IEA INTERNATIONAL ENERGY AGENCY

HYBRID & ELECTRIC VEHICLE IMPLEMENTING AGREEMENT

IA-HEV

Hybrid and Electric Vehicles

THE ELECTRIC DRIVE ACCELERATES

2014

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International Energy Agency

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

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IA-HEV, formally known as the Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes, functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of IA-HEV do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

Cover Photo: The ZOE, Renault's fourth electric vehicle model, went on sale in mid-2013. It accounted for 40% of the European EV market that year, with sales just over 10,000 units. (Sources: http://evobsession.com/renault-zoe-sees-10000-sales-1st-year/ and http://www.autoexpress.co.uk/renault/zoe)

The Electric Drive Accelerates

Cover designer: Larisa Blyudaya, Argonne National Laboratory

International Energy Agency

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

Annual Report Prepared by the Executive Committee
as Part of Task 1 over the Year 2013

Hybrid and Electric Vehicles

The Electric Drive Accelerates

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Report Structure

This report consists of four main parts. Part A, "About IA-HEV," describes the Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV), its activities, and its plans for the coming years. The Chairperson's message in chapter 1 includes a summary of IA-HEV activities in 2013, 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 (H&EVs).

A general picture of H&EVs around the globe is painted in Part C, "H&EVs Worldwide." The first chapter (14) in this section gives the most recently available H&EV statistical information from all 18 member countries. More detailed information on H&EV activities in each IA-HEV member country is presented in chapters 15–32.

Finally, Part D gives practical information related to H&EVs and the Agreement, including a list of IA-HEV publications, definitions of vehicle categories, conversion factors for H&EV-related units, abbreviations, and contact information for the IA-HEV Executive Committee and Task Operating Agents.

The IA-HEV Annual Report series utilize a particular set of terms when referring to the different types of fully and partially electric powertrain technologies. These include the all-battery electric vehicle (EV), hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), and fuel cell vehicle (FCV). In the case of EVs, the synonymous term battery electric vehicle (BEV) is also used. In addition, occasionally the more general term plug-in electric vehicle (PEV) is used. Finally, in the case of FCVs, there exists the equivalent term fuel cell electric vehicle (FCEV). Please refer to the "Vehicle Categories" section for an explanation of these terms.

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1 Chairperson's Message 2014

The Implementing Agreement (IA) on Hybrid and Electric Vehicles (HEVs) is one of the roughly 40 different IAs of the International Energy Agency (IEA) and is now 20 years old. Over the last 20 years, the focus of energy supply has experienced a fundamental change. Energy security and the reduction of air pollution, along with energy supply, are the key issues today. Greenhouse gas emissions and their impact on the Earth's atmosphere are also discussed extensively. Combating climate change has hence become an important issue for the work of the IEA. Through its aptly named roadmaps, the IEA provides researchers, decision makers, and the interested public with sound background information on energy technology framed within the context of global warming (Figure 1.1).

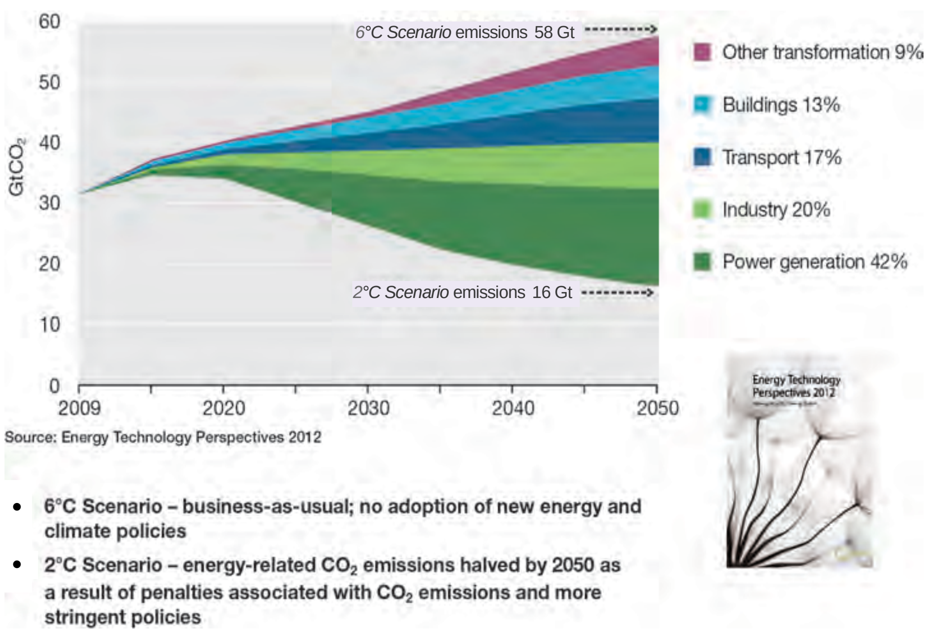

Fig.1.1 Key technologies for reducing global carbon dioxide (CO_2) emissions.

1.1 Strong Growth in the Car Market for the Last 20 Years

In 1995, the first year of our IEA IA-HEV, the world's annual production of passenger cars was 37 million vehicles (Automobilrevue Nr. 17/ 24.4. 2014). In 2013, annual production had increased by 83% to 67.8 million cars. In 2020, when the next 5-year program of the IA-HEV ends, the number of passenger cars produced will have doubled in 25years. This positive growth trend will continue (IEA Roadmap 2009), and production of more than 160 million passenger cars is expected by 2050. This huge growth is driven by demand in new markets, such as in China and India. It is impossible to balance this growth with production of more efficient vehicles. Rather, the world needs a change in paradigm: a new drivetrain to replace combustion engines, for which the solution is the electric motor powered with electricity from renewable energy sources.

1.2 Clean Electricity as a Precondition for the Breakthrough of Electric Cars

New renewable energy sources — especially wind and photovoltaic (PV) — provide electricity production with a new push. Passenger cars with an electric drivetrain fed by clean electricity no longer contribute to local, regional, and global emissions. Moreover, electric vehicles (EVs) using electricity produced from wind — or, even better, PV — have an unbeatable energy/surface ratio which is more than 50 times better than that of any biofuel. But even more important for potential buyers of EVs is that everyone can now produce his or her own energy from the rooftop (Figure 1.2) and can run the car with electricity from his or her own production. The ability for consumers to control these two levers can be an important driver in the sales process.

Fig. 1.2 Solar cars attached to a "solar energy station" during the solar car race "Tour de Sol 86" in Switzerland in 1986. This concept has quickly developed to grid-connected PV installations or the combination of wind turbines and electric cars.

1.3 The Electric Drivetrain Made Its Breakthrough in the Last 20 Years

"Zero emissions" has been an important driver for electric vehicles for the last 20 years. Fleet tests in Rügen (Germany), La Rochelle (France), Mendrisio (Switzerland), and elsewhere demonstrated the feasibility of EVs for daily use. New models from U.S. car producers like the General Motors' "EV1," the Ford Motor Company's "Ecostar," and others have attracted a massive level of interest on the part of politicians, the media, and the public. In Europe, it was mainly French car producers who launched EV models into the market; examples are the Peugeot 106, Citroen AX and Saxo, and the Renault Clio. Yet, after the initial "hype," the general interest in EVs gradually decreased, which was also reflected in the decline (from 15 to 8) of IEA member countries participating in the IA-HEV. One of the reasons may have been the CO_2 emissions of EVs, which strongly depends on the electricity mix.

With the "hybrid" Prius car, first introduced in 1996, the Japanese car producer Toyota Motor Corporation realized a new kind of electric car concept. Consequently, the IA-HEVs reflected the launch of a new task on "hybrid vehicles" in 1998 and now address all three vehicle concepts (i.e., battery electric vehicles [BEVs], plug-in hybrids [PHVs], and hybrid cars). Hybrid cars are now popular, and many car producers offer such models. With the launch of new BEVs and PHVs with lithium batteries, these sales numbers rise quickly, as well. New kinds of EVs (e.g., the electric two-wheelers) are very popular, especially in European countries, but are also popular in Asia, especially in China. With this renaissance of the electric car, the number of member countries participating in the IA-HEVs has now reached 18.

1.4 The Electric Drivetrain Will Change the Automotive World

Transport is responsible for 22% of global CO_2 emissions (Figure 1.3). Car sales — and hence, emissions — will continue to increase, driven by the strong demand in countries like China and India. One solution to control CO_2 emissions from cars is offered by combining electric drivetrains and use of electricity (to recharge the vehicles) from new renewable energy sources. Transforming production away from cars with predominantly "combustion engines" to those having electric drivetrains represents a paradigm shift. The transition of associated industrial processes will require decades to implement and presents a tremendous challenge to both the automobile industry and society.

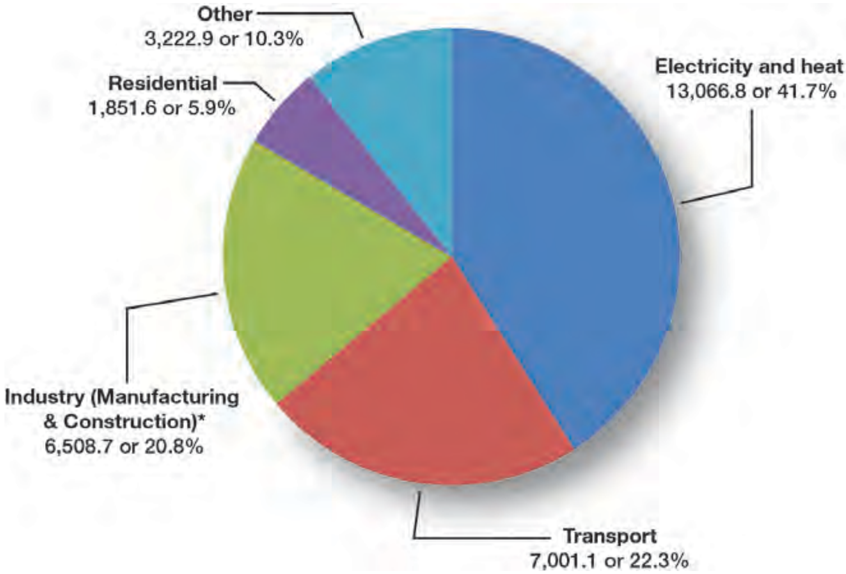

Fig. 1.3 World CO_2 emissions by sector. (Note: Total percentages do not sum to 100% because of rounding and categories used.) The total CO_2 emissions are 31.3 Gt CO_2 (2011). Electricity/heat generation and transport make up almost two-thirds of global emissions. This proportion has increased from one-half since 1971. (Source: IEA[1])

*Note that there is some uncertainty in how this sector is defined.

1.5 The Electric Car as Part of an Integrated Energy System

Shifting from burning fossil fuels to using electricity from renewable energy sources, electric car innovation is poised to make an important contribution to reducing future CO_2 emissions. With the strong growth of new renewable energy sources, the electric car is also perceived by many specialists as a possible means to balance the electric grid. The new renewable energy sources (mainly wind and PV) have to be balanced in order for the electric grid to remain stable. Stabilization, in turn, can be realized through storage by demand-side management (Figure 1.4). Electric vehicles with their batteries are perfect for a short-term balance of the grid. EVs can, therefore, be important in countries with a high share of new renewable electricity production. This potential is not yet in use and will be a topic of investigation for many task groups in the future.

[1] http://www.iea.org/publications/freepublications/publication/CO2EmissionsFromFuelCombustionHighlights2013.pdf

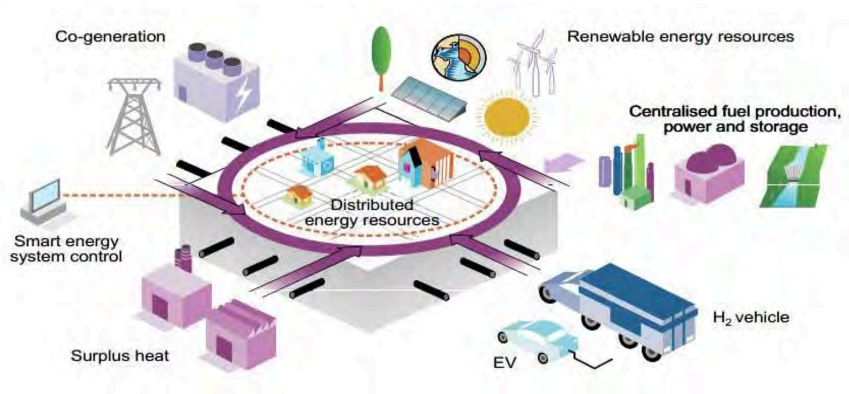

Fig. 1.4 EVs: part of an integrated energy system. (IEA 2013)

1.6 Avenues for the Next 20 Years (until 2035)

It is projected that in 2035, high numbers of hybrid cars will still be on the roads; however, increasingly at that time, BEVS will also be on the market. The future will invite car component producers to open plants for the production of electric drivetrains. Huge battery factories and significant amounts of new electricity produced in a clean way (i.e., from renewables) will be needed. Installation of charging outlets for EVs in private homes and public charging places will offer new business fields. Recycling of EVs can (if organized in a compelling way) improve the balance of "grey energy,"[2] present an interesting business opportunity to entrepreneurs, and attract new companies. Countries will have to remodel their taxation systems for cars, as currently a tax on gasoline often covers part of the infrastructure costs for roads, highways, and other relevant infrastructure.

1.7 IEA Scenario for 2050: Electrification of Drivetrains in All Passenger Cars on the Market

The IEA developed a roadmap that aims for drivetrain electrification (full or partial) of all passenger car sales by 2050 (see the IEA IA-HEV 2011 annual report; also Figure 1.5). Reaching the IEA goal of transforming the automotive industry such that it can offer pure EVs by 2050 so as to lower CO_2 emissions by 50% is still far away, and its implementation needs international efforts. If we project the IA-HEV 20 years into the future from now, we will likely be half of the way on this track. Today, the number of IEA member countries contributing to the IA-HEV is at a new maximum. Yet, the introduction of electric vehicles into the global market and integration in a new sustainable energy system would be smoother if nationwide activities at the country scale are shared and combined. We therefore invited several

[2] Grey energy is the energy hidden in a product (i.e., the amount of energy required to extract that product from nature, or to cultivate, manufacture, package and transport it).

other countries to join our IA-HEV, such as China, Columbia, and others. The implementation of the IEA goal for 2050 also draws on the support of international policymakers. As an example, in 2013, the "Green Party" in Switzerland announced "pure electric individual mobility" as a political goal for 2050.

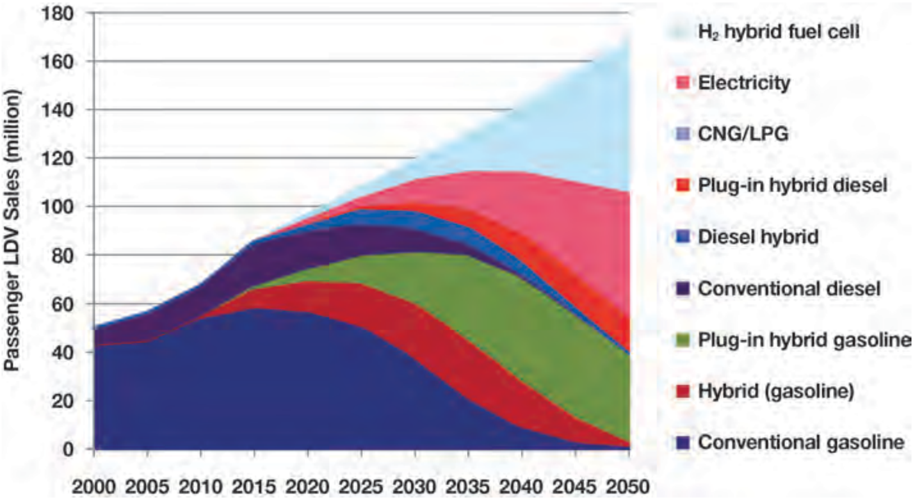

Fig. 1.5 IEA Roadmap: 2050 all-electric and strong growth in the production numbers of cars.

1.8 Managing the IA-HEV 1995–2014

The management of the IA-HEV is a very lean process. All of the work is performed by our country and the task experts, together with our secretary, Mr. Martijn van Walwijk. This organization structure is able to sustain low costs but may face difficulties if member countries do not see the benefit of financially contributing. As the Chair of the IA-HEV since 1999, I thank all of our members of the Executive Committee, the Strategic Committee, and the different heads of tasks for their valuable effort in bringing the IA-HEV forward over the last 20 years. I also thank our secretary, Mr. Martijn van Walwijk, and the custodian Verena Dubach from the Bern University of Applied Sciences (Berner Fachhochschule or BFH) for their invaluable and careful work. Let me also acknowledge the Swiss Federal Office of Energy (SFOE), which supports my work as the Chair of this important working group.

1.9 The Next Five-Year Program Starts in 2015

We are now preparing our new five-year working program, which has to be accepted by the Working Party on Energy End-Use Technologies (EUWP) of the IEA. With this new five-year working program, we hope to attract new member countries and even industrial sponsors.

1.10 Closing with a Personal Observation

In the last 20 years, electric vehicles have developed from the "pilot- and-demonstration" stage to a mass market product. I myself bought my first electric bike and the first grid-connected PV-installation 18 years ago. At that time, I was considered a "pioneer" when using such technologies. Today, (nearly) everyone in Switzerland has an electric bike, and the PV market has exploded.

Last year, I bought my first plug-in hybrid vehicle for daily commuting to work (I am directing the PV Laboratory at Bern University of Applied Sciences in Burgdorf, Switzerland [Figure 1.6]). My new plug-in hybrid car is more comfortable than any car I have driven in more than 30 years. What also makes driving a plug-in hybrid car in the city or on highways even more enjoyable and satisfying is producing the electricity for the car (and much more electricity) on two solar carports at home and at my place of work. This arrangement is not only much cheaper than purchasing gasoline but also much cleaner. My dream from 30 years ago — namely, to drive a clean solar car — has become reality. This is my most important personal achievement after 20 years of international collaboration and cooperation in the field of "hybrid and electric vehicles" and as the chair of the IA-HEV. And I am still perceived as a pioneer (especially by my students).

Fig. 1.6 Plug-in hybrid vehicle in front of the PV Laboratory at Bern University of Applied Sciences, Burgdorf, Switzerland.

My message for the future: I invite you also to personally experience that hybrid and electric vehicles offer a much better solution for many transportation duties. Join us, join the IA-HEV, and become a "pioneer of change"!

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April 2014

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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 participating at that time 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 – 2013

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

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

Note: Estonia joined in 2014, making it the 29th member.

With the evolution of the energy markets, the IEA mandate has broadened. It now focuses well beyond oil crisis management. Core agency objectives include improving energy efficiency, protecting the climate, enabling collaboration on energy technologies, and sharing its accumulated energy policy experience with the rest of the world. In 2013 alone, IEA held over three dozen workshops on wide-ranging topics, including energy storage technology, integration of carbon pricing with energy policies, and implications of climate change on the energy sector and opportunities for building resilience to its impacts.

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 phase-out 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 toward 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: (1) the Working Party on Fossil Fuels, (2) the Working Party on Renewable Energy Technologies, (3) the Working Party on Energy End-Use Technologies, and (4) the

Fusion Power Coordinating Committee. In addition, expert groups have been established to advise industry and stakeholders on electric power technologies; research and development (R&D), in the context of priority setting and evaluation; and oil and gas (Figure 2.1).

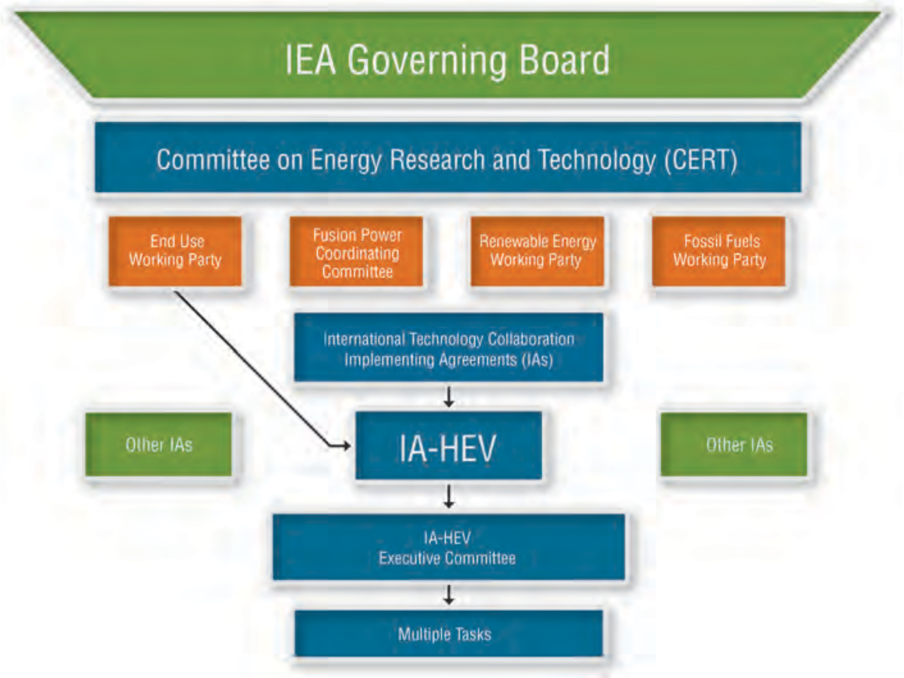

Fig. 2.1 The IEA energy technology network.

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, through multilateral technology initiatives known as Implementing Agreements (IAs). An IA may be created at any time, provided that at least two IEA members agree to work on it together. There are currently 40 IAs covering fossil fuels, renewable energy, efficient energy use (in buildings, energy, and transport), fusion power, electric power technologies, and technology assessment methodologies. One of these IAs is the Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). IA-HEV reports to the Working Party on Energy End-Use Technologies (EUWP). A full list of current IAs is available on the IEA website at www.iea.org.

IEA IAs 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 programs, and reduce costs.

Over three decades of experience have shown that these IAs 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" defines the minimum set of rights and obligations of participants in IEA IAs. Participants are welcomed from OECD member and OECD non-member countries, from the private sector, and from international organizations.

Participants in IAs fall into two categories: Contracting Parties and sponsors. As defined in Article 3 of the framework:

- *Contracting Parties* may 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, may be 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 IA.

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

The IA 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 validation of technical, environmental, and economic performance and on to final market deployment. Some IAs focus solely on information exchange and dissemination. The benefits of international co-operation on energy technologies in IAs 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
- An effective 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 IAs are the responsibility of each IA. The types of IA financing fall into three broad categories:

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

Effective dissemination of results and findings is an essential part of the mandate of each IA. 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 IAs. IA-HEV activities are regularly highlighted in the OPEN Bulletin. The IEA also issues the “Energy Technology Perspectives,” or ETP, which is an annual publication that presents updates on roadmaps for the technologies addressed by the IAs. The ETP has been published since 2006 and, most recently, in May 2014. These reports can be downloaded for a fee at www.iea.org/etp/.

In March 2008, the vice chairman for transport of the EUWP started a new initiative by organizing a Transport Contact Group (TCG) workshop for the transport-related IAs, 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 issues 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 and other vehicles. Today there exists a range of technologies available to address these problems — most notably hybrid and electric vehicles. A sound basis therefore exists for an IEA IA dedicated to developing and deploying these vehicles.

The IEA Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) was created in 1993 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) as of May 2014 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.

Compared to the automotive industry and certain research institutes, IA-HEV is relatively small, in the context of an organization. Nevertheless, IA-HEV is still playing an important role by (1) focusing on a target group of national and local governments and government-supported research organizations and (2) providing a forum for different countries to co-operate in joint research and information exchange activities. 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 governed 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 program. The actual work on hybrid and electric vehicles is done through a variety of different Tasks that are focused on specific topics. Each topic is addressed in a Task, which is managed by an Operating Agent (OA). (Before 2011, these task forces were called Annexes.) The work plan of a new Task is prepared by an interim Operating Agent (either on the OA’s own initiative or on request of the ExCo), and the work plan is then submitted for approval to the IA-HEV ExCo. The Tasks that were active during 2013 and in early 2014 are described in part B (chapters 3 through 13) of this report. The activities associated with hybrid and electric vehicles in individual 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 the second and third terms of its operation (Phase 2 and Phase 3), respectively. These are organized by task number. 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

Phase 2 of the 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 only for some market niches (such as neighborhood electric vehicles, small trucks for local deliveries, and 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 described 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 other 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 the most notable findings resulting from this task is 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 (deploying) 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 IAs: 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 marketplace 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 experiencing the same or worse air quality and traffic problems as cities in IEA countries. At the same time, innovative solutions and technologies were being worked out in some of these developing countries, and there was much 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 traveled to Bogotá to learn about the bus rapid transit system there, to construct a similar system in Dhaka.
- **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 that 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 coordinating the work of the fuel cell IA, 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 Phase 3 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 during Phase 3, with the others having concluded operation during Phase 3 or before. Phase 3 also witnessed 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, while 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 technology roadmap for electric and hybrid vehicles, as well as a move to interact more closely with different IAs of the International Energy Agency, in particular between the seven IAs containing 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, and information on non-IEA countries.)*
- Electrochemical Systems (Task 10)
- Electric Bicycles, Scooters, and Lightweight Vehicles (Task 11)
- HEVs and EVs in Mass Transport and Heavy-Duty Vehicles (Task 12)
- Market Aspects of Fuel Cell Electric Vehicles (Task 13)
- Market Deployment of Electric Vehicles (Task 14)
- Plug-in Hybrid Electric Vehicles (Task 15)

2.2.3 Description and Strategy for IA-HEV Phase 4, 2009–2015

Interest in HEVs, PHEVs, and EVs as a means to reduce energy consumption and emissions from road transport is increasing significantly worldwide. At the same time, many questions are still open regarding such issues as potential efficiency improvements, safety, durability, vehicle range, production potential, and the availability of raw materials for batteries, as well as issues associated with the 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 in order 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 ExCo prepared a Strategic Plan for a new phase of the Agreement, set to run from December 2009 until February 2015. In 2009, the Strategic Plan was presented to the IEA EUWP and to the IEA Committee on Energy Research and Technology (CERT), 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 Phase 4 (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. This is done by means of general studies, assessments, demonstrations, comparative evaluation of various options of application, market studies, technology evaluations, and identification of industrial opportunities, among others.
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 IAs (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. In all, it has approved eight new projects (Tasks) since 2010, including two new ones in November 2013. These projects include the following:

- Task 17 “System Optimization and Vehicle Integration” to study how EV system configurations (including vehicle components) could be optimized for enhanced overall EV performance.
- Task 18 “EV Ecosystems” to create a roadmap of the conditions required to support market growth needed for the mass adoption of EVs in cities.
- Task 19 “Life Cycle Assessment of EVs” to explore the sustainable manufacture and recycling of EVs.
- Task 20 “Quick Charging” to discuss the impacts and potential standards for EV quick charging.
- Task 21 “Accelerated Ageing Testing for Li-ion Batteries” for collaboration on such testing efforts.
- Task 22 “E-Mobility Business Models” to understand new revenue opportunities and ways to limit costs associated with EVs, recharging infrastructure, and associated links to energy systems.
- Task 23 “Light-Electric-Vehicle Parking and Charging Infrastructure.”
- Task 24 “Economic Impact Assessment of E-Mobility.”

The IA-HEV ExCo continuously monitors developments that are relevant for hybrid and electric vehicles in fields ranging from vehicle technologies to policy making and market introduction. Box 2.4 contains a list of potential new topics that might be addressed through the remainder of Phase 4. As developments warrant, the ExCo may start additional new Tasks in 2014 and 2015. 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, including smart grids
- Battery electric vehicles
- Drive cycles
- Test procedures
- Future energies for HEVs and EVs
- Lightweight constructions
- HEVs and EVs in mass transportation
- Market aspects of fuel cell electric vehicles
- HEVs and EVs for special applications
- HEVs and EVs in developing countries
- Testing standards and new vehicle concepts
- Impacts of HEVs and 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,” such as boats, light rail, and airplanes
- Standardization issues
- Deployment strategies for hybrid and electric vehicles
- Special electric vehicles (e.g., wheelchairs, one-person mobility)
- Electricity grid capacity issues
- Second life of batteries
- Cross-cutting technologies

In 2014, the IA-HEV ExCo will also prepare a strategic plan for a fifth term of operation, which will be submitted to the IEA CERT for approval. This Phase 5 will run from 2015 to 2020.

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3 Task 1 – Information Exchange

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 and best practices, as well as 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 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; and
- 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 (Electric 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 (Figure 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 IEA Desk Officer. Julie Perez serves as the Task 1 OA on behalf of the U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO).

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 IA-HEV 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 its 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 Task 1 experts' meetings had been conducted since the inception of the IA-HEV Task 1 in 1993. Other notable events in 2013 included the following:

- A Task 1 Information Exchange meeting was held in Barcelona in November during the larger 27th International Electric Vehicle Symposium and Exhibition (EVS-27),
- A 2012 IA-HEV annual report entitled *Hybrid and Electric Vehicles – The Electric Drive Gains Traction* was published, and
- Two IA-HEV e-newsletters *The Road Ahead* were issued (in January and October).

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

3.5 Further Work

Access to proprietary data and other “late-breaking” information will continue to be limited to participating members as an incentive 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 on the latest developments in hybrid and electric vehicles in their respective countries by 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 for the Operating Agent

For further information, please contact the Task 1 OA:

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4 Task 10 – Electrochemical Systems

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 this 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 focus of the task does not extend to the interface between the batteries themselves and the vehicle or circumstances of vehicular use, as those areas are covered by other tasks.

4.2 Goal and Objective

The goal of Task 10 is to advance the state of the art of battery and capacitor science and to address issues related to their uses in vehicles. All aspects of batteries and capacitors for vehicles are covered, ranging from basic electrochemistry to the testing of full systems.

The objective of Task 10 is to facilitate relevant information exchange among technical experts from the electrochemical power sources field. In contrast with 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 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.

Task 10 addresses selected topics through the use of focused working groups. Each working group meets once or twice to discuss a specific topic. Products from the working groups vary, depending on the nature of the discussions. The products 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 specific working group on the basis of their interest in the subject matter. As a result, each working group has unique members, and a country or an organization may participate in one or more working groups without making a multiyear commitment to attend every task-related meeting.

4.4 Results

From January 29 to 31, 2014, in Washington, D.C., the working group for Task 10 held a technical discussion on issues related to the safety of batteries in hybrid and electric vehicles. There were about 30 attendees from Europe, North America, and Asia who are affiliated with government agencies and laboratories, universities, the battery industry, and auto manufacturers. The 3-day meeting encompassed presentations and active discussions. The meeting concluded with a visit to the battery test facilities at a U.S. Navy laboratory located near Washington, D.C.

Items for discussion included the following:

- It is extremely important for the technical community to exchange information related to battery performance and safety — in a candid manner — on a regular basis. Such an information exchange will maximize the possibility for the technical, manufacturing, and regulatory communities to learn from past failures. It is important to avoid repeating the same mistakes.
- Many of the electric vehicle fires reported in the popular press did not start with or involve the vehicles' batteries. Some that did involve the batteries were caused by faulty wiring, not by the electrochemical cells.
- Incidents involving vehicles with batteries are reported more often and more widely than vehicle fires in conventional internal combustion engine vehicles.
- There can be a significant time delay (as much as three weeks) between the time when a battery is damaged and when a fire occurs. The possibility of such a delayed reaction requires that damaged batteries (inside or outside of a vehicle) be handled appropriately. Several agencies have published recommendations for the isolation of vehicles containing damaged batteries.
- There are significant concerns about how to deal with situations in which energy is "stranded" in a battery. These situations occur when a charged battery system is damaged in a way that it cannot be easily discharged. It can be easier to handle a battery that has burned up than one that is fully charged, with no way to discharge the stored energy.
- Internal short circuits that develop in a cell that has been in use remain a major concern. Many organizations are working to understand how these short circuits form, how they can be simulated in a controlled manner, how they can be detected before a cell fails in an unsafe manner, and how to mitigate the effects of a cell failing. The Operating Agent for Task 10 is working to organize a meeting to address these particular issues.
- The testing requirements for a battery and for a vehicle that contains a large battery vary significantly among different countries. Published standards and best design and manufacturing practices exist for some applications but are still under discussion and development for other applications.

- It is very hard to extinguish a fire that is associated with a large lithium-ion battery in thermal runaway; nevertheless, the application of water (or similar cooling techniques) can minimize the propagation of the fire from the battery to other components of the system. In a similar manner, cooling can prevent an external fire from spreading to the battery. In a limited experimental program, where a firefighter used water to extinguish a blaze, there were no concerns identified that were associated with high voltages.

4.5 Further Work

Planning for future workshops is under way. Workshops will focus on emerging topics that are highly relevant for the advancement of battery and capacitor technology. New developments in HEV and EV technologies and markets will impact the selection of future working group topics.

4.6 Contact Details for the Operating Agent

Individuals who are interested in helping to organize, host, or participate in a future working group meeting are urged to contact the Operating Agent and provide their specific topic(s) of interest.

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5 Task 15 – Plug-in Hybrid Electric Vehicles

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

5.1 Introduction

This study has focused on PHEVs rather than on "pure" all-electric vehicles (AEVs). PHEVs are capable of operating entirely on electric power for a limited number of km and then operating as hybrid electric vehicles (HEVs), using gasoline efficiently for the remainder of longer trips. The study examines PHEV powertrains with four separate designs. Two of these four are assigned the acronym "extended range electric vehicles" (EREVs) because they have enough battery pack power to allow all-electric operation in all driving conditions and even in the event of very hard acceleration. A variety of different battery power and energy levels are incorporated into the four different PHEV powertrain systems. A search of the results yields the least total cost of ownership (TCO) by powertrain type, and within that powertrain type, the least cost combination of battery pack power and energy.

5.2 Objectives

5.2.1 2008–2010

When the study was originally designed under Canadian management, the original work plan was rather ambitious. At the initial organizational meeting in 2008, four different topical subtasks were adopted under Task 15. These were as follows:

1. Advanced battery technologies and components,
2. Merits and policy issues,
3. Charging and grid issues, and
4. Marketability and impacts.

After some significant progress was made on these tasks in 2008 and 2009, a task extension and revision to the work plan was adopted during the transition of nations and operating agents. In addition, because of sustained high oil prices, the IEA IA-HEV membership began expanding, and support for new tasks emerged. In effect, some items within the subtask work intended in the 2008 plan became new tasks under the IEA IA-HEV management.

5.2.2 2011–2013

The remaining topical subtasks — redefined for a narrowed Task 15 focus — were:

1. Powertrain attributes and vehicle lifetime use costs and
2. Policy issues and marketability.

During the 2011–2013 time period, multiple country experts from Germany, France, and the United States met, exchanged views, and planned subtask research. Both Germany and France had participating country experts from two research organizations, while the United States provided two experts and the Operating Agent from one institution. France hosted two country expert meetings in 2011, and the United States hosted the final meeting in 2012. A subtask meeting with the Operating Agent and two German country experts was held in Switzerland, with IEA IA-HEV support, which also took place in 2011.

For subtask 1, country experts from France's IFP Energies Nouvelles and the United States' Argonne National Laboratory (Argonne) Center for Transportation Research conducted joint vehicle simulation/modeling research on powertrain attributes for multiple types of plug-in hybrids, with varying amounts of electric drive power and energy, as well as different powertrain configurations.[1] Country experts from France's IFP Energies Nouvelles, the Institute of Vehicle Concepts at the German aerospace center (DLR), and Argonne's Center for Transportation Research collaborated on the topic of lifetime vehicle use costs, incorporating selected cases from the vehicle and powertrain modelling results.[2] Subsequently, U.S. country experts simulated an expanded subset of some types of powertrains, focusing on those available in the United States.[3,4] From the time of approval of the modified work plan until Task 15 completion, 15 papers were completed with one or more participating country experts co-authoring each of the papers. Five presentations were delivered, and two supporting reports on battery technical attributes and costs

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[1] Da Costa, A., et al. (2012). *Fuel Consumption Potential of Different Plug-in Hybrid Vehicle Architectures in the European and American Contexts*. EVS26, Los Angeles, CA, May 6–9.

[2] Rousseau, A., et al. (2012). *Comparison of Energy Consumption and Costs of Different HEVs and PHEVs in European and American Context*. Presented at the European Electric Vehicle Congress, Brussels, Belgium, Nov. 19–22.

[3] Santini, D.J., et al. (2013). *Deploying Plug-in Electric Cars Which Are Used for Work: Compatibility of Varying Daily Patterns of Use with Four Electric Powertrain Architectures*. Paper 13-4925. Presented at Transportation Research Board 92nd Annual Meeting. Also appears as "Plug-in Electric Cars for Work Travel: Evaluation of Four Electric Powertrains." *Transportation Research Record: Alternative Fuels and Technologies*. 2385:53–60, 2013.

[4] Santini, D.J., et al. (2013). *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.

were produced. A workshop on Batteries in Extreme Temperatures was co-hosted under Task 10 leadership in October 2012.

5.3 Results

The final report for Phase 1 of Task 15 has been completed and was published in February, 2014. The report is available for download on the IA-HEV website and provides extensive details on the achievements and future of Task 15.

France, Germany, and the United States — the nations that had been actively participating at the close of Task 15 — agreed to conduct a second phase. Major recommendations from the Phase 1 report are to:

1. Make a comparison of American and German, component-by-component, vehicle cost estimates to be used for vehicle cost models;
2. Conduct several supplemental vehicle simulations by American and French modelers; and
3. Create more comprehensive total cost of ownership comparisons across all five plug-in vehicle powertrain types for both fuel prices and driving patterns in the United States and Europe.

One suggestion under the second recommendation is that simulation of parallel plug-in hybrid electric vehicles (PHEVs) be done with a greater range of peak battery pack electric power than was used in Phase 1. Another is that more configurations of the series hybrid range extender be investigated, taking into account the California Air Resources Board (CARB) battery electric vehicle (BEVx; BEV with auxiliary power unit [APU]) regulations and intentions. The additional series hybrid extended-range electric vehicle configurations would include a greater range of peak auxiliary power unit (APU) engine power than in the Phase 1 simulations, particularly by including some much lower power APU cases.

A Phase 2 planning meeting was held in March 2013 at DLR, focusing on one major recommendation: make a comparison of American and German, component-by-component, vehicle cost estimates to be used for vehicle cost models.

5.4 Further Work

Many of the participating country experts in Task 15 are interested in conducting another phase of the study of plug-in hybrid and extended-range electric vehicles. As noted, some of the topics that had been planned for coverage in the latest Task 15 phase have not been completed. Further, in many cases, the coverage of the topics that were addressed was limited and merits additional investigation. It is desirable to further scrutinize and cross check the financial viability comparisons. While the collective papers written cover the sensitivity of market potential to gasoline prices, battery pack costs, or infrastructure availability, there is no single paper that covers all three under a consistent methodological approach using the latest BatPaC methodology for battery costs. None of the Task 15 financial viability analyses have investigated regional variation in electricity prices, variation in residential and commercial electricity rates, nor voluntary consumer response to time-of-use rates.

The following topics have been suggested for the follow-on phase or “spin-off” into an additional task:

1. Conduct a systematic cost methodology comparison (multiple TCO models).
2. Compare full-function HEVs, PHEVs, and EREVs to advanced conventional powertrains (clean diesel, turbocharged direct injection petrol, CNG, other).
3. Study powertrain depreciation attributes and impact on vehicle lifetime use costs. In particular, determine whether batteries must be replaced during vehicle lifetime, or vehicle use patterns must be adapted to less capable packs, or both.
4. Using consistent methodologies, evaluate potential causes of increases in market(s) size, such as rising oil prices, lower battery pack costs, economical infrastructure adaptation, changes of consumer perception.
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 available lithium-ion battery chemistries could enable more lifetime cost-efficient micro HEV/PHEVs rather than promotion of use of lead-acid batteries supporting simple start/stop technology.
7. Examine whether a standard peak battery pack and electrical machine power level for both HEVs and PHEVs can be cost effective in spreading component costs across both HEV and PHEV platforms. If such a power level exists, simulations to date suggest that it is in the range of 30–60 kW for the size of car simulated in Task 15. In addition, simulate a PHEV with adequate power to run the US06 City and full US06 cycle all electrically to determine the minimum peak battery and motor kilowatts (kW) required to obtain the maximum PHEV credit under CARB regulations.
8. Simulate costs and fuel consumption for what CARB defines as a BEVx using the required control strategy and HEV range specified in CARB regulations. This vehicle type will be a series EREV according to the definition used in this study, although with a much less powerful engine and generator. Simulate an EREV spin-off of the BEVx with a control strategy that uses its small engine and generator essentially to avoid full battery pack depletion, recharging the battery pack much sooner than would be the case for a CARB BEVx and thus enabling use of the battery pack to climb mountain grades. In addition, add a much larger fuel tank to enable a range comparable to that of conventional gasoline vehicles.

9. Simulate plug-in versions of what are called “crossover” sport utility vehicles (SUVs), which are increasingly popular in the United States. Examine the benefits of increased battery pack space created by placement within the chassis below the passenger compartment and body in high seating position vehicles. Consider drag area “costs” in high-speed driving vs. pack space benefits for everyday metro area driving.
10. Critically review methods of computing the greenhouse gas (GHG) emissions that result when different assumptions about electric generation caused by various charging strategies for plug-in vehicles are employed.

The process of discovery within the study, as well as many developments outside of the study, led to the “further work” suggestions made here.

5.5 Contact Details for the Operating Agent

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6 Task 17 – System Optimization and Vehicle Integration

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

6.1 Introduction

This Task involves analyzing technology options for the optimization of electric vehicle (EV) components and drivetrain configurations (Figures 6.1 and 6.2) 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.

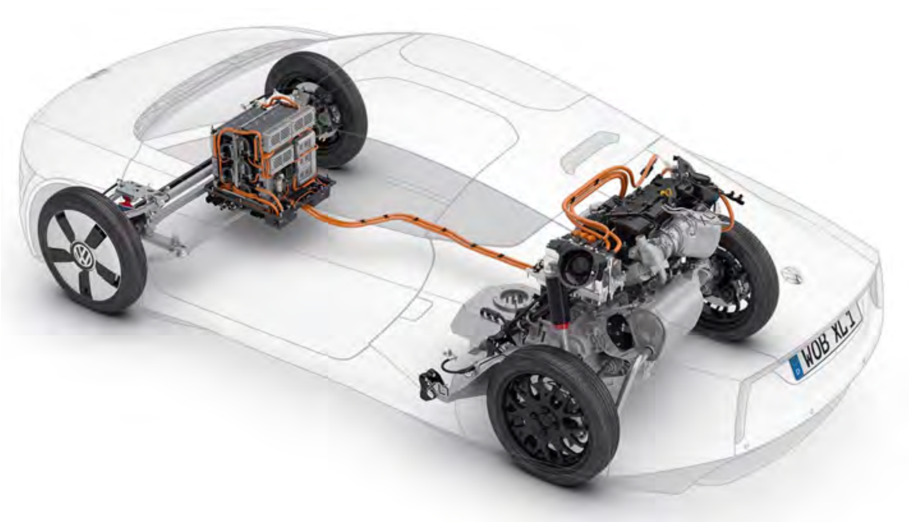

Fig. 6.1 VW XL1 drivetrain. (Image courtesy of VW)

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 (e.g., through increased efficiency in operation and production, alternative materials);
- 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) and electronic control concepts for range extenders;
- Configurations for energy storage systems and/or range extenders; and
- Drivetrain configurations (e.g., 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. 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 capabilities and fields of expertise of the participants and basically covered the monitoring and analysis of component development 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:** overview and comparison of selected current configurations of components in vehicles on the market.
- **Components — State of the Art/Prospects/Trends:** analysis of existing component technologies and their development potential and a cost assessment.
- **Vehicle Integration:** 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 Results

In response to studies that show heating and cooling the passenger cabin in vehicles significantly reduces the driving range of EVs, two workshops that addressed innovative thermal management for hybrid and electric vehicles took place in 2013. In the most critical case, heating the car in winter can lead to losses of up to 50% of the range. This creates the need for intelligent thermal and energy management systems. The latest meeting was held on October 2, 2013, at the Austrian Institute of Technology in Vienna, Austria. The workshop before was held in April 2013, at Argonne National Laboratory near Chicago, Illinois, United States of America.

Participants of the workshops discussed specific thermal management technologies, such as heat pumps, in combination with intelligent air management, which significantly increases the EV driving range at low temperatures. They explored innovations in such components as the electrical compressor and electrical coolant heater. Design and integration aspects were also treated. Phase-change materials (PCMs), which can store and then release large amounts of energy as they undergo phase transitions between liquid and solid states, could provide thermal storage that assists engine performance.

For example, the latent heat storage using PCM can provide heating capacity at the start of driving and serve as a buffer while driving. When used as a PCM evaporator, the technology can maintain the passenger cabin temperature in micro hybrids, the engines of which are designed to shut off automatically during a stop. For hybrids, recovering energy offers the ability to keep the engine off for longer periods, since the air-conditioning system is not required, which therefore increases fuel economy.

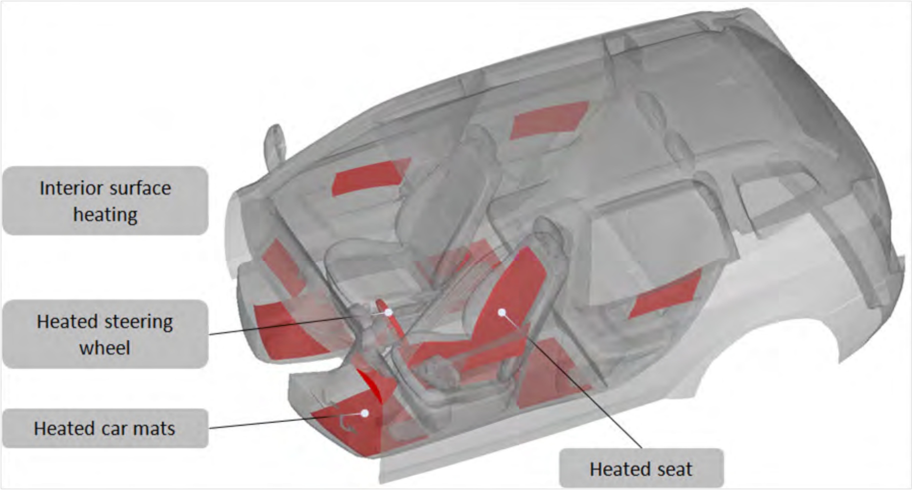

Fig. 6.2 Heatable surfaces and heated areas. (Image courtesy of qpunkt [http://qpunkt.at/])

6.5 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.

Two topics with high priority identified in the areas of system optimization and improvements in energy efficiency are:

1. **Decrease Weight:** integration of the energy storage system into the chassis and integration of the drivetrain into lightweight vehicles, with workshops in Switzerland and Austria, and
2. **Electronic/Electrical Architecture:** power electronics and electric energy management, with workshops in Germany and other locations to be determined.

Future workshops will focus on these topics, and information on state of the art, as well as the potential of technology improvements in these areas, will be covered in the vehicle integration section of the Task 17 report. Results from a study on the impacts of the vehicle's mass efficiency and fuel economy for different drivetrain configurations conducted by Argonne National Laboratory were already presented and discussed in a previous workshop and will be included in the report.

The contact details of the new Operating Agent leading this Task from the beginning of 2014 are provided in section 6.6.

6.6 Contact Details for the Operating Agent

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

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7

Task 18 – EV Ecosystems

Members: *Austria, Germany, Portugal, Spain, United Kingdom, United States*

7.1 Introduction

The focus of Task 18, Electric Vehicle (EV) Ecosystems, is to shape a global vision of the infrastructure required to support mass adoption of plug-in electric vehicles (PEVs) 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 PEV pilot programs and investigating the markets, technologies, and business models relative to PEVs 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 for Task 18 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 transportation 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. Task 18 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 10–20 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 challenges and opportunities in EV markets, technologies, and services.
3. **A Web portal of EV cities and ecosystems**, developed at the University of California, Davis, will provide a database of pioneering EV programs and connect international experts to facilitate policy exchange and problem solving.
4. **Conferences of pioneering EV cities and regions** will convene 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, 10–20 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 transportation 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 2014. 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 (United Kingdom) and Thomas Turrentine (United States) 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 (DOE) Vehicle Technologies Office (VTO), 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 fourth 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.

7.4.1 Foresight Workshops and Conferences

Six workshops on various topics have occurred to date in cities in the UK, Istanbul, Barcelona, United States (Los Angeles), Vienna, and Berlin, as summarized in Table 7.1.

Table 7.1 Completed Task 18 Workshops.

Special Topic	Location
The Future of Recharging Infrastructure	Newcastle, UK
Intelligent Transport Systems for EVs	Newcastle, UK
Open Architectures and Payment Systems for EVs	London, UK
International Policies and Programs to Support the Operation of EVs in Cities	Istanbul, Turkey
New Economic Opportunities and EV Business Models	Barcelona, Spain
World EV Cities and Ecosystems Conference	Los Angeles, United States
Future of Markets for Electric Vehicles	Vienna, Austria
Technologies and Infrastructure for Electric Vehicle Ecosystems	Berlin, Germany

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,[1] which is a partnership among IA-HEV Task 18 EV Ecosystems, Rocky Mountain Institute, IEA, Clinton Climate Change Initiative, and University of California at Davis. The web portal www.worldevcities.org (Figure 7.2) continues to add new cities and regions. Table 7.2 lists the cities currently shown on button 1, Visit Partner Cities, on the web portal.

1 http://www.ieahev.org/task-18-ev-ecosystems-on-the-move-from-business-models-in-barcelona-to-a-website-launch-in-los-angeles/?pg=2

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

Table 7.2 List of World EV Cities at www.worldevcities.org.

World EV Cities as of March 2014		
North America	• Los Angeles Region • Maui • Montreal • New York City	• Portland • Research Triangle, North Carolina • San Diego County
South America	• Santiago de Chile	
Europe	• Amsterdam • Barcelona • Berlin • Brabantstad • Copenhagen • Hamburg • Helsinki Region	• London • Northeast England • Northern Ireland • Oslo • Paris Region • Rotterdam • Stockholm
Asia	• Goto Islands, Nagasaki • Kanagawa • Shanghai • Shenzhen	

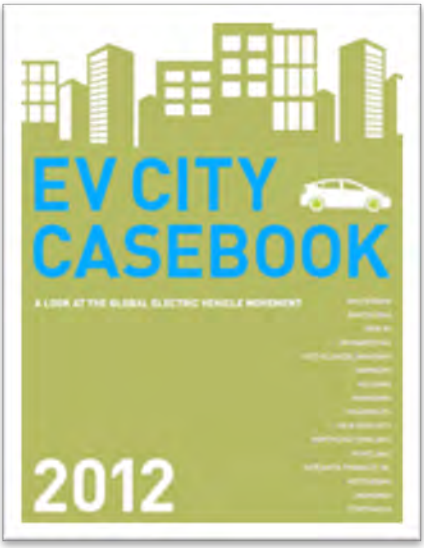

Fig. 7.3 *EV City Casebook* available at www.iea.org.

Along with the web portal, the *EV City Casebook* (Figure 7.3) was published in 2012, 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 the cities' EV goals, progress, policies, incentives, and lessons learned to date.

The purpose of the *EV City Casebook* 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.

7.4.3 EV City Casebook: Big Ideas Shaping the Future of Electric Mobility

A new *EV City Casebook* being published in 2014 will have a slightly different focus from the first edition. Instead of profiling the key activities in individual cities, it will highlight examples of transformative policies, technologies, projects, and business models. The concept is to profile 50 big ideas to showcase the most inspiring and innovative developments from around the world. An open call for nominations was launched in February 2014, and the new Casebook is planned to be published in autumn 2014.

7.5 How to Participate

Task 18 is now in its final year of operation and so is no longer accepting new members.

7.6 Contact Details for the Operating Agents

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8 Task 19 – Life Cycle Assessment of EVs

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

8.1 Introduction

Electric vehicles (EVs) provide many benefits compared with traditional internal combustion vehicles, such as improved powertrain efficiency, lower maintenance requirements, and zero tailpipe emissions. EVs have the potential to replace conventional vehicles, thereby contributing to the development of a sustainable transportation sector and reducing greenhouse gas (GHG) and particulate emissions worldwide. Task 19 examines, based on life-cycle analyses, the environmental effects of vehicles that have an electric drivetrain. The task began in 2012 and will continue through the end of 2014.

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

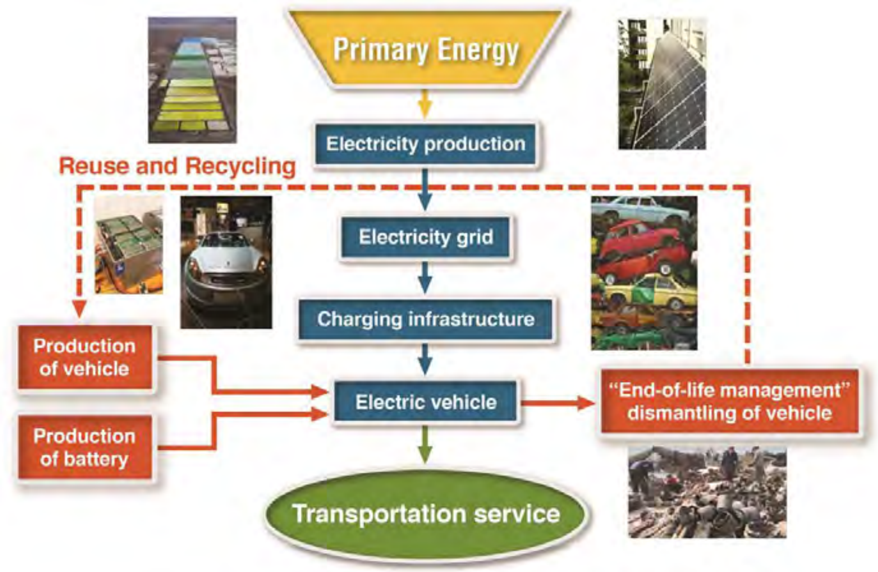

Fig. 8.1 Assessment of LCA aspects over the full value chain. The LCA includes three phases: production, operation, and end of life. The blue boxes are the elements of the operation phase of the electric vehicle. The red boxes comprise the production (at left) and dismantling phases (at right) of the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

8.2 Objectives

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

On the basis of the LCA activities conducted 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 increase the benefits and competitiveness of vehicles with an electric drivetrain.

The following topics will be addressed over the 3-year working period:

1. LCA methodology;
2. Overview of international LCA studies;
3. Parameters that influence 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; and
7. Demand for further research and development (R&D).

Task 19 considers the following propulsion systems and vehicles:

- 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
- Vehicles
  - Passenger cars
  - Light utility vehicles
  - Buses
  - Two-wheelers (motorcycles, electric bikes)
  - Forklift trucks

8.3 Working Method

Task 19 is a networking activity in which the results and experiences from national projects are examined and discussed on an international level and included in the IA-HEV LCA platform. Each participant contributes different topics to Task 19 on the basis of a work-sharing principle.

Task 19 members from the participating organizations will complete the following individual work packages:

1. LCA methodology (establishing the system boundaries, model recycling);
2. Overview of international studies about LCA of vehicles with an electric drivetrain;
3. LCA impact 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; and
12. Management and operation of Task 19.

The most important networking activity in this LCA platform is the five workshops held in different member countries. The objectives of these workshops is to involve the different stakeholders in the EV value chain. The workshops, which include technology policy experts and participants from industry and research organizations, provide an international forum for the exchange of information.

8.4 Results

Contributors to Task 19 compiled information from existing LCA analyses to provide a full picture of approaches to resource usage, recycling, and end-of-life disposal. This knowledge will help the EV-related industry and governments increase the benefits and competitiveness of EVs.

Task 19 established an international research platform for LCA and end-of-life management for EVs to increase the benefits and competitiveness of EVs. The platform is based on data from LCA activities in IA-HEV member countries. So far, three workshops have been conducted; the key results from each are presented here.

8.4.1 LCA Methodology and Case Studies of Electric Vehicles

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 scheduled to coincide with the 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 and/or drawbacks;
4. Discussion of best practices in LCA methodology as applied to EVs;
5. Establishment of the “international platform on LCA of EVs”; and

6. Identification of key issues in LCA for EVs, the methodology, and its application (case studies).

The main sessions were divided into the following segments:
- LCA methodology for EVs;
- International LCA case studies on EVs from Austria, Belgium, Germany, Denmark, Israel, Portugal, Switzerland, United States, and United Kingdom; and
- 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 and/or 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 during use, including auxiliary energy (heating, cooling), user behavior (urban driving), and information about buyers of EVs or PHEVs
    - End of life (including recycling for production: "closed loop")
3. Fuel cycle (electricity production)
    - Average and/or 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
    - 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

8.4.2 LCA of Vehicle and Battery Production

The second workshop on “LCA of Vehicle and Battery Production” took place in Chicago, Illinois, on April 26, 2013. The objective of this workshop was to present, discuss, and reach conclusions regarding LCA aspects of the production of vehicles and batteries. Thirty participants from six countries met to discuss LCA case studies of battery and vehicle production, structural materials, and active materials in the batteries.

The objectives of the workshop were as follows:

1. Assess and discuss the state of knowledge, best practices, available data, and data gaps;
2. Identify steps to mitigate data gaps and uncertainty in existing data;
3. Present LCA methodology and its application (case studies);
4. Review current assessments of the life-cycle impacts of battery and vehicle production;
5. Identify the greatest sources of uncertainty and steps to improve analyses; and
6. Discuss key issues to facilitate improvement of LCA application for EVs.

The following key results of LCA of vehicle and battery production were summarized at the workshop:

- The influence of battery production in LCA of EVs, including where the main environmental impacts are and how they might be reduced in future mass production of automotive batteries (Figure 8.2);
- The future development of methods for mass production of automotive batteries;
- The influence of future recycling of automotive batteries — today, there is no infrastructure in place to recycle a huge amount of automotive batteries, but from an LCA perspective, efficient recycling of battery materials might significantly reduce the environmental impacts of battery production; and
- Dissemination and communication strategies for LCA results.

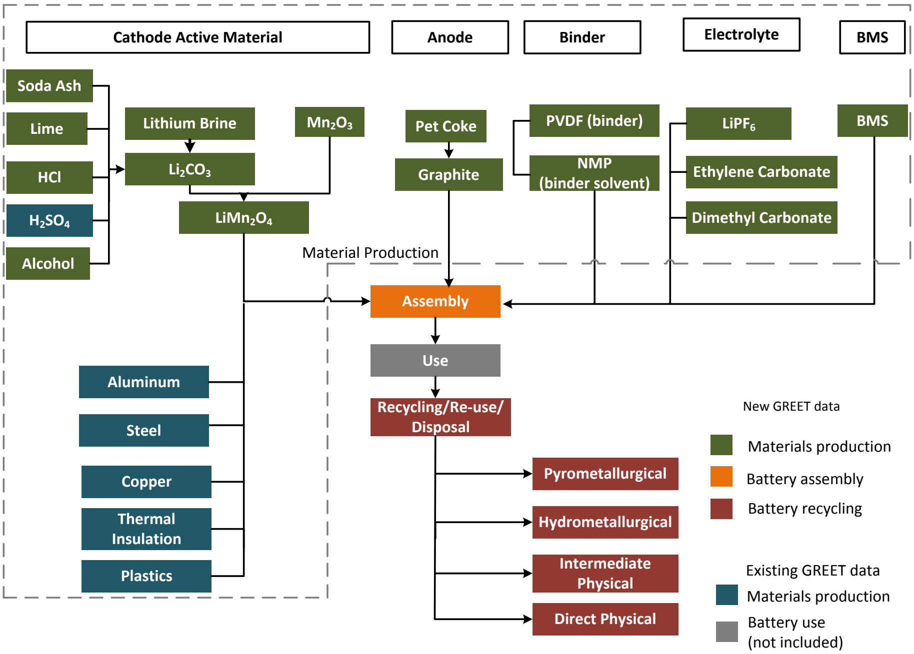

Fig. 8.2 Argonne National Laboratory's battery analysis covers battery production and recycling. (Source: A Review of Battery Life-Cycle Analysis: State of Knowledge and Critical Needs [https://greet.es.anl.gov/files/batteries_lca])

8.4.3 Recovery of Critical Metals from Vehicles with an Electric Drivetrain

The third Task 19 expert workshop on “Recovery of Critical Metals from Vehicles with an Electric Drivetrain,” was held in Davos, Switzerland, on October 9–10, 2013. The workshop was co-located with the World Resources Forum 2013. The goal of the two-day program was development of a strategy paper on how to address the main R&D demand for the topic, with scientific visits to nearby waste and recycling plants on the second day.

The distribution of critical metals in end-of-life vehicles with an electric drivetrain and their recovery potentials have been addressed only very recently. So, in this workshop, the focus was to review the current state of research regarding recovering critical metals from electric vehicles and to discuss a possible outline for a research strategy.

The program was divided into four parts:

- Part I: Presentations of the context and interim results of selected projects carried out in various countries
- Part II: A World Café addressing the following three questions:
  1. What do we know about possible sources and the current fate of (critical) scarce metals in electric vehicles?
  2. What are the main challenges to be met in view of a better understanding and governance of the (critical) scarce metal stocks and flows related to electric vehicles?
  3. How shall these challenges be addressed (e.g., possible initiatives, potential project ideas)?
- Part III: Scientific visits:
  1. KEZO/MVA in Hinwil: municipal waste incineration plant for R&D (e.g., light fraction of vehicle waste, recovery of [rare] metals from ash and slag) where, among other waste, shredder light fractions (SLF) from end-of-life vehicle shredders is incinerated (http://www.kezo.ch/) (Figure 8.3)
  2. Immark AG in Regensdorf: Recycling plant for elecronic-waste (http://www.immark.ch/) (Figure 8.4)
- Part IV: Round table discussion on research strategy

Fig. 8.3 Separation of metals from ash and slag at the pilot facility of KEZO/MVA in Hinwil, Switzerland.

Fig. 8.4 Recycling of e-waste at the Immark AG recycling plant in Regensdorf, Switzerland.

The main issues and statements discussed were as follows:

- Is the focus for recovering and recycling of rare materials from vehicles the right one? Or do we have other, more relevant, waste streams (e.g., computers, mobile phones) for recycling?
- Because aluminium is readily degraded by other materials, the quality of recovered aluminium is low.
- A more flexible recycling system is necessary to more efficiently recover rare materials from vehicles.
- Making the data from vehicle manufacturers available to the waste management sector might improve the overall end-of-life management system for recovering rare materials.
- The vehicles of today are not designed for recovery of materials.
- Research must provide more information about the types, amounts, and qualities of rare materials to be recovered from vehicles today and in future.
- The recovery of rare materials must address the whole value chain — from raw material production through vehicle manufacture to end of life.
- To establish an efficient recovery system, economic and/or legal drivers are necessary.
- Methods need to be identified to make recycling a key priority for car producers.
- New technologies are needed to recover and recycle rare materials, in the most effective and efficient way, in terms of cost and quality.

- A unique classification of relevant materials must be developed (e.g., by differentiating what is "rare," what is a "critical," and what is "strategic" material).
- Car manufacturers need a sense of global product responsibility for the recovery and recycling of rare materials from their products.

8.4.4 LCA Aspects of Electricity Production, Distribution, and Charging Infrastructure

The next workshop on "LCA Aspects of Electricity Production, Distribution, and Charging Infrastructure" will take place October 15–17, 2014, in Barcelona, Spain.

The main topics of the workshop are listed below.

1. Connecting additional renewable electricity and loading strategies of EVs (Figure 8.5)
2. Environmental effects of current and future electricity production
3. Vehicle-to-grid: when does it make sense?
4. Modeling of electricity production for EVs
5. Case studies and examples
6. Identification of key issues

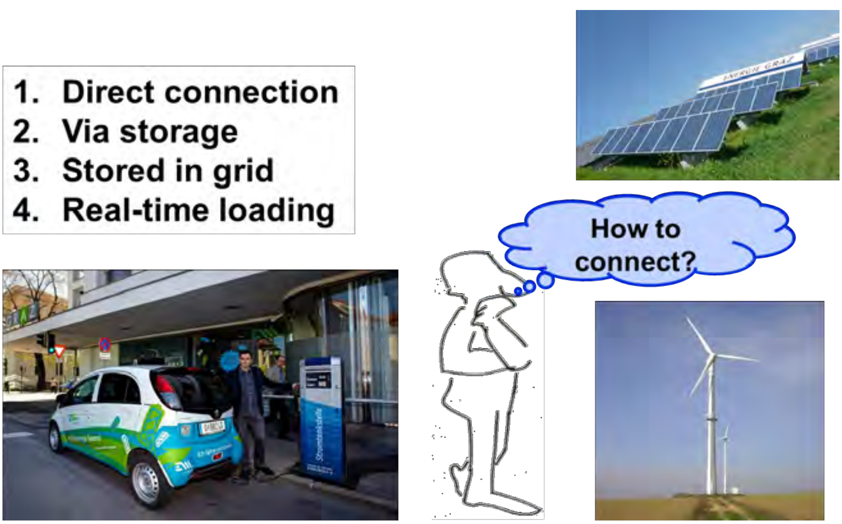

Fig. 8.5 Connecting additional renewable electricity and loading strategies of EVs.

In addition, Task 19 activities were presented at the following EV relevant conferences in 2013:

- 9th International Colloquium on Fuels in Stuttgart, Germany, in January 2013;
- 22nd International Expert meeting on Power Engineering in Maribor, Slovenia, in May 2013;
- 8th A3PS — Eco-Mobility 2013 — International Conference in Vienna, Austria, in October 2013; and
- EVS27 (International Electric Vehicle Symposium & Exhibition) in Barcelona, Spain, in November 2013.

8.5 Contact Details for the Operating Agent

IA-HEV member countries confirm their participation by signing a notification of participation and by delegating a country expert for Task 19. 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

Task 20 – Quick Charging

Members: *Germany, Ireland, Spain, United States*

9.1 Introduction

Task 20 addresses quick charging technology for plug-in electric vehicles, including plug-in hybrid vehicles (PHEVs) and all-battery electric vehicles (EVs). The Task was approved November 11th, 2011, at the 35th Implementing Agreement on Hybrid and Electric Vehicles (IA-HEV) Executive Committee meeting in Lisbon, Portugal, and the Task is expected to run through the end of 2014, as defined by the Committee's multi-stage plan.

This Task is going through the second stage of the plan, which aims to develop a useful and robust framework that facilitates the exchange of information and to create a strong consensus on the main upcoming developments in the field of quick charging (QC). To reach this goal, several actions were completed in 2013 and the first half of 2014.

One of the main activities of the Task is to develop a *business case*, which is needed to foster a larger more extensive use of QC technology. All stakeholders have concerns about the future model of a larger deployment of EVs using QC technology, as well as about how to incorporate the associated equipment into real-world scenarios (cases).

The business case should be based on real-life data from the field; it could offer different solutions for each specific-use case. The data must be collected from EV users and should focus on such issues as how much users would need to pay in each of the various strategies (e.g., monthly fixed rate, pay per use). New opportunities in the area of fully integrated power and information technology (IT) might trigger the necessary infrastructure deployment to handle a significant increase in the number of EVs and PHEVs while guaranteeing both power quality and safety. To realize such a scenario, a dialogue among all QC technology stakeholders is necessary. This dialogue requires an exchange of information and points of view in order to provide an understanding of the whole picture, including identification of potential technology gaps and possible better approaches to deployment.

This dialogue is already under way; however, Task 20 participants agree that there is no clear and unique business model solution. Several ongoing demonstration projects and deployment activities that incorporate different approaches are taking place across the globe. One approach involves promoting the potential added customer value of QC. In other demonstration cases, infrastructure and cars are at the forefront of the strategy.

No matter how the hurdles are confronted, whether technical or nontechnical, it is clear that the full Task 20 business plan will not be completed without investments of financial and other resources and a push toward deployment. The means used should be flexible and evaluated, adapted to real prices and needs in the hope of enlarging the network and customer base. A two-way monitoring approach is necessary between the infrastructure managers and the customers; open interfaces between the two parties would enormously facilitate greater use of different kinds of QC infrastructure at different locations. Furthermore, different kinds of customers and requirements must be taken into consideration; those considered should not be limited to a certain number of users with known profiles. Last, not all countries or customers have standard or replicated behavior. This adds an additional challenge when trying to replicate the good practices of original equipment manufacturers (OEMs) from one country in other countries and markets.

Despite these differences between countries and markets, EV network alliances are needed from the outset to share costs and investments in technology development. Strong coordination among the involved stakeholders is a very fruitful way to launch a smart business model, bearing in mind that QC services alone are not economically viable. Task 20 therefore encourages the establishment of a system to understand EV users' behaviors and driving patterns, so that better EV user profiles can help facilitate the provision of more convenient services as soon as fee-based EV charging begins.

Most advanced deployment initiatives are based on the fact that owners install and operate QC stations primarily for non-economic reasons. This initial deployment often follows the case of Japan: a series of public service announcements give a sense of corporate social responsibility and communicate the value of making a contribution to environmental abatement. The message is further invigorated by making the connection between business-world models and real motivation targets (i.e., stakeholder commitment in conjunction with political support).

Before defining the placement of suitable measures, including infrastructure, a thorough analysis of driver behaviors is essential. Moreover, unexpected changes in behavior patterns should be prevented to enable the proper design of the network. Therefore, infrastructure planning must be accompanied by a set of services and support tools that address potential new customers. Successful implementation requires that governments and stakeholders have continuous interaction with existing and potential new customers, as well as promote more general public awareness.

On the other hand, price is of course a major factor for customer engagement. The prices of energy (in kilowatt-hours per currency unit) can affect the whole system, and consequently, the potential business scenario can be modified.

9.2 Objectives

As envisioned, Task 20 will aim to promote QC solutions and improvements to enable broad penetration of this technology. Through objective and fact-based discussions and through sharing knowledge about the development and trends for QC technologies, Task 20 participants will have access to up-to-date information from car manufacturers, utilities (e.g., distribution system operators, or 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 the European Committee for Electrotechnical Standardization (CENELEC) and the Society of Automotive Engineers (SAE) International.

There will be a special focus on the following:

- Minimizing the impact of QC on the electric grid and EV batteries;
- Breaking down nontechnical barriers to installing QC infrastructure; and
- Establishing common criteria for QC to enable correlations among potential standards, thus promoting vehicle electrification across the globe.

The main topics to be addressed in the 3-year working period are as follows:

1. Current QC technology development trends worldwide;
2. Outcomes from the latest QC pilot projects and the issues to be resolved;
3. Lessons learned from past charging network deployment plans;
4. Impact of QC on EV/PHEV 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 energy efficiency and the charge power of the charging station;
7. Managing trade-offs between the shortest time to a full charge and charger cost;
8. Need for quick chargers and public charging stations to counter range anxiety;
9. QC solutions that will help to popularize EVs;
10. Issues in the relationship (technical and socioeconomic) between EVs/PHEVs and the grid, including power quality, tariffs, regulations, incentives, etc.;
11. Analysis and proposal of the best technical solutions for interoperability and the optimum use of the electric infrastructure already in place;

12. How organizations developing emerging technologies (such as smart grids and EVs) can join efforts to accelerate market penetration;
13. The requirements of and issues with QC technology as they relate to future smart grid promotion;
14. Designing and ensuring convenient, safe, and secure handling for consumers; and
15. Future technology roadmap to help promote vehicle electrification.

9.3 Working Method

Task 20 bases its exchange of information and interactions on regular face-to-face meetings of key experts from the main QC stakeholders worldwide. Following the kick-off meeting, in conjunction with the 26th International Electric Vehicle Symposium (EVS26) held in Los Angeles in May 2012, another meeting took place in Japan June 3–5, 2013, in collaboration with the Ministry of Economy, Trade and Industry of Japan (METI).

This second technical exchange workshop was held in three cities in Japan. The goal was to discuss progress in the development and deployment of direct current (DC) QC technology in Japan, Europe, and the United States. The Japanese government has supported the installation of more than 1,700 QC stations throughout the country.

Task 20 aims to address barriers to the deployment of QC technology, such as the lack of robust charging point networks. Developing a viable business model for QC depends on obtaining data from the field, and the best solution for implementation of QC in different countries will depend strongly on how the QC network is used. It is here that Task 20’s multiple-stakeholder information exchange can help illustrate the big picture and identify any gaps and possible solutions.

A total of 39 experts from the United States, Germany, China, Spain, and Japan participated in the June 2013 meetings in Japan, representing automotive OEMs, charging equipment providers, research centres, utilities, and governments.

Late in 2013, in conjunction with the EVS27 held in Barcelona, Spain, a workshop was held with a special focus on interoperability as a trigger for greater QC deployment. Thirty-three participants from six countries represented different organizations and stakeholders with key roles in the overall interoperability chain on both the public and private sides. The main items of the agenda were the following:

- Compatibility of various EVs with various EV supply equipment (EVSE) (including topics such as nonexclusive customers and a variety of manufacturers, which will be an issue even after standardization);
- Harmonized EV–grid communication (i.e., “roaming” capabilities, management of identification, billing, and load); and

- Coexisting legacy and advanced (e.g., smart metering) systems (significant variations exist within countries).

Task 20 also posted an online questionnaire (http://www.fcirce.es/web/sites/IEA.aspx) to solicit input from the EV community on the current status and future applications of QC technology. The survey covers potential business models for QC/DC fast charging (DCFC), as well as issues in its value chain, including charger infrastructure, OEMs, and interoperability; the impact of QC/DCFC on the electrical grid; and the anticipated timeframe for technological and regulatory developments.

The motivation for the survey is to answer questions that need to be addressed in order to facilitate more widespread deployment of QC/DCFC technology. Using the survey will allow Task 20 to collect valuable information from all sectors involved, with the goal of extracting conclusions.

The information gathered will be analyzed and incorporated into the final report for Task 20. The goal is to hear from as many stakeholders as possible, in order to identify the issues that will need to be addressed to enable QC/DCFC technology to succeed worldwide.

9.4 Results

The information collected and the consensus among the members of the Task will contribute to the deployment of QC technology. This information should help standards bodies, industry, and governments to understand the benefits and improve the competitiveness of vehicles with an electric drivetrain.

The first results of the ongoing demonstration activities show that the trend is to charge for approximately 15 minutes (corresponding to 50–80% of battery capacity). This finding indicates the types of services that should be linked to customers while the charging process is taking place should be of comparable duration. It also demonstrates the strong correlation between the number of quick charger points and the sales rates in a region (in particular, in some areas of Japan where there is strong support from the local government).

These findings show that QC is clearly expanding EV range around cities and creating driving corridors; as a consequence, the demand for charges can, and will, have a drastic effect on cost per charge. Other studies in the United States reveal that fast charges occur most frequently in the evening, often coinciding with grid peak demand, which requires stronger cooperation with grid network companies to handle the extra load.

From the technical point of view, additional barriers remain. As far as the utility perspective is concerned, basic power quality (i.e., current, voltage, and active power) must be properly managed at any of voltage level while introducing QC. However, this requires an additional major investment (in particular, low voltage). This is an additional issue to be included in the business case. Disturbances in the grid due to the use of QC infrastructure can be avoided by incorporating adapted power electronics to the chargers, among other solutions (additional extra costs are required to produce good outcomes).

Depending on the location, lack of robustness in the grid network can hamper a larger deployment of QC infrastructure. However, the already-cited framework does not contain enough large demonstration cases involving new applications and beneficiaries (i.e., vehicle-to-grid [V2G] and vehicle-to-grid/home/building [bidirectional charging or V2X]) to test robustness. Near-term funding and execution is critical to meet deployment plans and test how robust these networks are.

In terms of charging systems, some uptakes are in the pipeline, such as available DC Combo suppliers with certified hardware. In line with this standard, combo connector fast charging has been developed and is starting to be deployed. As a result, there likely will be some need to support both Combo and CHAdeMO (http://www.chademo.com/wp/) because the existing EV/PHEV fleet must be included in the future. Compatibility between chargers and vehicles is key in test procedures (joint tests); this requires further effort to set appropriate test methods.

Charger manufacturers struggle to adapt to different charging systems as they attempt to increase the customer base (Combo and CHAdeMO). European charger manufacturers started to offer dual- and triple-arm chargers this year (with a relatively high increase of the total cost). Between 90 and 95% of the total cost of the installation of a quick charger point is not the cost of the equipment itself, but civil works, permits, and so forth — thus, between 5 and 10% of the overall cost is associated with the unique charger standard. On the other hand, retrofitting the existing QC points (representing an additional cost of €2,000–€3,000 [$2,682 US–$4,024 US]) offers a new, low-cost way to integrate DC Combo chargers into existing CHAdeMO systems during an infrastructure upgrade. Several political policies underscore the need for the coexistence of the two charger systems (i.e., Combo and CHAdeMO).

Last, a key issue for DC QC infrastructure is the location and type of local power supply available, rather than the type of charging system. All standards need to coexist and service all customers during the critical take-off phase of the market. In any case, it is becoming clear that the majority of OEMs support QC/DCFC, which represents a major step forward for the whole QC community.

To start describing how the near future should look with respect to QC technology and infrastructure, certain QC applications and needs were also assessed. For instance, vehicle-to-vehicle (V2V) is not a technical challenge, but the business case for it is still unclear. Moreover, V2X (which represents bidirectional charging) is evolving very quickly as a real enabler of a greater use of QC vehicles (already available in the Japanese market). The vehicle always arrives back home with a significant amount of power stored in the batteries (most likely over 50% of the total charge capacity of the battery), and this power then can be sent back to the grid. To minimize power spikes and demand charges on the local grid, it is necessary to quantify battery utilization and to integrate QC with renewable energy resources and energy storage. These issues must be further researched and integrated in the business case scenario.

QC technology is nearly available in terms of technical solutions and applications. However, smart charging infrastructure may consist of a mix of different types of charging capabilities, including direct current (DC) and alternating current (AC). These include ultra-quick charging stations (DC), quick-charging stations (3-phase AC), slow-charging stations (single-phase AC), and (in the near future) induction charging. Therefore, in order to prepare for the future, further work is encouraged to determine whether to integrate QC infrastructure with other systems and the extent to which the vehicle should be adaptable to different charging systems. Intelligent charging solutions, taking into account grid integration (demand response), functionality, and energy storage integration in current and future interoperability models, must be considered. Interoperability, in particular, is a major subject to be further analyzed.

Interoperability does not imply compatibility, unless the customer knows that the charger can be used regardless of the cost or method of billing. A well-designed strategy relies on system transparency and takes into account the availability of enabling technologies (as well as exploiting the future benefits of dispersed EV populations). More advanced testing procedures are needed to better understand how all related devices behave (i.e., overvoltage protection might be required). Proprietary interfaces lead to specific conditions to which interoperability solutions must respond (i.e., charge stations that are forced to support multiple proprietary network protocols). Standard EVSE and EV Service Provider (EVSP) protocols must be developed and tested.

Existing QC chargers are already being retrofitted at a much lower cost at the factory level than on site. (This is an issue to be considered in the deployment plan over the medium and long term.) Furthermore, cross-border projects (in different states, provinces, and countries) are necessary in order to decrease overall infrastructure costs. The integration of new features into the chargers implies a significant increase in costs, not only for the chargers, but for the whole system. The business case for long-distance QC infrastructures requires an analysis of how to incorporate subsidiary equipment within the cost plan, which may provide a solution.

Despite the issues and challenges described, it is apparent that the majority of OEMs support QC/DCFC and are beginning to develop charging corridors that support EVs between cities.

9.5 Next Steps

Looking ahead for Task 20, a new meeting on the topic of batteries is scheduled in Nice (France) for mid-September 2014. Battery cost still remains one of the main barriers to be overcome for a larger deployment of QC technology. Further studies and recommendations are needed regarding the degradation and capacity of batteries to achieve reasonable range that will be required to satisfy the needs of different-sized vehicles and different usage patterns. Batteries are expected to accept very high repetitive pulsed charging currents if regenerative braking is required, and they must be designed to maximize energy content and deliver full power, even with deep discharge, to ensure long range. Therefore, further efforts will be devoted within the Task 20 to identify smart and suitable innovations that can mitigate this problem.

Furthermore, a workshop with technical visits in various developed countries that have greater experience with QC is anticipated at the end of the 2014 or beginning of 2015. The Task 20 community will use the opportunity to agree on the general concepts to be included in the final report, as well as to plan the best way to widely publicize the main findings. The main findings of the final report should include the information coming from the survey tool and all information collected so far within the group.

9.6 Contact Details for the Operating Agent

IA-HEV member countries must confirm their participation in Task 20 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 (i.e., as sponsors), which must be negotiated with the Operating Agent and confirmed by the Executive Committee of the IA-HEV.

Task 20 is coordinated by Ignacio Martin, who is from the Research Centre for Energy Resources and Consumption (CIRCE), a private research organization in Spain, the mission of which is to create and develop innovative solutions and scientific/technical knowledge in the field of energy resources and usage for transfer to the business sector for commercialization.

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

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Task 21 – Accelerated Ageing Testing for Li-ion Batteries

Members: *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 5 years, until 2017. Task 21 will be beneficial in establishing and consolidating international collaboration for lithium-ion ageing testing.

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 ageing 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 Figure 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 ageing procedures,
- Experimental verification of Li-ion batteries in international laboratories, and
- Reduction of costs associated with testing.

Fig. 10.1 Accelerated testing of Li-ion batteries. (Image courtesy of NREL [National Renewable Energy Laboratory])

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 for 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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Task 22 – E-Mobility Business Models

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

11.1 Introduction

The IA-HEV Executive Committee (ExCo) unanimously approved Task 22 at the 36th Executive Committee meeting in May 2012, held in Los Angeles. New and profitable business models will be a key enabler of the sustainable introduction of electric vehicles (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. Task 22 is inviting experts from industry, policy, and research to contribute insights to support progress in this area.

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

Task 22 is collating expertise in two key areas. The first is related to electric mobility products and services to optimize the total cost of ownership and operation. This area 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.

The second area is ways to enhance user experiences, encompassing developments that make operation of EVs more convenient, desirable, and rewarding. This area may relate to enhanced functionality for driving and recharging, supportive policy frameworks, incentives, solutions for fleets, and flexible mobility services (such as car sharing to meet the needs of both individuals and businesses).

Task 22 recognizes that failure to develop these products and services could delay the growth in markets for EVs and limit adoption to niche applications.

11.3 Working Method

In May 2013, Task 22 announced an open call to invite researchers and practitioners to share their expertise from many sectors: business, policy, economics, engineering and technology management, and innovation. Papers were received from 14 countries across four continents. Topics included EV ecosystems, charging infrastructure, car sharing, batteries, and energy systems. These papers will be published in a book in late 2014 as part of Springer's Lecture Notes in Mobility series.

At the 37th ExCo meeting in November 2013, Task 22 was extended to include a sub-group on interoperability of EV charging infrastructure. This sub-group is led by Mr. Carlo Mol, who has committed to track relevant developments in this area and provide bi-annual updates at ExCo meetings.

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

As of March 2014, Task 22 was collecting the final papers to be featured in the book and completing the editorial review of all submissions received. The final book is planned for publication in 2014.

Task 22 is also investigating opportunities to organize a conference to bring together authors that have contributed papers to the upcoming book. Any potential sponsors and hosts for this conference are encouraged to contact the Operating Agent.

11.6 Further Information

Mr. David Beeton, Urban Foresight (david.beeton@urbanforseight.org)
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11.7 Contact Details for the Operating Agent

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12 Task 23 – Light-Electric-Vehicle Parking and Charging Infrastructure

Members: *Belgium, Germany, Spain*

12.1 Introduction

Task 23 is focused on addressing the range of opportunities and challenges associated with light electric vehicles (LEVs). LEVs are a class of electric vehicles propelled by an electric motor that uses an energy storage device (such as a battery or fuel cell), has two or three wheels, and typically weighs less than 100 kg (although weights can range up to 250 kg[1,2]). LEVs include electric scooters (e-scooters), electric bikes (e-bikes), and the hybrid pedal/electric bicycle known as the pedelec. Both e-scooters and e-bikes are throttle controlled, but the e-scooter has a foot-rest platform for the driver while the e-bike is straddled by the driver.[3] E-scooters also typically have a more powerful electric motor and larger batteries. By contrast, the pedelec has a motor that assists the rider during pedaling.[4] In this way, the pedelec is low-powered e-bike and from a legal or regulatory sense is simply classified as a type of conventional bicycle. It was first introduced in Japan in the 1990s.

The use of LEVs and especially pedelecs is gaining momentum worldwide as evidenced by the dramatic increase in the number of public bicycle-sharing programs around the world. As of April 2013, there were 535 such systems in 49 countries and a total of 517,000 bicycles. While many of these systems use conventional bicycles, pedelec usage is also rapidly growing in such places as Japan and Europe. It is projected that by 2050, annual global sales of pedelecs will reach 250 million — higher than any other vehicle presently sold. Even using a

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1 "Light Electric Vehicles (LEV) 2011–2021." Brief Synopsis in *Reportlinker*, July 7, 2011. Available online at Disabled-World.com, http://www.disabled-world.com/disability/transport/lev.php (accessed July 14, 2014).

2 LEV glossary term. Available online at http://www.energybus.org/Further-Info/Glossary (accessed July 14, 2014).

3 "Electric Bicycles Reduce Oil Dependence, Pollution and Are Potential Economic Users of Solar Electricity." Report by Alan Parker to the Select Committee on the Impact of Peak Oil on South Australia. Reposted by the Adelaide Touring Cyclists Inc. Available online at http://www.adelaidetouringcyclists.org/bosa/Electric%20bikes%20Types.pdf (accessed July 14, 2014).

4 "Pedelec Electric Bikes." Available online at http://www.nycewheels.com/bike-info.html (accessed July 14, 2014).

conservative estimate of 500 watt-hours for battery capacity, that works out to 125 million kilowatt-hours of battery capacity, not including replacement needs. The charging infrastructure required for such a fleet will be sizable.

Yet today, pedelecs are typically not included in governmental considerations on how electric mobility could improve living conditions in both urban and rural areas and enable more general ecological and human health benefits.

12.2 Objectives

The rapid growth in LEVs, in particular pedelecs, requires addressing issues related to parking and charging infrastructure. In terms of charging infrastructure, harmonized charging standards are already being developed by the IEC/ISO (International Electrotechnical Commission/International Organization for Standardization) joint working group on LEV standardization. Task 23 seeks to mirror these activities to a governmental level and to help ensure that the outcome is most suitable both to local and global policies. Task 23 also will encourage the development and establishment of pedelec sharing and private pedelec usage. This is intended to help local governments that often struggle finding the right technology and right partners, which results in major delays and a waste of taxpayer money. Because bike sharing systems are now a global phenomenon, pedelecs and other LEVs could increase the relevance even more, such as in locations that are hilly or windy.

The planned output of Task 23 includes the following set of activities and outcomes:

- Documentation of existing solutions for best practice sharing that will then be made publicly available for local governments and companies.
- Creation of comprehensive (turnkey) guidelines for local governments, including samples for a public procurement by tender for rental pedelecs, as well guidelines as for parking and charging infrastructure.
- Biannual “E-Bike Award” with an international conference. The next such conference is scheduled for October 2014 to be financed through sponsoring and the German electric utility company RWE.
- Workshops for interested communities in local languages in Task 23 member countries. Workshops will include materials in the local language, and costs will be covered by the member country.
- Biannual reports to be published in an easy-to-read, easy-to-understand format. Such reports will be directed toward local political officials who do not have an engineering background.
- Task 23 presence at key trade shows and conferences worldwide to connect with relevant target groups and stakeholders, including mayors and other local political figures, city planners, mobility managers, and representatives of the bicycle industry and the charging infrastructure industry.

- Organization of joint excursions to visit best practice applications (where applicable), together with mini-workshops.
- Cooperation with other projects on the national and regional level.

12.3 Working Method

As discussed in section 12.2, members of Task 23 envision achieving task objectives through a series of activities. These include documentation and information sharing of best practices; development of various guidelines; and regular conferences, workshops, and attendance at trade shows in task member countries to highlight ongoing developments, with a heavy focus on reaching out to target groups, recognizing the non-technical background of those who will nevertheless have to make decisions (e.g., local political figures).

Because Task 23 is a new IA-HEV task, it is useful to highlight the pre-task activities that have already occurred. These pre-task activities will inform the working method going forward. These included:

- An educational trip with 12 Chinese industry and government representatives (August 2012).
- E-Bike Award, together with a dedicated conference (October 2012).
- Publication of the global processes, including the IEA's IA-HEV approach in the European Networks Book No. 5, similar to what is available for download as an EnergyBus.org brochure (http://www.energybus.org/Further-Info/Downloads/EnergyBus-Brochure-2014) (February 2013).
- Presentation at the Taipei Cycle Show (March 2013).
- Participation in and monitoring of the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) joint working groups, in particular the LEV standardization group, IEC/ISO/TC69/JPT61851-3.

12.4 Results

Task 23 is a new IA-HEV task. Results will be reported in subsequent IA-HEV Annual Reports and other publications. Pre-task activities are reported in section 12.3.

12.5 Next Steps

Task 23 is a new IA-HEV task with work yet to start. The estimated duration of the task is at least eight years. This duration is the estimated time required to complete international standards harmonization. As a practical matter, the first period should run from 2013 through 2016, at which point a decision can be made on whether to continue the task.

12.6 Contact Details for the Operating Agents

Task 23 is coordinated by EnergyBus e.V. For further information on Task 23, please contact:

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13 Task 24 – Economic Impact Assessment of E-Mobility

Members: *Belgium, Germany, the Netherlands, Switzerland*

13.1 Introduction

The IA-HEV Executive Committee (ExCo) unanimously approved this new task at the 39th Executive Committee meeting in November 2013, held in Barcelona, Spain.

Worldwide, policy makers are implementing supportive measures to facilitate the introduction or implementation of electric transportation in their regions for many reasons. Electric mobility has a great potential to solve some of our environmental, societal, and economic challenges. In this new task, we want to focus on the economic impact of the introduction of electric mobility. How can electric mobility strengthen the economic position of a country? What is the economic growth we can expect in the electric mobility sector?

Current members include Belgium, Germany, the Netherlands, and Switzerland. Other countries are still planning to join.

13.2 Objectives

The introduction of electric mobility can create many new economic opportunities. Governments are anxious to stimulate economic growth in their own regions, but to be able to develop good supportive policies and assess their impacts, it is necessary to have a good look at the local e-mobility sector. This raises a number of questions: How is the value chain for e-mobility defined? Which factors are active in each part of the value chain? What is the situation today in production volume, turnover, employment, export volume, and innovations/patents, and in which part of the value chain can we expect further growth? The answers to these questions are very region-specific, because they depend on the specific activities and competencies of the local stakeholders (industry, research, etc.) and their desires to become players in the electric mobility market. A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis per region on product/service/market combinations can give better insight into local situations.

The objective of the task is to get a better look at the value chain of electric mobility in general and, more specifically, a better understanding of the economic potential of the local e-mobility sector in every participating country in Task 24. We will achieve this objective by performing a SWOT analysis and a baseline measurement of some important indicators, such as turnover/production volume, employment, export volume, and innovations/patents, for example, for each participating country.

In this task, it is important to take into account the fact that electric mobility is not about vehicles alone, but that it requires a whole “ecosystem” into which electric vehicles are integrated. Beside vehicles, we need a charging infrastructure that is well-connected to the electricity network (such as smart grids, financing services, etc.). Electric vehicles can also be integrated into new mobility concepts that are increasingly multi-modal and partly based on sharing concepts (instead of vehicle ownership). In Belgium, we call this “networked and shared mobility.” In addition, Task 24 will mainly focus on electric passenger cars, but some countries will also take into account electric bicycles, scooters, trucks, buses, and even boats (if that is important in a specific country, like in The Netherlands) because every sector has its own economic opportunities.

13.3 Working Method

The working method in Task 24 will be based on task sharing. No participation fee is required. Task 24 will run for 18 months and will start in May 2014.

Task 24 will consist of three subtasks:

1. Development of a common methodology for the economic impact assessment (duration: six months);
2. In each participant country, collection of data on the agreed indicators (duration: nine months); and
3. Analysis of all results, summarized in a final report (duration: three months).

The work of Task 24 will use mainly mail and phone conferences to reduce travel costs. However, some meetings can be organized in conjunction with the ExCo meetings to discuss and present work progress in more detail.

13.4 Results

Task 24 is just beginning, so it is too early to present first results.

13.5 Next Steps

During the first half of 2014, countries can still join Task 24. Joining at the beginning of the task means that each participating country can still influence the common methodology to be developed in subsequent phases.

We recognize that data collection and comparisons will be challenging, because many different organizations collect different types of data, and it will not be possible for all indicators to be collected in the same detail for feeding into the economic impact assessment. Therefore, setting up a common methodology is an important first step in setting feasible targets and aligning expectations.

13.6 Contact Details for the Operating Agents

Countries interested in getting better insight into the economic opportunities of e-mobility (in general and in their own regions) are still welcome to join Task 24. As mentioned above, it is a task-shared effort without a participation fee.

Please contact one of the Operating Agents for more information:

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14

Overview of Hybrid and Electric Vehicles in 2013

The sales of EVs and PHEVs increased significantly in several countries. The top three countries with the greatest increases in sales were the United States, the Netherlands, and France. Two of the 18 countries saw sales in the tens of thousands, while nine of the countries saw sales in the thousands. The total EV and PHEV fleet for all of the IA-HEV member countries grew by 136%, on the basis of the numbers reported. The worldwide HEV market also experienced healthy sales, with seven of the countries seeing tens of thousands of sales and one country seeing nearly 500,000 in sales. The top three countries in HEV sales were the United States, France, and new 2013 member South Korea. The total HEV fleet for all of the IA-HEV member countries increased by 11%. The country chapters provide numbers for 2013 sales and fleet totals for EVs, PHEVs, and HEVs. Table 14.1 provides the 2013 sales totals in each of these categories. Table 14.2 shows the fleet totals for these vehicles over the last three years. South Korea joined in 2013, and its sales totals for this year are reflected in Table 14.1; however, its historic fleet totals are not available.

We have again this year separated out the sales figures for electric bicycles and scooters from the sales of other vehicles in Table 14.3, because many IA-HEV member countries do not track these two-wheeled vehicles that do not require a driver's license. 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 fleet totals for these scooters in Table 14.3 as well.

Table 14.1 Actual or estimated (*estimates in italic*) electric vehicle (EV + PHEV) and hybrid electric vehicle (HEV) sales in IA-HEV member countries, as of December 31, 2013 (exceptions are noted). Though numbers for 2013 were not yet available in some countries, a total may be estimated by extrapolating from the previous year's total and sales trends.

Country	HEV Sales	EV and PHEV Sales
Austria	2,574	1,093
Belgium	6,088	1,170
Canada	22,633	3,121
Denmark	1,140	668
Finland	2,422	237
France	46,785	9,622
Germany	*19,526*	*7,348*
Ireland	*964*	54
Italy	14,930	3,059
Netherlands	18,356	22,795
Portugal	n/a	n/a
South Korea	29,060	614
Spain	10,240	2,543
Sweden	5,349	1,382
Switzerland	6,755	4,151
Turkey	n/a	31
UK[a]	–	–
USA	495,685	96,602

n/a = not available

[a] Because of discrepancies in the definition of vehicle categories, the total number of HEVs, EVs, and PHEVs is unclear. See Chapter 31, United Kingdom, for more information.

Table 14.2 Actual or estimated (*estimates in italic*) electric vehicle (EV + PHEV) and hybrid electric vehicle (HEV) populations in IA-HEV member countries, as of December 31 of each year that is shown (exceptions are noted). Though numbers for 2013 were not yet available in some countries, a total may be estimated by extrapolating from the previous year's total and sales trends.

	HEVs			EVs and PHEVs		
Country	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
Austria	n/a	8,125	10,504	n/a	2,965	2,070
Belgium	n/a	20,636	25,553	n/a	3,467	4,446
Canada	86,579	108,190	*130,823*	617	2,591	5,712
Denmark	760	1,593	2,599	1,516	2,118	2,083
Finland	3,973	2,500	3,915	n/a	224	489
France[1]	*57,000*	*84,000*	*130,785*	*3,610*	9,939	*19,561*
Germany	n/a	65,491	85,017	n/a	15,350	22,698
Ireland	n/a	6,781	7,745	n/a	408	393
Italy	27,990	*34,789*	*49,719*	18,198	21,798	57,178
Netherlands	*72,000*	88,627	106,918	1,499	7,431	30,229
Portugal	n/a	*2,500*	n/a	1,334	1,429	n/a
South Korea[2]	n/a	n/a	n/a	n/a	n/a	n/a
Spain	32,888	44,649	54,170	2,490	6,523	8,816
Sweden	21,417	*24,000*	n/a	520	1,285	2,677
Switzerland[3]	n/a	28,056	34,883	n/a	12,253	*15,072*
Turkey	*500*	n/a	n/a	*30*	*684*	*715*
UK[4]	99,007	121,766	–	6,391	8,153	–
USA	2,153,486	2,592,354	3,087,892	18,108	71,915	225,375
Total IA-HEV[5]	***2,500,000***	**3,234,076**	**3,600,240**	**100,000**	**167,849**	**396,799**

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 South Korea joined IA-HEV as the 18th member country in the Spring of 2013 and this is its first Annual Report chapter.

3 In Switzerland, the fleet totals were available only as of September 30, 2013.

4 Because of discrepancies in the definition of vehicle categories, the total number of HEVs, EVs, and PHEVs is unclear. See Chapter 31, United Kingdom, for more information.

5 The 2011 and 2012 totals are as reported in the 2012 Annual Report.

Table 14.3 Actual or estimated (*estimates in italic*) electric bicycle and e-scooter sales and populations in IA-HEV member countries, as of December 31, 2013 (exceptions are noted).

Electric Bicycles + Scooters			
Country	2012 Fleet Totals	2013 Sales	2013 Fleet Totals
Austria	3,604	379	3,984
Belgium	n/a	*50,000*	50,000
Canada	n/a	n/a	n/a
Denmark	50,000	20,000	70,000
Finland	500	n/a	500
France	n/a	n/a	n/a
Germany	1,200,000	n/a	1,200,000
Ireland	n/a	n/a	n/a
Italy	*260,000*	51,405	311,405
Netherlands[1]	975,000	205,154	1,122,902
Portugal	n/a	n/a	n/a
South Korea	n/a	n/a	n/a
Spain	670	n/a	670
Sweden	n/a	n/a	n/a
Switzerland	200,000	51,212	251,212
Turkey	n/a	n/a	n/a
UK[2]	–	–	–
USA	1,000,000	89,000	1,089,000
Total IA-HEV	**3,689,774**	**467,150**	**4,159,324**

n/a = not available

[1] The Netherlands sales totals include 5,154 electric scooters and the 2013 fleet totals include 22,902 electric scooters.

[2] Because of discrepancies in the definition of vehicle categories, the total number of HEVs, EVs, and PHEVs is unclear. See Chapter 31, United Kingdom, for more information.

15

Austria

15.1 Major Developments in 2013

The Austrian Federal government still holds to its Implementation Plan, "Electromobility in and from Austria,"[1] which was released in June 2012 and covers a broad range of measures that aim to pave the way for electric vehicles (EVs) within Austria's transportation 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 electric mobility (E-Mobility) in Austria.

The "Future Mobility"[2] program is one of Austria's mobility programs, focused on personal mobility, freight mobility, transportation infrastructure, and vehicle technologies. The first two calls for proposals were focused on alternative vehicle technologies (fuel cell technologies, hybrid and battery electric propulsion systems, and alternative fuels) and mobility design possibilities (multimodal lifestyle, active forms of mobility,[3] and equal mobility[4]). Up to €8 million ($10.84 million US) were reserved for both calls. The current call is focused on the freight mobility and the development of alternative automotive technologies. The main topics of the call are the sustainable transportation chain, alternative energy sources, thermal management, fuel cell technologies and hydrogen, and innovative forms of transportation. Up to €10.3 million ($14.01 million US) are reserved for these topics.

Additional E-Mobility research activities in Austria are conducted under the funding programs of the Climate and Energy Fund.[5] This fund includes the "Lighthouses of

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1 http://www.bmvit.gv.at/en/service/publications/downloads/electromobility_implementation.pdf

2 http://www.bmvit.gv.at/en/innovation/mobility/index.html

3 Active forms of mobility means all forms of mobility within the short-range/for the so called last mile, either through cycling or walking by foot or by using any kind of mobility with power assist.

4 Equal mobility is focusing on people with mobility restrictions. The focus is on innovations and technologies that ensure a barrier-free usability of the transport system.

5 http://www.klimafonds.gv.at/

E-Mobility"[6] program, which issued its last call in September 2013 with a budget of €4 million ($5.49 million US). The program "E-Mobility for All"[7] focuses on the implementation of demonstration projects in urban areas of more than 50,000 inhabitants, with funding of €6 million ($8.16 million US). The "E-Mobility Model Regions"[8] Program, with funding of €1 million ($1.35 million US), expired at the end of 2013.

15.1.1 Field Trial of E-LOG-Biofleet Launched

As part of the "Lighthouses of E-Mobility" program, Austrian Federal Minister Bures placed into service logistical vehicles with fuel cell hybrid drives, as well as Europe's first indoor hydrogen refueling station (Figure 15.1).

The goal of the program is to increase the productivity of battery-powered fork-lift trucks and warehouse equipment, which up to now is limited as a result of the time involved in recharging and changing the battery, the battery's service life, and high maintenance costs. The solution is based on the HyLOG Fleet system from Fronius,[9] which replaces the battery and was developed for use with warehouse equipment in collaboration with Linde Material Handling.

Fig. 15.1 Successful field trial of E-LOG-Biofleet. Federal Minister Doris Bures (center) is shown with the project partners. (Image courtesy of Linde Material Handling)

6 http://www.klimafonds.gv.at/foerderungen/aktuelle-foerderungen/2013/leuchttuerme-der-e-mobilitaet-5-as/
7 http://www.klimafonds.gv.at/foerderungen/aktuelle-foerderungen/2013/e-mobilitaet-fuer-alle-urbane-elektromobilitaet/
8 http://www.klimafonds.gv.at/foerderungen/aktuelle-foerderungen/2013/modellregion-elektromobilitaet/
9 http://www.linde-mh.com/en/main_page/news/pressreleases/pressreleases_1_3392.jsp

15.1.2 The Goal of Sustainable Mobility

Wiener Linien,[10] the municipal public transport system in Austria, is choosing to modernize its fleet of buses by deploying increasing numbers of electric buses (e-midi-bus). As a result, Wiener Linien was awarded Austria's State Prize for Mobility in 2013 for its project "zero emissions buses," which cruise throughout Vienna's downtown area and show a tremendous potential for E-Mobility (Figure 15.2). The prize was financed by the BMVIT. It is the highest award which the BMVIT can award in this area.

The e-midi-bus is ideally suited for transportation in historic old towns. With only one battery, it can cover a daily distance of 150 kilometers. Charging can be done via an overhead line but also via an electrical outlet.

In 2013, Wiener Linien operated 12 e-midi-buses and 6 hybrid buses in downtown traffic. In addition, Wiener Linien started to modernize the whole bus fleet, which will include more than 1000 of its buses by 2023. The eco-friendly Mercedes Citaro bus was chosen for this modernization effort because it complies with the €O 6 emission standard.

As the largest logistical company in the country, the Austrian Post[11] wants to be a pioneer in the field of E-Mobility. "E-Mobility Post" is a program of the Austrian postal service, and it has made continued progress in developing an EV fleet for postal delivery in order to reduce unsafe vehicle emissions. The program started in 2012, and 1,157 (single and multilane) EVs will be acquired by 2015 for delivery services, with a focus on the city of Vienna and its surrounding areas (Figure 15.3).

At the end of 2013, Austria's postal service was operating 265 EVs (247 single- and 18 multi-lane) and 9,200 conventional vehicles. To power these EVs with renewable energy, Austria's postal service has built the largest photovoltaic plant in Austria on the roof of its letter distribution center in Vienna.

10 http://www.wienerlinien.at/eportal/ep/home.do?tabId=0
11 http://www.post.at/en/index.php

Fig. 15.2 The State Prize for Mobility was awarded to Wiener Linien for its zero-emissions bus. (Image courtesy of BMVIT)

Fig 15.3 Austria's postal service EV fleet will grow to 1,000 vehicles by 2015. (Image courtesy of Austrian Post)

15.1.3 Austrian National Policies

For vehicles with CO_2 emissions below 120 g/km, upon registration, drivers can receive a one-time monetary bonus of €300 ($404 US) given per vehicle. If CO_2 emissions are over 150 g/km, a penalty is assessed. For vehicles with an environmentally friendly engine (using hybrid drive, E85 fuel, methane in the form of natural gas or biogas, liquefied petroleum gas, or hydrogen), a driver's tax liability will be reduced to a maximum of €500 ($673 US) by the end of August 2014. Many insurance companies give a policy discount of 10–20% if the driver owns an EV.

Austrian national policies for hybrid electric vehicles (HEVs) and EVs are listed in Table 15.1.

Table 15.1 Summary of Austria's policy instruments for HEVs and EVs.

Policy	Description
Hybrid vehicle tax reduction	As of January 1, 2013, the motor-dependent insurance tax for HEVs and range-extended vehicles has to be paid for combustion engines only.
Electric vehicle	Vehicles powered by electricity are exempt from the motor-dependent insurance tax.
Emission taxation system	As of January 1, 2013, taxes on a new vehicle purchase are determined by the vehicle emission rating as follows: • Emissions >150 g CO_2/km: Tax is €25 ($33 US)/g CO_2 • Emissions >170 g CO_2/km: Tax is €50 ($66 US)/g CO_2 • Emissions >210 g CO_2/km: Tax is €75 ($99 US)/g CO_2

15.2 HEVs, PHEVs, and EVs on the Road

According to Statistics Austria, 415,313 new motor vehicles were registered in 2013. New registered passenger cars accounted for 319,035 of those vehicles, which is a 5.05% decrease (16,959 passenger cars) from 2012. A total of 654 EV passenger vehicles and 2,573 HEV passenger vehicles were registered in 2013. Thus, the number of new EVs increased by 0.2% (from 427 new EV registrations in 2011). The number of new HEVs also increased by 0.9% (from 1,171 new HEVs in 2011).

Renault Austria has sold 1,200 EVs in Austria and has delivered more battery-powered models (including Twizy, Kangoo Z.E., ZOE, and Fluence Z.E.) than all other volume manufacturers combined. Renault is in first place among suppliers of pure battery-powered vehicles and holds a market share of 64% (as of December 2013) in Austria. The most successful model is still the Renault Twizy.

Fleet totals and total sales during 2013 are displayed in Table 15.2. Table 15.3 lists the plug-in vehicle models available in 2013 and their prices.

Table 15.2 Distribution, sales, and models of Austrian EVs and HEVs in 2013.

Fleet Totals as of December 31, 2013					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	n/a	n/a	n/a	0	293,371
Motorbikes	n/a	n/a	n/a	0	450,287
Quadricycles	n/a	n/a	n/a	0	30,425
Passenger vehicles	2,070	10,504	n/a	0	4,641,308
Multipurpose passenger vehicles	n/a	n/a	n/a	n/a	n/a
Buses	n/a	n/a	n/a	0	9,579
Trucks	n/a	n/a	n/a	0	408,560
Industrial vehicles	n/a	n/a	n/a	0	502,546
Totals with bicycles	n/a	n/a	n/a	n/a	6,336,076
Totals without bicycles	n/a	n/a	n/a	n/a	6,042,705
Total Sales during 2013					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	379	1	n/a	0	17,055
Motorbikes	60	4	n/a	0	26,027
Quadricycles	146	1	n/a	0	3,003
Passenger vehicles	654	2,573	n/a	0	319,035
Multipurpose passenger vehicles	n/a	n/a	n/a	n/a	n/a
Buses	15	0	n/a	0	713
Trucks	191	0	n/a	0	38,144
Industrial vehicles	27	0	n/a	0	9,787
Totals with bicycles	1,472	2,575	n/a	n/a	415,313
Totals without bicycles	1,093	2,574	n/a	n/a	398,258

n/a = not available

[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.

Table 15.3 Prices of plug-in vehicle passenger models available in 2013 in Austria.

Plug-in Vehicle Passenger Models Available in 2013		
Model Name	Model Price (untaxed, unsubsidized)	
	Euros (€)	US Dollars ($)
Chevrolet Volt	38,000	51,942
Citroen C-Zero	27,588	37,709
Fisker Karma	109,800	150,083
Ford Focus Electric	39,990	54,662
Mitsubishi i-MiEV	29,500	40,322
Nissan Leaf	29,500	40,323
Opel Ampera	38,400	52,488
Peugeot iOn	29,640	40,515
Porsche Panamera S E-Hybrid	110,409	150,916
Renault Fluence Z.E.	25,950	35,186
Renault Kangoo Z.E.	24,360	33,024
Renault Twizy	6,990	9,554
Renault ZOE	20,780	28,404
Smart Fortwo Electric Drive	19,420	26,545
Tesla Roadster	101,700	132,160
Toyota Prius Plug-in Hybrid	37,500	51,258
Volvo V60 Plug-in Hybrid	57,400	78,459

15.3 Charging Infrastructure for EVSE

One EVSE (electric vehicle supply equipment or 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 1,160 public charging stations installed as of December 2013. Including private charging, there are 3,296 places to charge an EV in Austria, which represents a 0.76% increase from 3,271 in December 2012.

Wien Energie, an energy service provider, plans to build 300 new charging and quick charging points in Vienna by 2015; currently there are 150 available.

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

At the end of 2013 there were three fuel cell vehicle hydrogen stations available. The only public one is owned by the OMV Group.

Table 15.4 Public EVSEs installed as of December 31, 2013.

EVSE Type	Number
Level 2/standard AC	3296
DC fast charging	8
Fuel cell vehicle	1

15.4 EV Demonstration Projects

Table 15.5 EV demonstration projects in Austria.[a]

Name	Location	Duration	BEVs	EVSE	URL
VLOTTE	Vorarlberg	since 2008	400	156	http://www.vlotte.at/
ElectroDrive	Salzburg	2009–2014	180	192	http://www.electrodrive-salzburg.at
e-mobility on demand	Vienna	since 2010	55	164	http://www.e-connected.at/content/e-mobility-demand-wien
e-mobility Graz	Graz	since 2010	78	122	http://www.emobility-graz.at/
e-mobilisiert	Eisenstadt	since 2010	3	9	http://www.e-mobilisiert.at/index.jspa
e-pendler in nieder-österreich	Lower Austria	since 2011	2	2	http://www.ecoplus.at/de/ecoplus/cluster-niederoesterreich/e-mobil/
E-LOG	Klagenfurt	since 2011	0	50	http://www.e-connected.at/content/e-log-klagenfurt-0
E-Mobility Post	Vienna	since 2011	58	n/a	http://www.post.at/co2neutral/e_mobilitaet.php
VIBRATe	Bratislava	2007–2013	20	5	http://www.emobility-vibrate.eu/at

[a] Number of vehicles and charging stations according to a June 2013 status report (only two-lane battery electric vehicles [BEVs], no bikes).

16 Belgium

16.1 Major Developments in 2013

16.1.1 Automotive Sector

The automotive sector has always been one of the most important industrial sectors in Belgium. The country still hosts some car assembly plants: Ford in Genk (until 2014), Audi in Brussels, and Volvo Cars in Gent. The European headquarters, logistics center, 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.

In the last ten years, production of passenger cars in Belgium has dropped by half: from more than 1,000,000 cars in 2002 to fewer than 500,000 cars in 2013. The closure of factories like Opel Antwerp and Ford Genk are, of course, one of the main reasons. Within the remaining factories, however, we see more positive trends. Volvo Cars Gent produced more than 250,000 cars in 2013, which was the fourth best year since the start of production in 1965. China has become the main vehicle export country.

But the automotive sector is under pressure. The end of 2012 was difficult for the automotive sector in Belgium because Ford announced that it would close its factory in Genk in 2014. 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 these jobs and has developed a regional strategic action plan (SALK) to mitigate the projected economic impacts of the factory closure.

How can electric mobility strengthen the economic position of a country? Worldwide, policy makers are implementing supportive measures to facilitate the introduction or implementation of electric mobility in their region for environmental, societal, and economic reasons. But what economic growth can we expect in the electric mobility sector? Belgium and the Netherlands created a new IA-HEV Task on this topic. For more information, see “Task 24: Economic impact assessment of e-mobility.”

16.1.2 Brussels Motor Show

The 92nd Brussels Motor Show displayed new electric vehicles arriving on the market in Belgium in 2014 (Figure 16.1). Despite low sales numbers in Belgium, attendees expressed considerable interest in electric vehicles. More than 5,000 test drives were taken on the "Cleaner Mobility & Eco Test Track."

Fig. 16.1 Cleaner Mobility & Eco Test Track at the Brussels Motor Show. (Source: FEBIAC)

16.1.3 EV Boost

Company fleets are expected to be one of the first adopters of electric mobility. To stimulate the use of electric vehicles in company fleets, the EV Boost Concept was launched during the Brussels Motor Show (Figure 16.2).

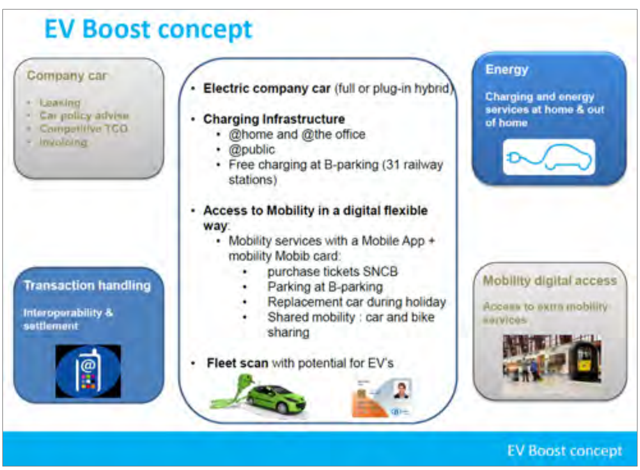

Fig. 16.2 EV Boost concept. (Source: OLYMPUS)

Belfius Auto Lease, NMBS, Electrabel, and Accenture worked out an integrated mobility solution called "Belfius E-Fleet" (Figure 16.3). This unique "all-in-one" leasing offer makes the use of electric vehicles in company fleets much more attractive for the company and the employee. The lease contract contains all the elements necessary for easy process administration by the company and a flexible, multi-modal, and sustainable mobility solution for the employee.

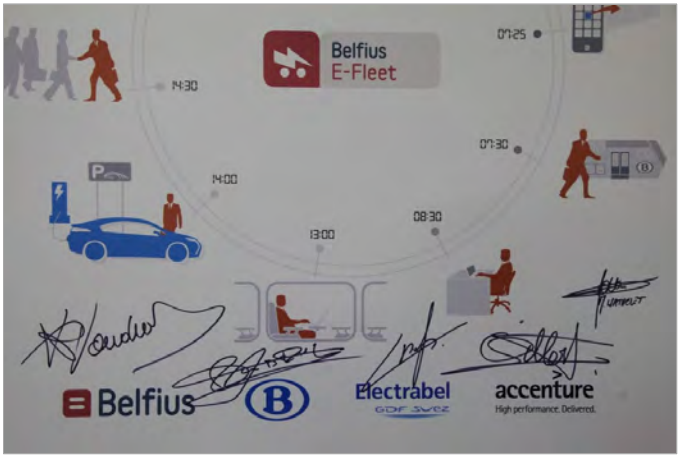

Fig.16.3 Belfius E-Fleet: A unique collaboration to move electric fleets forward.

Charging infrastructure will be installed, as part of the lease contract, at the company and at the driver's home. The driver will also get easy access to extra mobility services, like public transportation, car and bike sharing, parking, and more, by using the MOBIB mobility card and a dedicated smartphone app (Figure 16.4).

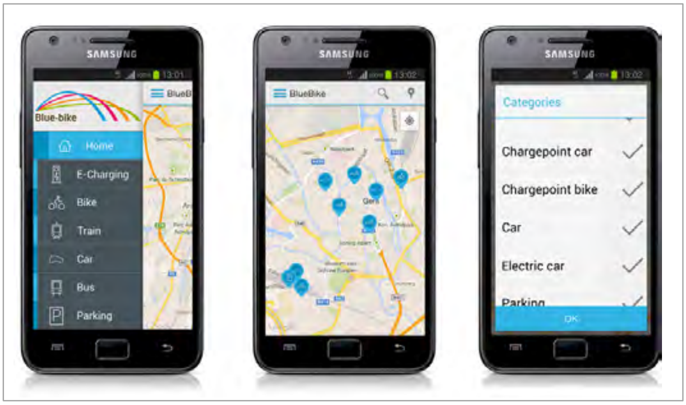

Fig. 16.4 Smart App "MoveFree." (Source: OLYMPUS)

To connect all these mobility services, a dedicated open service platform, called OLYMPUS, has been developed. This open platform will be the central place where information about available transportation modes comes together. The smartphone app “MoveFree” will provide drivers with information about available mobility services and the status of their “mobility budget.”

16.1.4 Federal Promotion of Alternative Fuels in the Transportation Sector

The government is working on a federal plan to promote alternative fuels in the transportation sector (as also stipulated in the proposed Clean Power for Transport Directive).

The proposed measures in the current federal plan relate to five pillars, including:

- Tax measures
- Infrastructure
- Communication
- Policy coordination
- The role of the government as the launching customer

The current goal is to coordinate all policy initiatives in order to head toward a coherent and coordinated national policy. A steering group, bringing together the principal stakeholders in Belgium, will play a vital role in the development of a Belgian plan for alternative fuels.

16.1.5 Flemish Living Lab Electric Vehicles Program

More than 70 local e-mobility stakeholders are intensively working together in the Flemish Living Lab Electric Vehicles program to facilitate and accelerate innovation (Figure 16.5). New products, services, and business models are being tested under real-life conditions. An open test infrastructure containing more than 300 electric vehicles and more than 800 charging points for electric bicycles and cars has been set up. A test population of more than 2,000 people has access to this infrastructure.

Fig. 16.5 The five platforms of the Flemish Living Lab Electric Vehicles.

During 2013, the focus of the Flemish Living Lab Electric Vehicles was to increase the collection of data on travel and charging behavior. More than 1,000,000 km have been driven, and data from onboard loggers are complemented by surveys of the test-population.

In addition to data-logging, a goal has been to set up extra research projects. The living lab is an open innovation platform, meaning that it is open for collaboration with external stakeholders. Research projects can be set up on a regional/national level (more than 30 projects are ongoing), but the Flemish Living Lab Electric Vehicles is also now collaborating more extensively with organizations at a European level.

The Programme Office Manager is active as co-chair in the Green eMotion Stakeholder Forum[1] (Figure 16.6) and is an associate member of eMI³,[2] the eMobility ICT (Information and Communication Technology) Interoperability Innovation Group. eMI³ is an open group of significant stakeholders from the global electric vehicles market who joined forces under the umbrella of ERTICO–ITS Europe (European Road Transport Telematics Implementation Coordination – Intelligent Transportation System) to harmonize ICT data definitions, formats, interfaces, and exchange mechanisms in order to enable a common language among all ICT platforms for electric vehicles. In addition, within "Four Motors for Europe,"[3] collaboration with other European regions was set up in 2013.

Fig. 16.6 Green eMotion Stakeholder Forum at EVS27 Barcelona. (Source: Green eMotion)

Companies from the Flemish Living Lab Electric Vehicles program are also stepping up to the European level. Van Hool has been very active in hybrid, electric, and fuel cell buses (Figure 16.7) for a long time and is now coordinating the

1 http://www.greenemotion-project.eu/stakeholder-forum/
2 http://emi3group.com/
3 http://www.4motors.eu/?lang=en

EU-funded High V.LO-City project.[4] Via this project, five fuel cell electric buses will operate in Belgium starting in the fourth quarter of 2014 in the Antwerp area, fueled by residual hydrogen from the Solvay plant in Antwerp. Van Hool has been manufacturing fuel cell electric buses since 2005 and has supplied 48 buses to the United States and Europe, including Norway, Germany, Italy, and the UK.

Fig. 16.7 Fuel cell bus. (Source: Van Hool)

Finally, the Flemish Living Lab Electric Vehicles website can also play a role in the communication of "lessons learned" with an introduction to electric mobility. One of the Living Lab's platforms has won an award for its website, where external stakeholders can learn about the activities under way in the living lab and electric mobility in general (Figure 16.8).

For more information on the Flemish Living Lab Electric Vehicles, visit www.livinglab-ev.be.

4 http://highvlocity.eu/

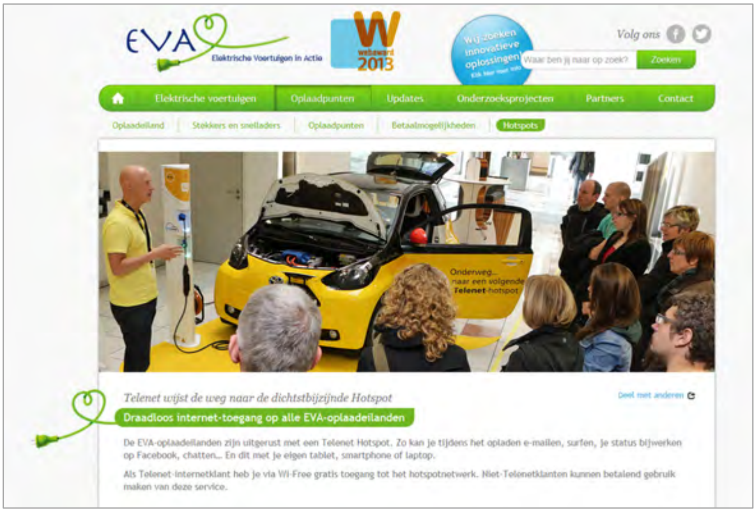

Fig. 16.8 Electric Vehicles in Action website wins web award 2013. (Source: EVA)

16.2 HEVs, PHEVs, and EVs on the Road

16.2.1 Fiscal Measures for Electric Vehicles

Sales of hybrid electric, plug-in hybrid electric, and electric vehicles (HEVs, PHEVs, and EVs) have grown more slowly than expected in Belgium. Industry is asking government for further support to stimulate the market. Unfortunately, the Belgium government stopped some beneficial tax incentives for electric vehicles at the end 2012. This had, of course, a negative impact on the sales numbers for 2013 (see Table 16.1). The industry is hoping for new supportive measures from the government in 2014. The “federal plan to promote alternative fuels in the transport sector” may be a solution because one of the five pillars focuses on tax measures.

In this section, we briefly summarize existing tax measures. In Belgium, tax measures related to the purchase and use of electric cars differ according to the legal status of the taxable person and the region they live in. In Belgium, both income taxes and company taxes are regulated at the national level.

16.2.2 Private Electric Vehicles

Regarding the purchase of an electric vehicle, the tax credit is calculated as 15% of the purchase price, with a maximum of €3,280 ($4,214 US) for quadricycles or €2,000 ($2,570 US) for motorcycles or tricycles. There is no longer an incentive for passenger cars.

16.2.3 Company Cars

Companies can deduct 120% of the purchase cost for zero-emission vehicles and 100% of the cost for vehicles emitting up to 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 ($32 US) per month.

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 leased cars. This change in the calculation of benefits has led to protests from the automotive sector in Belgium.

For new vehicles purchased in 2013, the tax calculation is made by using the following formula: taxable amount = purchase price × 366 × 6/7 × percentage of CO_2 in the exhaust. For pure electric vehicles, the lowest CO_2 percentage is used (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%.

The yearly vehicle tax and the car registration tax vary by region. In Flanders, EVs and PHEVs are exempt from the registration tax, and owners of EVs pay the lowest tariff of the circulation tax.

16.2.4 On the Road

16.2.4.1 Passenger Cars

Sales of electric passenger cars (PHEVs and EVs combined) decreased by 15% in 2013 compared to 2012. In absolute numbers, 769 electric passenger cars were sold in 2013. This leads to a total fleet of 1,795 electric passenger cars in Belgium.

Electric vehicles available on the Belgian market can be found at http://www.asbe.be/en/availableevs.

Table 16.1 shows the EV, HEV, PHEV, and FCV sales and fleet for 2013 (Source: FPS Mobility and Transport).

Table 16.1 Belgium sales and fleet numbers in 2013. (Source: FPS Mobility and Transport)

Fleet Totals per 01 January 2014					
Vehicle Type	EV Fleet	HEV Fleet	PHEV Fleet	FCV Fleet	Total Fleet
Bicycles (no driver's license)	[a]				
Motorbikes	170	0	0	0	421,061
Quadricycles	559	0	0	0	23,679
Passenger vehicles	1,205	25,493	590	1	5,505,332
Light commercial vehicles	430	0	0	0	641,225
Buses[b]	3	56	0	0	16,261
Trucks[b]	7	4	0	0	150,229
Industrial vehicles	1,482	0	0	0	249,207
Total	**3,856**	**25,553**	**590**	**1**	**7,006.994**
Total Sales during 2013					
Vehicle Type	**EV Fleet**	**HEV Fleet**	**PHEV Fleet**	**FCV Fleet**	**Total Fleet**
Bicycles (no driver's license)	50,000[c]				
Motorbikes	45	0	0	0	21,084
Quadricycles	96	0	0	0	1,505
Passenger vehicles	507	6,086	262	0	495,816
Light commercial vehicles	108	0	0	0	53,981
Buses[b]	0	1	0	0	779
Trucks[b]	0	1	0	0	8,671
Industrial vehicles	152	0	0	0	6,034
Total	**908**	**6,088**	**262**	**0**	**587,870**

[a] No official registrations on electric bicycles.

[b] These are the official registrations in the DIV database; however, hybrid buses and trucks are sometimes categorized under non-hybrid vehicles.

[c] Number is an estimate based on information from the sector federations FEDERAUTO and FEDERPROCYCLE.

16.2.4.2 Hybrid Buses

Public transportation saw a further increase in the use of hybrid buses. At present, 79 buses, or 3.5% of the bus fleet of the Flemish Public Transport Operator "De Lijn," are hybrids. De Lijn will place an extra order for a maximum of 386 new buses for €93 million ($121 million US). A mix of alternative drivetrains is represented in the bus order: three fully electric buses, five fuel cell buses, and 123 hybrid buses.

16.2.4.3 Electric Bicycles

In 2013, more than 400,000 bicycles had been sold in Belgium, which was growth of more than 4% compared to 2012. On the basis of an estimate from this sector (source: Federauto and FederProCycle), about 50,000 electric bicycles were sold. Electric bicycles are becoming increasingly popular with younger people and commuters. This sector is the largest growing market within electric mobility. Electric bicycles are also being used increasingly in bike sharing systems, like Blue-bike.

16.3 Charging Infrastructure for EVSE

The rollout of a charging infrastructure in Belgium depends mostly on industry initiatives. Many different companies are involved as charging infrastructure operators or mobility service providers.

Governments can play an important supporting role to stimulate the introduction of a charging infrastructure — for example, by setting up a framework for charging infrastructure concessions in the public arena or via incentives. The Flemish Government has set up the "ecologiepremie" framework to support companies making investments in ecology-friendly technology. A budget of €10 million has been estimated as needed to set up a charging infrastructure.

The Flemish Government also supports innovation in the field of electric mobility via the Flemish Living Lab Electric Vehicles program. The Living Lab program is an open platform for testing new products and services related to e-mobility in real life, in order to stimulate innovation. More than 800 charging points for electric bicycles and cars have been installed in the Living Lab. Different ways of user authentication and business models are being tested in real life. The interoperability working group is bringing together different market players from within the Living Lab, and at the end of 2013, Living Lab opened up the lab to all stakeholders in Belgium. Many charging infrastructure operators and mobility service providers are now connecting to the "open service platform," which was developed with the OLYMPUS platform.

Obtaining a current overview of all charging points available in a country is not an easy task because this information is spread out across many different market stakeholders. It would be easy to obtain a real-time overview of installed charging points in Belgium if all stakeholders were connected to a central platform (e.g., OLYMPUS). For this annual report, we collected this information via a survey that was sent to different stakeholders in Belgium.

The following companies participated in the survey:

- Arabel: www.arabel.be
- BeCharged: www.becharged.eu
- eNovates/Blue Corner: www.enovates.com and www.bluecorner.be
- EV-Point: www.ev-point.be
- Nissan: www.nissan.be
- P2SE (Products Supplies and Services Europe): www.e-p2se.com
- Powerdale: www.powerdale.com
- The New Motion: www.thenewmotion.com
- ThePluginCompany: www.theplugincompany.com
- Total Belgium: www.total.be
- VitaeMobility: www.vitaemobility.com/

Table 16.2 gives an idea of the number of charging points installed in Belgium at the end of 2013, while Table 16.3 gives an indication of the number of charging points expected in 2014.

Table 16.2 Number of EVSE charging points installed in Belgium as of December 31, 2013. (Source: Survey Programme Office)

Data Source: 11 Operators				
	Private		Publicly Accessible	
Power	Residential	Companies	Companies	Public Domain
AC, normal power (<22 kW)	978	332	566	222
AC, high power (≥22 kW)	23	231	443	150
DC	0	1	39	12
Total	**1001**	**564**	**1048**	**384**

Table 16.3 Number of EVSE charging points expected to be installed in Belgium in 2014. (Source: Survey Programme Office)

Data Source: 8 Operators				
	Private		Publicly Accessible	
Power	**Residential**	**Companies**	**Companies**	**Public Domain**
AC, normal power (<22 kW)	600	210	745	50
AC, high power (≥22 kW)	145	450	904	650
DC	0	0	56	19
Total	**745**	**660**	**1705**	**719**

Note: A charging pole can contain multiple charging points. The numbers mentioned in this table are unique charging points.

17 Canada

17.1 Major Developments in 2013

17.1.1 Electric Vehicle Infrastructure Incentive Program for Buildings – April 2013

The Building Owners and Managers Association (BOMA) of British Columbia in partnership with the Province of British Columbia (BC) offered a new incentive program for electric vehicle (EV) charging stations for buildings called the BOMA Clean Connect Program. The program was intended to support increasing the number of installations of EV charging stations across multiple building types and locations throughout BC by offering a substantial incentive to participants (up to a maximum of C$4,500 per station). This limited-time incentive program, which was launched in April 2013 and ended on March 31, 2014, surpassed its target of adding 125 new Level 2 (240 V) charging stations with the installation of a total of 128 stations in 60 buildings across 13 cities throughout BC.

17.1.2 Electric Vehicle Dealership Awards Program – October 2013

The all-new annual Canadian Electric Vehicle Dealership Awards Program — the first of its kind in Canada — recognizes car dealerships that demonstrate leadership in EV sales. The Awards Program, which is a joint initiative between the Canadian Electricity Association (CEA) and the not-for-profit organization Plug'n Drive, was announced at the EV 2013 VÉ Electric Vehicles Conference and Trade Show. Hosted annually by Electric Mobility Canada, it is Canada's premier electric vehicle event. The presentation of the 2014 awards will take place at the EV 2014 VÉ Conference. For more information, please visit www.electricvehicleawards.ca.

17.1.3 Québec Unveils Multi-Year Plan to Electrify Transport – November 2013

On November 1, 2013, the Provincial Government of Québec unveiled the details of its Transportation Electrification Strategy 2013–2017. The government will invest C$516.1 million over this period. The government is mobilizing another C$244.3 million so that electric transportation can make inroads quickly into public transit, personal transportation, and freight transportation. In addition to projects in electrified public transit, the government is allocating an additional C$65 million to extend the Drive Electric Program, providing a rebate of as much as C$8,000 to EV buyers for the next three years (that is, through December 31, 2016), or until the available funds are exhausted (see more at http://vehiculeselectriques.gouv.qc.ca/

english/particuliers/rabais.asp). A major electric taxi demonstration project with an ambitious plan of "greening" 525 taxis will also be undertaken. The government's goal is that more than 12,500 additional electric vehicles will be on the road by 2017. The government is also developing a plan to install 5,000 charging stations across Québec on roadways and at workplaces, including at Québec government buildings. In addition to these measures, the government will invest in research and development to leverage Québec's electrical expertise, as well as dedicate funds to initiatives that build a productive industrial network. For additional details on the plan, see a two-page summary[1] and the full 113-page report.[2]

17.1.4 Montréal to Become City of Electro Mobility – November 2013

Volvo Group's North American subsidiary, Nova Bus, and the Société de Transport de Montréal (STM) have entered into an agreement on an electrification project for the city of Montréal's public transit system. Nova Bus and STM signed a Memorandum of Understanding (MOU) on November 22, 2013. This MOU followed the formal launching by the Volvo Group of its City Mobility Program in April 2013 with partnerships in Gothenburg, Hamburg, Luxembourg, Montréal, and Stockholm. The plan is to expand the program to 10 cities worldwide. Montréal will be testing three Nova electric buses and two charging stations. The goal is to have the noiseless and emissions-free buses operational for demonstration in the third quarter of 2015 and in regular traffic for three years beginning in 2016. The buses will be used in city operations and will charge rapidly at bus terminals. The program will test a range of new technologies in real operating conditions to assess their impacts on planning, operations, maintenance, and the improvement of customer service.

17.1.5 Provincial-Level Clean Energy Vehicle Incentives – February 2014

As of February 14, 2014, the Clean Energy Vehicle Point of Sale Incentive Program in British Columbia reached its budget limit and is fully depleted. The program offered a rebate of up to C$5,000 of the pre-tax sticker price of eligible clean energy vehicles. As of September 30, 2013, 668 vehicles had been purchased using the incentives.

Ontario's Electric Vehicle Incentive Program and Québec's Drive Electric Program are still available for EV buyers. For details on the Ontario incentive program, visit www.mto.gov.on.ca/english/dandv/vehicle/electric/electric-vehicles.shtml, and for information on the Québec incentive program, visit www.vehiculeselectriques.gouv.qc.ca/english/particuliers/rabais.asp.

[1] http://www.mce.gouv.qc.ca/publications/electrification-transports/sommaire-en.pdf
[2] http://www.mce.gouv.qc.ca/publications/electrification-transports/strategie-electrification-en.pdf

17.2 HEVs, PHEVs, and EVs on the Road

Provincial rebate and incentive programs such as those described in the preceding section are a driving force for hybrid EV (HEV), plug-in HEV (PHEV), and EV sales across Canada. The Provinces of British Columbia, Ontario, and Québec have the highest EV adoption rate both in terms of total sales and percentage of new sales. EV/PHEV sales as a fraction of total passenger vehicle sales are showing steady increases. Fleet totals as of December 2013 and total sales of all vehicles during 2013 are provided in Table 17.1.

The number of HEV sales in 2013 was 22,633 and reached a fleet total of 130,823 by December 31, 2013. Meanwhile, the number of all-battery EVs and PHEVs registered in Canada also grew significantly. The combined total reached 5,712 by the end of December 2013, which is more than double the 2,591 on the road at the end of December 2012.

While the total number of PHEV sales remained stable in 2013, the number of battery-only EVs saw a significant percentage increase compared to 2012. As a result, the fraction of all-battery EVs versus PHEVs on the road in Canada at the end of 2013 was split: 44% EVs to 56% PHEVs.

A further breakdown of these results shows that the most popular type of electric car was the plug-in hybrid Chevrolet Volt. Of the 14 PHEV and EV models registered in Canada at the end of 2013, the Chevrolet Volt accounted for fully 44% of the combined fleet total. The next two most popular types were the all-electric Nissan Leaf with 16% of the total and the Tesla Model S with 13% of the total. In terms of actual 2013 sales numbers, the Tesla Model S significantly surpassed the Nissan Leaf (638 versus 470), whereas the Chevrolet Volt remained in the lead (931). In all, these three models accounted for 73% of the combined PHEV/EV fleet. The other 11 PHEV or EV models accounted for the remaining 27%.

Table 17.1 Vehicle fleet in Canada at the end of 2013.

Fleet Totals as of December 31, 2013					
Vehicle Type	EV Fleet	HEV Fleet	PHEV Fleet	FCV[a] Fleet	Total Fleet
Passenger vehicles	2,516[b]	130,823[c]	3,196[b]	n/a	21,261,600[d]
Total Sales during 2013					
Vehicle Type	EV Sales	HEV Sales	PHEV Sales	FCV Sales	Total Sales
Passenger vehicles	1,641[b]	22,633[b]	1,480[b]	n/a	1,776,461[e]
Plug-in Vehicle Models Available (passenger only)					
Model	Untaxed, Unsubsidized Price of Vehicle Model (all values in Canadian dollars)				
Chevrolet Volt	$36,895				
Ford C-MAX ENERGI	$36,499				
Ford Focus Electric	$36,199				
Ford Fusion ENERGI	$38,899				
Mitsubishi i-MiEV	$33,998				
Nissan Leaf	$31,698				
Smart Fortwo Electric Drive	$26,990				
Toyota Prius Plug-in	$35,705				
Cadillac ELR	$78,250				
Tesla Model S	$78,970				

n/a = not available

[a] FCV = fuel cell vehicle

[b] Source: Electric Mobility Canada and CrossChasm

[c] Estimate based on 2010 registration data (Desrosiers) and 2011–2013 sales data (Electric Mobility Canada and Polk)

[d] Source: Statistics Canada — Road motor vehicles weighing less than 4,500 kg at www5.statcan.gc.ca/cansim/

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

17.3 Charging Infrastructure for EVSE

The number of public and residential electric vehicle charging stations is increasing in Canada. This trend is a result, in part, of the EVSE incentive programs in the Provinces of British Columbia, Ontario, and Québec. Ontario's EV Charging Incentive Program started January 1, 2013. The incentive program covers 50% of the purchase and installation expenses up to a maximum of C$1,000 for eligible new

Level 2 (208 V or 240 V AC [alternating current]) electric vehicle charging stations for residential or business use. Some of Canada's smaller provinces (e.g., New Brunswick, Nova Scotia, and Prince Edward Island) are also starting to consider installing EV charging infrastructure.

Because EV charging stations do not require any form of registration or special permitting, there is no direct way to know the total number of charging stations in Canada. The data provided in Table 17.2 is from stations with verified locations and represents a conservative estimate of the actual number of public charging stations in Canada.

Table 17.2 Charging points in Canada.

Number of Public EVSE Installed as of March 2014	
Level 2/Standard AC	DC Fast Charging
1172[a]	7[a]
Number of Fueling Locations for Fuel Cell Vehicles	
1[b]	

[a] Source: Electric Mobility Canada and CrossChasm

[b] Semi-publicly accessible

17.4 EVSE Developments in 2013

17.4.1 AddEnergie's VERnetwork – February 2013

AddEnergie, a Québec City–based company, was selected to provide its electric charging solution and will install more than 30 public charging stations in the City of Victoria, B.C., and neighboring communities and no fewer than 26 public charging stations throughout the entire Okanagan Valley, for a total of 56 systems installed. The charging stations will be connected to AddEnergie's VERnetwork™. AddÉnergie now manages an installed base of nearly 650 Level 2 charging stations in Québec, Ontario, British Columbia, and New Brunswick.

17.4.2 Québec and Vermont Electric Charging Corridor – June 2013

The Province of Québec and the State of Vermont announced the implementation of the first electric charging corridor linking Québec and Vermont. Some 160 kilometres long, the route is marked by 31 charging stations that are part of Hydro-Québec's Electric Circuit and the Drive Electric Vermont network. This number is expected to grow as more partnership agreements are signed. To locate a charging station, users can visit the Electric Circuit website (http://www.lecircuitelectrique.com/index.en.html).

17.4.3 Plug'n Drive Launches an Open Network of Charging Stations – July 2013

In July 2013, Plug'n Drive, a not-for-profit organization committed to accelerating the adoption of electric cars, announced the launch of Charge My Car on the Road, an open network of electric vehicle charging stations in Ontario. Plug'n Drive has partnered with Greenlots, a San Francisco-based company that provides networked solutions for electric vehicle charging networks. The Charge My Car network will be supported by Greenlots SKY, allowing drivers to find and access the charging stations on their smartphones or tablets. In the project’s first phase, Plug'n Drive is working with Eaton Corporation and AddEnergie to establish the network in Ontario.

17.4.4 One Million Kilometers of Roads with “Charge Coverage” – October 2013

Sun Country Highway (https://suncountryhighway.ca/), a privately funded Canadian company that installs public chargers across Canada, has now installed enough infrastructure to provide “charge coverage” along 1 million km of Canadian roads. That is, charging stations are spaced closely enough that EV drivers can access 1 million km of roads across the country using the Sun Country trans-Canada network. Although the stations were originally spaced to accommodate the range of a Tesla Roadster, the company has been steadily filling the gaps in its network to accommodate lower-range vehicles such as the Nissan Leaf.

17.4.5 Highway 401 in Canada Now Electrified – October 2013

Sun Country Highway has recently expanded its network alongside Highway 401, one of the busiest roads in North America. In total, more than 20 public charging stations have been placed alongside the highway every 50 to 98 km, allowing EV drivers to make the 900+-km trip from Detroit, through Toronto, to Montréal completely on electricity. The charging stations are all Level 2 (240 V) and their use is completely free to the public.

17.4.6 DC Fast-Charging Stations Open in British Columbia – November 2013

With the official opening of an electric vehicle fast-charging station at the Surrey Museum in November, British Columbia is well on its way to becoming the first Canadian province to provide electric vehicle drivers with a fast-charging network of 13 direct current (DC) Level 3 stations. In addition to the Surrey station, fast-charging stations in Kamloops, Nanaimo, Duncan, Squamish, and Merritt are now operational. The seven remaining stations are scheduled to be put online in 2014. The 13 fast chargers are a first step toward meeting the British Columbia government’s goal to install 30 fast-charging stations in a three-year period.

17.4.7 GO Transit Offers Electric Car Charging at Train Stations – November 2013

In an effort to make it easier for commuters to make environmentally friendly choices, five GO Transit train stations in the Greater Toronto and Hamilton area have been equipped with Level 2 (240 V) charging stations, with five more planned for next year. The charging stations are available to the public whether or not they ride transit. The cost is C$2.50 per charge, and users can pay with a credit card or a ChargePoint smart card. GO Transit stations plan to open electric vehicle charging facilities in five more cities in Ontario in 2014.

17.4.8 The Electric Circuit – January 2014

The Electric Circuit is the largest public charging network in Québec. There are approximately 250 Level 2 (240 V) charging stations installed in 57 cities in 14 Québec regions, as well as one fast-charge (400 V) station that has been available since November 28, 2013. Since its launch in March 2012, 55 private and institutional partners have joined the Electric Circuit. It continues to expand in order to offer greater geographical coverage and serve more EV drivers in many regions of Québec. Almost 70% of EV drivers now have Electric Circuit cards and use them for top-ups as needed. Since December 2012, the number of charges per month has surged from 200 to almost 1,000 throughout the system, with 40 monthly charges taking place at the new fast-charge station. Electric Circuit users also have access to a 24/7 telephone help line run by CAA-Québec, as well as a charging-station locator service. The Electric Circuit website (http://www.lecircuitelectrique.com/index.en.html) is updated as new stations are installed or commissioned.

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18 Denmark

18.1 Major Developments in 2013

Denmark has a very well developed publicly available charging infrastructure, thanks to the two major e-mobility providers — CLEVER and E.ON. CLEVER and E.ON each operate separate countrywide charging networks.

The number of electric vehicles (EVs) in Denmark is still relatively low, but government-supported programs from 2013 to 2015 will double the number that are in use in 2014 and perhaps quadruple it by the end of the program. The program has developed from small projects in 2008 to larger deployment projects that were started in 2013.

Electrification of the transport sector plays a significant role fulfilling the Danish goal of being 100% independent of fossil energy in 2050 and with electricity being based 100% on renewables in 2035. In 2020, 70% of electricity will be generated from renewable sources (50% wind power, 20% biomass). Major drivers for the electrification of transport are its very high-energy efficiency, the synergies between the storage needs, and flexible consumer capabilities of batteries used for transport, as well as rapidly increasing and fluctuating wind-power production.

The first focus of the Danish effort has been on public EV fleets; the results are summarized below.

- EVs, in terms of total cost of ownership (TCO) and functionality, are a real and competitive alternative to internal combustion engine (ICE) cars in company and municipality fleets.
- EVs can fulfill very large parts of the daily driving range.
- 54% of municipalities have EVs in their fleets — some with high shares.
- 11% of municipalities have more than 5 EVs in their fleet.
- EVs constitute a huge potential in companies' and municipalities' car pools (where the vehicles typically are typically used by employees to attend meetings and make on-site inspections).
- The next steps are to further document and disseminate TCO business cases and to further reduce prices through coordinated large-scale purchases (rebate) and transactions costs (common tenders) on the EVs and their supporting infrastructure.

The second focus is on **private EV fleets**:

- A lot of work needs to be done since experience shows that companies are more hesitant than municipalities to use EVs.
- The next step is to include private fleets in the activities for public fleets and the large deployment projects.
- The new EV models, such as BMW i3 and Tesla S, have spurred considerable interest among private fleet owners.

The third focus is on **private consumer use of EVs**:

- A lot of work still needs to be done.
- Private consumers are hesitant to purchase EVs. In 2013, only 138 EVs were sold to private consumers (that is 21% of the EVs sold in Denmark).
- The main barriers discouraging private consumers from purchasing EVs are high purchase prices, concerns about vehicle range, a lack of knowledge about EVs, and a limited selection of EVs.

The fourth focus is on **synergy with the electricity system**:

- Denmark is preparing a smart grid system that allows e-mobility providers, electricity companies, and other stakeholders to trade energy services affiliated with EV charging (i.e., delayed or accelerated EV charging) and eventually vehicle-to-grid (V2G) services.
- Utility distribution system operators (DSOs) are entitled to use time-differentiated distribution grid transport tariffs, which give end users incentives to charge their EVs when electricity prices and the demand on the power grid are low.
- By 2020, remotely read hourly meters will be installed at all locations for customer convenience.
- Retail markets and wholesale models are being prepared that can manage flexible electricity consumption.

18.1.1 EV Partnerships

The Danish Energy Agency (DEA) is administering a grant scheme of DKK 40 million ($7.3 million US) allocated to supporting EV partnerships during 2013–2015. Private companies and public entities can apply for funding of EV fleet projects. The purpose of EV Partnerships is to increase the visibility of EVs on the roads and, hence, increase the familiarity of companies, public bodies, and private consumers with EVs, as well as their willingness to purchase them. The DEA gives priority to cost-effective projects to ensure high visibility of EVs on the roads. Award criteria are yearly mileages and applied funding for each EV.

In 2013, DEA supported 4 large EV partnerships with a total of DKK 23.4 million ($4.3 million US), resulting in 1,475 new EVs on the roads. The co-funding of EVs by project owners and the EV charging infrastructure is approximately DKK 343 million ($62.4 million US).

DEA has supported the following EV partnerships:

- The Capital Region of Denmark's (CRD) EV partnership with 511 EVs in 18 municipalities, 11 companies, the Capital Region of Denmark, and the Danish Defence.
- A free-flow car-sharing service in Copenhagen with 400 EVs organized by Arriva, a public transport service provider. The car-sharing system will be similar to the Autolib and Car2Go schemes in Paris and Amsterdam, respectively. The EVs will be charged at the e-mobility provider E.ON's charging station network.
- Flexible leasing of 400 EVs available for public organizations and companies. AVIS Denmark is providing a plug-and-play leasing concept that includes a car-sharing fleet management system that allows easy sharing of the EVs among users.
- EV partnership in East Jutland organized by the Danish EV Alliance. The partnership encompasses 96 EVs among 6 municipalities and 10 companies.

18.1.2 Regional EV Secretariat in the Capital Region of Denmark

The CRD launched, in 2013, an EV initiative where the region has allocated DKK 12 million ($2.2 million US) to establish a regional EV secretariat (Copenhagen Electric). The secretariat runs for 3 years and has 4 employees to promote EVs in the region. An additional DKK 4.5 million ($0.82 million US) is allocated to fleet analyses that are offered in all 29 municipalities in the region and including all hospitals. On the basis of a full analysis of driver use of vehicles and their driving patterns, passenger cars and light-duty vehicles (LDVs) that can be substituted with EVs are identified and the costs associated with them are calculated. On the basis of total cost of ownership (TCO) analyses, between 25 and 50% of the municipalities' fleets of passenger cars and small vans can be replaced with EVs without additional costs.

The EV Secretariat conducts a range of activities, including:

- Coordination of regional EV projects where municipalities and companies in the region can try EVs for 14 days.
- Information-sharing events about EVs for municipalities, companies, and private citizens.
- Co-funding by the Capital Region of Denmark of a free-flow car-sharing scheme in Copenhagen with DKK 6 million ($1.1 million US).

18.1.3 Procurement Targets for EVs

As a part of its Climate Action Plan, the City of Copenhagen has a target for the addition of low-carbon vehicles to the city's car fleet. By the end of 2015, 85% of all passenger cars must be EVs or fuel cell vehicles (FCVs), and by 2025, all passenger cars and LDVs should be propelled by electricity or hydrogen. Since 2011, the City has only purchased EVs and FCV passenger cars. As of February 2014, EVs and FCVs made up 41% of the City's fleet of passenger cars. The total number of EVs in the City's fleet was 237 (101 of those were quadricycles), and there were 16 FCVs. In 2014–2015, the City of Copenhagen plans to purchase an additional 132 EVs. Starting in July 2014, the Capital Region of Denmark will introduce a similar policy of only purchasing fossil-free passenger cars and LDVs.

The DEA, the Regional EV Secretariat, and the City of Copenhagen have organized a procurement partnership on EVs and electric vehicle supply equipment, also known as EV charging stations (EVSE) for Danish municipalities and regions. Public entities are bound by Danish and European Union (EU) procurement rules. The City of Copenhagen has extensive experiences with organizing EU tenders for the purchase of EVs. By participating in the procurement partnership, each municipality does not have to use its own resources to carry out its own tenders. Moreover, by pooling the purchasing power it is expected that the procurement partnership can obtain significant discounts. In 2014, 14 public entities will purchase approximately 150 EVs and associated EVSE through the procurement partnership.

18.1.4 Public Tender of EVSE at the Danish Motorway Network

In the spring of 2014, The Danish Road Directorate organized a tender of charging stations on the Danish motorway network. The purpose was to establish a countrywide network of publicly available charging stations on the motorway network. Concessions have been granted to the e-mobility provider E.ON, which will establish changing stations at 13 locations. This will connect Copenhagen, the capital, with the second-largest and third-largest Danish cities, Århus and Odense. The network of charging stations is planned to open by the end of 2014. No direct financial support is given to establish the charging station. The Danish Road Directorate plans to negotiate with e-mobility providers and gasoline retailers on providing EV recharging on the remaining parts of the motorway network. The charging stations will be compatible with the Combo 2, the CHAdeMO, and the AC Type 2 standards. Open access to the charging stations is required.

Other regulations and incentives that support the deployment of EVs in Denmark are summarized in Table 18.1.

Table 18.1 Other regulations and initiatives that support deployment of EVs.

Other Regulations and Initiatives That Support the Deployment of EVs
• Until the end of 2015, EVs and FCVs are exempted from the Danish registration tax for passenger cars, which is very high (up to 180%), and is based on the value of the car. EVs are also exempted from the annual road tax.
• Until the end of 2015, Companies that supply commercial EV charging can get an electricity-tax reimbursement that amounts to approximately DKK 1 ($0.18 US) per kilowatt-hour.
• Transport is included in energy-saving efforts that DSOs can support. Fleet owners purchasing energy efficient vehicles — including EVs — can receive funding from the utility companies. Through the competitive market, among the DSOs for energy savings, fleet owners may receive up to DKK 2,000–4,000 ($350–700 US) per vehicle.
• Besides the EV partnership program, the DEA also administers the smaller Danish EV Test Scheme. Funding of DKK 10 million ($1.8 million US) is available in 2014–2015 for EV and plug-in hybrid electric vehicle (PHEV) projects.

18.2 HEVs, PHEVs, and EVs on the Road

Fleet sizes are shown in Table 18.2, and Table 18.3 shows the number of new registered vehicles.

Table 18.2 Total fleet of HEVs, PHEVs, and EVs as of December 2013.

Stock	Fleet Totals as of December 31, 2013				
Vehicle Type	EV	HEV	PHEV	FCV	Total
Bicycles (no driver's license)	65,000	0	0	0	5,000,000
Motorbikes	300	0	0	0	150,360
Quadricycles	232	0	0	0	n/a
Passenger cars	1,257	2,181	26	17	2,265,349
Vans	245	405	0	0	401,133
Buses	14	13	0	0	8,646
Trucks	9	0	0	0	41,659
Industrial vehicles	n/a	n/a	n/a	n/a	n/a
Total with bicycles	67,057	2,599	26	17	7,867,147
Total without bicycles	2,057	2,599	26	17	2,867,147

n/a = not available

Table 18.3 Number of new registered vehicles as of December 2013.

Sales	Fleet Totals as of December 31, 2013				
Vehicle Type	EV	HEV	PHEV	FCV	Total
Bicycles (no driver's license)	20,000	0	0	0	452,000
Motorbikes	7	0	0	0	1,566
Quadricycles	46	0	0	0	n/a
Passenger cars	497	1,089	11	15	182,087
Vans	104	51	0	0	24,009
Buses	2	0	0	0	431
Trucks	1	0	0	0	4,312
Industrial vehicles	n/a	n/a	n/a	n/a	n/a
Total with bicycles	20,657	1,140	11	15	664,405
Total without bicycles	657	1,140	11	15	212,405

n/a = not available

18.3 Charging Infrastructure for EVSE

Two e-mobility providers, CLEVER and E.ON, dominate the Danish market for EV recharging from publicly available charging stations. Both e-mobility providers are operating countrywide charging networks. In September 2013, the German energy company E.ON took over all charging posts that were formerly owned by Better Place Denmark. Table 18.4 summarizes the number of publicly available EVSE installed as of December 31, 2013.

Table 18.4 Publicly available EVSE in Denmark.

Number of Publicly Available EVSE Installed as of December 31, 2013		
	Points	Posts
AC, slow charge (3,7 kW)	123	89
AC, semi-fast charge (11 kW)	702	352
AC, fast charge (22 kW)	110	55
DC, fast charge (50 kW)	47	47
Number of fueling locations for fuel cell vehicles		
700 bar	3	–

In May 2013, Better Place Denmark filed for bankruptcy. Better Place had established a countrywide network consisting of 18 battery-swapping stations (BSSs). All BSSs have subsequently been closed. The Danish Road Authorities have announced that the two BSSs located on the authority's areas will be dismantled. What will happen with the other BSSs has not yet been settled, but they will most likely also be removed. The Renault Fluence Z.E. was the only vehicle that was designed to use the BSSs. Renault has offered to buy back, at an attractive price, all Renault Fluence Z.E.s that were sold in Denmark. So far, 152 of the 268 Renault Fluence Z.E.s have been returned to Renault.

In September 2013, E.ON announced that it had taken over Better Place's network of charging stations. E.ON operates a network of 11-kW AC charging stations. The network consisted, by the end of 2013, of 350 publicly available charging stations (each equipped with 2 socket outlets). E.ON plans to expand its network by adding another 230–250 publicly available charging stations.

By the end of December 2013, CLEVER's network of publicly available AC and DC charging stations (see Figure 18.1) consisted of:

- 46 CHAdeMO (50 kW DC) stations
- One combined charging standard (CCS) (50 kW DC) station (equipped with a Type 2 Combo plug)
- 55 Type 2 charging posts (22 kW AC) (each equipped with 2 socket outlets)
- 55 Type 1 charging stations (3.7 kW AC) (equipped with 1 socket outlet)

Fig. 18.1 Renault ZOE at CLEVER 22-kW charge station. (Image courtesy of CLEVER)

In 2014, CLEVER expects to expand their charging infrastructure with 50 CO_2 CCS (50 kW DC) stations and 150 Type 2 (22 kW AC) charging posts (with a total of 300 socket outlets). CLEVER has located all of their DC fast-charging stations at supermarkets, gasoline stations, and other locations where the EV driver can spend time while the car is charging.

Both E.ON's and CLEVER's business models are based on customers subscribing to the company's charging infrastructure (with a monthly subscription fee) and paying for energy usage. Both e-mobility providers also offer non-subscription based charging services. The subscription cost is DKK 99 ($18 US), and prices for using the e-mobility providers' publicly available charging stations are DKK 3.25–3.50 per kWh ($0.59 US–$0.64 US). The non-subscription cost is DKK 5.25–5.50 per kWh ($0.95 US–$1.00 US). E.ON has developed a new business model that allows their customers to get a reduced rate at selected charging stations. For an additional monthly fee of DKK 50, E.ON's subscribers can select a specific charging station where the price is reduced to DKK 1.60 per kWh ($0.29 US). This solution is attractive for people who do not have access to dedicated parking lots (e.g., residents living in multi-unit dwellings).

CleanCharge Solutions is a Danish e-mobility operator and also a part of the RWE network of cooperation partners in Europe. The company's business model is based on supplying and installing equipment and providing value-added services (billing services, charging data processing, etc.) to charging point operators. CleanCharge cooperates with EasyPark, a parking billing provider that provides open access with direct payment for usage of the charging stations. Payment for usage is based on the amount of time that the EV is charging at the charging facility.

18.4 EV Demonstration Projects

18.4.1 Electric Buses

For 2 years, MOVIA, a public transport provider, is testing two electric buses manufactured by BYD (Figure 18.2). The buses are the same size (12 meters) as traditional diesel-powered buses. MOVIA is using the buses as a part of the regular transport services in Copenhagen. The project is supported by the Danish Road Authorities with DKK 5 million ($0.9 million US).

The City of Copenhagen is managing a new project with electric buses. The electric buses will be recharged at the terminus and/or at bus stops. The Danish Road Authority supports the project with DKK 6.6 million ($1.2 million US).

The City of Copenhagen is co-financing both projects.

Fig. 18.2 BYD electric bus. (Image courtesy of MOVIA)

18.4.2 EVs for Residents and Companies in Multi-Unit Buildings

E.ON is testing the shared use of charging infrastructure. The idea is to give residents in multi-unit buildings access to charging stations. The residents have priority to use the charging stations in the evening and overnight. When the residents are not using the charging stations, they are available for use by the public. The project is supported by the DEA with DKK 0.5 million ($90,000 US).

With support from DEA, DKK 1.2 million ($200,000 US), Green Mobility (a company that provides green fleet transition services) and SIXT are providing EV leasing services to private consumers and companies that do not have access to their own parking lots. The consumer is offered an integrated solution, including leasing rates competitive with ICE cars and dedicated parking facilities with access to EV chargers. The target of the project is to provide leasing services to users of 50 EVs.

18.4.3 Potential for EV Car-Sharing in Municipalities

LetsGo, a car-sharing operator, is investigating the potential for using EV car sharing services in municipalities as “critical start-up mass” for increasing local EV car-sharing. The project is investigating the potential for municipalities to optimize their car fleets by participating in EV car-sharing schemes — typically, by taking some of the least cost-effective cars out of their own fleets. The project is also investigating whether this demand could be the starting point of local car-sharing, when the car-sharing operator includes demand from private companies and citizens. As a part of the project, 6 municipalities are testing 14 shared EVs. The purpose of the project is to boost the application of EV car-sharing in Danish municipalities. The project is supported by the DEA with DKK 2 million ($360,000 US).

18.4.4 Electrification of Postal Services

Post Danmark, the Danish provider of postal services, is phasing in EVs in its car fleet. In 2013, its EV fleet reached 53 units (Mercedes Vito E-Cell). In 2014–2015, Post Danmark plans to purchase an additional 96 EVs (vans and trucks). The purpose of this change is to use EVs for all postal distribution on the Island of Bornholm and in central Copenhagen. Post Danmark is participating in the EV Partnerships that have been organized by the Capital Region of Denmark and the Danish EV Alliance.

19

Finland

19.1 Major Developments in 2013

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- or EV-related policy announcements or legislation changes during 2013. Current Finnish fuel taxes are based on energy content, carbon dioxide (CO_2) emissions, and impact on local air quality.

Regarding 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. Starting 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 ($129 million US) program budget. The EVE program is creating a new international community focused on developing new EV-related businesses, along with their machinery and systems. There is also funding reserved for vehicles and charging points participating in a national EV development program.

Some 2013 developments in Finnish industry:

- **New charging operator company was founded in December 2013.** Seventeen of the most important Finnish energy companies have founded Liikennevirta Oy, a charging operator company for electric cars. The new company makes it possible for electric car drivers to charge their cars at all charging stations equipped with the Virta. Ltd. symbol throughout Finland.

- **Helsinki goes green with electric and hybrid buses.** Helsinki is planning to go green by introducing approximately 100 new all-electric buses and 350 hybrids to the Helsinki region by 2018, if the test of buses proves successful. Helsinki Region Transport (HSL) aims to cut public transportation emissions detrimental to air quality by 80% by 2018. Electric buses are seen as ideal for city traffic, as they are quieter and do not produce emissions during operation.
- **Ensto develops modern parking services in France.** Ensto takes part in an international project that is developing something new: a multiservice parking kiosk. The multiservice kiosk is an intelligent solution that combines a parking meter, electric vehicle charging, and internet-based city services. The kiosk is part of a new parking system being introduced in Nice, France (Figure 19.1).

Fig. 19.1 Enstos Chago kiosk in Nice. (Source: Enstos [http://www.ensto.com/newsroom/references/evcharging/101/0/spot_ensto_chago_kiosks_along_garibaldi_2])

- **Hybrid stone crusher saves 16,000 liters of diesel with Finnish electric powertrain of VISEDO.** The new Rockster R1100DE full hybrid stone crusher (which uses a full VISEDO electric drive train) is now available for sale, with a first delivery to a major French road construction company. The Rockster hybrid crusher is the first of its kind on the market. The innovative machine brings 16,000 liters of annual diesel savings and at the same time, increases crusher productivity by 40%.
- **Valmet Automotive started series production of the new Mercedes A-class in 2013.** In March 2013, Valmet presented its first concept vehicle with a range-extended drivetrain (Figure 19.2). The concept vehicle's specified electric range is over 90 km (per the New European Driving Cycle, or NEDC), while the total range with range extender and 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. 19.2 The Valmet range-extended concept vehicle is potentially one solution toward a larger selection of EVs for the market. (Source: Valmet Automotive [http://www.valmet-automotive.com/automotive%5Ccms.nsf/pages/103A9A89EF4ADE99C2257B5C0036DDDC?opendocument])

19.2 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 19.1, but this number is increasing as a result of CO_2-based taxation of cars and consumers' growing desire to go "green."

Table 19.1 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, 2013					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total Fleet**
Motorbikes	30	0	0	0	30
Passenger vehicles	159	3,915	296	1	4,371
Buses	4	n/a	n/a	n/a	4
Total Sales during 2013					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total Sales**
Motorbikes	16	0	0	0	16
Passenger vehicles	50	2,422	168	1	2,641
Buses	3	n/a	n/a	n/a	3

n/a = not available

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

19.3 Charging Infrastructure for EVSE

Finland is the world's northernmost industrialized nation and its Nordic climate necessitates preheating of vehicles (see Figure 19.3). There are about one million block heaters in Finland used for engine preheating that can also be used for Level 2 EV charging (240 V). There are also about 250 public EV slow-charging points (120 V) around the country and nine direct current (DC) fast charging stations.

Fig. 19.3 Block heater poles typically have two-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 under way to increase EVSE numbers and strengthen the existing charging infrastructure. Table 19.2 lists Finland's current EVSE.

Table 19.2 EVSE in Finland as of December 31, 2013.

Type of Public EVSE	Number
DC fast charging	9
Level 2/standard AC	36 public charging stations with 244 charging points (additional ~1–1.5 million private ones primarily for block heaters)
Number of fueling locations for FCVs	2

19.4 EV Demonstration Projects

In 2011–2013, there were five big demonstration projects within the EVE (described in Section 19.1) to develop new EV-related businesses:

19.4.1 Electric Traffic: Helsinki Test Bed

Traffic solutions for large cities are the most promising area for EVs in Finland; an example is Helsinki (see Figure 19.4). In the Electric Traffic project (http://www.electrictraffic.fi/), participants from the greater Helsinki area, together with dozens of companies, are developing test environments for electric public transportation 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. 19.4 Helsinki drivers tested EVs in cold temperatures that reached –20°C. (Image courtesy of Tekes)

19.4.2 EUL: EcoUrban Living

The EUL project (http://www.eco-urbanliving.com/) 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. The demonstration project is located in Espoo, the second largest city in Finland. The key partners are Valmet Automotive, Aalto University, Hanken, the Lappeenranta University of Technology, and the VTT Technical Research Centre of Finland.

19.4.3 ECV: Electric Commercial Vehicles

The electrification of vehicles and mobile machinery offers great opportunities for reducing noise and air pollution. The ECV consortium (http://www.ecv.fi/) provides a world-class research and development network, as well as a platform for the development of a wide range of electric commercial vehicles, 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.

19.4.4 EVELINA: Countrywide Testing Facility

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.

19.4.5 WintEVE: Arctic Testing Facilities

The WintEVE consortium (http://www.winteve.fi/) 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.

These five programs will be replaced in 2014–2015 with three new programs:

- EVGA Electric Vehicles goes arctic,
- ECV Electric Commercial Vehicles, and
- ÄSL Intelligent Electric Traffic.

20

France

20.1 Major Developments in 2013

In 2013, the Minister of Productive Recovery, Arnaud Montebourg, confirmed the strategy aimed at fostering a domestic electric vehicle (EV) market through the automotive industry support plan. In the plan, the French government continues to make special efforts to achieve this goal.

20.1.1 Evolution of the Bonus-Malus System

In France, cars are taxed (malus) or credited (bonus) if their carbon emissions (http://en.wikipedia.org/wiki/Carbon_emissions) are above or below certain targets. Table 20.1 shows the levels for the subsidies "Bonus-Malus" as of January 1, 2013.

Table 20.1 Bonus-Malus system for 2013.

Bonus-Malus System for 2013	
CO_2 Emissions (g/km)	Bonus-Malus
20 and less (EV)	€-7000 (-$9425 US)
21–50	€-5000 (-$6732 US)
51–60	€-4500 (-$6059 US)
HEV (-110 g/km)	€-4000 (-$5386 US)
61–90	€-550 (-$741 US)
91–105	€-200 (-$269 US)
106–135	€0
136–140	€100 ($135 US)
141–145	€300 ($404 US)
145–150	€400 ($539 US)
151–155	€1000 ($1346 US)
156–175	€1500 ($2020 US)
176–180	€2000 ($2693 US)
181–185	€2600 ($3501 US)
185–190	€3000 ($4039 US)
191–200	€5000 ($6732 US)
201 and more	€6000 ($8079 US)

This table demonstrates the purchase incentives for low-CO_2-emitting vehicles.

20.1.2 Government Commitment to Order HEVs and EVs Redirected

In 2013, the national government confirmed its decision that 25% of the cars it buys should be hybrid or electric.

20.1.3 Continuation of the Investment for the Future Program

A new call for projects from the Investment for the Future program dedicated to vehicle research was launched in 2013. The "Vehicle of the Future" program aims to accelerate innovation and technology deployment and the use of efficient mobility. The goal is to reduce the impacts of vehicles on the environment. The program takes into account changing demands and customers behaviors that may occur in the next 20 years.

This call supports innovative research demonstrator projects involving public and private sectors that are pooling resources and experimentation projects, to make the connection between research and industry.

20.1.4 Creation of GIREVE

In 2013, GIREVE, a group that promotes widespread EV recharging, was created. The aim of GIREVE is to develop the widest range of charging services available through visible, accessible, and interoperable charging spots. The group was set up by major players in the electric mobility market to promote the use of battery electric and plug-in hybrid electric vehicles. New value-added services are required to support infrastructure development: access to a comprehensive charging equipment database, remote access to real-time availability and booking of charging spots, and roaming and clearing of charging transactions, among others.

20.1.5 Development of EV Car-Sharing Programs

Different EV car-sharing programs have been developed, with additional services opening in Paris (Autolib), Lyon (Bluely), Bordeaux (Bluecub), and Nice (AutoBleue). Following the success of Autolib in 55 municipalities in and around the Paris region, as well as the contracts with the Bolloré Group in Lyon and Bordeaux, the Renault and Bolloré groups will look at the possible founding of a joint venture to implement new projects in order to meet growing demand in France and international markets for electric car-sharing services.

In France, Renault could join forces with the Bolloré Group by taking a stake in Bluely (Lyon) and Bluecub (Bordeaux). The partnership between Bolloré and Renault exists in order to develop joint car-sharing solutions and to implement industrial and commercial cooperation agreements in the field of electric vehicles. The expected increase in the number of Bluecars (the existing 4-seater model) will lead to a production increase. The two groups will look at the possible transfer of some production processes to the Renault group's Dieppe plant, along with the supply of parts and components by Renault. The two groups will also look at the possible support that Renault could give the Bolloré group in the development and production of a 3-seater electric vehicle (3.1 m long) with a range of more than 200 km (124 miles).

20.1.6 Program "2 Liters per 100 km Vehicle"

The program "2 liters per 100 km vehicle" was launched in early 2013. In terms of CO_2 emissions, this objective corresponds to average emissions of 50 g of CO_2/km, a target that is even more ambitious than that set by the European Union for 2020. The program is coordinated by the Automobile Sector Platform (PFA) and aims at developing the technological building blocks for:

- Producing breakthroughs in CO_2 which have an acceptable cost increment to the client, with the goal of attaining a fuel consumption of 2 liters per 100 km and
- Meeting consumer expectations in terms of safety (driving aids) and connectivity (multimedia and navigation systems).

Four priority areas were identified:

1. Hybridization of vehicles,
2. Improved powertrain efficiency,
3. Improved vehicle efficiency (e.g., aerodynamic, mechanical losses), and
4. Driving assistance systems and connectivity.

20.2 HEVs, PHEVs, and EVs on the Road

In 2013, the French market for electric and hybrid vehicles showed growth. Both hybrid and electric cars represented 3.1% of the French passenger car market in 2013 (about 200,000 vehicles). Compared to 2012, sales of electric vehicles (passenger cars and light commercial vehicles) increased by 50% and sales of hybrid vehicles by 60%.

The UGAP, a central purchasing organization, is behind this success since it gathered 20 public and private players together to meet a demand of 50,000 cars over four years. Renault won the "Versatile 4-seater electric vehicle" and "Compact electric sedan" contracts in this call for bids. Two thousand Renault ZOE and 100 Renault Fluence Z.E. vehicles will be ordered over the next three years.

20.2.1 Passenger Cars EV Sales

The top-selling models are Renault Zoé (5,511 cars sold in 2013), the Nissan Leaf (1,438), and the Bolloré Bluecar (658). Sales of the Smart Fortwo also increased, with 478 vehicle registrations.

In total, 8,779 EV passenger cars were registered in France for the year 2013. Sales rose 50% compared to the 5,663 vehicle registrations recorded in 2012. Figure 20.1 shows the number of EV sales by model in 2013.

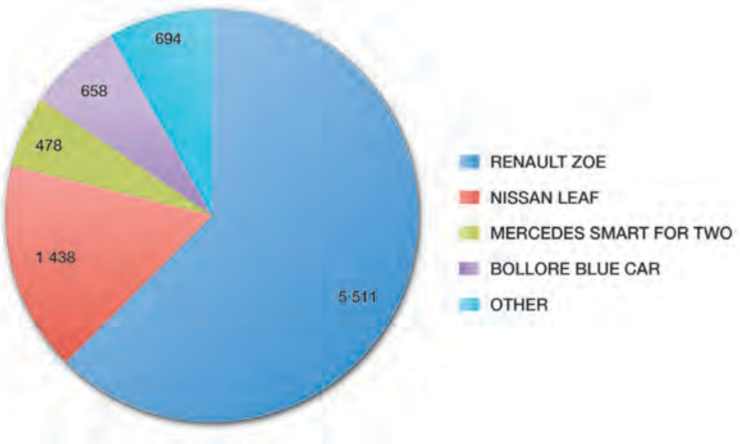

Fig. 20.1 Registrations of EV in 2013 by model. (Image courtesy of AVERE France)

20.2.2 Light Commercial EV Vehicle Sales

In 2013, the Renault Kangoo II led in EV sales, with 4,174 registrations or a 75% share of this market segment.

A total of 5,175 light commercial EV vehicles were registered in France in 2013. Sales increased 42% compared to the 3,651 registrations recorded in 2012.

Figure 20.2 compares the 2012 and 2013 sales of EV passenger cars and light commercial vehicles.

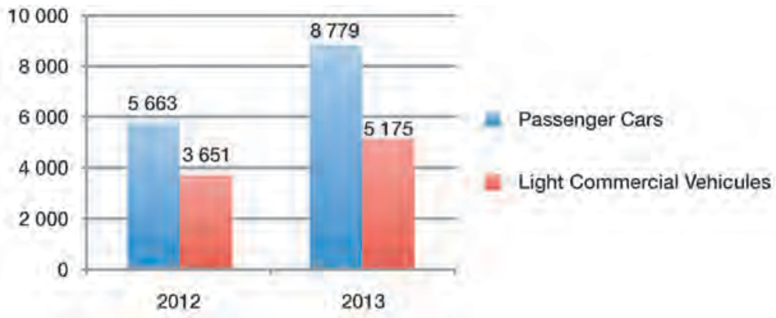

Fig. 20.2 Comparison of 2012 and 2013 registrations of EV passenger cars and light commercial vehicles. (Image courtesy of AVERE France)

20.2.3 HEV Sales

A total of 46,785 hybrid vehicles, including 32,799 hybrid gasoline and diesel 13,986 diesel hybrids, were registered in France in 2013. Sales increased by 60%, as compared to the 29,120 registrations recorded in 2012.

Despite a decrease in overall passenger vehicle sales, sales of hybrid cars continued to rise in 2013, with an increase of 60% compared to 2012. In total, more than 45,000 hybrid cars were sold in France last year, representing 2.5% of all passenger car sales in 2013.

Fig. 20.3 Toyota Yaris. (Image courtesy of AVEM [http://www.avem.fr/])

The top selling models of hybrid cars sold in France in 2013 were the entry-level models. By themselves, the Toyota Yaris (Figure 20.3) and Auris account for nearly half of the market share, with 13,905 (28.25% market share) and 9,856 registrations (21.09%), respectively.

In third, fourth, and fifth place are the hybrid-diesel models of PSA Peugeot Citroën (PSA = Peugeot S.A.): the Peugeot 3008, Peugeot 508 RXH, and the Citroën DS5 with 5,708, 4,589, and 3,100 registrations, respectively.

Next in line is the Prius family, the Prius + and Prius classic, with 2,177 and 1,858 registrations, respectively. Finally, the Lexus CT 200h, the Honda Jazz, and the new Lexus IS 250h had 1,047, 1,012, and 884 registrations, respectively.

Figure 20.4 shows the 2013 sales of HEVs by model.

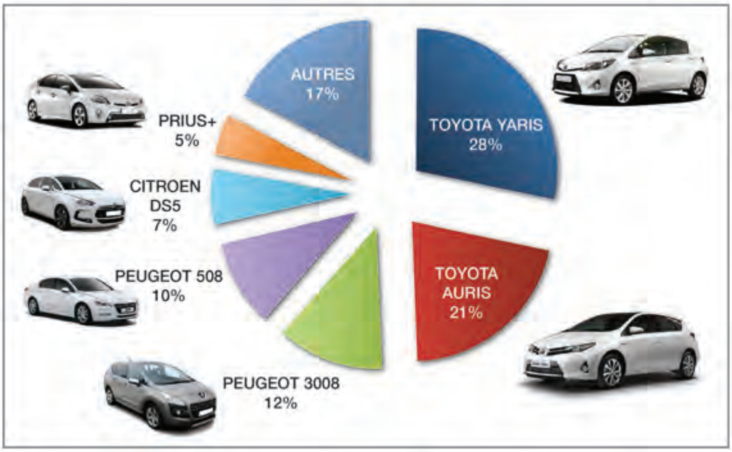

Fig. 20.4 Percent of total HEV sales by model. (Image courtesy of AVEM [http://www.avem.fr/])

Toyota took the largest market share, with nearly 60% of total sales in 2013. Boosted by the success of the new Auris and Yaris, the automaker doubled its sales compared to 2012, totaling more than 27,000 units sold in 2013.

In second place was Peugeot, with totals of just over 10,000 registrations and a 22% market share. Peugeot was followed by Citroën and Lexus with 3,100 and 2,900 registrations, respectively, or approximately 6% market share each.

Because of the lack of new models, Honda saw its sales fall by 30%, with only 1,200 new vehicle registrations. The manufacturer could, however, improve its market share in 2014 with the arrival of the next-generation Jazz and its new hybrid i-DCD system.

Figure 20.5 shows the 2013 sale of HEVs by manufacturers.

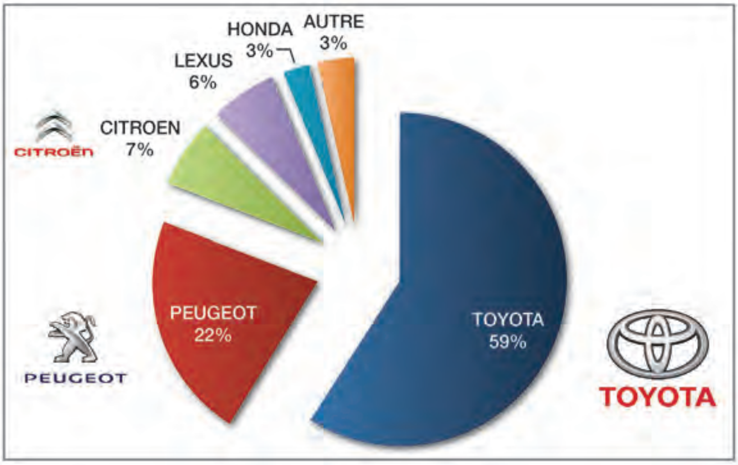

Fig. 20.5 Percent sales of HEVs by manufacturer. (Image courtesy of AVEM [http://www.avem.fr/])

PSA Hybrid4 models allowed the hybrid diesel to take 40% of the vehicle market share in 2012; however, the gasoline hybrid resumed its growth in 2013, amassing 70% of hybrid vehicle registrations versus 30% for diesel.

A predominance of hybrid gasoline vehicles also reflects the current composition of the market, where more than three-quarters of proposed models combine gasoline and electricity rather than diesel and electricity.

20.2.4 PHEV Sales

A total of 843 PHEVs were registered in 2013; they represented about 1.5% of the hybrid market (Table 20.2). The French PHEV market is still emerging, and PHEV models are rare and expensive compared with ICE (internal combustion engine) vehicles. In 2013, the Toyota Prius led this PHEV micro-segment, with 398 registrations; it was followed by the Volvo V60 plug-in hybrid with 241 registrations. The Opel Ampera sales fell to 72 registrations in 2013, compared to 190 registrations in 2012.

Figure 20.6 shows the portion of PHEV sales in 2013 by model.

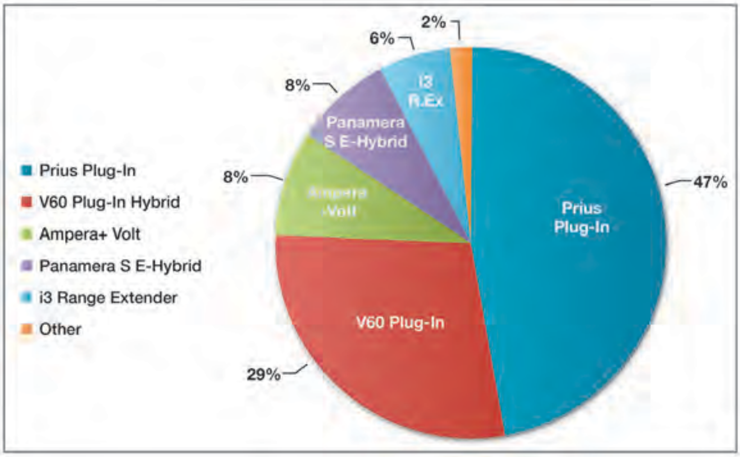

Fig. 20.6 PHEV sales in France, 2013. (Image courtesy of ADEME)

Table 20.2 EV, HEV, PHEV, and FCV Sales in France for 2013.

Total Sales during 2013					
Vehicle Type	EV Sales	+HEV Sales	PHEV Sales	FCV Sales	Total Sales
Passenger vehicles	8,779	46,785	843	0	56,407
EV Models Available (passenger only)					
Make and Model		Retail Price			
BMW 1 Series		n/a			
Bollore Bluecar		€19,000 ($25,583 US) +€80 ($108 US)/month for battery			
Citroen C-Zero		€29,500 ($39,721 US)			
Ford Focus		n/a			
Lumeneo Neoma		n/a			
MIA Electric		€19,900 ($26,795 US)			
Mitsubishi I-MiEV		€29,500 ($39,721 US)			
Nissan Leaf		€32,990 ($44,420 US)			
Peugeot Ion		€29,500 ($39,721 US)			
Renault Fluence		€26,900 ($36,220 US) +€82 ($110 US)/month for battery			

Table 20.2 (Cont.)

EV Models Available (passenger only) (Cont.)	
Make and Model	**Retail Price**
Renault ZOE	€20,700 ($27,872 US) +€79 ($106 US)/month for battery
Smart Fortwo	€24,500 ($32,989 US)
Tesla Model S	n/a
Tesla Roadster	€120,000 ($161,604 US)
Volkswagen Up!	n/a
PHEV Models Available	
Make and Model	**Retail Price**
BMW i3 Range Extender	n/a
Chevrolet Volt	€43,500 ($58,572 US)
Fisker Karma	€102,300 ($137,745 US)
Mitsubishi Outlander	n/a
Opel Ampera	€43,900 ($59,111 US)
Porsche Panamera S E-Hybrid	n/a
Toyota Prius Plug-in	€37,000 ($49,820 US)
Volvo V60 Plug-in Hybrid	n/a

n/a = not available

20.3 Charging Infrastructure for EVSE

To strengthen efforts in the development of a charging infrastructure, Hirtzman mission deployment plans are now integrated into one of the 34 plans announced by French President Hollande in his 10-year industrial policy to increase French competitiveness. These plans aim to unite economic and industrial stakeholders around a common goal and improve the effectiveness of the tools implemented by the government. Prefect Francis Vuibert heads the plan to develop charging stations. As of December 31, 2013, the number of public EVSE installed in France was 2,523 Level 2/standard AC units and 50 DC fast-charging units. The number of fueling locations for fuel cell vehicles was three.

Charging infrastructure is essential to EV deployment and is supported with €50 million ($66.4 million US) in funding through the national Investment for the Future program. Large-scale charging infrastructure deployment projects in areas with more than 200,000 inhabitants are supported by the ADEME-managed call for charging infrastructure deployment projects.

At the end of 2013, there were 2,523 charging stations in France; they represented 12,676 charging spots, of which 2.2% (50 stations) were fast-charging stations (Table 20.3). Figures 20.7 and 20.8 show the types of locations used for EVSE and their geographic distribution across France.

Table 20.3 EVSE in France as of December 31, 2013 (2,523 charging stations; each has multiple charging spots).

Type of Charging	Charging Stations	Number of Charging Spots
DC fast charging	50	170
Level 2/standard AC	2,523	12,506
Fuel cell vehicles fueling locations	3	3
Total	**2,576**	**12,676**

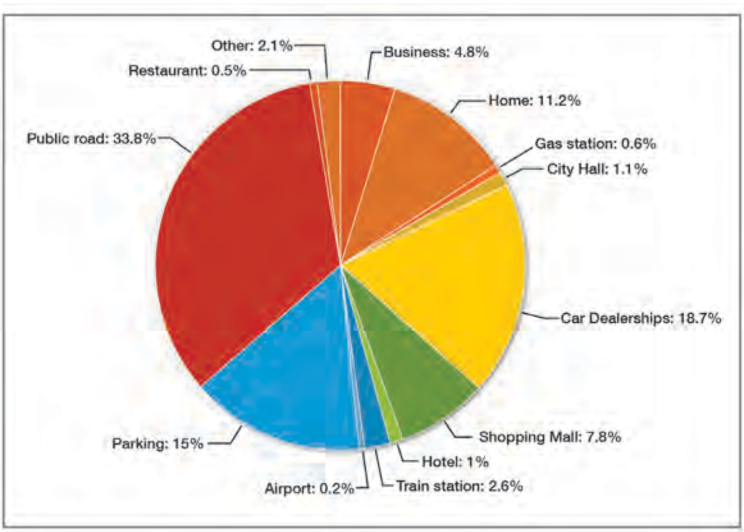

Fig. 20.7 Locations for charging spots. (Image courtesy of Chargemap)

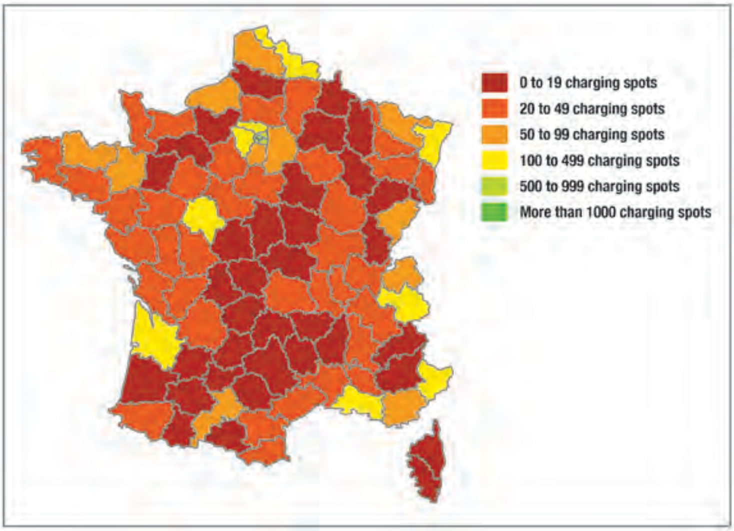

Fig. 20.8 Regional distribution of charging spots. (Image courtesy of Chargemap)

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21 Germany

21.1 Major Developments in 2013

21.1.1 Electric Mobility in the New Coalition Contract

The new coalition contract[1] in 2013 for the 18th legislation period (2013–2017) stresses the importance of electric mobility particularly (CDU 2013). This contract confirms the existing goal of 1 million passenger electric vehicles (EVs) and proposes that the German government-owned development bank KfW start a new program with low interest rates especially for EVs, although the idea is to give user-oriented incentives instead of providing a buyer's premium. Furthermore, the contract states that the new government is aware of the importance of the EV infrastructure requirements.

21.1.2 The Mobility and Fuels Strategy of the German Government

The Federal Ministry of Transport and Digital Infrastructure released in June 2013 a report[2] detailing the mobility and fuel strategy of the government. The key messages of this report are to diversify the energy sources in the transport sector, to increase electrification of passenger cars, to exploit the synergies between heavy-duty and passenger car sectors, to optimize the interfaces between transport and energy sectors, and to establish international alliances for example in areas of electric mobility and hydrogen technology (BMVI 2013).

21.1.3 Income Tax Exemptions for Company EVs and PHEVs

In Germany, the personal use of company cars driven mainly (i.e., more than 50% of the driven km) for business purposes is regulated in such a way that the driver can benefit financially. Thus, the owner of the car must only pay 1% of the list price of the vehicle each month as income tax. By end of June 2013, the German Bundestag decided to adjust this law for income tax to include both all-battery EVs and plug-in hybrid vehicles (PHEVs) and make their purchase more attractive. With this change, the list prices of all-battery EVs and PHEVs are reduced by €500 ($671 US) per kilowatt-hour (kWh) of on-board battery for the income tax calculation retroactive to January 1, 2013. Starting in 2014, this amount will decrease by €50 ($67 US)/kWh each year. The total reduction of the list price of the vehicle may not initially exceed

1 https://www.cdu.de/sites/default/files/media/dokumente/koalitionsvertrag.pdf
2 http://www.bmvi.de/SharedDocs/EN/Anlagen/UI-MKS/mfs-strategy-final-en.pdf?__blob=publicationFile

€10,000 ($13,424 US) and subsequently decreasing by €500 ($671 US) per year (BGBL 2013).

21.1.4 Technical Guideline for Infrastructure Released

The National Platform for Electromobility (NPE) published the "Technischer Leitfaden Ladeinfrastruktur" (Technical Guide for Charging Infrastructure[3]) in August 2013. This guideline is mainly targeted toward homeowners, car park operators, architects, city planners, public administrators, grid operators, and electricians. The report presents an overview of the different charging technologies, recommendations for different target groups, requirements for charging infrastructure in different places, and possible future developments (NPE 2013a).

21.1.5 The German Standardization Roadmap for Electromobility Now Available

NPE also published The German Standardization Roadmap[4] in May 2013. This document presents a continuation of the first roadmap and addresses the latest developments for electromobility standardization. The report argues that political action for standardization is needed at both the European and international levels as soon as possible. Furthermore, it stresses that the coordination of standardization is essential to avoid duplication of work (NPE 2013b).

21.1.6 Studies on Market Introduction of EVs

The study by Plötz et al. (2013), which is carried out for the NPE, argues that the target of one million electric passenger cars would be achieved under optimistic scenario assumptions. The targets may also be fulfilled for intermediate scenario (see "Mittleres Szenario") with the purchasing incentives (greater than €1,000). Similar results are also generated by Propfe et al. (2013). That study suggests introducing purchase price incentives in combination with original equipment manufacturer (OEM) mark-up reductions in order to achieve the given target. Furthermore, it argues that the OEMs should focus on large-segment cars when introducing new technologies due to the minor profit margins in other segments.

21.1.7 New Electrified Series and Concept Cars in Germany in 2013

In 2013, German OEMs introduced six new electrified vehicles in series production to the market, three of which are all-battery EVs and three of which are either PHEVs or full hybrid electric vehicles (HEVs) (Table 21.1). The price ranges from €26,900 ($36,110 US) for the Volkswagen e-up! to €768,026 ($148,210 US) for the Porsche 918 Spyder.

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[3] http://www.dke.de/de/std/e-mobility/Documents/Technischer_Leitfaden_Ladeinfrastruktur.pdf

[4] http://www.dke.de/de/std/AAL/Documents/NPE-Normungsroadmap_EN_2.0a_RZ-v01.pdf

Table 21.1 Specifications of new series electrified vehicles in Germany in 2013.

Brand	Model	Segment	Type	Price (€)	Total Power (hp)	CO_2 Emissions (g CO_2/km)	Electric Range (km)
BMW	i3	Medium (C)	EV	34,950 ($46,916 US)	125	–	150
Mercedes-Benz	SLS AMG Electric Drive	Sports coupés (S)	EV	416,500 ($559,097 US)	552	–	250
Porsche	Panamera S E-Hybrid	Executive (E)	PHEV	110,409 ($148,210 US)	306	71	36
Porsche	918 Spyder	Sports coupés (S)	PHEV	768,026 ($1,030,975 US)	652	79	31
VW	Jetta Hybrid	Medium (C)	Full-HEV	31,700 ($42,553 US)	130	98	2
VW	e-up!	Mini (A)	EV	26,900 ($36,110 US)	60	–	130

EV: Electric vehicle, PHEV: Plug-in hybrid electric vehicle, HEV: Hybrid electric vehicle

Source: DLR Vehicle Concept Database

Beside these cars that are available for customers today, German OEMs plan to increase the variety of HEVs and all-battery EVs in their model offerings within the next years. Presented at international motor shows throughout the world, many prototypes and concept cars provide a look at what to expect in the near future. Concept cars that were shown to the public in the year 2013 include, for example, the Audi Sport Quattro Concept (PHEV, Large [D] segment), which is planned to enter markets in a limited edition in 2016; the BMW Concept X5 eDrive (PHEV, SUV [J] segment); the Opel Monza (REEV with CNG Range Extender, Large [D] segment) (Figure 21.1); and the Volkswagen e-Co-Motion (all-battery EV, Multi-purpose [M] segment).

Fig. 21.1 Concept car Opel Monza (© GM Company).

21.1.8 Volkswagen Group Enthusiastic about Plug-in Concepts

Dr. Ulrich Hackenberg, responsible for steering the development at the Volkswagen group and technical development at Audi, argues that “plug-in hybrid is our future path, which is mobility without limits.” Audi is planning to offer the entire passenger car portfolio also as plug-in hybrid powertrain. The first plug-in model will be Audi A3 e-tron, which will be available in the market in 2014 (Automobilwoche 2013).

21.1.9 Fuel Cell Alliance among Daimler, Ford, and Nissan

Daimler, Ford, and Nissan announced that they are building an alliance for fuel cell development. Renault is also in discussions to join to this alliance. The idea is to develop a common powertrain and share the engineering costs, which will lead to lower production costs. The goal is to introduce several fuel cell vehicles in 2017 (Handelsblatt 2013). Figure 21.2 shows the fuel-cell-powered Mercedes-Benz B-Class under development.

Fig. 21.2 Mercedes-Benz B-Class fuel cell (© Daimler AG).

21.1.10 Colibri Inspires with Micro Mobility

Colibri, a one-seater EV, is inspiring in Germany (Figure 21.3). Innovative Mobility Automobile GmbH (IMA) stated in a February 12, 2013, press release[5] that there are more than 700 preorders for the Colibri. The price for such micro-mobility is about €8,900 ($11,947 US) plus €55 ($74 US) for monthly battery lease. The production is scheduled to begin in 2015 (IMA 2013).

[5] http://www.innovative-mobility.com/en/press/downloads/PR_IMA_700_Preorders.pdf

Fig. 21.3 Colibri electric one-seater (© Innovative Mobility Automobile GmbH).

21.2 HEVs, PHEVs, and EVs on the Road

In 2013 there were 2.95 million newly registered passenger vehicles in Germany, 130,000 or 4.2% fewer than in 2012. Of this newly registered total, 6,051 were electric vehicles and 7,835 were hybrids (KBA 2013a). This brought the total number of registered vehicles in Germany to 52.97 million as of January 1, 2014, including 43.85 million passenger vehicles, 4.05 million motorbikes, 2.63 million trucks, and 76,794 buses, as well as 2.35 million other types. Of this total, there were 85,017 HEVs, 21,324 EVs, and 1,374 PHEVs. While the majority of the electric and hybrid electric types were passenger vehicles, there were 5,596 all-electric motorbikes and 264 hybrid motorbikes (KBA 2013a). Table 21.2 summarizes this information.

Table 21.2 Total registered vehicle fleet in Germany as of January 1, 2014.

Fleet Totals as of January 1, 2014					
Vehicle Type	**Total Vehicle Fleet**	**HEVs**	**PHEVs**	**BEVs**	**FCVs**
Motorbike without e-bikes	4,054,946	264	0	5,596	77
Passenger vehicle	43,851,230	84,245	1,371	12,156	174
Multipurpose vehicle (MPV)	n/a	n/a	n/a	n/a	n/a
Bus	76,794	244	0	99	16
Truck	2,629,209	139	0	2,931	4
Light goods	n/a	n/a	n/a	n/a	n/a
Tricycle	n/a	n/a	n/a	n/a	n/a
Other	2,354,640	125	3	542	6
Total	**52,966,819**	**85,017**	**1,374**	**21,324**	**277**

n/a = not available

The most popular all-electric vehicle models in 2013 were Smart's Fortwo, Renault's ZOE, and the Nissan Leaf. Among the PHEVs and HEVs, the top sellers were various Toyota models, including the Yaris/ Daihatsu Charade, Auris, and Prius (KBA 2013b).

The figures show that despite the increasing growth of the electric and hybrid alternatives, their share of the new car market in 2013 in Germany was only 1.6% of the total. Conventional gasoline (petrol) accounted for just over half (50.9%), and diesel engines comprised much of the remainder (47.5%).

21.3 Charging Infrastructure for EVSE

This section provides an overview of the EV charging infrastructure in Germany, including both public and semi-public Level 1 and Level 2 stations, as well as fast-chargers. This charging infrastructure is also referred to as EV supply equipment (EVSE). As of March 18, 2014, there were 848 Level 1 charging stations, 3,604 Level 2 charging stations, and 34 fast chargers. Table 21.3 provides an overview of the EV charging infrastructure.

Table 21.3 EVSE installed in Germany as of March 18, 2014.

Sector	Level 1	Level 2	Fast Charging
Public	848	3,604	34
Semi-Public	n/a	n/a	n/a

n/a = not available

Fast chargers include the DC Chademo and the DC Combined Charging System only. AC 3-phase charging points are considered Level 2, and AC 1-phase charging points are considered Level 1. These data were collected by the German Association of Energy and Water Industries (BDEW), and complete coverage of the whole EVSE charging infrastructure cannot be guaranteed.

21.4 EV Demonstration Projects

In 2012, the German government nominated four regions (Baden-Württemberg, Bavaria/Saxony, Berlin/Brandenburg, and Lower Saxony) as showcases for electric mobility. These showcases are discussed in more detail below.

21.4.1 Baden-Württemberg: "LivingLab BW^{e} mobil"

This showcase[6] consists of about 40 individual projects involving more than 100 partners with a broad range of topics, such as e-bikes, all-battery EVs, PHEV buses, and e-trucks. In addition to intermodal mobility concepts (such as fleet tests), other important topics include information and communication technologies, charging infrastructure, urban/transport planning, and vehicle powertrain technology. In LivingLab BW^{e} mobil, the goal is to deploy about 2,000 and to install about 1,000 charging points in the region of Stuttgart and Karlsruhe.

21.4.2 Bavaria and Saxony: "Electric Mobility Connects"

Over 150 companies and public institutions from Bavaria and Saxony[7] are working together on a series of more than 60 projects designed to achieve technical progress in order to develop holistic and sustainable electric mobility that includes viable business models and a functioning electric mobility market. The projects can be divided into five areas: long-distance mobility, urban mobility, rural mobility, international cooperation, education and training.

One of the projects in Bavaria and Saxony is the DC-Charging on the Motorway A9.[8] As the map in Figure 21.4 shows, the goal of this project is to enable electric mobility for long-distance driving between Munich and Leipzig via Nuremberg. To achieve this goal, Siemens is working with E.ON and BMW to build 8 DC charging

6 http://www.livinglab-bwe.de/
7 http://www.elektromobilitaet-verbindet.de
8 http://www.elektromobilitaet-verbindet.de/projekte/A9.html

stations with the new combination plug and an AC charging point. The operation for DC charging became available after January 2014.

Fig. 21.4 Project map for quick (DC) chargers on the motorway A9.

21.4.3 Berlin and Brandenburg: "International Showcase"

Today, the capital region Berlin-Brandenburg[9] has the largest fleet of vehicles for electric mobility in Germany and serves as a laboratory. The aim is to be the leading metropolis of electric mobility in Europe and, thus, an internationally visible location for electric mobility testing and application. With more than 100 partners and about 30 core projects, the approach of the international showcase is to interlink vehicle, transport, and energy with the help of concepts for intermodal mobility and storage of renewable energy.

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9 http://www.emo-berlin.de/

21.4.4 Lower Saxony: "Our Horsepower Will Be Electric"

With more than 200 partners and about 30 projects, the showcase[10] tests the suitability of solutions across the entire range of electric mobility. It is intended to create awareness of the potential of electric mobility and combine the most innovative elements of electric mobility throughout the metropolitan areas of Hannover, Braunschweig (Brunswick), Göttingen, and Wolfsburg. The showcase relies on numerous elements, including concepts of sustainable intermodal mobility and modern/intelligent charging, information and communication technology (ICT) services for production of (additional) renewable energy education and training opportunities, development and production of EVs and their components, international trade fairs and collaborations, and the full administrative commitment of state and local governments.

[10] http://www.metropolregion.de/pages/themen/schaufenster_emobilitaet/index.html

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22 Ireland

22.1 Major Developments in 2013

Revised motor tax bands for passenger vehicles were introduced in 2013, and these have encouraged consumers to further move toward lower-CO_2-emitting vehicles as motor manufacturers respond to European Regulations on vehicle emission levels. Despite this intended shift, consumer sentiment was considered weak in Ireland in 2013, as reflected in vehicle sales in general. A revised number plate system was introduced in 2013 in order to smooth out vehicle sales more evenly over the course of the year. Electric vehicle (EV) prices were seen to fall in 2013 with the introduction of new models to the market.

Progress has continued on the development of electrical vehicle charging infrastructure around the country. Issues still remain with respect to internal combustion engine (ICE) vehicles parking in charging areas designated for EVs. Legislation is being developed to empower parking authorities to introduce fines in order to prevent this from happening.

Grant support levels remain the same as in 2012, with accelerated capital allowances measure also available to commercial purchasers of EVs.

Table 22.1 provides a list of the incentives toward the purchase of EVs in Ireland.

Table 22.1 Summary of Ireland's policy instruments for PHEVs and EVs.

Policy Instrument	Details
EV grant scheme	A grant of up to €5,000 ($6,977 US) is available for passenger vehicles (M1) and light commercial vehicles (N1) from the Sustainable Energy Authority of Ireland. The grant is available for both BEV and PHEV vehicles.
Vehicle registration tax relief	Vehicle Registration Tax (VRT) relief of up to €5,000 ($6,977 US) is available for BEVs and up to €2,500 ($3,488 US) for PHEVs.
Accelerated capital allowances	Accelerated capital allowances are available for EVs and HEVs. This allows a company to reduce its taxable income by the full value of the vehicle capital cost in year 1 rather than across the more normal 8-year period.

22.2 HEVs, PHEVs, and EVs on the Road

Overall consumer confidence was considered to be low in general throughout 2013, and this was reflected in vehicle sales in Ireland, also. The new model of the Nissan Leaf was introduced in July 2013, and multiple options were made available to the customer. The price of the Leaf dropped further as Nissan began operations from its European factory based in Sunderland, UK. As a result of the price improvement, EV dealers noted significant interest in the Leaf toward the end of 2013, with consumers expressing interest in purchasing in the following year. The number of vehicles on the road (as well as vehicle sales for 2013) is shown in Tables 22.2 and 22.3.

Table 22.2 Statistics on Irish vehicles on the road.

Fleet Totals as of End of December 2013			
Vehicle Type	**EV Fleet**	**HEV Fleet**	**Total**
Bicycles (no driver's license required)	n/a	n/a	n/a
Motorbikes	53	0	36,623
Passenger vehicles	273	7,729	2,002,817
Multipurpose passenger vehicles	11	n/a	298,504
Buses	0	0	10,153
Trucks	51	11	29,905
Industrial vehicles	5	5	104,555
Total	393	7,745	2,482,557

n/a = not available

Table 22.3 Annual Irish vehicle sales as of December 31, 2013.

Vehicle Type	EV Fleet	HEV Fleet	Total
Bicycles (no driver's license required)	n/a	n/a	n/a
Motorbikes	n/a	n/a	n/a
Passenger vehicles	47	n/a	74,303
Multipurpose passenger vehicles	7	n/a	11,076
Buses	n/a	n/a	163
Trucks	n/a	n/a	1,554
Industrial vehicles	n/a	n/a	n/a
Total	408	6,781	95,093

n/a = not available

22.3 Charging Infrastructure for EVSE

The Republic of Ireland has a single Distribution System Operator, which is owned by the Electricity Supply Board (ESB). The organization ESB Ecars has been established to promote the uptake of electric vehicles and to select, deploy, and manage an appropriate nationwide EV charging infrastructure. For an island with a high-wind-energy resource like Ireland, EVs are viewed as a demand control mechanism that will assist the grid operator in managing future high levels of intermittent wind power.

ESB has delivered a nationwide rollout of smart-charging infrastructure that consists of the following installations, as of the end of 2013:

- 600 domestic and work location chargers
  - As home infrastructure continues to be the primary source of EV charging, ESB has taken responsibility for specification, procurement, and installation of home chargers for EV drivers for the initial period of EV rollout. A mixture of domestic chargers and units for work locations were installed.
- 700 public AC charge points (concentrated in urban areas)
  - The majority of these chargers provide 22 kW.
  - Installation locations include service stations, transport hubs, retail parks, on-the-street, and car parks, among others.
- 50 fast chargers (urban areas and intercity routes)
  - All of these chargers support DC fast-charging (based on Chademo and CCS standards), and the units to be deployed in 2014 will also support 43-kW AC charging.

ESB’s IT architecture (delivered in 2013) is built around a number of components, including:

- A charge point control and management system;
- A back-end data aggregation and core transaction processor;
- CRM (customer relationship management) and asset management systems;
- A dedicated Access Point Name/Virtual Private Network (APN/VPN) service;
- Thin radio frequency identification (RFID) access tokens; and
- Call center support systems.

22.3.1 Open Standards and International Cooperation

To avoid the limitations associated with proprietary systems, ESB has pursued a policy of promoting and supporting open standards in relation to deployed charging infrastructure and IT systems. ESB is a founding member of the Open Charge Alliance together with E-Laad (initially formed by ESB, E-Laad, and Greenlots), promoting the Open Charge Point Protocol (OCPP), which is now deployed in 50 countries and across more than 10,000 charging stations.

22.3.2 North-South EV Charging Interoperability

ESB Group is also the owner of the transmission and distribution assets in Northern Ireland. ESB Ecars and its sister company NIE are core members of the UK Plugged-in Places (PIP) project in Northern Ireland. This program is being led by the Department for Regional Development in Northern Ireland. The project in Northern Ireland is one of eight projects selected by the UK Government to develop and roll out EV charging infrastructure across the UK. As a result, a compatible and interoperable charging infrastructure has now been deployed on an all-island basis in Ireland (Figure 22.1). This was the first major fully interoperable and cross-jurisdictional deployment in Europe. ESB is also a core member of all of the major EU electro mobility projects, including Green eMotion and Mobi Europe. Additionally, ESB is part of the successful consortium of bidders responsible for the deployment of fast-charging infrastructure under the EU TEN-T project in both the UK and Ireland.

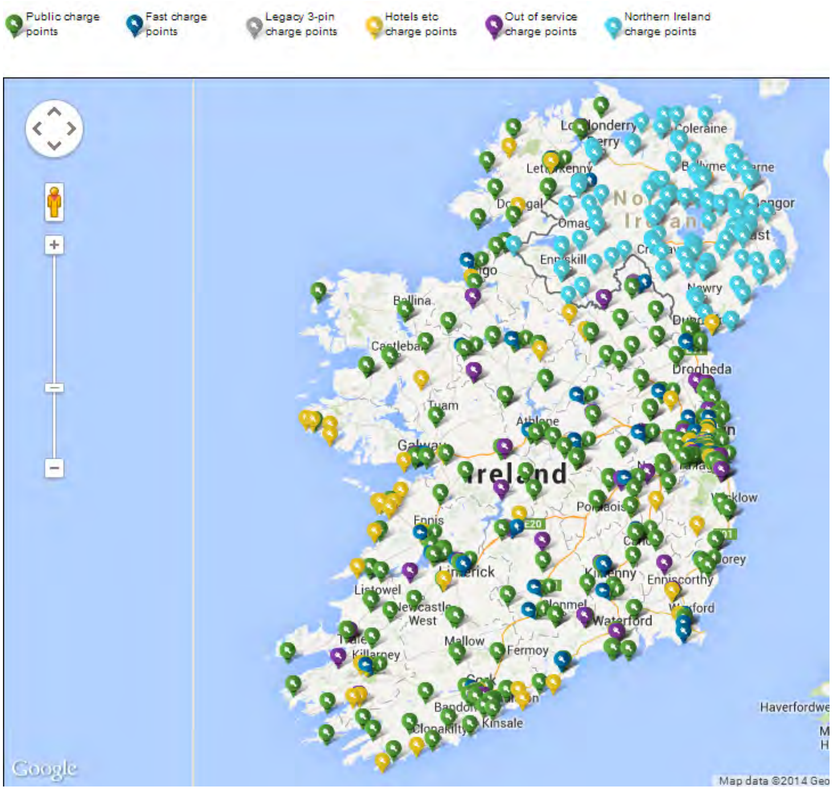

Fig. 22.1 Map of available charge points in both the Republic of Ireland and Northern Ireland. (Source: ESB [http://www.esb.ie/electric-cars/electric-car-charging/electric-car-charge-point-map.jsp])

23 Italy

23.1 Major Developments in 2013

In 2013, major national measures to promote and financially support the introduction of cleaner vehicles began (as a result of a national law approved in August 2012). Funding was made available to incentivize the purchase of new clean vehicles by eventually scrapping old ones (this obligation was not mandatory for private users, but only for fleet companies). At the end of 2013, a total of 2,493 vehicles in all categories (passenger cars, commercial vans, 2-wheel motorcycles, mopeds, and quadricycles) were subsidized with a total fund of €40 million (about $54 million US), of which only 545 vehicles had CO_2 emissions lower than 50 g/km. Complete statistics pertaining to the subsidy law and advancement are available on a dedicated website (http://www.bec.mise.gov.it/site/bec/home.html). Purchase subsidies are strictly related to measured CO_2 emissions based on homologation measurements and are differentiated by type of vehicle and end user. Table 23.1 summarizes details of the purchase incentives schemes.

The same 2012 law defined a national charging infrastructure plan for any type of electrical vehicle and how it could be realized. After a public review of the first draft of this plan in 2013, a revised version was published that defined incremental targets for meeting a European Commission directive to create 125,000 public charging points in Italy by 2020. The published plan has the following objectives: make 90,000 public charging points available by 2016, 110,000 by 2018, and 130,000 by 2020. (Source: Ministry of Infrastructure and Transport[1])

The approved law also aims to create a set of clear and simplified rules, to be agreed upon by local authorities, 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 dedicated electricity meters and charging points in homes and public spaces. From 2013 to 2015, total public funding of €120 million or ($160 million US) will be available (covering 50% of the total installation cost) for the realization of the charging infrastructure.

[1] http://www.mit.gov.it/mit/site.php?p=cm&o=vd&id=2524

Table 23.1 Italy's purchase incentives.

Policy Instrument	Details
Government purchase incentives	Purchase contribution of up to 20% of retail price (max €5,000 or $6,750 US) for new vehicles with CO_2 emissions lower than 50 g/km, as a direct rebate upon purchase. The incentive declines with emissions between 50 and 120 CO_2 g/km and is mostly aimed at service fleets (almost 90% of the overall fund), with mandatory scrappage of an old vehicle in the same category as the purchased vehicle. Subsidized vehicles must use alternative fuels: electricity, natural gas, liquefied petroleum gas (LPG), biofuels, or hydrogen. Vehicles that qualify for the subsidy include two- and three-wheeled motorbikes and mopeds, quadricycles, commercial vans, and passenger cars. In 2013, the available fund was divided as follows: • **€4.5 million ($6.1 million US)** for the purchase of vehicles by any end user (without the scrappage obligation and with CO_2 emissions no greater than 95 g/km), with a reserve of €1.5 million ($1.1 million US) for the purchase of vehicles with CO_2 emissions not greater than 50 g/km. • **€35.5 million ($47.9 million US)** for the purchase of vehicles by commercial end users (with scrappage obligation), with some reserved funds of: – €7 million ($9.4 million US) for the purchase of vehicles with CO_2 emissions no greater than 95 g/km – €3.5 million ($4.7 million US) for the purchase of vehicles with CO_2 emissions no greater than 50 g/km

In 2013, EV research was executed and/or completed in various national program projects (Industria 2015, PRIN-Research Project of National Interests) and as part of the final year of European Union 7th Framework Programme, with the participation of Italian industries and research organizations and with some valuable results. These projects covered EV technologies from component research and development (batteries, innovative drivetrains) up to complete vehicles in various configurations (including battery-powered EVs and plug-in HEVs, charging systems and infrastructure, and large demonstrations). Figure 23.1 shows an innovative electric motor inverter being tested. The inverter is able to accept charge and convert the charge to driving power, making it one device for two key EV functions. This electronic device was developed by ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) as part of the National Research Programme for the Electrical System.

In various European projects, novel and improved batteries (lithium-ion, lithium-air, lithium-sulphur) and advanced supercapacitors were investigated with interesting results, while various categories of new hybrid and battery-powered electric vehicles with new configurations and applications (from large buses up to small two-wheel motorbikes for private and commercial use) were researched and developed.

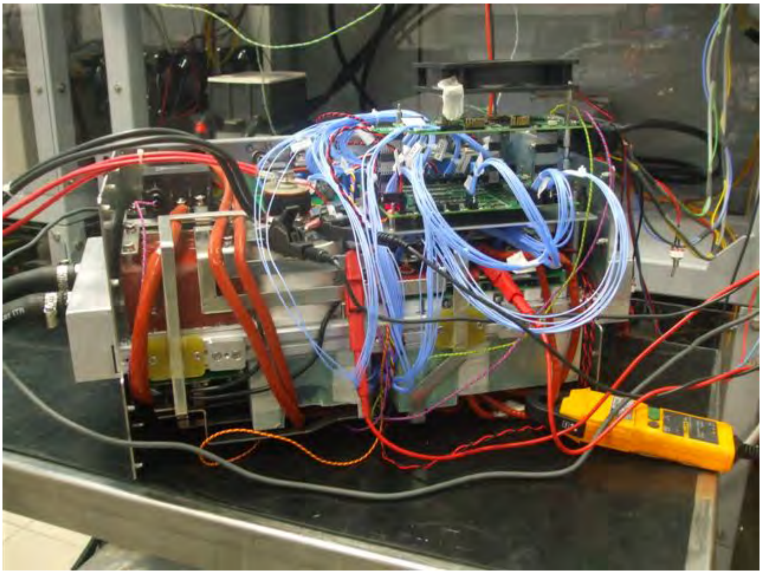

Fig. 23.1 Reversible battery charger with integrated power section for EV electric motors.

EV manufacturers (national and international) have significantly increased their presence and efforts to better promote the introduction of EVs and HEVs of any category (buses, passenger cars, commercial vans, two-wheel motorbikes, mopeds, and quadricycles) in Italy. Large car companies (Renault, Toyota, and Honda) have introduced more types of electric vehicles, while national small manufacturers have encountered financial difficulties related to the late start of public subsidies and the enlargement of the National Recharging Infrastructure. However, some important signals for the EV community arrived from Ferrari with the official launch of an exclusive hybrid sport car named "La Ferrari," shown in Figure 23.2.

Fig. 23.2 “LaFerrari,” the first Ferrari hybrid sport car.

Small national manufacturers continued to propose new models of small passenger cars and quadricycles. However, despite the general economic crisis that has greatly affected small and medium manufacturers of EV vehicles in 2013, attention has been more focused on the extension of EV fleets and available services for electric vehicles: renewal of public parking, enlargement of the charging infrastructure, car-sharing systems, and dedicated services from electric utilities and local authorities (implemented and made operative via agreements with large EV manufacturers). In 2013, many cities (Rome, Milan, Naples, and others) have promoted electric vehicle car-sharing services; for example, in the city of Milan, EQ Sharing is now operational with an initial fleet of more than 100 electric quadricycles, as shown in Figure 23.3. Figure 23.4 shows the Renault Twizy quadricycle, which is also part of the car-sharing system fleet (initially 40 Twizys) started in Naples.

Fig. 23.3 Ducati Energia Free Duck quadricycle, part of the EQ Sharing fleet in Milan.

Fig. 23.4 Renault Twizy quadricycles for the Bee e-car sharing in Naples.

23.2 HEVs, PHEVs, and EVs on the Road

The Italian vehicle market, continuing the trend of recent years, declined in 2013: overall passenger car sales declined by approximately 7% (going back to the market of about 30 years ago) with respect to 2012. Conversely, cleaner passenger car shares (natural gas vehicle [NGV], LPG, EV, and HEV) have exceeded the goal of 7% of the overall passenger car market.

HEV/PHEV/EV sales during 2013 increased despite the economic crisis, with HEVs overcoming the threshold of 1% of the overall car market. This growth was supported by the availability of governmental incentives, greater domestic availability of vehicles from international car companies, municipal limitations for conventional car circulation in urban areas, the increase in the number of charging points, and increased public consciousness (more information, more advertisement from car companies, and more pro-activity from local and governmental authorities).

Statistics for the total vehicle fleet in Italy reported in Table 23.2 are estimated for 2012. The data for EVs and HEVs on overall fleets were adapted from CEI-CIVES (Italian EV Association) analysis, based mostly on interviews of manufacturers and importers in the last 13 years.

Table 23.2 Fleet totals for Italy as of December 31, 2012, and 2013 total sales.

Fleet Totals (January 2013)			
Vehicle Type	**EV Fleet**	**HEV Fleet**	**Total Fleet[a]**
Bicycles (no driver's license)	260,000	n/a	33,600,000
Motorbikes	36,900	n/a	8,582,796
Quadricycles	7,050	n/a	Included in motorbike total
Passenger vehicles	3,378	34,439	37,078,274
Multipurpose passenger vehicles	8,750	n/a	678,409
Buses	1,100	350	99,537
Trucks	n/a	n/a	3,989,009
Total Sales during 2013			
Vehicle Type	**EV Sales**	**HEV Sales**	**Total Sales[a]**
Bicycles (no driver's license)	51,405	n/a	1,542,758
Motorbikes	1,048	n/a	185,511
Quadricycles	946	n/a	3,830
Passenger vehicles	864	14,930	1,303,382
Multipurpose passenger vehicles	188	n/a	101,199
Buses	13	n/a	2,375
Trucks	n/a	n/a	12,596
Plug-in Vehicle Models Available (passenger only)	**Untaxed, Unsubsidized Price of Vehicle Model**		
Toyota Prius Plug-in	€40,250		
Volvo V60 D6 All-Wheel Drive (AWD) Plug-in Hybrid	€60,395		

n/a = not available

[a] Fleet totals and sales data are not available for PHEV and FCV categories.

23.3 Charging Infrastructure for EVSE

Italy has reached 2,250 standard charging points (in public areas and in private ones open to public usage). The fast-charging stations are still limited and mainly for demonstration purposes; however, limited private installations occurred in 2013.

The national EVSE plan, released in July 2013, has defined a supporting budget, as described above, to support installation of charging points to reach the target of 130,000 charging points by 2020. At the end of 2013, the Transport Committee of the European Parliament drafted a directive defining a minimum number of recharging points to be available to general public by 2020 in European member countries: for Italy the minimum is 72,000. Existing charging stations also can have multiple charging points; current statistics do not clearly distinguish between EVSE and charging points. (Source: VeiCOLi eLettriCi news[2])

Table 23.3 gives the number of public EVSE installed as of December 31, 2013. Existing charging stations also can have multiple charging points; current statistics do not clearly distinguish between EVSE and charging points.
(Source: VeiCOLi eLettriCi news[2])

Table 23.3 Number of public EVSE installed as of December 31, 2013.

Type of EVSE	Quantity
Level 2/Standard AC	2,250
DC fast charging	<10
Number of fueling locations for fuel cell vehicles	14 (only 4 in operation and not accessible to public)

An example of an electric "refueling" charging station proposed by the Italian electric utility EnEL is illustrated in Figure 23.5.

Fig. 23.5 The "refueling" charging station proposed by the Italian electric utility EnEL.

2 http://www.veicolielettricinews.it/mappa-delle-colonnine-di-ricarica/

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24 The Netherlands

24.1 Major Developments in 2013

Companies, non-governmental organizations, knowledge institutions, and governments are working together to accelerate electro-mobility and economic change in the Netherlands (Figure 24.1). Table 24.1 summarizes policies for PHEVs and EVs in the Netherlands in 2013. The number of electric vehicles on the road increased enormously in 2013. The number of entrepreneurs in the field of e-mobility also increased, especially in the area of custom-made vehicles (in particular, light electric vehicles and buses), electric drive techniques, charging infrastructure, and services.

Fig. 24.1 Electric vehicles in the Netherlands. (Source: Metropole Region Amsterdam)

In September 2013, more than 40 organizations signed the Energy Agreement for Sustainable Growth, of which the main objectives are to reach an annual saving in final energy consumption of 1.5% annually and to stimulate sustainable economic growth. E-mobility is part of this agreement.

Quick-charging stations (including one Tesla supercharger) along the highways were opened in 2013 (Figure 24.2). Ultimately, installation of more than 250 quick-charging stations (set up by ANWB, FastNed, Greenflux, and Mister Green) is planned along Dutch highways, providing nationwide coverage. In addition, publicly accessible quick-charging points are available at other locations, such as wayside restaurants. Tesla opened its European headquarters in Amsterdam and a European assembly and distribution centre in Tilburg. BMW launched its BMWi3 in Amsterdam, showing the Netherlands' position as a front runner in e-mobility.

Fig. 24.2 FastNed quick charging station along Dutch highway. (Source: FastNed)

There were developments in specific market segments. Several taxi companies (such as Taxi Electric Amsterdam, RTC [Rotterdamse Taxi Centrale], and TCA [Taxi Centrale Amsterdam]) successfully used e-taxis. E-distribution was started in several projects (by UPS [United Parcel Service], DPD [Dynamic Parcel Distribution] Parcel Service, and Heineken by Hytruck). On the isle of Schiermonnikoog, six battery-electric buses began running in May 2013. In Maastricht, battery-electric buses were tested during scheduled service.

More 2013 highlights and important milestones in e-mobility in the Netherlands can be found at http://www.nederlandelektrisch.nl/english/.

Different policy measures were in place in 2013 in the Netherlands to support e-mobility. Please refer to Table 24.1 for more details on these policies.

Table 24.1 Summary of the Netherlands' policies for PHEVs and EVs in 2013.

Policy	Details
Subsidy scheme for low-emission taxis and vans	A subsidy of €3,000 ($4,159 US) for a BEV is given. If registered in the cities of Amsterdam, Arnhem, The Hague, Rotterdam, and Utrecht – or cities adjacent to these cities – an extra subsidy of €2,000 ($2,773 US) is given for a BEV (to address specific bottlenecks in air quality).
Innovation vouchers electro-mobility	Subject matter experts (SMEs) are stimulated to make better use of existing knowledge on electro-mobility at universities and research institutes. For a maximum of €5,000 ($6,932 US), 100 SMEs can pose a research question in the field of electro-mobility to be answered by a university or research institute.
Registration tax exemption	Electric cars are exempt from paying a registration tax until 2018. This tax has to be paid when registering a car. The amount of this tax depends on the CO_2 emission and the vehicle catalogue price. The exemption for clean vehicles (between €5,000 and €8,000 ($6,932 and $11,090 US) for mid-size cars) partially compensates for the high purchase price of EVs.
Road tax exemption	Electric cars are exempt from road tax until at least 2014. This tax has to be 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 petroleum car, this is €400–700 ($555–970 US) a year.
No surcharge on income taxes for private use of company cars	In the Netherlands, income tax has to be paid on the private use of company cars. This is done by imposing a surcharge (14–25% of the catalogue value) on the taxable income. Electric cars registered before 2014 are exempt from this surcharge for 60 months. This gives a tax advantage of approximately €2,000 ($2,773 US) a year compared to a regular company car.
Tax deductible investments	The Netherlands has a system of facilitating investments in clean technology by making these investments partially deductible from corporate and individual income taxes. Electric vehicles are on the list of deductible investments. The Environmental Investment Allowance (Rebate) and Arbitrary Depreciation of Environmental Investments (MIA-VAMIL) tax relief provides companies investing in electric vehicles and recharging stations with a tax advantage of up to 19% of the investment.

24.2 HEVs, PHEVs, and EVs on the Road

In 2013, a large number of BEVs and PHEVs were registered in the Netherlands (Figure 24.3). Over 5% of all registrations of newly sold passenger cars were either a BEV or a PHEV. In total, 2,251 BEVs (an increase of 217% compared to 2012) and 20,164 PHEVs (an increase of 564% compared to 2012) were registered in 2013. There were even more PHEV registrations than HEV registrations (see Table 24.2). A major reason for the large increase in EVs and PHEVs on the road was the fiscal stimulation measures that were in place in 2013 and are going to change in 2014.

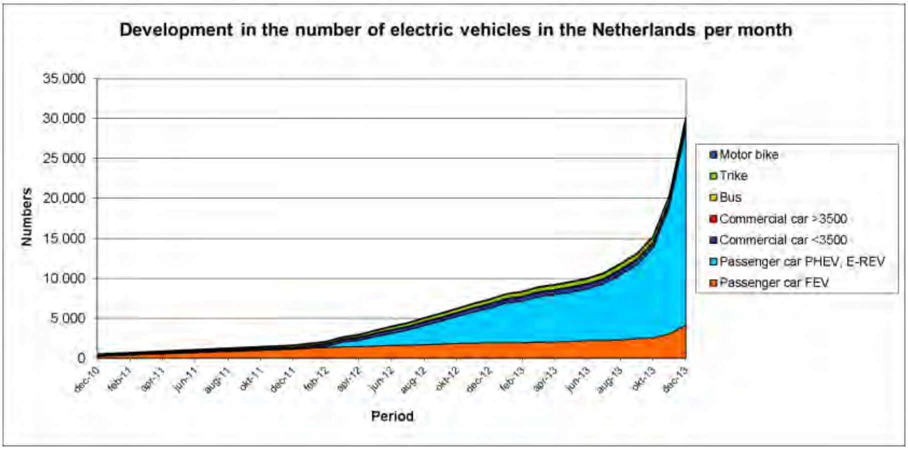

Fig. 24.3 Development in the number of electric vehicles in the Netherlands per month. (Source: Dutch Vehicle Authority [RDW])

Table 24.2 Fleet totals, vehicle registrations, and PHEV models in 2013.

Fleet Totals as of December 31, 2013					
Vehicle Type	EV Fleet	HEV Fleet	PHEV Fleet	FCV Fleet	Total Fleet
Bicycle (no driver's license)	1,122,902[a]	0	0	0	23,141,000[b]
Motorbikes	125	n/a	0	0	721,750
Quadricycles[c]	632	n/a	0	0	n/a
Passenger vehicles	4,161	106,918	24,512	3	8,142,000
Multipurpose passenger vehicles	Included in passenger vehicles				
Commercial cars/vans (<3.5 tons)	669	n/a	0	1	906,000
Buses for public transportation[d]	73	0	0	3	5,000

Table 24.2 (Cont.)

Fleet Totals as of December 31, 2013					
Vehicle Type	**EV Fleet**	**HEV Fleet**	**PHEV Fleet**	**FCV Fleet**	**Total Fleet**
Trucks	39	n/a	n/a	0	140,000
Industrial vehicles	18	15	0	0	15,000

Sources: RDW, BOVAG, Royalty Amsterdam International (RAI), DOET

n/a = not available

[a] Including 22,902 electric scooters (no driver's license needed); assumption: 100,000 e-bikes were substituted in 2013.

[b] Including 1,1410,000 scooters (no driver's license needed)

[c] Total of three-wheeled vehicles (1 third) and L7e (2 thirds)

[d] Including trolley buses

Total Registrations during 2013					
Vehicle Type	**EV Registrations/Sales**	**HEV Registrations**	**PHEV Registrations**	**FCV Registrations**	**Total Registrations/ Sales**
Bicycle (no driver's license)	205,154[a]	0	0	0	1,059,633[b]
Motorbikes	26	n/a	0	0	9,335
Quadricycles	163	n/a	0	0	n/a
Passenger vehicles	2,251	18,356	20,164	2	417,036
Multipurpose passenger vehicles	Included in passenger vehicles				
Commercial cars/vans (<3.5 tons)	175	n/a	n/a	1	50,571
Buses for public transportation	n/a	n/a	n/a	0	n/a
Trucks	16	n/a	n/a	0	13,837
Industrial vehicles	n/a	n/a	n/a	0	n/a

Sources: RDW, BOVAG, RAI, DOET

n/a = not available

[a] Including 5,154 electric scooters (no driver's license needed)

[b] Including 59,633 scooters (no driver's license needed)

Table 24.2 (Cont.)

PHEV Models Available (passenger cars only)	Untaxed (no sales and other taxes), Unsubsidized Price of Standard Vehicle Models
BMW i3 range extender	€33,050 ($45,817 US)
Chrevolet Volt	€36,112 ($50,062 US)
Fisker Karma	€88,021 ($122,024 US)
Mitsubishi Outlander	€35,942 ($49,826 US)
Opel Ampera	€39,913 ($55,331 US)
Porsche Panamera S E-Hybrid	€93,636 ($129,808 US)
Toyota Prius Plug-in Hybrid	€32,764 ($45,421 US)
Volvo V60 Plug-in Hybrid	€52,888 ($73,319 US)

Source: Prices based on internet search

24.3 Charging Infrastructure for EVSE

The number of EVSE (charging points) increases steadily. At the end of 2013, there were over 3,500 public charging points in the Netherlands, 2,250 semi-public charging points, and an estimated 18,000 private charging points (all regular charging). In addition, there were 106 fast-charging points (Table 24.3). Overall, at the end of 2013, the ratio of charging point to electric vehicle was 0.8 in the Netherlands. The growth of charge point availability is shown in Figure 24.4.

A “Green Deal” (an agreement between public and private organizations) on public infrastructure is being prepared, to be signed in 2014. This agreement is designed to reduce the economic barriers to charging station development, and thus stimulate the materialization of public charging stations through 2016. After that, it is expected that a business case will exist and further roll-out of EVSE can be left to the market. The Green Deal also stimulates R&D to decrease EVSE costs.

Specific cities and regions have initiated contracts to install public EVSE in 2013 and will continue to do so in 2014.

Table 24.3 Number of EVSE installed as of December 31, 2013.[a]

Level 2/Standard AC	DC Fast-charging
5,770	106
Number of Fueling Locations for Fuel Cell Vehicles	
2	

Sources: Oplaadpalen.nl, The New Motion, Rijkswaterstaat (RWS, Public Works and Water Management in Government of the Netherlands)

[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 EVSEs).

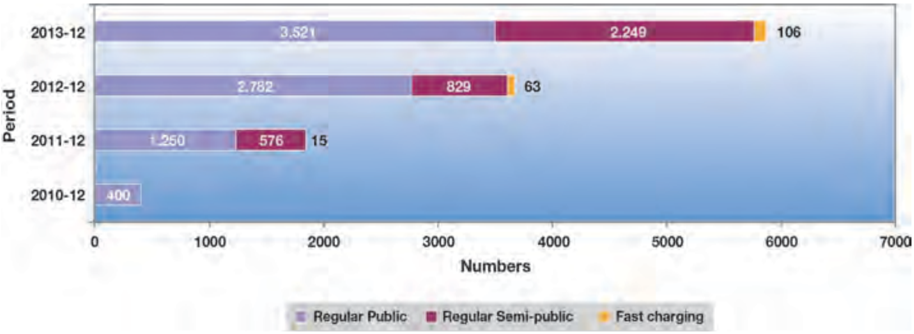

Fig. 24.4 Development in the number of charging points in the Netherlands (excluding private charging points). (Source: Oplaadpalen.nl, The New Motion [http://www.thenewmotion.com/laadpas/aanvragen/])

24.4 EV Demonstration Projects

Several demonstrations projects with both BEVs and PHEVs have been completed or are still running in the Netherlands. Vehicle types include passenger cars, vans, and trucks with applications in various market segments. Project A15 (http://www.projecta15.nl/wat-is-project-a15) aims to create the first really sustainable highway in the world, striving to have 40,000 people on the road in electric (shared) cars using sustainable energy. A mid-term evaluation of nine government-subsidized projects that put various EVs into practice can be found at http://www.nederlandelektrisch.nl/english/.

In addition, several Green Deals for e-mobility are active; some focusing on a region (cities of Amsterdam, Rotterdam and Utrecht; provinces of Brabant, Friesland and Utrecht; Metropole Region of Amsterdam) and some on specific topics (smart grids, EV charging and zero-emission public transportation). A full description can be found at http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/praktijkverhalen/green-deals.

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25 Portugal

25.1 Major Developments in 2013

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

25.1.1 MOBI.E Electric Mobility Model

In early 2008, the Portuguese Government launched a national Program for Electric Mobility, aimed at creating an innovative electric mobility system that includes intelligent electric grid management. As a result, MOBI.E (from the phrase Mobilidade Eléctrica) was created as an innovative electric mobility model and technology, and it is the first charging network in the world with national coverage. The MOBI.E electric mobility model, developed by INTELI, a Portuguese think tank, is a fully integrated and totally interoperable system.

MOBI.E®

MOBI.E is based on an open-access, fully interoperable system that is able to integrate different players of the service value chain. MOBI.E enables the integration of several electric mobility electricity retailers and charging service operators into a single system, thus stimulating competition. The central management system, with a dedicated layer for full compatibility, makes it possible to integrate any charging equipment from any manufacturer and to connect to multiple systems from third parties. Hence, MOBI.E allows any user to charge any vehicle in any location by using a single subscription service and authentication mechanism.

The MOBI.E model has led to the creation of three new types of electric-mobility entities:

1. **Electric Mobility Operator:** *the physical interface*. This entity operates the charging points, making the charging service available to vehicle users/customers through the different electricity retailers. The operators are remunerated according to the electricity that runs through the infrastructure maintained by them.
2. **The Electricity Retailer:** *the arena for competition*. This entity supplies and sells electricity (through the charging points managed by operators). And this is where the market is open to competition. To differentiate from its competitors, every retailer can set different electricity tariffs and enable access to associated services. Every EV user may have a contract with any retailer (one or more).
3. **The Managing Authority:** *a clearing house.* At the top of the system, there is a managing authority for the operation of the electric mobility network that is responsible for managing energy and financial flows from the network operations. Thus, the managing authority is a platform for the integrated management of electric mobility, available to all operators, electricity retailers, and users.

25.1.2 Complementary Legislation and Incentives

The support for implementing a national mobility network based on the MOBI.E model is the country's key policy initiative related to electric vehicles. Under the coordination of the Office for Electric Mobility (GAMEP), established within the Portuguese Ministry of Economy with direct connection to the Prime Minister's Office, a specific legislative package establishing a well-defined and flexible framework for electric mobility was introduced in April 2010, based on MOBI.E. The legislation package is designed to ensure full integration and transparency, lowering the barriers to entry and enabling business-stakeholders to have a clearer picture of return-on-investment and attract private investors. The legislative framework defines actors and roles, high-level specifications, and a comprehensive set of incentives for vehicle purchase and operation, circulation and parking, infrastructure installation, and the main structure for market regulation.

In addition, several direct and indirect incentives for EVs have been enacted. According to Portuguese legislation, an electric vehicle is defined as a vehicle that can be plugged into the grid. However, incentives as outlined in Table 25.1 are restricted to fully electric vehicles (PHEVs are not included) to maximize the effectiveness and impact of each measure.

Table 25.1 Summary of Portugal's policies targeting EVs.

Incentives Targeting EVs in Portugal
• Exemption of EVs from Vehicle Acquisition Tax and Circulation Tax
• Corporate tax deduction for fleets that include EVs
• Mandatory installation of electric mobility charging infrastructure in the parking areas of new buildings, starting in 2010
• Special EV access to priority lanes and exclusive circulation areas
• Preferential parking areas for EVs in urban centers
• Annual renewal of state and municipal fleets with 20% of EVs, from 2011 on
• Financing of pilot network infrastructure

25.1.3 Research

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

The technological solution was developed by a consortium, led by the innovation center INTELI, that consists of such companies and research centers as EFACAC in the integrated and differentiated electromechanical and electronic systems business, the IT companies Novabase and Critical Software (IT systems and solutions), and the Centre for Excellence and Innovation in the Auto Industry (CEIIA). This effort began in 2008, and a pilot test phase extended through 2012.

25.1.4 Mobility Intelligence Center

A good example of the outcome of this research is the Mobility Intelligence Center, based in Maia, which is the MOBI.E network monitoring center (Figure 25.1). At this center, charging network managers and retailers have real-time access to all charging stations, with information on which stations are in use and which are available, daily and monthly charging averages, and the amount of power supplied.

Fig. 25.1 The MOBI.E Intelligence Center in Maia in northern Portugal. The center manages the EV charging network in real-time. (Source: MOBI.E [http://www.mobie.pt/en/mic])

Today, electric mobility is a core area for Portuguese R&D, and Portugal has many other research projects under way, as shown in Table 25.2. Among these, one of the first electric mobility demonstration projects in Europe, MOBI.Europe, aims at setting a framework for the standardization and openness of EV business and service approaches, integrating four electromobility initiatives in partner countries.

Table 25.2 Summary of main research initiatives related to electromobility.

Project Name	Short Description/Objectives	Main Entities Involved (in Portugal)
MOBI.E Pilot Project	Research project for the full development of a large-scale national demonstrator with the following components: normal, fast, and home charging solutions, and an ICT platform for full-network management — both from an energy and a business perspective.	INTELI, EFACEC, Critical Software, Novabase, CEIIA
MOBI.Europe	Pan-European research project focused on setting standard approaches for providing EV users with universal access to an interoperable charging infrastructure. • Includes the setup of energy-efficient mobility services through their seamless integration with the transportation systems and with the EV ecosystem. • Also, establishes the management interface between the EV infrastructure and the electric grid, the information from which will help create a more reliable and efficient end-to-end energy system.	INTELI, CEIIA, Critical Software
MOBILES	To create ICT-based solutions to support electric mobility, in particular mobile-based applications with navigation systems for support.	NDrive, FEUP[1], INTELI, CEIIA, and INESC-Porto[2]

Table 25.2 (Cont.)

Project Name	Short Description/Objectives	Main Entities Involved (in Portugal)
MERGE	Development of a management and control concept that will facilitate the actual transition to electric vehicles; adoption of an evaluation suite of tools based on methods and programs enhanced to model, analyze, and optimize electric networks.	INESC-Porto, among other international partners
Green Islands Azores Project	MIT[3]-Portugal flagship research project developing new energy planning tools to assist the local government and people in identifying strategies to meet their energy needs with indigenous energy resources, namely through smart energy networks.	MIT-Portugal community
MOBI.CAR	Flagship project within the competitiveness pole for the mobility industries that aims to fully engineer and design a light EV that embodies the green car revolution.	CEIIA, VNAutomóveis

[1] FUEP stands for the engineering faculty of the University of Porto.

[2] INESC-Porto stands for The Institute for Systems and Computer Engineering of Porto.

[3] MIT stands for Massachusetts Institute of Technology.

25.1.5 Industry

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

The automotive sector is forward-looking and benefits from several important ongoing R&D initiatives and support programs. The CEIIA is a driving force behind the electrification of the auto industry in Portugal — it also plays a defining role in the engineering development and design of the charging stations that are being installed. An industrial electric mobility cluster is forming, and it includes some of the major industrial companies in Portugal that are developing products and solutions related to electric mobility.

25.2 HEVs, PHEVs, and EVs on the Road

Taxes on the Portuguese automotive market represent roughly 20% of the total state tax income. Over the past five years, annual car sales have maintained an approximately constant rate of around 250,000 units (272,761 in 2010). The total number of all vehicles in Portugal is provided in Table 25.3.

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

Table 25.3 Total vehicle fleet in Portugal.[a]

Vehicle Type	Total Vehicle Fleet (including HEVs, PHEVs, and EVs)[b]	EVs
Bicycle (no driver's license)	n/a	n/a
Motorbike	498,000	795
Passenger vehicle	4,515,500	504
Multipurpose passenger vehicle	n/a	n/a
Bus	15,600	22
Truck	1,337,000	13
Industrial vehicle	n/a	n/a

n/a = not available

[a] Date and source of vehicle fleet information is EV2011 Tot 2010.

[b] Separate numbers for PHEVs and HEVs are not available.

As a consequence of the direct incentive for EV acquisition of €5,000 ($6,921 US) for the first 5,000 vehicles (exclusively for individual private users) and the strong disincentive of internal combustion engine (ICE) -based vehicles in favor of EVs for company fleets, it is expected that the number of EVs on the road by the end of 2012 will be over 10,000 units. Two-wheelers will be one of the drivers for EV adoption, as a result of the deployment of specific charging solutions in some locations.

25.3 Charging Infrastructure for EVSE

Portugal's electric mobility program is widely known as MOBI.E, and much of the structure of this program was explained in Section 25.1. The initial phase of MOBI.E includes both building a nationwide recharging infrastructure and growing the domestic market for EVs, which began commercial sales in Portugal in 2011 (Figure 25.2).

Fig. 25.2 MOBI.E vehicle electrification project includes installing charging stations in 25 municipalities and along main highways in its pilot phase, as well as developing a 80-km-range battery-electric vehicle Mobicar, primarily aimed at the export market. (Source: MOBI.E)

At present, there are two predominant types of charging stations:

- *Normal-charging stations:* At home, for fleets, on-street and off-street parking
- *Fast-charging stations:* On main roads and highways, service stations, and at strategic urban locations

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

The initial phase for MOBI.E is publicly funded, but one of the program goals is for private business development using renewable energy sources to expand the network. This network will gradually grow with the involvement of private partners, some of which have already joined the network. A wide and comprehensive network is under development, and it includes charging points along streets and in public parking lots, shopping centers, service stations, hotels, airports, and private garages. Legislation has defined that it is mandatory for all publicly accessible charging stations (either in private or public sites) to be operated by charging point operators (see Section 25.1), which in turn must have them connected in real time to the central MOBI.E system. The MOBI.E charging network includes different charging profiles, according to developing technologies and standards.

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

25.4 Outlook

The government estimates that Portugal could have roughly 200,000 EVs on the roads by 2020, with approximately 25,000 public charging stations in its network. In best-case scenarios, these figures will be amplified by continued strong interest from public authorities and private companies, as well as the necessary technological breakthroughs that are predicted. Portugal's major electricity operator, EDP, estimates that the recharging market could be worth up to €2 billion ($2.8 billion US) in 2020. From an environmental perspective, electric mobility will account for roughly 700 kton of avoided CO_2 emissions in the year 2020, in addition to over €300 million ($415.3 million US) in energy-import savings.

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

26 Republic of Korea

26.1 Major Developments in 2013

26.1.1 Expansion of Government Subsidies for Electric Vehicles to Private Sector

The South Korean government has, and will continue, to scale up its efforts to promote the purchase of EVs by expanding government subsidies on EVs in the private sector; these subsidies have been limited to the public sector for the past 3 years. The South Korean Ministry of Environment offers a subsidy of 15 million KRW (South Korean won), which is approximately $14,670 US, per vehicle, for purchase of an EV. Ten provinces or cities offer further incentives that range from 3 million KRW to 8 million KRW ($2,800 US–$7,824 US). Previously, the majority of local governments had applied the subsidies only to a specific region, such as Jeju, and public institutions, but now the government offers these incentives to citizens for promoting the use of EVs — even in Seoul, Daejeon, Gwangju, Changwon, Yeonggwang, Dangjin, Pohang, Ansan, and Chuncheon. Several cities, such as Changwon, Yeonggwang, Dangjin, and Pohang, which are home to a large number of industries, provide a subsidy for companies switching to EVs for their office fleets.

Figure 26.1 shows EVs available in South Korea, including their capacity, maximum speed, mileage, battery type, and selling price.

Fig. 26.1 EVs available in South Korea.

Jeju, a semi-tropical island, offers the maximum 8 million KRW local subsidy and intends to convert to entirely emission-free transport by 2030. The small island has about 300,000 vehicles and offers a perfect driving environment for electric cars, with travel distances capped by its finite network of roads. It has already installed more than 500 240-volt Level 2 charging stations, with more on the way. The first subsides in Jeju are limited to 160 cars. Priority for subsidies will be given to individuals of national merit, the disabled, and multi-child families (more than three children). The only car models for which the subsidy is available are the Ray EV, SM3 Z.E. (released last October), and Spark EV (released last October). In Jeju, individuals who purchase an EV can receive an additional 8 million KRW to purchase a battery charger for the vehicle.

Because five or six EV models are scheduled to go on sale early next year, the domestic EV market is anticipated to improve. The 10 leading EV-promoting cities submitted their plans to expand the distribution of EVs starting in July. As the program expands, more purchasers of EVs have access to the government subsidy of 15 million KRW, municipality subsidy of between 8 million KRW and 15 million KRW, and free EV charger (worth less than 8 million KRW).

26.1.2 Standardization of Vehicle Battery Charger

South Korea has adopted a national standard for battery chargers: the CHAdeMO type (a fast-charging direct-current [DC] battery charger) from Japan and the alternating-current (AC) three-phase charger from Renault Samsung. The DC combo-type charger for the General Motors (GM) Spark EV, BMW i3, and VW EV Golf from North America and the European Union (EU) will be adopted in 2014, as these vehicles are now available for purchase in South Korea. Table 26.1 lists the vehicles, their charger requirements, and dates of market introduction.

Table 26.1 State of the art for fast electric chargers.

Car Maker	Hyundai·Kia	Renault Samsung	GM Korea	BMW
Car Name	Ray EV	SM3 ZE	Spark EV	i3
Charger Type	DC CHAdeMO	3-phase AC	DC combo-type 1	DC combo-type 1
Date of Market Introduction	April 2012	October 2013	October 2013	May 2014
Date of Adoption as Korean Standard	September 2011 (group standard)	June 2013	2014	2014

26.1.3 Pohang City's e-bus Pilot Project

The Ministry of Land, Transport, and Maritime Affairs announced that it will launch a test operation of "automatically battery switching electric buses," which are known as an environmentally friendly means of transport. Unlike existing EVs, which are charged through plug-in, the automatic battery switching electric buses have easily accessible batteries to allow swift battery swapping at bus stops while the buses are in operation and before the batteries are completely drained. The Ministry plans to establish a battery switching electric bus system on Pohang City's Facilities Management Corporation shuttle bus route, at a cost of 2.5 billion KRW (additional 1.3 billion KRW from the local government), and to provide technical and administrative support. The route is about 22 km and has three bus stops (Figure 26.2).

Major equipment and facilities include two electric buses, one battery swap facility (Figure 26.3), and six batteries. The Ministry announced that it plans to establish the e-bus system after a final consultation with the City of Pohang on how to operate the system and to initiate the test operation for the public beginning in 2013, after safety verification.

Fig. 26.2 E-bus route.

Fig. 26.3 E-bus battery exchange.

26.2 HEVs, PHEVs, and EVs on the Road

According to the Korea Automobile Manufacturers Association (KAMA), sales of hybrid electric cars decreased by 20% (29,060 cars) compared with the previous year. As a result, the proportion of hybrids electric cars decreased to below 2% of the cars sold. Sales of EVs, however, increased by 18.8% (614 cars) compared with the previous year; these cars were registered primarily to government offices. Table 26.2 provides the total vehicle registrations, broken down by vehicle type, number of units, and growth, in 2013.

Table 26.2 New cars registered in 2013.

Vehicle Type	Number (units)	Growth Compared with Previous Year (%)	Percent of Total
Gasoline	672,025	-9.3	42.5
Diesel	656,128	13.5	43.5
Liquefied Petroleum Gas (LPG)	175,958	2.5	11.4
Hybrid Electric	29,060	-20.6	1.9
EV	614	18.8	0.1
Other	9,779	20.6	0.6
Total	1,543,564	0.7	100.0

Source: KAMA Annual Report

26.3 Charging Infrastructure for EVSE

Electric Vehicle Charging Infra System (EVCIS) (Figure 26.4) is a system that can provide real-time information regarding charging infrastructure locations and status to users via the Web and their smart phones anytime and anywhere (for more information, see http://evcis.or.kr). Statistics show that use of the charging infrastructure facilities has increased as a result of furnishing such real-time information via geographic information system (GIS) techniques. Before EVCIS was implemented, there were 28,657 charging events across the EV fleet of 1,146 cars, which results in 25 charging events per car. The average charge per event was 5.44 kWh. After the implementation of EVCIS, the size of the fleet, the number of charging events, and the average charge amount all increased. The EV fleet grew from 1,146 to 1,186. There were a total of 50,166 charging events, which is approximately 42 charging events per car — an increase of about 90%. The average charge per event was 6.11 kWh, or an increase of 12% per charging event.

Fig. 26.4 Website showing charging infrastructure locations.

27 Spain

27.1 Major Developments in 2013

Electric vehicles (EVs/plug-in hybrid EVs [PHEVs]) and hybrid electric vehicles (HEVs) maintained firm progress in terms of sales and consumer acceptance in 2013 in Spain because of the policy plans and programs described in the following sections.

27.1.1 MOVELE Program

The MOVELE Program was approved and provided a €10 million ($13 million US) budget for incentives to acquire EVs and PHEVs in 2013 (Royal Decree [RD] 294/2013 normative). The amount expended was €4.2 million ($5.7 million US), and 1,290 EVs/PHEVs were put on the road. The majority of new EVs/PHEVs were bought for professional transport fleets. Since 2011, MOVELE grants have benefited the sales of 5,900 EVs/PHEVs.

An additional €10 million ($13 million US) budget for incentives to acquire EVs/PHEVs has been approved for the current year of 2014.

27.1.2 PIVE Program

On October 1, 2012, the national government launched the PIVE Program, an incentive program for purchasing efficient vehicles, including EVs/PHEVs. These incentives can be combined with buyer incentives provided by the MOVELE Program, up to a total incentive of €8,000 ($10,850 US) for a vehicle purchase.

The PIVE Program involves providing incentives for buyers to "scrap" old vehicles, including passenger vehicles (M1 category) that are more than 12 years old and light-duty vehicles (N1 category) that are more than 7 years old, with new and more efficient vehicles. Buyers receive €1,000 ($1,350 US) per vehicle, an amount that can be increased by an additional €1,000 ($1,350 US) discount contributed by car manufacturers.

The PIVE Program has been running on funds dedicated at four phases throughout 2012–2013:

- Plan PIVE 1: approved on October 1, 2012, and funded with €75 million ($102 million US)

- Plan PIVE 2: approved on February 1, 2013, and funded with €150 million ($204 million US)
- Plan PIVE 3: approved on July 27, 2013, and funded with €70 million ($95.2 million US)
- Plan PIVE 4: approved on October 29, 2013, and funded with €70 million ($95.2 million US)

Within the framework of this PIVE Program (Plan PIVE 1 to Plan PIVE 4), a total of 3,815 HEVs and 124 EVs/PHEVs have been acquired.

Cumulatively, goals for these plans are to result in the replacement of around 350,000 vehicles with a total budget of €365 million ($496.4 million US).

The next phase of the PIVE Program (Plan PIVE 5) was approved on January 28, 2014, to provide continuity to the PIVE Program in 2014 and received funding of €175 million ($238 million US).

27.1.3 PIAM Program

Plan de Incentives Autotaxi Madrid (PIAM) is a strategic program within the Madrid region that aims to renovate the taxi fleet. The idea is to replace older and inefficient vehicles with more efficient ones. The program began in 2013 as a pilot program with a budget of €100,000 ($136,000 US), and it has been extended into 2014 with a dedicated budget of €900,000 ($1.22 million US). In 2013, 48 taxicabs were replaced, of which 44 were HEVs (92%).

27.1.4 Plan PIMA Aire

"Plan PIMA Aire" (Plan de Impulso al Medio Ambiente) is another car scrapping program focused on commercial vehicles that ran from February 9, 2013, to December 31, 2013, with a dedicated budget of €38 million ($68 million US). Incentives were for €1,000 ($1,350 US) for the acquisition of older vans up to 2,500 kg weight; for acquisition of vans weighing more than 2,500 kg, incentives of €2,000 ($2,700 US) per van were available. Since October 25, 2013, electric motorcycles, scooters, and bikes were also included in this incentives program ("Plan PIMA Aire 2"), with incentives of up to €400 ($540 US), €250 ($325 US) and €200 ($272 US), respectively, per each category.

Incentives for Plan PIMA Aire can be added to MOVELE Program incentives but not to the PIVE Program.

Plan PIMA Aire has resulted in the replacement of approximately 20,000 light-duty vehicles. In addition, 700 motorbikes, scooters, and bikes have been withdrawn and replaced with electric or hybrid-type bikes.

A new extension of Plan PIMA Aire, “Plan PIMA Aire 3,” was approved on February 28, 2014, in order to provide continuity to the plan; it was funded with a budget of €5.5 million ($4.48 million US).

27.2 HEVs, PHEVs, and EVs on the Road

In 2013, 10,222 HEV passenger cars were sold, representing 1.4% of the total passenger car market. The entire Spanish fleet of HEVs reached 54,710 vehicles on the road at the end of the year (Table 27.1).

Table 27.1 EV, HEV, and PHEV fleet and sales in Spain at the end of 2013.

Fleet Totals as of December 31, 2013					
Vehicle Type	EV Fleet	HEV Fleet	PHEV Fleet	FCV[a] Fleet	Total Fleet[b]
Urban motorbikes (mopeds)	1,045	0	0	0	2,052,503
Motorbikes	2,742	0	108	0	2,910,323
Quadricycles	2,022	0	0	0	69,047
Passenger vehicles	1,750	54,683	136	0	22,227,173
Multipurpose passenger vehicles (commercials)	968	0	0	0	4,715,148
Buses	5	27	40	0	60,234
Trucks	n/a	n/a	n/a	n/a	215,576
Total	**8,532**	**54,710**	**284**	**0**	**32,250,004**
Vehicle Sales Total for 2013					
Vehicle Type	EV	HEV	PHEV	FCV	Total
Urban motorbikes (mopeds)	262	0	0	0	14,754
Motorbikes	767	0	21	0	92,558
Quadricycles	463	0	0	0	2,914
Passenger vehicles	819	10,222	64	0	722,689
Multipurpose passenger vehicles (commercials)	143	0	0	0	85,459
Buses	4	18	0	0	1,719
Trucks	n/a	n/a	n/a	n/a	13,150
Total	**2,458**	**10,240**	**85**	**0**	**933,243**

Table 27.1 (Cont.)

Selected Model Prices of EVs in Spain in 2013		
Plug-in Vehicle Models Available (passenger only)	**Untaxed, Unsubsidized Price of Vehicle Model/Category**	
BYD E6	€45,368 ($61,500 US)	M1
Toyota Prius PH	€35,550 ($48,200 US)	M1
Fiat EV500	€36,500 ($49,500 US)	M1
Nissan Leaf	€24,000 ($32,550 US)	M1
MICRO-VETT Fiorino M1	€50,202 ($68,100 US)	M1
Smart Electric Drive Cabrio	€34,655 ($47,000 US)	M1
THINK City 2010	€34,810 ($47,200 US)	M1
Renault ZOE	n/a	M1
Renault Fluence	n/a	M1

n/a = not available

[a] FCV = fuel cell vehicle

[b] Total fleet accumulated, October 2013

Note: The total fleet numbers include all propulsion systems and fuels; thus, they include gasoline, diesel, liquefied petroleum gas (LPG), natural gas, and biofuels, for example.

EVs/PHEVs sales in Spain have generally been steadily increasing: amounts totaled 111 vehicles sold before 2008; 164 in 2008; 524 in 2009; 834 in 2010; 1,257 in 2011; and 3,383 in 2012, with a bit of a drop-off to 2,543 vehicles sold in 2013.

As just mentioned, Spanish sales of EVs/PHEVs were lower last year compared to the year before (Figure 27.1) because of the ending of grants available for motorbike acquisitions within the framework of the MOVELE Program and the final transition of these incentives to Plan PIMA Aire.

The aim of this change is to refocus the MOVELE Program on the passenger car category (M1), resulting in an even stronger sales increase of EVs/PHEVs in the passenger car category: passenger car sales increased by 62%, from 546 vehicles in 2012 to 883 in 2013 (Figure 27.2).

Figure 27.3 provides data for historical sales of HEV passenger cars. Passenger car sales amounted to 6,361 vehicles before 2008; 3,892 in 2008; 5,399 in 2009; 8,465 in 2010; 10,333 in 2011; 10,011 in 2012; and 10,222 in 2013. As reflected in the figure, annual sales figures for passenger cars are similar over the past 3 years.

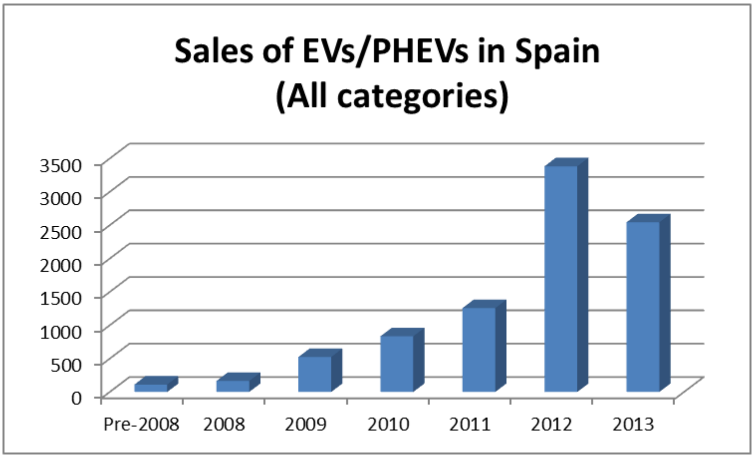

Fig. 27.1 EV/PHEV sales in Spain from pre-2008 through 2013.

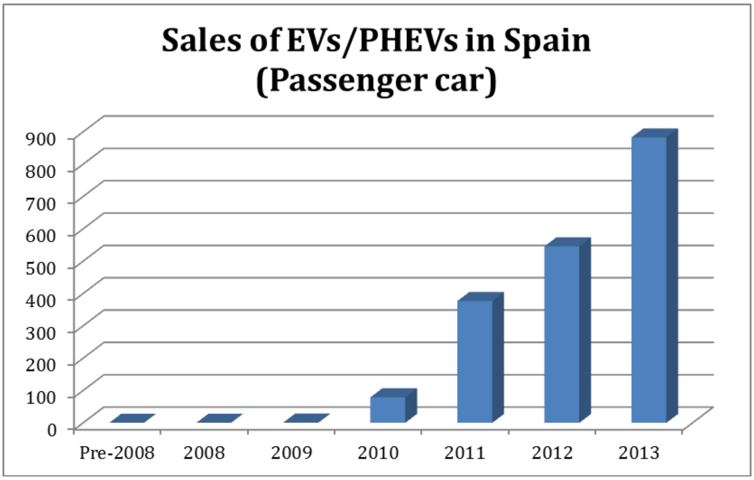

Fig. 27.2 EV/PHEV passenger car sales in Spain from pre-2008 through 2013.

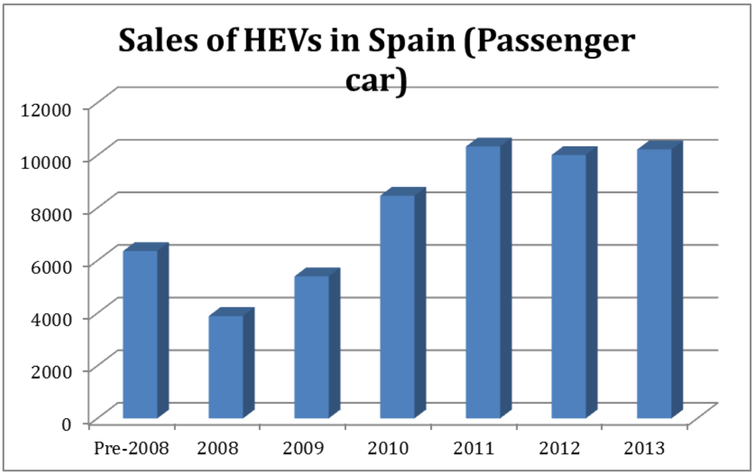

Fig. 27.3 HEV passenger car sales in Spain from pre-2008 through 2013.

27.3 Charging Infrastructure for EVSE

Current information related to infrastructure in Spain for EV recharging is gathered in Tables 27.2 and 27.3.

Table 27.2 provides the number of public-use charging points deployed in Spain at the end of 2013.

Table 27.2 Public-use recharging infrastructure.

Recharging Infrastructure	
Cities	91
Stations	288
Total CHP[a]	761
Type of Charge	
CHP Single Phase	682
CHP 3-phase	79
Location	
CHP covered	353
CHP not covered	408

[a] CHP = charging points

Table 27.3 shows the number of public EVSE installed, attending to its type. Regarding 2012 figures, there is a slight decrease (10 units), due to a data base correction: some new charging points have been included and underutilized charging points have been removed.

Table 27.3 Number of public EVSE installed as of December 31, 2013.

Total Public EVSE	761
Level 1	682
Level 2/standard AC	79
DC fast charging	11

Note: The DC fast-charging stations are not included in the total (AC = alternating current; DC = direct current).

A current number of 64 public-use charging points are deployed by “Recharging Managers,” a legal figure created by Spanish law (RD 647/2011, May 9), which is oriented toward commercializing the service of recharging EVs and energy storage.

At the end of 2013, 11 companies were numbered as registered Recharging Managers and figure in the following official website of the Spanish government created to disseminate this information: https://sede.cne.gob.es/c/document_library/get_file?uuid=8be589c8-9bbc-4881-b05f-baffd8e49afd&groupId=10136.

The rest of the public-use charging points installed in Spain, that is, those which are not installed by Recharging Managers, were deployed in the framework of pilot city projects and programs, usually in joint collaboration with city councils and regional and national governments.

Since the establishment of the Recharging Managers, all public-use charging points will be operated under these agents, and thus new pilot city projects must be developed with the participation of the Recharging Managers. In fact, Recharging Managers are currently starting to assume responsibility for the maintenance and operation activities of many of the recharging points.

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28 Sweden

28.1 Major Developments in 2013

In 2010, the Swedish Government set a target for the transportation sector to become "fossil fuel independent" by 2030. In 2012, a commission was appointed to investigate how this could be enforced, and in December 2013, the commission presented their report, in which suggested actions focused on the road transportation system. The commission reported five action areas: three where improvements could be attained by more efficient transportation solutions (targeting both vehicles, as well as spatial planning), and the remaining improvements could be carried out by using either biofuels or electricity as the energy carrier. Sweden is a part of the Nordic electricity market, which is dominated by hydro and nuclear power, and therefore considers electricity as CO_2 neutral. Hence, the electrification of the transportation system is not only considered an energy-efficiency measure, but it is also a way to achieve reductions in CO_2 emissions. The report suggested several measures and actions, with many aimed to accelerate the introduction of electric vehicles. For example, one measure would offer governmental financial support for the development of a normal charging infrastructure and the requirement to install, or prepare for installation, charging equipment when building a new parking site. This report was delivered to the Swedish Government and what actions they chose to implement are still uncertain. The report may be found on the Government Offices of Sweden website (http://regeringen.se/sb/d/108/a/196433) (in Swedish).

The Swedish Transportation Administration, the Swedish Energy Agency, and the Swedish Governmental Agency for Innovation Systems have initiated an innovation/technology procurement process for demonstration of electric road systems (ERSs). In ERS, the vehicles are continuously supplied with electricity during the entire, or just parts of, the journey. This pre-commercial procurement initiative aims to gather partners from industry, academia, and authorities, with the shared ambition of electrifying heavy-duty vehicles. During 2013, different consortiums were formed. A consortium could, for example, consist of a vehicle manufacturer, a road construction company, a logistic delivery system such as a mining company or a bus company, and academia. The budget is SEK 100 million (i.e., 100 million Swedish krona), which is approximately €10 million ($13.4 million US), and the goal is to have 1 to 3 operating demonstration systems by 2015.

ElectriCity, a public-private partnership, was granted €4.8 million ($6.4 million US) by the Swedish Energy Agency to demonstrate an attractive public transportation system in Gothenburg, Sweden's second largest city, using plug-in electric hybrid buses and fully electric buses (Figure 28.1). In addition to the electrified buses, the project will demonstrate new concepts for bus stops (for example, indoor stops) and aims to function as an open test and demonstration arena for new technologies and services that can change the future design of vehicles and their use in society. Project partners include Volvo AB, Johanneberg Science Park, Lindholmen Science Park, Region Västra Götaland, and City of Gothenburg.

Fig. 28.1 Project ElectriCity includes quiet, emission-free, and fuel-efficient electric buses; future bus stop solutions; ITS solutions; safety concepts; green depots; and energy solutions.

Table 28.1 summarizes the scope of policy instruments in Sweden for PHEVs and EVs.

Table 28.1 Summary of Sweden's policy instruments for PHEVs and EVs.

Policy Instrument	Details
Super Green Car Rebate	The Super Green Car Rebate was effective on January 1, 2012, with the support of $5,410 US (40,000 SEK or €4,000) for the purchase of passenger 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 with the PEV Technology Procurement scheme. Participating organizations receive up to 50% of the additional cost, up to a maximum of $15,840 US (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 with the condition that data be collected on vehicle usage.
Reduced value of fringe benefits	For company cars, the value of fringe benefits is reduced for PEVs to balance the additional cost as compared to an equivalent, conventional fossil-fueled car. After adjusting for the cost of a comparable internal combustion engine (ICE) car, the value of fringe benefits are reduced by 40%, to a maximum of €1,600 ($2,142 US).

28.2 HEVs, PHEVs, and EVs on the Road

By June 2014, 4,640 electric vehicles (EV) were registered in Sweden. This is an increase by over 190% since 2012 (1,594), and the big increase may be explained by three factors: increased number of models, introduction of several new plug-in hybrid electric vehicles, and a continuation of the Super Green Car Rebate.

A majority of the vehicles (approximately 80–85%) operate today in commercial vehicle fleets (Table 28.2).

Table 28.2 Fleet totals and PHEV models in Sweden.

Fleet Totals as of December 30, 2013					
Vehicle Type	EV Fleet	HEV Fleet	PHEV Fleet	FCV Fleet	Total Fleet[a]
Motorbikes and quadricycles	83	n/a	n/a	n/a	285,149
Passenger vehicles	979	n/a	1,615	n/a	4,502,320
Buses	n/a	n/a	n/a	n/a	13,995
Trucks	678[b]	n/a	n/a	n/a	566,139
Total Sales as of December 30, 2013					
Vehicle Type	**EV Sales**	**HEV Sales**	**PHEV Sales**	**FCV Sales**	**Total Sales**
Passenger vehicles	452	5,349	930	n/a	292,200

Table 28.2 (Cont.)

Plug-in Vehicle Models Available (passenger only)	Untaxed, Unsubsidized Price of Vehicle Model (€100 = 923 SEK)	
Opel Ampera	€37,990	$59,868 US
Toyota Prius Plug-in	€36,440	$48,793 US
Volvo V60 Plug-in	€55,990	$74,970 US
Chevrolet Volt	€43,400	$58,112 US
Mitsubishi Outlander	€41,990	$56,224 US

n/a = not available

[a] The total fleet numbers include all propulsion systems and fuels, and so they include, for example, gasoline, diesel, LPG, natural gas, and biofuels.

[b] EV fleet total as of June 30, 2014

28.3 Charging Infrastructure for EVSE

There are about 1,700 public charging points in Sweden, but many of them are not always as accessible to the public as drivers would like. Information about locations and charging specifications is available at the charging station website, www.uppladdning.nu.

Today, Swedish authorities have no common charging infrastructure development plan. In Sweden, municipalities play an important role as the prominent landowner, and several local initiatives are taking place. The City of Stockholm has, for example, budgeted for the installation of 100 public, normal-charging facilities and 10 fast-charging stations during 2014. Municipalities and municipality-owned companies, such as utility, parking and property companies, have initiated many local projects, sometimes together with private companies, to encourage the development of a charging infrastructure. The municipal utility Öresundskraft has, for example, supplied car pool company Move About with attractive parking facilities that have a solar panel roof. There are also private initiatives, and these tend to focus on fast-charging concepts. A Nordic partnership between utility company Fortum and Nissan has restaurant chain McDonald's as their Swedish partner wherever they install fast-chargers.

In Sweden, approximately 800,000 car parks are already equipped with block heaters (600,000 in private homes and 200,000 at corporate parking facilities) since Nordic winter conditions risk freezing the coolant in the vehicle's motor block. By preheating the engine, emissions coupled with a cold start could be avoided. These outlets could easily be modified and upgraded with charging specifications suitable for PEVs. Existing outlets could be used unmodified, but this is not advocated as a long-term solution.

28.4 EV Demonstration Projects

Several demonstration projects are under way in Sweden. The longest-running project is the PEV Technology Procurement scheme, which has been in effect since 2010 and will continue through 2014 (Figure 28.2). This project is taking place all over Sweden and encompasses approximately 100 PHEVs and 500 battery-electric vehicles (BEVs). In 2011, the Green Highway project began in Östersund and is also scheduled to run through 2014. Two additional projects were started in 2012, namely Elbilsoffensiven and Greencharge Sydost. Elbilsoffensiven is operating in the regions of Västerås, Gävleborg, Falun, and Östersund, while Greencharge Sydost is taking place in Karlskrona. Both of these projects will operate through 2014.

Fig. 28.2 By participating in the PEV Technology Procurement scheme, municipally owned property company Kopparstaden now operates several different models of PEVs.

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29 Switzerland

29.1 Major Developments in 2013

29.1.1 Master Plan for Electric Mobility

With the Motion titled "Electric Mobility, Master Plan for a Sensible Development," the Swiss Parliament has asked the Federal Council to draw up a master plan for the accelerated market penetration of individual electric motorized vehicles. The Federal Office of Energy[1] is taking care of the order together with other involved federal offices. The focus is on:

- Development of a nationwide base network for rapid charging stations, with the support of private efforts;
- Partial electrification of the federal vehicle fleet;
- Strengthening of information and consulting services for companies and individuals;
- Continuation and selective reinforcement of R&D;
- Provision of the required electricity demand in line with the energy strategy for 2050;
- Support for pilot projects where necessary and useful; and
- Concerns about funding of vehicles and charging infrastructure.

29.1.2 Rebates for Motor Vehicle Taxes

In 2013, there was still no national legislation concerning electric vehicles. Switzerland has a federal system with 26 cantons, and each one maintains individual regulations for rebates for motor vehicle taxes. However, more and more cantons are moving toward a bonus-malus rebate system favoring low CO_2 emissions rather than a combination of efficiency categories, such as gross weight or engine power of vehicles.

[1] http://www.bfe.admin.ch/org/index.html?lang=en

In the canton Ticino, for example, 2013 was an intensive year of preparing the environmental incentives for “eco2incentivi.” The new regulations were put in place on January 1, 2014. Under these regulations, cars up to 3.5 tons and first registered after January 1, 2009, are evaluated by their CO_2 emissions in 13 categories. The best five categories get a bonus up to 80% (0–30 g CO_2/km), while the seven categories with emissions over 150 g CO_2/km get a “malus” (penalty). Cars with an output of over 400 g CO_2/km, for example, get a malus of 60%. This means that their motor vehicle tax increases by 60%.

29.1.3 KORELATION Project

In 2013–2014, the Association e’mobile[2] (Swiss association for electric and efficient vehicles) evaluated the practical experience of private and corporate users of 200 electric cars. The investigation called KORELATION[3] (Cost - Range - Charging Stations) is one of the largest brand-independent studies of this kind in Europe (Figure 29.1). The project aims at strengthening the confidence of car dealers and potential customers in electric transportation, thus accelerating the short-term market introduction of electric cars.

Examined in this study are characteristics of battery electric vehicles, electric vehicles with a range extender, and plug-in hybrid vehicles in the categories of passenger cars, small commercial vehicles (maximum empty weight of 3.5 tons) and small-motor vehicles. Of special interest are vehicles of the latest generation (from 2011 onward). Older cars are used for comparison.

The user experience with these vehicles is documented online by:

- Questionnaires on purchase decisions and installed charging infrastructure
- Consumption measurements and charging habits during one month in the cold and in the warm seasons
- Reportings of special incidents during the year

The project is supported by the Federal Office of Energy as part of its program SwissEnergy[4] and by several partners in the automobile and energy industry.

[2] http://e-mobile.ch/index.php?sprache=en
[3] http://e-mobile.ch/index.php?pid=de,3,20
[4] http://www.bfe.admin.ch/energie/00458/index.html?lang=en

Fig. 29.1 User meeting of the project KORELATION. (Photo by Association e'mobile)

29.1.4 Development of Electric Truck and Charging System

The eCarTec Award 2013[5] — the Bavarian State Prize for Electric Mobility — was awarded in Munich to E-FORCE ONE Inc. and BRUSA Elektronik AG. The E-FORCE electric truck and its new inductive charging system (ICS) beat off stiff competition to be crowned winners in their particular categories.

E-FORCE[6] is an electric 18-tonne truck for regional distribution of city goods (Figure 29.2). With the assistance of LithiumStorage and Designwerk GmbH, the recently founded company E-FORCE built the electric truck and was able to acquire such customers as the brewery Feldschlösschen and the food retailer Coop. Each E-FORCE truck uses two BRUSA electric motors, controllers, and chargers, as well as a DC converter. While the E-FORCE truck may be twice as expensive as a conventional truck of its size, it pays for itself, thanks to its extremely low running costs.

BRUSA[7] developed a compact ICS with integrated power electronics and wireless charging. Experts agree that, in the future, electric vehicles will be wirelessly charged. ICS is compact and only comprises a floor and vehicle plate — the required power electronics are already integrated.

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5 http://www.brusa.biz/index.php?id=55&L=1&tx_ttnews%5btt_news%5d=233

6 http://eforce.ch/

7 http://www.brusa.biz/index.php?L=1

Fig. 29.2 E-FORCE truck. (Photo by Feldschlösschen)

29.1.5 Development of Electric Bus

TOSA[8] (Trolleybus Optimisation Système Alimentation) is the first full electric-powered bus that runs without overhead lines (Figure 29.3). With its flash charging system, it recharges the batteries on the roof at selected bus stops along the route in a record time of 15 seconds with a 400-kilowatt boost. This is enough energy to reach the next charging station. At the end of the bus line, a 3–4-minute boost enables the full recharge of the batteries. This is innovative in two aspects:

- Technological, as it goes beyond a traditional prototype and is based on 19- to 24-meter articulated buses.
- Operational, as it involves this mode of transport in an urban context with all its constraints.

To implement this innovation, a pilot operation on an urban public transport line was set up at the International Association of Public Transport (UITP) 2013 conference held in Geneva. The electric bus was developed by ABB,[9] and it operates between the Geneva airport and the international exhibition centre Palexpo. The project runs until March 2014.

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8 http://www.tosa2013.com/#/tosa2013
9 http://www.abb.com/cawp/seitp202/f32c9ded54dc0b20c1257b7a0054972b.aspx

Fig. 29.3 TOSA bus in Geneva. (Image courtesy of ABB)

29.2 HEVs, PHEVs, and EVs on the Road

In Switzerland, 402,117 new motor vehicles were registered in 2013. This number was 6.7% less than it was in the previous record year because new CO_2 emission standards had been introduced in July 2012 and there had been an extraordinary increase in the number of new registrations in the first half of 2012 before that.

Although there were fewer new registrations in 2013 than 2012, the total stock of registered road vehicles rose by 1.6% in 2013 to 5.7 million, of which 4.3 million were passenger cars. The overall trend toward diesel and four-wheel-drive vehicles continued. In 2013, one out of four vehicles was a diesel car, and one out of four was a four-wheel-drive vehicle.

In comparison with 2012, 24% more hybrid and 52.6% more electric cars were registered in 2013. Despite these high growth rates in 2013, only 1 of 124 cars was a hybrid, and just 1 of 1,610 vehicles had an electric drivetrain. In addition, 1,850 e-scooters and 49,362 e-bikes were sold in 2013. The e-bike sales, 6.8% less than those in the year before, reflected the influence of bad weather in the important first half of 2013.

The growth rates in electric vehicle (EV), hybrid EV (HEV), and plug-in HEV (PHEV) sales may have been supported by many related favorable press reports (e.g., reports on the Tesla Model S and the arrival of the Renault ZOE at an attractive sales price; battery leasing). Furthermore, test drives, road shows, and communications from car manufacturers, dealers, infrastructure providers, and other organizations may have helped to increase market sales.

In Switzerland, the fleet totals were available only as of September 30, 2013, whereas total sales were reported for the entire calendar year (January 1 through December 31) (Table 29.1).

Table 29.1 Fleet and sales totals and prices for selected models in Switzerland, 2013.

29.1a Fleet totals

Fleet Totals (as of September 30, 2013)						
Vehicle Type	EV Fleet	HEV Fleet	PHEV Fleet	EREV Fleet[a]	FCV Fleet[a]	Total Fleet
Motorbikes	8,584	n/a[a]	n/a	n/a	n/a	674,419
Quadricycles	939	n/a	n/a	n/a	n/a	13,571
Passenger vehicles	2,203	34,883	230	498	4	4,320,885
Buses	49	n/a	n/a	n/a	5	60,151
Trucks	321	n/a	n/a	n/a	n/a	371,361
Industrial vehicles	2,746	n/a	n/a	n/a	1	253,255
Total	**14,842**	**n/a**	**n/a**	**n/a**	**n/a**	**5,693,642**

29.1b Total sales

Total Sales (January – December 2013)						
Vehicle Type	EV Sales	HEV Sales	PHEV Sales	EREV Sales	FCV Sales	Total Sales
Motorbikes	1,962	0	0	0	0	45,727
Quadricycles	284	15	0	0	0	1,597
Passenger vehicles	1,176	6,709	394	183	0	310,154
Buses	4	22	0	0	0	4,138
Trucks	119	7	0	0	0	32,633
Industrial vehicles	212	2	0	0	0	7,868
Total	**3,757**	**6,755**	**394**	**183**	**0**	**402,117**

29.1c Available vehicles and prices

Market-Price Comparison of Selected EVs and PHEVs in Switzerland	
Available Passenger Vehicles	Untaxed, Unsubsidized Sales Price
BMW i3	CHF 39,950
Chevrolet Volt	CHF 48,500
Citroën Zero	CHF 31,600

29.1c (Cont.)

Market-Price Comparison of Selected EVs and PHEVs in Switzerland	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price**
Fisker Karma	CHF 129,900
Mia electric	CHF 19,900
Mitsubishi i-MIEV	CHF 24,999
Mitsubishi Outlander PHEV	CHF 51,999
Nissan Leaf	CHF 35,690
Opel Ampera	CHF 45,400
Peugeot iOn	CHF 31,600
Porsche Panamera S E-Hybrid	CHF 150,500
Renault Fluence	CHF 30,600
Renault ZOE	CHF 22,800
Renault Kangoo Maxi[b]	CHF 30,024
Renault Twizy[b]	CHF 9,600
Smart Fortwo Electric Drive[b]	CHF 24,500
Tesla Model S 60 kWh	CHF 85,900
Tesla Model S 85 kWh Performance	CHF 111,800
Toyota Prius Plug-in	CHF 51,900
VW e-up!	CHF 32,700

[a] EREV = extended-range electric vehicle, FCV = fuel cell vehicle, n/a = not available

[b] Sales price excludes monthly battery rental fee of CHF 59–103, depending on brand and model.

29.3 Charging Infrastructure for EVSE

EKZ, the electricity utility provider of the Canton of Zurich, presented results of the pilot project Smart Charge.[10] Smart Charge includes a smartphone app that EKZ developed with IBM and the Zurich University of Applied Sciences (ZHAW). No intelligent charging infrastructure is needed; thus, low costs for smart charging are possible thanks to the use of car telematics rather than nonexisting smart grids. This project demonstrates how EVs can create a balance between the supply of and demand for smarter energy grids.

[10] http://www-03.ibm.com/press/us/en/pressrelease/35627.wss

ABB has launched its Terra 53[11] charging platform, the world's first platform to meet all DC fast-charging standards. With its multi-standard architecture and near-term option to cascade the stations to higher power, the Terra 53 is ideal for highway and city centers, fueling stations, fleets, and other infrastructure investors interested in the growing EV charging market.

Tesla opened its first fast DC Supercharger[12] station in Switzerland in Lully, which is northeast of Geneva on the A1 motorway. This station is part of a network connecting the Netherlands, Belgium, Luxembourg, Germany, Switzerland, Austria, and Denmark.

Groupe E, the electricity utility provider from Fribourg and Neuchâtel, launched the public charging network MOVE.[13] This network is accessible to all standard EVs, and its identification system lets subscribed users use a personal card, hotline, or smartphone application to charge their vehicles.

By the end of 2013, the partners in the project EVite[14] had installed 11 public DC fast-charging stations that complied with the CHAdeMO-standard; the goal is 150 stations by 2020. This project — which involves companies in the energy and public sector, the car and telecommunication industries, and mobility associations — intends to reduce EV range limits and charging times and promote market development of electric mobility in Switzerland.

Green Motion[15] from Lausanne installs its charging stations across Europe; in Switzerland, there are 150 installations serving more than 50 institutional customers. In 2013, Green Motion prepared its charging range with a new system that enables interconnected car park charging infrastructures to grow flexibly and economically, in line with their use. This new product was launched at the booth of the Swiss Association e'mobile[16] at the 84th International Geneva Motor Show in 2014 (Figure 29.4).

11 http://www.abb.ch/cawp/seitp202/a0ce3b4279fff081c1257bf800248cc9.aspx
12 http://www.teslamotors.com/de_CH/supercharger
13 http://www.groupe-e.ch/de/move
14 http://www.swiss-emobility.ch/home/evite.html
15 http://www.greenmotion.ch/Home.aspx
16 http://e-mobile.ch/index.php?pid=en,1,51

Fig. 29.4 Greenmotion charging stations at the e'mobile stand at the Geneva Motor Show, 2014.

Public charging stations in Switzerland (Table 29.2) are normally equipped with one to several outlets, depending on brands and models. A typical AC charging station has two to four outlets for as many EVs. A typical DC fast-charging station has one or two outlets.

Table 29.2 Number of public EVSE charging stations installed as of December 31, 2013.

Type	Number
Level 2/standard AC	About 320 locations, each with 1 or 2 charging EVSE stations
DC fast charging	26 charging points, each with 1 or 2 charging EVSE stations complying with the CHAdeMO-Standard; 1 Tesla Supercharger
Fuel cell filling stations	No public but a few industrial filling stations

29.4 EV Demonstration Projects

Table 29.3 briefly describes the projects in Switzerland and shows where to find more information.

Table 29.3 Demonstration projects in Switzerland, 2013.

Name	Location	Duration	No. or Description of PHEVs	URL
TOSA	Geneva	2013–2014	1 electric bus	www.tosa2013.com
KORELATION	Switzerland	2013–2014	200 plug-in vehicles	www.e-mobile.ch
Commercial use of e-bikes, e-scooters, and small EVs	Three Swiss agglomerations	2013–2015	Commercial use by at least 15 companies	www.newride.ch
e-scooters Geneva	Geneva	2013–2016	Support of e-scooters	www.m-way.ch
Caki-bikes	Berne	2013–2015	Provision of Cargo e-bikes for families	www.caki-bike.ch
Evaluation of Swiss2Grid	Ticino	2012–2014	30 EVs	www.riparti.ch
MOVE	Fribourg, Neuchâtel	2011–2014	Support of charging infrastructure	www.groupe-e.ch
vRbikes	Switzerland	2012–2016	Support of e-scooters	www.vRbikes.ch

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Turkey

30.1 Major Developments in 2013

The Turkish hybrid and electric vehicle (H&EV) market is in its initial stages of development. Alternative vehicle options and environmental and clean vehicle awareness are becoming more and more common within Turkish industries, research and development organizations, and society as a whole. Turkish policies and legislation are encouraging entrance of H&EVs in the market, as well as reduction in greenhouse gas emissions.

During 2013, the government launched 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 have started research for these project topics: electric motors and battery technologies in all-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, with an approximate budget of €5–€6 million ($6.5−$7.5 million US).

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

In addition, a project entitled “Developing Electric Vehicle Technologies,” a national support program with an estimated budget of $84−91 million US, which was announced in 2012, has reached its second phase with six project consortiums that consist of industries, research centers, and universities. Project duration is expected to be 4 years, and project goals are as follows:

- EV conceptual design, detailed design, and design verification;
- Development of battery cell, module, pack, and management system;
- Development of electric machine, driver, converters, and high voltage components; and
- Development of vehicle control systems, including energy management, vehicle dynamics control, vehicle safety, and thermal management.

In parallel with the support programs described above, implementation programs and new legislation are under way:

- 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 nation’s 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.

Moreover, individual efforts were also made by private companies to develop electric vehicles and associated components domestically. In February 2013, Derindere Motor Vehicles (DMA) launched its pure electric vehicle, DMA All-Electric, the first vehicle with a type approval certificate for electric vehicles in Turkey, and made the first test drives (Figure 30.1). The vehicle will be able to be charged in 8 hours on a 220-V outlet, will be compatible with European Standard type 2 charging stations, and will travel approximately 280 km on one charge. Purchase ($53,500 US) and rental ($1,200 US per month) options will be available for operational fleets. The company’s target is to produce 100 vehicles per month. The motor and the battery for the vehicles are currently being imported; however, the electric control unit is developed in Turkey. The vehicle has a 40-kWh lithium battery and 62-kW electric motor (with 225–325-N•m [newton meter] torque) and will have a 3-year, 100,000-km warranty.

Fig. 30.1 DMA all-electric vehicle. (Image courtesy of Derindere Motor Vehicles)

In addition, after a year of research, in July 2013, Malkoçlar Automotive developed a pure electric vehicle with all the R&D and manufacturing done in Turkey (with the exception of the electric motor). This vehicle can travel 100 km with an energy cost of under a dollar (Figure 30.2). The vehicle has two versions, a two-seater and a four-seater, and is mainly designed for inner city traveling and commercial use. It is mostly made out of plastic and has an aluminum construction space frame for collision safety. It weighs approximately 800 kg and can travel up to 130 km/h with a maximum range of 150 km. Charging from a regular outlet will take approximately 6–7 hours, with a fast-charging option of 45 minutes. The vehicle is currently under testing and waiting for a type approval certificate. The plan is for it to be sold for $13,500 US in 2014 after the all tests are successfully completed.

Fig. 30.2 Malkoçlar Automotive's pure electric vehicle.
(Image courtesy of Malkoçlar Automotive)

At the moment, Turkey has two types of taxation measures for vehicles. The first is a tax on an initial new vehicle purchase. The second is an annual vehicle tax, which is paid yearly and is currently based on the engine cylinder volume and the age of the vehicle.

The special consumption tax (SCT) for conventional vehicles was increased on the first day of 2014. Depending on the engine volume, the tax increased from 40% to 45% for under 1,600 cc, from 80% to 90% for between 1,600 cc and 2,000 cc, and from 130% to 145% for over 2,000 cc. With the new regulations, the current prices of conventional vehicles are expected to increase approximately by 10%. Since the SCTs on EVs have not changed, EVs now have a greater economic advantage compared to conventional vehicles when a new vehicle is purchased. 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 reduction in SCT; light-duty trucks, trucks, and buses maintain the same levels of taxation. Table 30.1 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 cc.

Table 30.1 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	45	<85	3
	1,600–2,000	90	85–120	7
	>2,000	145	>120	15
Motorbike	<250	8	<20	3
	>250	37	>20	37

30.2 HEVs, PHEVs, and EVs on the Road

30.2.1 Fleet

The number of vehicles on the road in Turkey is increasing. Although the total fleet of vehicles on the road is over 17 million (Table 30.2), there are only a few EVs and HEVs among them. The official EV/HEV fleet statistics are not available, but new EV sales are being collected by the Automotive Distributors Association (ODD).

Table 30.2 Total vehicle fleet according to the vehicle type.

Vehicle Type	2010	2011	2012	2013
Passenger car	7,544,871	8,113,111	8,648,875	9,283,923
Minibus	386,973	389,435	396,119	421,848
Bus	208,510	219,906	235,949	219,885
Light commercial vehicle	2,399,038	2,611,104	2,794,606	2,933,050
Truck	726,359	728,458	751,650	755,950
Motorcycle	2,389,488	2,527,190	2,657,722	2,722,826
Special purpose vehicle	35,492	34,116	33,071	36,148
Tractor	1,404,872	1,466,208	1,515,421	1,565,817
Total	**15,095,603**	**16,089,528**	**17,033,413**	**17,939,447**

Source: TURKSTAT Road Motor Vehicle Statistics

30.2.2 Sales

Compared to those in 2012, passenger car sales in 2013 increased by 19.48%, with total units of 664,655 (Table 30.3). The light-commercial market, on the other hand, shrank by 14.79%. Thus, the combined total passenger car and light-commercial market had a 9.72% increase, from 777,761 units in 2012 to 853,378 units in 2013.

When the passenger car market is examined according to engine volume in 2013, the passenger cars below 1,600 cc had the highest share of sales with 94.13% and 625,621 units because of the lower tax rates (Table 30.3). In 2013, there were 31 EV passenger cars sold in Turkey compared to 184 the year before.

Table 30.3 Passenger car market according to the engine/electric motor size in 2013.

Engine Size	Engine Type	2012 Cumulative		2013 Cumulative		2013/ 2012	SCT Tax Rates	VAT Tax Rates
		Units	%	Units	%	%	(%)	(%)
≤1,600 cc	Gas/diesel	514,861	92.60	625,621	94.13	21.51	40	18
1,601 cc to ≤2,000 cc	Gas/diesel	35,850	6.40	33,035	4.97	-7.85	80	18
≥2,001 cc	Gas/diesel	5,385	1.00	5,968	0.90	10.83	130	18
≤85 kW	Electric	184	0.00	31	0.00	-83.15	3	18
86 kW to ≤120 kW	Electric	0	0.00	0	0.00	0	7	18
≥121 kW	Electric	0	0.00	0	0.00	0	15	18
Total		**556,280**	**100.00**	**664,655**	**100.00**	**19.48**		

Source: ODD

When the passenger car market is examined according to average emission values in 2013, the passenger cars that fell below 140 gCO_2/km limits accounted for more than 75% of vehicle sales (Table 30.4). This is primarily a result of the lower tax values for engine volumes ≤1,600 cc, which also helps in reducing the total fleet emission averages of the vehicles in Turkey.

Table 30.4 Passenger car market according to average emission values in 2013.

Average Emission Values of CO_2 (g/km)	2012 Cumulative		2013 Cumulative		2013/ 2012
	Units	%	Units	%	%
<100 g/km	18,635	3.30	56,570	8.51	203.57
≥100 to <120 g/km	173,218	31.10	238,816	35.93	36.19
≥120 to <140 g/km	202,118	36.30	216,016	32.50	7.83
≥140 to <160 g/km	118,107	21.20	116,245	17.49	1.29
≥160 g/km	44,202	7.90	37,008	5.57	16.28
Total	**556,280**	**100.00**	**664,655**	**100.00**	**19.48**

Source: ODD

30.3 Charging Infrastructure for EVSE

Various ongoing efforts are under way in Turkey to install EVSE across Turkey. These efforts are mostly concentrated in Istanbul, since it is the country's most populous city. The installation projects are mainly 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 over 100. 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, plans are to increase the number of charging stations over the next years.

In January 2013, Sabancı University became the first university in Turkey to have a charging station. In June, the first domestically developed charging station producer, Gersan Electric Incorporated Company, started building charging stations in pilot areas of Istanbul, with a target of 60–65 units. In September, legal ground was established in fuel station areas to build electric charging, compressed natural gas, liquefied petroleum gas, and hydrogen filling stations. In November, Izmir Metropolitan Municipality installed charging stations at a number of parking stations, where electric vehicle owners can charge their vehicles for free in order to increase the number of electric vehicles in the city. A map showing some of the charging stations throughout Turkey is shown in Figure 30.3.

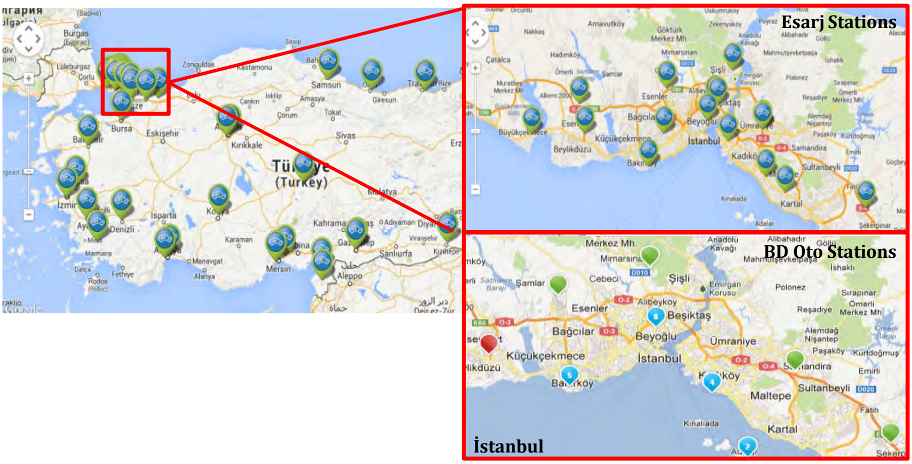

Fig. 30.3 Map of charging stations throughout Turkey. (Courtesy of Esarj Electric Vehicle System Incorporated Company)

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31 United Kingdom

31.1 Major Developments in 2013

The UK Coalition Government has committed £1.4 billion (€1.75 billion/ $2.3 billion US) through 2020 to support the development, manufacturer, purchase, and use of ultra-low emission vehicles (ULEVs). This includes funding for consumer incentives of up to £5,000 (€5,800/$7,600 US) for eligible cars and up to £8,000 (€9,250/$12,100 US) for eligible vans; funding to kick-start the installation of recharging points; and £580 million (€720 million/$970 million US) for research and development (R&D) and procurement programs. Work is also under way to encourage UK businesses to take advantage of economic opportunities created by the transition to ULEV, to develop world class skills and facilities for the development of ULEV technologies, and to strengthen ULEV manufacturing capability 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 policy unit composed of staffing and funding from three departments: the Departments for Transport, Business Innovation and Skills (BIS), and Energy and Climate Change. OLEV is also responsible for the European Union (EU) regulations that set performance targets on carbon dioxide (CO_2) emissions from road vehicles (car and van regulations are set to deliver the largest reductions in CO_2 emissions from road transport to 2020) and that provide for the alternative fuel infrastructure (Figure 31.1).

On September 4, 2013, the UK Government's strategy to drive forward the ULEV industry in the UK was launched, signaling a major change in the way vehicles will be powered in the future and reaffirming the commitment to provide new opportunities for industry that will grow the UK economy. The strategy can be viewed at www.gov.uk/olev and sets out UK Government's five main aims:

1. Supporting the early market for ULEVs,
2. Shaping the necessary infrastructure,
3. Securing the right regulatory and fiscal measures,
4. Investing in UK automotive capability, and
5. Preparing the energy sector.

A Call for Evidence was launched inviting industry to have its say on how best to invest a further £500 million (€623 million/$834 million US) to drive the revolution and establish the UK as a premier market for ULEVs.

Fig. 31.1 The BMW i3:[1] 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)

31.1.1 Progress

31.1.1.1 Consumer Incentives

As of December 31, 2013, there were 6,709 claims made through the Plug-in Car Grant[2] scheme and 404 claims made through the Plug-in Van Grant[3] 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 1.4% of the market share in 2012.

These figures demonstrate a positive effect from the consumer incentives in the ULEV market, although uptake has been slower than manufacturers' forecasts had anticipated. It is expected that sales volumes will rapidly increase through 2014 as a greater range of more affordable ULEV models enter the market. Manufacturers

[1] http://www.bmw-i-usa.com/en_us/bmw-i3/
[2] https://www.gov.uk/government/publications/plug-in-car-grant
[3] https://www.gov.uk/government/publications/plug-in-van-grant

plan to offer around 30 car models that may be eligible for the Plug-in Car Grant by the end of 2014.

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 leases the battery in its vehicles, which will reduces its initial purchase price and alleviate any lingering customer concerns about the technology.

31.1.1.2 Other Fiscal Incentives

Table 31.1 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/$46,978 US) compared to the best-selling equivalent in its segment, the Ford Focus Zetec 1.6 L (£18,637/€21,663/$28,363 US). The table also identifies potential savings for an electric compared to a diesel Ford Connect van.

Table 31.1 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 with a cost of 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: Value-added tax (VAT)-registered businesses can write down the whole purchase price of an EV against tax in the first year; this is confirmed until 2018.	**Additional benefit** of about **£4,000** for a firm purchasing a Leaf instead of a Focus (at 2011–2012 rates)	**Additional benefit** of about **£5,000** 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.	**Savings of about £600 per year** for an employer when an employee (40% income tax bracket) opts for a Leaf instead of a Focus	Not applicable to Ford Connect van

Table 31.1 (Cont.)

Incentives and Measures	Nissan Leaf vs. Ford Focus Zetec	Electric vs. Diesel Ford Connect Van
Incentives That Are Also Available to Business Buyers (Cont.)		
Employee company car tax and fuel benefit charge: Will remain zero rated for employees receiving a zero emission company car until 2015; thereafter until 2018, there will be a differential of four percentage points between the 0–50 and the 51–75 g/km CO_2 bands and between the 51–75 and 76–94 g/km CO_2 bands.	**Savings of about £2,500 per year** for employees (in 40% income tax bracket) who opt for a Leaf instead of a Focus	Not applicable to Ford Connect van
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 and tapered to 2020.	Not applicable to Nissan Leaf or Ford Focus Zetec	**Savings of £3,000** of 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.	**Savings of £2,000** for a vehicle entering a CCZ zone for 200 days in a year	**Savings of £2,000** for a vehicle entering a CCZ zone for 200 days in a year

31.1.1.3 R&D

The UK Government is providing £580 million (€720 million/$970 million US) to support low-carbon R&D. 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 do 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: This is fundamental to electric and hybrid technology performance and efficiency.
5. Development and application of intelligent transport systems to existing and new technologies: To improve travel efficiency and travel choices.

The Advanced Propulsion Centre UK (APC UK) was formed as the result of an analysis by the UK's Automotive Council. It is the centerpiece of the joint industry and government strategy for the automotive sector. This is an industry-led opportunity for the UK to become a world leader in advanced propulsion techniques. The APC UK will channel £1 billion into the UK automotive industry over the next decade. This investment is intended to put the UK ahead in the global race for the development of new low-carbon technologies.

A new low-carbon vehicle innovation platform competition to "build an automotive supply chain for the future" has supported more grant-funded collaborative R&D. The competitions are supported by OLEV working in partnership with the UK's innovation agency, the Technology Strategy Board. The latest projects are valued at around £10 million (€12 million/$16 million US) in public funds and have taken the value of support from Government to £82 million (€102 million/$137 million US) since 2010. The total value is likely to approach £240 million (€300 million/ $400 million US) once matched funds and other leveraged support are taken into account.

31.2 HEVs, PHEVs, and EVs on the Road

As of end of 2013, there were 17,469 ULEVs on the road in the UK, as shown in Table 31.2 (in this context, ULEV is a term used to encompass HEVs, PHEVs, and EVs – refer to Section 31.1 for the more conventional definition of ULEVs).

Table 31.2 ULEV fleet numbers and sales.

Vehicle Type	Total Vehicle Fleet Including ULEVs	ULEVs
Motorbike	1,218,400	1,063
Passenger vehicle	29,140,900	8,346
Bus	164,500	123
Truck	468,900	590
Light goods	3,353,900	3,663
Others	686,900	3,605
Total	35,034,500	17,469

Note: ULEVs refer to electric, plug-in hybrid, and hydrogen fuel cell vehicles. Vehicles with fully electric powertrains and cars with tailpipe emissions below 75 g/km of CO_2 are included.

31.3 Charging Infrastructure for EVSE

The Plugged-in Places (PIP) program has significantly increased the number of recharging points in areas across the UK. More than 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 (Figure 31.2). Data provided by charge point manufacturers indicate that other organizations also may have installed about 10,000 charging points nationwide. The UK is already home to Europe's largest network of rapid (43–50 kW) points, with 500 due to be installed by March 2015.

Fig. 31.2 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/$56 million US) package of measures that further support the installation and use of the recharging infrastructure. The nationwide package includes these opportunities:

- Up to £13.5 million (€15.6 million/$20.5 million US) is available for a 75% grant for UK homeowners for the cost of a charge point and its installation.
- £11 million (€12.7 million/$16.7 million US) 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/$13.6 million US) is available to fund the cost of charge points and their installation at railway stations.

- Up to £3 million (€3.5 million/$4.5 million US) 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 per kilometer 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/$425,000 US) 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.

31.4 EV Demonstration Projects

31.4.1 UKH2Mobility Program

UKH2Mobility brings together leading businesses from the automotive, energy, infrastructure, and retail sectors with government 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.

31.4.2 Green Bus Fund

The £95 million (€110 million/$144 million US) 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.

31.4.3 Low-Carbon Truck Trial

The UK Department for Transport recognizes that the options currently available for low-carbon heavy goods vehicles (HGVs) are different from those for low-carbon cars and vans. Up to £9.5 million (€11 million/$14.4 million US) has been designated to support the purchase of low-carbon trucks that offer carbon savings of at least 15% compared with standard equivalent vehicles. In the trial, there are 300 trucks now on the road using supporting infrastructure, such as gas refueling hubs.

The trials are taking place over two years, with data being collected for analysis to demonstrate the wider benefits of low-carbon trucks (e.g., potential fuel cost savings). 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.

31.4.4 LCV 2013 Event

Cenex hosted its sixth annual low-carbon vehicle (LCV) event on September 4 and 5, 2013, at Millbrook Proving Ground in Bedfordshire, welcoming almost 1,700 individual attendees and 765 organizational attendees to the UK's premier low-carbon technology and vehicle showcase.

32 United States

32.1 Major Developments in 2013

In December 2013, the U.S. Environmental Protection Agency (EPA) reported that model year 2012 U.S. vehicles had achieved an average fuel economy of 23.6 miles per gallon (mpg), reaching an all-time high and representing a 12% increase[1] from the 2008 average (and a 22% increase from the 2004 average). Also, this increase is likely to continue because of U.S. National Clean Car Program standards, which require a doubling of the fuel economy standards by 2025.

Currently, there are 16 plug-in electric vehicle (PEV) models available in the United States from 11 manufacturers (BMW, Fiat, Ford, GM, Honda, Mercedes, Mitsubishi, Nissan, Smart, Tesla, and Toyota). The three highest-selling 2013 PEV models included the Chevrolet Volt, Nissan Leaf, and Tesla Model S – annual sales were 23,094, 22,610,[2] and 22,450,[3] respectively.

Commercial U.S. production of the Nissan Leaf started in January 2013 at the Nissan factory in Smyrna, Tennessee, adjacent to its $1 billion US battery plant (operational since September 2012). Nissan estimates[4] it has an annual manufacturing capacity of 150,000 vehicles.

The Tesla Model S received the World Green Car of the Year award, as well as the Car of the Year award by *Motor Trend* and *Automobile* magazines.

The 2014 Honda Accord PEV model won the 2014 Green Car of the Year Award at the Los Angeles Auto Show.

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1 http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/c1dc6b1675fe8d2285257c3f005cb58f!OpenDocument

2 http://green.autoblog.com/2014/01/03/nissan-leaf-ends-2013-best-sales-month-ever-chevy-volt/

3 http://www.bloomberg.com/news/2014-01-14/tesla-delivered-6-900-cars-in-fourth-quarter-executive-says.html

4 http://www.tennessean.com/article/20131219/BUSINESS03/312190038/Smyrna-made-Nissan-Leaf-sales-soar

BMW released its i3 electric vehicle (EV) in the U.S. market – which was later named Kelly Blue Book's Best Green Car of 2014[5] and rated #6 in its list of vehicles with the lowest total cost of ownership (over the five-year period following purchase) (Figure 32.1). Its lightweight structure (which uses a full carbon fiber body) enables over 4.7 miles per kWh and an average range of 80–100 miles. BMW also offers a gasoline engine range extender to augment it by an additional 60–80 miles.

Fig. 32.1 BMW i3 electric vehicle. (Image courtesy of BMW)

32.2 HEVs, PHEVs, and EVs on the Road

In 2013, U.S. EV sales, including hybrid electric vehicles (HEVs), PEVs, and battery-electric vehicles (BEVs), reached a high of 662,821 units. This represents a 20% increase over 2012 (with Toyota's Prius in the lead), and it includes 96,602 PEVs, which amounts to an 81% increase over 2012[6] for those vehicles. In spring of 2013, the total number of PEVs on U.S. roads crossed the 100,000 mark.[7] Fleet totals as of December 2013 are listed in Table 32.1a, and total sales of all vehicles are provided in Table 32.1b. The prices for PEVs sold in the United States are listed in Table 32.2.

5 http://insideevs.com/bmw-i3-named-kelley-blue-books-best-green-car-2014/
6 http://www.hybridcars.com/december-2013-dashboard/
7 http://www.pluginamerica.org/drivers-seat/100000-happy-drivers-no-end-sight

Table 32.1a EV, PHEV, and EV fleet totals as of December 2013.

Fleet Totals as of December 31, 2013					
Vehicle Type	**EV Fleet**	**HEV Fleet**	**PHEV Fleet**	**FCV Fleet**	**Total Fleet**
Passenger vehicles	129,750[a]	3,087,892[b]	95,625[a]	421[a]	242,060,551[c]
Buses	n/a	n/a	n/a	n/a	n/a
Trucks	n/a	n/a	n/a	n/a	n/a

n/a = not available

[a] EV, PHEV, and FCV fleet totals are taken from the U.S. Department of Energy (DOE) Alternative Fuels Data Center (AFDC) "AFVs [alternative fuel vehicles] in Use" (http://www.afdc.energy.gov/data/#tab/all/data_set/10300) (through 2010). Additional EV and PHEV numbers were taken from Hybrid Market Dashboard (http://www.hybridcars.com/market-dashboard/) (2011–2013).

[b] HEV fleet total is compiled from DOE AFDC's "U.S. HEV Sales by Model" (http://www.afdc.energy.gov/data/#tab/fuels-infrastructure/data_set/10301) (1999–2011) and Hybrid Market Dashboard (http://www.hybridcars.com/december-2012-dashboard) (2012–2013).

[c] Data from Office of Highway Policy Information, Federal Highway Administration (FHWA) (http://www.google.com/publicdata/explore?ds=gb66jodhlsaab_#!ctype=l&strail=false&bcs=d&nselm=h&met_y=Vehicles&scale_y=lin&ind_y=false&rdim=state&ifdim=state&tdim=true&tstart=-2199384000000&tend=1271908800000&hl=en_US&dl=en_US&ind=false). Number represents most recently updated statistics from U.S. vehicle registrations through 2010.

Table 32.1b Total EV, HEV, PHEV, and FCV sales in 2013.

Fleet Sales during 2013					
Vehicle Type	**EV Sales**	**HEV Sales**	**PHEV Sales**	**FCV Sales**	**Total Sales**
Bicycles (no driver's license)[a]	89,000	n/a	n/a	n/a	89,000
Passenger vehicles[b]	47,559	495,685	49,043	n/a	15,531,609

n/a = not available

[a] Estimates are from Navigant Research (http://www.navigantresearch.com/newsroom/the-electric-bicycle-market-in-the-united-states-will-more-than-triple-by-2018-forecasts-pike-research).

[b] Sales figures for EVs, HEVs, PHEVs, and the total are from Hybrid Market Dashboard (http://www.hybridcars.com/december-2013-dashboard/).

Table 32.2 Current retail prices of Plug-in Electric Vehicles (PEVs) sold in the U.S. market.

PEV Models Available (passenger only)	Vehicle Price[a]	URL Link
Chevrolet Volt	$34,170 US	http://www.chevrolet.com/volt-electric-car.html
Chevrolet Spark	$26,685 US	http://www.chevrolet.com/spark-ev-electric-vehicle.html
Fiat 500e	$31,800 US	http://www.fiatusa.com/en/500e/
Ford C-Max Energi	$31,635 US	http://www.ford.com/cars/cmax/trim/energi/
Ford Fusion Energi SE	$34,700 US	http://www.ford.com/cars/fusion/trim/seenergi/
Ford Focus Electric	$35,170 US	http://www.ford.com/cars/focus/trim/electric/
Honda Fit EV (lease only)	$259 US/month	http://automobiles.honda.com/fit-ev/
Mitsubishi iMiEV	$22,995 US	http://www.mitsubishicars.com/imiev
Nissan Leaf	$28,980 US[b]	http://www.nissanusa.com/electric-cars/leaf/
Smart Electric Drive (ED)	$25,000 US	http://www.smartusa.com/Downloads/2013-smart-electric-drive-brochure.pdf
Tesla Model S	$71,070 US[c]	http://www.teslamotors.com/models/design
Toyota Prius Plug-In	$29,990 US	http://www.toyota.com/prius-plug-in-hybrid/
Toyota RAV4 EV	$49,800 US	http://www.toyota.com/rav4ev/

[a] Manufacturer's suggested retail price (MSRP) excludes $7,500 US Federal tax credit and destination, taxes, title, and registration fees.

[b] This is a net value after Federal tax savings.

[c] This amount is the cash price before $7,500 US Federal tax credit.

32.3 Charging Infrastructure for EVSE

Table 32.3a provides an overview of the number of public charging stations in the United States by type, including Levels 1 and 2, DC Fast Charging, and fuel cell vehicles (FCVs).

Table 32.3a Number of public charging stations in the United States by type.

Type of Charging Station[a]	Total
Level-1	1,788
Level-2 (Standard AC)	7,448
DC Fast Charging	426
Fuel Cell Vehicle Fueling Locations (California only)	10

[a] Data taken from AFDC EVSE Location Database ([http://www.afdc.energy.gov/fuels/electricity_locations.html] December 2013). Multiple outlets are available at most EVSE.

DOE's Idaho National Laboratory (INL) has been the test data collection partner for two recently completed projects to demonstrate EVSE deployment (which involves several automakers, as well as the EV charging network ChargePoint, formerly known as Coulomb Technologies). Table 32.3b provides statistical highlights of these demonstration projects for 2013.

The first project, entitled the EV Project[8] (run by the CarCharging Group[9]), which is a deployment and evaluation project, deployed over 12,000 Level-2 EVSE and over 100 DC fast chargers in 20 U.S. metropolitan areas. The CarCharging Group, an EVSE network provider, acquired rights to Ecotality's assets[10] after the latter's bankruptcy filing (September 2013), and it has gained prominence in the EVSE industry following the earlier acquisition of the charge provider 350Green. The project's data collection phase was completed (December 2013), and test data were posted on INL's Advanced Vehicle Testing Activity (AVTA) website.[11]

The second project, entitled ChargePoint America,[12] which is a partnership between ChargePoint and DOE, deployed 4,600 public and home ChargePoint-networked charging stations at locations throughout the United States. It was completed (June 2013);[13] again, reports were posted on INL's AVTA website.[11]

Table 32.3b EV Project and ChargePoint America demonstrations.

Name	Location	Duration	Total EVSE	Charging Events	Electricity Consumed (MWh)
The EV Project[a, 8]	Nationwide	Completed	12,356	4,173,933	34,151
ChargePoint America[b, 12]	Nationwide	Completed	4,253	1,516,665	10,999

[a] As of December 2013

[b] As of September 2013

8 http://avt.inel.gov/pdf/EVProj/EVProjectOverviewQ42013.pdf
9 http://www.carcharging.com/about/news/all/carcharging-completes-3-335-million-purchase-of-ecotalitys-blink-assets-and-the-blink-network
10 http://www.plugincars.com/carcharging-group-announces-acquisition-bankrupt-ecotality-blink-network-128539.html
11 http://avt.inl.gov/evproject.shtml
12 http://avt.inel.gov/pdf/evse/CoulombQtr3_2013.pdf
13 http://www.hybridcars.com/chargepoint-america-program-complete-over-4600-chargers-installed

32.3.1 EVSE Policy and Industry Update

DOE launched its *Workplace Charging Challenge* (WCC) as part of the *EV Everywhere Grand Challenge* (announced in 2012). WCC is expected to achieve a tenfold increase in the next five years in the number of U.S. employers offering workplace charging. There are currently 56 WCC partners[14] across the United States installing PEV charging infrastructure[15] for employee use.

32.4 EV Demonstration Projects

32.4.1 Deployment Projects

As mentioned above, INL was the test data collection partner (additional partners include Nissan and GM) for the EV Project,[16] which demonstrated the deployment/use of approximately 5,700 BEVs (including Nissan Leafs[17] and 2,600 Chevrolet Volts[18]) charged in private residence, fleet, and public locations. INL has also been separately funded to collect data via OnStar[19] for 150 Chevrolet Volts and to report testing results via fact sheets (see Table 32.4).

Table 32.4 EV Project and OnStar demonstrations.

Name	Location	Duration	Number of PHEVs[a]	Number of BEVs[a]
The EV Project[16]	Nationwide	Completed	2,023	5,789
INL Chevy Volt - OnStar[19]	Nationwide	Ongoing	150	n/a

n/a = not available

[a] As of December 2013

32.4.2 Technology Update

In March 2013, DOE announced over $50 million US in funding for new projects[20] to accelerate the development of PEV technologies as part of the *EV Everywhere Grand Challenge*. This funding covers 12 topics in the five major R&D areas of advanced light-weight and propulsion materials; battery development; power electronics; heating, ventilation, and air conditioning systems; and fuels and lubricants. DOE also issued an initial progress report entitled EV Everywhere Grand

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14 http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/partners.html
15 http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/workplace_charging.html
16 http://avt.inel.gov/pdf/EVProj/EVProjectOverviewQ42013.pdf
17 http://www.nissanusa.com/leaf-electric-car/?dcp=ppn.39666654.&dcc=0.216878497
18 http://www.chevrolet.com/pages/open/default/future/volt.do?seo=goo_%7C_2009_Chevy_Awareness_%7C_IMG_Chevy_Volt_Phase_2_Branded_%7C_GM_Volt_%7C_gm_volt
19 http://avt.inel.gov/pdf/EREV/GMMay11-Dec13.pdf
20 https://eere-exchange.energy.gov/Default.aspx?Search=Vehicles&SearchType=#FoaIdce3230af-f911-45d8-93b5-814150d1b7fd

Challenge Road to Success,[21] highlighting the significant cost reduction in batteries and the recent efforts related to WCC.

Battery development contractors for the United States Advanced Battery Consortium (USABC) recently achieved significant reductions in battery cost by using advanced cathode materials, making processing improvements, developing lower-cost cell designs, and using pack optimization techniques. The modeled cost of PHEV batteries has thus come down from over $625 US/kWh (of usable energy) in 2010 to $325 US/kWh currently (i.e., by about 50% over the last four years). Additional information on DOE-funded energy storage projects is available in its Energy Storage R&D Annual Progress Report.[22]

Also in 2013, Delphi Automotive Systems and DOE worked on a high-temperature inverter R&D project to achieve DOE's 2015 cost target of $5 US/kW (while exceeding its component-level targets for specific power and power density) (Figure 32.2). Delphi is incorporating the resulting technologies (e.g., low-loss semiconductors and packaging, thermal materials, and inverter design concepts) into production by mid-2015. DOE is also partnering with the Arkansas Power Electronics International to research the feasibility of wide bandgap inverters for EV traction drives. The project explores two parallel design paths:[23] one based on silicon carbide and the other based on gallium nitride. Additional information on DOE-funded advanced power electronics R&D projects is available in its Advanced Power Electronics and Electric Machines R&D Annual Progress Report.[24]

[21] http://www.energy.gov/eere/vehicles/downloads/ev-everywhere-grand-challenge-road-success
[22] http://www.energy.gov/eere/vehicles/fy-2012-progress-report-energy-storage-rd
[23] http://www.apei.net/about/news/news.aspx?Id=44
[24] http://www.energy.gov/eere/vehicles/downloads/vehicle-technologies-office-2013-advanced-power-electronics-and-electric

Fig. 32.2 Delphi prototype production inverter incorporating DOE inverter innovations.

DOE-funded researchers made significant progress in developing new materials for vehicle structure, focusing on joining magnesium-intensive substructures to incorporate and interface with steel and aluminum and demonstrating aluminum-magnesium joints. Additional information on DOE-funded light-weighting projects is available in its Lightweighting Materials R&D Annual Progress Report.[25]

The emerging PEV wireless power transfer (WPT) charging technology involves transferring power from the electric grid to a PEV battery without wires, cords, or plugs. By 2013, WPT project partners demonstrated power transfer rates of 10 kW, well exceeding that of most commercially available PEVs (usually 3.3–6.6 kW). Additional information on DOE-funded vehicle and systems simulation and testing (VSST) R&D projects is available in its VSST R&D Annual Progress Report.[26]

25 http://www.energy.gov/eere/vehicles/downloads/vehicle-technologies-office-2013-lightweight-materials-rd-annual-progress

26 http://www.energy.gov/eere/vehicles/downloads/vehicle-technologies-office-2012-vehicle-and-systems-simulation-and-testing

IA-HEV Contact Information

IA-HEV Contact Information

The website of the IEA Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) can be found at www.ieahev.org.

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Vehicle Categories

In the "On the road" sections of the country chapters, 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's license)	Two-wheeled motorized (internal combustion engine or electric motor) vehicle with an appearance similar to that of a conventional bicycle or moped.
Motorbike	Vehicle designated to travel with not more than three wheels contacting the ground.
Passenger vehicle	Vehicle with a designated seating capacity of 10 or less, except for a 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 of more 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.
Electric vehicle	An electric vehicle (EV) is defined as any autonomous road vehicle exclusively with an electric powertrain drive and without any on-board electric generation capability. The term battery electric vehicle (BEV) is considered to be a synonymous term.
Hybrid vehicle	A hybrid vehicle is one with at least two different energy converters and two different energy storage systems (on vehicle) for the purpose of vehicle propulsion. A hybrid electric vehicle (HEV), as defined by the 1990s IA-HEV Annex I, is a hybrid vehicle in which at least one of the energy stores, sources, or converters delivers electric energy. Other definitions of HEVs also exist but involve the same idea of different energy systems. Normally, the energy converters in an HEV are a battery pack, an electric machine or machines, and an internal combustion engine (ICE), although fuel cells may be used instead of an ICE. There are both parallel and series configuration HEVs.

Vehicle	Description
Plug-in hybrid electric vehicle	A plug-in hybrid electric vehicle (PHEV) is an HEV with a battery pack that has a relatively large amount of kilowatt-hours of storage capability. The battery is charged by plugging a vehicle cable into the electricity grid; thus, more than two fuels can be used to provide the energy propulsion.
Plug-in electric vehicle	A plug-in electric vehicle (PEV) is a vehicle that draws electricity from a battery and is capable of being charged from an external source. In this way, the PEV category includes both EVs and PHEVs.
Fuel cell (electric) vehicle	A fuel cell (electric) vehicle (FCV or FCEV) is 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, although an ESS is not technically necessary in an FCV.

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 liters per 100 kilometers 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 "Selected Conversion Factors" 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	Conversion
Energy	joule	J	1 J = 1 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 = 105 N/m^2
Time	hour	h	1 hour = 3,600 s
Volume	liter	L	1 liter = 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 in. = 0.0254 m	1 m = 39.3701 in.
Length	foot	ft	1 ft = 0.3048 m	1 m = 3.2808 ft
Length	mile	mi	1 mi = 1.60934 km	1 km = 0.62137 mi
Volume	barrel (petroleum)	bbl	1 bbl = 159 L	1 L = 0.0063 bbl
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 = 1,055.06 J	1 J = 0.0009478 Btu
Energy	kilowatt-hour	kWh	1 kWh = 3.6×10^{6} J	1 J = 277.8×10^{-6} kWh
Power	horsepower	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 N•m	1 N•m = 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)

Abbreviations

A	Ampere
AC	Alternating Current
ADEME	Agency for Environment and Energy Management (France)
AEV	All-Electric Vehicle
AFDC	Alternative Fuels Data Center (DOE)
AFV	Alternative Fuel Vehicle
ANR	Agence Nationale de la Recherche (France)
APC UK	Advanced Propulsion Centre United Kingdom
APN	Access Point Name
APU	Auxiliary Power Unit
AVEM	Avenir du Véhicule Electro-Mobile (France)
AVTA	Advanced Vehicle Testing Activity
AWD	All-Wheel Drive
A3PS	Austrian Agency for Alternative Propulsion Systems
BC	British Columbia
BDEW	German Association of Energy and Water Industries
BEV	Battery Electric Vehicle
BEVx	BEV with Auxiliary Power Unit
BFH	Bern University of Applied Sciences (Berner Fachhochschule)
BIS	Department for Business Innovation & Skills (United Kingdom)
BMLFUW	Federal Ministry of Agriculture (Austria)
BMVIT	Federal Ministry for Transport, Innovation, and Technology (Austria)
BMWFJ	Federal Ministry of Economy (Austria)
BOMA	Building Owners and Managers Association (British Columbia)
BSS	Battery-Swapping Station
CARB	California Air Resources Board
cc	Cubic Centimeter
CCS	Combined Charging Standard
CCZ	Congestion Charge Zone
CEA	Canadian Electricity Association
CEI-CIVES	Italian EV Association

CEIIA	Centre for Excellence and Innovation in the Auto Industry (Portugal)
CENELEC	European Committee for Electrotechnical Standardization
CERT	Committee on Energy Research and Technology (IEA)
CHF	Swiss Franc (currency)
CIRCE	Research Centre for Energy Resources and Consumption (Spain)
CNG	Compressed Natural Gas
CNR	National Research Council (Italy)
CO_2	Carbon Dioxide
CRD	Capital Region of Denmark
CRM	Customer Relationship Management
DC	Direct Current
DCFC	Direct Current Fast Charging
DEA	Danish Energy Agency (Denmark)
DLR	German Aerospace Center
DKK	Danish Crown (currency)
DMA	Derindere Motor Vehicles (Turkey)
DOE	U.S. Department of Energy
DOET	Dutch Organisation for Electric Transport
DPD	Dynamic Parcel Distribution
DSO	Distribution System Operator
ECV	Electric Commercial Vehicle
ED	Electric Drive
EET	European Ele-Drive Transportation Conference
eMI^3	eMobility ICT Interoperability Innovation Group (Belgium)
ENEA	Italian National Agency for New Technologies, Energy and Sustainable Economic Development
EnEL	Ente Nazionale per l'energia ELettrica
EPA	U.S. Environmental Protection Agency
EREV	Extended-Range Electric Vehicle
ERS	Electric Road System
ERTICO	European Road Transport Telematics Implementation Coordination
ESB	Electricity Supply Board (Ireland)
ETBE	Ethyl Tert-Butyl Ether
EU	European Union
EUL	EcoUrban Living (Finland)
EUR	Euro (currency; the standard “€” abbreviation is used in this report)

EUWP	Working Party on Energy End-Use Technologies (IEA) (this group was previously called the End-Use Working Party)
EV	Electric Vehicle
EVCIS	Electric Vehicle Charging Infra System (Korea)
EVE	Electric Vehicle Systems Program (Finland)
EVS	Electric Vehicle Symposium
EVSE	Electric Vehicle Supply Equipment
EVSP	Electric Vehicle Service Provider
EVX	(Global) Electric Vehicle Insight Exchange
ExCo	Executive Committee (IA-HEV)
FCV	Fuel Cell Vehicle (also called a Fuel Cell Electric Vehicle [FCEV])
FEUP	Faculdade de Engenharia da Universidade do Porto (Energy Faculty of the University of Porto) (Portugal)
FFV	Flex(ible) Fuel Vehicle
FHWA	Federal Highway Administration
g	Gram
GAMEP	Office for Electric Mobility (Portugal)
GEM	Global Electric Motorcars
GHG	Greenhouse Gas
GIS	Geographic Information System
GM	General Motors
h	Hour
HEV	Hybrid Electric Vehicle
HGV	Heavy Goods Vehicle
hp	Horsepower
HSL	Helsinki Region Transport
HSY	Helsinki Region Environmental Services Authority
HVO	Hydrotreated Vegetable Oil
H&EVs	Hybrid and Electric Vehicles
IA	Implementing Agreement (IEA)
IA-AMF	Implementing Agreement on Advanced Motor Fuels
IA-HEV	Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes
ICE	Internal Combustion Engine
ICS	Inductive Charging System
ICT	Information and Communication Technology
IDAE	Institute for the Diversification and Saving of Energy (Spain)

IEA	International Energy Agency
IEC	International Electrotechnical Commission
IMA	Innovative Mobility Automobile GmbH (Germany)
Inc.	Incorporated
INESC	Instituto de Engenharia de Sistemas e Computadores do Porto (Institute for Systems and Computer Engineering of Porto) (Portugal)
INL	Idaho National Laboratory (DOE)
INTELI	Inteligência em Inovação (Portugal)
ISO	International Organization for Standardization
IT	Information Technology
ITS	Intelligent Transportation System
KAMA	Korea Automobile Manufacturers Association
KETEP	Korea Institute of Energy Technology Evaluation and Planning
kg	Kilogram
km	Kilometer
KORELATION	Cost – Range – Charging Stations (Kosten – Reichweite – Ladestationen) (e'mobile project)
KRW	South Korean Won (currency)
kton	Kiloton
kW	Kilowatt
kWh	Kilowatt-Hour
L	Liter (also spelled Litre)
LCA	Life-Cycle Assessment
LCV	Low-Carbon Vehicle
LDV	Light-Duty Vehicle
LEV	Light Electric Vehicle
Li	Lithium
LPG	Liquefied Petroleum Gas
MERGE	Mobile Energy Resources in Grids of Electricity (Europe)
METI	Ministry of Economy, Trade and Industry (Japan)
MIA	Environmental Investment Allowance (The Netherlands)
min	Minute
MIT	Massachusetts Institute of Technology
MOBI.E	Mobilidade Eléctrica (Portugal)
MOU	Memorandum of Understanding
mpg	Miles per Gallon
mph	Miles per Hour
MPV	Multipurpose Vehicle

MRC	Marmara Research Center (TÜBITAK, Turkey)
MSEK	Million Swedish Krona (currency)
MSRP	Manufacturer's Suggested Retail Price
MVEG	Motor Vehicle Emissions Group (Europe)
MW	Megawatt
MWh	Megawatt-Hour
n/a	Not Available. In the data tables, this abbreviation can mean either no reported data or the technology is not commercially available at present.
NEDC	New European Driving Cycle
NGV	Natural Gas Vehicle
N•m	Newton Meter
NPE	National Platform for Electromobility (Germany)
NRCan	Natural Resources Canada
NREL	National Renewable Energy Laboratory (DOE)
OA	Operating Agent
OCPP	Open Charge Point Protocol
ODD	Turkish Automotive Distributors Association (Turkey)
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OERD	Office of Energy Research and Development (NRCan)
OLEV	Office for Low Emission Vehicles (United Kingdom)
OPEC	Organization of the Petroleum Exporting Countries
PCM	Phase-Charge Material
PFA	Automobile Sector Platform (France)
PHEV	Plug-in Hybrid Electric Vehicle
PHV	Plug-in Hybrid Vehicle
PIAM	Plan de Incentivos Autotaxi Madrid (Spain)
PIMA Aire	Plan de Impulso al Medio Ambiente (Spain)
PIP	Plugged-in Places (United Kingdom)
psi	Pound-Force per Square Inch
PV	Photovoltaic
QC	Quick Charging
RAI	Royalty Amsterdam International (The Netherlands)
RD	Royal Decree (Spain)
R&D	Research and Development

RD&D	Research, Development, and Deployment (also called Research, Development, and Demonstration)
RDW	Dutch Vehicle Authority
REV	Range Extender Vehicle
RFID	Radio Frequency Identification
RTC	Rotterdamse Taxi Centrale (The Netherlands)
RWE	Name of a German Electric Utility Company (originally Rheinisch-Westfälisches Elektrizitätswerk)
RWS	Rijkswaterstaat (The Netherlands)
SAE	Society of Automotive Engineers
SALK	Belgian Regional Strategic Action Plan (Belgium)
SCT	Special Consumption Tax (Turkey)
SEK	Swedish Krona (currency)
SFOE	Swiss Federal Office of Energy
SI	Système International (International System of Units)
SLF	Shredder Light Fractions
SME	Subject Matter Expert
STM	Société de Transport de Montréal (Canada)
SUV	Sport Utility Vehicle
SWOT	Strengths, Weaknesses, Opportunities, and Threats (a type of planning method or analysis)
t	Metric Ton or Tonne (1 t = 1,000 kg)
TCA	Taxi Centrale Amsterdam (The Netherlands)
TCG	Transport Contact Group (EUWP)
TCO	Total Cost of Ownership
Tekes	Finnish Funding Agency for Technology and Innovation
TNO	Netherlands Organisation for Applied Scientific Research
TOSA	Trolleybus Optimisation Système Alimentation (Switzerland)
TÜBİTAK	Scientific and Technological Research Council of Turkey
UGAP	Union des Groupements d'Achats Publics (Union of Public Purchasing Groups) (France)
UITP	International Association of Public Transport
ULEV	Ultra-Low Emission Vehicle
UK	United Kingdom
UPS	United Parcel Service (U.S.)
US	United States
U.S.	United States
USA	United States of America
USABC	United States Advanced Battery Consortium

V	Volt
VAMIL	Arbitrary Depreciation of Environmental Investments (The Netherlands)
VAT	Value-Added Tax
VITO	Vlaamse Instelling voor Technologisch Onderzoek (Flemish Institute for Technological Research) (Belgium)
vol-%	Percentage Based on Volume
VPN	Virtual Private Network
VRT	Vehicle Registration Tax
VSST	Vehicle and Systems Simulation and Testing (DOE)
VTO	Vehicle Technologies Office (DOE)
(ANR) VTT	Technical Research Centre of Finland (Valtion Teknillinen Tutkimuskeskus)
VW	Volkswagen
V2G	Vehicle-to-Grid
V2V	Vehicle-to-Vehicle
V2X	Bidirectional Charging
WCC	Workplace Charging Challenge (DOE)
Wh	Watt-Hour
WPT	Wireless Power Transfer
ZHAW	Zurich University of Applied Sciences

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