and EV deployments

As of December 31, 2011, 892 claims have been made through the Plug-in Car Grant scheme, with Society of Motor Manufacturers and Traders data showing that 1,052 cars eligible for the Grant were registered over the same period. Table 28.2 summarizes the numbers of various types of electric vehicles currently licensed in the UK.

Table 28.2 Vehicles licensed in the UK as of the end of September 2011.

Vehicle Type	Total vehicle fleet	EVs	PHEVs	HEVs
Motorbike	1,340,863	1,502	0	1
Passenger vehicle	29,526,324	2,504	24	98,930
Multipurpose passenger vehicle	99,339	18	0	0
Bus	76,862	68	0	0
Truck	495,682	893	0	0
Light Goods	3,364,756	3,735	0	38
Tricycle	15,299	43	0	0
Other	604,771	58,909	0	38
Total	**35,523,896**	**67,672**	**24**	**99,007**

Note: the total fleet numbers include all propulsion systems and fuels.

28.7 Outlook

Supporting the early market in the UK for low-emission vehicles—which are essential in realizing reductions in CO_2 emissions from road transport—is one of the Coalition Government's key priorities. Low-emission vehicles are new to the market, but the continued interest in this new technology from business and private consumers is cause for cautious optimism. Vehicle market penetration is expected to increase further as more vehicles come to market over the next year and infrastructure installation continues across the UK.

29 United States

29.1 Introduction

The United States, through the U.S. Department of Energy (DOE), actively supports research and development (R&D) on innovative vehicle technologies. DOE supports R&D on more energy-efficient and environmentally friendly highway transportation technologies at the national labs 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 import of oil, and less emission. For example, DOE's Clean Cities Program supports public-private partnerships that would deploy alternative fuel vehicles (AFVs) and build supporting infrastructure.

29.2 Policies and legislation

The Federal government policies and legislations are designed to promote the U.S. market for electric drive vehicles (EDVs), which include hybrid (HEV), plug-in hybrid (PHEV), and battery (BEV) electric vehicles. With increases in the Corporate Average Fuel Economy (CAFE) standards, vehicle manufacturers are required to increase fuel economy through 2016, with possible further increases beyond 2016. In recent years, there have been a number of policy initiatives to encourage the introduction and sales of EDVs. Through the American Recovery and Reinvestment Act of 2009 (Recovery Act), the United States made a significant investment to build its domestic manufacturing capacity in advanced lithium-ion battery technology. Recovery Act funds are also supporting the largest-ever coordinated demonstration of EDVs, including nearly 13,000 vehicles and more than 22,000 electric charging points in more than 20 cities across the country. Companies are matching this $400 million public investment. The Recovery Act also established tax credits for purchasing electric vehicles ($2,500–$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). Additional information appears in the U.S. chapter of the June 2011 IA-HEV annual report on these topics: long-term Federal activities in developing solutions to replace less-energy-efficient transportation technologies with more efficient counterparts like EDVs; support for improved fuel economy standards; the setting of safety standards for new transportation technologies; and setting more favorable emission standards. The 2011 IA-HEV annual report is available on www.ieahev.org.

At the level of state government, at least 46 of the 50 states in the U. S. (and the District of Columbia) maintain regulations promoting HEV usage, including high occupancy vehicle (HOV)/parking/registration privileges, waived emissions inspection, tax credits/rebates/grants, or preferential purchase/promotion directives or mandates (see Table 29.1). A significant majority (31 out of 46) provides 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 29.1 2011 status of U.S. state-level incentives for hybrid electric vehicles.[1]

Type of Incentive	States
HOV/Parking/ Registration Privileges	Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Maryland, Nebraska, Nevada, New Jersey, New York, North Carolina, Tennessee, Utah, Virginia, and Washington
Emissions Benefits	Arizona, California, Colorado, DC, Idaho, Maryland, Michigan, Nevada, New Jersey, Oregon, and Washington
Tax/Rebates/Grants	DC and 31 states (except Alabama, Alaska, Arkansas, Mississippi, Nevada, New Hampshire, New Jersey, New York, North Dakota, Ohio, Rhode Island, South Carolina, South Dakota, Texas, Vermont, Virginia, Washington, Wisconsin, and Wyoming)
Purchase Directive/ Promotion/ Mandate	DC and 42 states (except for Michigan, Nebraska, North Dakota, South Carolina, South Dakota, Utah, West Virginia, and Wyoming)
[1]Source: *http://www.afdc.energy.gov/afdc/fuels/electricity_laws.html*	

29.3 Research

The U.S. DOE supports a broad portfolio of EDV battery R&D that spans basic research to applied development. Table 29.2 lists some of the offices within DOE involved in relevant research. Funding is provided for this research to the national laboratories and to private industry through government-industry partnerships. DOE offices also support research programs for enabling technologies for EDVs that include advanced energy storage technologies, vehicle systems, advanced combustion engines, lightweight materials, advanced power electronics, and fuel cells.

The DOE's Vehicle Technologies Program funds advanced energy storage technologies in three primary battery research areas:

- The developer program, performed in close collaboration with the industry through the United States Advanced Battery Consortium (USABC), which assesses, benchmarks, and develops advanced batteries for vehicles;
- Applied battery research, which provides near-term assistance to high-power battery developers to overcome the barriers associated with lithium-ion batteries for light and heavy-duty vehicles; and
- Focused fundamental research, which conducts research into the next generation of battery technologies for vehicle applications.

The Vehicle Systems Research activity 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. More information on those research programs is available at their specific websites.

Table 29.2 Summary of EDV-related research programs by Offices within the U.S. DOE.

Type of Incentive	Research Area
DOE Office of Science	Fundamental basic energy research on enabling materials through the Energy Frontiers Research Centers
The Applied Research Projects Agency - Energy (ARPA-E)	Transformational research on revolutionary, "game-changing" energy storage technology
Office of Electricity (OE)	Technology development/deployment programs to modernize the nation's electric delivery system
Office of Energy Efficiency and Renewable Energy (EERE)	Battery R&D focused on battery module development and demonstration of advanced batteries to enable a large market penetration of electric drive vehicles

29.4 Industry

During the 1990s, a limited number of battery electric vehicles became available mostly on lease to U.S. consumers (IA-HEV annual reports available on www.ieahev.org). Subsequently, few BEVs were manufactured for consumers. However, there has been a resurgence of interest, leading to newer generations of BEVs. Also, over the last decade, more and more HEVs have entered the market, with their total crossing the one million mark back in 2007 and reaching two million in 2011. Annual HEV sales, however, remain at below 3% of all light-duty vehicle sales. The currently available (and upcoming) EDVs are listed in Table 29.3. The following information summarizes the 2011 U.S. industry highlights for EDVs, by manufacturer:

- **Toyota:** Toyota added three models to the Prius family. The Prius V (Versatility) is a wagon version of the standard Prius. The Prius C (City) is a compact model equipped with a 1.5-liter four-cylinder engine and electric motor. The Toyota Prius PHEV (shown in figure 29.1, sales to start in 2012) is equipped with a 4.4 kWh lithium-ion battery pack, and a 1.8 liter four-cylinder engine. Lexus unveiled the 2013 GS 250h luxury sedan with a 3.5-liter V6 hybrid system. Toyota will build the new RAV4 electric at its plant in Ontario, Canada, alongside the gasoline RAV4.

- **Nissan:** Nissan presented the e-NV200 Concept van, expected to be commercially available in 2014. Nissan plans to start Leaf production at the Smyrna, Tennessee, facility in late 2012, producing up to 150,000 vehicles annually, starting with the 2013 model.
- **Honda:** The 2012 Insight HEV was introduced. Also, the all-electric Honda Fit will be available in summer 2012 for lease, and Honda will start production of its Accord Plug-in Hybrid in 2013.
- **General Motors (GM):** GM developed its 2-mode hybrid transmission (to be used in 2012 models of the GMC Sierra 1500, Yukon Denali, Yukon, and the Chevrolet Tahoe and Silverado). It has also implemented its hybrid-like “eAssist” system into the Buick LaCrosse, Buick Regal, and Malibu Eco. It plans to install its own electric drive motors in early 2013, starting with the Chevrolet Spark electric minicar. Cadillac will release the extended-range rear wheel ELR in 2013.
- **Other automakers:** Ford is launching its EV effort in 19 different markets, starting with the all-new Ford Focus Electric in New York and California. BMW announced it will introduce its i3 electric city car in 2013, part of BMW’s new sub-brand which also includes the sports model i8 PHEV, to go on sale in 2014. Volkswagen demonstrated the Jetta gasoline-electric HEV (to sell in late 2012) and the E-Bugster BEV concept (to sell in 2013). Tesla will launch its Model S in 2012. There will be four different models, with different range and features. Fisker started production of the Karma PHEV in summer 2011 (see figure 29.2). Its Surf, a PHEV wagon with a 50-mile electric range, is scheduled to go on sale in summer 2012. Mitsubishi launched sales of the “i” EV in North America in November 2011. Coda Automotive made the first deliveries of its 2012 CODA sedan in March 2012.

Fig. 29.1 The 2012 Toyota Prius PHEV. (Photo courtesy of Toyota.)

Table 29.3 An overview of planned HEVs, EVs, and PHEVs for the U.S. market. (Source: www.electricdrive.org.)

Model Year	Advanced Technology Vehicles
2011, 2012 Models (available)	**Hybrid Electric Vehicles** BMW (7-Series ActiveHybrid, X6 ActiveHybrid), Cadillac (Escalade Hybrid), Chevrolet (Silverado Hybrid, Tahoe Hybrid), Ford (Escape Hybrid, Fusion Hybrid), GMC (Sierra 1500 Hybrid, Yukon Denali Hybrid, Yukon Hybrid), Honda (Civic Hybrid, CR-Z Sport Hybrid, Insight), Hyndai (Sonata Hybrid), Infinity (M Hybrid), Kia (Optima Hybrid), Lexus (CT Hybrid, GS Hybrid, HS Hybrid, LS Hybrid, RX Hybrid), Lincoln (MKZ Hybrid), Mercedes (M450, S400), Nissan (Altima Hybrid), Porsche (Cayenne S Hybrid, Panamera S Hybrid), Toyota (Camry Hybrid, Highlander Hybrid, Prius V, Prius - 3rd Generation), Volkswagen (Touareg Hybrid) **Battery Electric Vehicles** Tesla Motors (Roadster Sport 2.5), Ford (TRANSIT connect electric), Nissan (Leaf), Smart (Fortwo electric drive), Smith Newton (truck), TH!NK (City), Chevrolet Volt (EREV) **Plug-in Hybrid Electric Vehicles** Fisker Karma S Plug-in Hybrid
2012 Models (upcoming)	**Hybrid Electric Vehicles** Audi (A8 Hybrid, Q7 Hybrid), Mercedes (C-Class Hybrid, E-Class Hybrid), Suzuki (Kizashi Hybrid), Toyota (Prius C), Volkswagen (Jetta Hybrid) **Battery Electric Vehicles** Coda (Automotive Sedan), Mitsubishi (i), Audi (e-tron), Ford (Focus electric), Honda (Fit EV), Tesla Motors (Model S), Toyota (FT-EV, RAV4 EV), Volvo (C30 Electric) **Plug-in Hybrid Electric Vehicles** Bright Automotive (IDEA Plug-in Hybrid), Ford (Escape Plug-in Hybrid), Mercedes (S-Class Plug-in Hybrid), Toyota (Prius Plug-in Hybrid)
2013 Models	**Hybrid Electric Vehicles** Ford (C-MAX Hybrid) **Battery Electric Vehicles** BMW (i3 Megacity), Mercedes (SLS E-Cell AMG), Nissan (ESFLOW) **Plug-in Hybrid Electric Vehicles** BMW (i8), Ford (C-MAX Energi), Mitsubishi (Outlander), Subaru (PHEV), Volkswagen (XL1)
2014 Models	**Hybrid Electric Vehicles** Ferrari (HY-KERS Hybrid) **Battery Electric Vehicles** Infiniti (ZEV), Volkswagen (Golf Blue-e-motion), Cadillac (ELR) EREV
Post-2014 Models	**Fuel Cell Vehicles** Chevy (Equinox FC), Ford (FC EV), GM (Hydro-GEN3), Honda (FC Sport), Hyundai (Tuscon ix35 FC)

Fig. 29.2 2012 Fisker Karma S Plug-in Hybrid. (Photo courtesy of Fisker Automotive.)

29.5 Charging infrastructure

- **ChargePoint America:** Under the ChargePoint America program partly funded by the Recovery Act in 2009, Coulomb Technologies provides EV charging infrastructure to ten selected regions in the U.S. In 2011, 1,432 Electric Vehicle Supply Equipment (EVSE) charging units were installed, including those in California (657), in Michigan (251) and in ten other states (524). Of these installations, 48% were residential, 8% were private commercial, and 44% were public. The average EVSE utilization (vehicles connected to EVSE) was 31%.
- **The EV Project:** ECOtality designed and currently manages an EV infrastructure demonstration entitled the EV Project. This $230 million project will deploy and study over 10,000 Level 2 EVSE stations for residential and commercial use, and over 400 DC fast charge ports. By the end of 2011, 3,785 EVSE were installed. The majority are in California (1786, or 47% of the total), followed by Washington (658), Tennessee (511), and Oregon (429).
- **American National Standards Institute (ANSI):** The American National Standards Institute (ANSI) formed an Electric Vehicle Standards Panel to develop a roadmap to facilitate the development of comprehensive and streamlined standards and conformance programs applicable to the U.S. market for EVs and charging infrastructure. The roadmap will also help to maximize coordination and harmonization of standards and conformance programs domestically and internationally.
- **New York State Energy Research and Development Authority (NYSERDA):** NYSERDA issued an $8 million solicitation for an EVSE deployment program in the State to fund more than 400 public EVSE.

29.6 On the road and EV deployments

While two-wheeled transport remains the primary means of transport for millions of people in many other parts of the world, most consumers in North America and Europe have remained committed to their passenger cars. Now, however, high petroleum costs, improved customer perception, and government incentives are all contributing to a growing demand for motorcycles and scooters—including those powered by electricity.

Compared to its total inventory of light vehicles (around 237 million), the U.S. has a relatively small, but growing number of HEVs. Table 29.4 lists the number of BEVs and HEVs in the U.S. over the past few years. Until 2009, the U.S. population of BEVs remained stable (at about 57,000) due to the scarcity of BEVs on the market. However, this situation has started to change and the BEV population is beginning to grow again as new technologies enter the market, starting with the introduction in 2010 of the 2011 Chevy Volt extended range EV and 2011 Nissan Leaf. During 2011, a total 7,671 Volts and 9,674 Leafs were sold in the U.S. Also, 342 Smart EDs and 76 Mitsubishi i EVs sold. Though the sales seem modest, it is worth noting that sales of plug-in electric vehicles in their first full year exceeded the number of initial sales for hybrids in their first year (9,367 total in 2000, including 3,805 Honda Insights and 5,562 Toyota Priuses).

Table 29.4 Number of EVs and HEVs in the U.S. fleet at the end of 2011.

	PER DECEMBER 31, 2011		
Vehicle type	**EV fleet**	**HEV fleet**	**Total fleet (incl. EVs and HEVs)**
Bicycles (no driver license)	~800,000[a]	0	~800,000[a]
Passenger vehicles (M1)	18,108[b]	2,153,486[b]	237,000,000[c]
Total	**18,108**	**2,153,486**	**250,000,000[d]**

[a] Extrapolated from Electric Bikes Worldwide Reports, 2010.

[b] HEV and EV sales data are compiled from J.D. Power; EDTA, Hybrid Market Dashboard, and Green Car Congress. Total for EVs only includes new-technology EVs introduced since 2010. Tesla Roadster and Fisker Karma sales are not included. Prior to 2010, around 57,185 battery electric vehicles were estimated in the U.S., according to Transportation Energy Data Report, Edition 30. However, these vehicles rely on older technologies for batteries and design.

[c] Total of car fleet and two-wheel, four-axle truck fleet, which includes vans, pickup trucks, and sport utility vehicles, from the Transportation Energy Data Report, Edition 30.

[d] Total fleet (for all fuel types) from the Transportation Energy Data Report, Edition 30.

29.7 Outlook

Small Electric Vehicle Sales

As mentioned before, most consumers in North America and Europe have remained committed to their passenger cars, but high petroleum costs, improved customer perception, and government incentives are all contributing to a growing demand for motorcycles and scooters, including those powered by electricity. Particularly in urban areas, where large vehicles are often impractical and expensive to own, operate, and park, density has become a driving force for the e-motorcycle and e-scooter markets. According to a recent report from Pike Research, sales of these vehicles will rise sharply in Europe and North America over the next six years. In North America annual sales of e-motorcycles were predicted to rise at a compound annual growth rates (CAGR) that will surpass 71%. Also, according to Electric Bikes Worldwide Reports, although only 500,000 electric bikes had sold in the U.S. as of 2009, the U.S. electric bike sales were expected to double to 300,000 per year, though reports were that sales of electric bikes had remained flat in 2010 over 2009.

HEV and BEV 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. Since 2009, the annual sales figures for hybrids have remained below 300,000 at between 2–3% of the total light-duty vehicle sales in the U.S., even as overall U.S. light-duty vehicle sales rebounded from 10.4 million in 2009 to almost 12.8 million in 2011. It is not clear when the HEV percentage of light-duty vehicles (which rose rapidly in the past from nearly zero in 1999 to almost 2.8% in 2009) will regain its upward trend.

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 and EVs. Boulder-based Pike Research issued a report recently 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 comparable sales of hybrid trucks and commercial vehicles. The U.S. could become the largest market for fleet hybrids by 2015.

Projections from the Energy Information Administration

The U.S. Energy Information Administration (EIA) released an early edition of its Annual Energy Outlook 2012 which also 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 2035 (see Table 29.5) and flex-fuel, at about 17%, will dominate the AFV market. However, the U.S. will see an increase in EDVs (BEVs, HEVs, and PHEVs) to nearly 8% of the total light-duty vehicle sales, under the EIA's reference case which assumes a 2.6% annual growth rate, as well as specific assumptions about world oil prices and how technology will develop.

Table 29.5 Alternative light-duty vehicle sales projections for the U.S. (Source: Annual Energy Outlook 2012 (early edition), Table on Light Duty Vehicles by Technology Type – United States.)

Light-Duty Vehicle Sales by Technology Type, U.S. (reference case in thousands)						
Technology Type	2010	2015	2020	2025	2030	2035
Conventional Gasoline	9281.9	12389.7	11562.7	12053.4	12126.2	12322.9
TDI Diesel	170.4	643	702.1	729.7	747.3	753.8
Flex-Fuel	999.3	1924.2	2528.8	2541.6	2835.7	2944.2
Electric	1.8	6.4	40.1	103.5	218.4	354.7
Plug-in Electric Hybrid	0	77	147.6	171.9	205.8	219.9
Electric Hybrid	283.5	436.7	557.9	732.8	818.2	856.9
Gaseous (LPG and Natural Gas)	43.8	71.4	69.6	72.9	75.8	77.6
Fuel Cell	0	2.8	5.8	6.8	7.5	8.1
Total Vehicles Sales	**10780.6**	**15550.9**	**15614.6**	**16412.5**	**17035**	**17538**
Conventional Gasoline	86.1%	79.7%	74.1%	73.4%	71.2%	70.3%
TDI Diesel	1.6%	4.1%	4.5%	4.4%	4.4%	4.3%
Flex-Fuel	9.3%	12.4%	16.2%	15.5%	16.6%	16.8%
Electric	0.0%	0.0%	0.3%	0.6%	1.3%	2.0%
Plug-in Electric Hybrid	0.0%	0.5%	0.9%	1.0%	1.2%	1.3%
Electric Hybrid	2.6%	2.8%	3.6%	4.5%	4.8%	4.9%
Gaseous (LPG and Natural Gas)	0.4%	0.5%	0.4%	0.4%	0.4%	0.4%
Fuel Cell	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

30 Developments in selected IA-HEV non-member countries

The IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicles (IA-HEV) has attracted several new members in recent years. However, current IA-HEV members are not the only countries that are active in technologies for hybrid and electric vehicles. For completeness, we include brief overviews of developments in the key East Asian countries of China, Japan, and South Korea, as well as activities at the European Union, which governs certain Europe-wide efforts that impact a majority of IA-HEV members.

30.1 China

Introduction

China is the world's most populous country with a rapidly growing economy, which has contributed to higher overall energy demand. China's real gross domestic product (GDP) grew at an estimated 10% annually between 2000 and 2010, according to the International Monetary Fund. China is the world's second largest oil consumer behind the United States, and the largest global energy consumer, according to the International Energy Agency.

China continued to expand its lead as the world's largest automotive sales market in 2011. China's Ministry of Public Security announced that China had 217 million motor vehicles on its roads at the end of June 2011, including more than 98 million automobiles and 102 million motorcycles. According to the China Association of Automobile Manufacturers (CAAM), from January to December 2011, Chinese auto sales exceeded 18,505,100 units, a rise of 2.45% from 2010. A survey by the CAAM showed that 8,159 hybrid and electric cars were sold nationwide in 2011. In total there are more than 10,000 green cars on China's roads. The central government aims to have 1 million electric-powered vehicles on the road by 2015. Although China is not an IA-HEV member, their robust car industry affects the worldwide market and global carbon-dioxide (CO_2) levels.

China has also become a major source of automotive parts for the rest of the world, including the big three United States (U.S.) automakers. These trends are likely to intensify over the coming years. China plans to invest more than US$18 billion over the next ten years to become the world's leading producer of electric and hybrid vehicles and their key components.

Policies and legislation

The electric vehicle market known as "New Energy Vehicles" (NEVs) in China is heavily influenced by the Central Government's policies and legislation. Standard hybrid vehicles are classified as "energy-saving" instead of "new energy" vehicles, according to Xinhua News. NEVs are clearly defined as plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and fuel cell vehicles (FCVs), according to the relevant government departments. The Ministry of Science and Technology (MOST), the Ministry of Industry and Information Technology (MIIT), the Ministry of Finance (MOF), and the National Development and Reform Commission (NDRC) are jointly responsible for developing a national NEV development plan.

The automotive industry in China has been designated as a "pillar industry" since at least 1991, and it continues to play a central role in the government's economic development policies today. In March of 2011, the National People's Congress approved the 12th Five-Year Economic and Social Development Plan, the blueprint for China's economy from 2011 through 2015. NEVs have been identified as one of seven "strategic and emerging industries" in the plan. From 2011 through 2020, the government plans to invest at least RMB 115 billion (US$18 billion) to build up its energy-saving and new-energy automotive industry, nearly half of which will subsidize the development and industrialization of core technologies.

The 12th Five-Year Plan sets out two core sets of goals for the Chinese automotive sector over the next five years:

- First, the plan aims to improve domestic automakers' capability to produce entire vehicles in addition to parts, and it aims to develop an independent indigenous capacity to produce key components. Specific auto parts targeted in the plan include batteries, electric motors, electronic control systems, and fuel cells.
- Second, the plan places particular focus on NEVs, and it identifies the production of such hybrid and electric vehicles as the key means by which China will be able to develop the technology to leapfrog over its competitors and become a global player in the world auto market.

Government subsidies for new auto manufacturing plants were reduced on January 30, 2012. Now, carmakers will only be eligible for incentives on factories approved by the government before January 30, 2012. This policy is designed to prevent overproduction of vehicles and stabilize the overall market. However, the auto component industry, including components for NEVs, has now been approved for broader government support.

Fig. 30.1 Hood ornaments of various Chinese manufacturers. Developing indigenous car models and innovative technologies is now a priority in China. China's policy is to encourage Chinese automotive companies to carry out more R&D activities.

Vehicle electrification is expected to be strategically important to China's future in the following four areas: global climate change; energy security; urban air quality, and China's auto industrial growth. In many cities there is an immediate need to address localized urban transport problems of congestion, accidents, and pollution. A slow and congested transport system stifles the efficiency of the urban economy that accounts for over 80% of the national economy. A timeline of selected national policies supporting hybrid and electric vehicles are listed below in Table 30.1.

Table 30.1 Selected milestones of electric vehicle policy support in China.

2001: *863 Electric Fuel Cell Vehicles Project* – Government investment of RMB 800 million. (US $127 million)
2006: *863 Energy-Saving and New Energy Vehicles Project* – MOST invests RMB 1.1 billion, (US$174 million) setting technology roadmap for the EV industry
2008: *1000 Vehicles, 10 Cities Demonstration Project* funded by MOST, MOF, NDRC, and MIIT
2009: *Plan on Adjusting and Revitalizing the Auto Industry* – State Council planned to invest RMB 3 billion (US$477 million) to develop key EV technology
2010: *Subsidy Standards for Private Purchase of New Energy Vehicle* – MOST, MIIT, and MOF selected 5 cities for private EV purchase subsidy with maximum subsidies of RMB 50,000 (US$7,900) for PHEVs and RMB 60,000 (US$9,500) for BEVs
2010: *863 Key Technology and System Integration Project for Electric Vehicles* – RMB 738 million (US$117 million) for battery and EV integration with 42% of funds for battery research
2011: *Vehicle and Vessel Tax Law* was adopted at the National People's Congress and became effective on January 1, 2012. The regulations reduce or exempt vehicles that conserve energy or use new energy from certain taxes. Tax of traditional vehicles with displacement between 1.6 liters and 3.0 liters is lowered and that of the vehicles of 3.0 liters and above remains at a higher level.
2011: The *Management Rules for Government Fleet Model Catalogue* – The *Rules* became effective on November 14, 2011. According to the Rules, models for general government departments, including courts, police stations and other law-enforcement organizations should be no larger than 1.8L in displacement with prices at RMB 180,000 (US$26,470) at most. (Note: NEVs should meet these guidelines.)

Acronyms: MOST: Ministry of Science and Technology; MOF: Ministry of Finance; NDRC: National Development and Reform Commission; MIIT: Ministry of Industry and Information Technology
Source: United Nations Electric Vehicles in the Context of Sustainable Development in China, 2011.

Rare earth minerals

Many auto components such as batteries require rare earth metals, shown in figure 30.2 (called rare earth minerals). China produces about 97% of the world's supply of a set of 17 rare earth metals needed to manufacture many new energy vehicle components such as car batteries. In recent years, new demand for rare earths have has strained the world's supply. Today, due to the increased demand and market price, many mines in countries outside of China are reopening after having closed in the 1990s. China maintains strict export quotas for raw minerals such as rare earth minerals, which contain one or more rare earth metals as major metal constituents, but it does not have quotas for completed components such as batteries that contain the rare earth metals in these minerals.

Fig. 30.2 The use of rare earth elements for use in batteries has increased dramatically over the past years. Clockwise from top center: praseodymium, cerium, lanthanum, neodymium, samarium, and gadolinium. (Photo courtesy of U.S. Department of Agriculture.)

In 2009, world production of rare earth minerals was 132,000 metric tons; China produced 129,000 of those tons. As a result of China reducing exports of rare earth minerals, component manufacturers that are based in China have access to these materials needed to produce NEV auto components that producers outside of China do not have.

Industry

Passenger vehicles

Passenger vehicles are one of the major focuses of auto manufacturers in the electric vehicle sphere. Table 30.2 offers a brief overview of select Chinese automakers and their EV products, with some vehicles still in the concept or testing stage, and figure 30.3 shows an example of a domestically produced plug-in electric vehicle by major automotive and battery manufacturer BYD. Research by the China Greentech Initiative indicates that in 2010, at least 7 foreign OEMs and 11 Chinese OEMs were investing and partnering with at least 13 Chinese lithium-ion battery makers to produce batteries for their vehicles. According to statistics from CAAM, the biggest car sellers in 2011 were Shanghai Auto, Dongfeng, FAW, Chang'an, Beijing, Guangzhou Auto, Chery, Brilliance, JAC, and Great Wall. These brands accounted for 87% of the cars made and sold in China, with the majority of these being via joint venture companies rather than via independent brands.

Table 30.2 Sample of Chinese manufacturers and EV model names as of 2011.

Manufacturer	EV Model Name
BYD	E6
Chery	M1 EV, QQ3 EV
Chana	Benni EV-Chana
Zotye	5008 EV
Gonow	GA6380 EV
Haima	Freema EV
Lifan	620 EV, 320 EV
Great Wall Motors	ULLA

Source: United Nations Report, Electric Vehicles in the Context of Sustainable Development report, 2011.

Fig. 30.3 The e6, a pure electric vehicle, represents new energy, new power, and a new concept in transportation. BYD's Fe battery, which powers the e6, represents one of the company's core technologies. (Photo courtesy of BYD.)

Other types of electric vehicles in China include buses, e-bikes, and low-speed rural electric vehicles. China is the largest producer of e-bikes in the world. In 2009, China produced 23.69 million bicycles with a total estimated population of 150 million including both e-bikes and conventional bicycles by the end of 2011. E-bikes primarily use lead-acid batteries.

Batteries

China is one of the world's major battery producers. BYD, BAK, and Lishen battery companies, among others, produce most of the lithium-ion batteries for consumer electronics. In 2010, China's lithium-ion battery market reached RMB 27.61 billion (US$4.3 billion), an increase of 37.9% compared with 2009. In terms of production capacity, China produced 3.67 billion lithium-ion batteries in 2010, an increase of 33.9% compared with 2009.

Today, a great deal of research and development (R&D) is underway regarding EV battery and charging technology development for the auto sector, including joint projects between universities and battery manufacturers, auto manufacturers and others.

In spite of the large number of institutions undertaking R&D on lithium-ion batteries, Chinese companies are still lagging behind on patent registration. Japan owns 52%, the U.S. owns 22%, and the Republic of Korea owns 15% of international patents for lithium-ion batteries. By contrast, China holds just 1% of the total patent registrations for lithium ion batteries.

China's R&D spending on batteries falls well short of that of other major countries. The Republic of Korea has planned US$342 million in EV battery R&D between 2009 and 2014 and up to US$12.4 billion through 2020. Japan had announced spending that would total at least US$116 million through 2012. The U.S. has put up US$1.5 billion towards building battery manufacturing facilities as part of the 2009 American Reinvestment and Recovery Act, and the U.S. Department of Energy has had annual battery R&D budgets of more than US$70 million in recent years. Yet China has only allocated US$26 million for the first three years of the 12th Five-Year Plan (2011–2015).

On the road, deployments, and charging infrastructure

As described previously, annual vehicle sales figures exceeded 18 million in both 2010 and 2011. In 2009, vehicle ownership in China was equivalent to 4.7% of the population, compared with about 51% in Japan and 81% in the U.S., according to the Japan Automobile Manufacturers Association. These percentages demonstrate that the Chinese domestic market growth potential is still large despite slower sales growth rates than had been seen for much of the previous decade.

As listed in Table 30.1, buyers of plug-in hybrid cars are entitled to a direct central government subsidy of RMB 50,000 (US$7,950) per vehicle, while a rebate of up to RMB 60,000 (US$9,500) on the purchase price is offered to buyers of battery electric vehicles. Additionally, local governments may offer subsidies as well. Auto manufacturers are also luring buyers of their alternative cars with free maintenance and a range of personalized services.

Demonstration projects

"New Energy Vehicle" demonstration projects

In 2009, the Chinese government initiated the "Ten Cities, Thousand Vehicles" program to stimulate electric vehicle development through large-scale pilots in ten cities, focusing on deployment of electric vehicles for fleet applications. The Program has since expanded into 25 cities and includes consumer incentives in five cities. In these cities, public service vehicles receive significant national government subsidies. Shanghai, Changchun, Shenzhen, Hangzhou, and Hefei are the first 5 pilot cities which offer subsidies for private electric and other NEV purchases.

Charging infrastructure

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/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/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.

Fig. 30.4 A worker cleans a Toyota Hybrid Prius displayed at the Shanghai Auto Show in April 2011. Car makers are struggling to sell environmentally friendly vehicles in China, even as Beijing pumps billions into clean energy. (Source: Shanghai Auto Show.)

Charging infrastructure standards

Development of common national standards for charging infrastructure, vehicle charging methods, vehicle/charger connectors, battery cells, charging network communications, charging network billing, and standards development were not initial areas of focus during the Ten Cities program. In the absence of national standards, local approaches were developed in the different pilot implementations.

The local approaches that were developed are beginning to be evaluated for the development of national standards with the first to emerge being the standard for vehicle charging. Led by the Ministry of Science and Technology, infrastructure companies, automotive component suppliers, and automakers are collaborating to develop a national standard for the charging method and connector. While not yet finalized, State Grid has joined with industry to develop a seven-pin vehicle/charger connector that will enable both AC and DC charging. Other standards for battery cells and network communications are yet to be developed.

Outlook

The Chinese government is projecting a +7.5% GDP growth for 2012, which is a slower rate of growth than in previous years. Undoubtedly, China's auto industry and sales are on track to maintain their number-one world ranking. New policy under the 12th Five-Year Plan removes incentives for foreign auto companies to become established in China, but conversely the new polices will benefit auto component a manufacturers. As vehicle production stabilizes, analysts expect that China will increasingly develop its auto component industry as its auto industry is maturing. Along with the rest of the world, NEV adoption by the market has been slower than expected in 2011. The national government's support for NEVs increases the likelihood of a strong NEV market and industry in 2012.

30.2 Japan

The deadly March 11, 2011 earthquake and tsunami that triggered the Fukushima nuclear power station meltdown temporarily set back production by the Japanese auto industry. Thailand's massive floods in October also affected Japanese automotive manufacturing plants. These production disruptions reverberated worldwide. However, a year after the initial disasters, the country's automakers and suppliers are now back on solid footing.

The automotive industry is one of the Japanese economy's core industrial sectors. Japan is considered to be a world leader in battery technology and manufacturing of electric and hybrid vehicles (EVs and HEVs). Auto-related employment in Japan at present totals 5.32 million people. According to JAMA (the Japan Automobile Manufacturers Association), the first half of 2011 saw a major decline from the previous year in Japan's motor vehicle demand, attributable to the disaster-related disruptions in the vehicle supply chain. Market supply normalized at the beginning of autumn, enabling the delivery of backlogged orders and a subsequent shift to more robust sales, supported by the launch of new and revamped models. Nevertheless, total demand in 2011 finished below the 2010 level. Domestic sales of passenger cars and commercial vehicles were tracked at 4.21 million units, a decline of 15.1% from the previous year. Japan dropped into third place in the 2011 world auto-production rankings, falling slightly behind the United States. In 2011, a total of 8,398,654 vehicles were produced, which is a 12.8% decrease from 2010 production figures. Exports during 2011 decreased from 2010 by 7.8%.

In late 2011, as part of a national disaster relief plan, the Japanese government announced the renewal of tax reductions and subsidies that had been due to expire in 2012. Among the H&EV-related measures extended until 2015 was a suspension of the acquisition and tonnage taxes. The combined savings totalled ¥103,500 (US$1,247) per vehicle. In addition, purchase subsidies were offered for consumers, varying by type of vehicle purchased. Subsidies were ¥100,000 (US$1,205) for a standard or small car and ¥50,000 (US$602) 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$3,012) or ¥125,000 (US$1,506).

There were still some bright spots in 2011 for all types of EVs and the overall Japanese auto industry. Fuel was scarce after the dual natural disasters, and since EVs require no gasoline, they were identified as an ideal transport mode for relief operations in the disaster-affected areas where electricity was still available. Nissan, Mitsubishi, and cities sent their Leafs and i-MiEVs, both with an average 100-mile all-electric range, into daily use transporting doctors, food supplies, and relief workers, with the car batteries recharging at night.

Additionally, Mitsubishi and Nissan are each developing systems that allow the car battery to be used as an emergency generator. Mitsubishi is developing an i-MiEV Power Box and Nissan is developing the Leaf-to-Home system. Mitsubishi plans to offer the i-MiEV Power Box for sale in April 2012, while the Leaf-to-Home system is still in the concept phase.

By May, Nissan's Iwaki plant in Fukushima Prefecture was almost completely restored to full operations. The automaker had a record sales year of 4.7 million vehicles in 2011. That was an increase of 14% over the previous year. Nissan says it has sold more than 20,000 all-electric Leafs worldwide from the car's debut in December 2010 through late December 2011. Most of the cars were sold in Japan and the United States. Nissan is aiming to sell 40,000 Leafs in 2012. Among other awards and recognition, the Nissan Leaf won the 2010 Green Car Vision Award, the 2011 European Car of the Year award, the 2011 World Car of the Year, and the 2011–2012 Car of the Year Japan.

The Mitsibushi i-MiEV achieved worldwide sales of 17,000 units between its launch in 2009 and October 2011. This figure includes 4,000 units rebadged and sold as the Peugeot iOn and Citroën C-Zero in France.

The all-star of hybrid vehicles, the Toyota Prius, reached 2.5 million in sales as of February 2012. The car is now sold in more than 70 countries and regions. In late 2009, Toyota began delivery of 600 Prius Plug-in Hybrid vehicles, equipped with lithium-ion batteries, to participate in a global demonstration program. The Toyota Prius Plug-in Hybrid is a mid-size plug-in hybrid electric vehicle (PHEV) with deliveries to the general market scheduled to begin in March 2012. The Prius PHEV is based on a third-generation Toyota Prius outfitted with 4.4 kWh lithium-ion batteries co-developed with Panasonic which enable all-electric operation at higher speeds and longer distances than the conventional Prius hybrid.

Also of note in 2011, Toyota launched more models in the hybrid Prius family. The 53-mpg Prius C hybrid, is smaller than the existing Prius and is offered at under US$20,000. A seven-seater Prius Alpha option uses lithium-ion batteries, and a five-seater Prius Alpha uses a standard nickel-metal hydride (NiMH) battery pack. These models were first offered in May 2011 to the Japanese market and then to a limited worldwide market in early 2012.

The disasters severed global parts supply chains enough that it took months to restore production to pre-quake levels. The Japanese auto industry is changing in order to diversify purchasing, secure alternate plants, and stockpile parts to prevent disruptions if another disaster occurs. Some questions about resiliency remain. For example, when a big earthquake cuts off roads and closes ports, how can relief supplies and equipment needed to restore production reach the plants that need them? These questions and others will be addressed as car makers seek to prevent another disruption to the vital Japanese auto industry.

30.3 Republic of Korea

South Korea consumed over 2.2 million barrels of oil per day in 2010, making it the ninth largest consumer of oil in the world. The country has no proven domestic crude oil reserves, and is wholly reliant on imports to meet its demand. Despite its lack of domestic energy resources, South Korea is home to some of the largest and most advanced oil refineries in the world. The transport sector accounts for 21% of Korean energy consumption, with an annual average increase rate of 6.3%.

As the world's fifth-largest car manufacturer (4,657,000 units in 2011), the Republic of Korea has an important role to play in enabling greater efficiency in the automobile industry and significantly reducing emissions from the transport sector. The South Korea government suggested "Low Carbon-Green Growth" as a national vision in October 2009. The Korean government has set a goal of one million electric vehicles (EVs) and 2.2 million recharging stations by 2020. As part of this low-carbon growth drive, South Korea's Ministry of Knowledge Economy launched a "Green Car Forum". The Forum aimed to establish a detailed EV strategy, including starting mass production of small-sized EVs in 2012 and mid-sized EVs in 2014. South Korea plans on becoming the world's fourth-largest EV market by 2015. To back up such ambitious goals, in 2011, the government earmarked a total R&D investment of KRW400 billion (US$345 million) on high-performance batteries and other related systems through 2014.

The Ministry of Knowledge Economy has recently pledged that EV buyers would be exempted from taxes worth up to KRW 4.2 million (US$3,600) from 2012. Additionally, all-electric car buyers will receive: a 5% reduction in the special consumption tax, which also covers the education tax; a 7% cut in acquisition tax; and an additional discount of up to 20% automobile bond purchases.

To help the suppliers, the government plans to provide a tax reduction of up to 20% on new growth engine components and 25% on source technologies. In addition, the government has built a "Green Network" to improve cooperation among the local parts companies. Various government supports will be offered through the Green Network.

As part of the plan to put 1 million EVs on the road, government organizations will receive a subsidy for more than 50% of the total purchase price in 2012 with a maximum of US$20,000 per single EV. There is an incremental percentage obligation for public organizations to purchase EVs going from 20% in 2011 up to 50% by 2013.

In January 2011, Korea Electric Power Corp (KEPCO) opened up the country's first EV charging stations on major highways. These charging facilities will be used as a model for the roll-out of EV infrastructure in the future. Currently, standardization of the EV charging system remains one issue for EV development. In 2011 the Korea Automotive Technology Institute (KATECH) established an International EV Standardization Center for the global standardization of EV technology.

Commercial Developments

EVs

Hyundai Motor Company formally unveiled the BlueOn in early September 2010, South Korea's first mass-produced battery-only electric vehicle. A total of 44 local companies, including Hyundai Motors, participated in the BlueOn project (one vehicle manufacturer and 43 component manufacturers). The BlueOn is a compact car (just 12 feet or 3.66 m long) with a 16.4 kWh lithium-ion polymer battery. Hyundai plans to manufacture 2,500 units by late 2012.

After the completion of the BlueOn Project, Hyundai-KIA Motors group developed the mass production capability for a small-sized box-type crossover utility vehicle (CUV) EV called TAM (but commonly known as "Ray"), and will soon begin mass-producing the vehicle. The company plans to manufacture more than 2000 TAM EVs by the end of 2012. In addition to the BlueOn and Ray, the company also plans to develop a mid-sized EV with a targeted release date of 2014.

Hyundai-Kia Motors has plans to make compact EVs. It also introduced Korea's first electric bus "Elec-city" in June 2010 with five buses going into service on Seoul streets in late 2010.

Hybrids

Hyundai's Sonata Hybrid was introduced in April 2011 and is designed to compete in the mid-sized hybrid market. The Kia K5 hybrid car was introduced to South Korean consumers in April 2011 during the Seoul Auto Show. According to industry observers, the Hyundai/Kia Motor group sold just 7,193 units of its Sonata and 5,279 K5 hybrids last year in the South Korean domestic market. The company's domestic 2011 sales targets for the two vehicles were 11,000 units of the Sonata and 6,000 units for the K5. Observers had predicted a sensation when pre-launch advance orders exceeded 2,000, but the monthly sales numbers were down to triple digits by the second half of the year.

General Motors has been promoting its hybrid Chevrolet Volt in Korea this year. The U.S. automaker said in August 2011 that it would expand its cooperation with Korea's LG Group on EVs. The two companies will jointly design and engineer future EVs for sale around the world.

LG Chem currently supplies batteries to the Chevrolet Volt and Opel Ampera hybrids. It is also a partner in a demonstration program for the Chevrolet Cruze EV.

General Motors and its Korean unit, GM Daewoo, have been developing both EVs and hybrid EVs. They developed their first full speed EV, the Lacetti Premiere EV compact sedan, in September 2010. General Motors says it will begin selling fully electric Chevrolet Sparks globally in 2013. Chevrolet Sparks might be made in Korea in the future if demand rises in the country.

Renault Samsung aims to mass-produce the electric version of its SM3 model which is based on Renault Fluence Z.E by the end of 2012. The company has deployed five SM3 EVs in the Jeju Smart Grid Test-Bed, the site in Jeju Island for testing the information technology-integrated power grid designed to optimize energy efficiency.

Advanced Battery Production

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.

In April 2010, LG Chem formally opened what it claims to be 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.

30.4 European Union

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. Thirteen of the IA-HEV member countries also belong to the EU: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

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. 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.

Within the Green Cars Initiative launched in the context of the European Recovery Plan, the European Union supports research and development of road transport solutions which have the potential to achieve a breakthrough in the use of renewable and non-polluting energy sources. With dwindling fossil resources, electromobility and EV become ever more important, especially with respect to climate change. To this end, the project Green eMotion (www.greenemotion-project.eu) was selected to enable a mass deployment of electromobility in Europe and funded at € 41.8 million (US$54.8 million).

The EU framework facilitates the communication between countries for issues such as standardization across national boundaries, and it supports joint research efforts. EU policies also affect all member countries.

Policies and legislation

The European Commission does not currently have regulations or incentives that specifically encourage purchases of hybrid and electric vehicles. However, some current and forthcoming regulations do address issues of greenhouse gas (GHG) emissions, safety, and standardization which may indirectly encourage the adoption of green vehicle technologies. Additionally, the EU is considering measures to stimulate the demand side, such as incentives and revising the Energy Tax Directive 2003/96/EC to create standards for taxation that would link taxes to energy content and CO_2 emissions of fossil fuels.

The EU Renewable Energy Directive mandates a 20% share of renewable energy sources in energy consumption by 2020, with a 10% binding minimum target for biofuels in the transport sector. Another tool to facilitate the adoption of clean vehicles is Directive 2009/33/EC requiring that all public purchases of road transport vehicles must take into account their energy and environmental impact. The Clean Vehicles Portal (www.cleanvehicle.eu) is a tool to facilitate the implementation of the Directive in the EU member states. 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 April 28, 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.

Regulations

The most significant EU regulation impacting hybrid electric vehicles (HEVs), plug-in hybrid vehicles (PHEVs), and electric vehicles (EVs) is 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. The goal of reducing new car emissions to 120 gCO_2/km by 2012, as defined in the strategy, is however not likely to be achieved because some measures have been implemented late. Despite a low probability of achieving the 2012 target, the strategy, and the measures it includes, has played an important role in reducing CO_2 emissions from light-duty vehicles. To improve planning certainty for the automotive sector while ensuring that CO_2 reductions from light-duty vehicles continue to take place, the Commission considers, based on a thorough impact assessment, to propose a target for passenger car emissions to be reached by 2025. Among other options, the Commission will assess the feasibility of the target suggested by the European Parliament of reaching 70 gCO_2/km by 2025.

The EU is also indirectly 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.

On the safety side, a UNECE (United Nations Economic Commission for Europe) regulation requiring shock protection for electric vehicles has been incorporated into European law. Also, test requirements for electrical safety have been harmonized between EU countries.

The EU is working to establish Europe-wide standards between the electricity supply point (charging point) and EVs, so that these will be interoperable and connect 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.

An Informal Group on Rechargeable Energy Storage Systems has also been established by UNECE Working Party .29 in order to develop requirements for batteries in electric vehicles that may ultimately be part of a regulation. Furthermore, two working groups were created in November 2011 at the UNECE level with the EU, Japan, and the U.S. They will focus on future regulatory requirements regarding the safety and environmental aspects of electric vehicles, respectively.

Other policies relevant to HEVs, PHEVs, and EVs

In 2005, CARS 21 (Competitive Automotive Regulatory System for the 21st century) was launched to make recommendations for short-, medium-, and long-term public policy for the European automotive industry. The CARS 21 High Level Group was re-launched in October 2010 and adopted its Interim report in December 2011.

The EU has developed a commission to evaluate the impact of EVs on the electricity supply system and power grid. It is also engaged in the development of recycling, re-use, and transportation policies for batteries as well as regulations and policies for raw materials related to the whole EV industry.

Research

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 research on these technologies. Announced in November 2008, the EGCI is a public/private partnership created through the European Economic Recovery Plan in response to the world economic crisis. The first thirty projects funded by EGCI with a total budget of € 108 million focused on a range of technologies for fully electric vehicles. All programs were underway by early 2011. A second funding opportunity announcement (FOA) in 2010 also included a focus on EVs.

Industry

The EU has no automotive industry of its own, but it still has influence over the industries in its member nations. In addition to the regulations and incentives discussed previously, the EU also has the ability to aid its member nations through its financial system.

The European Investment Bank (EIB) made a major contribution to the EGCI by delivering more than €4 billion through the dedicated financial instrument, the European Clean Transport Facility (ECFT). In addition, loans for projects targeting greener transport have also been provided by another EIB instrument, the Risk-Sharing Financial Facility (RSFF).

Since December 2008, EIB loans to Europe's auto industry have grown to more than €11.3 billion, mostly to fund OEM and supplier development of powertrain efficiency and emissions projects.

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 of this infrastructure. However, it will fund large demonstration projects.

Outlook

Several EU member states have set ambitious targets in terms of number of vehicles and infrastructure. The EU has not set any targets, but its activities aim to create the right conditions for the deployment of these technologies through its policies described above. It is expected that the emerging market and business opportunities related to manufacturing, repair and maintenance, and broader mobility solutions are likely to create jobs and prosperity for the European economy in line with the Europe 2020 growth strategy.

The Directive on emissions reductions and air quality regulations are expected to provide an impetus for greater numbers of HEVs, PHEVs, and EVs on the roads. Another important ingredient for the success of these vehicles is likely to be the application of the Directive 2010/40/EU on the framework for the deployment of Intelligent Transport Systems (ITS). This should support the implementation of ITS applications that will report on conditions and charging infrastructure availability along a car's route, among other features.

The funding of research activities under EGCI will continue till 2013. In the longer term, the direction of research will be defined by Horizon 2020, the next Framework Programme for Research and Innovation, which is currently under preparation.

The EU plans to support market development for electric vehicles by improving the coordination of vehicle taxation measures of member states. Other projects to study consumer expectations and buying behaviors and to test tools that compare the benefits of different types of "green" cars are also expected to help develop the market.

At the European level, infrastructure funding will be increasingly 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. The electrical infrastructure will also be adapted and upgraded in the framework of the Strategic Energy Technology (SET) Plan, which will generalize the use of smart grids and look also at the possibilities of vehicle-to-grid (V2G).

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 workers will continue with the financial support of the European Social Fund and, in case of restructuring, of the European Globalization and Adjustment Fund.

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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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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.

Block Heater

An element that is installed inside a vehicle's motor block to warm up the cooling water and thereby the whole motor before starting. They are commonly used in Nordic climates to preheat a car before use and with modifications may be sued to charge EVs.

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).

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.

New Energy Vehicle (NEV)

In China, NEVs are typically defined as plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and fuel cell vehicles (FCVs).

New European Driving Cycle (NEDC)

This is a driving cycle consisting of four repeated ECE-15 driving cycles and an Extra-Urban driving cycle (EUDC). The NEDC is supposed to represent the typical usage of a car Europe, and is used, among other things, to assess the emission levels of car engines. It is also referred to as MVEG cycle (Motor Vehicle Emissions Group).

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 lower gravimetric and volumetric energy density than 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.

Rare Earth Metals

A set of seventeen chemical elements in the periodic table, many of which are used in components in the drivetrains of hybrid and electric vehicles.

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)
AEEG	Authority for Electrical Energy and Gas (Italy)
AEI	Advanced Energy Initiative (USA)
AER	All-Electric Range
AFV	Alternative Fuel Vehicle
AGV	Automatic Guided Vehicle
Ah	Ampere-hour
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)
ANSI	American National Standards Institute (USA)
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
APVE	Portuguese Electric Vehicle Association
ARPA-E	The Applied Research Projects Agency - Energy (USA)
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
BIS	Department for Business, Innovation and Skills (United Kingdom)
BMBF	The Ministry of Education and Research (Germany)

BMU	The Ministry for Environment, Nature Conservation and Nuclear Safety (Germany)
BMVBS	The Ministry of Transport, Building and Urban Development (Germany)
BMVIT	Federal Ministry for Transport, Innovation and Technology (Austria)
BMWi	Federal Ministry of Economics and Technology (Germany)
BTL	Biomass-to-liquid (fuel)
CAC	Criteria Air Contaminants
CAFE	Corporate Average Fuel Economy
CAGR	Compound annual growth rates
CARB	California Air Resources Board
cc	cubic centimetre
CCFA	Comité des Constructeurs Français d'Automobiles
CCS	CO_2 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
CIRCE	Research Center for Energy Resources and Consumption (Spain)
CITELEC	Association of European Cities interested in Electric Vehicles
CIVES	Italian Electric Road Vehicle Association
CIVITAS	CIty-VITAlity-Sustainability (throughout Europe)
CMVSS	Canada Motor Vehicle Safety Standards
CNG	Compressed Natural Gas
CNR	National Research Council (Italy)
CO	Carbon monoxide
Co.	Company
Corp.	Corporation
CO_2	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
DEA	Danish Energy Agency (Denmark)
DfT	Department for Transport (United Kingdom)
DLR	Germany’s national research institute for aeronautics, space, transportation and energy (Germany)
DKK	Danish Crown (currency)
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
DSO	Utilities distribution system operator
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
EERE	Office of Energy Efficiency and Renewable Energy, Department of Energy (USA)
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
EMC	Electric Mobility Canada
eMCI	the electric Motor Cycle Industry Association (United Kingdom)
EMO	Electric mobility operator
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
ESB	Electricity Supply Board (Ireland)
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
ETSI	European Telecommunications Standards Institute
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
EVE	Electric Vehicle Systems Program (Finland)
EVS	Electric Vehicle Symposium
EVSE	EV supply equipment
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)
FINSENY	Future Internet for Smart Energy (Europe)
FISR	Special Integrative Fund for Research (Italy)
FIT	Feed-in Tariff
FMVSS	Federal Motor Vehicle Safety Standard (USA)
FP	European Framework Programme for research and technological development

FP7	EU Framework Program 7 (European Union)
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)
H_2	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)
JAMA	Japan Automobile Manufacturers Association
JARI	Japan Automobile Research Institute
JCS	Johnson Controls, Inc. and Saft joint venture
KATECH	Korea Automotive Technology Institute (South Korea)
KEPCO	Korea Electric Power Corp (South Korea)
ktoe	kilotonnes equivalent
Kton	kiloton
kWh	Kilowatt-hour
L	Liter
LCA	Life Cycle Analysis
LCV	Low Carbon Vehicle
LCVIP	Low Carbon Vehicle Innovation Platform (United Kingdom)
LDV	Light-duty Vehicle
LEV	Light Electric Vehicle
LEV	Low Emissions Vehicle
LFP	Lithium Iron Phosphate
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
LTPI	Lighthouse Projects Initiative (Austria)
MATT	Mobile Advanced Technology Testbed
MCFC	Molten Carbonate Fuel Cell
MEA	Membrane Electrode Assembly
MERC	Mechatronics Education and Research Center (Turkey)
MERGE	Mobile Energy Resources for Grids of electricity (Europe)
MERC	Mechatronics Education and Research Center (Turkey)
MERGE	Mobile Energy Resources for Grids of electricity (Europe)
Mg	Magnesium
MH	Metal Hydride
MICINN	Ministry of Science and Innovation (Spain)
MIIT	the Ministry of Industry and Information Technology (China)
min	minute(s)
MKE	Ministry of Knowledge Economy (South Korea)
MOBI.E	Mobilidade Eléctrica (Portugal)
MOF	the Ministry of Finance (China)
MOST	the Ministry of Science and Technology (China)
MOU	Memorandum of Understanding
mpg	miles per gallon
mph	miles per hour
MPV	Multi Purpose Vehicle
MRC	Marmara Research Center (TÜBITAK, Turkey)
MVEG cycle	Motor Vehicle Emissions Group (Europe)
MVSA	Motor Vehicle Safety Act (Canada)
NAC	National Automotive Center (USA)
NAIGHT	New Automotive Innovation Growth Team (United Kingdom)
NDRC	the National Development and Reform Commission (China)
NEDC	New European Driving Cycle
NEDO	New Energy and Industrial Technology Development Organization
NEET	Networks of Expertise in Energy Technology (an IEA initiative)
NEV	Neighbourhood Electric Vehicle
NEV	New Energy Vehicle (China)
NEVIC	Nordic Electric Vehicle Interoperability Centre (Denmark)

NGO	Non Governmental Organization
NGV	Natural Gas Vehicle
NHTSA	National Highway Traffic Safety Administration (USA)
NiMH	Nickel-Metal Hydride
NL	The Netherlands
NMVOS	Non-Methane Volatile Organic Substances
NPE	National Platform for Electromobility (Germany)
NOx	Nitrogen Oxides
NRMM	Nonroad mobile machinery
NYSERDA	New York State Energy Research and Development Authority (USA)
NRC	National Research Council of Canada
NRCan	Natural Resources Canada
NREL	National Renewable Energy Laboratory (USA)
NRMM	Nonroad mobile machinery
NYSERDA	New York State Energy Research and Development Authority (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)
OIB	Exporters' Association of the Automotive Industry (Turkey)
OLEV	The Office for Low Emission Vehicles (United Kingdom)
OPEC	Organization of the Petroleum Exporting Countries
ORNL	Oak Ridge National Laboratory (USA)
OSD	Automotive Manufacturers Association (Turkey)
OTAM	Automotive Technology Research and Development Center (Turkey)
P.A.	Power-Assisted
PANER	National Plan for Renewable Energies 2011–2020 (Spain)
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

PIP	Plugged-In Places (United Kingdom)
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
RES-T	Renewable Energy Supply Target (European Union)
RFG	Reformulated Gasoline
RMB	Renminbi (the official currency of the People's Republic of China)
ROG	Reactive Organic Gases
RPS	Renewable Portfolio Standard
RSFF	Risk-Sharing Financial Facility (European Union)
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 (currency)
SFOE	Swiss Federal Office of Energy
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
ST-SP	Stop & Start system
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)
TCS	Swiss Touring Club
TEKES	Finnish Funding Agency for Technology and Innovation
TENT-T	Trans-European Transport Networks
TLVT	Technology Life Verification Test
TNO	The Netherlands Organisation for Applied Scientific Research TNO
TSB	The Technology Strategy Board (United Kingdom)
TTIS	Transportation Technologies and Intelligent Automotive Systems Application and Research Center (Okan University, Turkey)
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
Vinnova	Swedish Agency for Innovation Systems
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

IA-HEV Contact Information

IA-HEV contact information

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