IEA INTERNATIONAL ENERGY AGENCY
HYBRID & ELECTRIC VEHICLE
IMPLEMENTING AGREEMENT

IA-HEV

Hybrid and Electric Vehicles

THE ELECTRIC DRIVE GAINS TRACTION

May 2013

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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: The Tesla Model S electric vehicle (EV) began retail deliveries in the U.S. in mid-2012. It ranked as the top-selling plug-in electric car in North America curing the first quarter of 2013 with 4,900 cars sold.
(Photo courtesy of Tesla Motors.)
The Electric Drive Gains Traction.
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International Energy Agency

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

Annual report of the Executive Committee and
Task 1 over the year 2012

Hybrid and Electric Vehicles

The Electric Drive Gains Traction

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Contents

D: Practical information

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 2012, 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.

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

The Implementing Agreement for co-operation on Hybrid and Electric vehicles (IA-HEV) is one of 42 technology collaboration programs of the International Energy Agency (IEA). Now with 18 member countries from Europe, North America, and Asia, we launched in 1993 and are now halfway through our fourth term that began in December 2009 and will finish at the end of February 2015. IA-HEV is well on its way towards achieving the current term's objectives (listed in Box 1.1) of collaborating on producing and disseminating new knowledge and information on hybrid and electric vehicles (HEVs and EVs).

Box 1.1
IA HEV objectives for the fourth phase (2009 – 2015)

1. To produce objective information for policy and decision makers on hybrid and electric vehicle technology, projects and programs, and their effects on energy efficiency and the environment.
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.

Over the past year, as the international EV market has grown, more and more countries are asking about how to participate in IA-HEV. The Republic of Korea (South Korea) was invited to join our Implementing Agreement in October 2012, and officially became a member in April 2013. During the year we welcomed many observers and prospective members at our meetings, many from Asian countries. Asia is an important player in the transition from internal combustion engines (ICE) to the electric vehicle (EV), and we hope to see more participation in IA-HEV from this region.

In summer 2012, IA-HEV signed a collaboration agreement with the Electric Vehicles Initiative (EVI) of the Clean Energy Ministerial. EVI is a forum for global co-operation on EV development and deployment. The IEA's Paris headquarters office coordinates the data transfer work. The EVI member countries as of early 2013 are China, Denmark, Finland, France, Germany, India, Italy, Japan, the Netherlands, Portugal, South Africa, Spain, Sweden, the United Kingdom (UK), and the

United States (US). EVI seeks to facilitate the global deployment of 20 million EVs by 2020, including plug-in hybrid electric vehicles (PHEVs) and fuel cell vehicles (FCVs). IA-HEV is cooperating with EVI as an observer, and many countries are members of both organizations.

Transition from ICE to EVs

All of the IA-HEV member countries along with the entire world are in the initial stages of transitioning from reliance on ICE vehicles to more sustainable transport modes such as EVs. The progress in the past few years has been remarkable, but we are still in the early stages of the transition. It will take patience and determined effort from all EV stakeholders to overcome technology, financial, market, and policy challenges. IA-HEV continues to work to build a solid foundation for EVs to become mainstream.

Governments can offer tax incentives and other subsidies, but ultimately it is consumers who will determine whether EVs succeed as a viable transport option. Automotive OEMs will manufacture and sell vehicles as the market demands, so they are making big investments in building new EV and PHEV models. There is a huge amount of potential for new industry growth, but as with any new industry, there is high risk for investors.

It will take considerable work to adapt the current auto industry and supporting industries to a new world of electromobility. Research and development (R&D) investment in HEV and EV technology will grow along with the need to train an EV workforce, from the mechanics who work on EVs, to building the natural resource supply chain needed to make advanced batteries for EVs. As markets shift from using fossil fuels, the fossil fuel companies are competing with emerging EV electricity markets. So, oil companies and the associated industries may view electricity markets that supply EVs as competitors.

Electric vehicle market introduction requires patience and careful planning. Governments can foster an atmosphere conducive toward EV acceptance. International coordination lowers the cost for governments to introduce EVs and demonstrates broad commitment to this new way of transportation. To this end, IA-HEV has several Tasks working on the topic of how to create a supportive marketplace for EVs, including the new IA-HEV Task 22 on E-Mobility Business Models.

Markets, Consumers, and Choice

Hybrids such as the Toyota Prius are the established hybrid vehicle choice for most consumers. The HEV models today range from small and economical up to large and luxurious. Consumers have accepted them as a proven technology, and they are also seen as trendy and more efficient. Hybrids have paved the way for PHEVs such as the Opel Ampera and Chevrolet Volt and pure EVs such as the Nissan Leaf and Renault Twizy.

Along with EVs, fuel cell vehicles (FCVs) offer a sustainable transport option. For years, many automakers have been testing hydrogen FCVs, but to date they have not been able to bring costs down enough to sell the vehicles in mass markets. The need to install a hydrogen charging infrastructure is also a hurdle for this technology. Car makers such as Daimler and Renault-Nissan have formed alliances for fuel cell R&D, but market introduction is estimated to be years away. However, fuel cell technologies are worth watching because of their environmental benefits.

Enough "green electricity" for the EVs

Electricity produced by fossil fuels that is used to power EVs produces high carbon dioxide (CO_2) emissions. Additionally, electricity produced by nuclear power plants suffers from a poor environmental image, especially in light of the Fukushima nuclear meltdown where the environmental effects two years after the incident are still coming to light. Renewable, clean energy is the best choice for powering EVs. Many initial EV buyers are "early adopters" who are motivated to buy an EV for their green benefits.

In 2012 the photovoltaic (PV) industry installed more than 30 gigawatts peak (GWp) of PV modules worldwide. This creates enough electricity for 15 million EVs. But the lifetime of the PV installations is three times higher than for a car, so these 30 GWp could power 90 million EVs a year. This is more than the total annual car market in the world. These figures show that generating electricity for EVs is not a serious problem. In five years, wind energy alone could power all the cars in the world if they were all fuelled by electricity.

IA-HEV member country Germany surpassed 30 GWp of PV in 2012. The US, an IA-HEV member, has established the Electric Vehicle Grid Integration Project that supports the development and implementation of electrified transportation systems, particularly those that integrate renewable-based vehicle charging systems. Another IA-HEV member, Portugal, is a leader in renewable energy sources with more than half its energy coming from wind, solar, and hydro power. Their MOBI.E information and communication technologies (ICT) network is tying EVs into the smart grid. So, while most IA-HEV countries primarily depend on fossil fuels, a transition from fossil fuels and renewable energy is occurring.

Niche markets for EVs – Pedelecs and Special Vehicles

Electric bikes (e-bikes) or pedelecs are succeeding worldwide, from the mass market in China to selected high-price markets in Europe. The final publication, Go Pedelec!, of the concluded IA-HEV Task 11, Electric Cycles, is now available online at www.gopedelec.eu for download in multiple languages. Along with the handbook, the website contains a wealth of information for municipalities about best practices for pedelecs. So, we have a good base of information to proceed in investigating how to advance e-bikes going forward. It may be time for IA-HEV to revisit e-bikes and their niche markets.

Another interesting EV market niche is for trolley buses. In Europe there is a renaissance for this kind of public transportation. In my hometown of Berne, capital of Switzerland, more than 60% of inhabitants do not own cars but instead use the public transportation system. Both of these EV types have important roles to play in achieving better urban air quality and reliable, clean modes of transport.

I recently received an e-mail from our former IA-HEV secretary Frans Koch, who retired in 2004. He now drives a Chevrolet Volt as his second car that he plans to use mainly in the all-electric mode. The Volt's fuel consumption is about 1 liter gasoline per 100 km and 20 kilowatt-hours (kWh) per 100 km. Frans filled the tank so rarely that he forgot where the gas tank button was located, which is a good sign for operating in the all-electric mode without using any fossil fuel. He charges his Volt in "off-peak" hours. People like our former secretary are "EV pioneers." All new technology markets begin with early adopters like Frans. The EV emerging market is the most exciting time for EV pioneers and entrepreneurs while they help build the EV marketplace.

The transition needs a careful management of resources and a close collaboration of industry, public, and government

According to the IEA World Energy Outlook 2012, fossil fuel subsidies rose by 30% to US$ 523 billion in 2011 while renewable energy subsidies were US$ 88 billion. CO_2 emissions were at a record high, and an all-time high in oil prices is affecting the global economy. Policy makers face critical choices in reconciling growing energy needs with environmental and economic objectives. The foundation of the global energy system is shifting. There is resurgence in oil and gas (particularly unconventional gas) in some countries, a retreat from nuclear energy, and signs of an increasing policy focus on energy efficiency. Government subsidies for electric vehicles and the associated renewable energy provide a means for governments to achieve energy security and environmental goals.

Industry theoretically benefits from cheaper, subsidized oil and has very little motive to develop clean technologies. Therefore the government should either create an open, unsubsidized oil market or should help industries that transition away from fossil fuel use like the EV industry. IA-HEV brings industry, government, and organizations together to collaborate and find solutions to overcoming barriers for EVs and provide sound, objective information for policy makers.

Solving technical problems

Technology is constantly evolving. "Building a better mouse trap" to achieve energy-related and environmental goals requires robust technologies and concentrated effort. Very rarely do we find a technology that "leapfrogs" into the mainstream. IA-HEV investigates promising technologies, components, and systems for cheaper and better electric vehicles.

IA-HEV meets twice yearly at an Executive Committee meeting. Part of the meeting is devoted to "special topics" where country experts exchange information from a wide-range of policy and technological topics. This is an efficient forum to gather real-world experience and best practices from the world over. Each country member takes this knowledge to their home country, which informs and advances each member- countries EV program decisions.

Summary of IA-HEV 2012 Activities

During 2012, IA-HEV continued to deliver results and launch new projects. Two Executive Committee (ExCo) meetings were held in Los Angeles (36th ExCo, May 2012) and in Stuttgart, Germany (37th ExCo, October 2012).

Fig. 1.1 Participants at the 36th ExCo meeting exchange EV information.

Highlights of the 36th Executive Committee meeting, May 2012, Los Angeles

Increasing industry participation in IA-HEV and the interoperability of charging solutions across country borders were big topics as IA-HEV member and guest country delegates met in Los Angeles (LA). The LA ExCo meeting met directly before EVS 26 (the 26th Electric Vehicles Symposium). Many IA-HEV member representatives attended EVS 26 and also presented papers. Also IA-HEV-related, the first-ever World Electric Vehicle Cities & Ecosystems (WECE) conference was held prior to EVS 26. Partners between leading global electric vehicle (EV) readiness initiatives— IA-HEV Task 18 (EV Ecosystems), the Rocky Mountain Institute's Project Get Ready, the Clean Energy Ministerial Electric Vehicles Initiative (EVI), and the University of California, Davis Plug-in Hybrid & Electric Vehicle Research Center co-hosted the event, launched the website www.worldevcities.org about EV deployment best practices, and presented the *EV City Casebook*. The World EV Cities and Ecosystems website is populated with the data presented in the *EV City Casebook* that features details about EV programs currently implemented in 16 cities and regions in Asia, Europe, and North America.

Delegates at the 36th ExCo meeting came from the IA-HEV member countries Austria, Belgium, Canada, Denmark, Finland, Germany, Ireland, Italy, the Netherlands, Switzerland, Turkey, the United Kingdom, and the United States. Guests from Australia, Colombia, the European Commission, and EV-related organizations such as AVERE (the European Association for Battery, Hybrid, and Fuel Cell Electric Vehicles), the California Plug-in Electric Vehicle Collaborative, the City Council of Santa Monica, and APVE (the Portuguese Association for Electric Vehicles) also participated.

Fig. 1.2 car2go fleet in Stuttgart, Germany. Image courtesy of car2go.

Highlights of the 37th Executive Committee meeting, October 2012, Stuttgart, Germany

Special topics of the 37th ExCo meeting held in Stuttgart, Germany, focused on data collection with other EV-related organizations and interoperability and standardization for EVs. IA-HEV and the IEA on behalf of the EVI are beginning to collaborate on collecting data on deployments of hybrid and electric vehicles and EVSE (electric vehicle supply equipment, also known as charging stations). Both organizations currently collect these kinds of data, but with different definitions of categories. Because four EVI countries (China, India, Japan, and South Africa) are not members of IA-HEV, a consistent data format collected across both groups would enable direct comparison of statistics from more than 20 countries.

EV interoperability, with charging infrastructure from multiple service providers and across international borders, remains a major focus of EV-related efforts in Europe. Companies providing EV charging services want to identify the solutions that are flexible and cost-efficient for the future. As a result, there are multiple European activities discussing interoperability, including E-clearing.net, Hubject, eMobility ICT Interoperability Interest Group, Green eMotion Marketplace, MOBI.Europe, etc. IA-HEV is tracking interoperability activities and may start a new Task in this area if gaps are identified that are not being addressed by the other efforts.

Meeting participants included representatives from the IA-HEV member countries Austria, Belgium, Canada, Denmark, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland, Turkey, the UK, and the US. Guests from the European Commission, Japan, Latvia, and South Korea also attended and presented. A representative from the IEA Implementing Agreement on Advanced Motor Fuels (IA-AMF) shared information on their topics and procedures. Leaders of the organizations AVERE (the European Association for Battery, Hybrid, and Fuel Cell Electric Vehicles) and ACEA (the European Automobile Manufacturers Organization) also participated.

IA-HEV Members as of 2012

Members are Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. We were happy to welcome the Republic of Korea (South Korea) as a new member in spring 2013.

IA-HEV Tasks

Ten Tasks are currently active, which is a record number of international research collaborations for IA-HEV. Two new Tasks were approved in 2012: Task 21, Accelerated Ageing Testing for Li-ion Batteries, was approved by the ExCo in May 2012, and Task 22, EV Business Models, began in October 2012.

TASK 1: INFORMATION EXCHANGE

Task 1 serves as a platform for information exchange among member countries. The objectives are to collect, analyze, and disseminate information relating to HEVs, EVs, and FCVs from both member and nonmember countries. The Task meets in conjunction with the semi-annual ExCo meetings.

Membership is automatic for all IA-HEV members. Ms. Kristin Abkemeier acts as the Operating Agent on behalf of the United States Department of Energy.

TASK 10: ELECTROCHEMICAL SYSTEMS

Task 10 focuses on topics related to the chemistry and performance of electrochemical energy storage devices (batteries and ultracapacitors). About once a year, a working group forms to address a specific topic of current interest and holds one or two workshops. The most recent workshop, Batteries Under Extreme Temperatures, was held in October 2012 in Montreal, Canada.

Representatives from industry, government, and the research sector are invited to participate. Any IA-HEV member country may participate in Task 10 workshops. Country experts from the private and public sector then choose to participate according to the workshop topic. Mr. James Barnes of the US serves as the Operating Agent.

TASK 14: MARKET DEPLOYMENT OF ELECTRIC VEHICLES: LESSONS LEARNED

Task 14 collected experiences from past plug-in electric vehicle (PEV) demonstration and market introduction programs to identify lessons learned from these pioneering efforts over a three-year period.Task work began in 2007 and concluded in 2012. Eleven workshops were held to provide a solid foundation of knowledge to inform the initial roll-out of PEVs, and provided a base to launch Task 18, EV Ecosytems. A final Task report is scheduled for completion in 2013.

Task members are Austria, Sweden, Switzerland, the UK, and the US. Mr. Tom Turrentine, Plug-in Hybrid Electric Vehicle Research Center, Institute of Transportation Studies at the University of California, Davis, US, served as the Operating Agent.

TASK 15: PLUG-IN HYBRID ELECTRIC VEHICLEs

Task 15 provides essential information to understand the current variables related to PHEVs entering the market. Questions to be answered include identifying which types of PHEVs are best in various applications, and how much PHEVs will actually increase the sustainability of transport. The final report for this phase of research is being written, and a second phase of this Task is under consideration.

Here are some of the findings of Task 15:

- For personal use, the type of PHEVs that were evaluated in this study would be most suitable for use in suburbs and towns, not in dense city centers.
- Intensive use of these vehicles is required for cost-effective operation.
- Today, battery costs appear to be a major hurdle for large-scale deployment of PHEVs.
- Although fuel prices are different between Europe and the US, general conclusions can be drawn. People in the US generally drive more than people in Europe.
- Combined with the lower fuel price in the US, it appears that the best application for PHEVs is similar in Europe and the US.

Canada, France, Germany, Sweden, Switzerland, and the US are Task 15 members. Mr. Danilo Santini, Argonne National Laboratory in the US, is the Operating Agent.

TASK 17: SYSTEM OPTIMIZATION AND VEHICLE INTEGRATION

Task 17 is analyzing technology options for the optimization of electric vehicle components and drivetrain configurations that will enhance a vehicle's energy efficiency performance. A Task workshop was held in May 2012 in Los Angeles. Another strategic meeting was held at TechGate in Vienna on December 10th in conjunction with the 7th annual Austrian Agency for Alternative Propulsion Systems (A3PS) conference *Eco-Mobility 2012*.

Going forward, this Task will focus on two topics:

- **System optimization:** This is a huge area of attention. So far the Task has reviewed EV drivetrain components and the way they are combined. An inventory was made of components that are currently available on the market and also for components expected to be available on the market in the near future. Major effort was made to make the data comparable between components. The aim is not to advise industry, but to make an inventory of the options/configurations that have been chosen and to explain why.
- **Vehicle integration:** This topic involves the analysis of the potential of lightweight structures and materials used in EV drivetrains to achieve higher energy efficiency, and their impact on vehicle safety and end-of-life recycling. Involvement of the Implementing Agreement on Advanced Materials for Transportation would be valuable.

Ms. Gabriela Telias who served as the Task 17 Operating Agent has moved on from A3PS, Austria. Many thanks to Gabriela who contributed much effort to Task 17 and IA-HEV over several years, and we send warm wishes for success in her future endeavors. We are pleased to welcome Mr. Mark-Michael Weltzl of A3PS as the new Task 17 Operating Agent.

Austria, Germany, Switzerland, and the United States are members. Current Task 19 member representatives are from the Austrian Agency for Alternative Propulsion Systems (A3PS, Austria), eNOVA Strategy Board for Electric Mobility (Germany), Bern University of Applied Sciences (Switzerland), and the US Department of Energy and Argonne National Laboratory (US).

TASK 18: EV ECOSYSTEMS

Task 18 actively collaborated with other international projects in 2012. The web portal www.worldevcities.org was launched in May 2012 at the first World Electric Vehicle Cities & Ecosystems (WECE) conference through a partnership between IA-HEV Task 18, Electric Vehicles Initiative, Rocky Mountain Institute, IEA, Clinton Climate Change Initiative, and University of California Davis. The conference attracted about 300 participants from around the world.

The Global EV Insight Exchange WECE is pooling resources and expertise from international city networks by sharing data, extending opportunities for outreach and dissemination of results. The initial collaboration focused on the WECE web portal and the publication of the *EV City Casebook*. The WECE web portal is continuing to add cities, most recently London, UK, Kanagawa Prefecture, Japan, and Shenzhen, China. The *Casebook* has spurred much interest and cities are inquiring on how to be included.

Austria, Germany, Portugal, Spain, the United Kingdom, and the United States are members. Mr. David Beeton, Urban Foresight, UK and Mr. Tom Turrentine, UC Davis, US are the Operating Agents.

TASK 19: LIFE CYCLE ASSESSMENT (LCA) OF ELECTRIC VEHICLES

Task 19 is looking at the entire EV value chain from production through to end-of-life recycling in order to measure the total environmental costs and benefits. The first Task workshop was held on December 7, 2012 in Braunschweig, Germany, entitled "LCA Methodology and Case Studies of Electric Vehicles."

Austria, Germany, Switzerland, and the United States are Task 19 members. Mr. Gerfried Jungmeier, Joanneum Research Institute for Water, Energy, and Sustainability, Austria is the Operating Agent.

TASK 20: QUICK CHARGING TECHNOLOGY

Task 20 held its kick-off meeting on May 6, 2012, in Los Angeles with about 40 participants from four stakeholder groups: OEMs, charger providers, battery developers, and utilities. Participants agreed that the use of EVs and charging can realize environmentally-friendly "green" mobility. Achieving this will require the co-operation of multiple stakeholders to implement efficient EV charging timed for minimal impact on the electrical grid. One size will not fit all in the case of EV charging business models—a wide-portfolio of solutions will be needed to enable EVs and quick charging to succeed. Plans are underway for the next workshop in May, 2013 that will be held in Japan.

Task 20 members are Germany, Spain, and the United States. Mr. Ignacio Martin, CIRCE (Research Center for Energy Resources and Consumption), Spain is the Operating Agent.

TASK 21: LITHIUM AGEING ACCELERATED TESTING PROCEDURES

The objective of Task 21 is to take an inventory of worldwide efforts used in the development and application of accelerated testing procedures for analyzing the ageing of lithium-ion batteries in various vehicle applications.

Inaugural members are Italy, Switzerland, and the US. Mr. Mario Conte, ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) is the Operating Agent.

TASK 22: E-MOBILITY BUSINESS MODELS

Task 22 will advance understanding of the opportunities to generate revenue and limit costs in the provision of EVs, charging infrastructure, and the associated links to energy systems. Now that the EV market is moving beyond demonstration projects into the mainstream, policy makers face the challenge of creating supportive environments to promote EV investment and enterprise as they enter the mass market. The UK and the US are initial members, but individual experts who are not IA-HEV members can also participate by contributing articles about EV business models. Mr. David Beeton, Urban Foresight, UK is the Operating Agent.

Future Task Topics

Discussion among IA-HEV members is underway to determine what the new Tasks in 2013 will be. Below are new Task topics under consideration.

Pedelecs as extension of public transport systems like bus and trains as well as in tourism: A potential new Task on pedelecs should provide a database with examples of best practices of pedelec rental schemes, and a database of pedelecs that are built for this purpose. Additionally, the Task could organize an annual seminar and occasional study trips to observe best practice applications.

Other ideas for new Tasks:

- Wireless charging
- Interoperability of EV charging infrastructure
- Safety of rescue workers
- Decarbonize/fuel switch of cars
- Hydrogen and fuel cells
- Plug-in EVs and home grids
- 2nd use of batteries
- Test procedures
- Cross cutting technologies
- Drive cycles
- Lightweight materials construction

Word of thanks to the management team of our Implementing Agreement

Finally, I would like to thank the people who have been working every day to make IA-HEV the premier forum for Our Secretary-general Martijn van Walwijk continues in his excellent job of managing IA-HEV, representing the organization at international EV forums, and establishing contacts with other organizations and potential new member countries. The Task 1 Operating Agent Kristin Abkemeier and her co-worker, Alison Mize continue to produce the IA-HEV newsletter, *The Road Ahead*, and this annual report. They also maintain the informative IA-HEV website (www.ieahev.org) along with coordinating and leading the twice-yearly Task 1 meetings. Mr. Tali Trigg continues to serve as our IEA desk officer and also participates in our ExCo meetings. I must thank all of our Task leaders and the members who continue to do an exemplary job of addressing vital issues for hybrid and electric vehicles through our international collaborations. And I finally thank my colleagues from the Executive Committee for their ongoing commitment to make IA-HEV the best forum for experts to come together to advance the cause of hybrid and electric vehicles.

I look forward to continued work in 2013 with the members of the Executive Committee, Task members, and other specialists in the IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicles. As we journey forward, our electric vehicle work remains relevant and important for achieving sustainable transport systems and energy security.

Urs Muntwyler
IA-HEV Chairperson
April 2013

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 – 2012

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

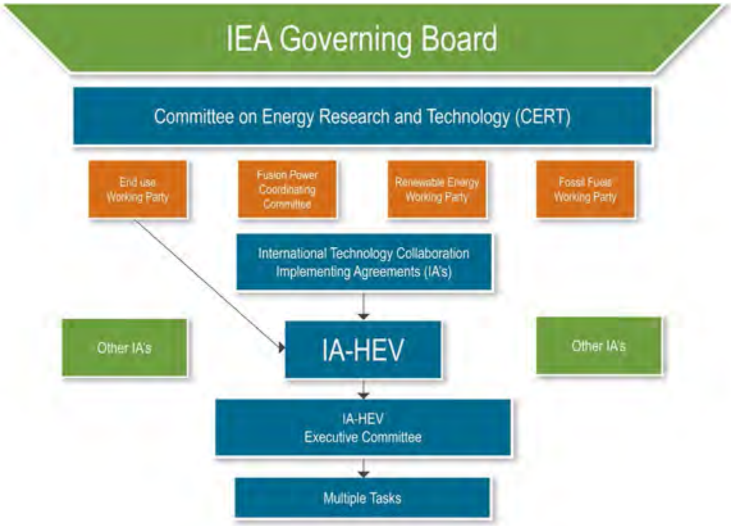

Fig. 2.1 The IEA energy technology network.

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. Most recently published in 2012, these reports can be downloaded for a fee from the internet at www.iea.org/etp/.

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 18 active Contracting Parties (member countries) per April 2013 are Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Republic of Korea, 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 2012 and in early 2013 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.

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.

Since 2010, the ExCo has approved six new projects, beginning with Task 17 on system optimization and vehicle integration of components for enhanced overall electric vehicle performance, and 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. Finally, during 2012, Task 21 on accelerated ageing testing for lithium-ion batteries and Task 22 on e-mobility business models were approved by the ExCo. Specific details on these new Tasks as well as the continuing Tasks that were operating during 2012 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 chairperson, 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
- 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 the EVS (Electrical Vehicle Symposium) meetings.

The Task 1 Operating Agent (OA) is responsible for coordinating and leading the semi-annual experts' meetings, compiling the minutes of these meetings, maintaining the IA-HEV website (Fig 3.1), 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 Office.

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 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

As of June 2013, thirty-five experts' meetings have been conducted since the inception of the IA-HEV in 1993. In 2012, two Task 1 meetings were held, the 2011 Annual Report was published, and two IA-HEV e-newsletters were issued.

IA-HEV Task 19 considers EV sustainability

The Task focus is on the life cycle assessment (LCA) of electric vehicles (EVs). The objective is to learn how electric drivetrain vehicles should be designed for optimal recyclability, minimal resource consumption, and proper recycling or disposal.

Task 1. Information Exchange
Collects, analyzes, and disseminates information

Task 10. Electrochemical Systems
Forum for current issues in advanced batteries

Task 14. Market Deployment of Electric Vehicles: Lessons Learned
Analyzed past EV demonstrations to identify best practices

Task 15. Plug-in Hybrid Electric Vehicles
Focuses on how PHEVs can address real market needs

Austria
Belgium
Canada
Denmark
Finland
France
Germany
Ireland
Italy
The Netherlands
Portugal
Republic of Korea
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

IA-HEV is honored to welcome the Republic of Korea as its newest member.

The Road Ahead newsletter January 2013

Fig. 3.1 Home page of the IA-HEV website, 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 the 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 time slot that includes both a presentation and follow-up discussion. Because of the growth in the number of members, the focus at each meeting is on fostering in-depth discussion of critical new developments in a subset of countries. Generally, each member country participates at least once per year.

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 IA-HEV 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 up to full systems testing.

The objective of Task 10 is to facilitate relevant information exchange among technical experts from the electrochemical power sources field. In contrast to the objectives of 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 once 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 on the basis of the participant's 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

Task 10 held a one-day workshop on battery performance under extreme temperature conditions in Montreal, Canada, on October 22, 2012, immediately prior to the EV 2012 VÉ conference and tradeshow on "The Business of Going EV." The workshop was co-hosted with IA-HEV Task 15, Plug-in Hybrid Electric Vehicles, and hosted by Natural Resources Canada. There were about 30 attendees from all over North America affiliated with government agencies and laboratories, universities, the battery industry, and auto and equipment manufacturers.

Fig. 4.1 EV advanced batteries must perform well in a hot or cold climate. (Image courtesy of Renault.)

Thermal management of advanced battery systems is critical to the success of EVs because extreme temperatures can affect the performance, reliability, safety, and durability of batteries.

The effects of hot temperatures are well known:

- High temperatures may result in brief improvements in power and energy.
- Long-term high temperatures reduce calendar life and performance.
- Very high temperatures (>100°C) can cause significant safety problems.

Cold temperatures can cause a variety of problems:

- Charging a lithium-ion battery when cold can cause serious safety problems and/or result in a permanent loss of capacity.

- Cold lithium-ion batteries deliver less energy and much less power than the same batteries at room temperature.
- If the battery is used to provide energy for passenger heating, this use can have a substantial negative effect on vehicle range.

Drivers expect to be able to use electric drive vehicles year-round. Critical to meeting this expectation is for advanced batteries, such as lithium-ion systems, to perform consistently in seasonal temperature extremes ranging from heat in the summer to cold in the winter (Fig. 4.1). Workshop discussions focused on the following questions:

- What are the real temperature requirements for batteries in light passenger vehicles?
- What are the effects of temperature on batteries, as measured by an experiment or predicted by modeling?
- How can these effects be addressed, both through cell chemistry and design and through battery thermal management?

The workshop attendees addressed these questions through a combination of informal presentations that were followed by group discussions accompanied by performance data. Examples of different approaches for managing temperature extremes included the following suggestions:

- Address low temperatures through vehicle storage in a garage, especially a heated garage.
- Address temperature extremes at the battery level through cell heaters for low-temperature operation and cell cooling for high-temperature environments.
- Improve cell performance at temperature extremes through modifications in cell chemistry, such as novel electrolytes.

4.5 Further work

Planning for future workshops is under way. Workshop topics will be held on emerging topics that are highly relevant for the advancement of battery and capacitor technology. Developments in HEV and EV technologies and markets will affect 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 on a specific topic are urged to contact the Operating Agent.

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United States
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Fax: +1 202 586 2476
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5

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

Members: *Canada, France, Germany, Sweden, United States*

5.1 Introduction

The transportation sector ranks high in national oil use and greenhouse gas (GHG) emissions in IA-HEV member countries. Plug-in electric energy for transportation is one option for reducing oil use and GHG emissions and improving local air quality. Using electricity from the grid leads to greater energy security by reducing oil use per mile of service delivered. Plug-in electric drive's potential to eliminate oil use has become more attractive in recent years because technical and economic feasibilities have improved and because, on average, oil prices have increased significantly. Concerns about possible actual restrictions of supply have also recently emerged.

Depending on the modes of electricity used, grid-supplied vehicle energy can either modestly or dramatically reduce GHG emissions. Improved knowledge about health impacts from particulate matter has caused an increased emphasis on eliminating tailpipe and "upstream" emissions caused by motor vehicles, increasing the conventional powertrain's costs.

Thus, more than ever, low consumption of refined petroleum products per kilometer of operation is becoming a primary focus of powertrain product development, with reduced overall carbon emissions also having 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 PHEV concept is increasingly seen as an excellent, implementable powertrain that is the logical first step toward a long-term transition to more sustainable transportation.

In Task 15, PHEVs, which are not capable of all-electric charge depletion under some driving conditions, are distinguished from extended range electric vehicles (EREVs) that have more powerful electric engines and battery packs and can charge-deplete all of the electricity in all cases within metropolitan areas.

5.2 Objectives

The objectives and history of Task 15 have been discussed in previous IA-HEV annual reports. Broadly speaking, the objectives of Task 15 involve finding the best niches for various PHEV technology options, evaluating PHEVs against competing technologies, and considering PHEVs in the context of the electricity grid and the use of renewable energy sources.

Since the Task 15 work plan was revised in 2011 and two original goals were spun off to Task 10 (Electrochemical Systems) and Task 17 (Vehicle Optimization and System Integration), Task 15 subtasks have largely been limited into these segments:

- Subtask 1: Powertrain attributes and vehicle lifetime use costs
- Subtask 2: Policy issues and marketability
- Subtask 3: Group administration, communication, and coordination by the Operating Agent (OA)

5.3 Working method

Task 15 work has been conducted through workshops and expert meetings. Germany joined Task 15 in 2011, which extended the end date for the initial three-year phase to 2013. After two meetings and a workshop during 2007–2009 led by an OA from Natural Resources Canada, the active membership of Task 15 changed over 2011–2013 to include multiple country experts from Germany, France, and the United States. France hosted two country expert meetings in 2011, and the United States hosted the final meeting in 2012.

Since 2011, the U.S. Department of Energy (DOE) has provided support for the OA, Danilo Santini of Argonne National Laboratory, through the Energy Storage Program managed by David Howell in the Vehicle Technologies Office within the DOE’s Office of Energy Efficiency and Renewable Energy. Aymeric Rousseau of Argonne National Laboratory is the vice-OA as well as the co-leader of Subtask 1. Subtask leaders for Subtask 2 topics were other participating country experts, including Bernd Propfe and Martin Redelbach, both of the Institute of Vehicle Concepts at the German Aerospace Center (DLR); David Dallinger of the Fraunhofer Institute for Systems and Innovation Research; and Argonne’s Danilo Santini.

For Subtask 1, country experts from France’s Energies Nouvelles and the United States’ Argonne National Laboratory Center for Transportation Research conducted joint vehicle simulation/modeling research on powertrain attributes for multiple types of plug-in hybrids having varying amounts of electric drive power and energy, as well as different powertrain configurations (DaCosta et al. 2012). Country experts from Energies Nouvelles, the Institute of Vehicle Concepts at DLR, and Argonne’s Center for Transportation Research collaborated on the topic of vehicle lifetime use costs, incorporating the vehicle and powertrain modeling results (Rousseau et al. 2012).

From the time the modified work plan was approved until Task 15 was completed, participating country experts co-authored 14 research papers, gave 5 presentations, and produced 2 supporting reports on battery technical attributes and costs. Under Task 15 together with Task 10, a workshop on batteries in extreme temperatures was co-hosted in October 2012.

These publications and workshop findings supported the completion of the summary report on Task 15, delivered at the IA-HEV Executive Committee meeting in April 2013.

Topics addressed in the final Task 15 report and the supporting papers prepared (the complete references are provided at the end of this chapter) are listed in Table 5.1.

Table 5.1 Topics in the final report for Phase 1 of Task 15 (PHEVs).

Task 15 Final Report Topics	Papers Prepared
Find the best consumer niche(s) for multiple PHEV technology options	Zhou et al. (2012); Propfe et al. (2012); Rousseau et al. (2012); Santini et al. (2012); Santini et al. (2013b); Santini and Burnham (2013)
Evaluate vehicle purchase and operations costs	Propfe et al. (2012); Rousseau et al. (2012); Santini et al. (2013b)
Effects of taxes – road, registration, fuel, etc.	Addressed in a 2010 conference paper by D. Dallinger, a participating country expert from Germany's Fraunhofer Institute
Vehicle regulation impact on powertrain choice	DaCosta et al. (2012); Rousseau et al. (2012); Santini et al. (2013b)
Infrastructure/charger attributes and costs	Santini (2011); Rask et al. (2012); Santini et al. (2012)
Choice of marginal, incremental, or average as an evaluation method	Elgowainy et al. (2012a,b); Dallinger et al. (2012); DaCosta et al. (2012); Santini and Burnham (2013)
Net petroleum use reduction	DaCosta et al. (2012); Rousseau et al. (2012); Santini et al. (2013b); Santini and Burnham (2013)
GHG reduction versus hour/season of charging; generation type	Elgowainy et al. (2012a,b); DaCosta et al. (2012); Dallinger et al. (2012); Santini and Burnham (2013)

5.4 Results

Since the restructuring of Task 15 in 2011, participants have published 16 project-supporting publications and given 5 presentations. Seven of the publications were conference papers delivered at the 26th Electric Vehicle Symposium (EVS 26) meeting in May 2012. Immediately after this conference, a final Task 15 meeting was held in which a consensus was developed on key findings to be emphasized in the final report.

2008–2011 Activities. Charles Thibodeau of Natural Resources Canada managed Task 15 from December 2007 through December 2009. During this time, three major activities were concluded: (1) a meeting on the world lithium supply, (2) a session on the cold-temperature performance of PHEVs, and (3) a workshop evaluating grid-connected vehicles in support of integrating wind energy into the grid. The findings of these meetings and workshop were very important for Task 15 progression. These are presented with the results of the analysis that took place during 2011–2013.

5.4.1 World's supply of lithium

In December 2008, a meeting on the "World's Supply of Lithium," co-sponsored under this Implementing Agreement's Tasks 10 and 15, was held in Charlotte, North Carolina, USA. The general conclusions indicated that lithium availability will not be an issue; however, there could 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 by 2020.

5.4.2 Extreme-temperature performance of electric drive vehicles

In September 2009, during a PHEV conference in Montreal, Canada, the leader of the Task 15 battery subtask hosted a special session on the cold-temperature performance of electric drive vehicles. One of the general conclusions was that extreme temperatures did challenge the performance of batteries. When temperatures dropped, average fuel and electricity consumption rose and battery efficiency dropped in personal PHEVs that used nickel metal hydride and retrofitted lithium-ion packs. However, some results suggested that pre-heating battery packs when plugged in might reduce the range-shortening effect of cold starts for these vehicles. Very high temperatures also reduce PHEV operating efficiency, but not to the same degree as cold temperatures do. Finally, battery packs need designs that address salt-related intrusion problems from either road salt used in cold-weather conditions or coastal water-related "salt-fog."

Analytical reactions, 2011–2013. Building on this work after Task 15 was restructured, members completed several studies. The Rask et al. (2012) presentation documented hottemperature limitations during early testing regarding charging a hot battery and use of vehicle air conditioning to bring down battery pack temperatures. Elgowainy et al. (2012a) evaluated the "charge by departure" option currently provided by multiple plug-in vehicles, which could allow preconditioning not only of cabin air but also of battery pack temperature. The range limitation of pure electric vehicles in extreme conditions was anecdotally discussed as a market-limiting attribute in Santini et al. (2013b).

In October 2012, under Tasks 15 and 10 (Electrochemical Systems) a one-day workshop on battery performance under extreme temperature conditions was co-hosted in Montreal, Canada. Results of this workshop are summarized in the Task 10 report.

The advantage of PHEVs and ER-EVs relative to electric vehicles (EVs) in offsetting extreme temperature limitations of battery packs will be discussed in the Task 15 summary report.

5.4.3 Grid-connected vehicles and renewable energy

In November 2009, under Task 15, an international workshop entitled "Grid Connected Vehicles and Renewable Energy Workshop – Exploring Synergies" was sponsored in Frederica, Denmark. Initial findings discussed at the conference included that "smart grid" systems were essential to effectively manage growing loads of plug-in vehicles, including PHEVs. Grid-connected vehicles could also help to promote renewable energy, especially if suitable incentives can reduce life cycle costs. Regulatory and policy recommendations for vehicles — such as subsidies, tax rebates, building codes, smart metering, and codes and standards — were discussed.

Analytical reactions, 2011–2013. By using a least-cost dispatch simulation, Elgowainy et al. (2012b) estimated that wind power would contribute to 1%, at most, of PHEV charging, despite accounting for 20% of generation for a projected coal-dominated 2030 generation mix (as found in Illinois, USA). Similarly, Dallinger et al. (2012) estimated that wind would be allocated only 1–7% of generation for PHEVs in a coal-dominated 2030 generation mix in Germany, even though renewables were projected to provide over 60% of generation. These studies also imply that if coal provides the base load capacity of a utility or country, smart charging designed to occur at the lowest-cost time will lead to higher GHG emissions. In both studies, "uncontrolled" charging starting when the vehicle is plugged in resulted in lower GHGs than the smart charging case.

In other selected results, Santini and Burnham (2013) estimated that wind generation from all-electric operation of an EV or PHEV would use much less wind energy and total energy when providing a given amount of kilometers of service compared to wind-to-electrolysis-to-hydrogen for a fuel cell vehicle. With regard to daytime charging possibilities, Plotz et al. (2012), Santini et al. (2012), Zhou and Vyas (2012), and Zhou et al. (2012) addressed the opportunities and/or effects of daytime workplace charging interacting with battery size and/or total kilowatt-hours (kWh) of charge achievable.

5.5 2011–2013 subtasks

The revised work plan of 2011 indicated a focus on two subtasks: (1) powertrain attributes and vehicle lifetime use costs and (2) policy issues and marketability.

5.5.1 Subtask 1 – Powertrain attributes and vehicle lifetime use costs

This study assessed the marketability and oil-use reduction cost-effectiveness per kWh of the installed battery pack when grid-connected HEVs, PHEVs, and ER-EVs compete with available models head-to-head in the marketplace. The aim was to predict the best market niches for large fuel-use reductions per year of operation. The vehicles studied included EVs, diesels, and advanced gasoline (Santini and Burnham 2013).

Participating research institutions achieved good methodological agreement on the simulation of powertrain attributes (Da Costa et al. 2012) and made progress on a methodology for examining vehicle lifetime use costs (Rousseau et al. 2012).

Three key findings of Subtask 1 are as follows:

- High fuel prices are important to the financial viability and political support of electric drive. Propfe et al. (2012), Rousseau et al. (2012), and Santini et al. (2013b) each estimated scenarios for 2020 in which PHEVs could financially compete with gasoline vehicles under current average gasoline and electricity prices. Santini et al. (2013b) estimated that a real gasoline price increase of 43% (with no increase for electricity) would make many different plug-in vehicles a superior choice to gasoline vehicles.
- For personal use, the plug-in vehicles evaluated were most cost-effective when driven frequently in suburbs and towns, not dense core city markets. Propfe et al. (2012), Rousseau et al. (2012), and Santini et al. (2013b) estimated financial success only in simulations in which plug-in vehicles were driven far more intensively than the average vehicle. Rousseau et al. (2012) showed that the average annual use is least in major cities. Santini et al. (2012) examined the frequency of daily use as a factor, and Santini et al. (2013b) tested the sensitivity to this aspect of vehicle use.
- Unless oil prices increase, the broad success of battery-powered electric drive with a greater range and all-electric operation requires development of a less expensive next generation of battery technology/chemistries. Santini et al. (2013b) estimated that a 43% increase in gasoline prices would make nearly all intensively used plug-in vehicles financially superior to

> conventional gasoline vehicles. Considering generic PHEVs, Kley et al. (2010) investigated the effect of declining battery cost on the probable mix of battery pack nominal kWh ratings for PHEVs for German consumers. Their estimates implied that batteries between 5 and 10 kWh in capacity led to PHEVs capturing the largest share of the vehicle market. However, as battery prices dropped, PHEVs with higher kWh ratings became increasingly attractive. At EVS 26, Plotz et al. (2012) showed that when workplace and public charging are added, that favors smaller battery packs more than when PHEVs are charged only at home. Santini et al. (2013a) addressed the trade-off between the costs of adding range via larger battery packs versus adding infrastructure to allow more than one charge per day.

Subtask 1 participants also collaborated on a series of investigations into various aspects of PHEVs, including drivetrains, chargers, battery packs, and cost of ownership. The results will be described in further detail in the Task 15 report.

None of the publications completed under Task 15 has addressed the topics of control and communication equipment (on- or off-PHEV) or electric machines (permanent magnet versus induction), which were a part of the revised plan.

5.5.2 Subtask 2 – Policy issues and marketability

This subtask addressed policy issues of concern to participating country experts. Selected issues related to the effectiveness of resource usage (e.g., kilometers of service obtained and oil use reduced per unit of energy resource extracted or harvested) and GHG emissions (i.e., CO_2, CH_4, N_2O).

Elgowainy et al. (2012a,b), DaCosta et al. (2012), Dalinger et al. (2012), and Santini and Burnham (2013) each looked at the gasoline and life cycle GHG emission trade-offs under a range of different accounting approaches. An overall theme is that the least marginal cost dispatch methodology does not allow an evaluator to credit plug-in vehicles with the use of wind power (or, by inference, any “non-dispatchable” renewable). Thus, popular “green” images of plug-in vehicles with wind towers in the background are logically inconsistent under the least marginal cost dispatch rules used by most evaluators who study the allocation of generation to final demand.

Policy issues addressed included these:

1. **Vehicle configuration motivators.** The original design decision for the vehicles simulated in Task 15 required the majority of plug-in vehicles to have real-world, all-electric operational capability in urban driving (Da Costa et al. 2012). Such vehicles were said to have “all-electric range,” despite that not being the

case for all driving conditions. None of the PHEVs was simulated to be able to drive all-electrically on the European Artemis Highway cycle, which characterizes driving on limited-access highways, such as the Autobahn. The 100-kW output-split EREV was simulated to be able to drive all-electrically under all U.S. conditions, including limited-access highways. However, in the Artemis Highway cycle, it could not drive all-electrically on portions of the Autobahn without a speed limit. Only the 135-kW Series ER-EV was simulated to be capable of all-electric operation under any driving condition (Da Costa et al. 2012).

Larger battery packs will be necessary to maximize the all-electric operation capability. Either an increase in gasoline prices (Santini et al. 2013b) or a decrease in battery pack cost (Kley et al. 2010; Dong and Lin 2012) can make PHEVs with longer range and/or ER-EVs financially competitive.

The United States provides a subsidy for battery packs between 4 and 16 kWh. Investigations of participating country experts indicate that if the charging infrastructure is inexpensive, it may be more cost-effective to subsidize infrastructure rather than larger-kWh battery packs. A major question is the cost of workplace charging versus the cost of adding a battery pack from about 10 kWh up (Santini et al. 2012). In the Task 15 simulations, the step from 10 kWh up involves powertrain switches and increases in battery pack power (Da Costa et al. 2012), which leads to a bias against more pack kWh in these cases. Santini et al. (2013a) investigated the technical feasibility and cost-effectiveness of workplace charging for four different Task 15 powertrains. They found that not only is the pack kWh important, the kW level is as well, and there was no clear conclusion on whether adding pack kWh or adding workplace charging would be the better strategy.

2. **Charging patterns and incentives for their modification.** Gnann et al. (2012) deduced that increases in the power level above that found in standard residential electrical sockets did not appear to be very productive, either in the United States or Europe. One potential reason for such power increases would be to allow rapid charges for vehicles that returned home during the day for short periods. However, Santini et al. (2012) found that only 13% of vehicles returned home during the day. Santini et al. (2012, 2013b) examined the adequacy of workplace charge points operating at kW ratings equivalent to standard U.S. household electrical sockets and concluded that these would suffice in most circumstances. Dwell times at parking places were usually long enough to assure full charging at these levels, and fast charging is not needed for PHEVs and

EREVs, since they can run on gasoline, if necessary. Limiting charging rates to 1–4 kW also greatly reduces the odds of “avalanche” effects on the grid, in which many plug-in vehicles either begin or end charging at exactly the same time (Hadley 2009).

The harvesting of renewables — matching the time of charging to the time of higher wind or solar energy supply — is technically feasible in the sense that for most PHEVs, the time plugged in far exceeds the time charging, so there is the potential to manage the time of charging for parking overnight at home and during daylight at work. Simple strategies involving wireless communication to cell phones and voluntary selection of charging time would probably cost the least, when compared to the use of sophisticated controls by aggregators that implement varying charging rates to match wind or centralized solar availability; these controls would inevitably require much more expensive equipment to implement.

3. **Electric generation system operation and investment patterns.** This effort examined financial policy effectiveness designed to maintain or reduce capital costs and/or operating costs in support of market development. Elgowainy et al. (2012a,b) and Dallinger et al. (2012) addressed the costs of installing new infrastructure in relation to the pattern of charging chosen by plug-in vehicle owners. Elgowainy et al. (2012a) included the only examination of the charge by departure choice. This commonly available option moves the time of charging to early morning hours. When combined with low-kW charging suitable for PHEVs, this charging strategy moves the demand away from the usual late afternoon and early evening system peaks, allowing charging to take place with expanded use of existing power plants. In the case examined by Elgowainy et al. (2012a), this charging strategy led to a higher percentage of use of combined-cycle natural gas generation (97.5%) than use of time-of-arrival charging and smart charging and thus led to the lowest GHGs. Further, as in the smart charging case, no new generation capacity had to be installed.

None of the publications completed under Task 15 addresses the topic of local infrastructure needs (e.g., neighborhood distribution, inspections, circuit upgrade costs, metering costs), which had been part of the revised plan.

5.6 Further work

Many of the participating country experts in Task 15 are interested in conducting another phase of the study of PHEVs and ER-EVs. As noted, some of the planned research topic work has not been completed, and many topics that were studied merit additional investigation.

The following broad topics have been suggested for inclusion in a follow-on phase of Task 15:

1. Conduct a systematic comparison of cost methodologies (multiple total-cost-of-ownership models) that covers the sensitivity of the PHEV market potential to gasoline prices, battery pack costs, and infrastructure availability.
2. Compare full-function HEVs, PHEVs, and ER-EVs to advanced conventional technologies (clean diesel, turbocharged direct injection petrol, compressed natural gas, others).
3. Study powertrain depreciation attributes and their impact on vehicle lifetime use costs. In particular, determine whether batteries must be replaced during a vehicle's lifetime and/or whether vehicle use patterns must be adapted to less capable packs.
4. Using consistent methodologies, evaluate the potential causes of increases in market(s) size(s), such as rising oil prices, lower battery pack costs, economical infrastructure adaptation, and changes in consumers' perceptions.
5. Track, evaluate, and/or study methods to desirably alter charging behavior.
6. Given the lack of competitiveness of HEVs and PHEVs for less-than-average vehicle utilization, consider the possibility that lithium-ion batteries could enable the use of the more-cost-efficient (over vehicle lifetime) micro-HEV/PHEVs rather than the lead-acid batteries that support simple start/stop technology.

In addition, the three topics planned but presently left undone in this phase of Task 15 could be folded into the next phase of the analysis.

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5.8 References co-authored by participating country experts

Conference papers and journal articles

Da Costa, A., et al. 2012. Fuel Consumption Potential of Different Plug-in Hybrid Vehicle Architectures in the European and American Contexts. Electric Vehicle Symposium 26, Los Angeles, CA, May 6–9, 2012.

Dallinger, D., M. Wietschel, and D. Santini. 2012. Effect of Demand Response on the Marginal Electricity Used by Plug-in Electric Vehicles. Electric Vehicle Symposium 26, Los Angeles, CA, May 6–9, 2012.

Elgowainy, A., et al. 2012a. Impact of Plug-in Hybrid Electric Vehicle Charging Choices in 2030 Scenario. Transportation Research Record TRB 12-3800, pp. 9–17.

Elgowainy, A., et al. 2012b. Impacts of PHEV Charging on Electric Demand and Greenhouse Gas Emissions in Illinois. Electric Vehicle Symposium 26, Los Angeles, CA, May 6–9, 2012.

Gnann, T., P. Plotz, and F. Kley. 2012. Vehicle Charging Infrastructure Demand for the Introduction of Plug-in Electric Vehicles in Germany and the U.S. Electric Vehicle Symposium 26, Los Angeles, CA, May 6–9, 2012.

Plotz, P., F. Kley, and T. Gnann. 2012. Optimal Battery Sizes for Plug-in Hybrid Electric Vehicles. Electric Vehicle Symposium 26, Los Angeles, CA, May 6–9, 2012.

Propfe, B., et al. 2012. Cost Analysis of Plug-in Hybrid Electric Vehicles Including Maintenance and Repair Costs and Resale Values. Electric Vehicle Symposium 26, Los Angeles, CA, May 6–9, 2012.

Rask, E.M., H. Lohse-Busch, and D.J. Santini. 2013. Analysis of Input Power, Energy Availability, and Efficiency during Deceleration for X-EV Vehicles. SAE 2013-01-1473. SAE World Congress, Detroit, MI, April 16–18, 2013.

Rousseau, A. et al. (2012). Comparison of Energy Consumption and Costs of Different HEVs and PHEVs in European and American Context. European Electric Vehicle Congress, Brussels, Nov. 19–22, 2012.

Santini, D.J., and A.J. Burnham. 2013. Reducing Light Duty Vehicle Fuel Consumption and Greenhouse Gas Emissions: The Combined Potential of Hybrid Technology and Behavioral Adaptation. SAE 2013-01-1282. SAE World Congress, Detroit, MI, April 16–18, 2013.

Santini, D.J., Y. Zhou, and A. Vyas. 2012. An Analysis of Car and SUV Daytime Parking for Potential Opportunity Charging of Plug-in Electric Powertrains. Electric Vehicle Symposium 26, Los Angeles, CA, May 6–9, 2012.

Santini, D.J., et al. 2013a. Deploying Plug-in Electric Cars Which Are Used for Work: Compatibility of Varying Daily Patterns of Use with Four Electric Powertrain Architectures. Paper TRB13-4925. Transportation Research Board Meeting, Washington, DC, Jan. 2013.

Santini, D.J., et al. 2013b. Cost Effective Annual Use and Charging Frequency for Four Different Plug-in Powertrains. SAE 2013-01-0494. SAE World Congress, Detroit, MI, April 16–18, 2013.

Zhou, Y., A. Vyas, and D.J. Santini. 2012. Tracking National Household Vehicle Usage by Vehicle Type, Age and Area in Support of Market Assessments for Plug-in Electric Vehicles. Paper TRB12-4348. Transportation Research Board Meeting, Washington, DC, Jan. 22–26, 2012.

Presentations

Gallagher, K.G., D. Dees, and P. Nelson. 2012. PHEV Battery Cost Assessment. Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting, Washington, DC, May 14–18, 2012.

Rask, E., T. Bohn, and K. Gallagher. 2012. On Charging Equipment and Batteries in Plug-in Vehicles: Present Status. Innovative Smart Grid Technologies Conference, Washington, DC, Jan. 16–19, 2012.

Santini, D.J. 2011. U.S. V2G Implications of Varying G2V Charging kW Levels and Times — PHEVs, EREVs & EVs. Presented at “On the Way to the Mobile Electricity Storage: Electric Vehicles” part of Smart Grids Conference, Burgdorf, Switzerland, Nov. 18, 2011.

Santini, D.J. 2012. A Brief Discussion of Battery Properties and Goals for Plug-in Hybrid and Electric Vehicles Research Institution Report. Innovative Smart Grid Technologies Conference, Washington, DC, Jan. 16–19, 2012.

Zhou, Y., and A. Vyas. 2012. Keeping Plug-in Electric Vehicles Connected to the Grid — Patterns of Vehicle Use. Innovative Smart Grid Technologies Conference, Washington, DC, Jan. 16–19, 2012.

Research institution reports

Nelson, P.A., R.G. Gallagher, I. Bloom, and D.W. Dees. 2011. Modeling the Performance and Cost of Lithium-Ion Batteries for Electric-Drive Vehicles. Argonne National Laboratory Report ANL-11/32, Argonne, IL, Sept.

Nelson, P.A., R.G. Gallagher, I. Bloom, and D.W. Dees. 2012. Modeling the Performance and Cost of Lithium-Ion Batteries for Electric-Drive Vehicles: 2nd Edition. Argonne National Laboratory Report ANL-12/55, Argonne, IL, Dec. (http://www.cse.anl.gov/batpac/)

Additional references cited

Dong. J., and Z. Lin. 2012. Exploring Paths to One Million Plug-in Electric Vehicles by 2015 Using the MA3T Model. Electric Vehicle Symposium 26, Los Angeles, CA, May 6–9, 2012.

Kley, F., D. Dallinger, and M. Wietschel. 2010. What Is a Right-Sized PHEV? Considering Users Driving Profiles, Proceedings of Second European Conference on Smart Grids and E-Mobility, Brussels, Belgium.

Hadley, S.W. 2009. PHEV and Renewable Synergy: A U.S. Perspective. IEA IA-HEV Annex XV Group at the Grid Connected Vehicles and Renewable Energy Workshop – Exploring Synergies, Frederica, Denmark, Nov. 23.

6

System Optimization and Vehicle Integration (Task 17)

Members: Austria, Germany, Switzerland, and the United States

6.1 Introduction

This Task involves analyzing technology options for the optimization of electric vehicle (EV) components and drivetrain configurations (Fig. 6.1) that will enhance vehicle energy efficiency performance. The difficulties most often associated with electric mobility include battery performance, charging costs, and a missing charging infrastructure. However, other challenges, such as the optimized and sustainable use of available energy, are also important with regard to the adoption of electric mobility.

The integration and configuration of components, including the handling of interfaces as well as system management, merit increased attention because they contribute significantly to a reduced EV cost and increased customer acceptance.

Fig. 6.1 Opel Ampera drivetrain. (Image courtesy of General Motors)

6.2 Objectives

Electronic systems used to operate and monitor all vehicle types have benefited from substantial improvements during the past few years. These systems have also improved the prospects for EVs. Further optimization of these components is necessary, as are new concepts for integrating them in the overall system and tuning them to meet the specific requirements of different vehicle applications.

Improved power electronics have resulted in new opportunities to control and steer the increasingly complex-component configurations. In addition, new integration options for components (electric motors, batteries, supercapacitors, internal combustion engines, and fuel cells) have undergone rapid improvements during the past few years. These developments and the opportunities they provide are analyzed in Task 17.

Task work includes the assessment of progress in component development and drivetrain configurations and an analysis of the corresponding enhanced overall system performance. Impacts on the following aspects of system performance will be analyzed:

- Improvements in energy efficiency (by optimizing thermal and electric energy management), operational safety, and durability through better monitoring of component operation
- Integration and control of software solutions (by software architecture strategies for real-time minimization of losses)
- Reductions in the cost of components (through increased efficiency in operation and production, alternative materials, etc.)
- Reductions in weight and volume through the optimized assembly of the drivetrain
- Improved spatial arrangement of the drivetrain in the overall vehicle
- Range extender modules (internal combustion engine, fuel cell), electronic control concepts for range extenders
- Configurations for energy storage systems and/or range extenders
- Drivetrain configurations (fixed and variable gearing, single and multiple motor drive, in-wheel drive)

6.3 Working method

Task activities predominantly consist of preparing a technology assessment report on trends and providing opportunities for member countries to exchange information through organized workshops. The workshop participants include industry representatives, researchers, and technology policy experts. These meetings allow information dissemination about relevant activities in an international context.

The scope of work has focused on the participants’ capabilities and fields of expertise and basically covered the monitoring and analysis component and vehicle architecture relative to trends and strategies for EV progress. Key topic areas included in this Task report include these segments:

- **Original Equipment Manufacturer (OEM) and Industry Review.** Review of different OEM strategies and technologies for EVs and a follow-up review of new prototypes

- **Advanced Vehicle Performance Assessment.** An overview and comparison of selected current configurations of components in vehicles on the market
- **Components — State of the Art/Prospects/Trends.** An analysis of existing component technologies and their development potential and a cost assessment
- **Vehicle Integration.** An examination of theoretically possible operation and configuration concepts and an assessment of their advantages and disadvantages, including a comparative analysis of efficiency, performance, and price reduction potential
- **Simulation Tools.**

6.4 Further work

The work in Task 17 may continue until the end of Phase 4 (2009–2015) of the Implementing Agreement. Topics currently covered in the components section of the Task 17 report are battery management systems and electric motors. This discussion will be expanded to include, auxiliary units of the combustion engine, and power-electronic-component technologies, including their respective development potential.

In the Task 17 report's vehicle integration section, future work will focus on these three topics with the highest priority identified in the areas of system optimization and improvements in energy efficiency:

- **Thermal Management.** EV heating and cooling and sustainable use of available energy, with workshops in the United States and Austria
- **Lighten Weight.** Integration of the energy storage system into the chassis and integration of the drivetrain into lightweight vehicles, with workshops in Switzerland and Austria
- **Electronic/Electrical Architecture.** Power electronics and electric energy management, with workshops in Germany and other locations to be determined

Due to a change of Operating Agent in mid-2012, the continuation of Task 17 and its future direction were discussed in a meeting in December 2012 in Austria. At the same time, a Task focus was placed on the topic of lightening vehicle weight. A study on the impacts of the vehicle's mass efficiency and fuel economy for different drivetrain configurations was presented and discussed, along with the topics of advanced aluminium applications, battery housings, and joining methods.

Fig. 6.2 Tesla testing at Argonne National Laboratory. (Image courtesy of Argonne.)

The most recent workshop in April 2013 addressed the topic of thermal management. It was hosted by Argonne National Laboratory in the United States (Fig. 6.2). Participants had the opportunity 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 topics that require further research.

6.5 Contact details of the Operating Agent

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7

Electric Vehicle Ecosystems (Task 18)

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

7.1 Introduction

The focus of Task 18, Electric Vehicle Ecosystems, is to shape a global vision of the infrastructure required to support mass adoption of plug-in electric vehicles (EVs) and to determine how this endeavor can create “smart” cities. This Task is capturing practical experience from cities, regions, and businesses that are pioneering advanced EV pilot programs and investigating the markets, technologies, and business models relative to EVs that are designing “EV cities of the future.” The IA-HEV Executive Committee (ExCo) approved Task 18 work on November 4, 2010, at the 33rd ExCo meeting in Shenzhen, China, with plans to run through the end of 2013.

An EV ecosystem defines the total infrastructure system 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, 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 EV adoption in cities.

7.2 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 that are engaged in the following processes:

1. **Foresight workshops** in leading cities are assembling experts from municipalities, regional authorities, governments, and industry to explore specific areas of opportunity.
2. **An international roadmap** will be published that will showcase pioneering projects around the world and establish an expert view of the emerging chal-

lenges 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 and bring individuals together who are shaping the future development and design of EV ecosystems.

7.3 Working method

7.3.1 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 that will be promoted in a summary report to an international audience of policy makers and industrialists. Each workshop will investigate a different priority area, such as business models, social change, fleets, and smart grids.

7.3.2 Web portal

Sharing information to advance urban transport systems by using a Web portal designed for this purpose is the best method for instant worldwide delivery of information.

7.3.3 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.

7.3.4 Alliances with global EV city projects and initiatives

Over the last 24 months, Task 18 has developed partnerships with a number of international EV projects focused on cities and regions. These collaborative working relationships are facilitating the sharing of data and resources, thereby connecting Task 18 participants to 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.

7.3.5 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 approves amendments to Task activities and the budget. David Howell, at the U.S. Department of Energy's Vehicle Technologies Office, is the Steering Committee Chair. Luís Reis, of INTELI in Portugal, is the Steering Committee Co-chair.

7.4 Results and next steps

Task 18 is in its third year of operation and is making great strides toward supporting the development and design of "EV Ecosystems" that foster a total environment for the mass operation of plug-in EVs.

Six workshops on various topics have occurred to date in cities in the U.K., Istanbul, Barcelona, Los Angeles, and Vienna, as summarized in Table 7.1. Workshops scheduled for 2013 are listed in Table 7.2.

Table 7.1 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
EVs and Smart Grids	Vienna, Austria

Table 7.2 Task 18 Workshops Planned for 2013.

Special Topic	Location
Technologies and Infrastructure for Electric Vehicle Ecosystems	Berlin, Germany
Synthesizing EV Roadmaps	To be determined

7.4.1 Report on Vienna roadmapping workshop

Fig. 7.1 Roadmap Workshop Report.

In April 2013, Task 18 published a report on the results from the roadmapping workshop held in Vienna entitled *Future of Markets for Electric Vehicles: Expectations, Constraints & Long-Term Strategies* (Fig. 7.1). Breakout groups in the workshop developed three scenarios that considered the future development of markets for EVs, identifying "best," "worst," and "probable" cases. A roadmapping approach was used to structure key issues into different time horizons and to establish links between developments in markets, products, services, technologies, and the necessary underpinning resources. Prior to the workshop, participants identified and ranked a list of priority barriers to EV markets. In their opinion, high EV purchase costs and a lack of suitable business models for the provision of vehicles and recharging infrastructure are the main factors that will impact EV adoption. The three scenarios developed in the workshop highlight the consequences of failing to address the factors identified in the analysis of priority barriers. For example, the best-case and probable-case scenarios predict that EVs will eventually reach cost parity with internal combustion engine vehicles. However, this does not happen in the worst-case scenario. Furthermore, the worst-case scenario highlights two dangers: failing to address consumer concerns about the residual value of EVs and failing to educate consumers to value whole-life costs of a vehicle that include purchase price and operating costs.

Each scenario draws attention to the importance of communication and education activities to increase levels of knowledge and understanding among the general public. A key lesson that can be drawn from the scenarios is that it is far from certain that EVs will achieve mainstream market acceptance. The scale and rate of adoption of EVs are subject to a number of factors, some of which are outside the direct control of industry and policymakers. Nevertheless, the analysis undertaken in the workshop does provide a structured way to evaluate these issues and offers insights into the factors that may have the biggest influence in supporting future markets for EVs.

7.4.2 World EV Cities and Ecosystems Web portal and *EV City Casebook*

Task 18 involves active collaborations with other international projects. The Global Electric Vehicle Insight Exchange (EVX) World EV Cities and Ecosystems Web portal (www.worldevcities.org) was launched in May 2012 at the first EV Cities and Ecosystems Conference, which is a partnership among IA-HEV Task 18, Electric Vehicles Initiative, Rocky Mountain Institute, IEA, Clinton Climate Change Initiative, and University of California, Davis (UCLA). The Web portal continues to add new cities and regions. Table 7.3 lists the cities currently on www.worldevcities.org (Fig. 7.2).

Fig. 7.2 The website www.worldevcities.org shows the latest localities added.

Table 7.3 List of World EV Cities at www.worldevcities.org.

World EV Cities as of April 2013		
North America	Los Angeles Region New York City Portland	Research Triangle San Diego County
Europe	Amsterdam Barcelona Berlin Brabantstad Copenhagen Hamburg	Helsinki Region Northeast England Paris Region Rotterdam Stockholm
Asia	Goto Islands, Nagasaki Kanagawa Shanghai Shenzhen	

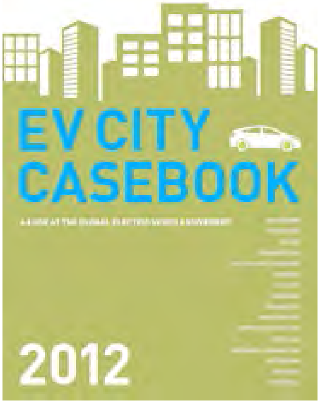

Fig. 7.4 EV City Casebook.

Along with the Web portal, the *EV City Casebook* (Fig. 7.3) was published, which presents informative case studies on city and regional EV deployment efforts around the world. These case studies are illustrative examples of how pioneering cities are preparing the ground for mass market EV deployment. They offer both qualitative and quantitative information on cities' EV goals, progress, policies, incentives, and lessons learned to date.

The purpose of the *EV City Casebook* (Fig 7.4.) is to share experiences on EV demonstration and deployment, identify challenges and opportunities, and highlight best practices for creating thriving EV ecosystems. These studies seek to enhance understanding of the most effective policy measures to foster the uptake of EVs in urban areas.

7.5 Further dissemination

The Operating Agents will be present at conferences in Los Angeles, Edinburgh, and Berlin to disseminate the emerging findings of Task 18. David Beeton, Task 18 Cooperating Agent, presented a paper, *Electric Vehicle Cities of the Future: A Policy Framework for Electric Vehicle Ecosystems*, at EVS 26 (Electrical Vehicle Symposium) in Los Angeles, California, in May 2012 (Fig. 7.5). Looking ahead to EVS 27 in Barcelona, Spain, in 2013, a paper about Task 18 will be published as part of the proceedings. Additional dissemination activities in 2013 are planned for the Smart City World Expo in Barcelona, the World EV Summit in Copenhagen, and E-Mobilia in Kuala Lumpur.

Fig. 7.5 Participants at the First EV Cities and Ecosystems Conference at the Luskin Center in Los Angeles. (Images courtesy of UCLA Public Affairs Office.)

7.6 How to participate

Task 18 is accepting new members, but only for a short while longer. Each nation and city engaged in the project is receiving focused support to advance local EV programs. Experts are connecting 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 maximizes the potential benefits to participants and broadens the prospective findings.

The Task is engaging established cities that are leading advanced pilots, as well as emerging regions that are advancing 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 that are in a position to contribute experts or host workshops.

7.7 Contact details of the Operating Agents

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8

Life Cycle Assessment of Electric Vehicles (Task 19)

***Members:** Austria, Germany, Switzerland, United States*

8.1 Introduction

Electric vehicles (EVs) provide many benefits over a traditional internal combustion vehicle, such as improved powertrain efficiency, lower maintenance requirements, and zero tailpipe emissions. Task 19 examines the environmental effects of vehicles with an electric drivetrain based on life cycle analyses. It started in 2012 and will continue until the end of 2014.

There is international consensus that improvements in EV sustainability can only be analyzed on the basis of a life cycle assessment (LCA), which includes an examination of the production, operation, and treatment of the vehicles. For example, about 90% of the greenhouse gas (GHG) emissions of a vehicle running on renewable electricity from hydropower are associated with the production and end-of-life treatment of the vehicle, while only 10% are the result of vehicle operation. Additionally, all environmental impacts must also include the entire value chain, as shown in Fig. 8.1.

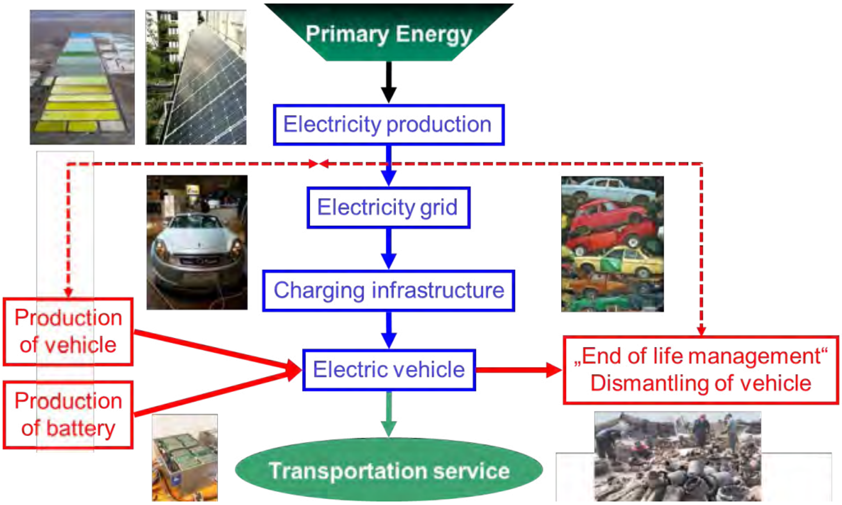

Fig. 8.1 Assessment of LCA aspects over the full value chain. The LCA includes three phases: production, operation, and end of life. The blue boxes are the elements of the operation phase of the electric vehicle. The red boxes are the production (at left) and dismantling phases (at right) of the vehicle, and the dotted arrow indicates possible recycling.

8.2 Objectives

The primary objective of Task 19 is to learn how EV-drivetrain vehicles can be designed for optimal recyclability and minimal resource consumption. The Task also aims to promote the best available technologies and practices for managing EV materials in EVs at the end of their useful life when the vehicles are dismantled.

Based on the LCA activities in the member countries, the main goals of Task 19 are as follows:

- Provide policy makers and decision makers with facts for addressing EV-related issues.
- Improve end-of-life management by identifying and promoting the best available technologies and practices.
- Improve the design of vehicles and battery systems for optimal recyclability and minimal resource consumption.
- Establish a "research platform for LCA and end-of-life management for EVs" to augment the benefits and competitiveness of vehicles with an electric drivetrain.

These topics will be addressed over the three-year working period:

1. LCA methodology
2. Overview of international LCA studies
3. Parameters influencing the energy demand of EVs
4. LCA aspects of battery and vehicle production
5. Vehicle end-of-life management (recycling) or the reuse of batteries in stationary applications
6. LCA aspects of electricity production, distribution, and vehicle battery charging
7. Demand for further research and development (R&D)

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 (motorcycles, electric bikes)
- Forklift trucks

8.3 Working method

The Task is a networking activity, in which the experiences from the national projects are discussed on an international level and included in the IA-HEV LCA platform. Each participant contributes different topics to the Task on the basis of a work-sharing principle.

Task members from the participating organizations cover these individual work packages:

1. LCA methodology (setting of the system boundaries, modelling of recycling)
2. Overview of international studies on LCA of vehicles with an electric drivetrain
3. Influences on the energy demand of vehicles
4. LCA aspects of battery and vehicle production
5. End-of-life management (second life of batteries in stationary applications)
6. LCA aspects of electricity production, distribution, and charging infrastructure
7. Necessary and available data
8. R&D demand
9. 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
10. Conclusions and outlook
11. Documentation: proceedings, reports, papers, notes, and presentations
12. 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—the aim is to involve the different stakeholders in the EV value chain. 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.

8.4 Results

Contributors to this Task will compile information from existing LCA analyses in order to complete a full picture of approaches to resource usage, recycling, and disposal at end of life. This knowledge should help the EV-related industry and governments increase the benefits and competitiveness of EVs. An international "Research Platform for LCA and End-of-Life Management for EVs" will be established to augment the benefits and competitiveness of vehicles with an electric drivetrain.

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 developed.

The first workshop for Task 19 was held on December 7, 2012 in Braunschweig, Germany, and was entitled "LCA Methodology and Case Studies of Electric Vehicles." The workshop was held to coincide with second stakeholder workshop of the European Project "eLCAr" (for further information, see www.elcar-project.eu).

This workshop brought together international experts on LCA of EVs to work on the following issues:

1. Presentation of LCA methodology and its application (case studies)
2. Discussion of key issues to facilitate improvement of LCA application for EVs
3. Development of workshops to review methodology choices and their advantages/drawbacks
4. Generation of discussion on best practices in LCA methodology as applied to EVs
5. Establishment of "international platform on LCA of EVs"
6. Identification of key issues in LCA for EVs, the methodology, and its application (case studies)

The main sessions were divided into these segments:

- LCA methodology for EVs
- International LCA case studies on EVs from Austria, Belgium, Germany, Denmark, Israel, Portugal, Switzerland, United States, and United Kingdom
- Identification of key issues in LCA for EVs

Six categories of key issues and their relevant factors were identified:

1. Overarching/general and life-cycle modeling (including end-of-life)
    - Average/marginal approach

   - Allocation
   - Future technology development
   - Uncertainty of data and future data (important for interpretation of results)
   - Rebound effect (using green vehicles more often)
   - Policy impact (incorporate new efficiency standards)
   - Reporting and eco-labeling
2. Vehicle cycle (production®use®end-of-life)
   - Battery production (lifetime of battery)
   - Material production for EVs (lightweight material, electricity mix in production)
   - Energy consumption in use, including auxiliary energy (heating, cooling), user behavior (urban driving), and information about buyers of an EV or PHEV
   - End of life (including recycling for production “closed loop”)
3. Fuel cycle (electricity production)
   - Average/marginal mix
   - Connecting renewable electricity to EVs (storage)
   - Charging behavior
   - Vehicle to grid (for balancing)
4. Inventory analyses
   - Battery data
   - Future technologies and mass production
   - Infrastructure (fast charging)
5. Impact assessment
   - Greenhouse gases (GHGs) and cumulative energy are “standard”
   - Other impact categories necessary
   - Mid-point impact assessment, end-point damage assessment, and single scoring methods (external costs)
6. Reference system
   - Gasoline and diesel current and future technologies (including biofuel blending)
   - Natural gas vehicles (potentially including new infrastructure)
   - Reference use of renewable electricity

Additionally, Task 19 activities were presented at several EV conferences: IAMF 2013 (International Advanced Mobility Forum) in Geneva, Switzerland, in March 2012; EVS 26 (Electric Vehicle Symposium) in Los Angeles, California, United States, in May 2012; and the 9th International Colloquium on Fuels in Stuttgart, Germany, in January 2013.

The second workshop on "LCA of Vehicle and Battery Production" took place in Chicago, Illinois, United States, on April 26, 2013. The objective of this workshop was to present, discuss, and reach conclusions on LCA aspects of the production of vehicles and batteries.

8.5 Contact details of the Operating Agent

IA-HEV member countries 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 sponsor special agreement that would be negotiated with the Operating Agent and confirmed by the IA-HEV Executive Committee.
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 Task 19 Operating Agent:

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9

Quick Charging Technology (Task 20)

Members: *Germany, Spain, United States*

9.1 Introduction

Task 20 addresses quick charging technology for plug-in electric vehicles (PEVs). It was approved on November 11, 2011, at the 35th IA-HEV Executive Committee meeting in Lisbon, Portugal, and is expected to continue through the end of 2014.

Quick charging technology represents one of the most promising technologies for promoting PEVs to help decarbonize the transport sector, contribute to innovative zero-emission drivetrain systems, and create new business opportunities. This Task also involves addressing the associated challenges.

Charging infrastructure is being installed worldwide. As of March 2013, there were around 2,460 CHAdeMO-type quick charging stations worldwide (Japan had 1,672, Europe had 616, United States had 160, others had 12). Additionally, Nissan plans to partner with eVgo to install 500 new fast chargers in the United States by mid-2014. There are 5,300 Level 2 chargers in operation in the United States, according to the U.S. Department of Energy's Web site (energy.gov; accessed in March 2012).

Quick charging faces both technical and nontechnical challenges. Some of the main technical issues include the impact on battery performance degradation over time (lithium-ion battery technology is evolving, with increases in power and energy densities expected), power grid stability and quality, infrastructure costs, and the high average energy consumption that occurs during the first part of the PEV battery charging process. Other challenges include improving public awareness of the 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 (EV) 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 (Fig. 9.1).

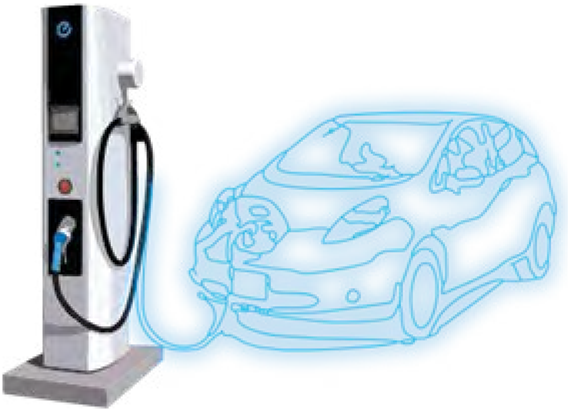

Fig 9.1 A direct current (DC) quick charger, 480 volts, 44 kW maximum, achieves 80% battery capacity in 30 minutes. (Image courtesy of Nissan.)

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 PEVs are typically charged through the low-voltage (400/230 V) grid, due to the low power rating. So-called quick chargers with more than 40 kW 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 to avoid problems with the local electrical system. Smart grid services will influence charging patterns and contribute to the optimization of energy use, as in the following examples:

- Aggregation of the power generated by a vehicle fleet
- Management of energy and power balance (including EVs).

In addition, there is no widespread quick charging infrastructure network in appropriate places that offers reasonable charging times. There are some exceptions. In the United States, Tesla Motors has built out eight “super charging” locations: six on the West Coast roughly between Los Angeles and San Francisco, and two on the East Coast in Milford, Connecticut, and in Newark, Delaware. Canada is the next location for an EV superhighway. It is widely accepted by EV stakeholders that there is a growing need for widely distributed and 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 EVs to travel long distances. Drivers of EVs have less anxiety about vehicle range when public quick chargers are available. However, the smart charging infrastructure may consist of a mix of different types of charging capabilities: ultra-quick charging stations (DC), quick-charging stations (three-phase AC [alternating current]), and slow charging stations (single-phase AC). Each type should target different consumers and end uses—home charging, occasional charging, public charging, fast charging, and breakdown recovery/roadside assistance—as well as address the appropriate level of power supply.

The main difference between quick charging and normal charging lies in the additional service for the customer. Smart quick charging that could enable an 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, such as the telecom or ICT (information, communication, and technology) industries that enable communication between the EV and the electricity grid, also need to be included in discussions. Improvements in power electronics for onboard systems may clear the way for a new class of high-power charger. It is important to consider the electrical safety of the charging processes, especially DC leakage, electrical safety at the vehicle inlet, electrical safety at the charging station, and earth quality verification. Currently, different improvements in fast charging are being considered worldwide. It is important to exchange information collected to date about the different approaches and experiences.

Standards are also a key element for the full deployment of quick charging technology. Standardization needs to include a possible evolution toward very high-power charging solutions. Furthermore, 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 EVs will ensure the required safety and security level for the consumer. A lack of interoperability between the different systems could cause concern among consumers that could slow down the development of the EV market. In addition, different safety standards must be considered (IEC 621963 Combo1, IEC 621963 Combo2, IEC 621962/3 Type 2, IEC 621963 CHAdeMO, IEC 621963 China).

All of these challenges will be tackled in Task 20 through open discussion and an 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 (Fig. 9.2).

Fig. 9.2 Nissan is working with eVgo to bring 500 quick charging stations to the United States by mid-2014. (Image courtesy of eVgo.)

9.2 Objectives

Task 20, Quick Charging Technology, aims to promote solutions and improvements that will enable the broad penetration of this technology. By 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 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 in the discussions and provide input to standardization bodies such as CENELEC and SAE.

There will be a special focus on the following topics:

- 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 following main topics will be addressed in the three-year working period:

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 PEV battery aging 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 infrastructure cost
8. The need for quick chargers and public charging stations to counter consumer anxiety about vehicle range
9. Quick charging solutions that will help to popularize EVs
10. Issues related to the technical and socioeconomic relationship between the PEV and the grid, including power quality, tariffs, regulations, and incentives
11. Analyses and ideas for the best technical solutions for interoperability and the optimum use of the existing electric infrastructure
12. Ways in which emerging technologies, such as integrated smart grids and EV batteries, can help accelerate EV market penetration
13. The requirements and issues related to quick charging technology for future smart grid promotion
14. Design and assurance of convenient, safe, and secure handling for consumers
15. Future technology roadmap to help promote vehicle electrification

9.3 Working method

Task 20 kick-off meeting

Task 20 held a kick-off meeting in May 2012 in Los Angeles in conjunction with EVS 26 and the 36th IAHEV Executive Committee meeting. It was a very successful meeting, with roughly 40 attendees from a wide range of stakeholders in various organizations worldwide. The agenda was split into four main areas addressing different viewpoints: original equipment manufacturers (OEMs), charger providers, battery developers, and utilities. Twelve speakers from the most active firms in the quick charging field from Europe, Japan, and the United States participated in the kick-off meeting.

The meeting’s goal was to identify the main challenges and barriers of the current framework for quick charging market growth. Attendees actively participated by sharing experiences, different approaches, and concerns. Case studies were presented from different perspectives, as were several solutions for the whole EV charging value chain. Participants agreed that the use of EVs and charging can enable the realization of environmentally friendly “green” mobility. Achieving this goal will require the cooperation of multiple stakeholders to implement efficient EV charging timed for minimal impact on the electrical grid. Nevertheless, several challenges must be overcome in the coming years. The general agreement is that there is not one unique solution but a wide portfolio of solutions to which a large number of stakeholders may contribute.

The participants identified four areas in which IA-HEV Task 20 can play a significant role through fostering information exchange over the next three years:

1. **Business cases.** All stakeholders have concerns about the future model of a larger deployment of EVs that will use quick charging, as well as how to incorporate their equipment into real-world cases. The business case should be based on real-life data from the field and may offer different solutions for each specific use case. Data must be collected from charging providers focusing on such questions as how much users would be charged for using various charging services (e.g., monthly fixed rate or pay-per-use option). New, fully integrated opportunities in power and ICT might trigger the deployment of infrastructure and EVs while guaranteeing power quality and safety. Further exchanges of information that involve stakeholders with varying viewpoints are needed in order to understand the whole picture; these will identify potential gaps and solutions related to quick charging technology. Self-sustaining business models for independent operators or new entities may manage the complexity of using different and beneficial methods. Governments, automotive industry, infrastructure builders, and operators should also coordinate their activities and strengthen their communication. Regional requirements should be considered because they are also significant factors. For example, the charging infrastructure installation cost depends on a local government's permission and conditions, which may affect price and subsequently the business model.
2. **Communication.** Predictions of the actual number of EV models that will be available to consumers vary, as do predictions by various governments of the number of EVs that will be on the road by a certain future date. As a result, in both cases, expectations affect public perception of the number of EVs on the road and of EV-related quick charging technology if targeted numbers are not reached. This uncertainty represents a barrier because customers and society may not perceive this technology as real. Consistent and clear positioning is a key factor to send clear market signals for manufacturers to produce the vehicles and the associated charging infrastructure. Transparent communication between customers and society as a whole is also required, and such communication is achieved by showing solutions and benefits to demonstrate commitments to sustainability.
3. **Batteries.** Battery cost still remains as one of the main barriers to a larger deployment of quick charging technology for EVs. Further studies and recommendations are needed regarding the degradation and capacity to achieve a reasonable range that will be required to satisfy the needs of different-sized vehicles

and different usage patterns. Batteries are expected to function with high repetitive pulsed charging currents if regenerative braking is required, and they are expected to deliver full power, even with a deep discharge, to ensure long-range driving. Further efforts within Task 20 will be devoted to identifying smart and suitable innovations.

4. **Interoperability.** Quick charging technology is currently available in terms of technical solutions and applications. However, the smart charging infrastructure may consist of a mix of different types of charging capabilities: ultra-quick charging stations (DC), quick charging stations (three-phase AC), slow charging stations (single-phase AC), and induction charging in the near future. More discussion is needed on these topics: how different systems interact and to what extent the EV should be adapted in order to be able to charge by using different solutions; intelligent charging solutions that take into account grid integration (demand response, functionality); and energy storage integration in current and future interoperability models.

Task 20 workshop

In collaboration with the Ministry of Economy, Trade and Industry of Japan (METI) and Task 20, a workshop in Japan will be held on June 3–5, 2013, on the topic of overcoming the barriers faced by business for a larger deployment of EV quick charging technology. Bringing stakeholders together will strengthen coordination between all involved in the EV value chain.

The June 2013 quick charging workshop is being designed to include OEMs, battery manufacturers, utilities, and charger manufacturers in addition to IA-HEV members. On the first day, a series of four parallel working sessions will be held, followed on the second day by a general assembly of participants to agree on guidelines developed from the working sessions.

Technical site visits and meetings with partners will round out the workshop on the third day. Input from North American and European Task members is being gathered by the Operating Agent in order to address relevant issues for those not attending.

9.4 Results

The baseline structure of the Task 20 final report is being determined. Additionally, intermediate reports may be released as a result of meetings in 2013. Availability of the full interim reports will be restricted to the Task participants and to public versions summarizing these reports. The main Task outcomes have been identified as follows:

- Suggestions 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 goal of publication in relevant international journals or presentation at conferences (e.g., EVS 27).
- Task conclusions and recommendations will be disseminated at conferences and events.
- Public versions of the reports will be distributed through existing communication channels (e.g., associations, technology platforms, federations).

The information collected and the consensus built among Task participants will contribute to goals for deploying quick charging technology and provide sound information for standardization bodies, industry, and governments to improve EV competitiveness.

9.5 Next steps

Looking ahead to fall 2013, Task 20 participants are anticipating a robust meeting to coincide with EVS 27 in Barcelona on November 17–20. The Task participants are planning to invite distinguished experts on quick charging to attend EVS 27. After the meeting in Barcelona, Task 20 participants will hold a workshop on batteries and quick charging.

9.6 Contact details of the Operating Agent

IA-HEV member countries 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 would to be negotiated with the Operating Agent and confirmed by the IA-HEV Executive Committee.

Task 20 is coordinated by Ignacio Martin from CIRCE (Research Centre for Energy Resources and Consumption), which is a private research organization in Spain with the aim of creating and developing innovative solutions and scientific/technical knowledge in the field of energy for commercialization.

For further information regarding Task 20, please contact the Operating Agent:

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10

Accelerated Ageing Testing for Li-Ion Batteries (Task 21)

***Participants:** Italy, Switzerland, United States*

10.1 Introduction

The IA-HEV Executive Committee unanimously approved this new Task in May 2012. The Task is expected to run for the next 5 years, until 2017. Task 21 will be beneficial in establishing and consolidating international collaboration for lithium-ion ageing testing.

Fig. 10.1 Accelerated testing of Li-ion batteries. (Image courtesy of NREL.)

10.2 Objectives

One key objective of Task 21 is to conduct an inventory of worldwide efforts used in the development and application of accelerated testing procedures for analyzing the aging of lithium-ion (Li-ion) batteries in various vehicle applications. Accelerated ageing testing is necessary for Li-ion batteries because electric vehicles (EVs) have not yet been on the road long enough for the performance and durability of Li-ion batteries to be tested under real-world conditions over several years.

Another key objective is to identify the expertise available in various laboratories, as seen in Fig. 10.1, in order to verify the compatibility of the different approaches. Finally, the Task aims to offer input to the organizations responsible for the development of standard testing procedures that are harmonized between countries.

Key topics include the following:

- Comparison of international Li-ion battery aging procedures
- Experimental verification of Li-ion batteries in international laboratories
- Reduction of costs associated with testing

10.3 Working method

First, Task 21 will facilitate communication and cooperation between researchers and testing bodies by supporting information exchange about current testing procedures, testing capabilities, and applied procedures. This primary activity will result in the first report on worldwide efforts in Li-ion battery ageing tests, which will be integrated with a survey of draft procedures and standards under development.

Second, Task 21 members will agree upon an initial coordinated testing plan for a round-robin analysis (an inter-laboratory test performed independently several times) of various Li-ion small cells, aimed at comparing existing accelerated testing procedures already developed in Europe, Japan, and the United States.

Finally, participating organizations will execute the testing plan and develop possible options to share for a standardized accelerated testing procedure. This working method will be applied mostly for the first year of joint activities.

10.4 Contact details of the Operating Agent

New members are welcome to join the Task. There is a fee for participation. Task 21 is coordinated by Mario Conte with the Italian National Agency for New Technologies, Energy and Sustainable Economic Development. For further information regarding Task 21, please contact the Operating Agent:

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11

E-Mobility Business Models (Task 22)

***Members:** Germany, United Kingdom, United States*

11.1 Introduction

The IA-HEV Executive Committee (ExCo) unanimously approved this new Task at the 36th Executive Committee meeting in May 2012, held in Los Angeles. Now that the electric vehicle (EV) market is moving beyond demonstration projects into the mainstream, policy makers face the challenge of creating supportive emobility environments to promote EV investment and enterprise as EVs enter the mass market. Task 22 will advance understanding of the opportunities to generate and limit costs in the provision of EVs, recharging infrastructure, and the associated links to energy systems (Fig. 11.1).

Fig. 11.1 The EV-value chain offers profitable opportunities for businesses to build a solid foundation for EVs to enter the mass market. (Image courtesy of Volkswagen.)

11.2 Objectives

The initial Task objectives for its first year of operation are as follows:

- Establish a steering committee to initiate a call for papers from experts around the world.
- Identify relevant topics to be included in the call.
- Invite experts affiliated with Task participants and the ExCo to contribute papers.
- Explore the possibility of working with a major publisher to feature the papers in a book.

11.3 Working method

Our working method is inclusive and designed to include relevant IA-HEV participants and experts that are not IA-HEV members. Task 22 will invite researchers and practitioners to share their expertise from many sectors: business, policy, economics, engineering and technology management, and innovation. Topics may include policy perspectives, vehicle provision, infrastructure systems, and energy systems. Task participants will set up a global editorial board, recruit experts to submit text, and publish the findings in a widely distributed report.

The initial plan is to perform the work without holding in-person workshops. The reasoning for this method is to overcome travel and scheduling barriers for people interested in contributing their expert knowledge.

11.4 Financing and sponsorship

Currently, there is no cost for participation, there are no formal requirements for hours committed, and no travel is required. This efficient framework allows for the broadest participation from the widest range of experts at the least cost. The Task work scope may be expanded, depending on the interest level, possible funding support, and wishes of the Task participants.

11.5 Next steps

Task 22 issued an initial call for papers in May 2013. The IA-HEV Web site (www.ieahev.gov) will post any modifications to the call for papers. Wide participation is encouraged and includes experts who are not IA-HEV members.

Background

New and profitable business models will be key enablers of the sustainable introduction of EVs to the mass market. The overarching objective for such developments is to provide benefits that are greater than any perceived costs and to broaden the base of potential adopters. Achieving this objective demands the development of (1) electric mobility products and services that optimize the total cost of ownership and operation and (2) new ways to enhance user experiences.

Optimizing the total cost of ownership encompasses measures to reduce purchase prices, address concerns over battery degradation, support residual values, and offer greater certainty on costs. It also relates to alternative models of ownership, financing, and leasing, as well as the realization of new revenue streams through third-party or ancillary services.

Enhanced user experiences will come from developments that make EVs more convenient, desirable, and rewarding. These developments may include enhanced functionality for driving and recharging, non-monetary incentives, and flexible mobility services that meet the specific needs of individuals and businesses.

Failure to develop these products and services could delay growth in markets for EVs and limit adoption to niche applications. Accordingly, this call invites experts from industry, policy making, and research to contribute insights to support progress in this area.

Publication
Global knowledge on the state of the art and development prospects of business models for electric mobility will be summarized in a book edited in the framework of Task 22 of the International Energy Agency's Implementing Agreement for Co-operation on Hybrid and Electric Vehicles (IA-HEV). The goal is to share best practices and to understand regional differences in order to accelerate the introduction of EVs as a means to reduce the consumption of fossil fuels and decrease emissions from road transport. Renowned experts from technical and socioeconomic fields are invited to submit papers that will be peer reviewed and published as a contributed volume in the Springer book series, *Lecture Notes in Mobility*, to appear by the end of 2013.

11.6 Contact details of the Operating Agent

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12

Overview of hybrid and electric vehicles in 2012

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. Though overall vehicle sales declined during 2012 in most of the European member countries due to the continuing slow economy, EVs and PHEVs began to accumulate in many places. For example, in Sweden sales of EVs gained traction in 2012 due to the introduction of a new Super Green Car Rebate and increased availability of the vehicles. In the U.S., sales of plug-in vehicles in 2012 were triple those of 2011 as overall vehicle sales continued to rebound towards pre-recession levels.

This year we have separated out the sales figures for electric bicycles and scooters from the sales of other vehicles in Table 12.1, because many IA-HEV member countries do not track these two-wheeled vehicles that do not require a driver's license. In order to put national totals on a more consistent footing, we omit these figures from the main EV and PHEV totals. However, the trend of drivers taking up electric two-wheeled vehicles is a welcome one, and so we tally those numbers in Table 12.2.

Table 12.1 Actual or estimated *(estimates in italic)* electric vehicle (EV + PHEV) and hybrid electric vehicle (HEV) populations in IA-HEV member countries, per December 31st of each year that is shown (exceptions are noted). Though numbers for 2012 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		2012	
Vehicle type	HEV	HEV	HEV	EV and PHEV	HEV	EV and PHEV	HEV
Austria	2,592	3,563	4,801	n.a.	n.a.	2,965	8,125
Belgium	*4,800*	*6,700*	n.a.	n.a.	n.a.	3,467	20,636
Canada	45,703	59,541	76,055	617	86,579	2,591	108,190
Denmark	300	380	535	1,516	760	2,118	1,593
Finland	1,142	1,876	3,073	n.a.	3,973	224	2,500
France[1]	*24,000*	*33,000*	*43,000*	*3,610*	*57,000*	9,939	*84,000*
Germany	n.a.	n.a.	37,748	n.a.	n.a.	15,350	65,491
Ireland	n.a.	n.a.	5,328	n.a.	n.a.	408	6,781
Italy[2]	11,254	19,045	27,459	18,198	27,990	21,798	*34,789*
Netherlands	20,005	40,000	*57,000*	1499	*72,000*	7,431	88,627
Portugal	n.a.	n.a.	n.a.	1,334	n.a.	1,429	*2,500*
Spain	n.a.	14,000	21,190	2,490	32,888	6,523	44,649
Sweden	13,500	16,102	19,261	520	21,417	1,285	*24,000*
Switzerland[3]	11,140	*13,000*	21,000	n.a.	n.a.	12,253	28,056
Turkey	264	n.a.	400	*30*	*500*	n.a.	n.a.
UK[4]	47,035	n.a.	78,590	6,391	99,007	8,153	121,766
USA[5]	1,324,497	1,614,768	1,888,978	18,108	2,153,486	71,915	2,592,354
Total IA-HEV	*1,500,000*	*1,800,000*	*2,250,000*	*100,000*	*2,500,000*	167,849	*3,234,076*

n.a. not available

[1] France reports only annual sales, not total vehicle counts. Numbers are extrapolated by adding annual sales to earlier estimates.

[2] Final EV and HEV fleet data from Italy reported for December 2011, along with sales from 2012. Totals for 2012 are extrapolated by adding 2012 sales to the 2011 fleet totals reported. Also, Italy EV + PHEV data for 2012 include 36,900 electric motorbikes, a much larger number than in other countries.

[3] Swiss figures are per September 30 of each year reported. EV + PHEV figures also include 7,271 motorbikes in 2012.

[4] The U.K. data are per September 30 of each year reported. Also, the EV + PHEV figures reported do not include the "Others" category of vehicles that make up the majority of plug-in vehicles registered in that country. This category includes vehicles like mobility assistance scooters, electric tugs for moving trailers, milk floats, and certain NEVs used in park maintenance, etc.

[5] U.S. EV + PHEV data consider sales of new-model EVs and HEVs only, omitting legacy neighbourhood electric vehicles. Also, Tesla sales are not included because they are not reported through the same channels as those of other automakers.

Table 12.2 Actual or estimated *(estimates in italic)* electric bicycle and e-scooter populations in IA-HEV member countries, per December 31st of 2012 (exceptions are noted).

Year	2012		2012
Vehicle type	**Electric bicycles + scooters**		**Electric bicycles + scooters**
Austria	3,604	**Netherlands**	975,000
Belgium	n.a.	**Portugal**	n.a.
Canada	n.a.	**Spain**	670
Denmark	50,000	**Sweden**	n.a.
Finland	500	**Switzerland**[2]	200,000
France	n.a.	**Turkey**	n.a.
Germany	1,200,000	**UK**	n.a.
Ireland	n.a.	**USA**	1,000,000
Italy[1]	*260,000*	**Total IA-HEV**	*3,700,000*

n.a. not available

1 Italy estimate from December 2011 with estimated e-bike sales from 2012 added in.
2 Swiss figure per September 30, 2012.

13

Austria

13.1 Major developments during 2012

In June 2012, the Austrian Federal government released its Implementation Plan, *Electromobility in and from Austria*. The document is available online in English (www.bmvit.gv.at). The detailed plan covers a broad range of measures that aim to pave the way for electric vehicles (EVs) within Austria's transport and energy systems.

This plan was agreed upon by the Federal Ministry of Agriculture (BMLFUW); the Federal Ministry for Transport, Innovation, and Technology (BMVIT); and the Federal Ministry of Economy (BMWFJ) in June 2012. It represents an important common step forward toward introducing electromobility in Austria (Fig. 13.1).

Fig. 13.1 Wiener Linien, the municipal public transport in Austria, in Vienna commissioned the first electric bus (eBus) supplied by Siemens and Rampini, which began operations in 2012. (Image courtesy of Siemans.)

The IV2Splus (Intelligent Transport Systems and Services plus) research program (2007–2012) of the BMVIT was replaced by the Future Mobility program, which focuses on personal mobility, freight mobility, transportation infrastructure, and vehicle technologies. The first call for proposals was open until February 14, 2013. Up to €4 million (US $5.42 million) was reserved for vehicle technologies; three main topics were fuel cell technologies, hybrid and battery electric propulsion systems, and alternative fuels.

Additional electric mobility research activities in Austria are conducted under the funding programs in the Climate and Energy Fund. This fund includes the Lighthouses of EMobility Program, which issued its last call in October 2012 with a budget of €5 million (US $6.77 million), and the Electric Mobility Model Regions Program, with funding of €1 million (US $1.35 million).

The Vienna Business Agency subsidized small- and medium-sized enterprises in the city with a maximum of €10,000 (US $12,846) for each EV they operated until the end of March 2013. This project was 50% co-financed by the European Union and available for Renault Kangoo Z.E., Mitsubishi i-MiEV, and Citroen Berlingo First Electrique (Fig. 13.2). The overall budget is €1 million (US $1.35 million).

Fig 13.2 The Mitsubishi i-MiEV. (Image courtesy of Mitsubishi.)

Austrian national policies for hybrid electric vehicles (HEVs) and EVs are listed in Table 13.1.

Table 13.1 Summary of Austria's policy instruments for HEVs and EVs.

Policy Instrument	Details
Hybrid vehicle tax reduction	As of January 1, 2013, the motor-dependent insurance tax for HEVs has to be paid for the combustion engine only.
Emission taxation system	As of January 1, 2013, the taxation system on a new vehicle purchase is calculated for each additional gram of CO_2, as follows: • Emissions over 150 g CO_2/km: Tax increase is €25 (U.S. $33)/g CO_2 • Emissions over 170 g CO_2/km: Tax increase is €50 (U.S. $66)/g CO_2 • Emissions over 210 g CO_2/km: Tax increase is €75 (U.S. $99)/g CO_2

13.2 HEVs and EVs on the road

According to Statistics Austria, 435,929 new motor vehicles were registered in 2012. New registered passenger cars accounted for 336,010— which is a 5.7% decrease from 2011. A total of 427 EVs and 2,171 HEVs were registered in 2012. Thus, the number of new EVs decreased by 32.3% (from 631 new EV registrations in 2011), but the number of new HEVs increased by 65.7% (from 1,310 new HEVs in 2011).

The fleet totals and total sales during 2012 are displayed in Table 13.2 followed by Table 13.3 that lists the plug-in vehicle models available in 2012 such as the Renault Twizzy (as seen in Figure 13.3) and their prices.

Fig. 13.3 The Renault Twizy is an electric city car that retails for less than US $10,000, making it attractive to buyers, especially in an urban setting. (Image courtesy of Christian Houdek for Renault.)

Table 13.2 Distribution, sales, and models of Austrian EV and HEV fleet in 2012.

Fleet totals as of December 31, 2012					
Vehicle type	**EVs**	**HEVs[a]**	**PHEVs**	**FCVs**	**Total**
Bicycles (no drivers license)	3,604	1	n/a	0	299,586
Motorbikes	401	10	n/a	0	430,842
Quadricycles	560	5	n/a	0	31,964
Passenger vehicles[b]	1,389	8,100	n/a	0	4,584,202
Multipurpose passenger vehicles	n/a[c]	n/a	n/a	n/a	n/a
Buses	126	4	n/a	0	9,546
Trucks	432	6	n/a	0	416,535
Industrial vehicles	57	0	n/a	0	481,065
Totals with bicycles	6,569	8,126			6,253,740
Totals without bicycles	2,965	8,125			5,954,154

Total sales during 2012					
Vehicle type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no drivers license)	681	1	n/a	0	21,201
Motorbikes	82	1	n/a	0	24,846
Quadricycles	331	2	n/a	0	3,573
Passenger vehicles[b]	427	2,171	n/a	0	336,010
Multipurpose passenger vehicles	n/a	n/a	n/a	n/a	n/a
Buses	14	2	n/a	0	722
Trucks	292	0	n/a	0	38,097
Industrial vehicles	14	0	n/a	0	10,012
Totals with bicycles	1,841	2,177			434,461
Totals without bicycles	1,160	2,176			413,260

[a] In the table, an EV is a fully electric vehicle, and an HEV is a hybrid electric vehicle, which also includes plug-in electric vehicles (PHEVs) because Austria does not differentiate between an HEV and a PHEV. An FCV is a fuel cell vehicle.

[b] Includes multipurpose passenger vehicles.

[c] n/a = not applicable.

Table 13.3 Prices of plug-in vehicle passenger models available in 2012 in Austria.

Plug-in vehicle passenger models available in 2012		
Model name	**Model price (untaxed, unsubsidized)**	
	Euros	**US dollars**
Opel Ampera	€45,900	$59,710
Nissan Leaf	€34,490	$44,860
Renault Twizy	€6,990	$9,090
Renault Kangoo Z.E.	€24,360	$31,319
Renault Fluence Z.E.	€25,950	$33,760
Mitsubishi i-MiEV	€29,500	$38,340
Citroen C-Zero	€27,588	$35,850
Citroen Berlingo First Electrique	€51,600	$67,050
Peugeot iOn	€29,640	$38,520
Toyota Prius Plug-in Hybrid	€37,500	$48,730
Smart Fortwo Electric drive	€24,590	$31,615
Tesla Roadster	€101,700	$132,160
Fisker Karma	€115,000	$149,440

13.3 EVSE (EV supply equipment), or charging infrastructure

One EVSE (charging station) can host several individual charging points. In Austria, EVSEs are counted by the number of stations rather than the number of plugs in a charging station.

There were 1,060 charging stations installed as of February 2013. Including private charging, there are 3,271 places to charge an EV in Austria, which represents a 3.2% increase from 3,167 in October 2011 (see Table 31.4).

E-Mobility Provider Austria GmbH&Co KG is a joint venture between Siemens Austria and electricity producer Verbund that has plans to put 4,500 charging and quick charging points into operation by 2020.

The OMV Group (www.omv.com) opened the only public fuel cell vehicle hydrogen station on October 17, 2012.

Table 13.4 Public EVSEs installed as of December 31, 2012.

EVSE Type	Number
Level 2/standard AC	1,060
DC fast charging	6
Fuel cell vehicle	1

Table 13.5 EV demonstration projects in Austria.[a]

Name	Location	Duration	BEVs	EVSE	URL
VLOTTE	Vorarlberg	since 2008	357	142	http://www.vlotte.at/
ElectroDrive	Salzburg	2009–2014	110	134	http://www.electrodrive-salzburg.at
e-mobility on demand	Vienna	since 2010	10	5	http://www.e-connected.at/content/e-mobility-demand-wien
Großraum Graz	Graz	since 2010	47	30	http://www.emobility-graz.at/
e-mobilisiert	Eisenstadt	since 2010	3	1	http://www.e-mobilisiert.at/index.jspa
e-pendler in niederösterreich	Lower Austria	since 2011	n/a[b]	n/a	
E-LOG	Klagenfurt	since 2011	n/a	n/a	http://www.e-connected.at/content/e-log-klagenfurt-0
E-Mobility Post	Vienna	since 2011	n/a	n/a	
VIBRATe	Bratislava	2007–2013	20	5	http://www.emobility-vibrate.eu/at

[a] Number of vehicles and charging stations according to June 2012 Status Report (only two-lane battery electric vehicles [BEVs], no bikes).

[b] “n/a” = “not available.”

14

Belgium

14.1 Major developments during 2012

Automotive sector

The automotive sector is one of the most important industrial sectors in Belgium. The country hosts several car assembly plants: Ford in Genk, Audi in Brussels, and Volvo Cars in Gent. The European headquarters, logistics centers, and technical R&D center of Toyota Motor Europe are also located in Belgium. In addition, there are assembly plants for buses (Van Hool and VDL Jonckheere) and trucks (Volvo Europa Trucks) in Belgium, and the country has about 300 local automotive suppliers.

The end of 2012 was turbulent for the automotive sector in Belgium because of Ford's October 24 announcement that it will close its factory in Genk in 2014. The factory is a production site for the midsize Mondeo model, the Sportvan S-Max, and the Galaxy van. It is projected that the region will lose 10,000 direct and indirect jobs as a result of the closure. The government is proactively seeking solutions to recover jobs and has asked for a regional strategic action plan to mitigate the projected economic impacts of the factory closure.

Innovation will be part of the solution for the Genk region, which is transforming itself and searching for new business opportunities. The electric mobility industry offers one such economic opportunity. Umicore is a good example of a company that is positioning itself in this new electric mobility "value chain" by providing innovative and sustainable solutions. Along with being an important material supplier for lithium-ion batteries, Umicore has also developed a unique recycling process at its recycling plant in Hoboken, Belgium. Japanese automaker Toyota signed a collaborative agreement in 2012 with Umicore to recycle the lithium-ion batteries used in its new hybrid models, but it will take a while before the new contract generates results because the new Prius models have just been introduced into the market. However, the agreement will undoubtedly earn Umicore similar contracts and is proof of Toyota's confidence in Belgium's innovative technologies.

Flemish Living Lab Electric Vehicles program

More than 70 local e-mobility stakeholders are working together intensively in the Flemish Living Lab Electric Vehicles program (Fig. 14.1) to facilitate and accelerate innovation. New products, services, and business models are being tested in real-life conditions. During 2012, progress was demonstrated with the rollout of the open test infrastructure containing more than 300 electric vehicles and more than 800 charging points for electric bicycles and cars. A test population of more than 2,000 people has access to this infrastructure. Valuable data will be collected in the next two years of the Living Lab program. More information on the program can be found in the IA-HEV 2011 annual report and on the website www.livinglab-ev.be.

Flemish Living Lab
Electric
Vehicles

Fig. 14-1 Logo for Flemish Living Lab Electric Vehicles.

Electric bicycles

Blue-Mobility, a partner in the OLYMPUS platform, put almost 100 electric bicycles in use during 2012. These electric bicycles, as shown in Fig. 14.2, can be used in different cities in the Flanders region and are part of the existing Blue Bike bicycle-sharing scheme. Most of Blue Bike's locations are near train stations to encourage the use of public transport trains combined with bicycle sharing. This scheme allows users to reach their destinations using 100% public transport.

Fig. 14.2 Blue-Mobility offers 100 EV bicycles in its bicycle sharing scheme. (Images courtesy of OLYMPUS platform.)

Electric cars

Volvo, a partner in the Volt-Air platform, continues to conduct research on the electric drivetrain via the fully electric Volvo C30, shown in Fig. 14.3, and the plug-in hybrid Volvo V60. During 2011 and 2012, approximately 400 electric Volvo C30s were produced for government and fleet use to evaluate whether Volvo will to commence Volvo C30 series production. The plug-in hybrid Volvo V60 is in series production and is available to the public market as of 2013.

Fig. 14.3 Starting in the summer of 2013, Volvo will begin leasing a fleet of 100 C30 EVs to European customers, and will begin taking feedback on the technology which the brand hopes to implement in a future series production of the vehicle. (Image courtesy of Volvo.)

Electric vans

Punch Powertrain, a partner in the EVTecLab platform, began building its first batch of electric Ford Connect vans during 2012, as shown in Fig. 14.4. These vans went through their homologation process and will be tested intensively over the next two years to evaluate the performance of their drivetrain components.

Fig. 14.4 The fully-electric Ford Connect offers a greener transport mode. (Image courtesy of EVTecLab platform.)

Hybrid, electric, and fuel cell buses

Hybrid, electric, and fuel cell buses received extra attention in Belgium during 2012. Such vehicles were the focus of some major decisions by local public transport companies in the country's various regions to increase the electrification of the bus fleets. Testing was conducted and some large orders were placed for hybrid, electric, and fuel cell buses

De Lijn in Flanders placed an order for 386 new buses that amounted to €93 million (US $121 million). A mix of alternative drivetrains is represented in the new bus orders: 3 fully electric buses, 5 fuel cell buses, and 123 hybrid buses (Fig. 14.5).

Fig. 14.5 De Lijn is heavily investing in a creating a clean bus transport fleet. (Image courtesy of EVTecLab platform.)

MIVB in Brussels announced that it will no longer purchase diesel buses beginning in 2015 and is looking for alternative bus drivetrains. Compressed natural gas (CNG) buses are certainly an option, but MIVB will also investigate using electric buses to replace diesel buses. MIVB tested an electric bus from BYD at the end of 2012.

Hybrid and electric trucks

Volvo Europa Truck in Ghent delivered its first diesel-hybrid truck for the Belgian market in 2012 (Fig. 14.6). The truck is being used by the Vanheede Environment Group to collect industrial garbage. Volvo Europa Truck is aiming at series production of 150 to 200 hybrid trucks per year. Production began in 2011, and 30 hybrid trucks had been delivered to other European countries as of 2012.

Fig. 14.6 Volvo Diesel-Hybrid Truck. (Image courtesy of Vanheede Environment Group.)

Fully electric trucks are also in operation. E-Trucks, within the EVTecLab project, has been developing two electric trucks for making city deliveries. CityDepot will use electric trucks and vans to deliver goods in inner cities. Also, the Brussels Airport is using an electric garbage truck to collect foreign object debris on the tarmac.

14.2 HEVs, PHEVs, and EVs on the road

Fiscal measures for electric vehicles

As they have in other regions of the world, sales of hybrid electric, plug-in hybrid electric, and electric vehicles (HEVs, PHEVs, and EVs) in Belgium have grown more slowly than expected. Industry is asking governments for further support to stimulate the market. Unfortunately, some beneficial tax incentives for electric vehicles were stopped at the end 2012.

In Belgium, the tax measures that are related to the purchase and use of electric cars differ according to the legal status of the taxable person and the region. Both income taxes and company taxes are regulated in Belgium at the national level.

Private electric vehicles

With regard to the purchase of an electric vehicle, the tax credit is calculated as follows:

- 15% of the purchase price, with a maximum of €3,280 (US $4,214) for quadricycles or of €2,000 (US $2,570) for motorcycles or tricycles.
- 30% of the purchase price, with a maximum of €9,190 (US $11,809) for cars, twin-purpose cars, or minibuses exclusively powered by an electric motor. (Note that this incentive expired at the end of 2012.)

Charging station

A 40% tax credit of up to a maximum of €250 (US $321) is allowed for charging station installation expenses.

Company electric vehicles used for private purposes

Employees who use an employer's car in Belgium are taxed under the "benefit in kind" regulation. The taxable amount is calculated by using a formula that is based on the purchase price of the vehicle, so the higher EV-purchase price negatively impacts their sale as lease cars. This change in the calculation of benefits in kind has led to protests from the automotive sector in Belgium.

For new vehicles purchased in 2013, the tax calculation is made using the following formula: taxable amount = purchase price x 366 x 6/7 x percentage of CO_2 in the exhaust. For pure electric vehicles, the lowest CO_2 percentage that applies is 4%. For comparison, the reference CO_2 percentage for a conventional petroleum car that emits 115 grams of CO_2 in the exhaust per 100 km is 5.5%.

Company cars

Companies can deduct 120% of the purchase cost for zero-emission vehicles and 100% of the cost for vehicles emitting between 1 and 60 g/km of CO_2. If the car is put at the disposal of an employee, the company pays a CO_2-solidarity tax. For electric vehicles, this tax is limited to €24.25 (US $32) per month.

The yearly vehicle tax and the car registration tax vary by region.

- Wallonia: In 2008, the Walloon region introduced the Eco-bonus and car registration tax system. The Eco-bonus regulation allows people who buy a low-emission car to receive a bonus instead of paying the registration tax. The bonus amount can be up to €2,500 (US $3,272); the €2,500 bonus applies to vehicles that emit less than 20 g/km of CO_2.
- Flanders: EVs and PHEVs are exempt from the registration tax in Flanders,

and owners of EVs pay the lowest tariff of the circulation tax.

Table 14.1 shows the EV, HEV, PHEV, FCV sales and fleet for 2012.

Table 14.1 Belgium: EV, HEV, PHEV, FCV sales in 2012 and total fleet figures.

Fleet totals per January 1, 2013					
Vehicle type	EV fleet	HEV fleet	PHEV fleet	FCV fleet	Total fleet
Motorbikes	133	0	0	0	414,886
Quadricycles	487	0	0	0	23,700
Passenger vehicles	826	20,576	347	1	5,454,386
Light Commercial Vehicles	330	0	0	0	628,515
Buses	3	55	0	0	16,054
Trucks	7	5	0	0	150,221
Industrial vehicles	1,334	0	0	0	247,166
Totals	3,120	20,636	347	1	6,934,928
Total sales during 2012					
Vehicle type	EV fleet	HEV fleet	PHEV fleet	FCV fleet	Total fleet
Motorbikes	62	0	0	0	24,481
Quadricycles	411	0	0	0	1,889
Passenger vehicles	568	5,675	340	0	501,177
Light Commercial Vehicles	265	0	0	0	55,511
Buses	0	0	0	0	738
Trucks	0	1	0	0	10,135
Industrial vehicles	133	0	0	0	6,499
Totals	1,439	5,676	340		600,430

Belgium Source : FPS Mobility and Transport

14.3 Electric vehicle supply equipment or charging infrastructure

The rollout of charging infrastructure in Belgium (Fig. 14.7) intensified during 2012. As part of the Flemish Living Lab Electric Vehicles program, 860 new charging points were installed in the public and semi-public domains: 405 for cars and 455 for bicycles. Charging points are defined as points where electric vehicles can charge simultaneously. The 860 new charging points are spread out over 172 different locations in Flanders. The Living Lab program is an open platform for testing new products and services related to e-mobility in real-life conditions in order to stimulate innovation. The program’s charging infrastructure is supplied by different companies: Blue Corner/eNovates, ThePluginCompany, P&V Elektrotechniek, BeCharged, Alfen, and Siemens.

Fig. 14.7 Charging Infrastructure in the Public Domain. (Images courtesy of EVA platform.)

Most charging points are Level 1 (120 V/12 A) or Level 2 (240 V/40 A), but activity in the direct-current (DC) fast-charging domain is growing. Companies such as The-PluginCompany, VitaeMobility, ABB, The New Motion, and Nissan are installing extra DC fast chargers in Belgium. It is estimated that in 2013, about 50–80 DC fast chargers will be needed for new installations. Currently, DC fast chargers are located at car dealerships, hotels, and retail outlets.

15

Canada

15.1 Major developments during 2012

QUÉBEC’S DRIVE ELECTRIC PROGRAM BEGINS – JANUARY 2012

The Drive Electric Program (“Programme Roulez Électrique”), effective from January 1, 2012, through December 31, 2015, offers a purchase rebate for individuals, businesses, nonprofit organizations, and Québec municipalities that acquire an eligible vehicle. This program replaces the tax credit program for purchasing or leasing a new fuel-efficient vehicle that was in place from 2009 to 2011. The new program also includes an incentive for purchasing and installing Level 2 charging stations at home for anyone who has purchased or leased an electric vehicle (EV). Additional information about the program is available at www.vehiculeselectriques.gouv.qc.ca.

QUÉBEC DEVELOPS ELECTRIC BUS – MARCH 2012

On March 7, 2012, the Québec government announced its support of a project for a Québec-built electric bus. The project, conducted through partnerships among industry specialists, will leverage Québec’s industrial strengths in manufacturing city buses, composite and aluminum structures, electric motors, smart transportation systems, and high-performance batteries. The project represents a total outlay of $73 million (US $70 million), funded by both the government (maximum of $30 million) and the private sector. Current plans are to have two different-sized prototype electric buses in operation in Québec in the next three years.

MERCEDES-BENZ FUEL CELL PLANT OPENS – JUNE 2012

On June 21, 2012, the world’s first automated fuel cell manufacturing plant, operated by Mercedes-Benz Canada, opened in the Vancouver suburb of Burnaby, Canada. The plant will manufacture fuel cells to be shipped to Germany for Mercedes-Benz’s new F-Cell cars, which will be available in 2014. The new 3,300-square-meter facility represents an investment of $53 million (US $51 million) by Mercedes-Benz. In collaboration with British Columbia’s world-class fuel cell research and development cluster, Mercedes-Benz is working toward reducing the cost of fuel cell technology.

ONTARIO PROVIDES CHARGING STATION INCENTIVE – JANUARY 2013

The Province of Ontario's Electric Vehicle Charging Incentive Program, effective January 1, 2013, provides a financial incentive to support the purchase and installation of eligible, new, Level 2 (208- or 240-volt alternating current [AC]) EV charging stations for residential and/or business use (Fig. 15.1). The value of the incentive is 50% of expenses for purchase and installation (including electrical inspection) up to a maximum of $1,000 (US $964).

Fig. 15.1 Ontario is helping electric car owners install charging stations at their homes and businesses to encourage sustainable transportation and fight climate change.

15.2 HEVs, PHEVs, and EVs on the road

Table 15.1 lists the estimated EV purchases and leases resulting from Québec's Drive Electric Program. In 2012, the number of EVs on the road in Québec was estimated at slightly more than 1,000.

Table 15.1 Estimated EV Purchases and Leases in Canada in 2012.

EV type[a]	Number of rebates for individuals	Number of rebates for businesses	Number of rebates for municipalities	Total number of rebates	Purchases (%)	Leases (%)
PHEV	515	73	12	600	91.8	8.2
HEV	3819	213	5	4037	57.5	42.5
BEV	156	35	27	218	83.9	16.1
EVSE at home	202			202		

[a] PHEV = plug-in hybrid EV, HEV = hybrid EV, BEV = biodiesel EV, EVSE = EV supply equipment.

Data collected from Ontario's vehicle incentive program indicate that since the program began in July 2010, approximately 800 unique green-vehicle license plates shown in Fig. 15.2 have been issued for PHEVs within the province. The green vehicle license plate allows the owner to use HOV lanes with a single occupant until

2015. The data also show that approximately 75% of the EV incentives issued have been for PHEVs versus 25% for BEVs and that approximately 75% of the EVs were purchased by individuals and 25% were bought by businesses.

Fig 15.2 Ontario's green vehicle license plate.

Factors that led to the successful deployment of EVs in Québec in 2012 (data are provided in Table 15.2) are as follows:

- Purchase incentives for EVs, which encourage manufacturers to make more EVs available in the Québec market and encourage users to acquire them
- Promotional outreach/awareness campaign for EVs (at auto shows, in advertising, etc.)
- Financial support for home-charging infrastructure
- Dynamism of other Québec organizations in the field of electric mobility and
- The number of public and private initiatives in the area of public charging for EVs.

Table 15.2 Vehicle fleet in Canada at the end of 2012.

Fleet totals as of December 31, 2012					
Vehicle type	EVs	HEVs	PHEVs	FCVs	Total
Passenger vehicles	875[a]	108,190[b]	1,716[a]		N/A
Total sales during 2012					
Vehicle type	EVs	HEVs	PHEVs	FCVs	Total
Passenger vehicles	621[a]	21,611[a]	1,399[a]		1,716,803[c]
Plug-in vehicle models available (passenger only)					
Model	**Untaxed, unsubsidized price of vehicle model (all values in Canadian dollars)**				
Chevrolet Volt	$42,000 (US $40,494)				
Fisker Karma	$106,850 (US $103,020)				
Ford C-MAX energi[d]	$36,999 (US $35,672)				
Ford Focus Electric	$40,699 (US $39,240)				
Mitsubishi i-MiEV	$32,998 (US $31,815)				
Nissan Leaf	$38,395 (US $37,018)				
Smart for Two Electric Drive	$26,990 (US $26,022)				
Tesla Model S	$77,800 (US $75,011)				
Toyota Prius Plug-in Hybrid	$35,700 (US $34,420)				

[a] Source: Electric Mobility Canada and Polk.

[b] Estimate based on 2010 registration data (Desrosiers) and 2011–2012 sales data (Electric Mobility Canada and Polk).

[c] Source: Statistics Canada – Passenger cars and trucks (trucks include minivans, sport-utility vehicles, light and heavy trucks, vans, buses) at http://www5.statcan.gc.ca/cansim/.

15.3 EV supply equipment (EVSE) or charging infrastructure

As expected, the three provinces most active in the deployment of EVs — Québec, Ontario, and British Columbia — were also those with the largest share of EVSE. However, the rollout of the public charging infrastructure is occurring differently in each province and is highly influenced by the focus of each province's EV program and related funding initiatives. In British Columbia, the largest proportion of public EVSE is installed at government or public facilities; in Québec, however, the largest proportion is installed at retail or restaurant locations. In Ontario, public EVSE is being installed across the province organically, without the direct involvement of the provincial government.

In the province of Québec, at least four deployments of charging station networks are in progress. One is a project headed by Hydro-Québec called Electric Circuit that is aimed at installing 150 Level 2 charging stations. Another is AddÉnergie Technologies VER network, which is installing 97 charging stations. There are an estimated 275 charging stations in Québec at this time.

In Ontario, the Ministry of Transportation and Infrastructure Ontario issued a joint Request for Information (RFI) in May 2012 regarding opportunities for publicly accessible EV infrastructure in the province. A number of organizations responded to this RFI, and the Ministry is currently using this information to help determine the appropriate role for government to play in supporting public EV infrastructure. In addition, Metrolinx, a provincial government agency, is investigating opportunities to install and operate public charging facilities at select GO Transit (commuter rail) locations.

On September 12, 2012, the government of British Columbia agreed to partially fund 454 charging stations in an effort to promote the use of EVs and HEVs. Seventy-one groups have been approved to install 286 charging stations. The remaining 168 charging stations will be installed by 12 local governments across British Columbia. The government is also investing $1.3 (US $1.25) million to install direct-current (DC) fast chargers in 13 communities throughout the province in 2013. Table 15.3 lists charging station data.

A map of publicly available charging stations in Canada can be found on Electric Mobility Canada's Web site at www.emc-mec.ca. A mobile solution to help locate EV chargers in Canada is also available. The application, developed by FleetCarma, is known as the *EV Charging Station Locator.* It helps drivers find the station that is closest to their current location and provides turn-by-turn directions.

Table 15.3 Charging points in Canada.

Number of public EVSE installed as of April 19, 2013		
Level 1/standard AC	Level 2/standard AC (individual heads)	DC fast charging
N/A	744 (923)	2

Source: FleetCarma.

15.4 EV demonstration projects

Table 15.4 lists selected EV demonstration and deployment projects in Canada.

Table 15.4 Various organizations and their cumulative EV demonstration efforts in Canada in 2012.

Name	Location	Duration	# PHEVs	# BEVs	# EVSE (Level 2)
Hydro-Québec Mitsubishi Project	Boucherville, QC	2010–2013	0	25 i-MiEV	46
Communauto Project	Montreal and Quebec, QC	Since 2011	0	25 Leafs	25
Toronto Hydro Smart Experience and EV Connections	Toronto, ON		49 (PHEVs and BEVs)		37
BC Hydro Demonstrations with OEM (Mitsubishi, Nissan, Toyota, GM)	British Columbia	Since 2009	18	2	
Sun Country Highway	Cross-Canada Electric Car Trip	2012		1	>80

16

Denmark

16.1 Major developments during 2012

In March 2012, a broad political Energy Agreement was reached in Denmark (www.ens.dk). It presents a wide range of ambitious and concrete initiatives designed to get Denmark on track to fulfill its target of 100% renewable energy in the Danish energy and transport sectors by 2050. By 2020, onshore and offshore wind farms (1800-MW and 1500-MW production capacities, respectively) will result in wind power that can supply almost 50% of Danish energy needs.

Denmark is in a strong position to integrate fluctuating and unpredictable energy sources, such as wind power, into a smart electrical grid. The country's knowledge associated with this effort will be used in the transport sector by focusing on intelligent battery systems and plug-in electric vehicles (PHEV). For example, a PHEV owner can recharge the car battery by plugging into the smart grid during the night when there is a plentiful supply of cheap electricity produced by wind energy. At other times, the battery's power can be used to run the PHEV or the stored energy in the battery can be sold back to the smart grid when the electricity price is high and electrical production is primarily based on CO_2-emitting coal and gas. When individual PHEVs are used together, they effectively become large, intelligent batteries plugged into the grid: the perfect partners for smart grids and distributed power generation.

STRATEGY FOR ENERGY-EFFICIENT VEHICLES

As a part of the 2012 Energy Agreement, DKK 70 million (US $12.3 million) was allocated for a strategy for energy-efficient vehicles (electric vehicles (EVs), natural gas vehicles, and fuel cell vehicles). DKK 40 million (US $7 million) of this funding will be used to deploy EV infrastructure in 2013 and 2014. Public entities and private companies can apply for this funding. Priority will be given to projects that ensure EV deployment and usage. (www.ens.dk)

EXTENSION OF THE DANISH EV TEST SCHEME

The Energy Agreement includes an extension through 2015 of the Danish EV Test Scheme, with funding of DKK 15 million (US $2.6 million). PHEVs are now included in this test scheme. Because PHEV prices are so high in Denmark, the scheme will only be able to partially fund a limited number of PHEVs. The EV Test Scheme is administered by the Danish Energy Agency. (www.ens.dk)

REIMBURSEMENT OF ELECTRICITY FEES FOR EV CHARGING PROVIDERS

Companies that supply commercial EV charging can get an electricity-tax reimbursement that amounts to DKK 0.91 (US $0.12) per kilowatt-hour; it corresponds to around 40% of the average electricity price. The fact that the emobility operators use different business models makes it unclear if their tax savings will reduce the price charged to consumers. CLEVER, a major Danish e-mobility operator, has reduced its price to consumers for home charging by DKK 1 (US $0.18) per kilowatt-hour as a result of the government's tax reimbursement for electricity fees. (www.clever.dk)

INCLUSION OF EVS IN UTILITY COMPANIES' ENERGY-SAVING EFFORTS

The Danish energy distribution companies (DSOs or utilities) are obligated to achieve a certain level of energy savings. They can achieve this by purchasing energy savings from consumers according to a validation system. Transport is now included in the array of energy-saving efforts that the DSOs are entitled to support. Hence, fleet owners purchasing a minimum of five new vans or passenger cars may receive funding from the utility companies. Through the competitive market created among the DSOs for energy savings, fleet owners may achieve savings of up to DKK 0.20–0.45 (US $0.04–0.08) per kilowatt-hour during the first year of a vehicle's operation. This corresponds to DKK 2000–4000 (US $350–700) per vehicle. EVs, PHEVs, and energy-efficient internal combustion engines combined will be able to meet the energy efficiency requirements. A selection of EV tax incentives is provided in Table 16.1.

Table 16.1 Selected EV tax incentives.

Danish EV tax incentives
‣ Battery-powered EVs and fuel cell vehicles are exempted from the registration tax and annual tax until the end of 2015.
‣ EVs are also exempted from the current Danish registration tax for passenger cars, which is very high (180%) and is based on the value of the car.
‣ Locally, there is free parking for EVs in cities.
‣ DSOs are now entitled to use time-differentiated distribution grid transport tariffs, which give end users incentives to charge their EVs when electricity prices are low and the demand on the power grid is low.

16.2 HEVs, PHEVs, and EVs on the road

The number of EVs deployed in Denmark during 2012 did not meet the expectations of several Danish EV stakeholders. Fleet sizes and sales figures are shown in Table 16.2. The vehicles' high purchase prices, uncertain resale values, range anxiety, and limited selection of models are generally perceived as the main barriers to EV market penetration. The secondary EV market is nascent.

Table 16.2 Vehicle fleet sizes and 2012 sales totals in Denmark.

STOCK	Fleet totals per 31 December 2012				
Vehicle type	**EV**	**HEV**	**PHEV**	**FCV**	**Total**
Bicycles (no driver license)	50,000	0	0	0	5,000,000
Motorbikes	316	0	0	0	149,665
Quadricycles	236	0	0	0	N/A
Passenger vehicles	1,215	1,579	27	13	2,654,138
Multipurpose passenger vehicles	1	0	0	0	N/A
Buses	14	13	0	0	13,485
Trucks	8	1	0	0	42,541
Industrial vehicles	301	0	0	1	119,447
Total with bicycles	52,091	1,593	27	14	7,979,276
Total without bicycles	2,091	1,593	27	14	2,979,276

16.3 EVSE (EV supply equipment), or charging infrastructure

Two e-mobility operators — Better Place and CLEVER (formerly known as ChoosEV) — dominate the Danish EV recharging market. During 2012, Better Place and CLEVER launched a countrywide network for EV recharging. EVSE totals (Table 16.3) are listed below.

Table 16.3 Public EVSE in Denmark.

Number of public EVSE installed as of December 31, 2012		
	Points	**Posts**
AC, slow charge (3,7 kW)	151	100
AC, semi-fast charge (11 kW)	672	336
AC, fast charge (22 kW)	18	13
DC, fast charge (20 kW)	8	8
DC, fast charge (max 50 kW)	50	50
Number of battery swap stations		
Battery Swap Station	18	
Number of fueling locations for fuel cell vehicles		
700 bar	2	
250 bar	2	
Data sources:		
Better Place Denmark, Clever, CleanCharge Solutions and H2Logic		

Fig. 16.1 Renault Fluence Z.E. at Better Place Battery Swap Station. (Image courtesy of Better Place Denmark.)

Better Place Denmark

The Better Place EV recharging network is based on battery swap stations: DC fast charging (480 V) and AC fast charging (Level 2, 240 V), and semi-fast charging (Level 1, 120 V). The battery swap process at Better Place battery swap stations takes around 5 minutes (see Fig. 16.1).

The Renault Fluence Z.E. is the only car that is equipped for a battery swap. At the end of 2012, there were 252 Renault Fluence Z.E.s in Denmark. The Better Place business model is based on a flat-rate-mileage subscription with free access to Better Place's charging infrastructure. As of June 2013, Better Place Denmark filed for bankruptcy. This new development will definitely impact Danish EV infrastructure.

CLEVER

CLEVER's EV recharging network offers DC fast charging, AC semi-fast charging, and slow charging. CLEVER has established most of its network of DC fast charge stations at a major Danish supermarket chain, Føtex. The EVs available in Denmark capable of AC fast charging include the Nissan Leaf, Mitsubishi iMiEV, Citroën C-Zero, and Peugeot iOn. There were 613 of these EVs in Denmark by the end of 2012, according to the Danish Car Importers Association. Charging a Nissan Leaf from 0 to 80% battery capacity takes around 30 minutes, according to correspondence with Ole Alm, Clever, April 2013 (see Fig. 16-2). CLEVER's business model is based on customers subscribing to CLEVER's charging infrastructure (with a monthly subscription fee) and paying for energy usage.

Fig. 16.2 Nissan Leaf at CLEVER fast charge station. (Image courtesy of CLEVER.)

CleanCharge Solutions

CleanCharge Solutions is a small Danish e-mobility operator that focuses on AC fast and semi-fast charging. The company's business model is based on supplying equipment and providing value-added services (billing services, charging data processing, etc.) to the charging point operator.

The Danish e-mobility operators have not disclosed their targets for EV recharging infrastructure deployment during 2013. Up to 93% of all Danish AC charging points are equipped with type 2 (”Mennekes”) plugs. All DC fast charge stations are equipped with CHAdeMO (Yazaki) plugs.

16.4 EV demonstration and research projects

Selected important EV projects with Danish participation are listed in Table 16.4. Some are EV demonstration projects and some are EV research projects.

Table 16.4 Examples of EV demonstration and research projects with Danish participation.

EV Demonstration and Research Projects				
Project title	Donor	Participant	Project period	URL
Test an EV (EV project)	DEA; DTA	CLEVER; DTU	2010–14	https://www.clever.dk/test-en-elbil
Green e-Motion (standards for interoperable emobility)	EC	BPD; CoC; DTU	2011–15	http://www.greenemotion-project.eu/home/index.php
e-mobility NSR (North Sea Region) (common emobility in the NSR)	ERDF	HTM; FDT	2011–14	http://e-mobility-nsr.eu/
CPH Clean Cap (EV taxi project)	DTA	TAXA 4x35; BPD CCS; EaE	2013–15	
SELECT (commercial EV usages)	EU, ERA-NET	DTU	2012–16	
E-Mission (EV charging interoperability)	EUI	CoC	2012–15	http://www.interreg-oks.eu/en/Menu/Projects/Project+List+%c3%96resund/E-mission+in+The+%c3%98resund+Region
City Logistic CPH	DTA	DTU	2013–16	
Nikola (intelligent EV integration)	ENDK	DTU	2013–16	

Definitions of abbreviations:

BPD: Better Place Denmark
CBS: Copenhagen Business School
CoC: City of Copenhagen
CCS: CleanCharge Solutions
DEA: Danish Energy Agency
DTA: Danish Transport Authority
DTU: Technical University of Denmark
DSB: Danish State Railways
EaE: Ea Energianalyse
EC: European Commission
ENDK: Energinet.dk
ERDF: European Regional Development Fund
FDT: Association of Danish Transport and Logistics Centres
HTM: Høje-Taastrup Municipality
NCM: Nordic Council of Ministers
SELECT: Sustainability of Electromobility for Commercial Transport

17

Finland

17.1 Major developments during 2012

Finland's government policies are tied to greenhouse gas (GHG) reduction targets and currently do not favor or subsidize electric vehicles (EVs). Currently, the overall targets for GHG reduction can be met by using biofuels, which are in ready supply from Finland's vast forests. There were no national hybrid-related or EV-related policy announcements or legislation changes during 2012. Current Finnish fuel taxes are based on energy content, carbon dioxide (CO_2) emissions, and the impact on local air quality.

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. This CO_2-based taxation system began in 2011 and remains in effect. The system favors hybrid vehicles and EVs, along with many biofuels. In 2015, the average new-car GHG emission level target will be 130 g/km. Beginning in 2010, the standard 95-octane gasoline has been 95E10 containing 10% ethanol, which has helped decrease vehicle emissions.

Tekes, the Finnish Funding Agency for Technology and Innovation, coordinates the Electric Vehicle Systems (EVE) program. Launched at the end of 2011, EVE is developing testing environments for EVs and has a €100 million (US $129 million) program budget. The EVE program is creating a new international community focused on developing new EV-related businesses, with their machinery and systems.

Valmet Automotive currently manufactures the Fisker Karma EV. The company announced that it will begin series production of the new Mercedes A-class in 2013–14.. In Uusikaupunki a team of over 100 professionals is working in the project in close cooperation with their colleagues at Daimler. In March 2013, Valmet presented its first concept vehicle with a range extender drivetrain shown in Fig. 17.1. The concept vehicle's specified electric range is over 90 km (on the New European Driving Cycle or NEDC), while the specified total with the range extender and a 30-L fuel tank reaches 580 km (NEDC). The optimized lithium-ion battery weighs 150 kg and has an energy capacity of 17.5 kWh. The battery can be charged by alternating current (AC) normal charging in 4.5 hours and by direct current (DC) fast charging in just 20 minutes.

Fig. 17.1 The Valmet range-extender concept vehicle is potentially one solution towards a larger selection of EVs for the market.

17.2 HEVs, PHEVs, and EVs on the road

The number of hybrid electric vehicles (HEVs) on the road in Finland is still relatively small, as shown in Table 17.1, but this number is increasing as a result of CO_2-based taxation of cars and consumers' growing desire to appear "green."

Table 17.1 Finland's EV, HEV, Plug-In Hybrid Electric Vehicle (PHEV), and Fuel Cell Vehicle (FCV) Fleet Totals and Sales.

Fleet totals as of December 31, 2012					
Vehicle type	EVs	HEVs	PHEVs	FCVs	Total fleet
Motorbikes	14	0	0	0	14
Passenger vehicles	81	2,500	128		2,709
Buses	1	n/a	n/a	n/a	1
Total sales during 2012					
Vehicle type	EVs	HEVs	PHEVs	FCVs	Total sales
Motorbikes	14	0	0	0	0
Passenger vehicles	51	1,365	128		1,544
Buses	1	n/a	n/a	n/a	1

* Total fleet numbers include all propulsion systems and fuels (e.g., gasoline, diesel, liquefied petroleum gas [LPG], natural gas, biofuels).

17.3 EV supply equipment (EVSE) or charging infrastructure

Finland is the world’s northernmost industrialized nation, and its Nordic climate necessitates preheating of vehicles (see Fig. 17.2). There are about one million block heaters in Finland that are used for engine preheating that can also be used for Level 2 EV charging (240 V). There are also about 40–50 public EV slow-charging stations (120 V) around the country, and two direct current (DC) fast charging stations opened in 2012.

Fig. 17.2 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. Lock Heater Pole (left) and View from the Car Parking Area of a Row House Condominium (right).

Plans are underway to increase EVSE numbers and strengthen the existing charging infrastructure. Table 17.2 lists Finland’s current EVSE. A consortium made up of ABC traffic stations, Fortum, and Nissan announced its plan for up to 20 new fast-charging stations. Some cities have announced their plans to build slow-charging stations: Helsinki has plans for 100, and Vantaa has plans for 70–80.

Table 17.2 EVSE in Finland as of December 31, 2012.

Type of Public EVSE	Number
DC fast charging	2
Level 2/standard AC	~1–1.5 million (including block heaters)
Number of fueling locations for FCVs	2

17.4 EV demonstration projects

There are five big demonstration projects within the EVE (described in section 17.1) to develop new EV-related businesses.

Electric Traffic: Helsinki test bed (www.electrictraffic.fi)

Traffic solutions for large cities are the most promising area for EVs in Finland; an example is Helsinki (see Fig. 17.3). In the Electric Traffic project, participants from the greater Helsinki area, together with dozens of companies, are developing test environments for electric public transport and private motoring. The consortium is developing an urban structure, infrastructure, and services that are favorable to and compatible with EVs. Technologies are developed on the basis of user experiences with the design goal of achieving a pleasant and functional urban environment. The aim is to create conditions that enable a speedy increase in the number of EVs in Finland.

Fig. 17.3 Helsinki drivers tested EVs in cold temperatures that reached –20°C. (Image courtesy of Tekes.)

EUL: EcoUrban Living (www.eco-urbanliving.com)

The EUL project is a development platform for new urban development and electromobility-related technologies. The goals of the EUL Initiative are to conduct research on, test, and demonstrate the features and functionality of fully electric vehicles and the economic feasibility of related components, including various charging solutions. The initiative operates on an open platform, allowing for the development and use of all types of equipment and services. Espoo, the second largest city in Finland, is the location for the demonstration project. The key partners are Valmet Automotive, Aalto University, Hanken, and Lappeenranta University of the Technology and Technical Research Centre of Finland VTT.

ECV: Electric Commercial Vehicles (www.ecv.fi)

The electrification of vehicles and mobile machinery offers great opportunities for reducing noise and air pollution. The ECV consortium provides a world-class research and development network, as well as a platform for the development of a wide range of electric commercial vehicles and their powertrains and key components. ECV offers a comprehensive approach that focuses on components through demonstration platforms, laboratories, and fleet tests. Finnish companies have a strong foothold in the manufacturing of electric mining machinery, forklifts, and buses, among other areas.

EVELINA: Countrywide testing facility (www.evelina.fi)

The EVELINA consortium is developing a countrywide testing environment to collect information about EV functionality and the user experience under varying conditions. The project also investigates the impact of electric traffic on energy distribution and other topics. Other goals are to improve the maintenance and service infrastructure for EVs and to develop testing services.

WintEVE: Arctic testing facilities (www.winteve.fi)

The WintEVE consortium concentrates specifically on the development and testing of EV systems and services designed for winter conditions. Finland’s Nordic climate is the ideal place to test EVs in winter conditions. Temperatures can drop to –30°C in northern Finland where snow covers the ground for up to six months of the year. Dozens of car manufacturers test their vehicles in Finland because equipment tested in the extreme Nordic climate functions well in most other operational environments and climates.

18

France

18.1 Major developments during 2012

As it did in many other European countries, the automotive industry in France struggled to overcome weak sales in 2012. To aid in its recovery, the Minister of Productive Recovery, Arnaud Montebourg, presented an automotive industry support plan on July 25, 2012. The government views the French automotive industry's development of cleaner internal combustion engine (ICE) vehicles, hybrid electric vehicles (HEVs), and electric vehicles (EVs) as being integral to its recovery. In the plan, the French government increases subsidies for HEVs and EVs through the following measures.

Evolution of the bonus-malus system

Purchase incentives for low-CO_2-emitting vehicles have been reinforced. In 2012, the government modified the existing annual eco-label for the average CO_2 emissions of passenger cars on new vehicles based on a bonus-malus (tax-deduction/tax-penalty) system that favors low-CO_2-emission vehicles.

A premium is granted for the purchase of a new car when its emissions are 105 g CO_2/km or less. The maximum premium is €7,000 (US $7,000) (for 20 g CO_2/km or less). An additional bonus of €200 (US $265) is granted when a car that is at least 15 years old is scrapped and the new car that is purchased emits a maximum of 105 g CO_2/km. A malus (penalty) is payable for the purchase of a car when its emissions exceed 135 g CO_2/km. The maximum tax amounts to €6,000 (US $7,962) (for emissions of more than 200 g/km). In addition to this one-off malus, cars emitting more than 190 g CO_2/km pay a yearly tax of €160 (US $212).

Tax exemptions are given for company cars:

- Total tax exemption for EVs and plug-in HEVs (PHEVs): Vehicles emitting less than 50 g CO_2/km, EVs, and plug-in hybrids like the Toyota Prius PHEV or Opel Ampera are exempt from tax.
- Partial tax exemption for HEVs: Hybrid vehicles emitting less than 110 g CO_2/km are exempt for the first two years after purchase.

Government commitment to purchase HEVs and EVs for fleets

In 2012, the national government agreed that 25% of the cars it buys should be hybrid or electric; this represents 1,500 vehicles per year. One commitment objective is to convince local governments to follow the national approach, which would result in a total of 11,000 HEVs or EVs purchased per year. Charging spots will also be installed in the ministries and public administration parking locations.

Continuation of the program Investment for the Future

A new call for projects from the Investment for the Future program dedicated to vehicle research will be launched in 2013.

18.2 HEVs, PHEVs, and EVs on the road

At the end of 2012, more than a dozen EV models (both electric and hybrid rechargeable vehicles) were commercially available in France. It is estimated that 28,000 electricity-consuming vehicles are on the road, of which 10,000 are entirely EVs. The increase in the number of EVs on French roads is mostly due to the use of the Bolloré Bluecar in the Autolib car-sharing service in Paris.

EV sales

In 2012, sales of passenger EVs totaled 5,659 units, which was more than twice the number of 2011 EV units. Fig. 18.1 compares 2011 and 2012 EV sales on a month-by-month basis. The Bolloré Bluecar sold the best, with 1,543 new sales/registrations. The Peugeot iOn and Citroen C-Zero had sales/registrations at 1,409 and 1,335, respectively, but this success was mostly due to the promotion by PSA Peugeot Citroën, which offered purchase prices below the market sales price during the summer of 2012. Despite intensive marketing, only 522 sales/registrations were recorded for the Nissan Leaf in 2012; however, that number still represented five times more than the amount in 2011. The Renault Fluence ZE had 295 sales/registrations. The arrival of the Renault Zoe ZE in 2013 should boost EV sales for the manufacturer. To complete its range of electric cars, Renault decided not to settle for conventional EVs, but to target a new approach in transportation with the launch of Twizy (Fig. 18.2) on the roads.

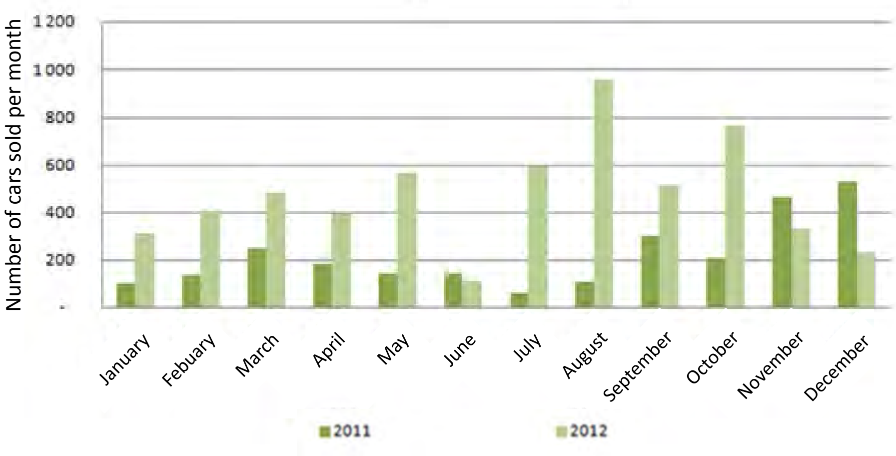

Fig. 18.1 Monthly comparison of sales of electric passenger cars in 2011 and 2012. (Image courtesy of www.avem.fr.)

Fig. 18.2 Renault Twizy. (Image courtesy of Renault.)

HEV sales

The arrival of new vehicle models combined with the environmental bonus increase described in Section 18.1 allowed HEV sales to double those of the previous year. Fig. 18.3 depicts HEV sales in France during 2012. Some details on the 2012 sales are listed as follows:

- A total of 27,730 hybrid cars were registered in France in 2012, which was an increase of 107% over the number in 2011.

- First in HEV sales in 2012 was the Toyota Yaris HSD, with 4,418 new registrations and a 16% market share despite its late entry into the market. It emits less than 85 g CO_2/km. In second place was the diesel-hybrid version of the Peugeot 3008, with a 15% market share. It emits 99 g CO_2/km. In third place was the Toyota Auris hybrid, with a 14% market share. It emits less than 93 g CO_2/km.

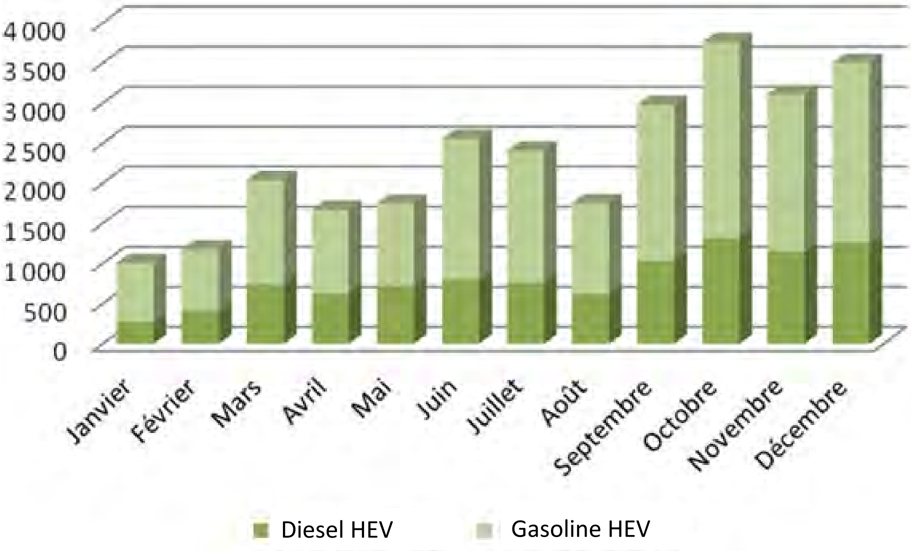

Fig. 18.3 Evolution of sales of diesel and gasoline hybrids in France in 2012. (Image courtesy of www.avem.fr.)

PHEV sales

A total of 666 PHEVs were registered in 2012; they represented about 2.4% of the hybrid market (Table 18.1). The French PHEV market is still emerging, and PHEV models are rare and expensive compared with ICE vehicles. In 2012, the Toyota Prius led this PHEV micro-segment, with 413 registrations; it was followed by the Opel Ampera, with 190 registrations, and the Chevrolet Volt, with 42 registrations.

Table 18.1 EV, HEV, PHEV, and FCV Sales in France for 2012.

Total sales during 2012					
Vehicle type	EV sales	+HEV sales	PHEV sales	FCV sales	Total sales
Passenger vehicles	5,663	27,730	666		34,059
Plug-in vehicle models available (passenger only)	Untaxed, unsubsidized price of vehicle model				
Mitsubishi I-MiEV	€ 29,500				
Nissan Leaf	€ 32,990				
Venturi Retish	€ 358,800				
Bolloré Bluecar	€ 19,000	+ €80/month for battery			
Citroën C-zero	€ 29,500				
Mia Electric	€ 19,900				
Peugeot iOn	€ 29,500				
Renault Fluence ZE	€ 26,900	+ €82/month for battery			
Renault Kangoo ZE	€ 26,300	+ €86/month for battery			
Renault Zoe ZE	€ 20,700	+ €79/month for battery			
Smart Fortwo Electric Drive	€ 24,500				
Tesla Roadster	€ 120,000				
Toyota Prius PHV	€ 37,000				
Opel Ampera	€ 43,900				
Chevrolet Volt	€ 43,500				
Fisker Karma	€ 102,300				

18.3 EVSE (EV supply equipment), or charging infrastructure

Charging infrastructure is essential for EV deployment, and it is supported with €50 million (US $66.4 million) in funding through the national Investment for the Future program. First, the Minister of Productive Recovery announced a new mission to organize EVSE installations in large cities. Additionally, large-scale charging infrastructure deployment projects in areas with more than 200,000 inhabitants can now be supported by the ADEME-managed call for projects on charging infrastructure deployment. Lastly, the group GIREVE (Group for Roaming of EV Charging) — which combines ERDF, the Caisse des Dépôts et Consignations, PSA, and Renault — signed an agreement to harmonize the mapping of charging spots.

At the end of 2012, there were 749 charging stations in France; they represented 2,561 charging spots (an average of three to four plugs per station), of which 5.6% (42 stations) were fast charging stations (Table 18.2). Figs. 18.4 and 18.5 show the types of locations used for EVSE and their geographic distribution across France.

Table 18.2 EVSE in France for 2012.

Number of charging spots installed as of December 31, 2012 (749 charging stations; each has multiple charging spots)	
DC fast charging	143
Level2/standard AC	2,418
Fuel cell vehicles fueling locations	3
Total	2,564

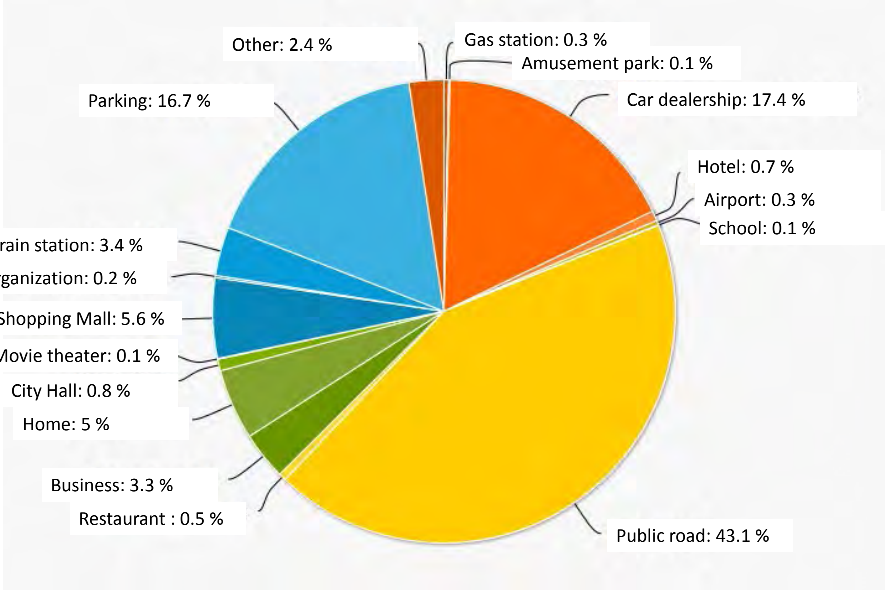

Fig. 18.4 Locations for charging spots. (Image courtesy of Chargemap.)

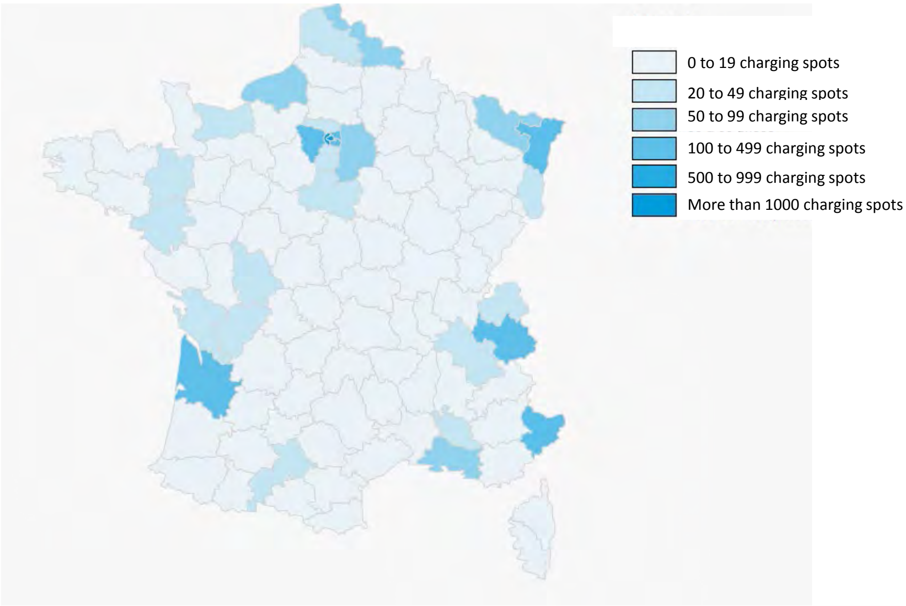

Fig. 18.5 Regional distribution of charging spots. (Image courtesy of Chargemap.)

18.4 EV charging infrastructure demonstration projects

Eight major charging infrastructure demonstration projects (see Table 18.3) have been funded since 2012 through the Investment for the Future program, which has a total budget of €54 million (US $70 million), with these objectives:

- Validate France's ability to adapt to and operate within the recharging infrastructure at both the national and cross-border levels.
- Test the safety, reliability, and robustness of charging solutions under real-world conditions.
- Test intelligent-infrastructure solutions for communicating data between a vehicle, the charging spot, and the user.
- Validate business models for possible deployment in different spheres (business, home, public domain).

Table 18.3 Description of EVSE projects.

EVSE Demonstration Projects	
1.	CROME: Introduce public-interoperable charging stations to ensure cross-border compatibility between the French and German CROME area.
2.	Eco2charge: Develop intelligent energy management solutions for EV charging systems that aim to minimize changes in the electrical infrastructure of the site and the network, so that a variety of EVSE brands and features are supported.
3.	Ever: Demonstrate the economic viability of an infrastructure for car-sharing applications composed of slow and fast charge spots with energy storage systems, while ensuring a supply of carbon-free electricity (predictive management, local storage, contracts with operators).
4.	InfiniDrive: Design and test an intelligent EV charging system that will be suitable for the mass conversion of fleets to EVs by considering the operating constraints and profitability of fleet operators.
5.	Mov'eo Treve: Develop a technical reference system based on the open-label EV READY (defined by Renault and Schneider Electric); it may be used to define proposals for likely regulatory changes.
6.	Telewatt: Implement "plug and play" charging points that are based on the existing public lighting network and will thus reduce the amount of installation work needed.
7.	Vert: Install charging stations powered by autonomous photovoltaic generators at client sites (companies, communities, and individuals). Test additional charging spots at fuel service stations connected to the grid. A fleet of 18 EVs (15 Kangoo and 3 Fluence EVs) will be provided by Renault for this purpose.
8.	Eguise: Develop a charging infrastructure based on existing solutions that are compatible with vehicles available on the market, then develop and add innovations to it (e.g., charging by induction and bidirectional exchange of energy between vehicles and infrastructure).

19

Germany

19.1 Major developments during 2012

The German government announced plans to introduce more electric vehicles (EVs) into the public vehicle fleet during 2012. EVs are part of a mix of transport options aimed at reaching a target of at least 10% of all purchased or rented public vehicles having emission levels of less than 50 grams of carbon dioxide per kilometer (g CO_2/km).

The taxation on company passenger cars that are also privately used is expected to change in 2013, with the cars being taxed on their value minus the value of their batteries. In addition, the government plans to exempt EVs from parking fees and to establish dedicated EV driving lanes. EVs will need to be clearly labeled as such for identification purposes. Work on these additional benefits is still ongoing. However, some individual cities like Stuttgart have already introduced local measures for public parking places without fees to promote the use of EVs.

Changes in legislation

On October 25, 2012, the German Parliament enacted these EV-related tax exemptions:

1. The tax exemption of (pure) EVs licensed before December 31, 2015, was extended for 10 years (previously it had been 5 years).
2. This exemption was extended to all battery EV classes.
3. (Pure) EVs licensed between January 1, 2016, and December 31, 2020, will be granted 5 years of tax exemption.

No tax reduction or exemption is planned for other alternative powertrains or fuels, such as hybrid electric vehicles (HEVs), biofuel vehicles, or bivalent natural gas vehicles. They will be treated similarly to vehicles with conventional internal combustion engine (ICE) powertrains for tax purposes. The typical annual vehicle tax for a Volkswagen Golf VII car is about €50 (US $65) for a traditional ICE vehicle and €190 (US $249) for a compression ignition powertrain.

The German National Platform for Electric Mobility (NPE) published its third report on July 20, 2012. The report stated that Germany is on the right track to become a leading provider of electromobility solutions and establish a well-functioning market by 2020. Four federal ministries that were involved in NPE presented the report at a joint press conference. The report is available for downloading in German and English at www.bmwi.de.

19.2 HEVs, PHEVs, and EVs on the road

Table 19.1 lists German fleet sizes for 2012.

Table 19.1 Vehicles in Germany as of December 31, 2012 (Registered Vehicles) .

Vehicle Type	Total Vehicle Fleet	HEVs	PHEVs	BEVs	FCVs
Motorbike (without e-bikes)	3,982,978	281	0	4,652	67
Passenger Vehicle	43,431,124	64,652	389	7,114	177
Bus	76,023	202	0	96	14
Truck	2,578,567	149	0	2,389	3
Other	2,322,320	207	0	710	16
Totals	52,391,012	65,491	389	14,961	277

Note: PHEVs have been counted as their own category since 2012. Before 2012, PHEVs were included within the number of HEVs (estimated 1,000 cars).

19.3 Demonstration Projects and Industry Developments

On April 3, 2012, the German government nominated four regions as showcases for electromobility. About 150 projects will be funded at levels of up to €67 million (US $87 million) by the Federal Ministry of Economics and Technology within the next three years. The four regions — Baden-Wuerttemberg, Berlin/Brandenburg, Lower Saxony, and Bavaria — will host these projects. The emphasis will be on testing and demonstrating electromobility in everyday life, with a special focus on linking EVs and the electricity system by using information and communication technology (ICT) in the transport system. To complete these projects, numerous small and medium-sized enterprises will join forces with industry, research establishments, and public authorities.

CAR2GO

Daimler’s Stuttgart-based car2go, an on-demand car-sharing company, began operation on November 29, 2012, with its 300 Smart ED (for electric drive) cars (Fig. 19.1); car2go has the largest fleet of electric cars operating in Germany. In March 2013, the number of vehicles in the fleet increased to 400, and plans are to increase the number to 500 by the end of 2013. Included in this very flexible car-sharing rental scheme are 500 charging stations. At the stations, customers can rent a Smart ED car and then drop it off or leave it any place within the 75km^2 project region. There were about 12,500 car2go users in the Stuttgart region as of March 2013.

Currently, there are 18 cities worldwide operating in the car2go scheme. Three of them (Stuttgart, Amsterdam, and San Diego) are equipped exclusively with EVs. In these three cities alone, more than 4.5 million km (2,796,170 mi) were driven by car2go customers. Daimler plans to expand its car-sharing scheme to more than 50 cities. More information is available on www.car2go.com.

Fig. 19.1 Smart EV Car in car2go scheme in Stuttgart (Image courtesy of Daimler.)

HIRIKO CITYCARS

The German railway operator Deutsche Bahn AG formed a collaborative agreement with Hiriko Citycars in October 2012. The "citycar" concept was developed in January 2010 through a collaboration with the Massachusetts Institute of Technology (MIT); the collaborators had a clear vision of transforming and regenerating the industrial grid in the Alava, Spain (in the Basque Country region).

The "foldable" electric car (Fig. 19.2) will be tested in 2013 in Berlin. The plan is to include Hiriko Citycars EVs in the Deutsche Bahn car-sharing fleet beginning in 2014.

Fig. 19.2 Hiriko Citycars “folding” EV will be tested and adapted for public use in Berlin. (Image courtesy of Hiriko.)

E-MOBIL WUPPERTAL PROJECT

The E-Mobil Wuppertal project (Fig. 19.3) has shown how public awareness campaigns can successfully mobilize people to invest in innovative technologies. Through a regional campaign that involved social media and test drives, the project motivated people to achieve a significant goal — licensing of 100 new electric cars — in a very short time period (less than five months) without any financial support. The newly purchased EVs were demonstrated during a public event on October 27, 2012. The majority of electric cars were purchased by companies such as Wuppertal Municipality Works, Autohaus Eylert Ltd., Proviel Ltd., and Villamedia; the remaining cars were purchased by individuals in the private sector.

Fig. 19.3 Wuppertal was named the capital of electromobility by Wuppertalaktiv. (Image courtesy of Wuppertalaktiv.)

VOLKSWAGEN (VW) BATTERY PRODUCTION

VW started to produce batteries in its Braunschweig facility. The annual production capacity is 11,000 units; these are initially being used for small vehicles (e.g., the VW EUp!). The goal is to also produce the Golf EV in this facility in the future.

BMW AND TOYOTA COOPERATION

Two vehicle manufacturers, BMW and Toyota, agreed to work together on several research topics, including next-generation battery cells, fuel cell systems, and the development of a new sports car. The current plan is not to establish a joint venture but rather to develop a good working partnership for developing relevant technologies.

20

The Republic of Ireland

20.1 Major developments during 2012

The Sustainable Energy Authority in Ireland (SEAI), together with the Department of Arts, Heritage and the Gaeltacht, began a project to develop technologies and methods for using electric vehicles (EVs) to store large amounts of wind (or ocean) energy that could potentially be available to the Aran Islands. In this way, a higher proportion of wind/ocean power could be used in a future energy system for the islands, which could reduce imports of energy to the islands and also serve as a blueprint for a similar system that could serve the island of Ireland (Fig. 20.1). In year one of the Aran Island EV Trial, 18.5% of the electricity supplied to EVs came from wind power. There is a national requirement that biofuels make up 6% of transport fuels in 2013. Therefore, an EV plugged in and charging using nighttime electricity in Ireland will contain a significantly higher percentage of renewable energy than a comparable biofuel-powered vehicle. (www.seai.ie)

Fig. 20.1 For an island with a high wind-energy resource like Ireland, EVs are viewed as a demand control mechanism that will help the grid operator manage future high levels of intermittent wind power. (Image courtesy of ESB.)

Following Nissan's launch in 2011, Renault launched its range of EVs in the Irish market in 2012; this helped to increase the number of passenger (M1) EVs and light commercial (N1) EVs sold from 46 in 2011 to 188 in 2012.

Infrastructure

- M2C (www.m2c.ie) and Carra (www.carra.ie) developed a low-cost EV charging system with built-in maintenance diagnostics and wireless telemetry functions. It is suitable for apartment and/or domestic applications (Fig. 20.2).

- EveoSolutions (www.eveosolutions.ie) has supplied a number of street charging systems to ESB, Ireland's main electricity distribution system operator (DSO), with intelligent maintenance technologies.
- JTM Power (www.jtmpower.ie) has developed a portable emergency rescue charging unit that is lithium-powered.

Fig. 20.2 M2C's Domestic Smart Charger Unit with Wireless Telemetry (left) and Carra's EV Hub System (right). (The hub system can use text messaging or an application on a web browser or smart phone to control an EV charger, such as M2C's model.)

Vehicle CO_2 emissions taxation policy

CO_2-related vehicle taxes were introduced in 2008, and together with vehicle labeling, they have proved to be a highly successful mechanism for reducing emissions from new vehicles. The taxes and labels led consumers to choose lower-emission vehicles and have resulted in a significant drop in government revenues. To address this loss while maintaining the positive effect on consumer choice, a consultation was held on revising the CO_2-related vehicle registration tax (VRT) and annual motor tax bands. For example, the proposed revision would provide four new bands within the A Band (which covers the vehicles with the lowest emissions), with A0 covering vehicles at 0 g CO_2/km emissions (€120 [US $155] per year motor tax) and A4 being for <120 g CO_2/km (€200 [US $259] per year). This would enable a clearer recognition of EV performance with respect to tailpipe emissions.

Table 20.1 provides a list of the incentives being offered for the EVs in Ireland.

Table 20.1 Ireland’s Policy Instruments for PHEVs and EVs

Policy Instrument	Details
EV grant scheme	A grant of up to €5,000 (US $6,470) is available for passenger (M1) EVs and light commercial (N1) EVs from the Sustainable Energy Authority of Ireland. The grant is available for both biofuel EVs (BEVs) and plug-in EVs (PHEVs).
Vehicle registration tax relief	VRT relief of up to €5,000 (US $6,470) for BEVs and up to €2,500 (US $3,235) for PHEVs is available. HEVs are entitled to VRT relief of up to €1,500 (US $1,941).
Accelerated capital allowances	Accelerated capital allowances are available for EVs and HEVs. They allow a company to reduce its taxable income by the full value of the vehicle capital cost in the first year rather than spread it across the usual eight-year period.

20.2 HEVs, PHEVs, and EVs on the road

Table 20.2 contains data on the number of vehicles and sales in 2012.

Table 20.2 Fleet and Sales Totals in Ireland.

	Fleet Totals as of December 31, 2013				
Vehicle Type	**EV Fleet**	**HEV Fleet**	**PHEV Fleet**	**FC Fleet**	**Total Fleet**
Bicycles (no driver license)	n/a	n/a	0	0	n/a
Motorbikes	62	0	0	0	35,106
Passenger vehicles	260	6,766	0	0	1,963,447
Multipurpose passenger vehicles	54	10	0	0	291,798
Buses	0	0	0	0	9,927
Trucks	0	0	0	0	27,781
Industrial vehicles	32	5	0	0	75,164
Total	408	6,781	0	0	2,403,223
	Annual Vehicle Sales as of End of December 2012				
Vehicle Type	**EV Sales**	**HEV Sales**	**PHEV Sales**	**FC Sales**	**Total Sales**
Bicycles (no driver license)	n/a	n/a	0	0	n/a
Motorbikes	1	0	0	0	955
Passenger vehicles	153	762	0	0	80,574
Multipurpose passenger vehicles	19	6	0	0	10,867
Buses	0	0	0	0	292
Trucks	0	0	0	0	n/a
Industrial vehicles	0	1	0	0	2,405
Total	408	6,781	0	0	95,093
Note: Data taken from draft National Vehicle Bulletin 2012 produced on 01/05/2012.					

20.3 EVSE (EV supply equipment), or charging infrastructure

ESB is the single DSO. ESB Ecars was established to promote the use of EVs and to select, deploy, and manage an appropriate nationwide EV charging infrastructure.

Total EVSE as of December 2013

- 30 fast chargers (43–50 kW) DC installed on interurban routes,
- 530 public charge (22 kW) AC points installed that cover 90% of major towns and cities, and
- 570 domestic chargers (3.6–7.2 kW) AC installed.

In April 2012, ESB ecars, together with the Tourism Board, also launched the Great Hotel Drive, which placed 74 EV charge points in hotels around the country.

20.4 EV demonstration projects

ESB ecars is recruiting members of the general public to become ecar ambassadors and trial-run electric cars for up to a year in an initiative called The Great Electric Drive (Fig. 20.3). The research from this trial is providing ESB ecars with important information about driving trends, charging patterns, and consumer attitudes on electric motoring. The trial is also extremely important in testing the infrastructure and gaining a better understanding of the characteristics of electric cars.

Fig. 20.3 The Great Electric Drive received 12,000 applications from citizens seeking to become "EV Ambassadors." Vehicles used in the trial include plug-in models from Renault, Nissan, and Mitsubishi. (Image courtesy of ESB.)

An Electric Taxi (Nissan Leaf) Trial in Dublin (Fig. 20.4) has covered 55,000 km since its launch in 2011, saving €6,500 (US \$8,412) and avoiding the release of more than four tons of CO_2 while delivering 3,000 passengers to their destinations.

Fig. 20.4 Dublin taxi driver Padraig Daly and his Nissan Leaf electric car. (Image by Patrick Bolger Photography.)

21

Italy

21.1 Major developments during 2012

In 2012, a national policy for the introduction of cleaner vehicles, including purchase incentives and charging infrastructure establishment, was formally enacted as part of a governmental law aimed at promoting the economic growth of the nation. The approved law specifically addresses sustainable development in three related ways: (1) build-up of a national charging infrastructure for any type of electrically propelled vehicle; (2) demonstration and diffusion of low-emission public and private vehicle fleets, mainly for use in urban areas; and (3) purchase subsidies for electric vehicles (EVs) and hybrid electric vehicles (HEVs) (any type). The purchase subsidies (in some cases, also with scrappage of old vehicles) are strictly related to the measured CO_2 emission based on homologation measurements. Table 21.1 summarizes details of the purchase incentives schemes.

The approved law also aims to create a set of clear and simplified rules, with which local authorities can agree, to promote the public and private installation of EV charging points. These rules will have a substantial impact on legislation, already under revision, for the installation of new electricity meters and charging points at homes and in public spaces. Total public funding of 120 M€ (US$ 160 million) will be available from 2013 up to 2015 (http://www.bec.mise.gov.it/site/bec/home.html).

Table 21.1 Italy's purchase incentives

Policy Instrument	Details
Governmental purchase incentives	Purchase contribution up to 20% of retail price (max €5,000, or US$ 6,500) for new vehicles with CO_2 emissions lower than 50 g/km, directly rebated at a retail shop. The incentive declines with emissions up to 120 CO_2 g/km and is mostly aimed at public service fleets (70% of the overall fund), with mandatory scrappage of an old vehicle within the same category as the purchased vehicle. The vehicles subsidized must use alternative fuels: electricity, natural gas, liquefied petroleum gas (LPG), biofuels, and hydrogen. The vehicle categories entitled to be subsidized are two- and three-wheeled motorbikes and mopeds, quadricycles, commercial vans, and passenger cars.

In the area of EV research, a large number of national and EU (European Union)-funded projects involving Italian industries and research organizations reached interesting results in 2012. These projects covered EV technologies from components research and development (batteries, innovative drivetrains, up to complete vehicles in various configurations, including battery-powered EVs and plug-in HEVs). Fig. 21.1 shows the second-generation parallel hybrid Industrial Vehicles Corporation (IVECO) Daily van, under development and demonstration in the European project Hybrid Commercial Vehicles (HCV) (http://www.hcv-project.eu).

Fig. 21.1 Hybrid IVECO Daily van.

Large and small national EV manufacturers have also announced new electric products in various categories (buses, passenger cars, commercial vans, two-wheel motorbikes and mopeds, and quadricycles). FIAT showcased the new electric compact car 500e, launching in the United States in 2013. Birò has increased its sell list with two new products—the quadricycle shown in Fig. 21.2 and a Ducati Energia Free Duck quadricycle shown in Fig. 21.3, which has been largely purchased by the Italian Post for its delivery fleet.

Fig. 21.2 Electric quadricycle Birò.

Fig. 21.3 Ducati Energia Free Duck quadricycle for the Italian Post delivery.

The general economic crisis, together with customer expectation for governmental subsidies, has had a strong impact on the overall national vehicle market. Small and medium enterprises involved in EV and HEV production and commercialization have also been affected, forcing some to reduce employment and others to close.

21.2 HEVs, PHEVs, and EVs on the road

The Italian vehicle market declined sharply in 2012: overall passenger car sales declined about 20% (the highest reduction in 20 years) with respect to 2011. Conversely, cleaner passenger car shares (natural gas vehicle [NGV], LPG, EV, and HEV) have increased from 30% to 130%; in 2012, these categories amounted, in total, to less than 15%.

HEV/PHEV/EV sales during 2012 increased because of larger market availability; availability at large car companies; municipal limitations for conventional car circulation in urban areas; the slight increase in the number of charging points; increased public consciousness (more information, more advertisement from car companies, and more pro-activity from local and governmental authorities); and sensitivity to environmental aspects, as demonstrated by a Deloitte study (http://www.deloitte.com/view/it_IT/it/servizi/consulting/1691793e828cd210VgnVCM3000001c56f00aRCRD.htm)

Statistics for the total vehicle fleet in Italy reported in Table 21.2 were only estimated for 2011. The data for EVs and HEVs on overall fleets were extrapolations done with CEICIVES (Italian EV Association), based mostly on interviews of manufacturers and importers in the last 12 years.

Table 21.2 Fleet Totals for Italy per December 31, 2011, and 2012 Total Sales.

Fleet totals per 31 December 31 2011 (or January 2012)					
Vehicle type	EV fleet	HEV fleet	PHEV fleet	FCV fleet	Total fleet
Bicycles (no driver license)	200,000				32,000,000
Motorbikes	35,670				8,816,126
Quadricycles	5,305				Included in motorbike total
Passenger vehicles	3,378	27,665			37,113,300
Multipurpose passenger vehicles	8,490				671,445
Buses	1,025	325			100,438
Trucks					4,022,129
Total sales during 2012					
Vehicle type	**EV sales**	**HEV sales**	**PHEV sales**	**FCV sales**	**Total sales**
Bicycles (no driver license)	60,000				1,650,000
Motorbikes	1,230				206,422
Quadricycles	2,745				Included in motorbikes
Passenger vehicles	520	6,774			1,410,824
Multipurpose passenger vehicles	260				116,742
Buses	75	25			2,131
Trucks					19,474

21.3 EVSE (EV supply equipment), or charging infrastructure

Italy has 1,350 Level 2/standard AC normal charging points (640 in public areas and about 710 in private ones). Only a few are the DC fast-charging type, and through 2012, all of these were private charging points for demonstration purposes.

EVSE plans related to running demonstration projects for 2013 may increase the count beyond the current total by about 30% to 40% (CIVES estimates). The National Charging Infrastructure Plan, which is under revision and approval, will give clear directions, guidelines, and concerted agreements with local authorities, which could substantially support this expansion. Table 21.3 gives the number of public EVSE installed as of December 31, 2012. Existing charging stations also can have multiple charging points; current statistics do not clearly distinguish between EVSE and charging points (http://www.colonnineelettriche.it/) (http://www.veicolielettrici-news.it/mappa-delle-colonnine-di-ricarica/).

Table 21.3 Number of public EVSE installed as of December 31, 2012.

Level 2/standard AC	1350
DC fast charging	3
Fueling locations for fuel cell vehicles	2

In 2013, Nissan installed the first public fast-charging station in a refuelling station on the expressway near Milan (Fig. 21.4).

Fig. 21.4 First public fast-charging station in Italy (March 2013). (Image courtesy of Nissan.)

22

The Netherlands

22.1 Major developments during 2012

For the Dutch government, electro-mobility is an intrinsic part of the transition to a truly sustainable energy system that it would like to achieve around 2050. Industry also offers many possibilities for enterprising individuals and companies to produce and market goods and services to attract consumers. By 2015, the Dutch government wants to have demonstrated that electro-mobility is a valid transport choice in specific markets.

Charging infrastructure in the Netherlands more than doubled during 2012. At the end of 2011, there were 1,265 public charging points (of which 15 were fast-charging); at the end of 2012, the number had increased to 2,782 (of which 63 were fast-charging). The association eViolin was founded by charging point operators and charging infrastructure service providers. eViolin supports an open market where parties work together to guarantee interoperability and make eroaming affordable. The pilot of E-laad ("E-load") for the installation of public charging infrastructure ended successfully with 2,500 charging points installed as shown in Fig. 22.1.

Fig. 22.1 E-laad uses an open charge point protocol (OCPP), which is an open protocol between charging stations and a central management system. The protocol started as an initiative from E-Laad foundation in the Netherlands, aiming to create an open communication standard that would allow charging stations and central systems from different vendors to easily communicate with each other.

Going forward, installation of charging points in public areas will be more market-driven. The government, along with several market parties, is researching various business options for public charging infrastructure, and a “Green Deal” is being prepared. The policy tool called a “Green Deal” enables the Dutch government, business, and civil society organizations cooperate to address barriers to sustainable initiatives, such as laws and regulations (http://www.government.nl/issues/energy/green-deal).

The Netherlands focuses on specific market segments where electro-mobility seems promising. These are “heavy user” segments like logistics and distribution; company vehicles; businesses and commuting; and public transportation, including taxis. The Zero Emission Bus Transport Foundation (where public and private parties cooperate) was created to specifically stimulate electrified buses for public transport. They arrange pilot projects and investigate the impact of Dutch concession rules on the deployment of electric buses. Interim results on the Dutch pilot projects on electro-mobility in various market segments were presented in early 2012. Car2Go runs a successful car-sharing project with more than 300 electric Smarts in Amsterdam. A subsidy scheme was introduced to stimulate electric taxis and small vans (Table 22.1).

Six specific Dutch focus areas on electro-mobility have implemented Green Deals with the Dutch government. Electro-mobility is stimulated in these focus areas in various ways, such as free parking for electric vehicles (EVs) and/or subsidy schemes. In total the Dutch government has concluded 16 EV-related Green Deals, ranging from the design of a new sustainable urban vehicle to supporting the innovative power of small companies.

Table 22.1 Summary of the Netherlands' policy instruments for electro-mobility.

Policy Instrument	Details
Subsidy scheme for low-emission taxis and vans	As of October 1, 2012, a subsidy of €3,000 (US$4,000) for battery electric vehicles (BEVs) is given. If living in the cities of Amsterdam, Arnhem, The Hague, Rotterdam, or Utrecht—or cities adjacent to these cities—an extra subsidy of €2,000 (US$2,600) is given for a BEV (to address specific urban sites for improved air quality).
Innovation vouchers electro-mobility	As of January 1, 2013, small- to medium-sized businesses are encouraged to make better use of existing knowledge of electro-mobility at universities and research institutes. For a maximum of €5,000 (US$6,500) a small- to medium-sized business can pose a research question to a university or research institute to answer in the field of electro-mobility.
Exemption of registration tax	Electric cars are exempt from paying registration tax until 2018. This tax is paid when the car is registered. The tax depends on the vehicle's CO_2 emissions and the catalog price. The exemption for clean vehicles gives a substantial fiscal advantage that can amount from €5,000 to €8,000 (US$6,500 to $10,500) for mid-size cars.
Exemption of road tax	Electric cars are exempt from road tax until at least 2014. This tax is paid for the usage of a motor vehicle, and the amount is dependent on the type of fuel, weight of the car, and regional circumstances. For a middle class petrol car, this is €400 to €700 (US$ 520 to 900) a year.
No surcharge on income taxes for private use of company cars	In the Netherlands, private use of company cars is subject to income tax. This is done by imposing a surcharge of 14 to 25% of the catalog value on the taxable income. Electric cars that are registered before 2014 are exempt from this surcharge for a period of 60 months. This gives a tax advantage of approximately €2,000 (US$2,600) a year compared to a regular company car.
Tax-deductible investments	The Netherlands has a system of facilitating investments in clean technology that implies these investments are made partially because they are deductible from corporate and income taxes. EVs have recently been added to the list of deductible investments. The MIA-VAMIL (tax relief for entrepreneurs willing to invest in environmentally friendly equipment) provides enterprises/ventures investing in EVs and recharging stations with an advantage of up to 19% of the investment.

22.2 HEVs, PHEVs, and EVs on the road

In 2012, almost 800 fully electric passenger vehicles were sold in the Netherlands, bringing the total EV passenger car fleet to almost 2,000 fully electric passenger cars (Table 22.2). PHEVs had the highest sales in 2012, with more than 4,300 PHEVs sold. At the end of 2012, there were 4,348 PHEV passenger cars registered in the Netherlands (compared to only 17 at the end of 2011). At the same time, 88,562

HEV passenger cars were registered, which means that about 5% of the total hybrid passenger fleet was composed of PHEVs (Table 22.3). Most of the EVs are used as company or lease cars. The major reason for this success is the fiscal stimulation for EVs in the Netherlands (see Table 22.1 for Dutch financial policy instruments).

Table 22.2 EV, HEV, PHEV, and FCV fleet totals in the Netherlands Fleet totals per December 31, 2012.

Vehicle type	EV fleet	HEV fleet	PHEV fleet	FCV fleet	Total fleet
Bicycle (no driver license)	767,748-1,017,748[c]	–[d]	–	–	19,573,000[g]
Motorbikes	99	NA[e]	–	–	712,000
Quadricycles[a]	469	NA	–	–	NA
Passenger vehicles	1,910	88,562	4,348	1	8,100,000
Multipurpose passenger vehicles	Included in passenger vehicles				
Commercial cars/ vans (< 3.5 tons)	494	NA	–	1	900,000
Buses for public transportation[b]	67	65	–	2	5,100
Trucks	23	NA	NA	–	140,000
Industrial vehicles	21	NA	–	–	65,000

a Total of three-wheeled vehicles (one-third) and L7e (two-thirds).

b Including trolley buses.

c Including 17,748 electric scooters (no driver license needed).

d A dash indicates a zero quantity.

e NA = not applicable.

f FCV = fuel cell vehicle.

g Including 573,000 electric scooters (no driver license needed).

(Sources: RDW, CBS, RAI/BOVAG, Agentschap NL)

Table 22.3 EV, HEV, PHEV, and FCV registrations and sales in the Netherlands during 2012.

Vehicle type	EV	HEV	PHEV	FCV	Total registrations/ sales
Bicycle (no driver license)	174,437[a]	–[b]	–	–	1,039,000
Motorbikes	11	NA[c]	–	–	10,093
Quadricycles	288	NA	–	–	NA
Passenger vehicles	786	16,091	4,331	–	502,544
Multipurpose passenger vehicles	Included in passenger vehicles				
Commercial cars/vans (< 3.5 tons)	336	NA	–	–	56,568
Buses for public transportation		NA	NA	NA	NA
Trucks	NA	NA	NA	NA	12,781
Industrial vehicles	NA	NA	NA	NA	NA

a Including 3,437 electric scooters (no driver license needed).

b A dash indicates a zero quantity.

c NA = not applicable.

(Sources: RDW, CBS, RAI/BOVAG, Agentschap NL)

The data in Tables 22.2 and 22.3 are primarily based on Dutch Road Admission Authority (RDW) registered number of vehicles instead of car sales. There is a slight difference in number between these two statistics as registrations lag somewhat behind sales.

Table 22.4 gives the EV, HEV, and PHEV models offered in the Netherlands.

Table 22.4 EV, HEV, and PHEV models offered in the Netherlands.

Plug-in vehicle models available (passenger only)	Untaxed, unsubsidized price of standard vehicle model
Opel Ampera	€48,295 (US$63,220)
Chevrolet Volt	€43,695 (US$57,196)
Fisker Karma	€108,295 (US$141,758)
Toyota Prius Plug-in Hybrid	€39,645 (US$51,895)
Volvo V60 Plug-in Hybrid	€69,234 (US$90,627)

22.3 EVSE (EV supply equipment), or charging infrastructure

There has been an enormous growth of semi-public and private charging infrastructure in the Netherlands. At the end of 2012, there were 2,782 public charging points, 829 semi-public charging points, and 63 fast-charging points (Table 22.5). It is estimated that there are between 4,500 and 5,500 private charging points in the country. There are 1.7 charging points available for every plug-in EV.

Table 22.5 Number of EVSE installed in the Netherlands as of December 31, 2012[a]

Level 2/standard AC	DC fast charging
2,782	63
Fueling locations for fuel cell vehicles	
1	

[a] EV supply equipment is counted in single charging points. For example, a single charging station that can charge two cars at the same time is counted as two charging points (or two EVSE).

EV SUPPLY EQUIPMENT PLANS FOR 2013

Specific cities or regions in the Netherlands (Amsterdam, Rotterdam, Utrecht, The Hague, and the provinces of Utrecht and Brabant) have put out invitations to tender for public charging infrastructure at the end of 2012, or will do so in 2013. Several municipalities are considering teaming up to invite tenders for public infrastructure.

22.4 EV demonstration projects

Tables 22.6 and 22.7 present demonstration projects in the Netherlands. Figure 22.2 depicts one of the EV pilot projects in the Haaglanden region.

Table 22.6 Demonstration Projects in the Netherlands.[a]

Name	Location	Duration	PHEVs	BEVs	EVSE
Electric Greenwheels Carsharing in G4 by Collect Car	Amsterdam, The Hague, Rotterdam, Utrecht	Mid 2010–mid 2013	0	25	50
https://www.greenwheels.com/nl/Home/Particulieren/Home					
Electric taxis by Prestige Greencab	Utrecht	Mid 2010–mid 2013	0	18	10
http://www.prestigetaxi.nl/home/slimmer-vervoer/					
Rotterdam Tests Electric Driving by Stedin, Eneco and City of Rotterdam (electric pool cars)	Rotterdam	Mid 2010–mid 2013	15	57	108
http://rotterdamtestelektrischrijden.nl/					
Electric Garbage Trucks by Van Gansewinkel	Tilburg, Breda, Zutphen, Den Haag, Amsterdam (Schiphol), Rotterdam, Groningen, Utrecht	Mid 2010–mid 2013	0	8	8
http://www.vangansewinkel.nl/elektrisch.aspx					
Texel Hospitable Electric Driving by Urgenda	Texel	Mid 2010–mid 2013	8	20	46
http://www.urgenda.nl/icoonprojecten/texel-en-waddeneilanden/project2.php					
Elektropool Haaglanden by The Hague Development Company	Haaglanden (region around The Hague)	Mid 2010–mid 2013	2	9	18
http://www.elektropoolhaaglanden.nl/					
Cityshopper Electric Urban Delivery Service by Combipakt	Nijmegen area	Start 2012–end 2013	0	0	2
http://www.combi-pakt.nl/					
Electric Urban Distribution by Boudesteijn Transport	Amsterdam	Start 2012–end 2013	0	0	0
http://www.boudesteijn.nl/milieu.aspx					
Dense Urban Distribution/ Package Delivery by UPS	Amsterdam	Start 2012 – end 2013	0	0	0
http://www.ups.com/europe/nl/dutindex.html					

[a] All of the above nine projects received subsidies from the Dutch government.

Table 22.7 Dutch Focus Areas on Electric Mobility (with Green Deals).[a]

Dutch Focus Areas on Electric Mobility	
City of Amsterdam	http://www.amsterdam.nl/parkeren-verkeer/amsterdam-elektrisch/
City of Rotterdam	http://www.rotterdam.nl/elektrischrijden
Province of Friesland	http://www.drive4electric.nl/nl/projecten/infrastructuur-rijden-en-varen?boodschap=1
Province of Utrecht	http://www.utrecht.nl/smartsite.dws?id=345044
Metropole Region of Amsterdam	http://www.metropoolregioamsterdam.nl/duurzaamheid/mra-elektrisch
Metropole Brabantstad (largest five cities in province of Brabant)	http://www.brabant.nl/dossiers/dossiers-op-thema/energie/elektrisch-rijden.aspx
Green Deals for smart grids, EV charging, and Zero Emission Public Transportation in various locations. Link to a short description of Green Deals: http://www.ondernemendgroen.nl/Pages/Zoek.aspx?tags=elektrisch+rijden	

[a] These cities and regions stimulate electric driving and boating in various ways and also by demonstration projects.

Fig. 22.2 April 2012: start of pilot project with company pool of EVs in the region of Haaglanden.

23

Portugal

23.1 Major developments during 2012

Portugal's economy slowed during 2012, as did the economy in many European countries this past year, which impacts plans for electromobility. Portugal is adjusting to economic and legal uncertainties. The European Commission forecasts economic stabilization for the second half of 2013.

23.2 HEVs, PHEVs, and EVs on the road

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).

Overall sales of light vehicles fell dramatically during 2012: a 40% drop from 2011 to 2012, or a 60% drop from 2010 sales totals.   For context, the number of light vehicles sold in 2012 was the same as that in 1985. Sales of HEVs have also fallen. In 2012, 65 BEVs (battery EVs) and 30 PHEVs (plug-in HEVs) were sold, which is a 68% drop in sales of plug-in vehicles from 2011 totals.

23.3 EVSE (EV supply equipment), or charging infrastructure

Fig. 23.1 The MOBI.E program covers all of Portugal.

MOBI®E Electric Mobility Model

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.

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 as shown in

Fig. 23.2. Hence, MOBI.E allows any user to charge any vehicle in any location by using a single subscription service and authentication mechanism (Fig. 23.3).

Fig. 23.2 The MOBI.E Intelligence Center in Maia, in northern Portugal, manages the EV charging network in real time. (Image courtesy of MOBI.)

Fig. 23.3 MOBI.E vehicle electrification project includes installing charging stations in 30 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. (Image courtesy of 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.

A public network with 1,126 public charging points in more than 30 cities across the country enables national coverage. By the end of 2012, the network registered a total of 438 regular users, including those operating cars, quadricycles, and two wheelers. Although the public charging points are operated by three different companies, Portugal's fully interoperable system enables any user to charge at any charging point with one single registration and contract. The Portuguese government extended the Pilot Phase from the end of 2012 until the end of June 2013, in order to set an evaluation and transition period.

24

Spain

24.1 Major developments during 2012

Electric vehicles (EVs) and hybrid electric vehicles (HEVs) significantly progressed in terms of sales and consumer acceptance in 2012 in Spain due to the following policy plans and programs.

PLAN MOVELE

Plan MOVELE (www.movele.es) was approved and provides a €10 million (US $13 million) budget for incentives to acquire EVs and plugin HEVs (PHEVs) in 2012 (RD 417/2012 normative). The budget was completely expended, and 3,436 EVs/PHEVs were put on the road. The majority of new EVs/PHEVs were bought for professional transport fleets. In 2013, the national budget includes €10 million (US $13 million) for incentives to acquire EVs/PHEVs under Plan MOVELE.

PLAN PIVE

On October 1, 2012, the national government launched PIVE, an incentive plan for purchasing efficient vehicles, with funding of €75 million (US $98 million) under the Action Plan 2008–2012 of the Spanish Strategy for Energy Efficiency and Savings (E4). PIVE is a program for purchasing efficient vehicles to replace 75,000 old vehicles, composed of Category M1 (passenger) vehicles that are more than 12 years old and Category N1 (commercial) vehicles that are more than 7 years old. Buyers receive €1,000 (US $1,300) per vehicle; this amount is combined with another €1,000 (US $1,300) from manufacturers. HEVs, PHEVs, and EVs are eligible for PIVE incentives. The incentives can be combined with buyer incentives provided by Plan MOVELE, for a total incentive of €8,000 (US $10,400) for a vehicle purchase. PIVE concluded successfully on March 31, 2013, and the National Government approved a PIVE 2 incentive program for 2013.

PIVE 2 is scheduled to run from February 2013 to February 2014 with a dedicated budget of €150 million (US $96 million) for incentives to buy efficient 150,000 cars and vans. The incentives are similar to those of the original PIVE Plan. More detailed information is available on PIVE 2 at www.planpive2.es.

PLAN PIMA AIRE

This plan will run from February 2013 to February 2014 with a dedicated budget of €50 million (US $65 million) for commercial vehicles. There are incentives for 30,000 vans at €1,000 (US $1,300) and €2,000 (US $2,600) per van.

STANDARDS FOR EV INFRASTRUCTURE

Guidelines and standards related to EV infrastructure installations (ICT 52), such as warranties and EV infrastructure for new building and public parking facilities, are expected to be announced in 2013. A temporary installation standard has been approved at the regional level in Catalonia until the approval of the ICT 52 at the national level.

"FIDAE" FINANCING FUND

This is a financing fund with a public budget of €123 million (US $160 million) that is co-financed by FEDER and IDAE and operated through BEI (European Bank of Investments). The FIDAE fund is for financing investments in sustainable urban development projects to improve energy efficiency and to introduce renewable energy. EV charging infrastructure is eligible for funding. Beneficiaries of this fund are energy service companies and private (or semi-public) companies. More information is available at www.idae.es.

24.2 HEVs, PHEVs, and EVs on the road

In 2012, there were 10,060 HEV passenger cars sold that represented 1.4% of the total market. The entire Spanish fleet of HEVs numbered 44,626 on the road at the end of the year. Taxis account for more than 20% of the entire HEV market, with more than 30% of the all new taxi-registrations using hybrid technology.

In 2012, there were 22,247,528 passenger vehicles on the road (Table 24.1), with 699,589 of them being new cars sold and registered in 2012. (Note: In the entire 2012 vehicle market, overall sales decreased by almost 15%.) EV/PHEV/HEV combined sales involved 51,149 vehicles, which made up 23% of the entire car fleet and 1.5% of the car-sales market.

Table 24.1 EV, HEV, and PHEV Fleet and Sales in Spain for 2012.

Fleet totals as of December 31, 2012					
Vehicle type	**EV fleet**	**HEV fleet**	**PHEV fleet**	**FCV fleet**	**Total fleet**
Urban Motorbikes (mopeds)	670	0	0	0	2,165,883
Motorbikes	1,988	30	419	0	2,852,297
Quadricycles	1,638	0	0	0	69,142
Passenger vehicles	874	44,596	61	1	22,247,528
Multipurpose passenger vehicles (commercials)	798	0	0	0	4,757,961
Buses	4	23	40	0	61,127
Trucks	31	0	0	0	221,469
TOTAL	6,003	44,649	520	1	32,375,407
Vehicle Total Sales for 2012					
Vehicle type	EV sales	HEV sales	PHEV sales	FCV sales	Total sales
Urban Motorbikes (mopeds)	311	0	0	0	NA
Motorbikes	1,035	8	209	0	NA
Quadricycles	1,211	0	0	0	NA
Passenger vehicles	437	10,060	49	0	699,589
Multipurpose passenger vehicles (commercials)	262	0	0	0	5,831
Buses	1	22	21	0	1,872
Trucks	2	0	0	0	12,827
TOTAL	3,259	10,090	279	0	720,119
Selected Model Prices of EVs in Spain in 2012					
Plug-in vehicle models available (passenger only)	Untaxed, unsubsidized price of vehicle model/Category				
BYD	F3DM		€27,272 (US $35,847)		M1
CITROËN	C Zero		€24,624 (US $32,368)		M1
Mitsubishi	I MiEV		€28,223 (US $37,103)		M1
NISSAN	Leaf		€28,886 (US $37,975)		M1
PEUGEOT	ION		€27,701 (US $36,417)		M1
RENAULT	Fluence		€21,423 (US $28,166)		M1

Note: the total fleet numbers include all propulsion systems and fuels, so include gasoline, diesel, LPG, natural gas, biofuels, etc.

EV and PHEV (plug-in hybrid electric vehicle) sales in Spain have been steadily increasing; they amounted to 144 before 2008; 164 in 2008; 482 in 2009; 800 in 2010; 1,395 in 2011, and 3,538 in 2012 (Fig. 24.1).

Fig. 24.1 EV and PHEV Sales in Spain from pre-2008 through 2012.

A similar figure (Fig. 24.2) is provided for sales of HEVs (considering only the passenger car category) from 2003 through 2012. Sales were 101 in 2003; 521 in 2004; 1,226 in 2005; 2,072 in 2006; 2,534 in 2007; 3,889 in 2008; 5,397 in 2009; 8,464 in 2010;10,332 in 2011; and 9,974 in 2012. The 15% decrease in overall vehicle sales is also reflected in the registrations of HEVs.

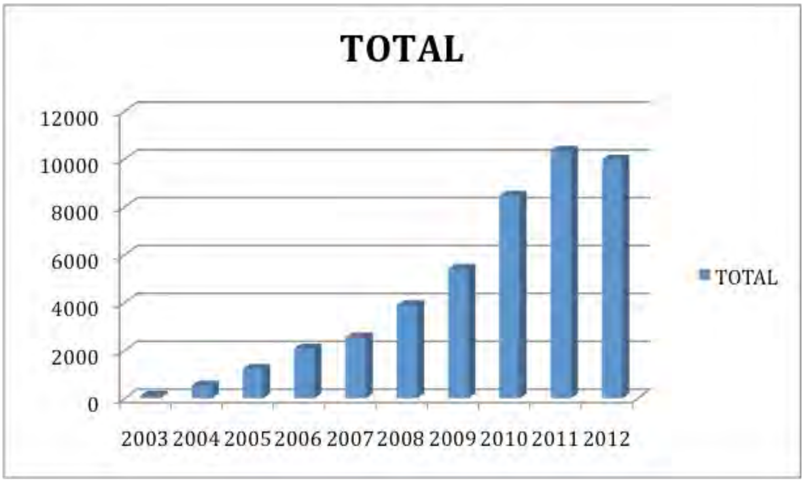

Fig. 24.2 HEV Passenger Car Sales in Spain from 2003 through 2012.

24.3 EVSE (EV supply equipment), or charging infrastructure

The European Commission issued COM(2013) 18/2a, a Directive of the European Parliament and of the Council for the deployment of an alternative fuels infrastructure. The Commission's communication on a European alternative fuel strategy evaluates the main alternative fuels available that can substitute for oil and help reduce greenhouse gas (GHG) emissions from transport. It also suggests a comprehensive list of measures that will promote the market development of alternative fuels in Europe while complementing other policies for reducing oil consumption and GHG emissions from transport.

The main alternative fuel options are electricity, hydrogen, biofuels, natural gas (as compressed natural gas [CNG], liquefied natural gas (LNG), or gas-to-liquid [GTL]), and liquefied petroleum gas (LPG). A minimum number of electrical charging points were given for each Member State. Spain's target numbers are 824 charging points and 82 publically accessible charging points by the end of 2020. Table 24.2 provides recharging infrastructure information and Table 24.3 provides the number of public EVSE installed.

Table 24.2 EV Recharging Infrastructure Public Deployment. CHP = charging points.

Recharging Infrastructure	
Cities	89
Stations	288
Total CHP	771
Type of charge	
CHP Single Phase	691
CHP 3-phase	80
Location	
CHP covered	355
CHP not covered	416
Supporting program	
MOVELE	223
Others	548

Table 24.3 Number of public EVSE installed as of December 31, 2012.

Total Public EVSE	771
Level 1	691
Level 2/standard AC	80
DC fast charging	11

(Note: DC fast charge stations are not included in the total.)

25

Sweden

25.1 Major developments during 2012

The first Swedish mass-produced plug-in hybrid passenger car (diesel) began production in 2012. The Volvo V60 plug-in is a result of a joint venture between Volvo Cars and utility company Vattenfall. The collaboration began as early as 2008, when the Swedish Energy Agency co-financed the production of the first two demonstration vehicles. The first year's production run of 1,000 model-year 2013 cars sold out before the vehicles reached the showroom. Plans are underway to increase production to 4,000 to 6,000 cars for model-year 2014.

In 2012, Volvo Buses increased its sales of parallel hybrid buses; a total of about 1,000 buses are in use worldwide.

In Sweden, considerable interest remains in the field of electric road systems. In these systems, the vehicle is continuously supplied with electricity during operation, either through direct electrical contact to power cables or through wireless charging, as shown in Figure 25.1. The Transport Administration and the Swedish Energy Agency may issue a call for an electric vehicle (EV) road system engineering contract in 2013.

Fig. 25.1 Electric road systems with inductive (wireless) transmission, as under development by Scania and Bombardier (left), and with conductive transmission as under development by Volvo and Alstom (right). (Images courtesy of Scania and Volvo/Alstom)

The McDonald's restaurant chain, together with the electrical power producer Fortum and the auto manufacturer Nissan, launched a project in 2012 to build an EV infrastructure in Sweden along the European highways E4 and E18. Fortum and Nissan signed a Nordic partnership that aims to link the capitals of Norway, *Sweden,* Denmark, and Finland with fast charging stations. McDonald's is the Swedish partner. The first phase tested fast charging stations at two restaurants in the Stockholm area. An assessment of the first phase is planned before the project continues.

The Swedish Energy Agency was given €22 million (US$ 28.5 million) for a new battery R&D program that focuses on battery manufacturing for the automotive industry and recycling for all types of battery applications.

In 2010, the Swedish Government set a target of 2030 for making the transport sector fossil-free. In 2012, it appointed a commission to provide suggestions for how this mandate will be enforced in practice. The report is due in December 2013.

Table 25.1 lists Sweden's policy instruments for plug-in hybrid electric vehicles (PHEVs) and EVs.

Table 25.1 Summary of Sweden's policy instruments for PHEVs and EVs.

Policy Instrument	Details
Super Green Car Rebate	The Super Green Car Rebate entered into force on January 1, 2012, with the support of US $5,410 (40,000 SEK or €4,000) for the purchase of cars that emit less than 50 g CO_2/km.
Technology procurement	Stockholm and the utility company Vattenfall initiated and are administering the procurement of EVs and PHEVs. Participating organizations receive up to 50% of the additional cost, to a maximum of US $15,840 (100,000 SEK or €10,000); funding is from the Swedish Energy Agency. This cost represents the price difference between a green car and the most comparable internal combustion engine (ICE) car. The subsidy is given on the condition that data be collected on the vehicle usage.

25.2 HEVs, PHEVs, and EVs on the road

By December 2012, 1,285 plug-in vehicles were registered in Sweden. Sales of EVs had been slow in Sweden, but they gained traction in 2012. The increase may be explained by the introduction of the new Super Green Car Rebate and also by the increased number of EVs available for purchase in Sweden. The largest increase in sales occurred in PHEV sales; 681 of the 685 cars in the PHEV fleet were purchased during 2012 (Table 25.2).

Table 25.2 Fleet and Sales Data for 2012 in Sweden.

Fleet totals per 31 December 2012					
Vehicle type	EV fleet	HEV fleet	PHEV fleet	FCV fleet	Total fleet
Passenger vehicles	600		685		4,400,000
		Total sales during 2012			
Vehicle type	EV sales	HEV sales	PHEV sales	FCV sales	Total sales
Passenger vehicles	247		681		279,000
Plug-in vehicle models available (passenger only)	**Untaxed, unsubsidized price of vehicle model**				
Opel Ampera	54,150 Euro				
Toyota Prius plugin	42,018 Euro				
Volvo V60 plugin	65,018 Euro				

25.3 EVSE (EV supply equipment), or charging infrastructure

Swedish authorities have no common charging infrastructure plan. Today, the number of EVs has no impact on the electricity grid; hence, there are no official efforts in this area.

Nordic winters require the use of block heaters to keep the cooling water in a vehicle's motor block from freezing while the vehicle is parked. Sweden has approximately 800,000 block heater electric outlets that may be used for charging EVs, either directly or with only minor modification. About 600,000 of these outlets are in Swedish homes, and about 200,000 are in corporate parking facilities. There are about 1,200 public charging points in Sweden, but many of them are not always as accessible to the public as would be preferred. Information about locations and charging specifications may be found through the website. www.uppladdning.nu.

There are a number of local initiatives for encouraging development of a charging infrastructure; they are often coordinated by a municipally-owned utility company. The Fortum-Nissan partnership mentioned earlier is an example of a more national initiative.

Data on the EVSE in Sweden are given in Table 25.3.

Table 25.3 Public EVSE Installed in 2012 in Sweden.

Number of public EVSE installed as of December 31, 2012	
Level 2/standard AC	800,000/1,200*
DC fast charging	15
Number of fueling locations for fuel cell vehicles	One station in Malmö

* 800,000 electric outlets for block heaters and 1,200 public charging points.

25.4 EV demonstration project

A major EV project is listed in Table 25.4.

Table 25.4 Major EV Demonstration Project in Sweden in 2012.

Name	Location	Duration	# of PHEVS	#BEVS	#EVSE	URL
Volvo C30 Electric	Sweden	2009–2013		50		

26

Switzerland

26.1 Major developments during 2012

The three major developments for hybrid and electric vehicles (EVs) in Switzerland in 2012 were (1) changes in legislation favoring lower carbon dioxide (CO_2) emissions, (2) fuel cell vehicle (FCV) buses operating for public use, and (3) the progress of fast charging stations used within the EVite project (described in Section 26.3).

NEW LEGISLATION FOR LOWER-EMISSIONS VEHICLES

The revised energy label for efficient cars launched by the Swiss Federal Office of Energy (SFOE) now includes EVs and plug-in-hybrid EVs (PHEVs) as well. The CO_2 limits for new passenger cars effective as of July 1, 2012, benefit EVs that comply with European Union (EU) standards. These EU regulations obligate Swiss importers to reduce the level of CO_2 emissions from cars registered for the first time to an average of 130 g/km by 2015.

The energy label for motor vehicles aims to reduce their average fuel consumption. It provides information about the fuel consumption and CO_2 emissions in relation to the unladen weight of the vehicle. The label must be displayed in a clearly visible manner directly on the vehicle or in its immediate vicinity; a sample label is displayed in Fig. 26.1. This increases the degree of transparency for buyers of new cars and thus helps them decide which model to buy. The model choice has a direct influence on vehicle operating costs and, in particular, ongoing fuel costs.

There is still no national legislation concerning EVs in general. Switzerland has a federal system with 26 cantons, and each one maintains individual regulations for rebates for motor vehicle taxes.

Fig. 26.1 Launch of the Energy Label for EVs at the e'mobile stand at the International Geneva Motor Show in 2012 (e'mobile is the Swiss association for electric and efficient vehicles. The e'mobile character is wearing a sample label.) (Image courtesy of e'mobile.)

FCV BUSES

PostBus Switzerland is the first public transport company in Switzerland to use FCV buses. Since December 2011, five Mercedes-Benz Citaro FuelCELL hybrids have operated in the area of Brugg. The test project is set to run for five years and is embedded in the EU project CHIC (Clean Hydrogen in European Cities). The improved fuel cell components and the hybridization with lithium-ion batteries in the new Citaro FuelCELL hybrid save 50% more hydrogen than did the previous generation of buses. As a result, the number of tanks has been reduced from nine (for the previously tested FCV buses) to seven, and a total of 35 kg of hydrogen is used. The range of the FCV buses is more than 300 km.

Steep-climbing conditions and low-oxygen levels in mountainous areas have proven to bé a major challenge for the bus. However, the successful tests in and around Davos during 2012 showed that FCVs can be also be very reliable and safe. This inital test opened the door for their use during the prestigous World Economic Forum in Davos in January 2013, as shown in Fig. 26.2. They were electric, quiet, and pollutant-free.

The PostBus Switzerland FCV project was given the “Prix Watt d’Or” in Berne in early January 2013. This prize for excellence is awarded every year by the SFOE for the best energy projects.

Fig. 26.2 One of two Mercedes-Benz Citaro FuelCELL hybrid vehicles provided by PostAuto Schweiz AG and tested during the World Economic Forum in Davos. (Image courtesy of Swiss Postauto.)

26.2 HEVs, PHEVs, and EVs on the road

In 2012, several new EV models were introduced into the Swiss market. This growing variety of choice and the corresponding attention in newspapers and journals with reports of the upcoming new technology have led to increased sales of HEVs, PHEVs, extended-range EVs (EREVs), and EVs, as seen in Table 26.1.

Furthermore, activities (e.g., test drives, road shows, and communications) from car manufacturers, dealers, infrastructure providers, and other organizations have supported the sales figures, as have rebates for motor vehicle taxes for alternative cars in most cantons.

In Switzerland, the fleet totals are only available as of September 30, whereas total sales are reported for the entire calendar year (January 1–December 31).

Table 26.1 Fleet and Sales Totals in Switzerland with the Price of Selected Models.

Fleet totals (as of September 30, 2012)						
Vehicle type	**EV fleet**	**HEV fleet**	**PHEV fleet**	**EREV fleet**	**FCV fleet**	**Total fleet**
Motorbikes	7,271	n.a.	n.a.	n.a.	n.a.	666,792
Quadricycles	659	n.a.	n.a.	n.a.	n.a.	13,030
Passenger vehicles	1,413	28,056	28	355	2	4,254,725
Buses	44	n.a.	n.a.	n.a.	5	58,278
Trucks	219	n.a.	n.a.	n.a.	n.a.	361,926
Industrial vehicles	2,619	n.a.	n.a.	n.a.	1	250,577
Totals	**12,225**	**28,056**	**28**	**355**	**8**	**5,605,328**

Total sales of 2012 (January-Dec)						
Vehicle type	**EV sales**	**HEV sales**	**PHEV sales**	**EREV sales**	**FCV sales**	**Total sales**
Motorbikes	2,269	4	0	1	0	47,880
Quadricycles	575	4	0	0	0	1,925
Passenger vehicles	525	6,516	63	395	0	334,045
Buses	2	23	0	0	0	4,321
Trucks	151	6	0	0	0	34,447
Industrial Vehicles	213	5	0	2	0	8,355
Totals	**3,735**	**6,558**	**63**	**397**	**0**	**430,973**

Market-price Comparison of Selected EVs and PHEVS in Switzerland for 2012

Plug-in vehicle models available (passenger only)	Untaxed, unsubsidized price of vehicle model in CHF (Swiss Francs. 1 CHF = 0.95 US $ at press time)			
Chevrolet Volt	CHF 50,490 (US $53,091)		*Renault Fluence*	CHF 30,600 (US $32,176)
Citroën Zero	CHF 31,600 (US $33,228)		*Renault Kangoo Maxi**	CHF 31,970 (US $33,617)
Fisker Karma Ever	CHF 129,900 (US $136,592)		*Renault Twizy**	CHF 9,600 (US $10,094)
Mitsubishi i-MIEV	CHF 32,999 (US $34,699)		*Smart fortwo ed**	CHF 24,500 (US $25,762)
Nissan Leaf	CHF 49,950 (US $52,523)		*Tesla Roadster*	CHF 118,300 (US $124,395)
Opel Ampera	CHF 52,900 (US $55,625)		*Think City*	CHF 34,900 (US $36,698)
Peugeot iOn	CHF 31,600 (US $33,228)			

(*) Sales price excl. monthly battery rental fee of CHF 59–103, depending on brand and model.

26.3 EVSE (EV supply equipment), or charging infrastructure

Switzerland is one of the first countries in the world to install a nationwide fast charging infrastructure (Table 26.2). In November 2012, a joint venture was initiated under the direction of the new association, Swiss eMobility. The project EVite aims to create a network of 150 public DC stations throughout Switzerland through 2020. Fig. 26.3 shows an EVite station launch in November 2012. This new infrastructure intends to reduce the EV's range limits and charging time and promote market development of electric mobility in Switzerland. Partners of the project EVite include companies in the energy and public sector, the car and telecommunication industry, and mobility associations.

Public charging stations in Switzerland include one to several outlets where EVs can plug in, according to the brand and system. A typical AC charging station includes two to four outlets for that many EVs. A typical DC fast charging station includes one or two outlets.

Table 26.2 Public charging EVSE in Switzerland.

Number of public EVSE installed as of 31 December 2012	
Level 2/standard AC	approx. 300 locations with 1-2 EVSEs each
DC fast charging	11 charging points with 1-2 EVSEs each
Fuel cell filling stations	2

Fig. 26.3 Launch of the first EVite DC fast charging station at the Kölliken Roadhouse occurred in November 2012. (Image courtesy of Alpiq E-Mobility)

26.4 EV demonstration projects

Table 26.3 lists selected EV demonstration projects in Switzerland.

Table 26.3 Demonstration projects in Switzerland

Name	Location	Duration	# of PHEVs	URL
Research project: EScooter	Switzerland	2011–2013	70 e-scooters	http://www.ikaoe.unibe.ch/forschung/e-scooter/index.html
Pilot project: Smart ED (electric drive) (as part of 18 countries)	Greater Zurich area	2010–2014	50 smart EDs (second generation) in a community of private and fleet customers	Claim: "learn together" (no website)

27

Turkey

27.1 Major developments during 2012

The Turkish hybrid and electric vehicle (H&EV) market is in its beginning stage. Environmental and clean vehicle awareness is increasing within Turkish industries, research and development organizations, and Turkish society as a whole. Turkish policies and legislation are encouraging reductions in greenhouse gas emissions and improved air quality.

During 2012, the government announced major research programs by supporting research and development projects at universities, research institutes, and industry regarding electric vehicles (EVs) and subcomponent technologies. Calls for project proposals have been announced and executed by TÜBİTAK (The Scientific and Technological Research Council of Turkey). Universities and research centers are eligible for funding for these project topics: electric motors and battery technologies in electric and hybrid electric vehicles (HEVs); energy management systems; dynamics and control of electric and hybrid electric vehicles; internal combustion engine performance and emission control in HEVs; and hydrogen and fuel cell technologies. The selected projects’ duration will be 2–3 years, and the total budget for the call is expected to between €5–6 million (US $6.5–7.5 million).

The project call for industry focused on these topics: development of electric motor/generator and driver systems for EVs/HEVs; energy management of EVs/HEVs, control system; hardware and algorithm development; vehicle electronics and electromechanical system components development; and design of innovative vehicle components and systems. More than 30 projects were selected with the total approximate budget of € 65–70 million (US $84–91 million) over the next 3–4 years.

During 2012, a national support program was announced concerning the development of electric vehicle technologies. The aim of the call is to develop the critical components for electric vehicles and build an electric vehicle that uses these components (Fig. 27.1). The project consortium is expected to consist of industries, research centers, and universities. Project duration is expected to be 4 years with these goals:

- EV conceptual design, detailed design, design verification
- Battery cell, module, pack, and management system
- Electric machine, driver, converters, high voltage components
- Vehicle control systems, energy management, vehicle dynamics control, vehicle safety, thermal management

Fig. 27.1 Çukurova University's proposed national EV is designed for two people. (Image of courtesy Çukurova University.)

In parallel with the support programs described above, implementation programs and new legislation are underway. Forty electric vehicles per year for a 5-year period will be purchased by the national ministry. Taxation will be revised according to the emission values of the vehicles. Other new incentives will be announced for other public institutions to purchase EVs. The electricity grid infrastructure will be strengthened, and electricity tariff deregulation will be completed. Access to charging stations near residences, car parks, and shopping centers will be increased. Awareness projects will be executed concerning EV technology and EV usage. Legislation regarding the recycling of EV batteries will be revised. The capacity of test centers will be improved.

At the moment, there are two types of taxation measures for vehicles in Turkey. The first 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 engine cylinder volume and the age of the vehicle.

The special consumption tax (SCT) on EVs when they are purchased is lower than that for conventional vehicles. The vehicle sales tax reduction includes only 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 SCT reduction; light-duty trucks, trucks, and buses maintain the same levels of taxation. Table 27.1 shows the vehicle sales SCT categories for initial new passenger vehicles and motorbikes. This new incentive is expected to only impact EV sales out of all H&EV types and only conventional vehicles with engine cylinder volumes below 1,600 cubic centimeters (cc).

Table 27.1 Special consumption tax classification categories for new vehicle sales.

	Conventional		Electric Only	
Vehicle Type	Engine Cylinder Volume (cc)	Special Consumption Tax (%)	Electric Motor Power (kW)	Special Consumption Tax (%)
Passenger Vehicle	<1,600	40	<85	3
	1,600-2,000	80	85-120	7
	>2,000	130	>120	15
Motorbike	<250	8	<20	3
	>250	37	>20	37

27.2 HEVs, PHEVs, and EVs on the road

Fleet

The number of vehicles on the road in Turkey is increasing. Although the total fleet of vehicles on the road is about 17 million (Table 27.2), there are only a few EVs and HEVs among them. The official EV/HEV fleet statistics are not available, but EV new sales are collected (by the Automotive Distributors Association [ODD]).

Table 27.2 Total vehicle fleet according to the vehicle types.

Vehicle Type	2010	2011	2012
Passenger car	7,544,871	8,113,111	8,648,875
Minibus	386,973	389,435	396,119
Bus	208,510	219,906	235,949
Light commercial vehicle	2,399,038	2,611,104	2,794,606
Truck	726,359	728,458	751,650
Motorcycle	2,389,488	2,527,190	2,657,722
Special purpose vehicles	35,492	34,116	33,071
Tractor	1,404,872	1,466,208	1,515,421
Total	15,095,603	16,089,528	17,033,413

Source: TURKSTAT Road Motor Vehicle Statistics

Sales

Passenger car sales in 2012 decreased by 6.27% when compared with 2011, going down to 556,280 units (Table 27.3). The light-commercial market also shrank. These decreases were partially attributable to the increase in SCT rates and the slower economy in general.

When we examine the passenger car market according to the engine volumes in 2012, because of the lower tax, the passenger cars below 1,600 cc received the highest share of sales with 92.6% and 514,861 units (Table 27.3). There were 184 EV passenger cars sold in Turkey in 2012.

Table 27.3 Passenger car market according to the engine/electric motor size in 2012.

Engine Size	Engine Type	2011 Cumulative		2012 Cumulative		2012/ 2011	SCT Tax Rates	VAT Tax Rates
		Units	%	Units	%	%		
≤1,600 cc	Gas/diesel	530,069	89.30	514,861	92.60	–2.90	40%	18%
1,601 cc to ≤2,000 cc	Gas/diesel	52,396	8.80	35,850	6.40	–31.60	80%	18%
≥2,001 cc	Gas/diesel	11,054	1.90	5,385	1.00	–51.30	130%	18%
≤85 kW	Electric	0	0.00	184	0.00	–	3%	18%
86 kW to ≤120 kW	Electric	0	0.00	0	0.00	–	7%	18%
≥121 kW	Electric	0	0.00	0	0.00	–	15%	18%
Total		593,519	100.00	556,280	100.00	–6.30		

Source: ODD

When we examine the passenger car market according to average emission values in 2012, the passenger cars that fell within the range of below 140 gCO_2/km accounted for more than 70% of vehicle sales (Table 27.4). This is primarily a result of the lower tax values for the engine volumes ≤1,600 cc, which also helps to decrease the total fleet emissions average of the vehicles in Turkey.

Table 27.4 Passenger car market according to average emission values in 2012.

Average Emission Values of CO_2 (g/km)	2011 Cumulative		2012 Cumulative		2012/2011
	Units	%	Units	%	%
<100 g/km	3,820	0.60	18,635	3.30	387.80%
≥100 to <120 g/km	172,652	29.10	173,218	31.10	0.30
≥120 to <140 g/km	223,020	37.60	202,118	36.30	−9.40
≥140 to <160 g/km	109,013	18.40	118,107	21.20	8.30
≥160 g/km	85,014	14.30	44,202	7.90	−48.00
Total	593,519	100.00	556,280	100.00	-6.30

Source: ODD

27.3 EVSE (EV supply equipment), or charging infrastructure

Ongoing installation efforts are underway in Turkey to put EVSE in different cities. These efforts are mostly located in Istanbul, which is the country's most populous city. The installation projects are conducted individually by a few private companies. The number of charging points is increasing slowly, keeping pace with EV sales. Although statistics have not been officially kept, the total number of charging points is estimated to be about 100–110. Most of the stations are equipped with standard charging; only a few of them are direct current fast-charging stations. The charging points are located at automotive dealers, parking lots, airports, and shopping centers. Despite the lack of an official announcement about new installations, there are plans to increase the number of charging stations over the next years.

28

United Kingdom

28.1 Major developments during 2012

Context

The UK Coalition Government has committed £400 million (€460 million/$600 million) through 2015 to support the purchase, use, and manufacture of ultra-low emission vehicles (ULEVs). This includes funding for consumer incentives of up to £5,000 (€5,800/US $7,600) for eligible cars and up to £8,000 (€9,250/US $12,100) for eligible vans; funding to kick-start the installation of recharging points; and £82 million (€95 million/US $125 million) for research and development (R&D) and procurement programs. Work is also underway to encourage UK businesses to take advantage of ULEV commercial opportunities and develop and strengthen the capability for ULEV manufacturing and its associated supply chain.

The Office for Low Emission Vehicles (OLEV) was formed in 2009 to simplify policy development and delivery in this area. It is a cross-departmental unit composed of staffing and funding from three departments: the Departments for Transport, Business Innovation and Skills (BIS), and Energy and Climate Change. OLEV also is responsible for the European Union (EU) regulations on carbon dioxide (CO_2) emissions from cars and vans designed to reduce the largest amounts of CO_2 emissions from road transport until 2020 (Fig. 28.1).

Fig. 28.1 The BMW i3: BMW's first electric vehicle designed from the start for mass production and will contribute to reducing CO_2 in the UK. (Image courtesy of BMW).

Progress

CONSUMER INCENTIVES

As of December 31, 2012, there were 3,021 claims made through the Plug-in Car Grant scheme and 215 claims made through the Plug-in Van Grant scheme. Data from the Society of Motor Manufacturers and Traders also show that alternative fuel vehicles represent a growing share of the total market, with registrations having risen to 1.3% of the market share in 2011, which is an 11.3% rise in volume from 2010.

These figures demonstrate a positive effect from the consumer incentives in the ULEV market, although uptake has been slower than anticipated. It is expected that sales volumes will increase through 2013 as less expensive ULEV models enter the market. Manufacturers plan to offer about 20 additional car models that may be eligible for the Plug-in Car Grant by the end of 2013.

More innovative finance options are also emerging from vehicle manufacturers that want to help reduce the upfront cost to consumers and address their battery concerns. For example, Renault is planning to lease the battery in its vehicles, which will reduce the vehicles' initial purchase price and alleviate any customer concerns about the technology.

OTHER FISCAL INCENTIVES

Table 28.1 summarizes the package of financial incentives available for buyers who choose a plug-in car or van instead of a petrol or diesel equivalent. For illustrative purposes, the table identifies potential savings for a Nissan Leaf electric car (list price £30,990/€36,043/US $46,978) compared to the best-selling equivalent in its segment, the Ford Focus Zetec 1.6L (£18,637/€21,663 /US $28,363). The table also identifies potential savings for an electric compared to a diesel Ford Connect van.

Table 28.1 Summary of the UK's policy instruments for PHEVs and EVs

Incentives and Measures	Nissan Leaf vs. Ford Focus Zetec	Electric vs. diesel Ford Connect van
Incentives that are available to all buyers		
Plug-in grant	Up to **£5,000**	Up to **£8,000**
Vehicle excise duty: exemption	**£135** saving each year	**£135** saving each year
Lower fuel taxes and costs: EVs typically cost 2–3 pence per mile compared to 13 pence per mile for a conventional car, saving £100 for every 1,000 miles.	**£1,200** over 12,000 miles	**£1,200** over 12,000 miles
Incentives that are also available to business buyers		
Enhanced capital allowance: VAT-registered businesses can write down the whole purchase price of an EV against tax in the first year; this is confirmed until 2015	Approximately **£4,000 additional benefit** for a firm purchasing a Leaf instead of a Focus (at 2011–2012 rates)	Approximately **£5,000 additional benefit** for a firm purchasing an electric instead of a diesel version (at 2011–2012 rates).
Employer company car tax and fuel benefit charge: National Insurance contribution exemption for an employer that provides a zero emission company car until 2015	Approximately **£600 per year saving** for an employer when an employee (40% income tax bracket) opts for a Leaf instead of a Focus	NA
Employee company car tax and fuel benefit charge: Will remain zero rated for employees receiving a zero emission company car until 2015	Approx. **£2,500 per year saving** for employees (in 40% income tax bracket) who opt for a Leaf instead of a Focus	NA
Van benefit charge: When an employer provides employees with a van for private and business use, a £3000 van benefit charge is payable; electric vans are exempt until 2015	NA	**£3,000 saving** for an employee who opts for an electric van
Local measures that can also benefit ultra-low-emission vehicles		
London congestion charge zone (CCZ) fee: EVs and plug-in hybrid electric vehicles (PHEVs) receive a 100% discount	**Save £2,000** for a vehicle entering CCZ zone for 200 days in a year	**Save £2,000** for a vehicle entering CCZ zone for 200 days in a year

R&D

The UK Government is providing £82 million (€95 million/US $125 million) to support research and development, which is mostly managed by the Technology Strategy Board, which is a nongovernmental organization sponsored and funded by BIS.
In 2009, an automotive-industry-led group called the New Automotive Innovation Growth Team published *An Independent Report on the Future of the Automotive Industry in the UK.* It set out the team's 20-year vision for the automotive industry and contained the team's recommendations to government and industry on how to achieve it.

The Automotive Council was formed to carry forward these recommendations and to set up 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-term to long-term, low carbon, electric hybrid and fuel cell vehicles;
3. Lightweight vehicles and power train structures: Lighter vehicles consume less energy to move than heavier vehicles; this area is applicable to all low-carbon vehicle materials, manufacturing methods, and assembly methods;
4. Development of power electronics and electric machines: Fundamental to electric and hybrid technology performance and efficiency; and
5. Development and application of intelligent transport systems to existing and new technologies to improve travel efficiency and travel choices.

Two new low-carbon vehicle innovation platform competitions (Integrated Delivery Program [IDP] 8 and IDP 9) for grant-funded collaborative R&D were announced in November 2012. The competitions are supported by OLEV working in partnership with the Technology Strategy Board. IDP 8 focuses on disruptive technology and research, while IDP 9 addresses specific technology needs defined by the Automotive Council. These efforts have received commitments of around £26.5 million (€30.6 million/US $40 million) in public funds. The total value is likely to approach £50 million (€58 million/US $76 million) once matched funds and other leveraged support are taken into account.

28.2 HEVs, PHEVs, and EVs on the road

As of September 2012, there were EVs, PHEVs, and HEVs on the road in the UK, as shown in Table 28.2.

Table 28.2 EV, HEV, and PHEV Fleet Numbers and Sales.

Hybrid and electric vehicle fleet numbers in the UK at the end of September 2012				
Vehicle Type	**Total vehicle fleet (including EVs, PHEVs, and HEVs)**	**EVs**	**PHEVs**	**HEVs**
Motorbike	1,334,850	1,310	0	1
Passenger vehicle	29,736,086	3,600	784	121,693
Multipurpose passenger vehicle	97,943	14	0	0
Bus	76,661	81	0	0
Truck	489,296	736	0	0
Light goods	3,396,126	3,769	0	36
Tricycle	15,751	37	0	0
Others	631,846	66,754	0	36
Total	35,778,559	76,301	784	121,766
Note: the total fleet numbers include all propulsion systems and fuels.				

UK Sales for 2008–2012					
Vehicle Type	**2008**	**2009**	**2010**	**2011**	**2012**
EV/PHEV sales (new registration)	428	357	515	1,485	3,125
All sales (new registration)	2,405,462	2,160,281	2,224,851	2,252,545	2,338,318
Vehicle Type	End 2008	End 2009	End 2010	End 2011	End Sept 2012
EV/PHEV stock	5,468	5,403	5,444	6,391	8,153
All stock	31,395,872	31,474,756	32,631,229	32,721,669	33,132,212
All figures refer to light-duty vehicles (i.e., cars [including taxis] and vans).					

28.3 EVSE (EV supply equipment), charging infrastructure

The Plugged-In Places (PIP) program has significantly increased the number of recharging points in areas across the UK. Over 2,800 charge points have been provided through the eight PIP projects through December 2012. About 70% of these PIP charge points are publicly accessible (Fig. 28.2). Data provided by charge point manufacturers indicate that other organizations also may have installed about 5,000 charging points nationwide.

Fig. 28.2 Multi-point Recharging Site at Olympic Park in London.

On February 19, 2013, the Department for Transport's Secretary of State announced a £37 million (€43 million/US $56 million) package of measures that further support the installation and use of the recharging infrastructure. The package includes these opportunities:

- Up to £13.5 million (€15.6 million/US $20.5 million) is available for a 75% grant for UK homeowners for the cost of a charge point and its installation.
- £11 million (€12.7 million/US $16.7 million) is available for a fund for local authorities in England that offers these options. Authorities can apply for:
  - Up to 75% of the cost of charge points and their installation for on-street charging for residents who own or have ordered a PHEV but do not have off-street parking, and
  - Up to 75% of the cost of installing rapid charge points in their areas around the strategic road network.
- Up to £9 million (€10.3 million/US $13.6 million) is available to fund the cost of charge points and their installation at railway stations.
- Up to £3 million (€3.5 million/US $4.5 million) is available to support the cost of charge points and their installation on government and wider public estates by April 2015.
- A commitment was made to review government buying standards (mandatory for central government departments) to lower the fleet average CO_2

emissions/km of new cars and to encourage the uptake of PHEVs by the central government.

The package also includes previously-announced funding of £280,000 (€323,000/ US $425,000) to expand the Energy Saving Trust's Plugged-in Fleets initiative in England to help 100 more public and private sector fleets understand and identify where ultra-low emission vehicles are an option rather than petrol-fuelled vehicles.

28.4 EV demonstration projects

UKH2MOBILITY PROGRAM

UKH2Mobility is a new government and cross-industry program to make hydrogen-powered travel in the UK a reality. The key findings of the program's evaluation phase were published on February 4, 2013; key stakeholders were invited to attend a presentation and panel discussion. The findings show that hydrogen fuel cell EVs could contribute significantly to the decarbonization of road transport and to the development of economic opportunities for the UK.

GREEN BUS FUND

The £95 million (€110 million/US $144 million) Green Bus Fund supports bus companies and local authorities in England by helping them buy new low-carbon buses. Its main purpose is to support and speed the introduction of hundreds of low-carbon buses across England.

LOW-CARBON TRUCK TRIAL

The Department for Transport recognizes that the options currently available for low-carbon heavy goods vehicles (HGV) are different from those for low-carbon cars and vans. Up to £9.5 million (€11 million/US $14.4 million) has been designated to support the purchase of low-carbon trucks that offer carbon savings of at least 15% compared with standard equivalent vehicles. Funding is also available for supporting infrastructure, such as gas refueling hubs.

The trials will take place over two years. Data will be collected for analysis to demonstrate the wider benefits of low-carbon trucks, such as potential savings in fuel costs. Investments made in the gas refueling infrastructure during the trials will help encourage other operators to consider using gas or dual-fuel HGVs.

The Department for Transport also encourages industry-led initiatives. For example, the Freight Transport Association's Logistics Carbon Reduction Scheme is a tool for recording, reporting, and reducing carbon emissions from freight. Currently, the scheme covers 58,000 vehicles, and members are committed to achieving a collective target of reducing CO_2 emissions by 8% by 2015.

LCV 2012 EVENT

Cenex hosted its fifth annual low-carbon vehicle (LCV) event on September 5 and 6, 2012, at Millbrook Proving Ground in Bedfordshire; there were almost 1,900 individual attendees and 765 organizational attendees.

The LCV aims to help promote a strong, industry-led economic recovery in the UK. In addition, LCV strives to (1) provide a showcase for UK capabilities by positioning the UK as a leader in LCV technology development and exploitation and (2) build organizations' awareness of LCV technologies and their confidence to adopt them for vehicles and fleet operations.

29

United States

29.1 Major developments during 2012

THE PRESIDENT'S "EV EVERYWHERE" CHALLENGE

In March 2012, President Obama announced EV Everywhere, one in a series of Clean Energy Grand Challenges launched by the U.S. Department of Energy (DOE) to address the most pressing energy challenges of today. EV Everywhere aims to engage the nation's scientists to develop and commercialize the next generation of technologies to achieve sufficient plug-in electric vehicle (PEV) cost, range, and charging infrastructure necessary for their widespread deployment. The initiative focuses on enabling U.S. companies to produce, within the next 10 years, PEVs that are as affordable and convenient for the average American family as today's gasoline-powered vehicles. On the basis of feedback received from participating experts (from industry, academia, state and local government, and other organizations) during a set of four EV Everywhere workshops held between June and September 2012, the DOE developed the *EV Everywhere Grand Challenge Blueprint*, a document outlining the goals and steps for achieving the Challenge's goal.

Fig. 29.1 New fast-charging combo coupler standard (SAE J1772) for PEVs and EVs. Image courtesy of SAE.

NEW SAE J1772 COMBO CONNECTOR STANDARD

SAE Electric Vehicle and Plug-In Hybrid Electric Vehicle Conductive Charge Coupler (SAE J1772), the first official charging standard for North American cars, was approved and published in October 2012. This reduces the charging time from as high as 8 hours, to as little as 20 minutes—and a revision incorporates DC fast-charging. The new charging outlet design uses paired couplers for both AC and DC charging using the same standard plug (Fig. 29.1).

TESLA MODEL S

Tesla started deliveries of its Model S vehicle in June 2012. It received the Motor Trend Car of the Year award – the first non-internal combustion engine–powered winner in the award's 64-year history. The Model S is available in four different configurations, from a 40-kWh battery pack (estimated range: 160 miles) to an 85-kWh battery pack (U.S. Environmental Protection Agency [EPA] official range: 265 miles).

In 2012, Tesla also unveiled its Supercharger network (Fig. 29.2), a network of high-powered electric vehicle supply equipment (EVSE), which can deliver DC charge rates of up to 80 kW, providing a 150–160 mile range enhancement in just 30 minutes.

Fig. 29.2 Tesla's supercharged network plans for 100 stations by 2015 across North America. (Image courtesy of Tesla.)

$11 MILLION FOR DOE CLEAN CITIES PROJECTS FOR EV READINESS

In November 2012, the DOE awarded U.S. $11 million (€8 million) to 20 Clean Cities alternative fuel projects to diversify the U.S. fuel economy and to facilitate the market adoption of advanced vehicles. Of the selected projects, several are related to EV and EVSE infrastructure deployment. This follows DOE's U.S. $8.5 million (€6.5 million) Clean Cities' Community Readiness and Planning for Plug-in EVSE awards in September 2011, several of whose projects are nearing completion.

29.2 HEVs, Plug-In Hybrid Vehicles (PHEVs), and EVs on the road

Tables 29.1 and 29.2 present fleet totals in the United States per December 31, 2012, and 2012 U.S. vehicle sales by type, respectively.

Table 29.1 U.S. Fleet totals for 2012.

Vehicle type	Fleet totals per December 31, 2012				
	EV fleet	HEV fleet	PHEV fleet	FCV fleet	Total fleet
Bicycles (no driver license)	~1,000,000[a]	-	-	-	~1,000,000[a]
Passenger vehicles (cars)	81,777[b]	2,592,354[c]	46,581[b]	421[b]	125,656,528[d,e]
Buses	-	-	-	-	666,064[d,e]
Trucks (all duty)	-	-	-	-	118,455,587[d,e]

[a] *Source: http://www.newsday.com/classifieds/cars/are-electric-bikes-catching-on-in-united-states-1.3821099.*

[b] *EV, PHEV, and fuel cell vehicle (FCV) fleet totals taken from DOE's AFDC "AFVs in Use" (through 2010) table at http://www.afdc.energy.gov/data/#tab/all/data_set/10300 and additional data from www.electricdrive.org (2011-2012).*

[c] *HEV fleet total obtained from DOE's Alternative Fuels Data Center (AFDC) "U.S. HEV Sales by Model" (for 1999–2011) at http://www.afdc.energy.gov/data/#tab/fuels-infrastructure/data_set/10301 and from www.electricdrive.org (for 2012).*

[d] *Includes internal combustion engine vehicles.*

[e] *Data from Office of Highway Policy Information, FHWA representing the most recent vehicle registration updates through 2010 (http://www.fhwa.dot.gov/policyinformation/quickfinddata/qfvehicles.cfm).*

Table 29.2 U.S. vehicle-type sales in 2012.

Vehicle type	Total U.S. sales during 2012				
	EV sales	HEV sales	PHEV sales	FCV sales	Total sales
Bicycles (no driver license)	~89,000[b]	-	-	-	~89,000[b]
Passenger vehicles (cars)[a]	14,251	434,645	38,584	-	7,154,723[c]
Buses	-	-	-	-	~32,000[d]
Trucks (all duty)	-	-	-	-	6,951,082[e]

a From www.electricdrive.org.

b Estimate by Navigant Research (formerly Pike Research). Source: press release "The Electric Bicycle Market in the United States Will More than Triple by 2018, Forecasts Pike Research," August 1, 2012.

c Includes internal combustion engine vehicles.

d Includes school bus fleet sales only. Source: http://www.schoolbusfleet.com/Channel/Management-Training/News/2012/12/18/School-bus-sales-up-10.aspx.

e National Automobile Dealers Association (NADA) State of the Industry Report 2012.

Table 29.3 presents PEV models available on the U.S. market in 2012.

Table 29.3 PEV models available on the U.S. market in 2012.

Plug-in vehicle models available (passenger only)	Vehicle price[a]
Chevrolet Volt	US $39,145
Coda Automotive	US $37,250
Fisker Karma	US $102,000
Ford C-Max Energi	US $32,950
Ford Focus Electric	US $39,200
Honda Fit EV (lease only)	US $389/month
Mitsubishi i	US $29,125
Nissan Leaf	US $35,200
Tesla Model S	US $59,900
Toyota Prius Plug-In	US $32,000
Toyota RAV4 EV	US $49,800

[a] Not including taxes, subsidies, or destination fees.

29.3 EVSE (EV supply equipment), or charging infrastructure

DOE's Idaho National Laboratory (INL) is partnering with ECOtality North America and ChargePoint (formerly called Coulomb Technologies) to demonstrate EVSE deployment in two separate projects. In the first project, ECOtality set up the EV Project, so far the largest deployment and evaluation project for electric drive vehicles and charging infrastructure, to deploy approximately 14,000 Level 2 (208-240V) EVSEs and 300 DC Fast Chargers in 16 major cities across the United States. In the second project, ChargePoint set up ChargePoint America, a DOE-supported program to deploy 4,600 public and home networked charging stations at locations throughout the United States (Table 29.3).

Table 29.3 Total EVSE, charging events, and electricity consumed in the EV and Charge Point projects.

Name	Location	Duration	Total EVSE[a]	Charging events[a]	Electricity consumed[a]
The EV Project	Nationwide	Ongoing	9,546	1,726,832	14,461.55 MWh
Charge Point	Nationwide	Ongoing	3,908	760,995	5,359.2 MWh

[a] As of September 2012.

The DOE Alternative Fuels Data Center (AFDC) counts one EVSE for each outlet available (Table 29.4).

Table 29.4 Number of public charging stations.[a]

Level 1	1,588
Level 2 (Standard AC)	5,980
DC fast charging	153
Fuel cell vehicle fueling locations (CA Only)	10

[a] Data accessed in July 2013 taken from the AFDC EVSE Location Database (http://www.afdc.energy.gov/fuels/electricity_locations.html).

29.4 EV demonstration projects

INL is partnering with ECOtality, Nissan, and General Motors to demonstrate the deployment/usage of approximately 5,700 Nissan Leaf battery electric vehicles (BEVs) and 2,600 Chevrolet Volt extended range electric vehicles (EREVs, listed as PHEVs in Table 29.5) that will be recharged in private residences, fleet sites, and public locations. As part of this project, the vehicles are equipped with suitable meters and/or data loggers. In support of the Chevrolet Volt testing and demonstration activity, INL is tasked by DOE to collect data via OnStar from 150 Chevrolet Volts and to produce testing report fact sheets for the Department (Table 29.5).

Table 29.5 Number of PHEVs and BEVs determined by Idaho National Laboratory.

Name	Location	Duration	No. of PHEVs[a]	No. of BEVs*
The EV Project	Nationwide	Ongoing	1,052	4,719
INL Chevy Volt - OnStar	Nationwide	Ongoing	150	N/A

[a] As of September 2012.

IA-HEV Publications

IA-HEV publications during the fourth term, 2009–2015

- *Hybrid and electric vehicles. The electric drive advances.* Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2009. Washington, DC, USA. March 2010.
- *Hybrid and electric vehicles. The electric drive plugs in.* Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2010. Washington, DC, USA. June 2011.
- *Hybrid and electric vehicles. The electric drive captures the imagination.* Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2011. Washington, DC, USA. March 2012.
- IA-HEV *electronic newsletter*.

  2010, issued in August.

  2011, issued in July.

  2012, issued in March and July.

  2013, issued in January.
- IA-HEV *website:* www.ieahev.org, revised in January 2012.
- Beeton, D. *Electric Vehicle Cities of the Future: A Policy Framework for Electric Vehicle Ecosystems*. Proceedings of EVS-26, Los Angeles, California, U.S.A. May 6–9, 2012.
- Beeton, D. and Budde, B. *Future of Markets for Electric Vehicles: Expectations, Constraints & Long-Term Strategies*. Document ref: IEA130228. Urban Foresight Limited (Newcastle, UK), 2013.
- Conte, Mario; Fiorentino Valerio Conte; Ira D. Bloom; Kenji Morita; Tomohiko Ikeya; Jeffrey Belt. *Performance and Life Testing Procedures for Lithium Batteries in an International Collaboration Context*. Proceedings of EVS-25, Shenzhen, China. November 5–8, 2010. (also J. Automotive Safety and Energy, 2011, Vol. 2 No.1.)
- Da Costa, A, et al.; François Badin; Aymeric Rousseau. *Fuel Consumption Potential of Different Plug-in Hybrid Vehicle Architectures in the European and American Contexts.* Proceedings of EVS-26, Los Angeles, California, U.S.A. May 6–9, 2012.
- Dallinger, A.; M. Wietschel; D. Santini. *Effect of Demand Response on the Marginal Electricity used by Plug-in Electric Vehicles*. Proceedings of EVS-26, Los Angeles, California, U.S.A. May 6–9, 2012.
- Elgowainy, A. et al. *Impact of plug-in hybrid electric vehicle charging choices in 2030 Scenario.* Transportation Research Record TRB 12-3800, pp. 9–17 (2012).
- Elgowainy, A. et al.; D. Santini. *Impacts of PHEV Charging on Electric Demand and Greenhouse Gas Emissions in Illinois.* Proceedings of EVS-26, Los Angeles, California, U.S.A. May 6–9, 2012.

- *EV City Casebook.* Published by the Clean Energy Ministerial, Electric Vehicles Initiative, Rocky Mountain Institute, Project Get Ready, IA-HEV, C40 Cities, and the International Energy Agency (IEA), 2012.
- ExtraEnergy e.V. (editor). *Go Pedelec!.* Published in English, German, Dutch, Czech, Hungarian, and Italian by the *Go Pedelec* Project Consortium, Vienna, Austria, 2012.
- Gnann, T.; P. Plotz; F. Kley. V*ehicle Charging Infrastructure Demand for the Introduction of Plug-in Electric Vehicles in Germany and the U.S.*. Proceedings of EVS-26, Los Angeles, California, U.S.A. May 6–9, 2012.
- Kleindienst Muntwyler, Sigrid. *Market deployment of hybrid and electric vehicles: The Swiss lessons learned.* Proceedings of EVS-25, Shenzhen, China. November 5–8, 2010.
- Mol, Carlo; Michael O'Keefe; Arie Brouwer; Jussi Suomela. *Trends and insight in heavy-duty vehicle electrification*. Proceedings of EVS-25, Shenzhen, China. November 5–8, 2010.
- Muntwyler, Urs. *The International Energy Agency's Transport Roadmap and the Strategy for the 4th Phase 2009–2014 of the Implementing Agreement "Hybrid and Electric Vehicle Technologies and Programmes"*. Proceedings of EVS-25, Shenzhen, China. November 5–8, 2010.
- Plotz, P.; T. Gnann; F. Kley. *Optimal Battery Sizes for Plug-in Hybrid Electric Vehicles.* Proceedings of EVS-26, Los Angeles, California, U.S.A. May 6–9, 2012.
- Propfe, B. et al.; D. Santini. *Cost analysis of Plug-in Hybrid Electric Vehicles including Maintenance & Repair Costs and Resale Values.* Proceedings of EVS-26, Los Angeles, California, U.S.A. May 6–9, 2012.
- Rask, E.M.; Henning Lohse-Busch; D.J. Santini. *Analysis of Input Power, Energy Availability, and Efficiency during Deceleration for X-EV Vehicles.* SAE 2013-01-1064. SAE World Congress, Detroit, April 16–18, 2013.
- Rousseau, A. et al. *Comparison of Energy consumption and costs of different HEVs and PHEVs in European and American context.* Presented at the European Electric Vehicle Congress Brussels, November 19–22, 2012.
- Santini, D,; Y. Zhou; A. Vyas. *An Analysis of Car and SUV Daytime Parking for Potential Opportunity Charging of Plug-in Electric Powertrains.* Proceedings of EVS-26, Los Angeles, California, U.S.A. May 6–9, 2012.
- Santini, D. et al. *Deploying Plug-in Electric Cars Which are Used for Work: Compatibility of Varying Daily Patterns of Use with Four Electric Powertrain Architectures.* Paper TRB13-4925. Presented at the Transportation Research Board Meeting, Washington, DC, U.S.A., January 2013.
- Santini, D.J. and A. J. Burnham. *Reducing Light Duty Vehicle Fuel Consumption and Greenhouse Gas Emissions: The Combined Potential of Hybrid Technology and Behavioral Adaptation.* SAE 2013-01-0069. SAE World Congress, Detroit, April 16–18, 2013.
- Santini, D.J. et al. *Cost Effective Annual Use and Charging Frequency for Four Different Plug-in Powertrains*. SAE 2013-01-0494. SAE World Congress, Detroit, April 16–18, 2013.
- Telias, Gabriela; Kristin Day; Philipp Dietrich. *RD&D Cooperation for the Development of Fuel Cell, Hybrid, and Electric Vehicles within the International Energy Agency*. Proceedings of EVS-25, Shenzhen, China. November 5–8, 2010.
- Van Walwijk, Martijn. *The International Energy Agency's Hybrid and Electric Vehicle* work in a landscape of change. Green Vehicle Congress, Newcastle, UK. March 24–25, 2010.

- Van Walwijk, Martijn. *IA-HEV Support for policy and decision makers*. IEA Advanced Vehicle Leadership Forum workshop, Paris, France. September 30, 2010.
- Van Walwijk, Martijn. *Expanding international collaboration*. IEA Advanced Vehicle EV 2012 VÉ Conference & Trade Show, Montreal, Canada. October 23–26, 2012.
- Zhou, Y.; A. Vyas; D.J. Santini. *Tracking National Household Vehicle Usage by Vehicle Type, Age and Area In Support of Market Assessments for Plug-in Electric Vehicles.* Paper TRB12-4348. Presented at the Transportation Research Board Meeting, Washington, DC, U.S.A., January 2012.

IA-HEV publications during the third term, 2004–2009

- *Annual report 2004 – Final report for phase 2. Progress towards sustainable transportation.* Report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2004. Angers, France. March 2005.
- *Hybrid and electric vehicles 2006. Past – present – future. Progress towards sustainable transportation*. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2005. Angers, France. February 2006.
- *Hybrid and electric vehicles. The electric drive takes off.* Progress towards sustainable transportation. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2006. Angers, France. February 2007.
- *Hybrid and electric vehicles. The electric drive gains momentum.* Progress towards sustainable transportation. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2007. Angers, France. March 2008.
- *Hybrid and electric vehicles. The electric drive establishes a market foothold.* Progress towards sustainable transportation. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2008. Angers, France. February 2009.
- *IA-HEV electronic newsletter.*

  2005, issued in January, May, and November.

  2006, issued in September.

  2007, issued in March and November.

  2008, issued in May and October.

  2009, issued in May and October.
- Five press releases to announce the *IA-HEV clean vehicle awards*.
- Conte, Fiorentino Valerio; François Badin; Patrick Debal; Mats Alaküla. *Components for hybrid vehicles: results of the IEA Annex VII "Hybrid vehicle" phase III.* Proceedings of EVS-22, Yokohama, Japan. October 23–28, 2006.
- Conte, Fiorentino Valerio; François Badin; Stefan Smets; Dan J. Santini; Arie Brouwer. *The IEA Annex VII "Hybrid vehicle" phase III experience*. Proceedings of EVS-23, Anaheim, USA. December 2–5, 2007.
- Dorda, Andreas. *IEA striving for fuel cells in vehicles.* IA-HEV Annex XIII. Proceedings of EVS-22, Yokohama, Japan. October 23–28, 2006.

- Dorda, Andreas; Bernhard Egger. *New Annex XIII: "Fuel cells for vehicles".* Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30–June 01, 2007.
- Dorda, Andreas; Bernhard Egger. *Worldwide Promotion and Development of Fuel Cell Vehicles*. Proceedings of EVS-24, Stavanger, Norway. May 13–16, 2009.
- Kleindienst Muntwyler, Sigrid. *Learning from successful market introduction programmes for clean city vehicles.* Proceedings of EET-2004, Estoril, Portugal. March 17–20, 2004.
- Kleindienst Muntwyler, *Sigrid. Market Introduction of Fuel Cell Vehicles: Lessons Learned by EV-, HEV- and Alternative Fuel Vehicles Promotion Programmes.* Proceedings of EVS-21, Monaco. April 2–6, 2005.
- Kleindienst Muntwyler, Sigrid. *Market deployment of hybrid and electric vehicles: Lessons learned.* Proceedings of EVS-22, Yokohama, Japan. October 23–28, 2006.
- Kleindienst Muntwyler, Sigrid. *Market deployment of hybrid and electric vehicles: Lessons learned*. Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30–June 01, 2007.
- Kleindienst Muntwyler, Sigrid. *Market deployment of hybrid and electric vehicles: Lessons learned.* Proceedings of EVS-23, Anaheim, USA. December 2–5, 2007.
- Kleindienst Muntwyler, Sigrid; Tom Turrentine. *Lessons Learned from the Market Introduction of Electric Vehicles.* Proceedings International Advanced Mobility Forum, Geneva, Switzerland, March 11–13, 2008.
- Laurikko, Juhani. *International Cooperation for Information Exchange on Electric Vehicle Technologies and Programmes – Annex I of IEA Implementing Agreement for Hybrid and Electric Vehicles*. Proceedings of EVS-21, Monaco. April 2–6, 2005.
- Muntwyler, Urs. *The IEA Hybrid and Electric Vehicle Agreement – Achievements of phase 2 and plans for phase 3*. Proceedings of EVS-21, Monaco. April 2–6, 2005.
- Muntwyler, Urs. *Into the focus of the public and the politics – The 3rd phase of the Hybrid and Electric Vehicles Implementing Agreement of the International Energy Agency*. Proceedings of EVS-22, Yokohama, Japan. October 23–28, 2006.
- Muntwyler, Urs. *Politics and sustainable transportation – The Hybrid & Electric Vehicles Implementing Agreement of the International Energy Agency.* Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30–June 01, 2007.
- Muntwyler, Urs. *Politics and sustainable transportation – The Hybrid & Electric Vehicles Implementing Agreement of the International Energy Agency.* Proceedings of EVS-23, Anaheim, USA. December 2–5, 2007.
- Muntwyler, Urs. *The Future of the Transportation is Electric and Solar.* Proceedings of EVS-24, Stavanger, Norway. May 13–16, 2009.
- Passier, Gerben; Fiorentino Valerio Conte; Stefan Smets; François Badin; Arie Brouwer; Mats Alaküla; Dan Santini. *Status overview of hybrid and electric vehicle technology (2007)*. Final report phase III, Annex VII, IA-HEV, IEA. December 6, 2007.
- Schwegler, Urs. *Electric Two Wheelers as a new IEA Task Force.* Proceedings of EVS-21, Monaco. April 2–6, 2005.
- Smets, Stefan. *Overview of Battery Technology for HEV.* (IA-HEV Annex VII – Hybrid vehicles.) Global Powertrain Congress, Novi, Michigan, USA. September 19–21, 2006.

- Smets, Stefan; Dan Santini; Valerio Conte; Thierry Brincourt; François Badin; Arie Brouwer; Robert van Mieghem. *Trends in Energy Storage Systems for HEVs*. Results of IA-HEV Annex VII. Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30–June 01, 2007.
- Thibodeau, Charles. *The International Energy Agency's Implementing Agreement on Hybrid and Electric Vehicles*. PHEV 2007 conference, Winnipeg, Canada. November 2, 2007.
- Van Walwijk, Martijn. *Outlook for hybrid and electric vehicles.* Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30–June 01, 2007.
- Vergels, Frédéric; Urs Schwegler. *Annex XI on electric cycles from the International Energy Agency Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes*. Proceedings of EVS-22, Yokohama, Japan. October 23–28, 2006.
- Vergels, Frédéric; Urs Schwegler. *Annex XI on electric cycles.* Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30–June 01, 2007.
- Winkel, Rob; Robert van Mieghem; Dan Santini; Mark Duvall; Valerio Conte; Mats Alaküla; François Badin; Cyriacus Bleis; Arie Brouwer; Patrick Debal. *Global prospects of plug-in hybrids.* Results of IA-HEV Annex VII. Proceedings of EVS-22, Yokohama, Japan. October 23–28, 2006.

Major IA-HEV publications during the second term, 2000–2004

- IEA Hybrid and Electric Vehicle Implementing Agreement, *Progress Towards Sustainable Transportation – Report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2000*, Ottawa, Canada, 2001.
- IEA Hybrid and Electric Vehicle Implementing Agreement, *Progress Towards Sustainable Transportation – Report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2001*, Ottawa, Canada, 2002.
- IEA Hybrid and Electric Vehicle Implementing Agreement, *Progress Towards Sustainable Transportation – Report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2002*, Ottawa, Canada, 2003.
- Frans Koch, *The IEA Agreement – Lessons Learned about Hybrid and Electric Vehicles*, Proceedings of EVS-17, Montreal, Canada, October 2000.
- Victor Hacker, *Start-up of a New Annex "Electrochemical Power Sources and Energy Storage Systems" in the Implementing Agreement Hybrid & Electric Vehicles of the International Energy Agency*, Proceedings of EVS-17, Montreal, Canada, October 2000.
- Frans Koch, Urs Muntwyler, Stephane Biscaglia, *Renewable Primary Energy for Hybrid, Fuel Cell and Electric Vehicles*, Proceedings of EVS-18, Berlin, Germany, October 2001.
- Urs Muntwyler, Sigrid Kleindienst, *Some Observations Concerning the Energy Consumption of Electric Vehicles in Real Traffic Conditions*, Proceedings of EVS-18, Berlin, Germany, October 2001.
- Tomohiko Ikeya, Ken-ichi Takahashi, Kojiro Miyake, *International Cooperation for Information Exchange on Electric Vehicle Technologies and Programmes at Annex I of Implementing Agreement for Hybrid and Electric Vehicles in IEA*, Proceedings of EVS-18, Berlin, Germany, October 2001.

- Sigrid Kleindienst Muntwyler, *Annex VIII “Deployment Strategies for Hybrid, Electric and Alternative Fuel Vehicles” of the IEA Implementing Agreement “Hybrid & Electric Vehicles”*, Proceedings of EVS-18, Berlin, Germany, October 2001.
- Urs Muntwyler, Frans Koch, *Sustainable Transport - RE Supply Options and Resource Potential for Transportation*, RE Focus, Kidlington, UK, July/August 2002.
- Sigrid Kleindienst Muntwyler, *Government Deployment Strategies for Hybrid, Electric and Alternative Vehicles Examined*, Proceedings of EVS-19, Busan, Korea, October 2002.
- Rob Winkel, Richard Smokers, Robert Kost, Terry Penney, Kenji Morita, Peter Coenen, David Bauner, François Badin, *Annex VII “Hybrid Vehicles” of the IEA Implementing Agreement “Hybrid & Electric Vehicles”*, Proceedings of EVS-19, Busan, Korea, October 2002.
- Nils Stelzer, *IEA HEV Implementing Agreement Annex X Electrochemical Power Sources and Energy Storage Systems for Electric and Hybrid Vehicles*, Proceedings of EVS-19, Busan, Korea, October 2002.
- Toru Nakatsu, Tomohiko Ikeya, Sari Nobell, *International Cooperation for Information Exchange on Electric Vehicle Technologies and Programmes of Annex I of IEA Implementing Agreement for Hybrid and Electric Vehicles*, Proceedings of EVS-19, Busan, Korea, October 2002.
- Sigrid Kleindienst Muntwyler, *Market Introduction Policy for Clean Vehicle Technologies*, Proceedings of EVS-20, Long Beach, CA, USA, November 2003.
- Sigrid Kleindienst Muntwyler, *Learning from Successful Market Introduction Programs for Clean City Vehicles*, Proceedings of the European Electric-Drive Transportation Conference, Estoril, Portugal, March 2004.
- Urs Muntwyler, Frans Koch, *International Energy Agency prepares third phase of its Hybrid and Electric Vehicle Agreement*, Proceedings of the European Electric-Drive Transportation Conference, Estoril, Portugal, March 2004.
- Frans Koch, *The IEA Hybrid and Electric Vehicle Agreement*, Windsor Workshop, Toronto, Canada, June 2004.
- Frans Koch, *Deployment Strategies for Clean Vehicles and Fuels (Annex 8)*, Windsor Workshop, Toronto, Canada, June 2004.
- IA-HEV *Newsletter*, 2000–2003.
- IA-HEV *website*: www.ieahev.org

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

References

[1] Kraftfahrtechnisches Taschenbuch. 25. Auflage. Robert Bosch GmbH, Plochingen, Germany. 2003.

[2] Dubbel - Taschenbuch für den Maschinenbau. 14. Auflage. Springer-Verlag Berlin, Heidelberg, New York. 1981.

[3] Walwijk, M. van; M. Bückmann; W.P. Troelstra; P.A.J. Achten. Distribution and use. Volume 2 of the Automotive Fuels Survey, published by IEA/AFIS (Automotive Fuels Information Service), on behalf of the IEA Implementing Agreement on Advanced Motor Fuels. Breda, the Netherlands. December 1996.

Glossary

This glossary of terms related to hybrid and electric vehicles also includes information on the "competition" to the electric drive, because plug-in hybrid electric vehicles illustrate the many ways that electric and conventional drives may be combined, including multiple fuel possibilities for the conventional drive.

Advanced Technology Partial Zero Emission Vehicle (AT-PZEV)

As defined by the California Air Resources Board in a regulatory incentive system, a vehicle that uses electric drive components that should ultimately help industry introduce ZEVs such as EVs or FCVs.

All-electric range (AER)

This is a term used by CARB which has legal meaning related to a requirement that a PHEV be able to operate electrically until a specified set of conditions is no longer met. Within CARB regulations as of 2007, a credit system within their LEV regulations existed for PHEVs with 10 (16) or more miles (km) of AER.

Ampere

The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} Newton per meter of length. The ampere unit is symbolized by "A".

Ampere-hour capacity

The quantity of electric charge measured in ampere-hours (Ah) that may be delivered by a cell or battery under specified conditions. One ampere-hour is the electric charge transferred by a steady current of one ampere for one hour. In EV applications, typical conditions involve a specific ambient temperature and a discharge time of 1 or 3 hours: in these cases the capacity is expressed as C_1 or C_3 (see also "Rated capacity", "Installed capacity", "Energy capacity").

Ampere-hour efficiency

The ratio of the output of a secondary cell or battery, measured in ampere-hours, to the input required to restore the initial state of charge, under specified conditions (also coulombic efficiency). It is not dependent on the change of voltage during charge and discharge.

Battery cell

A primary cell delivers electric current as the result of an electrochemical reaction that is not efficiently reversible, so the cell cannot be recharged efficiently. A secondary cell is an electrolytic cell for generating electric energy, in which the cell, after being discharged, may be restored to a charged condition by sending a current through it in the direction opposite to that of the discharging current.

Battery module

A group of interconnected electrochemical cells in a series and/or parallel arrangement, physically contained in an enclosure as a single unit, constituting a direct-current voltage source used to store electrical energy as chemical energy (charge) and to later convert chemical energy directly into electric energy (discharge). Electrochemical cells are electrically interconnected in an appropriate series/parallel arrangement to provide the module's required operating voltage and current levels. In common usage, the term "battery" is often also applied to a single cell. However, use of "battery cell" is recommended when discussing a single cell.

Battery pack

A completely functional system that includes battery modules, battery support systems, and battery-specific controls. It may also be a combination of one or more battery modules, possibly with an added cooling system, and very likely with an added control system. A battery pack is the final assembly used to store and discharge electrical energy in a HEV, PHEV, or EV.

Battery round-trip efficiency

The ratio of the electrical output of a secondary cell, battery module, or battery pack on discharge to the electrical input required to restore it to the initial state of charge under specified conditions.

Battery Electric Vehicle (BEV)

See electric vehicle (EV).

Battery State Of Charge (SOC)

The available capacity in a battery expressed as a percentage of rated nominal capacity.

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.

References

The main references used to produce this glossary are listed here.

[1] *Advanced Electrotechnical Vocabulary* - Chapter 111 - Physics and chemistry - Section 111/02: Electrochemical Concepts. Edition 1984.

[2] *Draft Document of Battery Vocabulary* - IEC - prEN 60050-486-1994.

[3] ISO 1176 - *Road vehicles - Masses - Vocabulary and codes.* 1990.

[4] *Handbook for Battery Energy Storage Photovoltaic Power Systems.* DOE - SAN-2192-T1. 1979. Pages 1-1 to 1-6.

[5] D. Linden. *Handbook of Batteries and Fuel Cells.* 1st Edition, 1985. Appendix A: Definitions.

[6] *Pathways to Electric Transportation: A compendium of Electric Transportation projects in the United States.* November 1994. ‘Electric Vehicle Glossary of terms’.

[7] E. H. Wakefield. *History of The Electric Automobile.* 1994. Glossary pages 517-527.

[8] E. R. Cohen and P. Giacomo. *Symbols, Units, Nomenclature and Fundamental Constants in Physics.* Physica, 146A, 1987, pages 1 - 68.

[9] *Unità di misura e simboli letterali da usare in elettrotecnica.* Italian Standards, CEI 24-1, 1986.

[10] D. Linden. *Handbook of Batteries.* 2nd Edition, 1994. Appendix A: Definitions.

[11] L. E. Unnewehr and S. A. Nasar. *Electric Vehicle Technology.* John Wiley & sons, 1982.

[12] *ABCs of Alternative Fuel Vehicles.* Southern California Edison, April 1996, 3rd Ed.

[13] California Environmental Protection Agency Air Resources Board. *Staff Report: Initial Statement of Reasons. 2008 Proposed Amendments to the California Zero Emission Vehicle Program Regulations.* Sacramento CA, February 8, 2008.

[14] Tate, E.D.; M. O. Harpster and P. J. Savagian. *The Electrification of the Automobile: From Conventional Hybrid to Plug-in Hybrids, to Extended Range Electric Vehicles.* Draft SAE 2008-01-xxxx. Warrendale, MI.

[15] Smokers et al. *Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars.* Final Report. TNO Science and Industry Automotive business unit, Delft, Netherlands. October 31, 2006.

[16] Gaines et al. *Sorting Through the Many Total-Energy-Cycle Pathways Possible with Early Plug-In Hybrids.* Proceedings of the Electric Vehicle Symposium 23, Anaheim CA. December 2007.

[17] http://www.extraenergy.org. January 15, 2008.

[18] United Nations. *Uniform provisions concerning the approval of vehicles with regard to the emission of pollutants according to engine fuel requirements.* UN Regulation No. 83, revision 3, 14 June 2005.

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)
AER	All-Electric Range
AFV	Alternative Fuel Vehicle
AGV	Automatic Guided Vehicle
Ah	Ampere-hour
AIM	Asynchronous Induction Machine
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)
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)
EDV	Electric Drive Vehicle
EET	European Ele-Drive Transportation Conference
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)
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 (10^9 tons)
GTL	Gas-to-liquid (fuel)
GVW	Gross Vehicle Weight
G2V	Grid-to-Vehicle
h	hour
HCCI	Homogeneous Charge Compression Ignition
HEV	Hybrid Electric Vehicle
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)
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
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
N_2O	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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