IEA INTERNATIONAL ENERGY AGENCY

HYBRID & ELECTRIC VEHICLE IMPLEMENTING AGREEMENT

IA-HEV

Hybrid and Electric Vehicles

The Electric Drive Delivers

2015

www.ieahev.org

International Energy Agency

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

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April 2015

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Cover Photo: StreetScooter's electric delivery vehicle. The first prototype developed together with RWTH Aachen University (Germany) was presented in 2012. In 2014 German post and logistics group Deutsche Post DHL took over StreetScooter. In early 2015 more than 100 StreetScooter vehicles were on the streets in Germany.

(Image courtesy of Deutsche Post DHL)

The Electric Drive Delivers

Cover Designer: Anita Theel, VDI/VDE Innovation + Technik GmbH

International Energy Agency

Implementing Agreement for Co-operation on

Hybrid and Electric Vehicle Technologies and Programmes

Annual Report Prepared by the Executive Committee
and Task 1 over the Year 2014

Hybrid and Electric Vehicles

The Electric Drive Delivers

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1 Chairperson's Message

Personal mobility is a basic need of humans. Growing income goes hand in hand with more individual mobility. But the share is still unbalanced. The rich 20% of humans on earth are driving most of the cars. This is shown in the old graph I made with our former secretary Frans Koch in 1998 when we prepared the 2nd 5-year term of the Implementing Agreement "Hybrid- and electric vehicles" in 1998.

Table 1: Data from 1998

	Population [million]	Cars [million]	Cars/1,000 inhabitants
IEA countries	852	516,4	606
"Tiger" states	1,767	159	90
Developing countries	3,253	31,6	10

In 1998 we had a total of about 700 million cars. In 2012 we surpassed the number of 1 billion cars. Now on the threshold of the start of our 5th 5-year program car numbers are still growing. China is now the biggest car producer and consumer in the world. IEA expects more than 2 billion cars in 2050. Even this is an unequal situation. – What could be the solution? Less cars in rich countries, as in the IEA states? I wish I could believe this. Would people resign car driving to limit their "personal footprint on earth"? I see the test in my home state of Berne in Switzerland, one of the richest countries in the world. We have the best public transport system in the world (more rail trips than all other countries in the world per capita). The community members of the state of Berne could vote for a tax reduction for big and heavy polluting cars. Most people don't drive such a car. Still they voted for the tax reduction, which was more than 120 million CHF in a year, a lot of money in a 1 million people state. – This is a sign for me, that the majority of a population is hardly willing to restrict their use of big cars.

Passenger Cars are the Main Energy User in Transport

The main user of energy in transport is the road transport with 90% of the energy consumption. Passenger cars contribute with 64%.

The challenge is therefore to compensate the energy consumption and the CO_2 emission of a strong growth in car numbers up to 2050. Plug-in-hybrid-vehicles

(PHV) and battery electric-vehicles (BEV) can do that. But they need a lot of material, space in cities and for streets. Actually we are in the beginning of this development. The actual electric cars are a good solution for innovators and pioneers. In total they cost not more than middle class cars in rich countries and the electric energy can be produced by photovoltaic cheaper than gasoline in Europe.

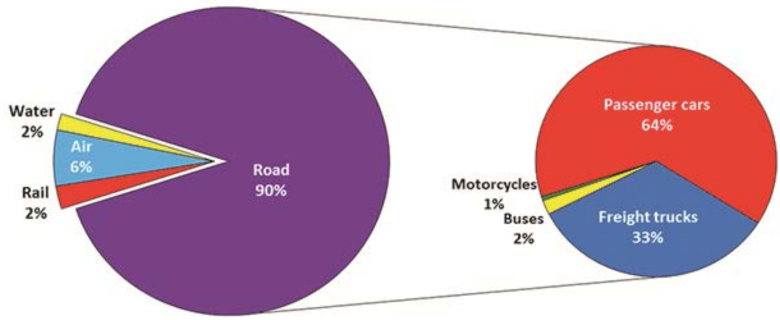

Figure 1: Cars are the dominant energy user in transport (IEA)

This is the status of the work of our Implementing Agreement “Hybrid- and electric vehicles” we reached in the period of 1993 to 2015. Actually HEVs are still minor. In a market of about 80 million cars annually, 1.2 million hybrid electric vehicles mainly in the US and in Japan are not very impressive. This is still the market of “innovators”.

The 2DS climate-target of IEA with 17 million cars in 2025 is a 20% market share (see Figure 2). This would tackle the market segments of the “opinion leaders” and even the “early majority”. It would mean that we could “cross the chasm”, the gap between “opinion leaders” and “early majority”. For this we need more HEV models and new marketing approaches.

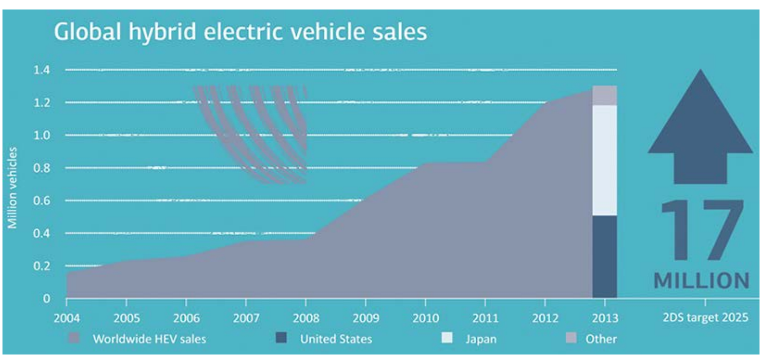

Figure 2: 2DS target of IEA of 17 million HEVs in 2025

Establishing PHVs and BEVs as a "Disruptive Technology"!

But for the PHVs and BEVs we need further efforts. They have the potential to be cheaper to buy and to use, than cars with internal combustion engines (ICE). The batteries, the motor, and the power electronics can be mass produced. This can lower the cost in a way that the sales price is lower for a BEV than for an ICE car. PHVs and BEVs are cheaper in use than ICE cars. This potential has to be developed in the next 10-20 years. Only with lower prices can we reach the mass market of the "early and late majority" of the car market. To reach this, we have to tackle "technical" and "non-technical" problems.

High Number of Tasks in the Implementing Agreement "Hybrid- and Electric Vehicles"

In 2014, we could start a high number of new Tasks. This was the result of a process to accelerate the participation in tasks. Efforts by many member countries and specialists made it possible. I hope we can keep this momentum for the 5th phase in 2015-2020. You can find all details in the following pages of the annual report. Please don't hesitate to contact the responsible person, the operating agent, of a Task. Collaboration is possible for non-member countries and for industry and associations ("Sponsors"). Our secretary or the operating agent can inform you about how you can collaborate.

New Member Countries are Welcome

The Implementing Agreement "Hybrid- and electric vehicles" IA HEV has 18 member countries. These countries share their effort in the research and the introduction of PHVs, HVs, and BEVs. Sharing efforts means lower costs for each of the countries, for the industry and the tax payers. But cars are not running in only 18 countries in the world. They are all around. We have to motivate more countries to share their efforts for a high efficient and low CO_2 transportation system. In the 5th phase we will especially contact countries outside the IEA members to participate in our group.

Dreams Can Become True

Electric mobility has many faces. While writing these lines, two Swiss citizens Bertrand Piccard and André Borschberg prepare a huge solar electric plane, the "Solar Impuls 2", to fly around the world. Their plane is fully electric and the energy will be produced by solar cells. This reminds me of 30 years ago when I organized the first solar car race in the world, the “Tour de Sol”, across Switzerland in a solar powered car.

Figure 3: The route of “Tour de Sol 85” and the picture of the winning solar car (alpha real/Mercedes Benz)

The aim was – similar to the “Solar Impuls 2” – a PR tour for solar energy. Later we tried to drive grid connected solar powered light electric vehicles. Everything worked well, and now, 30 years later, I drive my solar powered electric car (still a little too heavy) to work every day. – This shows: “dreams become true”. For that we have to use the expertise of engineers, experts in governments, local states and communes. Such changes need a lot of time and long life efforts. In the IA HEV we can foster this technological change, we can reach the CO_2 goals and give our countries a competitive advantage.

Thanks and Welcome

Before closing this chapter, I want to thank everybody who supports our work in the Tasks and in the administration. This time my thanks go to two members of our administration especially. Our secretary Martijn van Walwijk, who supported our work in the last 10 years, will leave our group at the end of June, 2015. He returns to his home country the Netherlands, to support applied research at a university of applied sciences. Our bookkeeper, Verena Dubach from the Berne University of Applied Sciences BUAS gives the responsibility over to a national lab in the USA.

I thank both of them for their efforts and wish them good luck in their new activities.

Figure 4: Mr. Urs Muntwyler, chair of the IA-HEV

My final thanks go to the deputy chairs Carol Burelle, David Howell, and Mario Conte, the members of the executive committee, and the Task leaders. Their effort and ideas are crucial to bring our program ahead.

Urs Muntwyler
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March 2015

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 29 member countries (see Table 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.

Table 1: IEA Member Countries – 2014

IEA Member Countries – 2014			
Australia	Finland	Luxemburg	Spain
Austria	France	The Netherlands	Sweden
Belgium	Germany	New Zealand	Switzerland
Canada	Greece	Norway	Turkey
Czech Republic	Hungary	Poland	United Kingdom
Denmark	Ireland	Portugal	United States
Estonia*	Italy	Republic of Korea	
European Union**	Japan	Slovak Republic	

***** Estonia joined IEA in 2014 as the 29th member.
****** The European Commission also participates in the work of the IEA.

With the evolution of the energy markets, the IEA mandate has broadened. It now focuses well beyond oil crisis management. 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 policies. 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 are:

- **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.

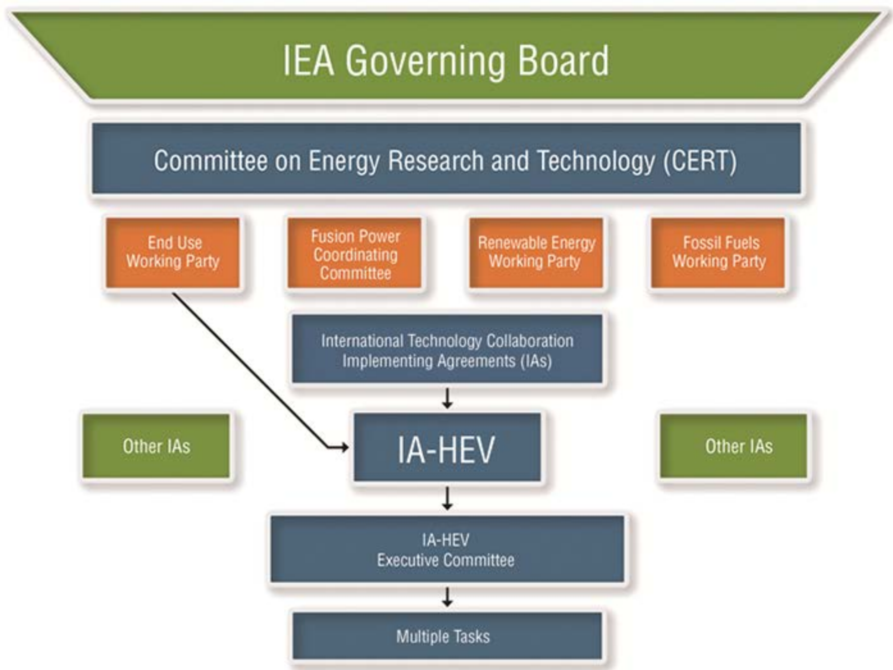

Figure 1: The IEA energy technology network

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).

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 programmes, 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 Table 2.

Table 2: Benefits of International Energy Technology Co-Operation through IEA Implementing Agreements

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 programme. 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 three subsections (2.2.1, 2.2.2 and 2.2.3) briefly report on IA-HEV activities and results in the second, third and fourth terms of its operation (Phase 2, Phase 3 and Phase 4), respectively. These are organized by task number. The strategy for the current term of operation, Phase 5 (2015-2020), and its details are reported in subsection 2.2.4.

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 of 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.

2.2.2 Description and Achievements of IA-HEV Phase 3, 2004-2009

The emphasis during Phase 3 of the Agreement, from 2004 to 2009, was 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. 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. Topics addressed during the third phase are shown in Table 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.

Table 3: Topics Addressed in the Third Phase of IA-HEV (2004–2009)

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 Achievements of 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 remain still to be answered 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.

For Phase 4 the ExCo has formulated the following strategic objectives:

1. To produce objective information for policy and decision makers on hybrid and electric vehicle technology, projects and programmes, and their effects on

energy efficiency and the environment. This is done by such means as general studies, assessments, demonstrations, comparative evaluation of various options of application, market studies, technology evaluations, and identification of industrial opportunities

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 defined strategies for Phase 4, the IA-HEV ExCo has also identified topics to be addressed during that 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”

During Phase 4 many of the Tasks completed: Task 11 “Electric Vehicles”, Task 12 “Heavy-duty Hybrid vehicles”, Task 13 “Fuel Cell Vehicles”, Task 14 “Market Deployment of Electric Vehicles”, Task 15 “Plug-in Hybrid Electric Vehicles” and Task 16 “Alternatives for Buses”. Nevertheless, many of the Task members are still involved in ongoing Tasks, for instance, members of the completed Task 14 are currently active in Task 18.

2.2.4 Description and Strategy of IA-HEV Phase 5, 2015-2020

In November 2014, the IEA Committee on Energy Research and Technology (CERT) approved the fifth phase of operation for IA-HEV, which is scheduled to run from March 1st, 2015 until February 29th, 2020.

In the strategic plan for phase 5, the participants in IA-HEV have formulated their expectations for the time frame 2015-2020. The first hybrid car – the Toyota Prius – has been introduced to the market at the end of the previous century. Today, hybrid electric vehicles have established a foothold in the market, and pure electric vehicles are becoming increasingly available. The market share of these vehicle technologies is still small and expected to increase in the coming five years. A number of developments in society play a role in how fast the market uptake will be. Decarbonisation of the global electricity mix is expected to continue by increasing the share of renewable energy, such as wind and solar power, resulting from climate policies in many countries. To bridge the time gap between renewable electricity production and electricity demand, smart grids with large numbers of battery electric vehicles plugged in may offer the electricity storage capacity that is required for large shares of renewable electricity. At the same time this will contribute to lowering the CO_2 emissions from road transport. Data history and long-term practical experience will become increasingly available and will play a key role for further hybrid and electric vehicle adoption. Incentives are expected to remain necessary for electric vehicle deployment during 2015-2020, and also policies aiming to build up a charging infrastructure will play a role. Regarding vehicle technology, battery R&D will continue to increase energy density and battery life, and at the same time reduce battery costs. Nevertheless, range anxiety may remain a concern for pure battery electric vehicles. Combining the electric drive with an internal combustion engine in plug-in hybrid electric vehicles (PHEVs) and in extended range electric vehicles (EREVs) may eliminate range anxiety. The price of hybrid and electric vehicles (H&EVs) is coming down so the difference in purchase price to conventional vehicles is diminishing, which is advantageous for H&EV deployment. However, the oil price halved in the second half of 2014, which counteracts hybrid and electric vehicle deployment. Consumers become increasingly aware of the impact of CO_2 on the environment and have started to appreciate the advantages of the electric drive. Still, vehicle costs will remain an important factor in vehicle purchase decisions. High vehicle price and lacking charging infrastructure are expected to remain the major hurdles for increased electric vehicle deployment in the coming five years.

The IA-HEV Executive Committee considers policy/decision makers in governmental bodies at national, regional and city levels, in the automotive industry, its component suppliers and in utilities as the target audience for its work.

These include the IA-HEV Contracting Parties, which are representing national governments. The IA-HEV mission is to supply this target audience with objective information to support decision making, to function as a facilitator for international collaboration in pre-competitive research and demonstration projects, to foster international exchange of information and experiences, and sometimes to function as a promoter for Research, Development, Demonstration and Deployment (RDD&D) projects and programmes.

Against this background and to fulfil its mission, the IA-HEV Executive Committee has formulated the following strategic objectives for phase 5 (2015-2020):

1. To produce and disseminate objective information – for policy and decision makers – on hybrid and electric vehicle technology, projects and programmes, and their effects on energy efficiency and the environment. This is done by means of general studies, assessments, demonstrations, comparative evaluations of various options of application, market studies, technology evaluations, highlighting industrial opportunities, and so forth
2. To be a platform for reliable information on hybrid and electric vehicles
3. To collaborate on pre-competitive research projects and related topics and to investigate the need for further research in promising areas
4. To collaborate with other transportation related IEA Implementing Agreements, and to collaborate with specific groups or committees with an interest in transportation, vehicles and fuels

Table 4: IA-HEV Tasks that were active in December 2014 and that are scheduled to continue into Phase 5

IA-HEV Tasks that were active in December 2014 and that are scheduled to continue into Phase 5
Task 1: Information Exchange
Task 10: Electrochemical Systems
Task 21: Accelerated ageing testing for lithium-ion batteries
Task 23: Light electric vehicle parking and charging infrastructure
Task 24: Economic impact assessment of e-mobility
Task 25: Plug-in Electric Vehicles
Task 26: Wireless power transfer for electric vehicles
Task 27: Electrification of transport logistic vehicles
Task 28: Home grids and V2X technologies

The existing IA-HEV working method, including meeting twice a year for information exchange and running projects in the form of Tasks, has proven to be appropriate to achieve the objectives of the Agreement, and no changes in the working method are anticipated for the fifth phase. Tasks that were active at the end of Phase 4 and that will continue in Phase 5 are shown in Table 4.

In addition to the active Tasks, new topics will emerge in the coming five years. The IA-HEV participants have listed possible topics for Phase 5 (2015-2020) and grouped these in three categories: technology evolution / progress (see Table 2.5), technology deployment/market facilitation (see Table 2.6), and environmental protection (see Table 2.7). Additional topics will certainly emerge, and depending on priorities and resources that can be made available, the IA-HEV Executive Committee will decide which topics will actually be addressed in Phase 5.

To pool resources and to increase the impact of its work, IA-HEV will aim to increase collaboration with other IEA Implementing Agreements such as IA-AMF (Advanced Motor Fuels), IA-AFC (Advanced Fuel Cells), IA-PVPS (Photo-Voltaic Power Systems) and the co-operative programme on smart grids (IA-ISGAN). IA-HEV will also aim to reinforce collaboration with organisations outside the IEA such as ACEA (European Automobile Manufacturers Association), AVERE (European Association for Battery, Hybrid and Fuel Cell Electric Vehicles), ICCT (International Council on Clean Transportation), and IRENA (International Renewable Energy Agency).

Table 5: Technology evolution / progress

Technology evolution / progress
• Battery and capacitor technology (Task 10) • Accelerated ageing testing for lithium-ion batteries (Task 21) • Effects of extreme conditions (temperature, highway grades, highway speed capability) on design of EVs • Optimal PHEV electric power for different kinds of use (urban, regional, or highway driving)

The Implementing Agreement for Hybrid and Electric Vehicles is an international platform with a global view. It is a network for the exchange of knowledge and experience that provides access to experts in other countries. The collaboration of people from governmental bodies, research institutes and the private sector makes IA-HEV unique. Participants in the Agreement get the different views on the subject in all domains related to hybrid and electric vehicle deployment. Having the complete picture contributes to effective progress in IA-HEV member countries. Other countries are invited to join the Agreement and share the benefits of IA-HEV membership.

Table 6: Technology deployment / market facilitation

Technology deployment / market facilitation
• Light electric vehicle parking and charging infrastructure (Task 23) • Plug-in Electric Vehicles (Task 25) • Wireless power transfer for electric vehicles (Task 26) • Home grids and V2X technologies (Task 28) • Electric and automated vehicles (proposal) • Total costs of ownership • 2nd use of batteries • Market development, strategies, incentives • Behavior, awareness and education of customers • Training and education of sales and vehicle maintenance staff • Standards • Interoperability • Changes in society - own or use cars? • Changes in society - attitudes of young people • Changes in society - public transport and EVs • Financing - next phase of vehicle deployment, without subsidies? • Financing - changes in tax revenues for governments • Assessment of infrastructure needs • Smart regulations

Table 7: Environmental protection

Environmental protection
• Renewable energies • Smart grids • Life Cycle Analysis • Battery recycling • City planning and EVs

3 Information Exchange (Task 1)

Members: Any IA-HEV member may participate

3.1 Introduction

Information exchange is at the core of IA-HEV's work, enabling members to share key policy insights and best deployment 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 5 (2015-2019) 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." Table 1 lists all phase 5 objectives, which include communication.

Table 1: Listing the Task 1 "new phase" objectives

IA-HEV Phase 5 Objectives (2015−2019)
• 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 non-member countries.

Information exchange focuses on these topics:

- Research and technology development
- Commercialization, marketing, sales, and procurement
- Regulation, standards, and policies
- Awareness raising measures
- 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 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 served as the Task 1 OA on behalf of the U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO) until the end of 2014 when responsibility for Task 1 was transferred to Gereon Meyer of VDI/VDE Innovation + Technik GmbH (Germany) as the new OA.

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, sales prices[1] by vehicle type); the progress of international, national, or local programs 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. 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

[1] indicated in original currency + converted into EUR or USD (1 EUR ≙ 1.054 USD in April 2015)

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

Notable events in 2014 included the following:

- Task 1 Information Exchange meetings were held in Copenhagen, Denmark, in May 2014, and in Vancouver, Canada, in October 2014
- The IA-HEV annual report on 2013 entitled Hybrid and Electric Vehicles – The Electric Drive Accelerates was published

Figure 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 Next Steps

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 of the Operating Agent

For further information, please contact the Task 1 OA:

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4 Electrochemical Systems (Task 10)

Members: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, The Netherlands, Sweden, Switzerland, Turkey, United Kingdom, United States

4.1 Introduction

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

4.2 Objectives

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

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

4.3 Working Method

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

The Task addresses selected topics 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 upon the nature of the discussions and may include publications in the open literature or restricted meeting notes. After an IA-HEV member joins Task 10, any individual or organization from the member country may participate in a working group based on their interest in the subject matter. As a result, each working group has unique members, and a country or organization may participate in one working group without making a multiyear commitment to attend every Task meeting. In order to maximize the information presented during the discussions of a working group, the Operating Agent sometimes invites representatives of non-member countries to attend meetings under his sponsorship.

4.4 Results

Task 10 sponsored working groups on two different topics in 2014. The first was a Technical Discussion on Issues Related to the Safety of Batteries in Hybrid and Electric Vehicles and was held in Washington, DC, USA on January 29th-31st, 2014. This discussion was summarized in the Implementing Agreement's 2013 Annual Report. The second was a Discussion of the Effects of Fast Charging on Batteries in Plug-In Electric Vehicles. It was jointly sponsored by Task 10, Electrochemical Systems, and Task 20, Quick Charging, and was held in Nice, France on 22nd–23rd September, 2014. This meeting was attended by about 15 individuals from nine member countries including representatives of automobile manufacturers, organizations developing standards, governments, and national laboratories.

4.4.1 Summary of the Discussion on Effects of Fast Charging

"Fast charging" is not that fast. Although some people talk about "fully" charging an EV's battery in less than 15 minutes, current fast charging technology is slower and gentler than this goal. Power available from fast chargers limits the rate of charging. "Standard" fast chargers can deliver 50 kW DC current. Tesla Superchargers are available in several versions; the most common new version can deliver 120 kW[2]. For an EV such as a Nissan Leaf with a battery of about 25 kWh, the maximum charging at 50 kW is only the 2C2 rate[3]. For a Tesla with an 85 kWh battery, the maximum charging is at less than the 2C rate.

[2] All information about Tesla and the Tesla Supercharger discussed at the meeting was taken from Tesla's Internet pages.

[3] The "C rate" convention links charging or discharging rates to a cell's capacity and to time in hours. For example, the 1C rate for a 1Ah cell is 1A; the 1C rate for a 50kWh cell would be 50kW. A 2C rate is twice the 1C rate, i.e. the 30 minute rate. A C/2 rate is half the 1C rate, i.e. the two hour rate. Because lithium-ion cells are normally charged with limits on both current and voltage, charging normally starts at the current (or power) limit with voltage increasing as charging proceeds. When the voltage limit is reached, the charging current tapers downward to a predetermined low value or to a predetermined charging time; one of these values will define the cell as "fully charged". Charging rates for lithium-ion cells are sometimes described in terms of the maximum charging rate with an implied understanding that the rate will taper when the voltage

In a state-of-the-art system, the fast charging process involves the exchange of data between the vehicle and the charger. These data are used to limit charging to prevent damaging the battery. Although the details will vary depending upon the system, these controls normally limit fast charging at the maximum rate to the "middle" states of charge (SOC), e.g. between about 20 and 70% SOC. If the charging begins at a very low SOC, the rate may be limited at first. Once the SOC reaches somewhere between 60% and 80%, the charging rate will also be reduced in a taper to zero at full SOC. A generalization that captures this effect is that if one starts with a battery at 20% SOC, one can transfer electrical energy equivalent to x km of driving in the first 15 minutes of fast charging. If charging continues, one will be able to transfer energy equivalent to x/2 km (or less) in the next 15 minutes; and the rate of charging will continue to taper downward if charging continues beyond 30 minutes[4]. It is recognized that fast charging of a lithium-ion battery at low temperatures can lead to lithium plating onto the negative electrode. This plating can result in degraded performance and potential safety issues. Fast charging a lithium-ion battery at warm/hot temperatures (often defined as 40°C or higher) can result in an acceleration of the degradation of battery performance. To avoid such degradation, fast chargers and the vehicle control systems often limit the rate of charging at temperature extremes. For example, Tesla notes that Supercharging rates may be limited in certain climates. Data available from Idaho National Laboratory has documented how two specific vehicles control fast charging as a function of temperature.

Experimental data shows that fast charging as described above does not cause significant additional damage to a lithium-ion battery when compared with lower rate charging. The performance (both capacity and power) of any lithium-ion battery will degrade with time and with cycling. This degradation will be accelerated by higher temperatures. Typical goals for the performance of an EV battery are a 10+ year calendar life and over 1,000 full discharge cycles with retention of at least 80% of its original performance when operated at 30°C. Accelerated testing of advanced batteries designed for EVs has confirmed that these life goals can be met using published testing protocols.

Testing at Argonne National Laboratory (ANL) (located outside Chicago in the United States) was done on small commercial cells in two different chemistries that were cycled using a range of charging rates. The degradation of cells charged at the 2C rate is slightly worse than that observed in cells charged at 1C or less.

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limit is reached. To fully describe actual charging or discharging rates, one needs to have detailed data on current flow and applied voltage as a function of time. The presentations from Idaho and Argonne National Laboratories include such data in graphical form.

[4] Tesla specifically writes that Superchargers are capable of delivering up to 50% battery capacity in about 20 minutes, but that charging the final 20% takes approximately the same amount of time as the first 80% due to a necessary decrease in charging current to help top-off cells.

Degradation increased with the charging rate. Warming of the cells, as measured on the surface of the cells, was observed even though the cells were located in a temperature chamber held at 30°C. Warming increased with the charging rate. The increased performance degradation at higher rates may be attributed to the increase in temperature. It has been proposed, but not yet confirmed by testing, that if the cells were actively cooled to keep their temperature at (or below) 30°C, little accelerated degradation would be observed.

Staff members from Idaho National Laboratory (INL) (located in Idaho Falls, Idaho in the United States) described data from a group of 4 EVs, 2 of which were charged at “normal” rates (Level 2, or a maximum of approximately C/4) and 2 were charged using modern fast chargers. Significant battery degradation was observed in both test samples, but the difference between the two groups was relatively small. Accelerated degradation could be correlated with other parameters such as elevated operating temperatures.

Studies reported by the National Renewable Energy Laboratory (NREL) (located outside Denver in the United States) showed that vehicle data supplemented with simulation calculations indicate that moderate use of fast charging, up to 10 times per month, does not seem to accelerate the rate of battery degradation significantly relative to Level 2 charging. In moderate climates (e.g. Seattle), the type of battery temperature management system does not have any significant effect on the rate of degradation. In hot climates (Phoenix), active cooling offers significant benefits relative to passive cooling. Batteries being charged in a high ambient temperature with only passive cooling can reach undesirably high temperatures. If these batteries are fast charged under these conditions, temperatures may reach very undesirable levels.

Automobile manufacturers’ statements about fast charging include Tesla’s statement that “Supercharging does not alter the new vehicle warranty. Customers are free to use the network as much as they like”. Nissan’s warranty on the Leaf guarantees 75% capacity retention for 5 years or 100,000 km for all forms of charging, including “QC”.

There are significant logistical and cost challenges associated with deploying a network of modern fast chargers. There are at least 4 different configurations/designs of cables and plugs associated with modern fast chargers: CHAdeMO, Combo Types 1 and 2 (SAE), Tesla, and Chinese. Outside of China, CHAdeMO and Combo systems are most common, but they use different plugs and different charger/vehicle communication protocols. Many new fast charging systems are equipped with at least two different cables so as to be able to accommodate vehicles that use different protocols.

At the meeting, it was mentioned that typical fast chargers cost about 20,000 USD. Cost quotations obtained after the meeting for dual port (SAE Combo and CHAdeMO) chargers varied from about 25,000 to 35,000 USD depending upon the manufacturer. Installation costs can vary from 10,000 USD to over 100,000 USD. During and after the discussion, several participants remarked that they thought that 10,000 USD was a very low cost and that typical installation costs are much higher. A recent project in British Columbia[5] worked to choose optimum locations (i.e. locations with moderate or low installation costs) for fast chargers and still had installation costs of 20,000 to 40,000 USD per site. In some locations, it can be very difficult and time consuming to get all of the necessary permits to install a fast charger.

The business model for fast chargers is uncertain. INL presented data on the use of a group of fast chargers as a function of time. As a part of a technology introduction project, there was no cost to use these chargers. The number of charging events grew steadily over several months as users learned the locations of the chargers and more vehicles were added to the project. When the company operating the charger network instituted a fee per charge, the use of the chargers dropped significantly. Eventually the company went out of business. The small fast charging network in British Columbia charges for electricity on a kWh basis; the charges are about 3.5 times greater than the cost of electricity at a residence (0.35 USD vs about 0.10 USD). This network received significant government support, and the operators of the network view it as a “marketing tool” for EVs, a means to help mitigate “range anxiety” and encourage purchase and use of EVs. The operators do not expect the network to make a profit.

4.5 Next Steps

Discussion meetings on new topics are being planned for 2015. Possible topics include the Second Use of Vehicle Batteries, a Discussion of the Safety of Batteries in Vehicles from a European Perspective, a Summary of the Issues Related to Internal Short Circuits in Lithium-Ion Cells, and a Discussion of How to Handle a Vehicle if the Battery Has Been Damaged (First Responder Issues and Training).

[5] Information about the British Columbia project was taken from a presentation by Ms. Christina Ianniciello given to the meeting of Task 1 of the Implementing Agreement on 22 October in Vancouver, BC, Canada.

4.6 Contact Details of the Operating Agent

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

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5 System Optimization and Vehicle Integration (Task 17)

Members: Austria, Germany, Switzerland, United States

5.1 Introduction

Electrically powered vehicles are seen as one way of reducing oil use and GHG emissions and of improving local air quality. In recent years, sales of these vehicles have risen steadily but sales figures are far behind the expectations of car manufacturers. The difficulties with bringing electric mobility (e-mobility) on the road is often focused on battery performance/charging/costs and missing charging infrastructure. Other important aspects, like the optimized and sustainable use of available energy are less considered, but are also important with regard to the adoption of e-mobility. Integration and configuration of components including handling of interfaces as well as system management and monitoring should also receive increased attention as they could contribute significantly to the reduction of vehicle cost and enlarge customer acceptance. Therefore, Task 17 analyzes the overall system optimization and electric vehicle (EV) performance and tries to analyze technology options for the optimization of EVs and drivetrain configurations (see Figure 1).

5.2 Objectives

Electronic systems used to operate and monitor all vehicle types have benefited from substantial improvements during the past few years. Additionally these systems have also improved the prospects for XEVs. Improved power electronics have resulted in new opportunities to control and steer the increasingly complex-component configurations. In addition, new integration options for components have undergone rapid improvements during the past few years. Further optimization of these components is necessary – like new concepts for integrating them in the overall system and tuning them – to meet the specific requirements of different vehicle applications.

These developments and the opportunities they provide are analyzed in Task 17.

Figure 1: BMW i8 drivetrain (image courtesy of BMW[6])

The scope of this Task is the monitoring and analysis of progress in design and configuration as well as trends and strategies for XEVs with a high degree of electrification. Thus, Task 17 is focusing on:

- overview and comparison of selected configurations of components in vehicles on the market in terms of an advanced vehicle performance assessment and overview and analysis of present vehicle components on the market available
- analysis of existing component technologies
- Original Equipment Manufacturer (OEM)s-review of different strategies and technologies for EVs and follow-up of new prototypes
- analysis of theoretical possible operation and configuration concepts and assessment of their advantages and disadvantages: comparison and analysis of efficiency, performance or price reduction potential
- overview and analysis of different simulation tools
- workshops with Task members and additional external experts' from industry and research institutions
- design considerations depending on different applications for EVs

[6] http://indianautosblog.com/2013/08/bmw-i8-specifications-90906/bmw-i8-drivetrain

Impacts on the following aspects of system performance are being analyzed:

- improvements in energy efficiency (by optimizing thermal and electric energy management), operational safety and durability through better monitoring of component operation
- integration and control of software solutions (by software architecture strategies for real-time minimization of losses)
- reductions in the cost of components (through increased efficiency in operation and production, alternative materials, etc.)
- reductions in weight and volume through the optimized assembly of the drivetrain
- configurations for energy storage systems, drivetrain and/or Range Extenders

5.3 Working Method

Task activities predominantly consist of preparing a technology assessment report on trends and providing opportunities for member countries to exchange information. The scope of work has focused on the participant's capabilities and fields of expertise and basically covered the monitoring and analysis of component development and vehicle architecture relative to trends and strategies for EVs progress. Thus, working methods include:

- questionnaires, personal interviews and several workshops with industry (in- and outside automotive companies, academia, user organizations, technology and innovation policy experts)
- foresight analyses of future options and opportunities
- simulation of different component configurations
- International networking using momentum and achievements of external partners (EU-FP7, EU-TPs, EU-H2020, FCH-JU, ERTRAC, EPoSS, ERA-NET)
- information exchange and close coordination with other running Tasks of the HEV Implementing Agreement using their results for vehicle integration investigations
- co-operation with other IEA- Implementing Agreements
- dissemination of results of participating countries in giving support to their policy and industrial decision makers and leading R&D representatives in their responsibility for setting of research priorities

The most common form is represented by Task 17 workshops. They enable the dissemination of information about relevant activities in an international context.

5.4 Results

Already treated subjects within Task 17 are:

- Components: Battery Management Systems, Electric Motors
- Performance Assessment: Comparison of different configurations
- Simulation Tools

As Task 17 tries to focus on current topics, those with the highest priority in the field of system optimization (energy efficiency) have been covered within the last workshops, which emphasizes the wide range of treated topics within this Task:

- Thermal Management (sustainable use of available energy)
- Functional and Innovative Lightweight Concepts and Materials for XEVs

5.4.1 Lightweight as a Major Topic for XEVs

Results from a Task 17 study on the impacts of the vehicle's mass efficiency and fuel economy for different drivetrain configurations (conducted by Argonne National Laboratory) highlighted the importance of the topic lightweight, especially in XEVs.

According to a McKinsey study[7] (2014), the proportion of high tensile steels, aluminum and carbon-fiber-reinforced plastics in vehicles is set to increase from 30% today to up to 70% in 2030. High-tensile steel will remain the most important lightweight material (market share: 15% to 40%) and carbon-fiber-reinforced plastics are expected to experience an annual growth of 20%.

Following the worldwide trend of dealing with the topic of Lightweight in 2014, Task 17 discussed and analyzed this topic through a workshop.

Task 17 Workshop: Functional and Innovative Lightweight Concepts and Materials for XEVs Major Topic

The workshop took place in Schaffhausen (Switzerland) in October 2014 and was hosted by Georg Fischer Automotive AG, a Swiss company specialized in the field of lightweight design, which is well known for their pioneering materials developed in-house, bionic design, and optimized manufacturing technologies in the automotive sector. The 28 participants included experts from industry as well as research institutes and representatives from the government. During the workshop experts from different working fields and technologies came together to discuss. The workshop was focusing on Functional and Innovative Lightweight Concepts and Materials for XEVs and covered four sessions about:

[7] Lightweight, heavy impact, McKinsey & Company (2014)

- Lightweight Activities in Switzerland (hosting country),
- Lightweight Materials and Components,
- Simulation and
- Functional & Innovative Concepts and Solutions

The aim of the workshop was an exchange of information in order to identify potentials for improvement in the field of lightening XEVs by giving an update on available lightweight materials and prognoses about future materials. Thus, representatives from all kinds of organizations working in the field of materials were invited to share their opinion. In the workshop it was pointed out, that there is no ultimate lightweight material available at the moment. The future of lightweight materials will be a mixture of the best materials available on the market combining their benefits: there is a need for the right material at the right place.

Beside the sessions, the participants were given the possibility to participate in guided tours:

- Automotive- and R&D- center of Georg Fischer (see Figure 2)
- Iron Library: the library's books and periodicals, offers an in-depth perspective like no other in the world. The collection comprises over 40000 publications that deal with the topic of iron, including classics by masters such as Isaac Newton as well as specialized modern literature.


Figure 2: Impressions from the guided tours: R&D center (left), iron library (right)

Some of the following subjects highlight the range of different materials and topics treated in the workshop:

Bionics: nature has provided ideas for high-strength materials, dirt-repellent coatings and even Velcro fastenings. This has led to the development of bionic car components, or even whole cars like the Mercedes-Benz bionic-car. *The Alfred-Wegener Institute (AWI)* designs and constructs vehicle components with an intelligent lightweight construction by using ELiSE – a new, versatile tool for lightweight optimization. After defining the technical specification and the objectives of a component, the optimization is done by five steps: screening for biological archetypes within 90,000 structures →structure assessment (natural structures are analyzed according to technical boundary conditions) →abstraction and functional transfer of natural structures to CAD model → application of parametric and evolutionary optimization (FEA optimization with focus on feasibility of manufacturing and cost performance) → assembly. Figure 3 shows the development of the ELiSE process using the example of a b-pillar. Finally a weight reduction of 34% – from 8.0 kg to 5.3 kg – can be achieved.

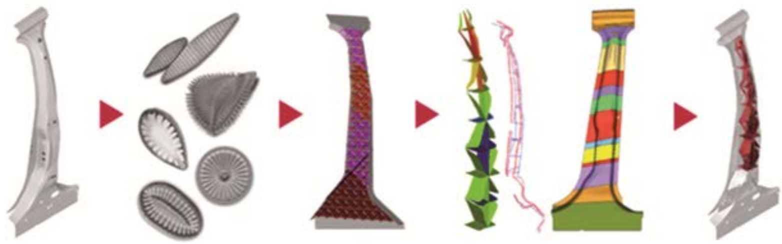

Figure 3: ELiSE process with b-pillar development (image courtesy of AWI)

Materials: despite the above ground-breaking achievements in key areas, OEMs are still searching for the development of strategies and technical solutions to integrate lightweight materials into multi-material vehicles inexpensively and to secure lightweight materials and components on a global platform. The combined use of various materials makes it possible to generate products displaying a broad spectrum of desired properties. By selecting the appropriate materials many mechanical characteristics can be influenced and optimized. Sandwich structures with 3 or more layers represent the basic technology for lightweight parts. The Austrian company *4a manufacturing*[8] offers the worlds thinnest sandwich structure used to optimize vehicles weight. There are materials produced having a very high bending stiffness at a low weight and a total thickness of 0.3 mm or more and a surface weight of 100 g/m² or more. Figure 4 shows the schematic build-up of the sandwich material. Automotive application fields are: firewall (-45% weight reduction compared to aluminum), rear panel (-30% weight reduction compared to aluminum).

[8] http://manufacturing.4a.co.at/

Figure 4: Material "Cimera" (left), schematic drawing (right) (image courtesy of 4a manufacturing)

AIREX Composite Structures produces sandwich materials being used in the application field of roofs for buses and trains. A weight reduction of up to 160 kg (-20%) can be achieved by using sandwich roofs (see Figure 5).

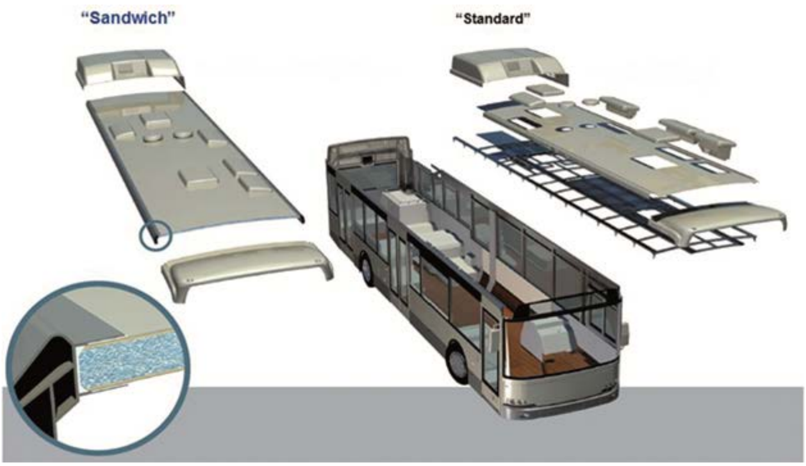

Figure 5: Sandwich technology for buses (image courtesy of Airex Composites)

Functional integration in the field of lightweight construction: functional integration provides parts with several functions in order to save on the final number of parts. There is for example, the possibility of replacing plastic interior trim with structural parts suitably designed with laminable, visually attractive surfaces. Individual close-to-the-wheel drives open up new possibilities for vehicle dynamics control strategies. This includes an associated increase of driving safety and energy efficiency through the targeted distribution of power and recuperation. On the other hand, the positioning of the motors close to the wheel increases the unsprung mass. This challenge can only be met by consistent lightweight design for all chassis components. The “LEICHT” concept by the *German Aerospace Centre DLR* presents a novel, drive-integrated chassis concept which in terms of its design and construction offers a significant chassis weight reduction (see Figure 6). By integrating the motor into the chassis in an intelligent way, easy modularization regarding drive power and steering ability becomes possible. This offers an adoption to a variety of vehicle concepts and an application as front or rear suspension module, by reaching about 30% weight reduction in comparison to conventional reference structures[9].

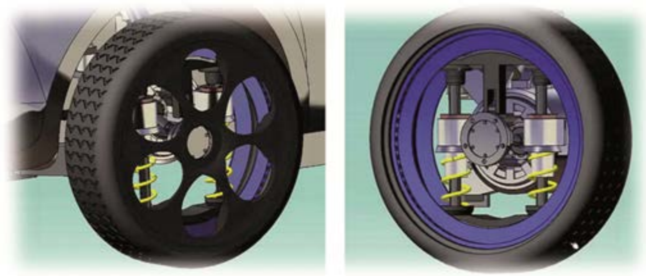

Figure 6: Lightweight Strategies Applied on the “LEICHT“: torque transmission demonstration (left), wheel travel demonstration (right) (image courtesy by DLR)

Another innovative concept called ESKAM was presented by Groschopp AG. In 2014 there were no optimized drive axles for BEVs available on the market. They are too heavy, too expensive, and too big, compared to the available power. The aim of ESKAM (Elektrisch Skalierbares Achs- Modul – electrically scalable axle module) is to develop technologies for flexible standard drive modules (see Figure 7). This innovative concept provides an integration of the drive prior to the axle module by limiting the weight of the drive module to a maximum of 100 kg. For this purpose, it is necessary to couple rapidly rotating electrical machines with corresponding gears and to integrate them in a common housing. In this case, only e-motors are used, which are not dependent on permanent magnets or on ever-increasingly expensive rare earth elements such as neodymium and samarium. The electric drive consists of two identical electrically excited, electronically commutated motors and transmissions, which are placed together with the power electronics in a housing and fitted to a drive axle module. The power range of the engine is scalable between 20 and 50 kWh.

[9] http://elib.dlr.de/89144/1/2013_04_08_Presentation%20SAE_The%20LEICHT%20Concept_From%20the%20Concept%20to%20the%20Prototype%20Andreas%20Hoefer.pdf

Figure 7: Project ESKAM (image courtesy of Groschopp AG)

Magna presented a vehicle called CULT[10] (Cars' UltraLight Technologies vehicle), a modern lightweight vehicle fueled by natural gas which shows significantly reduced CO_2 emissions (Figure 8). Lead-managed by Magna Steyr, the Polymer Competence Center Leoben GmbH worked on the development of an ultralight vehicle with minimal CO_2 emissions in the CULT project.

One of the methods employed to achieve this objective was the exploitation of the properties of thermoplastic fiber composite materials relating specifically to weight in order to reduce the overall vehicle weight by using lighter components. For example, thermoplastic continuous-fiber-reinforced semi-finished composites were used for the bumper beam, which consists of a crossbeam and shock absorbers.

The Fraunhofer Institute presented the requirements for a Composite Wheel with Integrated Hub Motor and described the development of a wheel of carbon fiber reinforced plastics with an integrated electric motor (see Figure 9). The main focus of the development was on the achievement of an optimum of lightweight potential considering structural durability.

[10] http://www.magnasteyr.com/de/kompetenzen/fahrzeugentwicklung-und-auftragsfertigung/innovation-technologie/technologietraeger-mila/mila-blue

Figure 8: CULT, vehicle (left) and explosion view (right) (image courtesy of Magna)

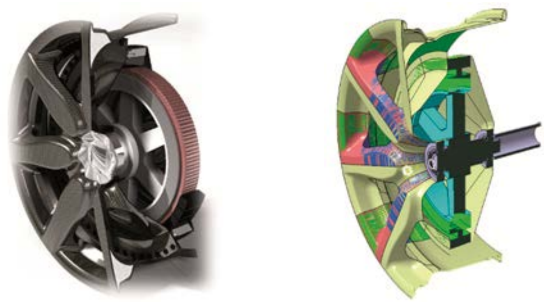

Figure 9: Wheel with Integrated Hub Motor (image courtesy of Fraunhofer)

During the realization, the technical challenges of multifunctional design were considered in the whole product life cycle. The CFRP lightweight wheel has a weight of approximately 3.5 kg. The motor housing is not directly connected to the rim, but to the inner area of the wheel axle. This prevents radial or lateral loads, especially shocks caused by rough roads or curbstone crossing, from being transferred directly to the hub motor (4 kW). Another advantage of separatign the load paths from the hub motor is that the rim can be more flexible than as if it were directly connected. To increase the flexural rigidity at a constant weight, foam cores were inserted into the spokes. A smaller, commercially available hub motor was used as the electric motor.

Through this workshop Task 17 successfully demonstrated that lightening the car, improving the electric power control unit, optimizing thermal management solutions, and improving the battery management system can help to improve the energy efficiency and the overall system performance of the vehicle. Thus it can increase the drive range and reduce costs and therefore makes the vehicle more attractive.

5.5 Next Steps

The work in Task 17 will continue till early 2015.

Future work within this Task includes:

- Workshop about Electronic/Electrical (E/E)- Architecture
- Final Task 17 report

A further topic of high priority identified in the areas of system optimization and improvements in energy efficiency deals with E/E-Architecture: power electronics and electric energy management. In the future, there might be autonomous cars everywhere. In 2014 (semi-)autonomous cars are in the phase of development and are becoming more and more popular. There are still hurdles to overcome but sooner or later these cars will be introduced into the market. Technologies like Advanced Driver Assistance Systems (ADAS) are representing a first step to fully autonomous driving. In 2014, ADAS is one of the fastest-growing segments in automotive electronics. There are many forms of ADAS available, mostly focusing on safety aspects and the increase in driving comfort. Besides that, they also can improve the overall economics of the vehicle.

As a next step, Task 17 will focus on the improvement of the eco-operational mode of XEVs by having a look at the E/E- Architecture of XEVs (incl. ADAS).

Thus, the last Task 17 workshop will focus on E/E- Architecture, including:

- Electrical Machines: higher partial load efficiency, lower volume and weight, higher failure safety, less dependency on scarce materials,
- Power electronics: higher efficiency, thermal strain on power electronics, resistance to vibration
- Power Tools for system optimization
- Electric energy management
- ADAS systems (evaluation, analyses of the benefits and potentials of existing ADAS especially used in XEVs

Final Task 17 Report: Since the beginning of Task 17 in 2010, seven workshops and expert meetings have taken place. In order to provide the Task members with these amounts of information, a final Task end report will be produced. Already existing information (status of previous years) has to be updated, in order to produce a contemporary report. The necessary work will be done by the OA in co-operation with the other Task members.

5.6 Contact Details of the Operating Agent

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

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6 Electric Vehicle Ecosystems (Task 18)

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

6.1 Introduction

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

An EV ecosystem defines the total infrastructure system required to support the operation of EVs. This system includes interfaces with “hard infrastructure,” such as recharging technologies, energy grids, buildings, and transport systems. It also requires the provision of “soft infrastructure,” such as regulation, information and communication technologies, commercial services, skills, and community engagement programs. Blending this complex mix of technologies and services into the fabric of cities requires alignment among governments, municipal authorities, and other key stakeholders from the automotive manufacturing sector, energy companies, and technology suppliers.

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

6.2 Objectives

The overarching goal of this Task was to advance international policy and the design of EV ecosystems. This included 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. A future outlook to 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

6.3 Working Method

6.3.1 Foresight Workshops

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

6.3.2 Web Portal

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

6.3.3 Alliances with Global EV City Projects and Initiatives

Over the last 36 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.

6.3.4 Task 18 Governance Structure

David Beeton (U.K.) and Thomas Turrentine (U.S.) are serving as the Operating Agents. Additionally, a Task 18 Steering Group approves amendments to Task activities and the budget. David Howell, at the U.S. Department of Energy’s

Vehicle Technologies Office, is the Steering Committee Chair. Luís Reis, of INTELI in Portugal, is the Steering Committee Co-chair.

6.4 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.

6.4.1 Foresight Workshops and Conferences

Six workshops on various topics have occurred to date in cities in the U.K., Istanbul, Barcelona, Los Angeles, Vienna, and Berlin, as summarized in Table 1.

Table 1: Completed Task 18 Workshops

Task 18 Workshops	
Special Topic	**Location**
The Future of Recharging Infrastructure	Newcastle, U.K.
Intelligent Transport Systems for EVs	Newcastle, U.K.
Open Architectures and Payment Systems for EVs	London, U.K.
International Policies and 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, USA
Future of Markets for Electric Vehicles	Vienna, Austria
Technologies and Infrastructure for Electric Vehicle Ecosystems	Berlin, Germany

6.4.2 World EV Cities and Ecosystems Web Portal and EV City Casebook

Task 18 involves active collaborations with other international projects. The Global Electric Vehicle Insight Exchange (EVX) World EV Cities and Ecosystems Web portal (www.worldevcities.org) was launched in May 2012 at the first EV Cities and Ecosystems Conference, which is a partnership among IA-HEV Task 18, Electric Vehicles Initiative, Rocky Mountain Institute, IEA, Clinton Climate Change Initiative, and the University of California, Davis (UCLA). The Web portal continues to add new cities and regions. Table 2 lists the cities currently on www.worldevcities.org (Figure 1).

Figure 1: The website www.worldevcities.org shows the latest localities added

Table 2: List of World EV Cities at www.worldevcities.org

World EV Cities as of March 2015	
North America	• Los Angeles Region • Maui • Montreal • New York City • Portland • Research Triangle • San Diego County
South America	• Santiago de Chile
Europe	• Amsterdam • Barcelona • Berlin • Brabantstad • Copenhagen • Hamburg • London • Northeast England • Northern Ireland • Oslo • Paris Region • Rotterdam • Stockholm
Asia	• Goto Islands, Nagasaki • Kanagawa • Kuala Lumpur • Shanghai • Shenzhen

Along with the Web portal, the EV City Casebook (Figure 2) 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 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.

6.4.3 EV City Casebook: 50 Big Ideas Shaping the Future of Electric Mobility

2014 saw the publication of a new EV City Casebook which highlighted examples of transformative policies, technologies, projects and business models. 50 Big Ideas were selected from an open call for nominations in February 2014, with the final casebook presented to the IA-HEV Executive Committee in Vancouver in Autumn 2014 (see Figure 2).

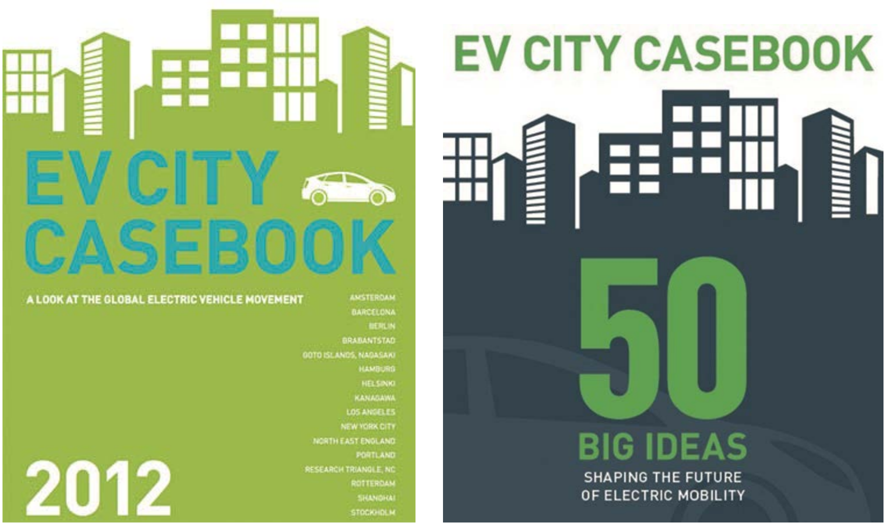

Figure 2: EV City Casebook available at www.ieahev.org and the "50 Big Ideas" Casebook which can be downloaded at www.urbanforesight.org/casebook.html

6.5 How to Participate

Task 18 was closed in November 2014.

6.6 Contact Details of the Operating Agent

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7 Life Cycle Assessment of Electric Vehicles (Task 19)

Members: Austria, Germany, Switzerland, United States

7.1 Introduction

Electric vehicles (EVs) have the potential to substitute conventional vehicles and to contribute to the sustainable development of the transportation sector worldwide. Task 19 examines the environmental effects of vehicles with an electric drivetrain based on life cycle analyses. It started in 2012 and will continue until the end of 2015.

There is an international consensus that the environmental assessment of electric vehicles can only be performed on a life cycle basis, including production, operation, and end of life by using Life Cycle Assessment (LCA) methodology (see Figure 1). For example, about 90% of the greenhouse gas (GHG) emissions of a vehicle running on renewable electricity from hydropower are associated with the production and end-of-life treatment of the vehicle, while only 10% are the result of the vehicle operation.

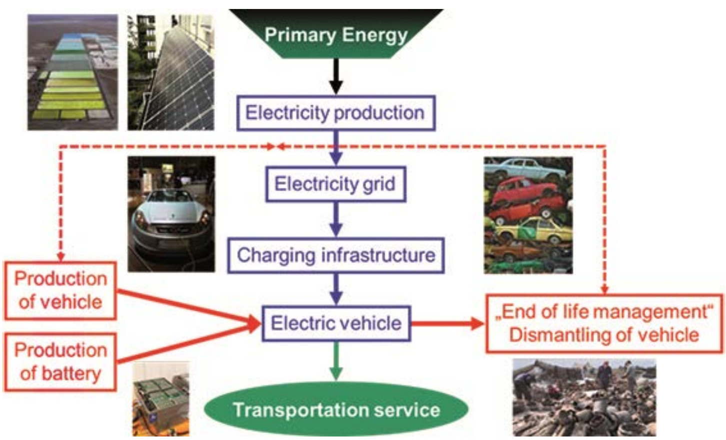


Figure 1: Assessment of LCA aspects over the full value chain. The LCA includes three phases: production, operation, and end of life. The blue boxes are the elements of the operation phase of the electric vehicle. The red boxes are the production (left) and dismantling phases (right) of the vehicle, and the dotted arrow indicates possible recycling.

7.2 Objectives

The main goals of this Task are:

- Provide policy and decision makers with FACTS on EV related issues
- Improve "END OF LIFE MANAGEMENT" by promoting best available technologies and practices
- Identify DESIGN for recyclability and minimal resource consumption
- Establish a "RESEARCH PLATFORM for life cycle assessment including end of life management for electric vehicles"

The Task is a networking activity, which means that the experiences from the national projects are fed into the IA-HEV LCA platform and discussed on an international level. The main topics addressed are:

- LCA methodology, e.g. system boundaries, and co-products handling methods
- Addressing frequently asked questions
- Overview of international LCA studies
- Parameters influencing the energy demand of electric vehicles
- LCA aspects of battery and electric vehicle production
- End of vehicle life management
- LCA aspects of electricity production, distribution, and vehicle battery charging
- Summarizing further R&D demand

The activities in Task 19 focus on LCA aspects of Battery Electric Vehicles (BEV) and Plug-in Hybrid Electric Vehicle (PHEV) for passenger transportation services in comparison to gasoline, diesel, and natural gas vehicles using current and future technologies.

7.3 Working Method

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

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

1. LCA methodology (setting of the system boundaries, modelling of recycling)
2. Overview of international studies on LCA of vehicles with an electric drivetrain
3. Influences on the energy demand of vehicles

4. LCA aspects of battery and vehicle production
5. End-of-life management (second life of batteries in stationary applications)
6. LCA aspects of electricity production, distribution, and charging infrastructure
7. Necessary and available data
8. R&D demand
9. Series of five workshops:
   - Workshop I: LCA methodology and case studies
   - Workshop II: LCA aspects of battery and vehicle production
   - Workshop III: End-of-life management
   - Workshop IV: LCA aspects of electricity production and infrastructure
   - Final event: Results of Task 19
10. Conclusions and outlook
11. Documentation: proceedings, reports, papers, notes, and presentations
12. Management and operation of the Task

The most important networking activity in this LCA platform is the organization of the five workshops in different member countries – the aim is to involve the different stakeholders in the EV value chain. The organization of workshops with participation from industry, research organizations, and technology policy experts provides an international basis for the exchange of information on relevant activities.

7.4 Results

7.4.1 Overview of Results

Contributors to this Task compile information from existing LCA analyses in order to complete a full picture of approaches to resource usage, recycling, and disposal at end of life with the associated environmental effects. This knowledge helps the EV-related industry, governments and research to increase the benefits and competitiveness of EVs.

The results so far are:

1. Task 19 has established an international Research Platform for LCA of EVs to further augment the benefits and competitiveness of EVs based on facts and figures reflecting LCA activities in IA-HEV member countries
2. So far four workshops were organised, and the key results are presented in the following paragraph

7.4.2 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 held 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/drawbacks
4. Generation of discussion on best practices in LCA methodology as applied to EVs
5. Establishment of “international platform on LCA of EVs”
6. Identification of key issues in LCA for EVs, the methodology, and its application (case studies)

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

1. Overarching/general and life-cycle modeling (including end-of-life):
    - Average/marginal approach
    - Allocation
    - Future technology development
    - Uncertainty of data and future data (important for interpretation of results)
    - Rebound effect (using green vehicles more often)
    - Policy impact (incorporate new efficiency standards)
    - Reporting and eco-labeling
2. Vehicle cycle (production – use – end-of-life):
    - Battery production (lifetime of battery)
    - Material production for EVs (lightweight material, electricity mix in production)
    - Energy consumption in use, including auxiliary energy (heating, cooling), user behavior (urban driving), and information about buyers of an EV or PHEV
    - End of life (including recycling for production “closed loop”)
3. Fuel cycle (electricity production):
    - Average/marginal mix
    - Connecting renewable electricity to EVs (storage)

- Charging behavior
- Vehicle to grid (for balancing)

4. Inventory analyses:
   - Battery data
   - Future technologies and mass production
   - Infrastructure (fast charging)
5. Impact assessment:
   - Greenhouse gases (GHGs) and cumulative energy are "standard"
   - Other impact categories necessary
   - Mid-point impact assessment, end-point damage assessment, and single scoring methods (external costs)
6. Reference system:
   - Gasoline and diesel current and future technologies (including biofuel blending)
   - Natural gas vehicles (potentially including new infrastructure)
   - Reference use of renewable electricity

7.4.3 LCA of Vehicle and Battery Production

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

The aim was to:

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 and presentation of LCA methodology and its application (case studies)
3. Review current assessments of life cycle impacts of battery and vehicle production
4. Identify the greatest sources of uncertainty and steps to improve analyses
5. Discussion of key issues to facilitate improvement of LCA application for EVs

The main results of LCA aspects in vehicle and battery production were summarized in 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 a future mass production of automotive batteries.

- The future development of automotive battery mass production.
- 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.
- The key elements of dissemination and communication strategies for LCA results were developed.

7.4.4 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^{th}-10^{th}, 2013. The workshop was co-located with the World Resources Forum 2013 (WRF 2013). The two-day program envisioned the 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 of 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 the recovery of critical metals from electric vehicles and to discuss a possible outline of a research strategy.

The main issues and statements discussed were:

- Is the focus of recovering and recycling of rare materials right on vehicles? Or do we have other more relevant waste streams from the society, e.g. computers, mobile phones?
- Aluminium is very much degraded by other materials, so the recovery of aluminium is of a low quality.
- A more flexible recycling system is necessary to recover rare materials from vehicles more efficiently.
- To make the data from vehicle manufactures available to the waste management sector might improve the overall end of life management system to recover rare materials.
- The vehicles are not designed for the recovery of materials today.
- Research must provide more information on 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 to manufacturing of vehicles to its end of life.

- To install an efficient recovery system economic and/or legal drivers are necessary.
- How to make recycling a key priority for car producers?
- New technologies are needed to recover and recycle rare materials most effectively in terms of costs and quality.
- A unique classification on relevant materials must be developed (e.g. by differentiating what is “rare”, what is a “critical” and what is a “strategic” material?).
- A global product responsibility of car manufacturers on their products is needed.

7.4.5 LCA Aspects of Electricity Production, Distribution and Charging Infrastructure

The fourth workshop “LCA Aspects of Electricity Production, Distribution and Charging Infrastructure for Electric Vehicles” took place in Barcelona, Spain on October 15^{th}-16^{th}, 2014. The aim of the workshop was to identify the key issues of electricity production, distribution, storage, and charging infrastructure by presenting, discussing and reviewing the international state of the art and future developments in applying LCA to vehicles with an electric drivetrain.

The source of electricity to operate vehicles with an electric drive train has a main influence on the environmental effects in life cycle assessment (LCA). The environmental benefits of electric vehicles by substituting for conventional fossil fuelled vehicles can be maximised by using a high share of renewable electricity (e.g. wind, photovoltaic, hydro or biomass). In addition, the electricity grid, the electricity storage, and the charging infrastructure have environmental effects that have to be considered in LCA as well.

The main topics are:

1. Connecting additional renewable electricity and loading strategies of EVs.
2. Environmental effects of current and future electricity production.
3. Vehicle-to-Grid – When does it make sense?
4. Modelling of electricity production for EVs.
5. Identification of key issues.

Within the 14 presentations, the 4 parallel sessions, and the discussion amongst the experts of 10 participating countries the following 6 main key issues on “LCA Aspects of Electricity Production, Distribution and Charging Infrastructure for Electric Vehicles” were identified and agreed upon:

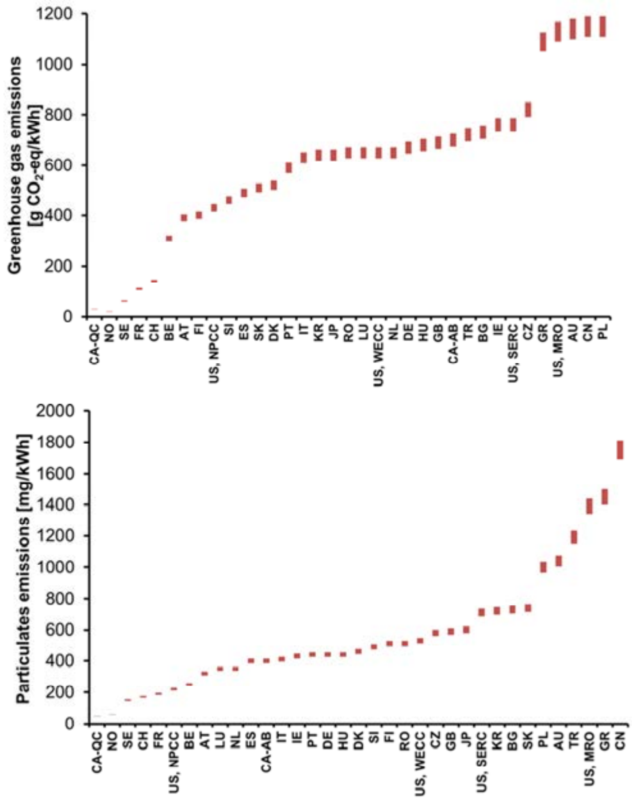


Figure 2: Possible GHG and PM emissions based on LCA of the current national electricity production mix in different countries

1. Electricity generation: The main influence on the environmental effects of EVs compared to conventional vehicles in an LCA is the type of electricity generation to drive the vehicle. Only a relatively low electricity consumption of the EV (> 15 kWh/100 km) or a relevant share of renewable electricity (> 40%) guarantees a significant reduction of environmental effects (e.g. GHG, PM cumulated fossil energy) from EVs. An adequate integration of additional renewable electricity in relation to the loading strategies of EVs is relevant in maximising environmental benefits. As the share of renewable energy grows – due to the national strategies in many countries – the environmental effects of electricity generation to power EVs (e.g. GHG and other air emissions including PM) will decline. Figure 2 shows the GHG emissions and the PM emission of the current electricity generation in different countries.

2. National electricity mix: The environmental effects of using the current national electricity production mix in various countries are a first relevant indicator on the possibilities to reduce environmental effects by using EVs instead of conventional diesel and gasoline vehicles. In most cases only additional renewable electricity makes it possible to realise significant environmental benefits; but the addition of renewables to the national grid is currently a rather political and economic issue.

3. Integration of fluctuating renewable electricity: The four main options of connecting renewable electricity with the loading of electric vehicles are the following (Figure 3):
   - "Direct connection": direct use of additional renewable electricity (PV or wind) for loading of EVs –the vehicle is only charged when the sun is shining or the wind is blowing –is more a theoretical than a practical solution
   - "Via storage": 100% of additional electricity (PV or wind) for vehicles is stored first in battery or hydro pump storage and then it is taken from the storage in accordance of the loading profile of the vehicle
   - "Stored in grid": 100% of additional renewable electricity (PV) for EVs is fed into the grid, which leads to the substitution of a thermal power plant using natural gas at that time, during the charging time of the vehicle the electricity is taken from the grid, in which the additional electricity is produced by a coal power plant
   - "Real time loading": e.g. 30% direct PV-electricity and 70% from the grid based on observations in an Austrian e-mobility model region, in which a part of the renewable electricity is directly used for loading when it is produced and the other part is produced from a fossil power plant in the grid

4. Energy consumption of vehicles: The energy consumption and emissions of real-world driving cycles (incl. auxiliaries like heating and cooling) of EVs and conventional ICEs strongly influence their overall environmental performance. In general the real-word energy consumption and emissions seems to be underestimated in many LCAs that use data from testing cycles advocated in regulations for the overall life time of vehicles (> 150,000 km). Additionally the consumer behaviour is relevant, and possible rebound effects should be taken into account, e.g. a "green powered" EV may be driven more often compared to a conventional ICE. But additional R&D is necessary to be able to identify or even quantify possible rebound effects of EVs. The current state of knowledge is still too poor to draw fact based conclusions predicting rebound effects.

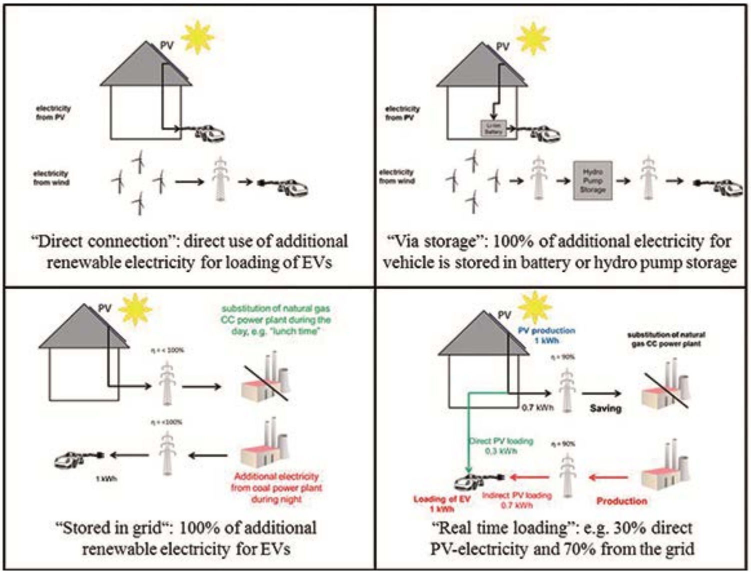
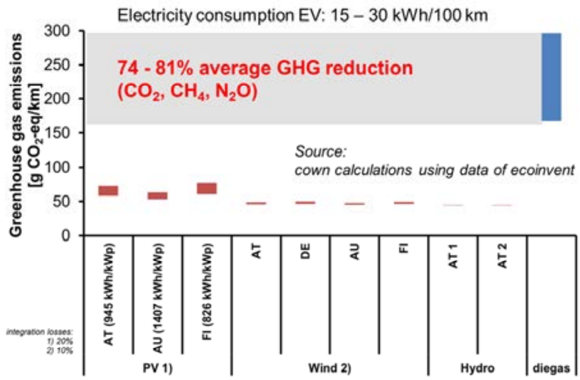


Figure 3: The four options of connecting renewable electricity with the loading of the electric vehicles

5. Database: As the electricity generation mix is changing relatively rapidly in some countries, e.g. PT, IR, regularly updating of basic data sets is essential. These updates will be even more valuable when they consider the import and export of electricity across international and regional (e.g., state/province) boundaries.

6. Communication of LCA results: In communicating LCA results to various stakeholders (e.g., LCA practitioners, automotive industry, electricity companies, government, NGOs) it is essential to provide factual and clear results that inform policy and research and development decisions. The LCA results should be presented in ranges to highlight the dependence of the environmental effects based on key LCA methodology assumptions and any limitations of the data source(s). The underlying LCA framework conditions that maximise EV environmental benefits should be identified and communicated. "No regret" strategies and actions must be identified for each country. If the country has a high share of renewable electricity, the implementation of EVs might lead to significant environmental benefits. On the other hand, if the country has still a high share of fossil and nuclear-based electricity actions, it should be first priority to implement additional renewable electricity production before implementing a broad market of EVs.

Figure 4 shows an example for the possible GHG and PM reduction based on LCA of BEVs using additional renewable electricity combined with adequately loading strategies in comparison to gasoline and diesel vehicles (“diegas”).



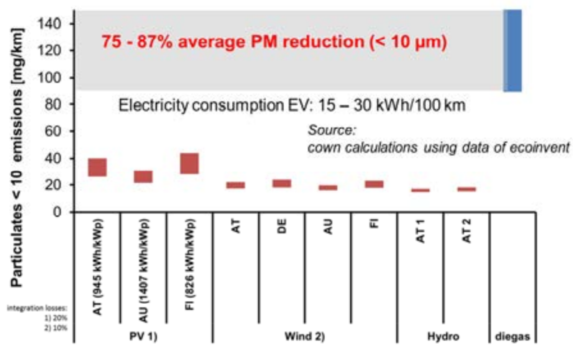


Figure 4: Example: Possible GHG and PM reduction based on LCA of BEVs using additional renewable electricity combined with adequately loading strategies in comparison to gasoline and diesel vehicles (“diegas”)

7.4.6 Dissemination Activities

The task activities are continuously presented and published at various events:

Jungmeier G., Dunn J., Elgowainy A., Ehrenberger S., Widmer R (2015) Environmental Benefits of the Worldwide Electric Vehicle Fleet in 2014 – A Life Cycle Assessment in Task 19 of the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV), Conf. Proc. PRES 2015, 28th Electric Vehicle Symposium, 2015; Barcelona, May 4th-7th, 2015.

Jungmeier G., Dunn J., Elgowainy A., Ehrenberger S., Widmer R. (2015) Environmental Effects of the Electric Vehicle Worldwide – A Life Cycle Assessment in Task 19 of the IEA HEV, Conference proceedings, IEWT 2015 – Energy Systems in Change: Evolution or Revolution, 9th International Energy Economy Conference in Vienna/Austria, February 11th-13th, 2015.

Jungmeier G. LCA to maximize environmental benefits of electric vehicles – Results of the LCA platform in IEA-HEV (2014), presentation at EV2014VÉ, Vancouver, Canada October 28th-30th, 2014.

Jungmeier G., Dunn J., Elgowainy A., Ehrenberger S., Özdemir D., Widmer R., Beermann M. (2014) Strategies to Maximize Environmental Benefits of Electric Vehicles Using Life Cycle Assessment in a Co-operation of 18 Countries in the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV), Conference Proceedings, TAP 2014 International Transport And Air Pollution Conference Graz/Austria, September 18th-19th, 2014.

Jungmeier G. (2014) Recent Developments in LCA of Electric Vehicles – Activities in the International Energy Agency (IEA) on Hybrid and Electric Vehicle, invited lecture, Conference “Electro Mobility: Assessing the Shift from Energy Efficiency to Material Efficiency in the Automotive Life Cycle”, Delmenhorst/Germany, June 16th-18th, 2014.

Jungmeier G., Dunn J., Elgowainy A., Gaines L., Ehrenberger S., Özdemirc E. D., Althaus H. J., Widmer R. (2014) Life cycle assessment of electric vehicles – Key issues of Task 19 of the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV), Conference Proceedings, TRA 2015 – 5th Conference Transport Solutions – From Research to Deployment, Paris April 14th-17th, 2014.

Jungmeier G., Dunn J. B., Elgowainy A., Özdemir E. D., Ehrenberger S., Althaus H. J., Widmer R. (2013) Key Issues in Life Cycle Assessment of Electric Vehicles – Findings in the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV); Conf. Proc. PRES 2013, 27th Electric Vehicle Symposium, 2013; Barcelona, November 17th-20th, 2013.

Jungmeier G. (2013) Strategies to maximize the environmental benefits of vehicles with an electric drivetrain – Results of life cycle assessment in an international context, 8th A3PS Conference “Eco-Mobility 2013”, October 3rd-4th, 2013, Tech Gate Vienna.

Jungmeier G. (2013) Life Cycle Assessment of Electric Vehicles, World Resource Forum Davos, Switzerland, October 9th-10th, 2013.

7.5 Next Steps

The final event of Task 19 will take place in Vienna, Austria on November 9th-11th, 2015 as part of the annual A3PS-Conference (www.a3ps.at).

The main topic areas are:

1. Results of Task 19 presented by the 4 participating countries (A, G, CH, US):
   - Wrap-ups of task 19 activities
   - Review of 100 LCA studies
   - Real world drive cycle of vehicles
   - LCA of electricity generation
   - Integration of renewable electricity and EVs
   - LCA of battery production and recycling (incl. recycling and sampling of metals for vehicles, controlling of material flows)
   - Scenarios, lightweight materials for EVs, EVs for urban applications technology development
2. Stakeholder discussion: “Communication of LCA results” with international stakeholders from government, automotive industry, NGO, e-mobility regions, electricity companies, and LCA experts
3. Presentations from “Call for contributions”
   - Environmental influences of social issues and user behavior, (e.g. noise)
   - “From LCA to LCSA (Life Cycle Sustainability Assessment)
   - Mining of metals (Co, Ni) e.g. human health effects
   - Resource efficiency of EVs e.g. criticality issues

7.6 Contact Details of the Operating Agent

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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8 Quick Charging Technology (Task 20)

Members: Germany, Ireland, Spain, United States

8.1 Introduction

Task 20 deals with quick charging (QC) technology. The Task was approved on November 11th, 2011, at the 35th IA-HEV Executive Committee meeting in Lisbon, Portugal, and plans to run through May 2015.

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

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

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

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

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

The main difference between quick charging and normal charging lies in the additional service for the customer. Smart quick charging that could enable the exchange of information between the electrical system operator and the customer such as energy cost and the demand curve could also become important. Consequently, companies that provide a service or equipment to the e-mobility market, e.g., telecom or ICT industries that enable communication between the EV and the electricity grid, shall also be taken into consideration within the discussion. Improvements in power electronics for onboard systems may open a new class of high power chargers. It is important to consider the electrical safety of charging processes, specially: DC current leakage, electrical safety at the vehicle inlet and at the charging station and earth quality verification. Currently, different improvements in fast charging are being considered worldwide. It is encouraged to exchange the different approaches and experiences collected so far.

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

3 Combo-2, IEC 62196-2/3 Type 2, IEC 62196-3 CHAdeMO, IEC 62196-3 China).

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

8.2 Objectives

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

A special focus will be on:

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

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

1. Current quick charging technology development trends worldwide;
2. Outcomes from the latest quick charging pilot projects and the issues to be resolved;
3. Lessons learned from past charging network deployment plans;
4. Impact of quick charging on PEV battery ageing and behavior;
5. Different charging infrastructure options (e.g., specific charging stations that can charge one or many cars in private or public locations);
6. Relationship between the energy efficiency and the charge power of the charging station;
7. Managing the trade-offs between the shortest time to a full charge and the charger cost;
8. The need for quick chargers and public charging stations to counter range anxiety;
9. Quick charging solutions that will help to popularize Evs;

10. Issues in the relationship (technical and socioeconomic) between the PEV and the grid, including power quality, tariffs, regulations, incentives, etc.;
11. Analyze and propose the best technical solutions for interoperability and the optimum use of the electric infrastructure already in place
12. How can emerging technologies (smart grids and EVs) join efforts to accelerate their market penetration;
13. Requirements and issues of quick charging technology for future smart grid promotion;
14. Designing and ensuring convenient, safe, and secure handling for consumers;
15. Future technology roadmap to help promote vehicle electrification.

8.3 Working Method

Task 20 bases its exchange of information and interactions on regular face-to-face meetings with the presence of key experts from the main QC stakeholders worldwide. After the kick off meeting in conjunction with the EVS26 held in L.A. US, and the two thematic meetings in 2013 in Japan (business models) and in Spain (interoperability), another meeting took place in Nice (France) from the 22nd to the 23rd of September 2014, jointly sponsored by Task 20 and Task 10 on Electrochemistry and in the framework of the International Batteries Congress 2014.

Task 20, Quick Charging Technology, held its fourth and last meeting in September 2014 with a focus on the effect of quick charging on batteries of Plug-in Electric Vehicles. Battery cost still remains one of the main barriers to be overcome to deploy quick charging technology for EVs. Further studies and recommendations are needed regarding the degradation and capacity to achieve a reasonable range, that will be required to satisfy the needs of different sized vehicles and different usage patterns. Batteries are expected to accept very high repetitive pulsed charging currents if regenerative braking is required and they must be designed to maximise energy content and deliver full power even with deep discharge to ensure long range. Through this meeting, both task 10 and 20 sought to identify smart and suitable innovations on this issue.

Specific topics discussed during the meeting are the following:

1. What Is Meant by Fast Charging?
   i. A fixed power, the same for all batteries?
   ii. A fixed C rate, power would vary with battery size?
   iii. A fixed recharge time?
2. How Much Energy Is Expected to Be Transferred by Fast Charging?
   i. A fraction of the battery’s capacity?
   ii. A “full charge”?

3. What Guidance Is Available to Guide Fast Charging?
    i. Automotive manufacturers?
    ii. Battery manufacturers?
    iii. Other parties?
4. How Is Fast Charging Affected by the Following?
    i. State of charge?
    ii. Temperature?
    iii. Battery chemistry?
    iv. Other parameters?
5. What Affect Does Fast Charging Have on Battery Performance?
    i. Calendar life?
    ii. Cycle life?
    iii. Power and energy?
    iv. Safety?

The meeting was also attended by a number of internationally acclaimed research groups, including the United States' Idaho National Laboratory, the National Research of Energy Laboratory, and the Argonne National Laboratory, Germany's DLR, the Spanish CIRCE, the UK's Newcastle University, and the European Commission's Joint Research Centre. Representatives from vehicle manufacturers, such as Ford and the Industrial Association for Charging under the CHAdeMO Protocol, also participated in the meeting. Finally, battery manufacturers were also present, including America's CSAGroup, BOSCH from Germany and Denmark's Lithium Balance.

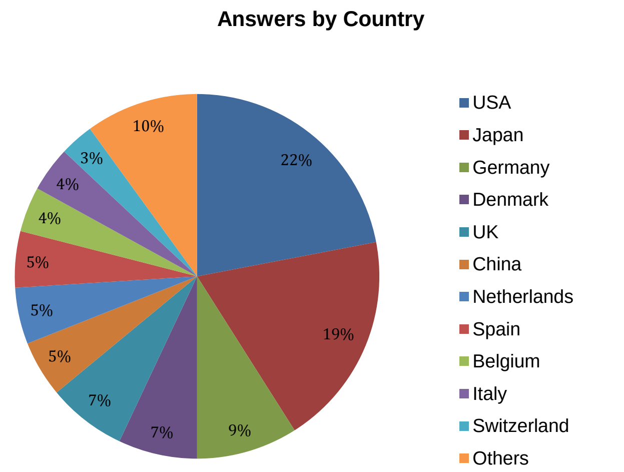
Furthermore, IA-HEV Task 20, Quick Charging Technology, has posted an online questionnaire[11] to solicit input from the electric vehicles (EV) community on the current status and future applications of QC technology. The survey covers potential business models for QC/DCFC as well as issues in its value chain, including charger infrastructure, OEMs, and interoperability, the impact of QC/DCFC on the electricity grid, and the anticipated timeframe for developments in technology and regulatory frameworks.

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

The information gathered will be analysed and incorporated into the final report for Task 20, but some preliminary results have been included in the following section. The aim of this survey is to hear from as many stakeholders as possible, which will

[11] http://www.fcirce.es/web/sites/IEA.aspx

allow Task 20 to identify all of the issues that will need to be addressed to enable QC/DCFC technology to succeed worldwide.



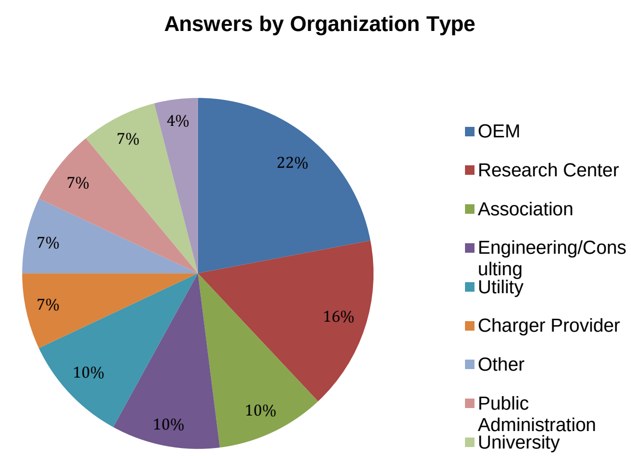


Figure 1: Distribution of the answers to the survey by country and type of organisation

So far, over 60 organisations from more than 10 different countries in Europe, Asia, and America have responded to the survey. These organisations cover all possible QC stakeholders: OEMs, charger providers, utilities, public administrations, academia, etc. The following figures show the distribution of these answers by country and type of organisation.

8.4 Results

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

8.4.1 4th Meeting of Task 20

The various studies carried out show that the batteries do not actually suffer more wear when charged with QC technologies than batteries used in other charging systems, which endure lower voltage rates or longer charging cycles.

Several studies assessing groups of EVs compare vehicles charged at “normal rates” (Level 2, or a maximum of approximately C/4) and vehicles using modern quick chargers. Significant battery degradation was observed in both test samples, but the difference between the groups tested is relatively small. Accelerated degradation could be correlated with other parameters such as elevated operating temperatures.

In the same line, studies with the focus on the combination of vehicle data and simulation calculations come to the conclusion that moderate use of fast charging, up to 10 times per month, does not seem to accelerate the rate of battery degradation significantly relative to Level 2 charging. In moderate climates (e.g. Seattle), the type of battery temperature management systems does not have any significant effect on the rate of degradation. In hot climates (Phoenix), active cooling offers significant benefits relative to passive cooling. Batteries being charged with a high ambient temperature and only passive cooling can reach undesirably high temperatures. If these batteries are fast charged under these conditions, temperatures may reach very undesirable levels.

However, quick charging of a lithium-ion battery at low temperatures can lead to lithium plating onto the negative electrode. This plating can result in a degraded performance and potential safety issues. Similarly, quick charging a lithium-ion battery at warm/hot temperatures (often defined as 40°C or higher) can result in an acceleration of the degradation of battery performance. To avoid such degradation, fast chargers and the vehicle control systems normally limit the rate of charging at temperature extremes.

Anyways, it has been made apparent that a battery management system (BMS) has to be worked on and that a charger should be designed that is sufficiently advanced as to “protect” the batteries and guarantee that they will work properly and suffer less wear.

To this end, battery management systems will need to be extremely precise and capable of detecting the battery’s condition. For instance, in hybrid quick-charging vehicles, batteries are never fully charged or discharged, which requires more advanced equipment, making them more complex and expensive.

In view of all these issues, the discussions during the last meeting clearly revealed that what the sector needs is a quick charging system where the chargers have the ideal power electronics and the battery management systems are run on sufficiently advanced communication protocols and structures. All these aspects are linked to the price, which in turn affects the battery’s control and charger design. Once again, this poses a challenge when it comes to developing a business model for all those involved in using vehicles that are charged in this way, including vehicle and charger manufacturers, energy supply companies, manufacturers of ancillary equipment and the like.

Technological solutions were also laid on the table, which are currently being researched in order to mitigate the impact of high and low temperatures on the performance of quick charging batteries.

Another of the issues covered in the discussions was that manufacturers lack a standard to define essential features in terms of battery safety and performance, which is further aggravated by the vast variety of batteries on the market. In response, it was decided that an international standard should be implemented to lay down the basic rules that are agreed on and proven effective in both aspects. This will establish a series of minimum parameters and thus provide both battery and vehicle manufacturers with the guarantees they need.

Lastly, it is of vital importance to include the battery design into the broader concept of mobility for the purpose of lessening costs and simplifying the business model. The fact is that battery performance is also affected by how the vehicles are used (i.e. by drivers), which means it is important to link their design to the specific use that will be made of them by consumers, a matter that varies by continent, country, social condition, availability of charging points, charge frequency and so on.

8.4.2 Preliminary Results of the Survey

The survey closed on January 2015 and the process of collecting and analysing the results has not yet finished. These results will feed the final report of the Task, due in May 2015. However, some preliminary results are outlined in this section:

- The survey showed that there is still a strong demand of public support to enlarge the number of quick charging points. The participants divided their preference between direct subsidies for installation and O&M costs and incentives at initial stage to be progressively decreased.

- Further work on interoperability and standardization is seen as the most relevant measure to foster the deployment of the QC. In this sense, the participants have been asked to identify the main areas for co-operation between OEMs and EV charger providers on standards for quick chargers; those areas are: communication protocols, standards for power and voltage, and paying methods.
- The use of storage and electric generation systems is considered the most promising solution to decrease the impact of the QC in the grid, together with adaptable chargers (either remote or autonomous managed). Other solutions, such us the improvement of power electronics is also very well valued and considered a much cheaper option (low increase of the final cost of electricity).
- In terms of power quality, the main barriers to be further studied are the power factor and the total harmonic distortion.
- On the future of some applications and uses for the QC, most of the respondents agreed that V2X systems using QC will stay in a research and innovation phase until at least 2020, and very likely 2025.
- There are mixed opinions concerning the possibility of having interoperable recharging infrastructures in the production phase before 2020, but it seems to be sure for the period of 2020-2025.
- Concerning the remote management of the chargers, there is consensus among the respondents: it will be in the R&I phase during 2015-2020 and in the production phase from then on.

8.5 Next Steps

The final report of the Task will be presented in Korea for the 42nd ExCo HEV-IA. This report will give an update on the current status and future trends of the quick charging technology on the basis of the discussions and other activities carried out during the life of the Task. This information should help standards bodies, industry and governments to realize the benefits and improve the competitiveness of vehicles with an electric drivetrain.

8.6 Contact Details of the Operating Agent

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

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

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9 Accelerated Ageing Testing for Li-ion Batteries (Task 21)

Members: Italy, Switzerland, United States

9.1 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. The work plan of the Task is under revision to allow for an update of the technical part and a possible extension to other electrochemical lithium storage technologies with the identification of new testing procedures.

9.2 Objectives

One key objective of Task 21 is to conduct an inventory of worldwide efforts used in the development and the 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 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:

1. Comparison of international Li-ion battery ageing procedures
2. Experimental verification of Li-ion batteries in international laboratories
3. Reduction of costs associated with testing

9.3 Working Method

Initially, Task 21 was aimed at facilitating communication and co-operation 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.

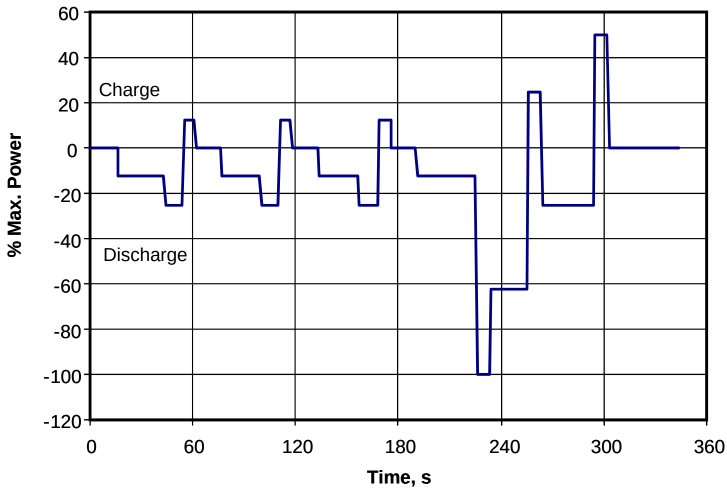

Figure 1: Dynamic stress test profile of the USABC test procedure

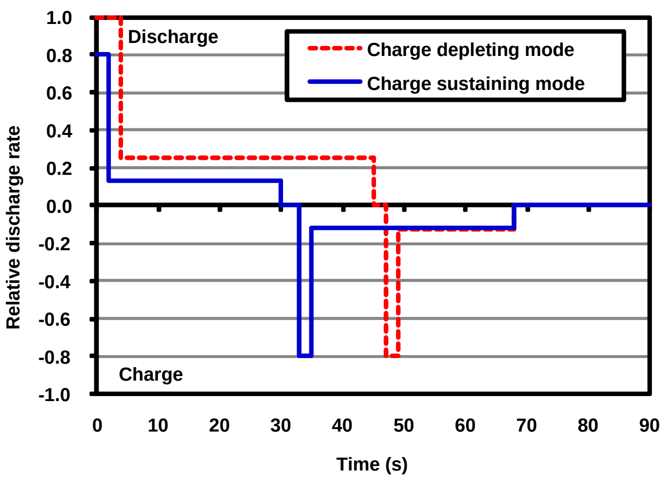

Figure 2: General CLT (Cycle Life Test) profile for PHEV battery developed at Japan Automobile Research Institute – JARI

Furthermore, Task 21 members, after a possible extension to the potentially interested new members, will agree upon a coordinated testing plan, with the revision of the initial one, 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. The revision under consideration will look at different lithium cell chemistries.

Figure 3: ENEA testing facility for electrical testing (Image courtesy of ENEA)

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 enlarged after the first year of joint testing activities to the possibilities of developing a general accelerating testing procedure with the capacity to estimate accelerating factors and effective degradation with reduced testing efforts.

9.4 Results

A preliminary survey of testing procedures at an international level was carried out in the preparatory phase of this Task with the selection of three experimentally verified procedures developed in Europe, Japan, and the United States.

9.5 Next Steps

The ongoing process is a complete revision of the initial work plan, with possible integration for additional funding with some European projects, and diffusion among IA members for the extension of membership. Immediately after the general agreement, an operative Task meeting will be organized in the first half of 2015 for the final distribution of activities and the effective start of the testing work.

9.6 Contact Details of the Operating Agent

New members are welcome to join the Task. There is a small fee for participation, as part of the common fund. 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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10 E-Mobility Business Models (Task 22)

Members: Belgium, Germany, United Kingdom, United States

10.1 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 which 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.

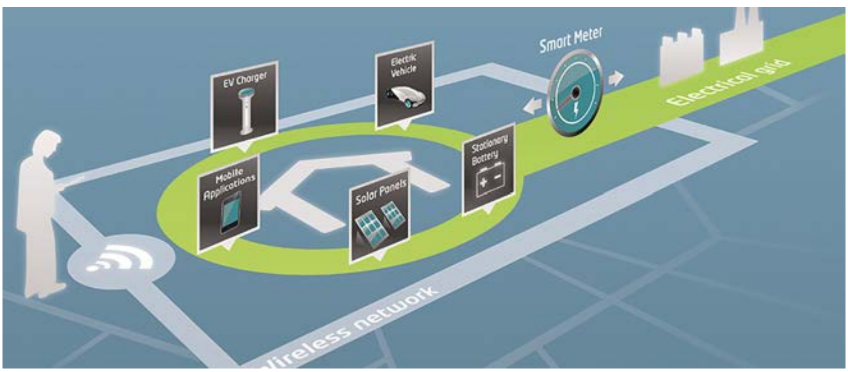

Figure 1: The EV-value chain offers profitable opportunities for businesses to build a solid foundation for EVs to enter the mass market (Image courtesy of Volkswagen)

10.2 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 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 realisation of new revenue streams through a third party or ancillary services.

The second area is ways to enhance user experiences, encompassing developments which make operation of EVs more convenient, desirable, and rewarding. This 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 recognises that failure to develop these products and services could delay the growth in markets for EVs and limit adoption to niche applications.

10.3 Working Method and Results

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. 15 papers were selected for publication in a book which was released in early 2015 as part of Springer's Lecture Notes in Mobility series (Figure 2). It presents commentary and case studies from experts in eleven different countries from across five continents.

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.

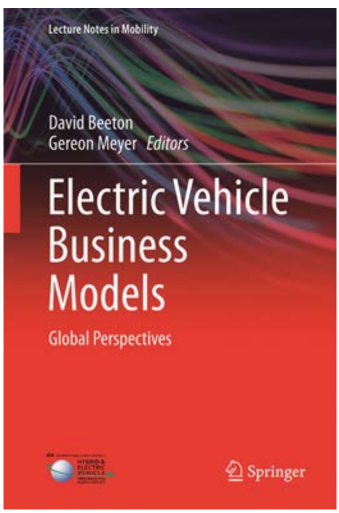

Figure 2: Electric Vehicle Business Models: Global Perspectives, Series "Lecture Notes in Mobility" (published 2015, Springer, Cham, Switzerland)

10.3.1 Financing and Sponsorship

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.

10.4 Next Steps

Task 22 is currently investigating opportunities to organise 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.

10.5 Contact Details of the Operating Agent

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11 Light Electric Vehicle Parking and Charging Infrastructure (Task 23)

Members: Belgium, Germany, Spain, Turkey

11.1 Introduction

The rapid growth in recent years in the usage of light electric vehicles (LEVs) including electric scooters (“e-scooters”), electric bikes (“e-bikes”), and especially the hybrid pedal/electric bike called the pedelec, requires addressing issues related to parking and charging infrastructure. This includes the development of harmonized charging standards which are embedded in a public parking space management solution. Task 23 seeks to ensure that these issues are addressed at a governmental level, so that the outcome is as applicable as possible to both local and global policies. Task 23 will also encourage the development and establishment of both pedelec sharing schemes and private pedelec usage.

11.2 Objectives

11.2.1 Representing the Interests of Local Governments in Standardization

The Task is following up the IEC/ISO/TC69/JPT61851-3 standardization activities which started the development of harmonized international standards for LEV charging and parking infrastructure, based on the Mandate of the European Union No. 468 published in the year 2010. The standardization group on Light Electric Vehicle standardization (system architecture, infrastructure, interfaces, batteries) is mainly driven by members coming from the following countries: Japan, Switzerland, Germany, Italy, Austria, China, USA, and from time to time additional participants from further nations. Participating parties who take part regularly are from the following companies: Yamaha, Honda, Suzuki, KTM Motorcycle, Piaggio, BMW Motorcycle, Bosch eBike Systems, and EnergyBus.org.

A key objective of Task 23 is to discuss the specific requirements from the governmental side (especially at the local level) as regards LEV charging and parking infrastructure, and deliver these requirements to the IEC/ISO/TC69/JPT61851-3 committee. This is to be done by the operating agent

EnergyBus.org, which is also leading the IEC/ISO/TC69/JPT61851-3 committee and the German mirror group with its key personnel.

11.2.1 Blueprint for Public Tenders for LEV Infrastructure

When IEC/ISO/TC69/JPT61851-3 is published as a TS (Technical Specification of the IEC), which is scheduled to happen within 2015, the next step will be to create a blueprint for public tenders, with reference to the IEC/ISO/TC69/JPT61851-3 standard for acquisition of public infrastructure, for parking space management for two-wheelers, and for charging infrastructure, which could be used for all kinds of two-wheelers, such as mechanical bicycles, combustion engine motorcycles, electric scooters, electric bicycles of all kinds, including both public rental two-wheelers and private vehicles. Such tenders would also include a section on the requirements and specifications of bicycles, pedelecs, and electric scooters for public use.

11.2.2 Creating Events for Information Exchange on LEV Infrastructure

The Task is organizing events such as expert workshops and conferences, on the subject of LEV infrastructure, involving governments, city planners, public transportation experts, operating companies, consumer organizations, standardization bodies as well as the vehicle and infrastructure industries.

11.2.3 Best Practice Sharing Study Trips

The Task is gGathering experts at locations where local governments have established successful LEV infrastructure systems, and sharing findings and summarizing the positive and negative experiences – distilling the findings into easy-to-follow recommendations.

11.2.4 Publications with Recommendations on LEV Infrastructure

The Task is reating publications summarizing key findings and listing recommendations on how to establish the most suitable LEV infrastructure.

11.2.5 Promoting the Needs to Potential Suppliers

The Task is making joint presentations at relevant trade shows and conferences, and explaining the use of suitable methods, the requirements for local governments of potential manufacturers and providers of LEV infrastructure and rental vehicles.

11.3 Working Method

Members of Task 23 can participate in events such as best practice sharing study trips, conferences (such as the LEV Conference, which was held on the 2nd and 3rd of October 2014 during the Intermot trade show in Cologne, Germany). They may also host their own local events on the subject of Task 23, and invite international experts to share their insights. They may create tenders and joint tenders with other cities or regions for LEV infrastructure. They may create supplier lists, and share experiences with suppliers and their products, with other local governments and operators interested in acquiring similar components.

11.3.1 Task 23 Members and Potential Members

It started with Antwerp (Belgium) and Barcelona (Spain), followed by Istanbul (Turkey), and talks about active involvement in Task 23 have subsequently been conducted with various local governments and stakeholders from around the world. To name just a few: Malta, the DIFU Institute representing most German cities, Karlskrona and Växjö (Sweden), Hangzhou (China), Taichung City (Taiwan), Kyoto and Osaka City (Japan), Copenhagen (Denmark), Warsaw (Poland), Graz & Bregenz (Austria), Indonesia, Delhi (India), Munich, Frankfurt, Cologne, Münster, Rostock, Hannover, Berlin, Merseburg, Tegernsee (Germany), Grenoble (France) – and that is just listing the most significant talks. To date, the active phase including the preparation of the blueprints for tenders to acquire LEV infrastructure has not yet started: this is expected to happen by October 2015.

11.4 Results

A central event for the Task 23 was in 2014 the E-Bike Award which was handed over in a ceremony to the winner, the Gobike company from Copenhagen, Denmark, which has developed a very innovative pedelec rental system and implemented it in Copenhagen as well as in Trondheim Norway. It was the first bicycle rental scheme which does cater the commuters and the tourists with a single approach and does earn money even if it was quite expensive in its development. This pedelec could be truly understood as a single seater public transport device which merges into the offerings like local train, tramway, bus, and waterbus at Copenhagen.

The Gobike system is station-based, but it can also offer a free-floating service. It does not require complicated stations with a user interface for registration. Each pedelec comes with an iPad-size, built in, ruggedized tablet computer which allows immediate establishment of a user account. All pedelecs are continuously online via a built-in GSM connection.

Figure 1: 1st Prize of the E-Bike Award 2014 within Task 23

Figure 2: The Gobike system installed in Copenhagen

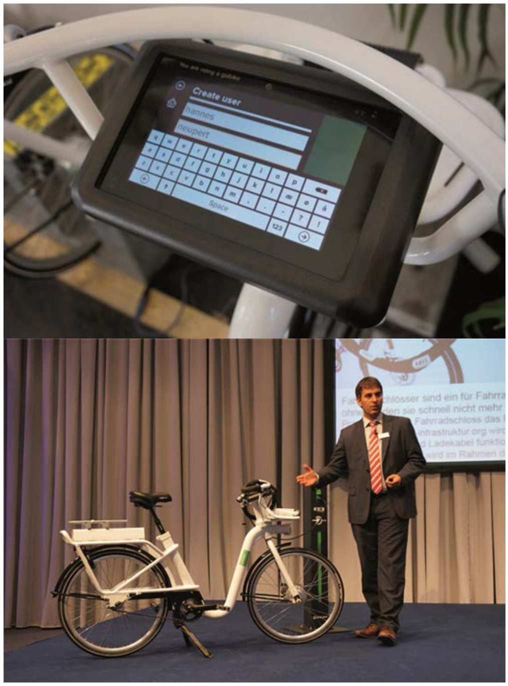

Figure 3: Mr. Hannes Neupert from EnergyBus.org presenting the Gobike at the LEV Conference organized in October 2014 in Cologne, Germany

A cost driver of the Gobike system installed in Copenhagen is still the specific, non-universal parking and charging interface which had to be installed all around the city.

At the LEV Conference, which was organized within Task 23 on October 3rd, 2014, Hannes Neupert of EnergyBus.org presented a proposal to separate the ownership and business models for public rental pedelecs from the infrastructure, which would then necessarily follow a universal standard. This would permit public LEV infrastructure to be paid for by renting and managing the public space according to political preferences by, for example, varying costs according to owner groups, vehicle type and time of the day, or by imposing additional demand-driven peak charges which might be used to influence the uptake of some of the city’s more welcomed transport modes.

Figure 4: The EnergyLock solution for many urban issues

Between the years 2011 and 2013, the first functional version of the EnergyLock was tested in the Tegernsee region, Germany. The idea was proven to work. But a clear finding was that the locking system, based around a heavy duty locking mechanism and a steel-reinforced cable, was considered as too heavy by users. This necessitated a complete reconsideration of the anti-theft concept. As a result, the mechanical safety layer was downgraded to a mild level, whereby the locking action is just good enough not to be unlocked easily by manual force, but it will pop open before it is damaged when pulled strongly. The anti-theft function is moved to the digital realm, where all electronic components on the pedelec will deactivate themselves in the event of unauthorized disconnection. This would make removing a vehicle very unattractive for a thief.

On March 18th, 2015, the next generation of the EnergyLock was presented to the public for the first time as a working model at the Taipei Cycle Show 2015. It was received enthusiastically. It is based on discussions held within the IEC/ISO joint project team on LEV Infrastructure in November 2014 in Taiwan and Japan, as well as in Germany in December 2014. It has changed on the electrical side, too: instead of 6 conductor contacts it now has just 2 or 3. CanOpen communication, and transfer of the 12V auxiliary voltage, is transferred to an induction-based system which is not sensitive to corrosion.

The female socket would always be of a universal shape. But the male plug attached to the vehicle would be available in 3 different versions, catering appropriately to the specific needs of all 3 types of two-wheelers. This would allow a single infrastructure to cater for all types of two-wheelers: the system can be used both to manage the use of public space for two-wheeler parking, and to provide free two-wheeler electrical charging. Charging power can be up to 6,000 Watts in the case of the 3 pin 120V/60A connector version intended for large electric scooters and electric motorcycles.

Figure 5: Lock & Charge female socket available for various kinds of two-wheelers

11.6 Next Steps

The further acquisition of members, cities, and regional governments is important to create as large a public tender base as possible for the procurement, with high purchasing and negotiating power, of LEV infrastructure and LEV rental fleet solutions.

11.7 Contact Details of the Operating Agent

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12 Economic Impact Assessment of E-Mobility (Task 24)

Members: Austria, Belgium, Denmark, France, Germany, The Netherlands, Switzerland, United States

12.1 Introduction

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

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?

12.2 Objectives

The introduction of electric mobility can create a lot of new economic opportunities. Governments are anxious to stimulate economic growth in their own region, but to be able to develop good supportive policies and to assess their impacts, it is necessary to have a good look on the local e-mobility sector. This raises a number of questions: How is the value chain for e-mobility defined? Which actors are active in which 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 a 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 like turnover/production volume, employment, export volume, 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 the 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 in new mobility concepts that are increasingly multi-modal and partly based on sharing concepts (instead of vehicle ownership). In Belgium this is called "networked and shared mobility". In addition, Task 24 will mainly focus on 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.

12.3 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 3 subtasks (partly overlapping in planning):

1. Development of a common methodology for the economic impact assessment (duration: twelve months)
2. In each participating country, collection of data on the agreed indicators (duration: nine months)
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. Good use will be made of the SharePoint facilities of the IA-HEV website. In conjunction with the ExCo meetings, task meetings will be organized to discuss and present work progress in more detail.

It is recognized that data collection and comparisons will be challenging, because many different organizations collect different types of data, and not all indicators will be possible to be collected in the same detail to feed into the economic impact assessment.

12.4 Results

A kick-off meeting was held in Copenhagen (Denmark) at May 20th, 2014. The outline of the Task was presented by the operating agents and details of the work (such as the preferred methodology and indicators) were discussed with participants who were interested to join in the Task. It was discussed that environmental and health benefits of e-mobility could also be interesting to include in this study. It was decided, though, to keep the focus on economic indicators.

Every participating country has since then collected relevant reports on the economic impact of e-mobility in their region and on the e-mobility value chain. These reports will be uploaded to the SharePoint server and the work of making summaries of relevant information will be divided among the participants.

At the Task meeting in Vancouver (Canada) on October 22nd, 2014, some first value chains were discussed. Further work is ongoing to fine-tune the complex e-mobility value chain, so it can be used as the common basis for other subtasks. Also some initial results from a patent study on European and international patents in the field of e-mobility were presented at the meeting. Patents give information on the R&D that is performed in a country on certain subjects. It is not a direct indicator of the number of jobs in the industry, but it does indicate industrial activity in the field that could lead to more jobs.

12.4.1 Patents in the Field of E-Mobility

The Netherlands Patent Office, a department of the Netherlands Enterprise Agency, performed a query on all patents in e-mobility requested at the European Patent Agency and the World Intellectual Property Office, in the period of 2005-2012 (patents are secreted for 18 months so data cannot be very recent). The following specific subsectors in e-mobility were distinguished in the study: drive trains, battery information systems, battery management, batteries, fuel cells, charging infrastructure, navigation, and smart grid.

Some subsectors showed a steep increase in the number of patents:

- Charging infrastructure
- Smart grids
- Batteries

The subsector of fuel cells, however, shows a steep decrease. The number of patents has been dropping since 2006.

Some results on patents from the participating countries in Task 24 are presented in figures 1 and 2. This query also gives the possibility to draw up lists of companies who filed for patents in the different subsectors.

The database used only gives information on patents that are requested for in Europe or worldwide. Patents that are only requested for in North-America (as many companies seem to do) are not included.

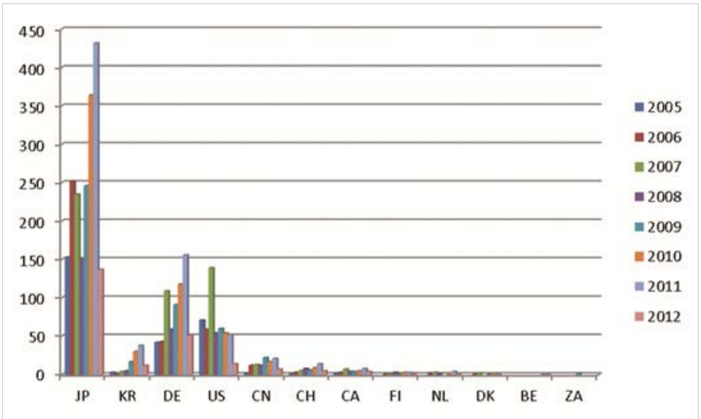

Figure 1: Number of patents in the drive trains subsector for selected countries (Netherlands Enterprise Agency)

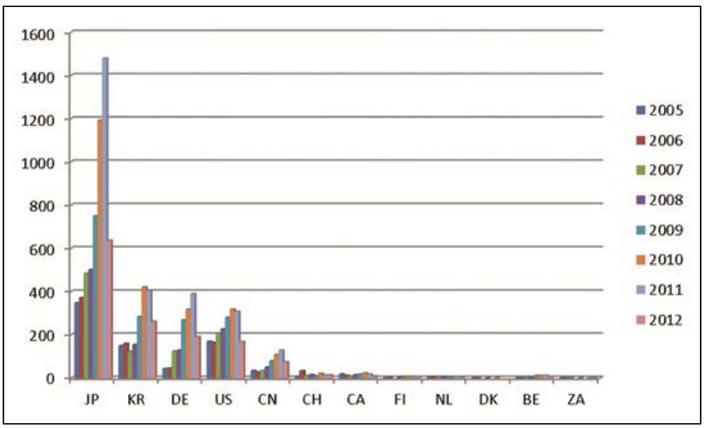

Figure 2: Number of patents in the batteries subsector for selected countries (Netherlands Enterprise Agency)

On the base of a further analysis of the data, it is researched whether a benchmark on strengths and weaknesses for participating countries can be done. We also try to get information to benchmark this patent data on e-mobility for all requested patents.

12.5 Next Steps

A Task meeting for participants only will be held in the spring of 2015 (March/April), to discuss and agree upon the common value chain, the methodology used, and the process of data collection.

In conjunction with the ExCo meeting in Gwanju (Korea) in May 2015, another Task meeting will take place where intermediary results will be presented and further arrangements for data collection and analyses will be made.

We strive to present some first results of the data collection and analyses at the ExCo meeting in autumn 2015.

Countries who are still willing to join, can do so after contacting one of the operating agents (see below). The methodology itself is almost set, but a new country can still participate in the data collection/analyses and their data will be part of the overall benchmark.

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13 Plug-in Electric Vehicles (Task 25)

Members: France, Germany, Republic of Korea, United States

13.1 Introduction

With increasingly stringent CO_2 fuel economy regulations, the number of electrified vehicle options available to customers from car manufacturers has significantly increased in recent years. However, the market penetration of these vehicles significantly varies based on the powertrain configurations as well as the policies of the countries. To better understand the potential impact of current and future Plug-in Electric Vehicles (PEVs) on vehicle energy consumption, technology cost, cost of ownership and market penetration, a task force was formed by the Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). Task 25, Plug-in Electric Vehicles (PEVs) looks at current and future vehicle energy consumption, cost, levelized cost of driving (LCD), and market penetration of all vehicles with a plug. The task is composed of five integrated sections: vehicle energy consumption, component cost, vehicle cost, total cost of ownership (TCO), and market penetration.

13.2 Objectives

Objectives associated with vehicle energy consumption are:

- Compare full-function HEVs, PHEVs, and ER-EVs to advance conventional powertrains (clean diesel, turbocharged direct injection petrol, CNG, other)
- Include a wide range of powertrain configurations (i.e. BEV with and without multi-gear transmissions, BEVx…)
- Evaluate the technology potential on both standard and real world driving cycles

Objectives associated with Component Cost, Vehicle Cost & Total Cost of Ownership (TCO) are:

- Conduct a systematic cost methodology comparison (i.e. battery, multiple TCO models)

- 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
- 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

Objectives associated with Market Penetration are:

- Conduct a systematic market penetration methodology comparison using the same set of inputs
- Using consistent methodologies, evaluate potential causes of increase in market(s) size, such as rising oil prices, lower battery pack costs, economical infrastructure adaption, and changes of consumer perception
- Evaluate policy alternatives to increase market(s) size
- Taxes at initial purchase, annual fees, fuel/electricity tax
- Subsidy structures and quantities

13.3 Working Method

Costs of ownership of hybrid and electric vehicles have been examined under IA-HEV Task 15 which indicated that certain hybrid configurations may be more economical to own than others, but relatively simple models of ownership costs were used. More comprehensive metrics for ownership costs have been developed to compare the economics of different drivetrain vehicles in different markets. Extending the previous work of this task, this report examines the TCO for four different powertrains in three different countries for the year 2020. TCO are calculated for four different use cases, showing a variation of the vehicle's service time and yearly mileage. The objective is to show the competitiveness of PEVs and the influence of (monetary) policy measures in terms of the consumer's ownership cost.

13.3.1 Vehicle Simulations

Passenger cars of different powertrain configurations and component technologies were simulated using Autonomie. The powertrains included are:

- Conventional spark-ignited (SI)
- Conventional compression-ignited (CI)
- Plug-in hybrid electric vehicle (PHEV), with SI combustion engine and a 32 km charge-depleting range
- Battery electric vehicle (BEV) with a 160 km range

Vehicles technologies, in terms of cost of performance, are intended to be representative of vehicles that will be offered for sale in the year 2020. Each vehicle was sized to meet similar performance criteria (including acceleration and gradability). Vehicles were then simulated under the Urban Dynamometer Driving Schedule (UDDS), Highway Fuel Economy test (HWFET), and the New European Driving Cycle (NEDC) in order to estimate the fuel economy under each driven cycle. To represent on-road fuel economy under conditions relevant to U.S. driving, the UDDS and HWFET fuel economies were combined in accordance with the U.S. EPA/NHTSA “derived MPG-based formulas” used to report combined, adjusted (“window sticker”) fuel economy values based on the UDDS and HWFET values. The vehicle energy consumptions were calculated according to the standard test procedures of each country. The characteristics of the four vehicles are listed in Table 1.

Table 1: Vehicle characteristics (note: the PHEV was modeled with a split powertrain with blended operation in CD mode).

		Conv SI	Conv CI	PHEV	BEV
Vehicle mass	kg	1,393	1,456	1,541	1,437
ICE power	kW	114	99	82	
Electric motor 1/2 power	kW			60/47	101/0
Battery capacity, rated	kWh			8.6	32.0
Vehicle manuf. cost	USD $_{2010}$	14,618	16,708	19,556	20,876
Of this, Battery pack manuf. cost	USD $_{2010}$			2,140	6,921
Fuel consumption, adjusted, UDDS/HWFET	MJ/km	2.629	2.274	1.013	
Electricity consumption, adjusted, UDDS/HWFET	MJ/km			0.283	0.739
Fuel consumption, NEDC	MJ/km	2.145	1.816	0.644	
Electricity consumption, NEDC	MJ/km			0.257	0.564

13.3.2 Relevant Cost of Ownership

The TCO considers all costs to a customer related to the purchase and operation of a vehicle during its service time. The exact definition of the TCO varies greatly. Hence, Mock specifies a measure of vehicle ownership costs that are relevant to a consumer’s purchase decision. This cost measure is termed as relevant cost of ownership (RCO). The RCO may be reported as a cost (net present value e.g, in dollars) or, as is done here, in cost per km.

The RCO includes the investment cost (C_{Invest}), the up-front amount paid for the vehicle, including the purchase price and any fees, taxes, and incentives or disincentives (e.g., tax credit or bonus/malus “feebate”). Also relevant are all operating costs, which include the costs of fuel/energy (C_{Energy}), maintenance and repair (C_{Maint}), and any annual fees or taxes (C_{Fees}). Furthermore, a resale or residual value (V_{Res}), depending on a vehicle’s age and total mileage, is considered. The RCO (C_{RCO}) is the sum of the investment cost and the present value of the annual costs subtracted by the expected residual value. Other cost factors, such as insurance, risk aversion to new technology, and uncertainty of benefits of advanced technology to consumers are not included. Also not included is the cost of the limited range of the BEV (160 km). These might be important influences, but they are subjective, widely variable among consumers, and difficult to quantify. However, neglect of the effective cost of the range limitation of the BEV might result in ownership cost estimates that appear low in comparison with the other powertrains.

RCOs were calculated for different powertrain options of a midsize passenger car (EU segment: D), using data and methods described below for energy prices and driving cycles relevant in France, Germany, and the U.S. For the U.S., RCOs were calculated for two regions: the ten states that offer the most generous incentives for PEV purchase, as identified by a recent study of state incentives, and the remainder of the U.S.. The ten US states offering the most valuable incentives are: Arizona, California, Colorado, Georgia, Hawaii, Illinois, Louisiana, Pennsylvania, South Carolina, and Washington.

$$C_{RCO} = C_{Invest} + \sum_{t}^{N} \frac{\left(C_{Energy,t} + C_{Maint,t} + C_{Fees,t}\right)}{(1+i)^t} - \frac{V_{Res}}{(1+i)^N} \qquad (1)$$

$$C_{RCOperkm} = \frac{C_{RCO}}{N \cdot M} \qquad (2)$$

where

N	=	ownership period, years
i	=	interest rate
$C_{RCOperkm}$	=	relevant cost of ownership per km
M	=	annual mileage in km

An interest rate of 1% was used here, representing a real, risk-free rate. Consumers often assign a low value to future energy savings, which can be represented as a high effective discount rate. Rather than vary the interest rate, we examine two ownership periods, 4 and 12 years, to represent two different consumer perspectives of savings and costs.

13.4 Results

13.4.1 Relevant Cost of Ownership

The RCO in USD 2010/km for the four markets France, Germany, U.S. non-PEV states, and U.S. PEV states is shown in Figure 1 for the reference case oil price. The upper two plots (a) and (b) show the RCO values for a 12-year ownership period, and the lower two plots (c) and (d) show RCO values (narrow, dark bars) for the 4-year ownership case, taking residual value into account (shown as negative). The bars in Figure 2 show the RCO disaggregated into costs per km of investment, energy, maintenance, repair and annual fees (M&R&F), and battery replacement (for PEVs). Uniformly, across all results displayed in Figure 1, initial investment cost comprises the largest portion of RCO (followed by residual value, in cases where it is relevant). Annual costs comprise a smaller portion, especially over short time horizons, and more specifically, annual costs associated with maintenance, repair, and fees comprise a larger portion than energy. The battery replacement cost (PHEV and BEV) is the smallest component, except for the BEV in the U.S.

Comparing RCOs between countries, PEVs compare favorably with conventional drive vehicles in France and the U.S. (in both PEV incentivized and other states); whereas, in Germany, the favorable PEV RCO may depend on battery replacement. In the case of a 12,000 km yearly mileage and a twelve year ownership period shown in Figure 1 (a), PEVs have lower RCOs in France and in the U.S. states with the most generous incentives ("PEV" states).

At 20,000 km per year, relatively efficient if more expensive vehicles travel a greater number of miles over which to amortize initial investment cost and accrue per-mile energy savings, so, accordingly, in the 20,000 km/a shown in Figure 1 (b), PEV RCOs are lower than those of conventional vehicle RCOs in all countries. It should be noted that the effective cost of the limited range of the BEV (160 km) was not included in this analysis. Depending on driving needs and the variability of driving distances, it may not be feasible for some drivers to use a limited-range BEV 20,000 km per year.

The influence of battery replacement costs is modest for the PHEV, but sufficient to increase the RCO for the BEV to slightly higher than that of the PHEV in Germany. Longer-life batteries can make PEV with large batteries more economical to own.

In the cases of a four year ownership period, the RCO, shown in Figure 1, shown in (c) and (d) as dark, narrow bars, is strongly influenced by the residual value. The residual value was taken to be a fraction of the investment cost (purchase price including taxes and fees minus incentives), and is therefore higher in France and Germany than in the U.S. In addition, the residual value is reduced by purchase incentives, which has the effect of reducing the influence of incentives on the RCO of PEVs. However, resale values that increase with the purchase price also decrease the influence of the higher cost of PEVs on RCO, which is notable for Germany, where having no incentive for PEVs show high investment costs and residual values for PEVs. Therefore, despite the higher purchase prices of PEVs, they show lower RCO values for a four year ownership period.

Residual values for PEVs are uncertain since the used market for these vehicles is only beginning, and resale value data in this nascent market is limited and may not be representative of residual value retention of PEVs in the year 2020.

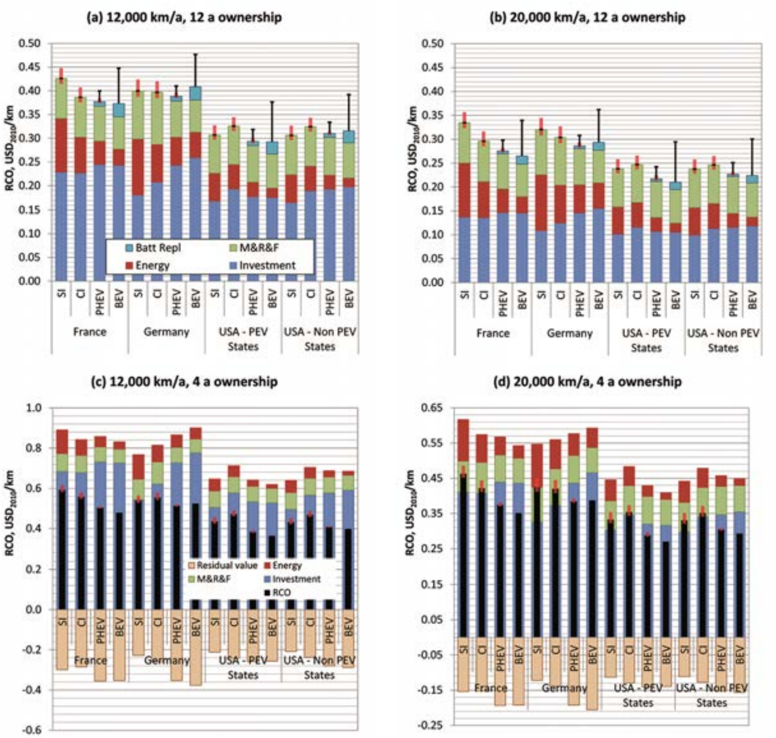

Figure 1: RCO for the four powertrains in the four regions estimated for (a) 12,000 km/year and a 12-year ownership period, (b) 20,000 km/year and a 12-year ownership period, (c) 12,0000 km/year and a 4-year ownership period, and (d) 12,000 km/year and a 4-year ownership period. Red error bars indicate ranges of RCO under a range of crude oil prices, and black error bars in (a) and (b) show the ranges of RCO with a 30% increase in battery prices. Dark, narrow bars in (c) and (d) show the RCO (the sum of all the components).

13.4.2 Policies

In order to examine effects of policy instruments such as tax rates, fees, and incentives in the three countries, the RCO values were further disaggregated to show pre-tax investment and fuel costs and taxes, fees for energy and vehicle purchase and ownership, and incentives. These disaggregated RCO values are shown in Figure 2 for the case of 12,000 km per year and a twelve year ownership period. The stippled areas of bars show the pre-tax portion, and the hatched areas show the portion due to taxes and fees. Taxes on maintenance and repair and on battery replacement are not shown. The hollow portion at the tops of bars shows the portion due to incentives (the bonus in France and tax credits and other incentives in the U.S.). The total height of the bars, including the hollow portion is the RCO without incentives.

Taxes and fees and the incentives per vehicle-km vary widely between the three countries for each vehicle. The difference in RCO values due to incentives for PEVs is apparent from the hollow portion at the tops of the bars for the PHEV and BEV. Incentives in the U.S. are specifically for plug-in vehicles having a battery capacity greater than 4 kWh, which is the case for the PHEV and BEV considered here. In France, where the bonus-malus system applies to all powertrains, the dependence on CO_2 emissions per km favors the BEV. In Germany, there are no purchase incentives for PEVs. The large incentives in the U.S. lower the RCO of the PEVs to just a little higher than that of the conventional SI vehicle in non-PEV states and lower than the conventional vehicles in the PEV states. Pre-tax energy costs are higher in the U.S. than in France or Germany due to the lower fuel efficiency estimated for the U.S. – due to the more aggressive driving cycle (adjusted, combined UDDS/HWFET) – than for Europe (for which the NEDC was used). The NEDC fuel efficiencies used here may not be realistic in light of the evidence, that actual on-road fuel consumption in European driving can be significantly higher (by more than 30%) than the values measured in the NEDC.

In France, even though the bonus/malus incentives are less than the incentives in the U.S. PEV states, they are sufficient to decrease the RCO of the BEV to lower than the other drivetrains. The high RCO for SI vehicles in France is in a large part due to the large taxes and disincentives, in particular the large malus premium. This is not as high for CI vehicles which, being more fuel efficient, also have lower fuel costs per kilometer.

In Germany, despite the lack of incentives, the RCO of the PEVs is not much higher than the conventional vehicle RCO, owing to the higher fuel efficiency (lower energy costs per km), lower annual fees for PEVs, and in particular, high fuel taxes. Electricity tax in Germany (including fees for electricity distribution and due to the Renewable Energy Act) is relatively high, contributing to a slightly higher RCO for the PEVs.

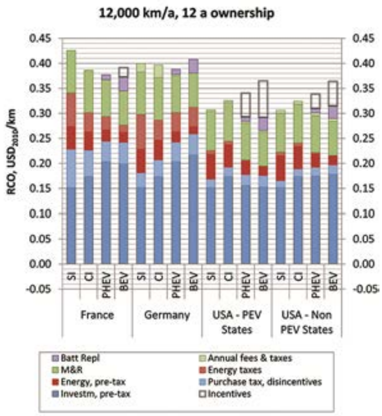

Figure 2: RCO for the four powertrains in the four regions estimated for 12,000 km/year and a 12-year ownership period, disaggregated into pre-tax and tax portions, showing the RCO for no incentives (top of hollow areas) and with incentives (top of filled areas).

Annual fees and taxes on vehicles contribute smaller amounts to the RCO, but these are significant in Germany, where they are higher for SI and CI vehicles than for PEVs.

Carbon dioxide emissions per vehicle-km were calculated from the fuel consumption of each vehicle under the two drive cycles. These were compared with approximate carbon dioxide emission targets for the U.S. and the EU. The U.S. target for year 2020 is for a midsize car with a 46 ft^2 footprint (the product of wheel base and average track width) is 171 g CO_2/mi (133 g CO_2/km). This was adjusted upward by 25%, since adjusted fuel economy values were used to calculate the CO_2 emissions. Based on current legislation, an EU target for 2020 of 95 g CO_2/km was assumed.

The conventional vehicle emissions exceed the targets, while the PEVs are well below. Although targets are not standards (standards are set for automakers' fleets, not individual vehicles), this indicates that significant shares of PEVs in a fleet of vehicles can help the fleet to meet the standards, given the estimated fuel economies of the conventional vehicles.

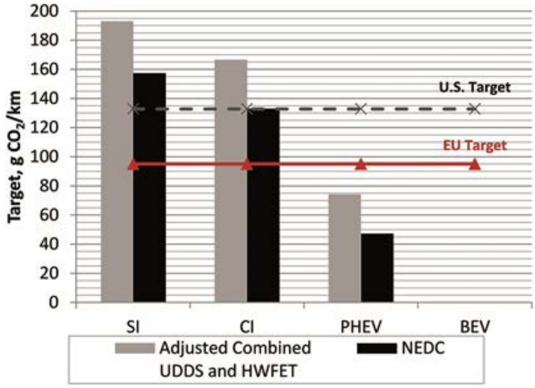

Figure 3: Carbon dioxide emissions per vehicle-km from the four powertrains under the US (adjusted, combined UDDS and HWFET) drive cycle and the NEDC drive cycle. Approximate targets for the year 2020 are shown for the U.S. and the EU.

13.4.3 Conclusions so far

The relevant cost of ownership of conventional vehicles and PEVs were estimated for the year 2020 for France, Germany, and the U.S. The components of RCO ranked by importance are initial investment cost, residual value, maintenance/repair/fees, energy costs, and possible battery replacement costs.

Within all three national contexts, longer ownership periods and greater annual mileages proved more favorable to PEV RCOs, due to the greater distance over which to amortize initial investment cost and accrue per-km energy savings. Additionally, examining CO_2 emissions shows that PEVs can contribute to meeting emissions targets in Europe and the U.S..

A sensitivity analysis revealed relatively small RCO changes due to oil price uncertainties, but showed that PEVs can still provide some hedge against oil price volatility – and potentially critical RCO changes due to battery technology sensitivities, wherein high-cost batteries yield unfavorable electric-drive RCOs in all cases.

This novel, internationally comparative RCO framework offers a foundation on which to build future analyses, including additional relevant powertrain configurations (i.e., gasoline-powered hybrid vehicles, battery electric vehicles with range extenders, etc.), more detailed consideration of real-world driving cycles and patterns, vetting RCO market implications with real-world PEV sales, and even the expansion of the study into other countries (with unique policies and markets).

13.5 Next Steps

The study so far has focused on the analysis of TCO for a specific vehicle class (midsize car). Future investigations will include a larger number of vehicle classes as well as the market penetration of the different technologies for multiple geographical areas.

The planned deliverables and outcomes of Task 25 include the following:

- A database including vehicle energy consumption, component characteristics and cost for multiple powertrain configurations, and timeframes on standard driving cycle
- Recommended practice methodology to assess total cost of ownership (TCO)
- Comparison of market penetration methodologies
- Assess the potential of advanced vehicle technologies from an energy, cost, and market penetration point of view for multiple geographical areas (i.e. EU, US…)
- Analyze results & summarize in a report

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14 Wireless Power Transfer for Electric Vehicles (Task 26)

Members: Denmark, Germany, Sweden, Switzerland, United Kingdom, United States

14.1 Introduction

The wireless charging of plug-in electric vehicles (EVs) offers the promise of untethering EVs from their charger cables and potentially reducing the size of electric vehicle (EV) batteries if the vehicles can be charged while in motion in the future. Research groups in industry, academia, and in national laboratories around the world are working to improve wireless power transfer (WPT) technologies so that EVs can charge by parking over a coupling device (referred to as static charging), by charging at natural stopping points but not parking (referred to as opportunity charging), or even while the vehicle is in motion (called dynamic charging).

However, the standards for WPT appear to vary in different member countries, or no standards currently exist, which limits the interoperability among systems and slows the maturation of this technology. This task aims to develop a greater global understanding of WPT systems and interoperability through a focused study of WPT technologies being developed in the participating countries. Topics covered by this task include a study of country-based standards (JARI, SAE, ISO/IEC), technical approaches, grid interactions, regulatory policy, and safety codes for WPT. The focus of the task does not extend to bidirectional charging but does include provisions to gather information on both passenger vehicle and commercial vehicle applications.

14.2 Objectives

The Task will coordinate a study of various country-based standards, technical approaches, grid interactions, regulatory policy and safety codes for WPT for EVs and address interoperability, data security, and safety. The cataloging and comparison of standards (JARI, SAE, ISO/IEC) in areas such as power transfer, center frequency, alignment, and communications will occur. In addition there are many fields of interest in WPT that this task might address. Areas considered will be broad as task gets underway and narrow in focus as meetings progress. As there is an ongoing effort in many of these objective areas, the objectives are:

- Categorize deployment approaches and requirements for WPT technologies such that participants develop an understanding of what challenges are faced in different countries or markets and what it takes to put this technology into the field in these markets
- Compare the characteristics of WPT systems being developed in the participating countries, and discuss how to address interoperability concerns
- Catalog, discuss, and compare standards for WPT in different countries (JARI, SAE, ISO/IEC, etc.)
- Discuss and summarize safety issues in regards to misalignment, leakage fields, and debris tolerance and response
- Begin cataloging potential grid impacts associated with higher levels of wireless power transfer

14.3 Working Method

The Task will conduct bi-annual meetings and support conference calls, which may include viewing locations of WPT research or deployment activities to gain first-hand knowledge of how this technology is progressing and to inform the committee of new work. Based on information gathered from participating countries, specific areas may be identified as critical interest for off-line research.

14.3.1 Process

The process for how this task will operate is as follows;

- Develop an understanding of the challenges faced in various countries or markets by categorizing deployment approaches and requirements for WPT technologies
- Conduct comparison of current WPT technology development and address interoperability concerns for both static and dynamic systems
- Catalog and compare standards (JARI, SAE, ISO/IEC) in areas such as power transfer, center frequency, alignment, data security, and communications
- Summarize safety issues arising from misalignment, leakage fields, and debris tolerance and response
- Catalog potential grid impacts with higher levels of WPT
- Establish a repository for the data collected and links to other activities available to the members of the task

14.4 Results

Task 26 is a new IA-HEV task. Results will be reported in subsequent IA HEV Annual Reports and other publications. This year the task met with interested member countries in October 2014 as part of the ExCo meetings and in December 2014 via telecom.

14.5 Next Steps

This task will hold its first workshop in May 2015 in conjunction with EVS-28. Two workshops a year are anticipated as show in Table 1.

Table 1: Draft meeting schedule for Task 26

Special Topic	Anticipated Dates	Location/Host
Loading Applications	May 2015	Seoul, Korea (EVS-28)
Power Levels	Fall 2015	TBD
Interoperability	Spring 2016	TBD
Safety Concerns & Conclusions	Fall 2016	TBD
Summary Report Generation	Spring 2017	TBD

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15 Electrification of Transport Logistic Vehicles (Task 27)

Members: Austria, Germany, The Netherlands, Turkey, United Kingdom

15.1 Introduction

Road freight transport is one of the fastest growing modes of transport and has an increasing share in the total greenhouse gas (GHG) emissions of transport. Worldwide, road-freight activity and energy use have almost doubled in the last two decades [IEA 2012]. Furthermore, higher gradients are observed for freight emissions compared to passenger travel emissions for most of the IEA countries [Eom et al. 2012]. Various technical and non-technical options exist for reducing the GHG emissions of road freight transport, such as improving the efficiency of freight logistics or fuel consumption performance of vehicles. Currently the concentration is mainly on incremental technology developments to reduce fuel consumption of conventional vehicles. However, there may be potential for (near) zero tailpipe emission vehicles that could result in the large-scale GHG reduction that is needed.

15.2 Objectives

The aim of Task 27 "Electrification of Transport Logistic Vehicles (eLogV)" is to:

- summarize the status of vehicle and infrastructure technologies, implementation, and hurdles
- identify early niche markets and commercialization opportunities
- provide policy recommendations for further research and deployment activities

The focus of Task 27 eLogV is on electric road freight transport vehicles and on related charging/fueling infrastructure. This includes:

- vehicles of class N1 to N3 (range of gross vehicle weight: <3.5 tons up to 40 tons)
- battery electric technology coupled with conductive, inductive charging infrastructure or battery-switch stations
- hybrid electric technology (coupled with catenary charging)
- fuel cell trucks coupled with hydrogen fueling stations
- transport tasks and distances focused on urban and conurbation areas

Other non-road electric transport systems (e.g. city-trams, warehouse logistics) as well as infrastructure in terms of logistics (e.g. logistic terminals), and supporting traffic systems (e.g. telematics) may be subject to complementary overviews.

15.3 Working Method

The working method comprises workshops, desk work and public outreach. Figure 1 illustrates the proposed working method of the Task in order to perform the objectives described above. In general, the Task should be reflecting a networking activity by the exchange of information and answers to questions from participating members.

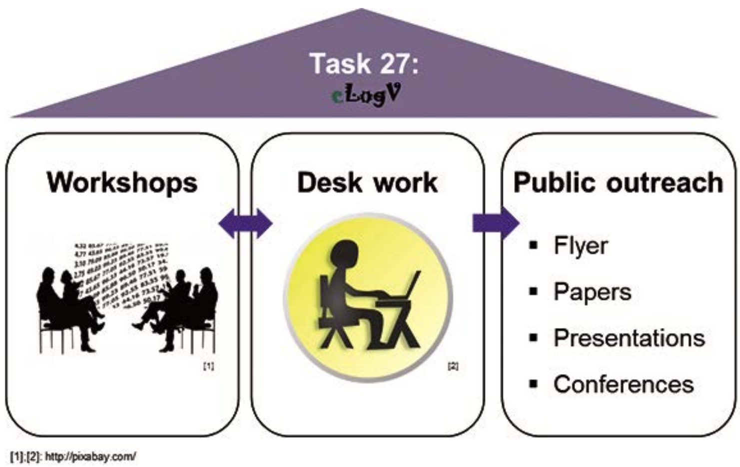

Figure 1: Task 27 working method

For the workshops, external experts will be invited from industry, research organizations, and technology policy institutions around the world to refer to and discuss about the topics of consideration. The desk work consists of review and analysis of documents and data, providing information and assistance to pre- and post-processing operations. The working results will be discussed in workshops and conferences, and will be published in papers and a final report.

Participation within the Task will be free of charge. However, the Task is based on a work sharing principle and in kind contribution is expected.

15.4 Results

A Task 27 information session was held in Vancouver (Canada) on October 24th, 2014. The purpose of the information session was to present the work plan in detail including Task 27 objectives, key questions addressed, and next steps. The information session was well-attended with several external participants.

The work plan of Task 27 is finalized. Furthermore, a Task 27 flyer is prepared and distributed in several conferences including IAA commercial vehicles-2014. The flyer is available to download at the IA-HEV – Task 27 website[12].

15.5 Next Steps

The first Task 27 workshop "Electric transport logistic vehicle technology and its application" will be held in Stuttgart (Germany) on March 19th, 2015. Dedicated topics at the workshop are:

- the state of battery and fuel cell technology for transport logistic vehicles
- experiences from demonstration projects in Germany - benefits and challenges
- hurdles of implementation and possible solutions

In order to allow for effective discussions, the attendance at the workshop is limited and by invitation only.

Furthermore, the first conference paper from Task 27 is submitted to EVS 28 (May 3rd-6th, 2015 in South Korea). In this paper, a techno-economic assessment of battery and fuel cell electric transporter will be presented for Austrian, German, Turkish and South Korean conditions.

15.6 Contact Details of the Operating Agent

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[12] http://www.ieahev.org/tasks/e-logistics-task-27

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References:

[Eom et al. 2012] Eom, J.; Schipper, L.; Thompson, L.: We keep on truckin': Trends in freight energy use and carbon emissions in 11 IEA countries, Energy Policy 45 (2012) 327-341, 2012

[IEA 2012] International Energy Agency, Energy Technology Perspective 2012, Pathways to a Clean Energy System, OECD/IEA, Paris 2012

16 Home Grids and V2X Technologies (Task 28)

Members: Denmark, Spain, Switzerland, United States

16.1 Introduction

The IA-HEV Executive Committee (ExCo) unanimously approved this new Task at the Executive Committee meeting in May 2014 held in Copenhagen. It is expected to continue through the end of 2016. This Task will explore the technologies and accompanying issues associated with the use of electric storage from plug-in electric vehicles (PEVs) for uses other than powering the vehicles. Customers may use their PEV electric storage capabilities for other applications such as vehicle-to-grid (V2G), vehicle-to-home (V2H), vehicle-to-load (V2L), and vehicle-to-vehicle (V2V). The characteristics of these applications include the following:

- **V2G:** Electric utility may be willing to purchase energy from customers during periods of peak demand, and/or use the EV battery capacity for providing ancillary services.
- **V2H:** Use of the PEV as a home generator during periods of electrical service outage and for increasing self-generated renewable energy usage.
- **V2L:** Use of the PEV storage to provide power to a remote site or load what does not otherwise have electrical service. Examples include construction sites or camp sites.
- **V2V:** Use of the PEV storage to transfer electrical energy to other PEVs in case of emergencies.

These four applications are known as Vehicle to Everything (V2X), a term that represents the strategic technology for ensuring sustainable, secure, and cost-effective deployment of electro-mobility.

16.2 Objectives

Task 28 aims to address the technical and economic knowledge gaps preventing V2X technology to fully deploy.

The initial Task objectives are as follows:

1. Analyze the technical and economic viability of V2X technology, specifically, give responses to a number of identified questions.
   - When will V2X be available as a consumer application?
   - What are the potential synergies with self-generated electricity in households?
   - What is the value provided by V2X in terms of security of supply?
   - Which impact is to be expected on tax revenues?
   - Which are the roles of the different industry players?
   - What is the impact of the different regulatory frameworks in different countries?
2. Develop a set of best practices by connecting and synchronizing the existing V2X research and demonstration projects.
3. Develop a policy-making toolbox and a technology roadmap definition in order to serve decision makers seeking to introduce V2X technology in their respective countries.
4. Establish a worldwide technical information exchange platform enabling information sharing among scientific institutions and industrial representatives working in V2X issues.
5. Promotion of new V2X technology demonstration projects.

Special attention will be put on the V2H concept as one of the most promising applications of V2X technology. V2H technology holds a high potential for energy cost reduction by means of enabling energy arbitrage and increasing an on-site renewable energy generation capacity while improving security and quality of the supply.

The gained knowledge and results of such analysis can be used by policy-makers and industrial partners in the promotion of the V2X technology as well as by different players on the EV market within their market research and business modelling.

16.3 Working Method

The overarching objective of Task 28 is to investigate the means of overcoming the technical, economic, and policy challenges of V2X technology. The whole V2X value chain will be considered in this process including power system operators, power electronics industry stakeholders, and the most relevant original equipment manufacturers (OEMs).

Utilizing the existing IA-HEV framework, Task 28 will provide the opportunity to bring together the key actors in the EV industry including research and industry players and energy policymakers in order to discuss the requirements for the development and the use of V2X technology. Two annual meetings on different strategic topics are planned (See Section X.5 Next Steps for Workshop specific content). By leveraging the technical skills and different experiences of the participants, it will be possible to improve the currently available market analyses of V2X technology.

In addition to expert workshops; a close relation and coordination with other HEV IA Tasks (such as Task 22, 18, 20, and 10) and major V2X technology players is planned in order to connect existing V2X research and demonstration projects.

The promotion of new V2X technology demonstration projects will be done by collaborating with international organizations and a call for proposals.

The policy-making toolbox and technology roadmap will be based on a preliminary cluster exercise based on typical country specific systems and regulatory frameworks.

16.4 Results

Task 28 held a half day workshop on user requirements, business models, and regulatory framework of V2X technology in Vancouver, Canada, on October 27th, 2014, immediately prior to the EVI V2X Workshop. There were about 16 international attendees, mainly from Canada, the US, and Europe. They were a good mix of representatives from research centers, universities, the industry, and decision makers active in V2X activities.

The intended outcomes of this session included: user requirements, current and future business models and the existing regulatory framework of V2X technology. The workshop attendees addressed these questions through a combination of technical presentations that were concluded by a round table on identified V2X regulatory challenges. Main results from this workshop were shared afterwards with a wider international audience attending the EVI V2X Workshop.

16.4.1 EV User Requirements

Users will be driven by the total cost of ownership (TCO) of a transport mode. V2X technologies can bring down TCO by a number of added value services that EVs can deliver (e.g. TOU rate arbitrage, emergency power, demand charge avoidance, etc.), but only if proper regulation is put in place.

The ease of use for different technologies is an essential requirement for EV users. They need education and engagement programs to understand the impact of their driving behavior in battery performance as well as the opportunities to maximize their benefits via V2X activities. Warranty implications of V2X activities are an essential factor for EV users as they will have a direct impact on their TCO.

In addition to the technical and economic factors, EV users might be concerned about privacy issues and cyber-security.

16.4.2 Business Models

The viability of different business models and use cases for V2X technologies are directly dependent on country regulatory frameworks and local specificities. A number of cases are presented to exemplify this:

- US driving patterns do no match the use of EV for renewable energy self-consumption (charging with excess PV generation during the day and discharging during the evening). Net metering policies do not support the development
- Strong Government incentives in Japan for V2H systems for emergency backup power. In May 2012, NISSAN launched LEAF to home in Japan and developed a charge/discharge bidirectional inverter
- V2G opportunities benefit from a better environment than other V2X activities in US regulations. Power availability benefits ($/MW) are higher than utilization benefits ($/MWh)

For a business to take advantage of value streams associated with V2X, the standardization of the different concepts included in V2X technology is required (e.g. communications, interoperability, etc.).

European grid codes are moving in the right direction for V2X business models to become viable. It was concluded that mandatory services to balance the grid (e.g. not remunerated automatic primary regulation provision), existing in a number of countries for synchronous power generating modules, should be avoided for V2X business to become viable.

16.4.3 Regulatory Framework

A number of barriers were identified for V2X business to be deployed:

- Limited payback for V2H applications in the US (for a rate arbitrage application, most US customers lease vehicles and would need paybacks in fewer than 3 years; for a backup power application cheaper generator alternatives exist)
- In V2G applications, it operates in wholesale markets which are fluid and paybacks are uncertain

- Energy storage in 2014 was very competitive and may rend V2X opportunities financially not interesting
- Need to characterize the impact on batteries of different applications and understand warranty implications
- Split the incentive problem: the power system could benefit from V2G technologies while OEMs may face the liabilities
- Vehicles need to meet utility and the aggregators' interconnection requirements.
- EV has not been defined yet as a storage energy resource

There are broad variations in V2G regulations (different building, electric and residential codes and standards, different procedures for permitting), utility services and policy structures within different regions in the US, rendering V2G deployment difficult. Non homogenous permit fees are bringing uncertainty to the business modelling and representing a market barrier. The importance of working towards common practices and nationally approved standards is evident.

Regarding international and regional technical standards for the V2X technology, it is worth to note that they should take into account the power electronic features that ancillary services will require (e.g. time of response, utilization, etc.). Additionally, in order to move towards a regulatory framework allowing VX2 technology to fully deploy, market players and demonstration projects should be exempted of certain technical regulations to encourage trial and error.

A new stakeholder appearing in the V2X market is the so-called EV aggregator. The aggregators will have the fundamental role of presenting an EV fleet as a unique entity to the TSO when participating in V2G applications. The paper of an EV aggregator for V2G applications is necessary because of a number of reasons: a unique EV does not have sufficient power capacity to contribute to frequency regulation services, the TSO need to ensure the reliability of their reserves and a unique EV cannot assure its full time connection and finally, TSOs do not have sufficient connection means to connect to individual EVs[13].

16.5 Next Steps

The work in Task 28 may continue until October 2016. The following subtasks, corresponding to the next workshops, focuses on the technical challenges that V2X technology may face:

- Workshop II in the second quarter of 2015 (Switzerland): "V2X and the power system" will include topics such as:

[13] P. Codani, M. Petit, Y. Perez, "Participation d'une flotte de véhicules électriques au réglage primaire de fréquence". Symposium de génie électrique (SGE'14), 2014.

- V2X integration into power and energy markets
- Communication protocols and standards
- Interfaces design and interoperability

- Workshop III in the first quarter of 2016 (US): “ Bidirectional chargers” will include topics such as:
  - Control, metering and connectivity standards
  - Power electronics topologies and cost comparison
  - Energy efficiency and security

- Workshop IV in the second quarter of 2016 (Denmark): “V2X enabled EVs” will include topics such as:
  - Effects of usage profiles on a battery lifespan
  - Improved models of battery degradation for V2X
  - Market potential as a function of mobility patterns

Subtask 5, conclusions and policy recommendations, to be finished with a final workshop at the end of 2016, will present the outcomes of the technology roadmap and a policy-maker toolbox.

The final subtask will include dissemination activities to promote V2X technology.

16.6 Contact Details of the Operating Agent

IA-HEV member countries confirm their participation by signing a notification of participation and by delegating a country expert for the Task. Non-member countries may participate on the basis of a sponsor special agreement that would be negotiated with the Operating Agent and ratified by the IA-HEV ExCo.

Task 28 is coordinated by Miguel Cruz from IREC (Catalonia Institute for Energy Research) which is a referent research center within the energy sector in Catalonia.

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17 Overview of Hybrid and Electric Vehicles in 2014

The country chapters provide numbers for 2014 sales and fleet totals for EVs, PHEVs, and HEVs. Table 1 shows the fleet totals for HEVs, EVs, and PHEVs over the last three years. Numbers for 2012 and 2013 have been taken from the previous IA-HEV reports. It should be noted that some countries have reported numbers for passenger cars only in the past, whereas others have indicated the sizes of fleets including motorcycles, quadricycles, buses, trucks, and industrial vehicles. This has not been changed for 2014, a unified representation of the statistics may be considered for the future, though.

Since final statistics for some countries were not available on time, Table 1 will be updated accordingly and made public over the IA-HEV website www.ieahev.org.

Table 1: Actual or estimated (estimates in italic) electric vehicle (EV + PHEV) and hybrid electric vehicle (HEV) populations in IA-HEV member countries, as of December 31st of each year that is shown (exceptions are noted).

	HEVs			EVs and PHEVs		
Country	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
Austria[a]	8,125	10,504	12,823	2,965	2,070	3,386[b]
Belgium	20,636	25,553	31,579	3,467	4,446	6,700
Canada[a]	108,190	130,823	143,917	2,591	5,712	10,778
Denmark	1,593	2,599	3,706	2,118	2,083	3,393
Finland	2,500	3,915	11,772	224	489	945
France[a]	84,000	130,785	173,520	9,939	19,561	30,121
Germany[a]	65,491	85,017	107,754	15,350	22,698	18,948[b]
Ireland	6,781	7,745	*8,746*	408	393	*550*
Italy	34,789	49,719	69,310	21,798	57,178	*56,289*
Netherlands	88,627	106,918	117,353	7,431	30,229	46,121
Portugal	2,500	n.a.	n.a.	1,429	n.a.	n.a.
South Korea	n.a.	n.a.	n.a.	n.a.	n.a.	*2,000*
Spain	44,649	54,170	62,850	6,523	8,816	11,444
Sweden	24,000	n.a.	35,000	1,285	2,677	8,253
Switzerland	28,056	34,883	40,577	12,253	15,072	18,705
Turkey	n.a.	n.a.	n.a.	684	715	n.a.
UK	121,766	n.a.	174,250	8,153	n.a.	26,167
USA	2,592,354	3,087,892	3,535,808	71,915	225,375	316,929
Total IA-HEV[c]	**3,234,057**	**3,730,523**	**4,528,965**	**168,533**	**397,514**	**560,729**

n.a. = not available
[a] passenger cars only
[b] does not include PHEV

18 Austria

18.1 Major Developments in 2014

Pushing e-mobilty forwards in Austria is done by two main steps: the exposure through promotions and funding programs and the increase of the attractiveness of mobility by regulatory (legislative) measures. Since 2007, the Austrian government has more than tripled public funding in the sectors energy research, development and demonstration (RD&D); adopted a new energy research strategy, and launched several priority programs. The major increase in public funding is a result of the Climate and Energy Fund to support R&D in renewable energy and energy efficiency as well as market demonstration and deployment. In 2013, Austria's public expenditure for energy-related research and development amounted to 124,545,848 EUR (see Figure 1).

The subcategories with the highest expenditures in 2013 in million EUR were: efficient residential and commercial buildings (about 16); electricity transmission and distribution (14.8); photovoltaics (11.1); energy efficiency in industry (10.6); communities, smart cities (10); bioenergy (8.4); hybrid and electric vehicles (7.6); energy storage (4.8); hydropower (4.3); and production and storage of hydrogen (3.5). About 65% of the means were used for applied research, and 18% for experimental development. Basic research represented a small yet very important portion of 7.5%.

18.1.1 Federal Programs for Funding Advanced Propulsion Systems

"klima:aktiv mobil" is Austria's Action Program for mobility management to reduce CO_2 emissions, to promote environmentally friendly and energy efficient mobility and to stimulate new innovative business opportunities and green jobs. The program provides free advice and financial support to help businesses, fleet operators and property developers, as well as cities, municipalities, regions, tourism operators, schools and youth groups, to develop and implement mobility projects and transport initiatives, which aim to reduce CO_2 emissions. Between 2007 and 2013 more than 4,900 eco-friendly mobility projects were initiated. This enabled an annual emission reduction of 570,000 tons of CO_2. The Austrian

Federal Ministry of Agriculture, Forestry, Environment and Water Management has allocated a total of around 12 million EUR to this program in 2014.

In 2006 the Federal Ministry for Transport Innovation and Technology (bmvit) established the "Austrian Association for Advanced Propulsion Systems (A3PS)" as a strategic public-private partnership for a close co-operation between industry, research institutions, and the Ministry with the common goal to develop and launch alternative propulsion systems and fuels.

"Mobility of the Future"[14] is Austria's national transportation research funding program for the period of 2012-2020. The program was developed and adopted by the bmvit based on the experience of earlier R&D-funding programs, national and European policy documents, interviews with key stakeholders from a wide variety of backgrounds, results of technology platforms, laws and regulations, and relevant action plans. It's a mission-oriented research and development program to help Austria create a transport system designed to meet future mobility and social challenges by identifying and refining middle- to long-term technological improvements. The program includes four complementary areas in which different research themes are addressed: passenger transport; transport infrastructure (roads, sensors, materials, and supplies); vehicle technologies (e.g. hydrogen and fuel cell technologies, hybrid and battery-powered drives, alternative fuels, lightweight vehicles) and freight transport (sustainable freight transport in towns and cities, sustainable solutions for "First-/ last-mile", intermodal hubs, innovative conveyance and transport media). The annual budget amounts to around 15 million EUR.

Additional e-mobility research activities in Austria are conducted under the funding programs in the Climate and Energy Fund. This fund includes the "Lighthouses of E Mobility"[15] program, which issued its last call at the end of 2014 with a budget of 3 million EUR – focusing on Low-Emission Electric Vehicles. Further calls will focus on: 2015: Low-Emission Electric Fleets; 2016: Low-Emission/Low cost Industrial Production for Electric Vehicles; 2017: Low-Emission Electric Vehicle and Infrastructure Design.

[14] http://www.bmvit.gv.at/en/service/publications/downloads/mobility_of_the_future.pdf
[15] http://www.klimafonds.gv.at/foerderungen/aktuelle-foerderungen/2013/leuchttuerme-der-e-mobilitaet-5-as/

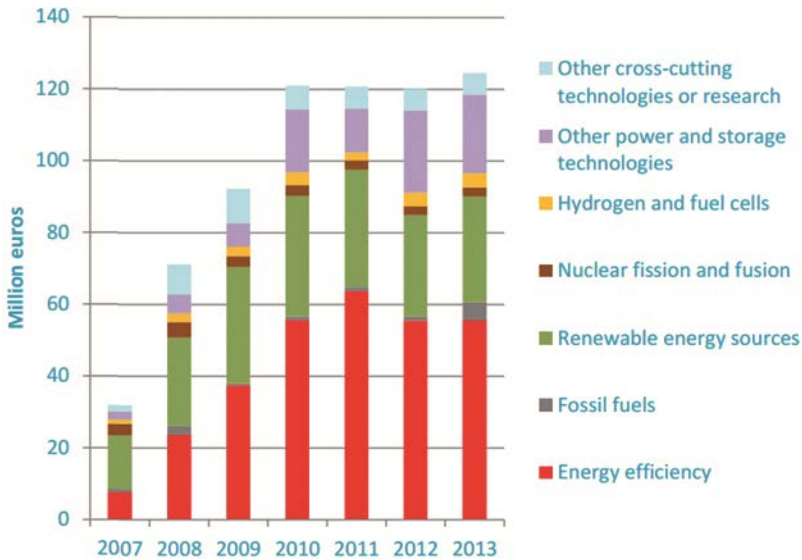


Figure 1: Austria’s public expenditure for energy-related research and development in 2013 (image courtesy of bmvit (2014[16]))

18.1.2 Successful Sustainable Projects and Concepts

Because of the high share of renewable energy in Austria (33%), e-mobility is an important element in the overall transport system. Therefore Austria profits from linking public transport systems with e-utility vehicles, e-scooters, e-car sharing, and e-bikes with the goal to create an attractive combination of electrified private transport services with public transport. Thus, a lot of projects have been started in Austria within the last years.

18.1.3 Linking Private and Public Transport

According to the slogan “use instead of ownership”, a various number of e-car sharing and rental models have been launched in Austria. First implementations for the establishment of e-car sharing fleets have been observed in 2014. Especially in urban areas, with well-developed public transport systems, and bicycle and walking infrastructure, these concepts are working very well. The interest for e-car rental concepts exceeded the supply by far, especially due to hotels and commuters. Another form of car sharing includes electrical taxis (see Figure 2). The Technical University of Vienna made a comprehensive feasibility study on the economic impacts of BEV- taxi fleets in Vienna.

[16] http://www.nachhaltigwirtschaften.at/iea/results.html/id7664

Figure 2: E-car rent models (left) and taxi fleets (right) (image courtesy of Taxi 40100)

The results showed that an upgrade of the existing taxi operation to BEVs could be easily realized in Vienna, although there are still a lot of hurdles to overcome, like the need for fast charging zones. Referring to this study, a few demo projects started in Vienna (Tesla) and Graz and Salzburg (Nissan Leaf). Vienna plans to have 60 e-taxis on the road at the beginning of 2015.

Train operators still realized the possibility and benefits of integrated e-mobility for commuters. eMORAIL (Integrated eMobility Service for Public Transport) is a pilot project of the Austrian train operator ÖBB and offers a mobility package for commuters – from their home to their workplace (see Figure 3). It's a systematic combination of public transport and electric individual transport (e-car, train and e-bike) for the first and last miles. eMORAIL was successfully implemented and tested in an approximately 16-month pilot phase. To ensure high vehicle utilization, e-cars were used operationally during the day.

Figure 3: eMORAIL – a combination of car, tram and bike (image courtesy of ÖBB)

E-Scooters and E-Motorcycles are gaining on interest too. "iO" an Austrian company developed the E-scooter "iO King Kong". With a driving range from 70 km (fully packed – up to 180 kg) to 140 km they are successfully used by the Austrian Post Service. Another pioneer of e-mobility is the Austrian company Johammer, which developed "Johammer J1" (see Figure 4).

Figure 4: Austrian post uses e-scooters for their delivery (left); the e-bike "Johammer J1" (right) – (image courtesies by Austrian Post Service and Johammer)

The e-bike is powered by a synchronous motor with an output of 11 kW, has an empty weight of 178 kg, and a top speed of 120 km/h. The batteries used (12.7 kWh) enable the e-bike a range between 150 and 200 km and the fast charging time amounts to 2.5 hours (80%). In 2015 150 e-bikes are expected to be sold. Due to the trend towards an increasing number of cyclists in Austria, e-bikes are getting popular too. Thus, there are already about 180,000 e-bikes in Austria. They are the most popular EVs - in 2014, every 9th-selling bike was an e-bike in Austria.

18.1.4 Logistics

A few Austrian projects are focusing on the goal of electrical vehicles for urban freight logistics. CITYLOG EMF (Electric Multifunctional Vehicle) is one of them and has the vision of a holistic approach concerning the reorganization of logistic structures and the concomitant reorganization of the transport technology of goods in sensitive areas - made in Austria. The e-motor propulsion is fuel-cell (hydrogen) based and the vehicle concept consists of a series of 'self-driven' vehicles and 'trailers' that can be coupled to a train, and be un-coupled for loading and unloading operations. Every vehicle is 'driving' itself, led by electronic signals to follow the trajectory of the first one, each vehicle is using its separate propulsion unit. Brake-energy will be saved and can be used if the vehicle needs more power. The serial production is expected to be ready in 2016. A similar project - "EMILIA" "Electric Mobility for Innovative Freight Logistics in Austria" (see Figure 5) - aims to the development and experimental implementation of new e-freight logistics concepts for urban areas, by increasing range and reducing costs.

Figure 5: EMILIA - Electrical vehicles for urban freight logistics

18.1.5 Austrian National Policies

For the introduction of e-mobility, regulatory framework is a key factor. Thus, the state and communities offer many promotions such as purchase premiums. Many insurance companies provide a discount of 10 to 20% for EVs. For companies, associations and non-profit organizations, there is support of 30% of the environment-related investment costs for the acquisition and conversion.

Conventional vehicles: since 2011 an increase of the mineral oil tax applies, which is + EUR 0.04/l for Gasoline and + EUR 0.05/l for Diesel. As compensation for drivers the commuting allowance was increased by 10%. In Austria pure biofuel is exempted from tax. Since December 2010 the tax rates for 1,000 liter fuel are: Gasoline: with a content of min. 46l biofuel and a sulphur max. of 10 mg/kg = 482 EUR, else 515 EUR and Diesel: with a content of min. 66l biofuel and a sulphur max. of 10 mg/kg = 397 EUR, else 425 EUR.

In 2008 the *Normverbrauchsabgabe* (NoVA), a uniquely bonus/malus system for CO_2 and NO_x emissions as well as the particle filter, was introduced for the taxation on the acquisition of new vehicles. Since 2014 the calculation of the NoVA accords to the CO_2 emissions of the car. New cars which cause < 90 grams of CO_2 per kilometer, do not have to pay the NoVA. The excess amount (to 90) is divided by five and gives the NoVA tax rate. For vehicles with CO_2 emissions > 250 g/km, the NoVA increased by 20 EUR/g CO_2. A car with 120 grams of CO_2 would mean a rate of 6% ((120 – 90)/5).

Vehicles with alternative drive trains: Until the end of 2015, vehicles running on alternative drivetrains (hybrid drive, use of fuel specification E85, CNG, LPG, H2), receive a tax reduction of 600 EUR. As of January 1st, 2013, the motor-dependent insurance tax for HEVs and range extenders has to be paid for the engine power of the combustion engine only, BEVs are exempt from the motor-dependent insurance tax.

18.2 HEVs, PHEVs and EVs on the Road

In 2014, 8.5 million people were living in Austria and 4.7 million passenger vehicles were available on Austrian roads. A study about consumers preference for buying a new car (2014) pointed out that 72% of all Austrian drivers changed their driving behaviour due to the increase of fuel costs (in the years before 2014). Thus, there is a significant trend towards increasing usage of public transport systems and car sharing models. In Austria, more than half of all journeys made by car paths lie within a distance of five kilometers, and more than 30% of all car trips end after only two kilometers. The study also analyzed that every second car owner plans to buy a new car within the next two years, but 45% of them would not pay „more“ for eco-mobility. 37% of all Austrian people prefer to buy a used car. The preferences are: conventional ones like diesel (50%) and gasoline (30%), followed by alternative ones like HEVs (15%) and BEVs (5%). This trend can also be seen at the numbers of vehicles on Austrian roads in 2014 (see Figure 6). According to Statistics Austria a total of 6,465,770 vehicles (including 4,694,732 passenger cars) were registered in Austria, as per December 31st, 2014. Thus 395,637 motor vehicles were newly registered in 2014. Newly registered passenger cars accounted to 303,318 – which is a decrease of 4.9% from 2013.

E-vehicles are gaining more and more in popularity, especially HEVs are very popular in Austria. A total of 1,281 BEVs (+95.9% to 2013) and 2,360 HEVs passenger vehicles (10.4% to 2013) were newly registered in 2014. Furthermore 279 pure CNG vehicles, 515 bivalent and 3 FCVs were newly registered in 2014 in Austria. Besides that, more than 180,000 e-bikes are available too.

In numbers, these are a total of 12,822 HEVs, which feature an e-motor via an internal combustion engine (95% gasoline/5% diesel). The number of BEVs increased to a total of 3,386 (63.6% to 2013). The number of vehicles powered by CNG (incl. bivalent ones) rose to 4,538 (23.83% to 2013). Taking into account the absolute number of new registrations based on alternative drivetrains (4,434 vehicles), their proportion of the total admission amounts to 1.5% of all new registered vehicles. The fleet totals and total sales during 2013 (data for 2014 not available yet) are displayed in Table 1 followed by Table 2 which lists the most common BEV, PHEV models available in 2014 and their prices.

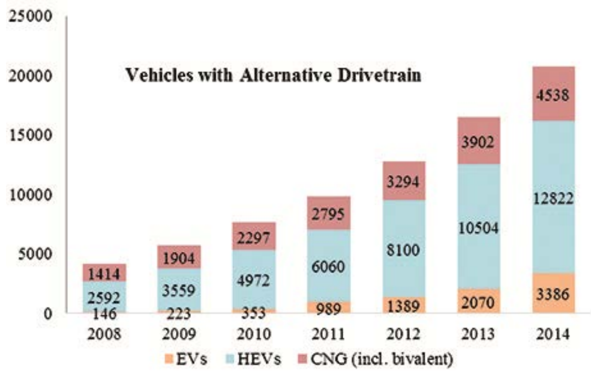


Figure 6: Development of vehicles with alternative drivetrain in Austria

18.3 Charging Infrastructure or EVSE

Regarding the development of price for diesel and gas, Austria is one of the cheapest countries within the EU. Thus, December 2014 was the cheapest month for refilling a conventional car since December 2010. As an annual average, Eurosuper cost 1.26 EUR (EU: 1.46 EUR) per liter at the petrol station; for diesel the price was 1.21 EUR (EU: 1.31 EUR) per liter. By the end of 2013, Austria counted 2,640 conventional petrol stations. With about 3,200 persons per petrol station, Austria ranks in the European middle, with Greece at the high end (1,705 person/stations) and Romania at the low end (9,811 person/stations).

Beside conventional petrol stations, the number of alternative filling stations has increased in recent years (see Table 3). Today, there are approximately 178 public filling stations in Austria with CNG dispensers. Remarkably, in 2014 Austria was the absolute champion in terms of number of CNG filling stations compared to the size of the country (best CNG coverage in Europe). Due the fact that there is no “official” map of electric charging stations (EVSE) available in Austria, it is difficult to represent the specific number. One EVSE 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 3,400 in total and 1,443 public charging stations (18 DC fast charging) installed as of December 2014.

Table 1: Distribution and sales of Austrian EV and HEV fleet in 2014

Fleet totals as of December 31st, 2014					
Vehicle type	**EVS**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	3,733	2	n.a.	0	**286,783**
Motorbikes	567	11	n.a.	0	**467,956**
Quadricyles	816	5	n.a.	0	**33,445**
Passenger vehicles*	3,386	12,823	n.a.	3	**4,694,921**
Buses	131	11	n.a.	0	**9,585**
Trucks	820	5	n.a.	0	**434,915**
Industrial vehicles	73	0	n.a.	0	**491,334**
Totals with bicycles	**9,526**	**12,857**	**n.a.**	**0**	**6,418,939**
Totals without bicycles	**5,793**	**12,855**	**n.a.**	**3**	**6,132,156**

Total sales during 2014					
Vehicle type	**EVS**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	343	0	n.a.	0	**15,281**
Motorbikes	160	0	n.a.	0	**25,182**
Quadricyles	169	0	n.a.	0	**2,902**
Passenger vehicles*	1,281	2,360	n.a.	3	**303,318**
Buses	1	7	n.a.	0	**900**
Trucks	203	0	n.a.	0	**37,997**
Industrial vehicles	8	0	n.a.	0	**8,404**
Totals with bicycles	**2,165**	**2,367**	**n.a.**	**3**	**393,984**
Totals without bicycles	**1,822**	**2,367**	**n.a.**	**3**	**378,703**

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.

* Includes multipurpose passenger vehicles

Table 2: Prices of PHEVs and BEVs passenger models available in 2014 in Austria (excerpt of the most popular ones)

Plug-in Hybrid/ Range Extender vehicle passenger models available in 2014	
Model name	**Model price (untaxed, unsubsidized) EUR**
BMW i8	129,900
Opel Ampera/ Chevrolet Volt	38,400
Porsche Panamera S E- Hybrid	110,409
Porsche 918 Spyder	776,800
Toyota Prius Plug-in Hybrid	37,500
Volvo V60 Plug-in Hybrid	57,400
BEV passenger models available in 2014	
Model name	**Model price (untaxed, unsubsidized) EUR**
BMW i3	35,700
Ford Focus electric	39,990
Nissan Leaf	29,290
Renault Kangoo Z.E.	24,000
Renault Zoe	21,180
Smart Fortwo Electric drive	24,580
Tesla Model S 60	65,740
VW e-up!	25,630

Table 3: Filling stations for alternative fuels and conventional gas stations in Austria (Source: Fachverband der Mineralölindustrie, Mineralölbericht 2014)

Filling stations	2012	2013	2014
CNG (public)	146	175	**179**
LPG	32	36	**38**
Biogas	1	3	**3**
E85	28	33	**33**
EV (Public charging station - Level 2 AC)	1,060	1,160	**1,449**
Hydrogen (Public station)	1	1	**1**
Vegetable oil	19	20	**20**
Conventional (Public)	**2,575**	**2,515**	**2,640**

19 Belgium

19.1 Major Developments in 2014

19.1.1 Automotive Sector in Belgium Anno 2014

The automotive sector has always been one of the most important industrial sectors in Belgium, but especially the car assembly is under severe pressure in the past years. December 18th, 2014 was a black day in our rich automotive history with the closure of the Ford Genk factory. The factory started its production in 1964 with the Ford Taunus 12M and produced up to almost 500,000 cars per year in the nineties.

Figure 1: Last car produced by Ford Genk factory in 2014 (Source: Belga)

In 2014, a Ford Galaxy was the last car that left the production line and almost 10,000 direct and indirect jobs have been lost. After the closure of Renault Vilvoorde and Opel Antwerp, this is another big loss of jobs in the automotive sector.

The government is proactively seeking solutions to recover these jobs and developed SALK, a regional strategic action plan, to mitigate the projected economic impacts of the factory closure.

Today, Belgium still hosts two car assembly plants: Audi in Brussels and Volvo Cars in Ghent. In fact, Volvo Cars Ghent is celebrating its 50 year anniversary in 2015. They started in 1965 with the production of the Volvo 120, also called the Volvo Amazon.

Figure 2: First car produced by Volvo Cars Ghent factory in 1965 (Source: Volvo Cars Ghent)

In 2014, Volvo Cars Ghent has built 264,000 cars (S60, XC60, V40, and V40 Cross Country) which was its second best result ever since the start in 1965. Biggest export country was China with a share of 13.4%. The number of jobs at Volvo Cars Ghent has been growing in 2014 and is now above 5,000 employees. Audi Brussels produced 115,000 cars (Audi A1) in 2014 and has 2,500 employees. In 2013, Audi Brussels became “Employer of the Year”.

Besides car assembly, Belgium has a lot of other activities in the automotive sector. There are assembly plants for buses (Van Hool and VDL Jonckheere) and trucks (Volvo Europa Trucks) in Belgium. Toyota Motor Europe has its European headquarter, logistics centers, and technical R&D center in Belgium and the country has about 300 local automotive suppliers. A lot of the innovations in the automotive sector are taking place on the suppliers side at companies like e.g. Umicore, LMS International, Melexis, and Punch Powertrain.

It is clear that the “classical” car assembly activities alone are not enough to safeguard the existing jobs in the sector. Continuous improvement of the efficiency of the remaining assembly activities is of course still needed and the Flemish government is supporting this by initiatives like Flanders MAKE. But further innovation, collaboration, and specialization in the sector are also crucial for new economic growth. A lot of new jobs can be created in the development of new products and services to build a more sustainable transport system. We really need a transition to a complete different way of transport to gradually replace the transport system of today which is still almost 100% based on petrol combustion cars.

Electric mobility can play an important role in this transition process to a more sustainable transport system, for ecological and for economic reasons. The Flemish government launched the Living Lab Electric Vehicles program (2011-2014) to facilitate and accelerate the innovation and adoption of electric mobility in the

Flemish region in Belgium. At the end of 2014, the Flemish Living Lab Electric Vehicles presented its end results. For more information see chapter 19.4 EV Demonstration Projects.

The Flemish Living Lab Electric Vehicles was mainly set up for and by the local industry, to accelerate the innovation process and roll-out of new e-mobility related products and services. At the same time, it gave a good insight in the "non-technological" hurdles and flanking policy measures that different governmental levels could take to support this innovation process. But innovation alone is not enough to get a broad market introduction.

19.1.2 IEA-IA-HEV Task 24: "Economic Impact Assessment of E-Mobility" (2014–2015)

Worldwide, policy makers are also implementing supportive measures to facilitate the introduction of electric mobility by stimulating the market demand for a certain period. This can be done via a lot of different incentives (financial and non-financial) and every country is setting up its own framework to stimulate the market demand.

But what is the economic return of all these efforts? What is the economic growth we can expect in the electric mobility sector? To answer these questions, VITO (Belgium) and Netherlands Enterprise Agency (The Netherlands) started a new IA-HEV Task on this topic together with Germany, Switzerland, Austria, Denmark, France, and USA. For more information see chapter Task 24 "Economic impact Assessment of E-Mobility".

19.2 HEVs, PHEVs and EVs on the Road

In Table 1 you can see the sales and fleet numbers of EVs and HEVs in Belgium. The market is still very small in absolute numbers, but in 2014 we saw a relative big increase in the sales of EVs compared to 2013.

19.2.1 Passenger Cars

Especially the sales in the high end passenger cars was growing fast. But also in the other vehicles types or market segments we saw increased activities.

In Brussels, the taxi sector made its first steps in introducing electric vehicles in its fleet. Starting at the end of 2014, 50 electric vehicles (35 BYD e6 and 15 Nissan Leaf) will be used as taxis in the city center of Brussels.

19.2.2 Buses

In 2014 we noticed some new activities on Belgian roads with electric and fuel cell buses. Van Hool, a Belgian independent manufacturer of buses, touring coaches and industrial vehicles, is very active in electric and fuel cell buses. They are partner in the Flemish Living Lab Electric Vehicles and also project coordinator of the European project “High VLO City”.

Figure 3: Electric taxis in Brussels (Source: Link2Fleet.com)

Figure 4: Fuel cell bus used by public transport operator De Lijn (Source: Van Hool)

The Flemish Minister of Transport, Ben Weyts, kicked off the first fuel cell bus route of bus operator De Lijn on December 1st, 2014. Five fuel cell buses, with a driving range of 350 km, are in public service and can refuel at the hydrogen station at the Solvay factory in Antwerp. The hydrogen is a “left over” product of the chlor alkali production on the Solvay site. For more information see: http://highvlocity.eu/.

19.2.3 Electric Vans and Trucks for Freight Logistics

Not only in passenger transport, but also for freight transport we noticed an increased interest in electric vehicles. New logistics concepts, where the diesel trucks deliver their goods in depots outside of the city centers and the last-mile delivery is done with smaller and more environment friendly vehicles, are being introduced more and more in Belgium. Companies like CityDepot and Bubble Post are using cargo bikes and also electric vans and trucks for these inner city deliveries.


Figure 5: Electric vans and trucks used for freight logistics (Source: CityDepot)

19.2.4 Pedelecs

Last year a total of 436,549 new bicycles were sold in Belgium, up 30,000 (+7.5%) compared to the total number of 2013. Pedelecs continue to increase its market share. A study at the Belgium's bike dealers concluded that e-bikes held 23% of the bike market share in 2014. Electric bicycles are getting more and more popular also for younger people and especially for commuting. This sector is the biggest growing market within electric mobility.

Table 1: The EV, HEV, PHEV, FCV sales and fleet for 2014 (Source: FPS Mobility and Transport)

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Motorbikes	254	n.a.	n.a.	n.a.	429,209
Quadricycles	596	n.a.	n.a.	n.a.	23,802
Passenger vehicles	2,198	31,518	1,517	2	5,572,573
Multipurpose passenger vehicles	521	n.a.	n.a.	n.a.	657,398
Buses	7	56	n.a.	5	16,770
Trucks	11	5	n.a.	n.a.	149,979
Industrial vehicles	1,596	n.a.	n.a.	n.a.	251,470
Totals without bicycles	**5,183**	**31,579**	**1,517**	**7**	**7,101,201**

Total Sales during 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Motorbikes	95	n.a.	n.a.	n.a.	20,749
Quadricycles	83	n.a.	n.a.	n.a.	1,342
Passenger vehicles	1,163	7,547	851	1	487,547
Multipurpose passenger vehicles	99	n.a.	n.a.	n.a.	53,337
Buses	3	n.a.	n.a.	5	1,143
Trucks	1	1	n.a.	n.a.	8,104
Industrial vehicles	154	n.a.	n.a.	n.a.	6,418
Totals without bicycles	**1,598**	**7,548**	**851**	**6**	**578,640**

n.a. = not available

19.3 Charging Infrastructure or EVSE

The rollout of charging infrastructure in Belgium is mostly depending on initiatives from the industry. Many different companies are active as charging infrastructure operator or mobility service provider. In Table 2 you can find the number of charging points installed in Belgium at the end of 2014.

Getting an up-to-date overview on all charging points available in a country is not an easy task, because this information is spread out over the different market players. If all market players should be connected to a central platform, it would be easy to get a real-time overview of the installed charging points. But for this annual report, we collected this information via a survey that has been sent to the different market players in Belgium.

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
- Power-Station: www.power-station.be
- Powerdale: www.powerdale.com
- The New Motion: www.thenewmotion.com
- ThePluginCompany: www.theplugincompany.com

- Total Belgium: www.total.be
- VitaeMobility: www.vitaemobility.com/

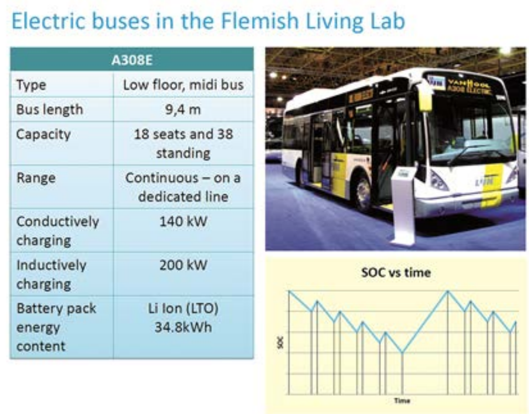
Table 2: Number of EVSE charging points installed in Belgium end of 2014 (Source: survey Programme Office)

Number of EVSE charging points installed in Belgium as of December 31st, 2014				
Data Source: 12 operators Remark: 7 operators data from 2014 and 5 operators data from 2013				
	Private		**Publicly available**	
	Residential	**Companies**	**Companies**	**Public domain**
AC, normal power (< 22 kW)	949	601	798	251
AC, high power (≥ 22 kW)	300	351	325	62
DC	0	0	37	8
Total	**1,249**	**952**	**1,160**	**321**
	2,201		**1,481**	

Concerning the information presented in Table 2, following remarks can be made:

- A charging pole can contain multiple charging points. The numbers mentioned in this table are unique charging points
- The numbers mentioned in Table 2 are based on data from 12 operators. Not all operators answered the survey for 2014. For 5 operators we used the data we collected for 2013
- Those numbers give only an indication and cannot be used for 100% correct comparisons between 2013 and 2014. Based on the collected numbers in the survey, we see the biggest growth of new charging points at the companies on their private parking lots
- Some charging points have been put in another category in 2014 compared to 2013 (mainly from “public domain” to “companies publicly accessible”). This explains the lower number in the category “public domain” compared to 2013. However, it is also always possible that some charging points were physically removed or replaced

All the charging points mentioned in Table 2 are based on conductive charging, meaning charging your electric vehicle with a charging cable. For the next years this will stay the most common way of charging your electric vehicle. However, for comfort reasons for the end users, we see more and more demonstration projects on wireless charging worldwide. Also some research/demonstration projects have been conducted on this topic in Belgium in the past years. In the framework of the Flemish Living Lab Electric Vehicles, the first project with inductive charging for electric buses in daily operation is starting up in the city of Bruges.



A308E	
Type	Low floor, midi bus
Bus length	9,4 m
Capacity	18 seats and 38 standing
Range	Continuous – on a dedicated line
Conductively charging	140 kW
Inductively charging	200 kW
Battery pack energy content	Li Ion (LTO) 34.8kWh

Figure 6: Inductive charging of electric buses (Source: EVTecLab platform)

19.4 EV Demonstration Projects

19.4.1 Flemish Living Lab Electric Vehicles (2011–2014)

Electric mobility can play an important role in the transition process to a more sustainable transport system for ecological and for economic reasons.

The Flemish government launched the Living Lab Electric Vehicles program to facilitate and accelerate the innovation and adoption of electric mobility in the Flemish region in Belgium.

Five different platforms – containing more than 70 companies, organizations, and research partners – were approved with a total funding of 16.25 million EUR. The aim of the investment was setting up an open real-life test infrastructure in which many EV-related innovations could be tested by representative end users in their own living and working environments. New products, services and business models have been tested under real-life conditions. These innovations were related to different domains: electric vehicles & charging infrastructure, energy and mobility.

Figure 7: More than 250 electric vehicles monitored in Flemish Living Lab Electric Vehicles (Source: Programme Office)

The Living Lab has been running from 2011 until the end of 2014. The results and lessons learned have been presented on its final conference in Brussels on December 1st, 2014. The final end report will be published at the beginning of 2015. For more information contact the Programme Office: carlo.mol@vito.be.

The open test infrastructure in the Flemish Living Lab Electric Vehicles contained more than 250 electric vehicles (bikes, scooters, cars, vans, trucks, and buses) and more than 800 charging points for electric bicycles and cars. A test population of more than 2,000 people had access to this infrastructure.

The Flemish Living Lab Electric Vehicles focused on different types of electric vehicles (bikes, scooters, cars, vans, trucks, and buses) to be able to study the potential of electric mobility in many different applications: from freight delivery up to individual passenger transport and public transport. Most vehicles were already commercially available and were bought on the market and instrumented with data loggers and used in research projects and/or by the broad test population. These vehicles were mainly passenger cars, vans, scooters, and bikes (see left part of Figure 7). In chapter “HEVs, PHEVs and EVs on the Road” you can find extra information about other commercially available electric vehicles on the road in Belgium.

Figure 8: Hybrid (left) and full electric (right) powertrain with SR-motor (Source: Punch Powertrain)

For innovation purposes, some Flemish companies have been building electric vehicles themselves (see EVTecLab platform right part of Figure 7). The electric drivetrain is partly based on own developed components like switched-reluctance motor, batteries with own battery management systems, inductive charging, etc.

Within the EVTecLab platform the focus was on heavy duty vehicles:

- 40 electric vans (built on Ford Connect chassis) by Punch Powertrain
- 2 electric trucks (built on DAF chassis) by E-Trucks
- 3 full electric buses (complete own design) by Van Hool
- 1 fuel cell bus (complete own design) by Van Hool

19.4.2 Data Monitoring in the Flemish Living Lab

Data on travel and charging behavior has been collected (see Figure 9). Data on more than 2,600,000 km has been collected and the data from onboard loggers (CAN or GPS) was complemented by surveys of the test-population. This gave very valuable insights in the performance of the vehicles itself and also in the end user feedback.

19.4.3 Public Charging in the Flemish Living Lab

Concerning charging infrastructure, the focus of the living lab was on public and semi-public locations. More than 800 charging points for electric bicycles and cars were installed over the whole Flemish region (Figure 10). The main goal was to study the usage and the performance of this charging infrastructure network in real-life. But a lot of other issues had to be studied in the living lab as well. In 2011, when the living lab was starting, the roll-out of public charging infrastructure was still in its very early phase. The market was immature and the role of the different market players was not clear yet.

19.4.4 Living Lab Interoperability

The living lab has therefore put a lot of effort in the working group on interoperability where the different stakeholders discussed aspects like standardization of the plugs, the methods of user access (RFID, SMS, QR, …), and the connection to a central IT-platform to exchange information between the different "mobility service providers" (Figure 11). Interoperability is very important for the end users' comfort, but it requires a broad concensus between the market players on a lot of different aspects as mentioned in Figure 10.

19.5 Outlook

19.5.1 "Clean Power for Transport" Directive

Governments can play an important supporting role to stimulate the introduction of charging infrastructure by setting up a national action plan as requested by the European "Clean Power for Transport" directive. Every country in Europe has to set up a national action plan before the end of 2016 to set targets and to stimulate the roll-out of charging/refueling infrastructure for different types of alternative fuels (electricity, hydrogen, CNG, LNG, and biofuels).

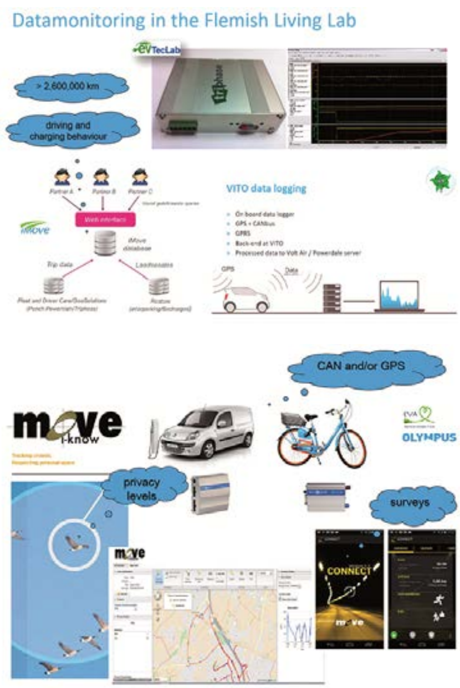


Figure 9: Data monitoring of travel and charging behaviour (Source: Programme Office)

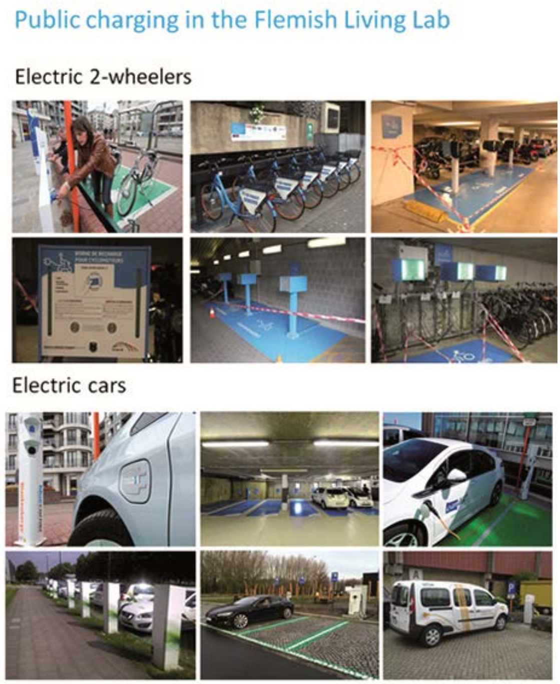


Figure 10: Charging infrastructure in the Flemish Living Lab Electric Vehicles (Source: Programme Office)

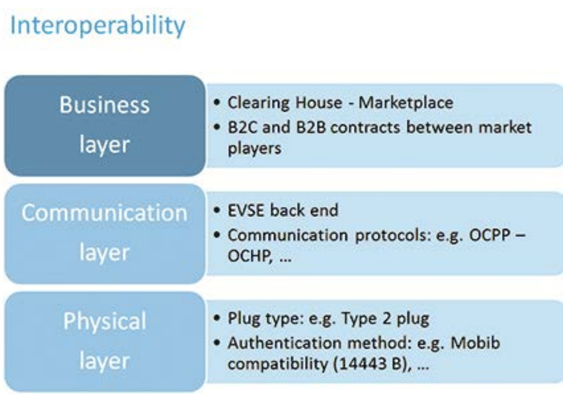


Figure 11: Interoperability layers (Source: Programme Office).

20 Canada

20.1 Major Developments in 2014

20.1.1 Amendment to the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations – Environment Canada

The *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* have been developed in order to reduce greenhouse gas (GHG) emissions from passenger automobiles and light trucks of model years 2011 through 2016. They have been developed in collaboration with the United States Environmental Protection Agency (U.S. EPA) to ensure alignment of Canada's regulations with those of the United States in a manner that is consistent with the authorities provided under the Canadian Environmental Protection Act, 1999 (CEPA 1999). The amended Regulations, which came into effect in September 2014, continue to apply to companies that manufacture or import new light-duty vehicles into Canada for the purpose of sale. Similar to the current Regulations, the amended Regulations establish progressively more stringent annual fleet average GHG emission standards over the 2017 to 2025 model years, while providing companies with flexibility mechanisms to allow them to comply in a cost-effective manner. The amended regulations also provide preferential treatment to electric vehicles and fuel cell vehicles by attributing them higher multipliers when calculating emissions credits.

20.1.2 British Columbia Reintroduces the Clean Energy Vehicle Program in Budget 2015

The new program will include incentives for vehicles and infrastructure, and support education and outreach activities. The previous Clean Energy Vehicle Program provided point-of-sale incentives of up to 5,000 USD (approximately 4,720 EUR) per vehicle, while funding electric vehicle (EV) charging infrastructure (over 1,000 public and residential stations), hydrogen fuelling infrastructure, 10 research and training projects with colleges and universities, and the Emotive outreach and awareness program. As a result of the program, its partners' efforts and the leadership of electric vehicle adopters, B.C. has the largest public charging network in Canada (703 stations) and one of the highest number of

EVs per capita on the road in Canada. Details on the new CEV Program are still being finalized and will be announced in the coming months.

20.1.3 Electric Vehicle Access to HOV Lanes in Ontario

The Ontario Ministry of Transportation intends to extend an existing five-year pilot project to allow single-occupant plug-in hybrid and full battery electric vehicles with green licence plates on high occupancy lanes, for one additional year, to June 30th, 2016. Currently, this pilot is set to expire on June 30th, 2015.

20.1.4 Québec Provides Charging Incentives in the Workplace

In early 2014, the Québec government launched the *Branché au travail* program, which facilitates the introduction of electric vehicles in the province Financial assistance for the purchase and installation of a workplace charging station (120 or 240 V) is 75% of eligible expenses, up to 5,000 USD (4,720 EUR). The rebate is available to individuals, businesses, municipalities, and non-profit organizations in Québec. The charging station must be kept in service for a period of at least three years and charging must be offered free to employees. This program is in force until December 31st, 2016. For more information, please visit: http://vehiculeselectriques.gouv.qc.ca/english/entreprises/entreprises.asp.

20.1.5 Québec Extends Maximum Rebate for Electric Vehicles

The Drive Electric program, launched by the Government of Québec in January 2012, offers a rebate on the purchase or lease of all-electric or plug-in hybrid vehicles. The maximum financial assistance, which was to be reduced to 4,000 USD on January 1st, 2014, has been maintained at 8,000 USD level. The program also provides financial assistance for the purchase and installation of 240 V home charging stations. In 2014, 2,398 all-electric or plug-in hybrid vehicles and 1,094 charging stations have benefited from the program. The Drive Electric program is in force until December 31st, 2016. For more information, please visit:

http://vehiculeselectriques.gouv.qc.ca/english/particuliers/vehicules-electriques.asp.

20.1.6 Commissioning of Street Charging Terminals in Montréal, Québec

As part of a pilot project taking place in downtown Montréal, two double terminal 240 V charging stations are available to drivers of EVs. The on-street charging allows drivers who do not have a private parking space to charge their vehicles.

The pilot project will consider issues such as cable management, aesthetics and sustainability of urban furniture, pricing and behavior of potential users.

20.1.7 HOV Lane on the Robert-Bourassa Highway in Québec City

A pilot project allowing drivers of BEVs and PHEVs, irrespective of the number of passengers, to travel in the reserved high occupancy vehicle lane on Québec City's Robert-Bourassa Highway has been underway since November 2014. This pilot project aims to determine whether the use of the lane by motorists, now including these EVs, can improve the flow of traffic.

20.1.8 Québec to Support the Electrification of Goods Transportation

Since April 1st, 2014, the Québec government offers incentives to electrification as part of its programs in freight transport: Écocamionnage, Assistance Program for improving the efficiency of maritime, air and rail transportation (PETMAF), and Program for the reduction or avoidance of greenhouse gas emissions through the development of intermodal transport (PREGTI).

20.1.9 Québec Government Leading by Example

Since January 2014, a government directive requires departments and agencies to replace any existing light duty vehicle or to meet any new need by an electric vehicle or plug-in hybrid. Overall, 460 organizations are targeted, and at the end of 2014, there were 350 electric vehicles in the government fleet.

20.1.10 An Electrified Corridor between Montréal and Québec City

A pilot project of rapid charging stations was launched in September 2014 on Highways 40 and 138 between Montréal and Québec City, covering a distance of approximately 250 kilometers. This first EV charging corridor in the province of Québec consists of five fast terminals (400 V) and seven 240 V terminals. All of the stations but one located in the city of Trois-Rivières, are located in rest and service areas, within 60 km of each other, and in proximity to restaurants open 24 hours a day. The project will study the behavior of users of the charging stations until December 2016, in order to plan the next corridors and better understand the role of charging terminals in the rapid deployment of EVs. This project is part of the Electric Circuit, a public charging infrastructure initiative supported by the provincial government.

20.2 HEVs, PHEVs and EVs on the Road

Provincial incentive programs such as those described previously played an important role in the continued deployment of hybrid vehicles (HEV), plug-in hybrid electric vehicles (PHEV) and pure electric vehicles (BEV) in Canada. The provinces of British Columbia, Ontario and Québec had the highest EV adoption rate in terms of sales and percentage of new sales, continuing on last year's momentum.

The Canadian EV market reached two milestones in 2014: the EV fleet reached the milestone number of 10,000 EVs at the end of 2014, and BEVs outsold PHEVs, with sales percentages respectively 56% vs 44%. PHEV sales doubled in 2014 compared to 2013, with 2,241 units sold, while BEV sales more than quadrupled to 2,825 vehicles compared to 2013. The electric vehicle market share increased to 0.28% from 0.1% of the light-duty passenger vehicle market, which was estimated at 1.8 million units[17].

A more detailed analysis of EV sales shows the 3 highest selling EVs for 2014 to be the Chevrolet Volt, Nissan Leaf and Tesla Model S. The Volt accounted for approximately 30% of the EV sales, while the Leaf and Model S accounted for 21% and 17% respectively. These three models also accounted for approximately 73% of the 16 combined BEV/PHEV models offered for sale in Canada in 2014.

HEV sales for 2014 reached 20,762, which is a slight decrease from 2013 which saw 22,633 units sold. The total estimated HEV fleet for Canada was 143,917 vehicles at the end of 2014.

20.3 Charging Infrastructure or EVSE

EV charging stations do not require any kind of registration or permitting, and there is no direct way to confirm the total number of charging stations in Canada; hence the numbers reported below are considered to be conservative. In addition to an undetermined number of Level 1 charging stations, according to the World Wildlife Fund (WWF) and Plug'n Drive[18], there should be at least 1,850 public charging points in Canada (in October 2014). The majority of public charging stations are Level 2, with the addition of 58 Level 3 (DCFC) stations across the country. In the province of Québec alone, financial assistance programs have so far helped to install 241 charging stations in the workplace and 1,819 home charging stations. This is in addition to the 475 public charging stations in operation in Québec, of which 358 are part of Québec's Electric Circuit, coordinated by Hydro-

[17] Good Car Bad Car 2014 Canadian Auto Sales http://www.goodcarbadcar.net/2015/01/2014-complete-canadian-auto-sales-rankings-by-make-model.html
[18] http://awsassets.wwf.ca/downloads/wwf_ev_progress_update_report_2014.pdf

Québec (a Crown corporation of the Government of Québec) and private developers[19]. Twelve of these terminals use 400 V AC. Additionally, for Ontario, 630 EV charging station incentives have been issued to date, and the WWF document estimates at 400 the number of public EV charging stations in the province[20].

20.4 EV Demonstration Projects

20.4.1 British Columbia Electric Vehicle Smart Infrastructure Project

This Project supports a market transformation towards the efficient use of clean energy in the transportation sector in the Province of British Columbia by addressing barriers to the adoption of EVs. This includes: range anxiety, electricity grid management, enabling technologies, business models for operating charging stations, increased level of public awareness, and new policies and standards. Over the course of the project, 300 Level 2 charging stations for public use in urban areas, and 30 DCFC stations along major transportation corridors will be delivered, as well as a data network, which centrally collects charging data (EVCloud).

Currently, 7 of the 13 DCFC stations scheduled for deployment in Phase 1 are completed and 2 are scheduled for construction. Three more sites have been secured with signed leases with municipal station hosts and 6 more have been engaged.

20.4.2 AddÉnergie – Commercial Demonstration of a Management System for Electric Vehicle Charging Station Networks

The project aims to demonstrate the operational viability of a network of EV charging stations of different charging levels installed on multiple sites throughout Canada (Figure 1), and controlled by a centralized management system (called Charging Station Network Management System – CSNMS™).

The objectives of this project are to demonstrate: that the installation of a charging station network stimulates and facilitates the use of EVs and that the CSNMS™ cloud-based server can support the growth of the charging station installed base in Canada; that the data base and telecommunications network architecture are able to support the growth of the charging station installed base and that charging stations are reliable in harsh weather.

[19] Communications with the Québec Ministry of Energy and Natural Resources
[20] Communications with the Ontario Ministry of Transportation

Figure 1: Workplace Charging (Source: AddÉnergie)

From January to December 2014, and with financial support from the federal RD&D funding program, ecoENERGY Innovation Initiative, AddÉnergie deployed 482 networked Level 2 charging stations across Canada. This allowed the company to test, demonstrate and improve the performance of its centralized charging station network management system, the CSNMS™. The company has also completed the installation of seven multi-standard (CHAdeMO and J1772 SAE COMBO) DC Fast Charging stations to be operated under conditions specific to Canada.

20.4.3 Electric City Bus Demonstrations

The city of Edmonton, Alberta, conducted a 4-month pilot project from June to October 2014 with an electric bus known as the Edmonton Transit System (ETS) Stealth bus. The project is part of ETS' commitment to explore emerging technologies that create a more effective, efficient and ecologically responsible public transit service.

A winter electric bus trial that was set to take place in early 2015 has been put on hold, as the heating system in the current prototype bus does not meet the City of Edmonton's zero emissions goal. ETS will continue to work with the supplier to encourage development of an electric bus that meets the city's environmental targets with plans to perform further testing in the winter of 2015/16.

The cities of Gatineau and Montréal in Québec tested a BYD electric bus over a period of 10 months between summer 2013 and spring 2014. The objective of the two transit authorities was to assess the overall performance of the BYD bus compared to a diesel-powered bus, in varying weather conditions and resulting road conditions. The project also helped to determine battery life, especially at low temperatures, as well as passenger comfort.

The bus accumulated an appreciable mileage through various seasons and operating conditions (note: the bus was equipped with an auxiliary diesel fuel heater for winter conditions) and overall performed very well. The main challenges were servicing delays related to accessing technicians located at BYD's home office.

20.4.4 Prototype and Demonstration Electric School Buses in Québec

The Québec government has provided financial support in the amount of 675,000 USD to Autobus Lion, a Canadian school bus manufacturer based in Quebéc, for the development of a fully electric prototype with a range of 100 km. The result of this project is a fully functional electric bus, which has been used in real-world applications. In a second phase of this project, the Québec government has awarded 2 million USD to Autobus Lion for the commercial demonstration of 6 electric buses. A significant proportion of the components are manufactured in Québec.

Table 1: Available plug-in vehicles in Canada at the end of December 2014

Market-Price Comparison of Selected EVs and PHEVs in Canada	
Available Passenger Vehicle Models	**Untaxed, Unsubsidized Sales Price in USD**
BEV	
BMW i3	35,180
Chevrolet Spark	23,480 (estimated values)
Ford Focus Electric	27,157
Kia Soul EV	27,388
Mitsubishi i-MiEV	21,912
Nissan Leaf	24,886
Smart ForTwo Electric	21,123
Tesla Model S	64,386
PHEV	
BMW i3 (with range extender)	38,310
BMW i8	113,480
Cadillac ELR	62,650
Chevrolet Volt	31,379
Ford C-MAX Hybrid SEL	22,382
Ford Fusion Hybrid SE	23,008
Porsche 918	845,000
Toyota Prius Plug-In	28,022

Table 2: Vehicle fleet in Canada at the end of December 2014

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**[21]	**Total**[22]
Passenger vehicles	5,341[23]	143,917[24]	5,437[25]	n.a.	21,261,660[26]
Totals without bicycles	**5,341**	**143,917**	**5,437**	**n.a.**	**21,261,660**

Total Sales during 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Passenger vehicles	2,825	20,762[27]	2,241	n.a.	1,888,696[28]
Totals without bicycles	**2,825**	**20,762**	**2,241**	**n.a.**	**1,888,696**

n.a. = not available

[21] FCV: fuel cell vehicle
[22] Total fleet includes passenger cars and trucks registered in Canada
[23] Source: Matthew Klippenstein for GreenCarReports, CrossChasm, Natural Resources Canada
[24] Estimate based on Natural Resources Canada, Desrosiers Automotive, and CrossChasm data
[25] Source: Matthew Klippenstein for GreenCarReports, CrossChasm, Natural Resources Canada
[26] Source Statistics Canada – Motor Vehicle Registrations, http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/trade14a-eng.htm
[27] Source: CrossChasm
[28] Source: Statistics Canada – Passenger cars and trucks (trucks include minivans, sport utility vehicles, light and heavy duty trucks, vans, buses) http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/trade12-eng.htm

21 Denmark

21.1 Major Developments in 2014

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). In 2014, wind power made up 39.1% of the total Danish energy consumption.

The Danish Energy Agency has analyzed a range of scenarios to meet the vision of a fossil fuel independent energy system by 2050. If import of biomass is to be avoided, wind power production will have to be expanded significantly and there is a need for a massive electrification within the transport sector.

The major drivers for electrification of the transport sector are very high energy efficiency, combined with the capability of car batteries to store excess capacity of wind-power.

21.1.1 EV Partnerships

The Danish Energy Agency (DEA) administrates a grant scheme of 40 million DKK (6.2 million USD) allocated to support Electric Vehicle (EV) Partnerships and 10 million DKK (1.5 million USD) to further develop hydrogen based infrastructure for transport in 2013-2015. Private companies and public entities can apply for funding towards EV fleet projects. The purpose of EV Partnerships is to increase the visibility of EVs on the roads and, hence, increase familiarity with EVs in companies, public bodies, and private consumers with EVs, as well as their willingness to purchase them.

DEA prioritizes cost-effective projects to ensure high visibility of EVs on the roads. Award criteria are high annual mileage and applied funding for each EV. It is a prerequisite for achieving the grant that financial support is needed for the partners to purchase the EVs. Hence, either the EVs would not otherwise be purchased or the acquisition of the vehicles will be accelerated.

In 2013 and 2014, DEA supported 8 strategic EV partnerships with a total of 36.6 million DKK (5.6 million USD). The EV partnerships will result in 2,425 new electric cars on Danish roads and 464 new public charging points. Some examples of these partnerships:

- The Capital Region of Denmark (CRD) and the Danish EV Alliance are organizing regional EV partnerships where 1,400 EVs are purchased by municipalities, regions, and companies. Furthermore, the support from DEA enables leasing companies to offer leasing contracts on 625 EVs at a price that is competitive with ICE cars.
- Arriva, a public transport provider, is organizing a free-flow car-sharing service in Copenhagen with 400 EVs. Financial support is granted to the e-mobility provider E.ON in order to deploy a charging infrastructure that will support the car-sharing system. All charging stations will be made publicly available. The partnership is also supported by the CRD.

21.1.2 Municipalities Can Provide Parking for EVs at Reduced Fee

In 2014, a new road law was passed which enables municipalities to differentiate parking fees based on a vehicle´s environmental impact. Starting in 2015, municipalities may offer reduced parking fees – or even free parking – for EVs.

21.1.3 Procurement Partnership

In 2014, CRD and the City of Copenhagen entered a partnership for procurement of EVs and chargers for Danish municipalities and regions. By participating in the procurement partnership, each municipality saves resources on separate tendering. Moreover, by pooling the purchasing power, the procurement partnership obtained significant discounts, up to 40% of the retail selling price. In 2014, nine public entities purchased 70 EVs through the procurement partnership. CRD and the City of Copenhagen plan to continue with a new procurement partnership in 2015.

21.1.4 Support Scheme for Electric Buses

During 2015-2017, a grant scheme of 14 million DKK (2. million USD) is available for local transport operators that want to test electric buses in the regular bus service. The purpose of the scheme is to promote the use of electric buses in local transport and to provide data on the total costs and practical issues of operating electric buses. The idea is that such data will reduce risks and thereby spur the use of electric buses among local transport operators. It is expected that with support from the scheme, local transport operators will be able to purchase up to 25 electric buses.

Other Danish regulations and initiatives that support deployment of EVs in Denmark are listed in Table 1.

Table 1: Other regulations and initiatives that support the 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 EV charging on a commercial basis can receive an electricity-tax rebate that amounts to approximately 1 DKK (0.15 USD) per kilowatt-hour.
• Transport has been included in energy-saving efforts that energy companies can support. Fleet owners purchasing energy efficient vehicles – including EVs – can receive funding from the utility companies, ranging from 2,000-4,000 DKK (300-600 USD) per vehicle.
• Aside from the EV partnership program, DEA also administrates a smaller Danish EV Test Scheme. In 2015, funding of 5.1 million DKK (0.8 million USD) is available for EV and plug-in hybrid electric vehicle (PHEV) projects.

21.2 HEVs, PHEVs and EVs on the Road

The number of EVs in Denmark grew significantly from 2013 to 2014. The stock of EV passenger cars has increased from 1,257 to 2,700. With 577 units, the Nissan Leaf was the most sold EV in 2014. The second most sold EV model was Tesla S with 460 units. The Danish registration tax for passenger cars renders it very expensive to purchase petrol or diesel powered premium segment cars. Due to the exemption of registration tax, a Tesla S has become an economically attractive alternative to a similar conventional car.

In 2014, the above mentioned EV Partnerships lead to 747 new EVs in Denmark, which corresponds to 46% of all new EVs – or excluding the sales of Tesla S and quadricycles – impressive 67% of all EVs (no support was granted to the purchase of quadricycles or Tesla S in the EV Partnerships). This illustrates the importance of the EV Partnerships for the dissemination of EVs.

Fleet totals and total sales during 2014 are displayed in Table 2. Table 3 lists the plug-in vehicle models available in 2014 and their prices.

Table 2: Distribution, sales, and models of EVs and HEVs in 2014

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	n.a.	0	0	0	5,000,000
Motorbikes	n.a.	n.a.	0	0	n.a.
Quadricycles	272	0	0	0	n.a.
Passenger vehicles	2,700	3,305	99	19	2,312,501
Light commercial vehicles	288	386	12	0	398,686
Buses	14	13	0	0	8,735
Trucks	8	2	0	0	41,216
Totals without bicycles	**3,282**	**3,706**	**111**	**19**	**2,761,138**

Total Sales During 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	18,000	0	0	0	452,000
Motorbikes	n.a.	0	0	0	1,942
Quadricycles	37	0	0	0	n.a.
Passenger vehicles	1,528	1,213	96	1	188,417
Light commercial vehicles	51	137	1	0	28,456
Buses	0	0	0	0	800
Trucks	0	0	1	0	3,556
Totals without bicycles	**1,616**	**1,350**	**98**	**1**	**228,479**

n.a. = not available

Table 3: Prices of plug-in vehicle models (passenger cars and vans) available in 2014 in Denmark (currency converted on February 24th, 2015)

Market-Price Comparison of Selected EVs and PHEVs in Denmark	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price in DKK and EUR, respectively**
BMW i3	225,600; 30,575
BMW i3 REX[a]	263,520; 35,714
Citroën Berlingo Electric	204,490; 27,713
Mitsubishi i-MIEV	163,996; 22,225
Nissan E-NV200	199,900; 27,090

Nissan Leaf	202,952; 27,505
Opel Ampera	278,800; 37,784
Peugeot Partner Electric	189,990; 25,748
Renault ZOE[b]	129,120; 17,500
Renault Kangoo Maxi[b]	158,900; 21,360
Renault Twizy[b]	46,720; 6,270
Tesla Model S 60 kWh	441,600; 59,850
Tesla Model S 85 kWh Performance	504,000; 68,305
Volvo V60 Plug-in Hybrid	347,186; 47,052
VW e-up!	149,052; 20,200

[a] EREV = extended-range electric vehicle
[b] Sales price excludes monthly battery rental fee of DKK 383-609 (59-94 USD or 52-83 EUR), depending on model and yearly mileage

21.3 Charging Infrastructure or EVSE

Denmark has a very well developed public charging infrastructure, thanks to three major private e-mobility providers: CLEVER, E.ON, and CleanCharge Solutions. Combined, the three companies provide publicly accessible recharging networks countrywide.

The total size of the public EVSE (Electric Vehicle Supply Equipment) in Denmark by the end of 2014 and the development plans of e-mobility providers for 2015 are summarized in Table 4.

E.ON's and CLEVER's business models are primarily based on customer subscriptions of the company's recharging infrastructure (with a monthly subscription fee) and charges for energy consumption. Both e-mobility providers also offer non-subscription based recharging services. The subscription costs 99 DKK (15.2 USD), and prices for using the e-mobility providers' publicly available recharging stations are 3.25-3.50 DKK per kWh (0.5-0.54 USD). The non-subscription cost is 5.25-5.50 DKK per kWh (0.81-0.85 USD).

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 49 DKK (7.54 USD), E.ON's subscribers can select a specific charging station where the price is reduced to 1.60 DKK per kWh (0.25 USD). This solution is attractive for people who do not have access to dedicated parking lots (e.g. residents living in multi-unit dwellings).

Table 4: Actual EVSE and hydrogen filling stations installed in 2014 and planned for 2015 in Denmark

Charge type	Total 2014		Additional planned 2015	
	Chargers	Outlets	Chargers	Outlets
3,7 kW AC	21	21	0	0
11 kW AC	686	1,372	250	500
22 kW AC	106	212	64	127
CHAdeMO 50 kW DC	30	30	-30*	-30*
CHAdeMO 50 kW DC, CCS 50 kW DC, 43 kW AC[29]	24	72	37	144
CCS 50 kW DC	1	1	0	0
CHAdeMO 50 kW DC, CCS 50 kW DC	5	10	6	12
Supercharger	19	38	6	12
Hydrogen filling stations	6	6	2	2
Total with hydrogen filling stations	**898**	**1,762**	**335**	**767**
Totals without hydrogen filling stations	**892**	**1,756**	**333**	**765**

* CHAdeMO chargers will be replaced by combined CCS/CHAdeMO and 43kW AC chargers

CleanCharge Solutions is a Danish e-mobility provider and also a part of the RWE network of co-operation 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 operator that provides open access with direct payment for the use of the recharging stations. Payment for usage is based on the amount of time that the EV is charging.

The public recharging infrastructure in Denmark is still being developed by the three private e-mobility providers. In 2014, one of the main focus areas has been the deployment of combined CHAdeMO/CCS/43 kW AC fast chargers at highway rest stops, supermarkets, gasoline stations, and other locations where the EV driver can spend time while the car is recharging.

In 2014, the Danish Road Directorate conducted a tender to establish a public recharging infrastructure at rest stops on Danish highways. The e-mobility provider E.ON won the concession for 13 different sites. By end of 2014, E.ON had deployed combined CHAdeMO/CCS/43 kW fast chargers on all 13 sites as part of the EU TEN-T supported Greening NEAR project (Figure 1).

[29] Combined charger offering 3 outlet sockets: one with CHAdeMO 50 kW DC (CHAdeMO plug), one with CCS 50 kW DC (Combined Charging System with Combo2 plug) and one with 43 kW AC (Type 2 plug)

Figure 1: E.ON charging station at rest stops on Danish highway (Image courtesy of E.ON)

After the above mentioned tender, the Danish Road Directorate has negotiated e-mobility charging concessions for an additional 10 sites along the Danish highways – 4 sites to be operated by CLEVER and additional 6 to be operated by E.ON. Combined CHAdeMO/CCS/43 kW chargers will be deployed at all 10 sites during 2015.

As part of the Greening NEAR TEN-T supported project, E.ON has published plans to deploy 27 additional fast chargers along the main Danish highways by end of 2015 as well a fast chargers in the city of Malmö in the south of Sweden and the city of Flensburg in the North of Germany allowing for transnational travel with EVs.

The e-mobility provider CLEVER began upgrading their current charging network in 2014. In 2015, CLEVER plans to establish 263 new charging points in Denmark. 63 out of the new charging stations will be combined CHAdeMO/CC/ 43 kW fast chargers whereof 23 will be deployed with co-financing from EU's TEN-T fund as part of the ELECTRIC project.

During 2014 and early 2015, Tesla has established a network of Superchargers (120-135 kW DC) in Denmark. With 7 sites – including the largest Supercharger site in Europe[30] – Tesla owners are able to travel across Denmark as well as connect with the Pan-European network of Superchargers for transnational travels (Figure 2).

[30] 6 Superchargers with 12 outlet sockets located near Køge, south of Copenhagen.

Figure 2: Europe's largest Tesla Supercharger facility in Køge south of Copenhagen (Image courtesy of Tesla)

21.4 EV Demonstration Projects

21.4.1 E-Bikes

Bicycles have been a popular part of the Danish transport for many years. And with the e-bike new opportunities for bike usage have emerged. To tap into the e-bike potential for further reducing air pollution and CO_2 emissions, demonstration projects have been launched aiming at different potential e-bike target groups.

One e-bike demonstration project – supported by the Danish Road Authority and spearheaded by the Danish Eco Council (a climate Non-Governmental Organization) – is focusing on car commuters in general and more specifically on

- The elderly with infirmities that would normally dissuade them from riding a bike
- Businesspeople who do not want to arrive sweaty at meetings
- People who normally take the car, because they feel the driving distance is too far for a normal bike ride
- People who live in hilly areas

By identifying and addressing potential barriers during 6 month e-bike test drive schemes, the project aims at disseminating positive e-bike stories to encourage others to join the e-bike movement.

The "Test an e-bike" demonstration project offers 1,700 current commuters in selected municipalities to test-drive an e-bike for 3 months on the condition that they are to replace 3-4 weekly +5 kilometer car commutes with the e-bike. Project partners are a number of Danish municipalities and the CRD with the organization Gate21 as project manager. In the period between April 2014 and February 2015, more than 800 commuters have ridden the e-bikes approximately 400,000 km. The project will be finalized by 2017.

In 2014, the first wave of 250 new, ”intelligent” city bikes (e-bikes) where placed in 20 specially designed hubs around Copenhagen. The city bikes are all electrical and equipped with a tablet computer to be used for payment, GPS maps, access to social media, etc. (Figure 3). The city bike aims at being the “missing link” between public transport and the locations where people work. By making the last (or the first) part of the commute more easy and convenient, the City of Copenhagen hopes to inspire more commuters to replace cars with public transport and city bikes. In actual figures, the City of Copenhagen estimates that approximately 19,000 current car commuters will be attracted to public transport combined with the new city bike. Users pay either 25 DKK per hour (3.9 USD) or subscribe with a monthly fee of 70 DKK (10.8 USD), which reduces the hourly rate to 6 DKK (0.9 USD). Based on the positive response to the first wave of city bikes it has been decided to rollout a total of 1,860 city bikes and to increase the number of hubs to 100 within the Greater Copenhagen area during 2015. The total budget is estimated at 86 million DKK (13.2 million USD) to be shared by the City of Copenhagen, the City of Frederiksberg, and DSB, the national Danish rail operator.

21.4.2 EVs for Craftsmen and other Companies

Analyses have pointed out that there is a potential for many craftsmanship companies and other companies to replace their current fossil fuel cars with EVs to the benefit of the environment and the company image. In some cases, EVs might even reduce the operating costs of the company. In reality, only a few craftsmanship companies have seized this opportunity so far.

Three demonstration projects in Denmark will try to change this:

The first project is targeted at craftsmen companies like e.g. electricians, plumbers, and carpenters. With support from the Danish Energy Agency, 5 project partners including an EV retailer, Nissan, the e-mobility provider E.ON, CRD and a craftsman supply wholesaler will offer companies the opportunity to lease 50 Nissan e-NV200 electric vans at a favorable price. In addition, it will be possible for the craftsmen to fast charge their new electric van at the supply wholesaler whilst getting their supplies. The “EVs for craftsmen” project will continue until 2017.

Figure 3: New city bikes in Copenhagen (Image courtesy of gobike)

Another project named “Meet the EV” focusses on the fact that most companies form barriers towards EVs without ever having tried them. The “Meet the EV” project is spearheaded by CRD and supported by the Danish Energy Agency and it offers companies with fleets an opportunity to test 4 modern EVs (2 passenger car EVs and 2 EV vans) under real life conditions for 10 days for a symbolic fee of 5,000 DKK (770 USD). The fee also includes a training session for all users, 24/7 help-desk and installation of temporary charging stations to ensure the best possible experience. After the test, all the EV test drivers receive a questionnaire on their experiences. The results have been very positive so far:

- Before the EV test, more than 30% of the test drivers where “Sceptical” or “Very sceptical” about EVs. After the test, more than 80% where “More positive” or “A lot more positive” towards EVs.
- More than 80% of the EV test drivers expressed the opinion that the company they work for could use EVs to replace or supplement their existing fleet.
- 3 out of 4 EVs in the test where evaluated above 4 on a scale from 0 (Very bad) to 5 (Very good). This was supported by many positive comments as well.
- The majority of companies have started an EV buying process after having taken part in “Meet the EV” project.

The “Meet the EV” project will continue until 2016.

The Danish Federation of Small and Medium Sized Companies has initiated the third demonstration project within this category. This project will identify 5–10 craftsmanship companies (e.g. carpenters, painters, plumbers, and locksmiths) with interest in investing in EVs. As part of the project, these craftsmanship companies will receive EV relevant advice and guidance to enable them to make a qualified decision on whether to buy/lease EVs. The project objective is that a minimum of 5 craftsmanship companies will buy/lease EVs. Their financial and operational experiences with EVs will be recorded and it will be analyzed to what degree present day EVs are ready for craftsmanship companies based on technological and logistical criteria. The project has a total max budget of 2.6 million DKK (0.4 million USD) and is supported by the Danish Transport Authority with 653,000 DKK (100,462 USD).

21.4.3 Test an EV – Northern Europe's Largest EV Demonstration Project

In 2014, the largest EV demonstration project in Northern Europe was concluded in Denmark.

1,578 private test drivers (and their families) had the opportunity to test drive one of the 198 EVs in the project for 3 months. Combined the test drivers drove more than 4 million kilometers in EVs during the project period and valuable insights and experience with private use of EVs was obtained:

- The EVs in the project (data was obtained from Peugeot Ion/Citroën C-Zero/Mitsubishi iMiev, but a few Nissan LEAF were also used) were considered safe, easy to drive and fully in line with conventional cars by the test drivers.
- Reliability was high for the EVs and service costs where measured to be more than 40% lower than for comparable conventional cars.
- 70% of all recharging was done at home.
- 58% of all test drivers said their prejudice towards EVs was reduced during the test period.
- The test families drove, on a daily average, around 50 km using 50% of the battery's capacity.
- The average energy consumption was measured at 205 Wh/km. The energy consumption, and hence, the vehicles' range depends widely on driving style, velocity and seasonal variations.
- The average energy consumption corresponds to the EV having a range of 65-106 km (depending on seasonal variations). Although some drivers managed to drive significantly longer.

- Analysis of the energy consumption for specific road stretches show that the energy consumption during winter is up to 50% larger than in summer.
- 97% of all car trips made in Denmark could be made by an EV, including connected trips (without possibilities for charging the vehicle between each trip). Only 12% of the daily trips would not be manageable with an EV.

In general the conclusions from the "Test an EV" demonstration project indicate that EVs are more market ready than many people think. There are, however, still some barriers to overcome. The project manager, the Danish e-mobility provider CLEVER, recommends to focus more on EV pricing structures based on a long term framework, conditions that enable EVs to be sold at competitive prices versus comparable conventional cars, and to make consumer information about EVs easily accessible and easy to understand.

The "Test an EV" project was supported by the Danish Energy Agency and the Danish Transport Authority, among others.

21.4.4 Smart Integration of EVs in the Power Grid

As the number of EVs increase it becomes important to look at how the EVs are integrated into the power grid in the best possible way. Two Danish projects look into this.

Nikola is a Danish research and demonstration project with focus on the synergies between EVs and the power system. The project investigates EV's potential to support a cost-efficient and secure power system with a high degree of renewable energy.

Project activities include analyses of:

- How to integrate EVs in the distribution grids.
- The economic viability of participation in current markets and form recommendations for future market products.
- How to inform and empower the EV user before altering the recharging practices of the vehicle.
- The technologies that need to be developed for EVs, charging spots, and back-end systems to enable EV services.

The total Nikola project budget is 15.1 million DKK (2.3 million USD). 10.3 million DKK (1.6 million USD) is financed by ForskEL (a PSO-financed research program). The project runs from 2013 to 2016.

In the Insero Live Lab project, 20 families test the latest technology within energy and ICT – controlled via a Smart Grid – in their own homes. It is the intelligent energy system of the future, which provides consumers with more information and access to manage their own energy consumption. As part of the project, the families have an EV and a home charger. All families will specify the desired range on their EV and the system will then optimize the charging based on a number of parameters including CO_2 emissions from the electricity production at any given time, price of electricity at any given time, opportunities to utilize own production of electricity from solar panels and local load management issues.

21.4.5 Electric Buses

For a period of 2 years, MOVIA, a public transport provider, is testing two electric buses manufactured by BYD. The buses are the same size (12 meters) as traditional diesel powered buses. MOVIA is using the electric buses as a part of the regular transport services in Copenhagen. The project is supported by the Danish Road Authorities with 5 million DKK (0.9 million USD) and co-financed by the City of Copenhagen. Learnings and experiences so far:

- Both driver and passenger evaluate comfort as fine and there has been very positive feedback from customers.
- The EV bus quality was evaluated to be on the same level as the diesel bus quality.
- There have been no issues with the main battery pack and charging has worked perfectly. But the long term reliability of the battery pack still needs to be proven.
- The fuel cost of the electric bus is approximately 60% lower than the fuel cost for a comparable diesel bus. However, the purchase cost is higher and range and passenger capacity are lower.
- There has been some minor start up issues with electronics and the 24V batteries need to be monitored and maintained.

The final evaluation of the electric buses is expected to be ready by May 2016.

21.5 Outlook

The public recharging infrastructure in Denmark is well developed and is still expanding with focus on fast charging at highway rest stops, supermarkets, gasoline stations, and other locations where the EV driver can spend time while the car is charging.

Danish experiences show that 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.

There has been a significant penetration of EVs in Danish municipalities. By the end of 2014, 62% of the Danish municipalities had EVs. By the end of 2014, two thirds of the municipalities with EVs had between 1 and 5 EVs in the fleet. Fleet analyses have estimated that more than 50% of the total municipality fleet can be replaced with EVs based on practical criteria. The City of Odense (the third largest city in Denmark) has published an objective to replace its entire 500 unit fleet with EVs. The City of Copenhagen is well under way to achieve its previously published objective to replace 85% of all passenger cars in the current fleet with EVs and fuel cell vehicles by 2015. It is expected that more municipalities will get EVs and that the EV share of the total municipality fleet will increase. Strategic EV partnerships, supported from public funds and procurement partnerships will support this development.

The uptake of EVs in private company fleets is not as strong as in municipality fleets. Results from demonstrations projects indicate that the companies' lack of knowledge about EVs needs to be addressed to boost EV penetration. Opportunities for EVs as e.g. pool cars, service cars, and city delivery cars needs to be conveyed to companies.

As for individuals, EV penetration is primarily driven by favorable leasing offers with public support. EVs are increasingly being considered by individuals as the second car of the household and for commuting purposes. Lack of knowledge and higher TCOs on small EVs are still barriers to be overcome.

The current framework conditions for EVs (exemption from registration tax and annual road tax and electricity tax reimbursement when charging) expire by the end of 2015. At present it is not clear what will happen, but the choice of conditions is likely to have a major impact on the future EV penetration in Denmark.

22 Finland

22.1 Major Developments in 2014

Finland's government policies are tied to greenhouse gas (GHG) reduction targets and currently do not favor or subsidize electric vehicles (EVs). Currently, the overall targets for GHG reduction can be met by using biofuels, which are in ready supply from Finland's vast forests. There were no national hybrid-related or EV-related policy announcements or legislation changes during 2014. Current Finnish fuel taxes are based on energy content, carbon dioxide (CO_2) emissions, and the impact on local air quality.

With regard to road traffic, the accepted target for average CO_2 emissions from new cars sold in 2020 will be 95 g/km. This emission level represents a reduction from the current average level of 144.8 g/km for new cars sold in 2011. This CO_2-based taxation system began in 2011 and remains in effect. The system favors hybrid vehicles and EVs, along with many biofuels. In 2015, the average new-car GHG emission level target will be 130 g/km. Beginning in 2010, the standard 95-octane gasoline has been 95E10 containing 10% ethanol, which has helped to 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 EUR (129 million USD) program budget. The EVE program has contributed in creating an internationally networked community focused on developing new EV-related businesses, with their machinery and systems. There is also support reserved for vehicles and charging points participating in the national EV development program.

Some developments of the year 2014 in Finnish industry:

22.1.1 Virta Ltd. Launches its Services for Finnish Market

A nationwide charging network continues to expand in Finland with both quick and semifast chargers. Virta's (www.virta.fi) Virtapiste charging network has launched its services including mobile applications with realtime visibility to the charging network, the possibility to start and stop charging or to reserve a station in advance. Applications also have route guidance, helping to find the way to charging stations. Charging can be activated through a mobile app, an RFID card of tag, or by SMS message. Virta Ltd. has been formed by 18 Finnish utilities.

22.1.2 Linkker onto the Market with an Electric Bus System

Electric mobility start-up Linkker (www.linkkerbus.com) has launched a series of products that help cities redefine their use of electric power as part of public transportation. Linkker has created an energy efficient electric bus concept taking benefit of lightweight constructions and energy efficient components. Besides enhanced travel experience and emission benefits, the total cost of ownership is reduced also. To support cities in transition towards electric bus systems, Linkker is active in an EU funded project with the objective to accelerate the transition towards electric bus systems by developing transition planning, sharing best practices, and creating a knowledge base.

22.1.3 Ensto Presents New Charging Products

The technology company Ensto and Symbicon, a manufacturer of digital display technology, have developed a charging station together that, besides charging the vehicles, shows digital advertising in order to cover the investment. Located in public places, these charging stations therefore provide a suitable advertising environment and enable the creation of income for both private and public service providers. This profitable and modern media solution is being provided by the out-of-home media company Clear Channel.

22.1.4 Visedo Opens New Factory

Visedo Oy, a developer and manufacturer of heavy duty electric and hybrid drive train components opened its new factory in November in Lappeenranta. The production in the new facility was already started before the official opening ceremony and several tens of new VISEDO PowerSERIES products have been shipped to customers. Visedo has signed several new partnership agreements with companies operative on electric buses and heavy duty electric machinery.

22.1.5 HSL to Test a New Fleet Procurement Model with Electric Buses

HSL (Helsinki Regional Traffic) is planning to launch an experimental project to procure new buses for test purposes. Within the experiment the transport operators can test new technology electric buses before the final procurement. A prerequisite for the project is supported by the Ministry of Employment and Economy and the Finnish Funding Agency for Technology and Innovation Tekes. In case the project proceeds HSL will lease 12 electric buses to be tested by transport operators without financial risks. HSL's goal is that in 2025 about one third of the buses operating in the Helsinki region would be electric. Also other experiments with new technologies have been planned.

Figure 1: Charging station and digital advertising platform merged by Ensto and Symbicon

22.2 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 1, but this number is increasing as a result of CO_2-based taxation of cars and consumers' growing desire to appear "green."

Table 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 31st, 2014					
Vehicle type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Passenger vehicles	410	11,772	530	1	2,595,867
Buses	5	n.a.	n.a.	n.a.	12,446
Trucks	n.a.	n.a.	n.a.	n.a.	95,176

Total Sales During 2014					
Vehicle type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Passenger vehicles	183	2,304	257	1	2,744
Buses	0	n.a.	n.a.	n.a.	n.a.

n.a.= not available

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

22.3 Charging Infrastructure or EVSE

There are about 250 public EV slow-charging points (up to 3.7 kW), about 100 AC charging points up to 22 kW, and 45 DC fast charging stations (CHAdeMO/CCS) around the country. There are two charging operators, Fortum and Liikennevirta, offering interoperable charging services for EV drivers throughout the country. Due to the fact that Finland's Nordic climate necessitates preheating of vehicles there are about one million block heaters for engine preheating. These can also be used for Level 2 EV charging (240 V) to a limited measure.

The number of EVSE equipment is increasing and existing charging infrastructure is strengthened continuously. Table 2 lists Finland's current EVSE.

Table 2: EVSE in Finland as of December 31st, 2014

Type of Public EVSE	Number
DC fast charging	45
AC charging up to 22 kW	102
Level 2/standard AC up to 3,7 kW	250
Number of fueling locations for FCVs	1

22.4 EV Demonstration Projects

During 2011-2013 there were five big demonstration projects within the EVE (described in section 22.1) to develop new EV-related businesses. These projects were Electric Traffic: Helsinki test bed (www.electrictraffic.fi), EcoUrban Living (www.eco-urbanliving.com), Electric Commercial Vehicles (www.ecv.fi), EVELINA, WintEVE (www.winteve.fi).

These five projects were replaced with three new projects for 2014-2015:

- Electric Vehicles Goes Arctic (EVGA)
- Electric Commercial Vehicles (ECV)
- Smart Electric Traffic

22.4.1 EVGA: Electric Vehicles Goes Arctic![31]

The Electric Vehicles Goes Arctic! project (EVGA) aims for arctic operability of charging systems for electric vehicles and related services and components. The main goal is to find out the needs and problems related to the operability and reliability of electric vehicles.

As a result of the project new products and services will be promoted. The ability to perform well in arctic conditions is ensured through thorough testing in different environments. The project concentrates on developing testing services and systems

[31] EVGA at http://evga.winteve.fi/about-evga/

for electric vehicles and utilizing the expertise in northern arctic conditions to create charging infrastructure products and services for electric vehicles.

Several companies and organizations representing industries like electricity, ICT, business and vehicle testing participate in EVGA. The development of a testing environment for electric vehicles and systems takes into account the special features of arctic environmental conditions thus enhancing the innovation of new products and services for the electric mobility market.

22.4.2 Electric Commercial Vehicles[32]

The Electric Commercial Vehicles (ECV) project entity creates extensive and diverse national testing and expert infrastructure for electric commercial vehicles including light and heavy passenger cars, as well as specialized vehicles, buses, cargo transport, and working machinery. ECV gathers together a large number of companies in the industry, research institutes, and universities. The network and results of ECV are directly exploited by approximately 30 domestic or international technology companies operating in the electric commercial vehicle value chain.

ECV targets at promoting the development of electric commercial vehicles and working machinery. Companies, research institutes, and universities benefit by gaining the support of the ECV environment for their activities (significant public funding), by achieving research results together, by competent purchasing, by participating in the construction of the environment, and by expanding their competence base.

The core themes of ECV joint research are testing and research as well as modelling and simulation. The cumulative analytical competence chain in modelling serves the commercial developer end user: components/subsystems/vehicles/field applications for vehicles. Testing activities accumulate knowledge and integrate it in the transition from component to vehicle and machine.

[32] ECV at http://www.ecv.fi/

22.4.3 Smart Electric Traffic

In the Smart Electric Traffic project dozens of companies are exploiting charging, energy and traffic ecosystem in building international business favourable to and compatible with EVs. The electric vehicle is a natural link and spearhead of the development between road traffic and the smart environment.

The target of the Smart Electric Traffic project is the utilization of the success of Finnish companies and organisations in the innovation of new business. Electric traffic, smart traffic, and smart grids are the cornerstones of the future smart society and we have the will and the technical capabilities to combine these three global growth markets and turn them into a success story. Finland has been a pioneer in smart grid technologies and in solutions for electric vehicle charging which has given us a head start in developing future electricity systems.[33]

The main objectives of the project are the implementation and development of charging business, the utilization of charging, consumption and vehicle information in consumer services, maintaining and enhancing of the energy system balance, improving energy and transportation effectivity with smart and electric traffic solutions, the integration of new electric transportation solutions into cities and transportation systems, and the utilization of IT in the transportation consumer service.

[33] http://www.sahkoinenliikenne.fi/

23 France

23.1 Major Developments in 2014

23.1.1 Specific Plan for Developing an EV and PHEV Market

In 2014, the French Government has led a strategy aimed at fostering a domestic electric vehicle market through the automotive industry support plan. In the plan, the French government makes special efforts to achieve the goal of developing the EV and PHEV market.

To strengthen efforts in the development of a charging infrastructure, EV Infrastructure deployment plans are now integrated into one of the 34 plans announced by the 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.

23.1.2 Law on Energy Transition

In 2014, France's government has also unveiled a bill to reduce the country's dependency on nuclear energy and fossil fuels over the next four decades. The legislation, proposed by Environment Minister Ségolène Royal, aims to cut France's energy consumption in half by 2050 in comparison to 2012. The ambitious bill also seeks to reduce the use of fossil fuels in the country by 30% in the next 15 years. Among the bill's 80 articles are plans to boost EV and PHEV markets. Among the many measures, the so-called "energy transition" law aims at encouraging the use of electric cars.

For instance, the bill plans the installation of 7 million EV charging points by 2030 (including public and private charging spots) and a conversion premium for the purchase of an electric vehicle in case of the disposal of an old diesel vehicle. With the new bonus system, and under certain resource conditions, the amount may reach 10,000 EUR. Furthermore, at the time of renewal of state car fleets and public institutions, the bill shows an objective of 50% of the public vehicle fleet to be "clean".

Figure 1: French National Assembly (Image courtesy of www.avere-france.org)

23.1.3 Evolution of the Bonus-Malus System

In France, cars are taxed (malus) or credited (bonus) if their carbon emissions are above or below certain targets. Those targets evolve every year.

Table 1: Bonus-Malus system for 2014

Bonus-Malus System in France for 2014	
CO_2 emissions (g/km)	**Bonus-Malus (EUR)**
20 and less (EV)	-6,300
21–50	-4,000
51–110	-3,300
111-130	0
131–135	150
136–140	250
141–145	500
146–150	900
151–155	1,600
156–175	2,200
176–180	3,000
181–185	3,600
186–190	4,000
191–200	6,500
201 and more	8,000

23.1.4 Conversion Premium

France is implementing a new initiative to financially compensate car owners who trade in a diesel vehicle, aged 13 years or more, for a fully electric vehicle or a plug-in hybrid. The campaign comes from the Ministry of Ecology, Sustainable Development and Energy, and seeks to target older cars, which are responsible for a disproportionate percentage of greenhouse gas emissions.

Figure 2: Ségolène Royal, Minister of Ecology, Sustainable Development and Energy (Image courtesy of Pierre Andrieu/AFP)

The bonus, or what the French government is calling the “conversion premium”, is available to any individual in the nation who trades in an old clunker for a vehicle that runs on clean energy. The amount depends on the type of vehicle purchased, and ranges up to 10,000 EUR, if a fully electric vehicle is selected, or up to 6,500 EUR for a plug-in hybrid. If the old car is replaced with a vehicle that meets Euro 6 specifications and emits less than 110 g CO_2/km, there’s an additional 500 EUR incentive for non-taxable households. This incentive plan is the brainchild of former presidential candidate Ségolène Royal, who is now head of the Ministry of Ecology, Sustainable Development and Energy.

23.1.5 Tax Credit

At the end of 2014, the French government decided to create a tax credit on the income. 30% of the expenditure for purchasing and installing a charging system for an electric vehicle is eligible for the credit. This initiative aims at easing the installation of an individual charging point, in particular in buildings and condominiums.

Figure 3: DC combo2, AC, and DC CHAdeMO plugs at a charging station (Image courtesy of www.moteurnature.com)

23.1.6 Technical Guide for the Development of Charging Infrastructure

In 2014, the government updated the national technical guide for the development of charging infrastructure for Plug-in vehicles. The new recommendations aim at simplifying the access to charging spots and facilitating their use. Specifically, the document provides updated information on charging spots standardization. It encourages the registration of each charging spot on a national website and gives recommendations about interoperability, which should allow the subscriber to a charging operator to use the network of another operator.

23.1.7 Installation of Specific Panels for EV Charging Stations

Specific panels to facilitate location and access to charging stations have been developed and installed. The road signs now include new signs to indicate the presence, proximity, or direction of an electric vehicle charging station.

23.1.8 Charging Infrastructure Deployment

As part of the "Investment for the Future" program, ADEME supports electromobility through a fund dedicated to local authorities willing to deploy charging infrastructure for Plug-in vehicles. This fund has already financed fifteen projects representing more than 5,000 charging points. It was renewed on July 17th, 2014 and will end on December 31st, 2015.

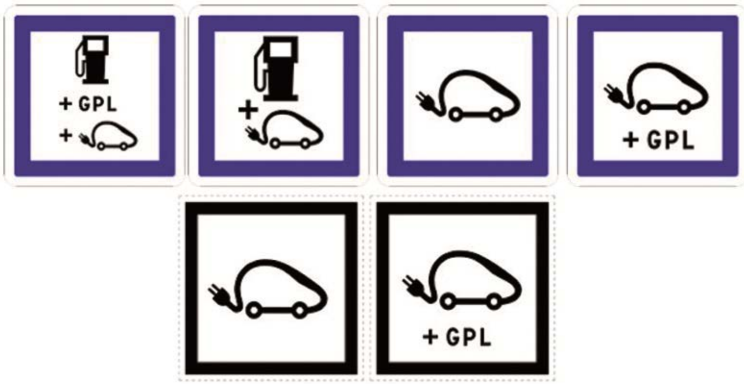


Figure 4: Road signs specific to alternative fueled vehicles (Image courtesy of www.avere-france.fr)

In addition to this incentive for local authorities, the French government also encourages private operators to build and maintain EV charging points by offering a tax exemption for the use of public space. The goal is to provide adequate infrastructure on the entire territory and not just in cities. The law passed in July 2014 and offers tax exemption for any operators which build, maintain, or operate public EV charging infrastructure as long as the charging points are located in at least two regions. French regulators hope to support the development of charging infrastructure without putting the financial burden on local authorities.

23.2 HEVs, PHEVs and EVs on the Road

23.2.1 EV Sales

The EV market ended 2014 on a 7.8% increase compared to 2013. It reached 15,045 registrations, 70% from private cars. Indeed, the passenger car segment has widened the gap to the light commercial vehicle segment. It crossed a new milestone in 2014 by reaching 10,560 registered units, 20.3% more than in 2013. Meanwhile, the light commercial vehicle segment decreased by 13.3% with 4,485 new units in 2014.

The most successful passenger car in France is the Renault ZOE with 5,970 registrations (+8.3%) followed by 1,604 Nissan LEAF (+11.5%) and 1,170 Bolloré Bluecar (77.8%). Unlike 2013, the market has diversified and expanded with new models like the Kia Soul EV, Volkswagen e-up! and e-course or even more recently, the Mercedes B-Class Electric. Most manufacturers now offer an EV, which covers much of the travel needs in France.

Electric vehicles represent 0.59% of the 1.7 million registrations in France.

Figure 5: Renault ZOE (Image courtesy of Renault)

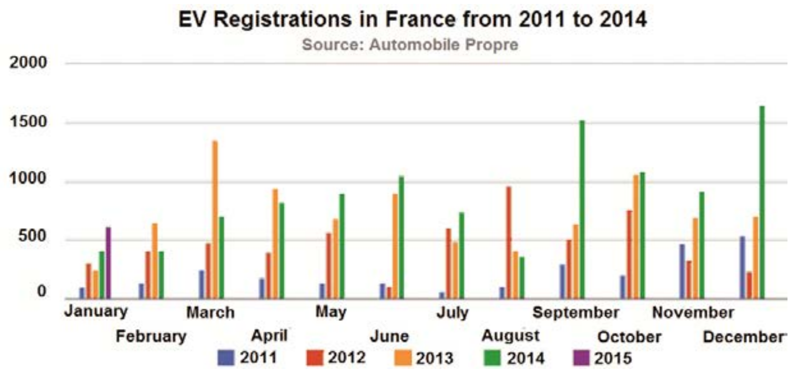


Figure 6: Evolution of EV sales month by month
(Graph courtesy of www.automobile-propre.com)

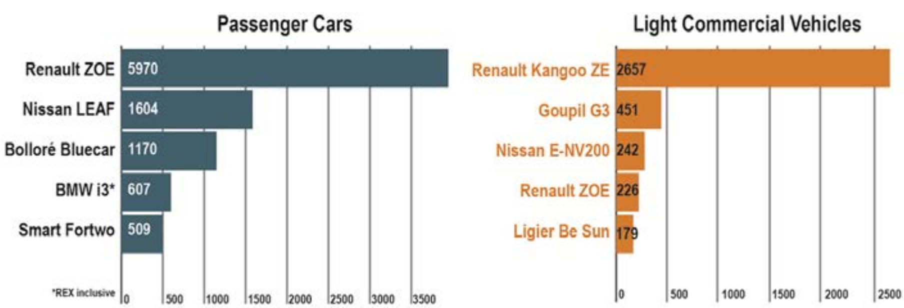


Figure 7: EV sales by models (Graph courtesy of www.avere-france.fr)

23.2.2 HEV and PHEV Sales

The hybrid vehicle market is in decline compared to 2013 (46,785 passenger cars registered). In total, 42,735 cars and 78 vans were registered in 2014: a decline of 8.5% compared to 2013.

The gasoline hybrid segment confirms its good results. In 2014, it raised by 1.5% with 33,295 registrations. The Toyota group is leader of the segment with a total of 26,635 Toyota units and 3,484 Lexus.

Figure 8: Toyota Yaris Hybrid (Image courtesy of www.toyota.groupe-ph.com)

The diesel hybrid segment is down by 32% (9,518 registrations). PSA Peugeot Citroën maintains its first position in this segment with 8,818 registrations.

PHEV are gradually gaining market shares with 1,519 units registered in 2014. They are expected to increase in 2015 with the arrival of new models on the market.

Table 1: Distribution, sales, and models of EVs and HEVs in 2014 (Example Table).

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Passenger vehicles	30,121	173,520	n.a.	n.a.	203,641

Total Sales during 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's licence)	56,000	n.a.	n.a.	n.a.	56,000
Motorbikes	1,158	n.a.	n.a.	n.a.	1,158
Passenger vehicles	10,560	42,735	1,519	0	54,514
Industrial vehicles	4,485	n.a.	n.a.	n.a.	n.a.
Totals without bicycles	**16,203**	**42,735**	**1,519**	**0**	**55,672**

n.a. = not available

Table 2: Available vehicles and prices in France in 2014

Market Price Comparison of Selected EVs and PHEVs in France	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Prices in EUR**
BMW i3	34,990
Courb – C-zen	25,000
Mitsubishi i-MIEV	29,500
Nissan Leaf	30,290
Venturi - Fetish	358,800
Peugeot iOn	29,500
Bolloré - Bluecar	n.a.
Citroën C-zero	29,500
Ford Focus Electric	39,900
Renault ZOE	22,400
Smart Fortwo Electric Drive	24,500
Tesla Model S	66,090
Tesla Roadster	120,000
VW e-up!	26,250
Chevrelot Volt	41,300
Fisker Karma	105,600
Mitsubishi Outlander	54,290
Opel Ampera	41,300
Porsche Panamera S-E Hybrid	115,609
Toyota Prius PHV	40,450
Volvo V60 PHEV	64,450

n.a. = not available

23.3 Charging Infrastructure or EVSE

The law on energy transition plans the installation of 7 million EV charging points by 2030 (including public and private charging spots).

Charging infrastructure is supported with 50 million EUR 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.

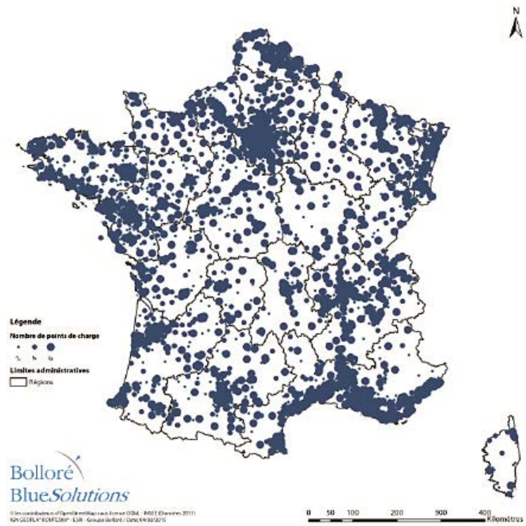


Figure 9: Charging network across France (Image courtesy of Bolloré)

In addition to this public initiative, the French government has launched a call aiming at designating national operators to install and manage EV charging infrastructure. Selected companies will pay reduced taxes when building charging stations. The tax exemption concerns rent for occupying public domain. Through this private initiative with public support, the goal is to accelerate the development of a national network of EV charging points in complement to the local authorities' deployment projects. This mandate will apply to recharging points which are "national" in scale, and will not prevent local initiatives. To profit from this initiative, companies must be operational in at least two regions in France.

As one of the selected companies, Groupe Bolloré, the French conglomerate that operates electric car-sharing services in Paris, Bordeaux, Lyon, and Indianapolis has become one of the national operators to develop and manage a charging network across France. Bolloré plans to invest 150 million EUR to install 16,000 Level 2 chargers over the next four years. Subscribers will be able to reserve time slots at chargers, and the network will also offer wi-fi and carpooling services.

At the end of 2014, the Company Nationale du Rhône (CNR) announced its intention to also submit its project to create a corridor of 23 fast charging stations along the Rhône axis. These stations will be fed by renewable electricity from CNR hydroelectric plants.

24 Germany

24.1 Major Developments in 2014

Germany is firmly committed to reduce its greenhouse gas emissions. Barbara Hendricks, Federal Environmental Minister, assured that Germany will reach its climate goal for 2020 (cutting greenhouse gas emissions by 40% by 2020 compared to 1990), which was set in 2007, with the help of the Climate Action Program 2020 adopted by the German cabinet on March 2014[34]. In order to achieve this target, all sectors have to contribute to the program.

For the transport sector, Germany confirmed the objectives of the government program for electric mobility of 2011. Several new measures have been decided, amongst others to strengthen research and development, tax-exemption and other privileges for EVs, and the organization of national conferences. The strategy to promote R&D, standardization as well as education and training proved its value and is very positively perceived. The extensive collaboration of industry and science along the value creation chain was successfully established[35].

According to the planning, the market preparation phase has ended in 2014, and is followed by the development of the market until 2017. At the right time, the National Platform for Electric Mobility presented its second progress report at the end of 2014 together with a bundle of measures and a roadmap, how to reach the 2020 objective of one million PEVs on German roads together with a national market of splendid international appeal – products and services "Made in Germany".

One of the central elements in its strategy is the Showcase Program. The four showcases are consequently built to gain practical experience of electric mobility by the citizens. At the same time, they serve as a living lab to answer open questions, which still exist about plug-in electric driving. The Showcase Program is supported by the federal government with 180 million EUR. About 90 projects with more than 330 single actions are currently running.

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[34] http://www.bmub.bund.de/en/press/press-releases/detailansicht-en/artikel/hendricks-deutschland-schafft sein-klimaziel/?tx_ttnews%5BbackPid%5D=1
[35] http://nationale-plattform-elektromobilitaet.de/

24.2 New Policies

24.2.1 New Legislation for Electric Mobility in Germany

The German government adopted the new electric mobility act (EmoG[36]), which is expected to be ratified in spring 2015. In this law, the privileged electric vehicles are defined as battery electric vehicles, fuel cell electric vehicles, and also plug-in hybrid vehicles (with a max. CO_2 emission of 50 g/km or with a min. electric range of 30 km until 2018 and 40 km thereafter). These privileged vehicles will be indicated throughout Germany by the number plate. The law empowers the municipalities to allow giving one or more of the listed privileges to the mentioned vehicles:

- Free and/or dedicated parking lots
- The use of bus lanes
- Access to restricted areas

This law is especially important for Germany, since there was no jurisdictive foundation to give privileges to EVs previously.

24.2.2 Special Permission for Electric Transporters

The Federal Ministry of Transport and Digital Infrastructure has issued an exemption regulation[37] for electric transporters. According to this regulation, it is possible to drive electric transporters up to 4.25 tons with a car license. This special permission aims at preventing the requirement of a special truck license only due to the additional weight of the battery.

24.2.3 National Platform for Electric Mobility Presents Progress Report 2014 to the Federal Government

The progress report analyses the current situation of electric mobility in Germany and gives recommendations for the government in order to accelerate the market penetration of electric mobility in Germany[38]. One of the conclusions of the report is that Germany is on the right track to become a major global producer and market of electric mobility. In the mentioned study, it is reported that all the relevant stakeholders (e.g. industry, research, and government) committed themselves to achieve this target.

[36] http://www.bmub.bund.de/presse/pressemitteilungen/pm/artikel/kabinett-verabschiedet-elektromobilitaetsgesetz/
[37] http://www.bmvi.de/SharedDocs/DE/Pressemitteilungen/2014/149-dobrindt-eu-kommission-ausnahme-verordnung.html
[38] http://www.bmbf.de/pubRD/NPE_Fortschrittsbericht_2014_barrierefrei.pdf

24.2.4 A Starter-Kit of Electric Mobility for the Municipalities is Released

The starter kit[39] aims to help municipalities to launch their activities on electric mobility easily and well-structured. It includes practical recommendations for actions. The recommendations are the lessons-learned derived from the funding program "Model regions electric mobility", where various stakeholders (OEMs, energy utilities, municipalities, transport enterprises, research institutes, etc.) are involved.

24.2.5 Industrial Co-Operation for Inductive Charging

BMW and Daimler agreed to jointly develop a standardized inductive charging system[40]. This system should be applicable for electric cars and plug-in hybrid vehicles. The system has two components (a primary coil on the floor and the secondary coil at the vehicle). The inductive charging would make the charging of electric vehicles more comfortable and therefore could enhance the acceptance of electric mobility by customers.

24.3 Automotive Industry

The German automotive industry is fully committed to electric mobility. At the End of 2014, 17 PEV-models were offered on the market by German manufacturers. For 2015, additional 12 new PEVs are announced. For example Audi plans two BEVs until 2018, a sports car and four-wheel driven "Sports Activity Vehicle" with more than 500 km of electric range. In addition, Audi endorsed to add each year a PHEV-model to its portfolio[41].

In year 2014, German OEMs introduced several new electrified vehicles in series production to the market, which are presented in Table 1.

[39] http://starterset-elektromobilität.de/info
[40] https://www.press.bmwgroup.com/global/pressDetail.html?title=bmw-group-is-pressing-ahead-with-the-development-of-systems-for-inductive-charging-of-electric-and&outputChannelId=6&id=T0186710EN&left_menu_item=node__5236
[41] http://www.faz.net/-i2l-7xykw

Figure 1: The e-Golf series car in police design, Volkswagen's most popular car in a 100% electric model (Image courtesy of Volkswagen AG)

Table 1: Newly introduced battery electric and plug-in hybrid electric vehicles from German OEMs in 2014

Vehicle manufacturer	Model	Type	Electric range (km)	Minimum list price (EUR)
BMW	i8	PHEV	37	126,000
VW	e-Golf	BEV	190	34,900
VW	Golf GTE	PHEV	50	36,900
Audi	A3-etron	PHEV	50	48,165
Mercedes-Benz	S 500	PHEV	33	109,778
Mercedes-Benz	B electric drive	BEV	198	39,151
Porsche	Cayenne SE	PHEV	35	82,087

24.4 EV Research

One of the highlights in EV research is the presentation of the Visio.M concept car to the public in October 2014. The goal of the project was to prove the feasibility of an attractive electric vehicle at an affordable price that provides safety and comfort combined with a reasonable driving range. The result is a very small vehicle that sets new standards regarding efficiency and safety. At the same time the overall costs in series production are expected to be lower than those of comparable combustion-engine cars. Visio.M has a driving range of around 160 kilometers and space for two people and luggage. Without the battery, the Visio.M weighs only 450 kilograms. A low coefficient of drag of only 0.24 due to excellent aerodynamics, a small frontal area of 1.69 square meters, and tires optimized for low rolling resistance (115/70 R 16) minimized the energy consumption.

Figure 2: The Visio.M concept car

In the Visio.M consortium specialists from universities, research, and industry joined forces. Amongst the 15 partners involved were the automotive companies BMW AG (lead manager), Daimler AG, and Technische Universität München (TUM). The project was funded with 6.7 million EUR over two and a half years by the German Federal Ministry of Education and Research (BMBF).

24.5 HEVs, PHEVs and EVs on the Road

Germany is the largest car market in Europe. In 2014, almost 3.04 million new cars were registered, a plus of 2.9% compared to 2013. The number of new battery electric cars increased by +40.8% to 8,522 units. Also HEVs could gain: 27,435 new hybrid cars are new on the road in 2014 of which 4,527 were PHEVs. Thus hybrids increased by a factor of 2.9 and EVs by 1.4 compared to the year 2013[42]. The share of conventional petrol and diesel powertrains is still high with 50.5% and 47.8% respectively. The CO_2 average emissions in new cars was 132.8 g/km. 8% of the new cars are below 100 g CO_2/km[43].

The total number of registered motor vehicles in Germany are 53.7 million as of January 1st, 2015, including 44.4 million passenger vehicles, 4.1 million motorbikes, 2.7 million trucks, and 77,501 buses. Of this total, there were 107,754 HEVs, an increase of 25.9%, and 18,948 EVs, an increase of 55.9% compared to 2013. Table 2 summarizes this information.

[42] Estimate by the author
[43] All numbers derived from Kraftfahrt-Bundesamt on http://www.kba.de

Table 2: Distribution, sales, and models of EVs and HEVs in 2014 in Germany (Source: Kraftfahrtbundesamt under www.kba.de, March 24th, 2015)

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs[a]**	**PHEVs**	**FCVs**	**Total**
Motorbikes	n.a.	n.a.	n.a.	n.a.	4,145,392
Passenger vehicles	18,948	107,754	n.a.	n.a.	44,403,124
Buses	n.a.	n.a.	n.a.	n.a.	77,501
Trucks	n.a.	n.a.	n.a.	n.a.	2,701,343
Totals without bicycles	**18,948**	**107,754**	**n.a.**	**n.a.**	**53,715,641[c]**

Total Sales during 2014[b]					
Vehicle Type	**EVs**	**HEVs[a]**	**PHEVs**	**FCVs**	**Total**
Motorbikes	n.a.	n.a.	n.a.	n.a.	148,849
Passenger vehicles	8,522	27,435	4,527	n.a.	3,036,773
Trucks	n.a.	n.a.	n.a.	n.a.	365,853
Totals without bicycles	**8,522**	**27,435**	**4,527**	**n.a.**	**3,551,475**

n.a. = not available; [a] including PHEVs; [b] new registrations in 2014; [c] total of motorized vehicles

The most popular plug-in models in 2014 were BMW i3 (2,231 including range-extender version), Smart Fortwo (1,589), Renault's ZOE (1,498), VW e-up! (1,354), Mitsubishi Outlander Plug-in-Hybrid (1,068), Tesla Model S (814), Nissan Leaf (812), VW e-Golf (601), Renault Twizy (573), and Audi A3 e-Tron (460)[44].

Table 3: Available vehicles and prices in Germany

Market-Price Comparison of Selected EVs and PHEVs in Germany	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price in EUR**
Fisker Karma	96,555
Mitsubishi i-MIEV	19,992
Mitsubishi Outlander PHEV	33,605
Nissan Leaf	19,992
Opel Ampera	32,454
Peugeot iOn	21,750
Porsche Panamera S E-Hybrid	87,581
Renault ZOE	18,931
Renault Kangoo Maxi	21,416
Renault Twizy	6,277

[44] Source: ecomento.tv based on Kraftfahrt-Bundesamt

Smart Fortwo Electric Drive	19,899
Tesla Model S 60 kWh	59,782
Tesla Model S 85 kWh Performance	68,101
Toyota Prius Plug-in	22,563
VW e-up!	22,605

n.a. = not available

24.6 Charging Infrastructure or 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 September 26th, 2014, there were 871 Level 1 charging points, 3,801 Level 2 charging points, and 44 fast chargers on about 2,400 sites publicly accessible in Germany. Table 4 provides an overview of the EV charging infrastructure.

Table 4: EVSE installed in Germany as of September 26th, 2014. Source: German Energy and Water Association (BDEW) 2015 and the progress report 2014 of the National Platform for Electric Mobility

Number of Charging Points			
Sector	Level 1	Level 2	Fast Charging
Public	871	3,801	44

n.a. = not available

Fast chargers include the AC3 CHAdeMO, the DC CHAdeMO, and the DC Combined Charging System. 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), a complete coverage of the whole EVSE charging infrastructure cannot be guaranteed.

Within the Showcase program, further charging infrastructure deployment, its expansion to regions/corridors, and the integration of fast charging points takes place. The charging infrastructure in Berlin will be expanded to include a total of 1,600 recharging points in public and semi-public spaces by the end of 2015. Further projects aims at the development and demonstration of rapid charging systems in urban environments and aims at the build-up of fast charging points along motorways.

24.7 EV Demonstration Projects

24.7.1 Electric Mobility Showcase Program

In 2011 the federal government decided to undertake steps to support electric mobility. This is implemented by means of a promotional program called “Electric Mobility Showcase”. In 2012, the German government nominated four regions (Baden-Württemberg, Bavaria/Saxony, Berlin/Brandenburg, and Lower Saxony) based on recommendations by an independent specialist jury. The aim is to create high visibility for EVs by integrating all technologies into large scale demonstration and pilot plans, including a considerable number of individual projects. This could be achieved through close co-operation between industry, science, and central government. Table 5 gives an overview on the showcase regions.

Table 5: Program “Electric Mobility Showcase” of the German federal government (further information at http://schaufenster-elektromobilitaet.org)

Overview Showcase Program					
Logo	**Title (Location)**	**Projects**	**EVs**	**EVSE**	**Funding[a] (million EUR)**
livinglab BWe mobil Unterstützt durch das Land Baden-Württemberg	Living Lab BWe mobil (Baden-Württemberg)	34 core projects	1,000[b]	800[b]	45
BAYERN – SACHSEN ELEKTROMOBILITÄT VERBINDET	Electromobility Connects (Bavaria-Saxony)	~40	3,000[c]	n.a.	39
Berlin-Brandenburg	International Showcase of Electric Mobility (Berlin-Brandenburg)	~20	1,800	500	37
eMobilität in Niedersachsen.	Our Horsepower Turns Electric (Lower Saxony)	~30	~4,500[d] (1,700 BEV)	n.a.	38

[a] Supported by the Federal Government only
[b] supported by the projects (NPE, 2014)
[c] registered EVs in Bavaria and Saxony (NPE, 2014)
[d] registered EVs in the metropol region as of September 2014
Further program information is to be found under the following sites: http://www.livinglab-bwe.de; http://www.elektromobilitaet-verbindet.de; http://www.emo-berlin.de; http://www.metropolregion.de

24.7.2 EV Success for Light Commercial Vehicles

It becomes more and more clear that electric commercial vehicles not have got the attention they deserved in the past. An outstanding example is the continuously growing fleet of EVs of Deutsche Post DHL. The German based transport and logistics provider with international activities currently operates over 300 electric vehicles and more than 300 hybrids. Deutsche Post DHL confirms that electric vehicles are particularly suitable for urban delivery on defined routes, where full advantage of their CO_2 efficiency, low noise levels, and efficient cost systems can be derived.

Figure 3: Overview on electric vehicles in use in Germany by Deutsche Post DHL (Image courtesy of DHL)

A variety of different types of vehicles from different manufacturers are used (see Figure 3). Overall DHL currently uses 304 battery electric vehicles including Kangoo Z.E., Renault ZOE, Ford, VW, Mercedes, and Street Scooter. The latter company, a former spin-off of RWTH Aachen University, was bought by Deutsche Post DHL in 2014. The EVs are used to transport DHL Express shipments at the moment in France, Aruba, Belgium, Denmark, and Germany.

One of the most recent projects takes place in Bonn/Germany, where the whole parcel delivery in the city and the surrounding areas will be changed to electric vehicles. By 2016 over 140 electric vehicles will be in use there.

25 Ireland

25.1 Major Developments in 2014

The primary methods for promoting the development of the electric vehicle market in 2014 continued to be subsidies and grid infrastructure development. The grant subsidy in Ireland comprises two elements namely tax relief from *Vehicle Registration Tax* and a grant provided on behalf of the customer to the vehicle dealer as partial payment for the car. There is some product development happening with respect to charge point technology, reliability, compatibility issues and electricity market system link-ups.

Supports available in 2014:

- Grant Support of up to 5,000 EUR for M1 and N1 vehicles
- Vehicle Registration Tax relief of up to 5,000 EUR for M1 vehicles
- Accelerated Capital Allowances provided for electric vehicles and charging infrastructure

25.2 HEVs, PHEVs and EVs on the Road

Electric vehicle registrations increased by a factor of 5 in 2014 with respect to the previous year. This contrasts with a 30% increase in overall car sales reflecting an increased level of consumer activity in Ireland. This provides evidence of strong growth for the electric vehicle segment in particular. 261 M1 and N1 EVs received grant support in 2014. The leading manufacturer was Nissan. In 2014, several new vehicles were added to the Irish market including the Nissan Env200, Mitsubishi Outlander, BMW i8, VW eGolf, the Audi A3, and the Renault Zoe. The total number of EV types is now 11 models representing a significant increase in consumer choice in the Irish car market.

25.3 Charging Infrastructure or EVSE

The Republic of Ireland has a single distribution System Operator, which is owned by the Electricity Supply Board (ESB). ESB e-cars has been established in order to deploy and manage a nationwide smart EV charging infrastructure.

The infrastructure is located in multiple location types and caters for a wide range of usage types. Output varies from typically 22 kW AC standard charging – which allows for opportunity charging – to 50 kW DC chargers located mainly on inter urban routes to allow for longer distance journeys. An outline of the types and number of charge points installed are below:

- 1,000 Domestic and work location chargers
  - As home and workplace charging continues to be the dominant method of charging, ESB has incentivized the purchase of EVS by supplying free domestic and commercial charge points to the first 2,000 new EVs purchased
- 787 Standard on-street charge points
  - The majority of these are AC 22kW chargers
  - Locations include on-street, shopping centers, service stations, car parks, inter modal sites etc.
- Fast charge points (urban areas and inter urban routes)
  - 69 DC 50 kW CHAdeMO fast charge point
  - 15 x DC 50 kW CCS fast charge points
  - 29 x AC 43kW fast charge points
  - A multi standard approach has been taken to fast charge points by installing units compatible with CHAdeMO, CCS, and 43kW AC

25.3.1 Reliability Issues and Suppliers

There is now a nationwide network of EV charge points in Ireland which makes EV driving a reality. As a new technology, there has been some issues regarding charge point reliability, however, uptimes have generally remained above 90%. We are now moving towards a smaller number of vendors in order to work more closely with these manufacturers to ensure further improvement.

25.4 EV Demonstration Projects

25.4.1 Drive4Zero Project

The Drive4Zero project is an initiative that aims to promote the use of electric vehicles in Ireland using Cork as a pilot area. The initiative involves employees, employers, parking providers, and car dealers. Employees benefit from free parking at selected city locations, driver efficiency training, free chargers (work and home), and free electricity at work for participating companies. The project team is based at the SFI Centre for Marine Renewable Energy (MAREI) at the University College Cork.

Figure 1: An induction charger – ESB Head Office

25.4.2 ESB Projects

ESB ecars is a prominent member of a number of EU funded electromobility projects including Green eMotion and Mobi.Europe. A number of important demonstrations were carried out in Ireland as part of these projects.

25.4.3 Green eMotion

As part of this project, an induction charging system was developed and demonstrated at ESB Head Office in Dublin which allows for wireless charging of an electric vehicle.

Interoperable roaming capability was tested through the GeM marketplace and clearing house. This was demonstrated by using charge point access cards from other regions to charge a vehicle in Ireland. The cards were authenticated using the marketplace and clearing house system developed by Green eMotion.

25.4.4 Mobi.Europe

In June 2014, ESB ecars and Alliander in the Netherlands demonstrated roaming by using a mobile app developed as part of the project in order to initiate an Irish charging session in Amsterdam.

25.4.5 TEN_T

ESB and the Department for Regional Development Northern Ireland delivered the results of a 4.2 million EUR cross border electric vehicle infrastructure project to the Innovative Networks Executive Agency (INEA). The project involved the installation of a network of 46 electric vehicle fast chargers, 10 inter modal AC chargers, and supporting IT and communications systems. It began in April 2012 and concluded at the end of September 2014. As a result, over 2,500 km of major routes are now served by an EV fast charging network.

25.4.6 Great Electric Drive

32 “ecar ambassadors” were announced by ESB in 2014 to take part in the Great Electric Drive. This is the second year of the EV trial, which gives 26 members of the public and five commercial organisations the opportunity for the trial of an EV for up to four months each. The ambassadors were selected from more than 20,000 applicants from all over Ireland.

Figure 2: Great Electric Drive launch in 2014

25.5 Outlook

Car sales in January 2015 show a 30% increase in sales with respect to January 2014 indicating a return to normal sales levels for passenger cars in Ireland. Electric vehicle sales in January surpassed the previous year level by a factor of 2.7. If this continues then the EV market growth rate will have slowed from a factor of 5 to 3, which would be expected in a normal growth profile for a new technology. This would suggest that the EV market is on course to eventually reach a lower more sustainable growth rate in the long term.

Table 1: Distribution, sales, and models of EVs and HEVs in Ireland in 2014. Full vehicle data records for 2014 were not available as of 13/02/2015, only interim results are provided. This data is supplied by the Society of the Irish Motor Industry (SIMI)

Fleet Totals as of December 31st, 2014			
Vehicle Type	**EVs**	**PHEVs**	**Total**
Motorbikes	n.a.	n.a.	36,573
Passenger vehicles (M1)	447*	32*	2,040,900
Light commercial vehicles (N1, <3,5t)	70*	1*	285,640
Buses	n.a.	n.a.	20,400
Trucks	n.a.	n.a.	31,738
Industrial vehicles	n.a.	n.a.	100,071
Totals without bicycles	**517**	**33**	**2,515,322**

Total Sales during 2014				
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**Total**
Passenger vehicles (M1)	218*	1,001	31*	96,338
Light commercial vehicles (N1, <3,5t)	11*	n.a.	1*	16,652
Buses	n.a.	n.a.	n.a.	207
Trucks	n.a.	n.a.	n.a.	1,793
Totals without bicycles	**229**	**1,001**	**32**	**n.a.**

n.a. = not available

*EV data provided by the Sustainable Energy Authority of Ireland (SEAI) only for M1/N1 cars which received grant aid.

Table 2: Available vehicles and prices in Ireland. All prices shown exclude Vehicle Registration Tax, VAT and have no subsidy applied. Therefore these prices represent the metal price of the car as purchased in Ireland.

Available Passenger Vehicles	Untaxed, Unsubsidized Sales Price in EUR
Audi eTron	32,794
BMW i3 BEV (REX)	30,668-33,887*
BMW i8	101,342
Fisker Karma	n.a.
Mia electric	n.a.
Mitsubishi i-MIEV	28,095
Mitsubishi Outlander PHEV	35,137-39,046*
Nissan Leaf	21,740-26,496*
Nissan ENV200	23,411
Opel Ampera	n.a.

Peugeot iOn	n.a.
Porsche Panamera S E-Hybrid	n.a.
Renault Fluence	20,139
Renault ZOE	15,514-19,748*
Renault Kangoo Maxi	20,000-22,049*
Renault Twizy	n.a.
Smart Fortwo Electric Drive	n.a.
Tesla Model S 60 kWh	n.a.
Tesla Model S 85 kWh Performance	n.a.
Toyota Prius Plug-in	n.a.
VW e-up!	n.a.
VW eGolf	30,216

n.a. = not available

*A price range is showing where a number of options exist for the car.

26 Italy

26.1 Major Developments in 2014

In 2014, the major national measures to promote and financially support the introduction of cleaner vehicles were continued, according mainly to the national law no. 134, approved in August 2012 and partially revised in October 2014. This national law contained making available financial incentives to support the purchase of new clean vehicles, by eventually scrapping old ones (this obligation was initially mandatory for fleet companies and was removed with the revision of October 2014). The cleaner vehicles allowed for subsidy could be powered with various fuels, including NG (Natural Gas) and LPG (Liquified Petroleum Gas), electricity, and hydrogen. The main scope of the law to reduce the CO_2 emissions in the transport sector was stressed with a technology-neutral approach, by associating the incentives to three levels of CO_2 emissions: lower than 120 g/km, lower than 95 g/km, and lower than 50 g/km. The complete statistics of the subsidy law and advancement is reported in a dedicated website (http://www.bec.mise.gov.it/site/bec/home.html). The purchase subsidies are strictly related to the measured CO_2 emission based on homologation measurements and are differentiated per type of vehicle and end users. Table 1 summarizes details of the purchase incentives schemes.

The approved law also aims at creating a set of clear and simplified rules, to be agreed 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 at homes and in public spaces.

26.1.1 Legislation and Regulation

The Law 134/2012 also stated the definition and realization of a national charging infrastructure plan for any type of electrically propelled vehicles. These rules have had a substantial impact on legislation, already under revision, for the installation of dedicated electricity meters and charging points at homes and in public spaces and for the modification of urban plans to take into account the introduction of a minimum number of electric charging stations. As a first official act, the National Plan for the Charging Infrastructure (PNIRE) – completed in May 2013 after a public consultation – was formally approved by the Government in September 2014. The published Plan aims at achieving the following objectives: a total of 90,000 public charging points available by 2016, 110,000 by 2018 and 130,000 by 2020[45]. In addition, the EU (European Union) Directive 2014/94/UE – approved by the European Parliament – on the deployment of alternative fuels infrastructure makes mandatory, among other rules, to the Member States, as Italy, the preparation of a National Policy Framework to be presented by November 2016, where the number of public charging points should be identified in relation to the foreseen number of electric vehicles in circulation by 2020. The recommended share is at least one public charging point for every ten EVs.

In 2009, the Italian Authority for Electrical Energy, Gas and Water System (AEEGSI) started the evaluation of neutral regulatory measures to assist the creation of the market for electric and plug-in hybrid electric vehicles (P-HEV). In 2014, the focus has continued to be on charging from electricity grids with attention to business models, which should be based on a competitive market: three business models are demonstration pilot projects to verify advantages and disadvantages of each option.

Finally, the Italian Electrotechnical Committee (CEI), the national section of the IEC (International Electrotechnical Committee), is working with various technical committees (mainly CT 21/35, CT69, and CT312) to support the international development of standards for electrically propelled vehicles, components, and charging stations.

26.1.2 Incentives and Funding

Due to the Law 134/2012, an overall budget of 63.4 million EUR was approved by the national Government at the beginning of 2014 for assisting the purchase of defined vehicle categories: passenger cars, commercial vans, motorcycles, mopeds, and quadricycles. The level of subsidy depends on the vehicle emissions and is decreasing over three years with the funding scheme summarized in Table 1. In 2014, the overall budget was divided for the three emissions levels in the following way:

- 15% for the purchase of vehicles by private and commercial customers, without scrappage obligation, with CO_2 emissions not larger than 50 g/km
- 35% for the purchase of vehicles by private and commercial customers, without scrappage obligation, with CO_2 emissions not larger than 95 g/km

[45] www.mit.gov.it/mit/site.php?) p=cm&o=vd&id=2524

- 50% for the purchase of vehicles by commercial customers for professional services, with scrappage obligation, with CO_2 emissions not larger than 120 g/km

A dedicated fund of 50 million EUR (60 million USD) in the same law is also available from the Ministry of Transport for supporting the installation of electric charging stations. This public funding will be available for three years (20 million EUR for the first year and 15 million EUR for each of the subsequent years) and will be allowed to cover up to a maximum of 50% of the total cost for the realization of the charging infrastructure. To accelerate the start of the process, an initial bid with a limited fund has been reserved to Regions with projects approved in November 2014 for about 4.5 million EUR (5.4 million USD).

Table 1: Subsidy scheme for the purchase of clean vehicles in Italy from 2013 to 2015

CO_2 emissions not larger than	2013		2014		2015	
	Max share purchase price, %	Max subsidy, EUR	Max share purchase price, %	Max subsidy, EUR	Max share purchase price, %	Max subsidy, EUR
50 g/km	20	5,000	20	5,000	15	3,500
95 g/km	20	4,000	20	4,000	15	3,000
120 g/km	20	2,000	20	2,000	15	1,800

Many other subsidy initiatives have been defined and applied by regional and municipal authorities, often in agreement with the central government, to promote the introduction of EVs and related charging infrastructures.

Moreover, other economical and promotional initiatives, not strictly related to the purchase subsidy, have also been applied in many places for EVs and HEVs:

- free parking in urban areas in any parking space
- free charging in public charging areas
- free circulation in limited circulation areas (ZTL zones)
- free circulation on “car-free” days

26.1.3 Taxation

There are reductions for major taxes on EVs and HEVs. In particular, EVs have no regional property tax for the first five years after the first registration. From the sixth year on, the property tax has a 75% reduction with respect to that of a conventional vehicle with the same nominal power. A few regions have extended the cancellation of the property tax even after the first five years.

For the HEVs, the regional property tax is calculated only on the nominal power of the engine, excluding the nominal power of the electric motor. In 2014, some regions have also extended the property tax exemptions to these vehicles (including also in some cases those fuelled with hydrogen) for short periods after the first registrations.

For the insurance tariffs in general, EVs receive an average discount between 30-50% from various insurance companies.

26.1.4 Research

In 2014, the research on electrically-powered vehicles has been prosecuted and/or completed in various projects in national programmes (Industria 2015, PRIN-Research Project of National Interests, National Research for the Electrical System) and – as part of the final year of the EU (European Union) 7th framework Programme – with the participation of Italian industries and research organizations with interesting results on components and complete systems. These projects covered EV technologies from components research and development (batteries, innovative drivetrains, up to complete vehicles in various configurations, including battery-powered EVs and plug-in HEVs, charging systems and infrastructure, and large demonstrations). Figure 1 shows an electric double layer capacitor (EDLC) under life cycling testing for the application in an advanced hybrid commercial van, developed by IVECO in the European project HCV (Hybrid Commercial Vehicle)[46].

Some research results are part of the National Research Programme for the Electrical System and of projects of the Industria 2015 Programme. Research activities were related to basic and applied research on batteries and their control systems, fast charging studies, the optimization of storage systems designs in hybrid configurations (battery plus supercapacitors), and to innovations in electric drivetrains.

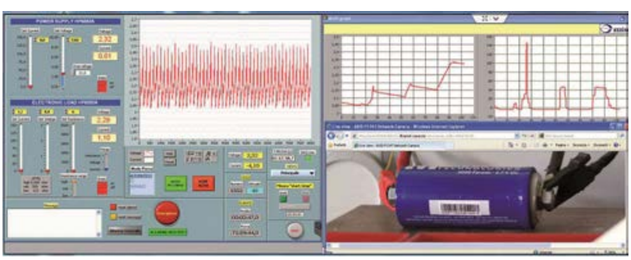

Figure 1: Supercapacitor cell under testing at ENEA Laboratory (Image courtesy of ENEA)

[46] M. Conte, et al., Experimental behaviour of Li-ion and supercapacitors cells for HEVs under standardized and tailored-life cycle testing, EVS-28, KINTEX, Korea, May 3-6, 2015.

26.1.5 Industry

In 2014, despite of the overall economic crisis, the EV and HEV industry (national and international) continued to increase the offer of new products and the market share. These efforts were also related to the available financial incentives, whose effective advantages for the industry are still under discussion. The vehicle industry made available the complete set of categories (buses, passenger cars, commercial vans, two-wheel motorbikes and mopeds, quadricycles, and power-assisted bikes). The national industry has been more focused on commercial applications of EVs and HEVs, with the development and commercialization of innovated buses and commercial vans, as demonstrated by IVECO, which produced the new version of the Daily, awarded as the “Van of the Year 2015”. IVECO also made an electric version of the Daily, together with a hybrid version concept, named “Vision”, shown in Figure 2. The innovation which characterizes IVECO Vision starts with the Dual Energy system, a technology which allows for the use of two different types of traction – one is exclusively electric, ensuring zero local emissions and low noise levels, and the other is hybrid (thermoelectric) and suitable for longer journeys and for extra-urban missions, reducing consumption and CO_2 emissions by up to 25%[47].

Small national manufacturers continued to propose new models of small passenger cars and quadricycles, together with some innovative concepts for the private and public transport with small passenger cars, commercial vans and buses of different sizes and powertrains (pure electric, hybrid, and even with fuels cells).

The largest national manufacturer, FCA (FIAT Chrysler Automobiles), is continuing some development on hybrid vehicles in its research center in Italy (CRF), but the current commercial plan for electric and hybrid passenger cars is mostly directed towards the United States, where the electric version of the FIAT 500 was initially sold in 2013, while in Italy it is not yet available on the market. However, in mid-2014 a car-sharing system “Io guido” (I drive) in the city of Turin has put in service six FIAT e-500, as shown in Figure 3.

However, the offer of EVs and HEVs in Italy covers all the categories from two wheels (power-assisted bikes, mopeds, and motorcycles) and quadricycles (heavy and light) up to commercial electric and hybrid vans and minis, and long 12-m electric and hybrid buses. The passenger car offer is mostly satisfied with electric and hybrid vehicles, including plug-in hybrid, imported by large car manufacturers from all over the world; local manufacturers account for a small share of the still small market.

[47] See more at: http://www.iveco.com/en-us/press-room/release/Pages/Iveco-VISION-a-technology-concept-for-future-mobility.aspx#sthash.qXwnjjwM.dpuf

Figure 2: IVECO Concept Hybrid Daily van “VISION” (Image courtesy of IVECO)

Figure 3: One of the six FIAT e-500 in the car-sharing system “Io guido” in the city of Turin (Image courtesy of Io guido)

26.2 HEVs, PHEVs and EVs on the Road

In 2014, the Italian vehicle market inverted the negative trend of the last six years in major market segments: overall passenger car sales have increased by about 4.9% with respect to 2013, reaching a total of 1,376,000. In addition, the 2014 market situation for cleaner passenger cars (vehicles fuelled with natural or liquefied gas, EV and HEV) was further improved with an overall share of 9.1% of the overall passenger car market with respect to 2013.

HEV/PHEV/EV sales during 2014 continued to increase, despite the economic crisis and the uncertainties related to the subsidy scheme, which was modified and stopped a few times during the year. However, the HEV market share in the passenger car sector reached 1.6% of the overall passenger car market, a more than a 30% increase in one year, while the EVs share remained stable (0.1%) with a numerical increase of 25%. The reasons for such good results for cleaner vehicles are mostly related to:

- The financial incentives, the policy aiming at assisting park renewal in public an commercial fleets
- A larger availability of offers from national and international car companies;
- Local (regional and municipal) initiatives and promotional, not only financial, measures to promote cleaner vehicles circulation and parking in urban areas, even with car-sharing systems
- The slow but continuous increase of the number of charging points, even in large near urban refueling stations
- The introduction of regulatory measures aimed at favoring major public awareness and involvement in clearer and more convenient rules and tariffs for charging at home and in public areas, with more dedicated attention from local and governmental authorities

Statistics for the total vehicle fleet in Italy reported in Table 2 were only estimated for 2014. The data for EVs and HEVs (and PHEVs) on overall fleets were mostly adapted from CEI CIVES (Italian EV Association) analysis and from different sources of official automobile and governmental organizations (ACI, ANCMA, ANFIA, UNRAE, Ministry of Transportation), and also based on interviews of manufacturers and importers in the last 13 years.

Table 2: Distribution, sales, and models of EVs and HEVs in Italy in 2014

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's licence)	351,405	n.a.	n.a.	n.a.	351,405
Motorbikes	38,850	n.a.	n.a.	n.a.	38,850
Quadricycles	8,642	n.a.	n.a.	n.a.	8,642
Passenger vehicles	5,343	68,960*	1,809*	n.a.	76,112
Multipurpose passenger vehicles	9,159	n.a.	n.a.	n.a.	9,159
Buses	1,128	350	n.a.	13	1,491
Totals with bicycles	**405,855**	**69,310**	**1,809**	**13**	**485,659**
Totals without bicycles	**54,480**	**69,310**	**1,809**	**13**	**134,254**

Total Sales during 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's licence)	40,000	n.a.	n.a.	n.a.	40,000
Motorbikes	902	n.a.	n.a.	n.a.	902
Quadricycles	646	n.a.	n.a.	n.a.	646
Passenger vehicles	1,101	20,762*	638*	n.a.	22,501
Multipurpose passenger vehicles	221**	n.a.	n.a.	n.a.	221
Buses	15	n.a.	n.a.	13	28
Totals with bicycles	**41,983**	**20,762**	**638**	**13**	**63,396**
Totals without bicycles	**1,983**	**20,762**	**638**	**13**	**23,396**

n.a. = not available
*PHEV are normally included in HEV statistics and the figures indicated here are re-elaborated from official statistics
**Estimation based on the same share of multipurpose (mainly commercial vans up to 3,5 tons of total weight) vehicles sold in 2013

Table 3: Available vehicles and prices in Italy

Market-Price Comparison of Selected EVs and PHEVs in Italy		
Available Passenger Cars and Commercial Vans	**Untaxed, Unsubsidized Sales Price in EUR**	**Category**
BMW i3	36,500	M1 (passenger car)
BMW i3 EREV	41,150	M1
BMW i8 PHEV	134,300	M1
Citroen C-zero	30,691	M1
Ford Focus Electric	39,990	M1
Mitsubishi i-MiEV	32,214	M1
Mitsubishi Outlander PHEV	44,900	M1
Nissan Leaf	30,690	M1
Nissan e-NV200	36,850	N1 (commercial van)
Opel Ampera EREV	40,220	M1
Peugeot iOn	30,639	M1
Renault Fluence	28,750	M1
Renault ZOE	23,450	M1
Renault Kangoo Maxi	28,432	N1
Smart Fortwo Electric Drive	25,701	M1

Tesla Model S 60 kWh	69,600	M1
Tesla Model S 85 kWh Base	79,200	M1
Toyota Prius Plug-in	40,250	M1
Volvo V60 D6 AWD PHEV	61,000	M1
VW e-Golf	37,000	M1
VW e-up!	27,000	M1

26.3 Charging Infrastructure or EVSE

The national effort on the preparation of the infrastructure for charging EVS is giving first interesting results with the active contributions from public (central and local governments and public research bodies) and private (electric utilities, oil companies, and component and vehicle manufacturers) organizations. Italy has reached the number of 2,500 normal charging points (in public areas and in private ones open to public usage) with an about 10% increase in one year, but with a foreseen outstanding acceleration in the next two years. The fast-charging stations are still limited but also growing thanks to the direct effort of vehicle manufactures, such as Tesla, and the initiatives of electric utilities and central and local authorities, with the current focus on demonstration activities. For example, ENEL (the largest Italian electric utility) is actively involved in analyzing various potentialities of the electric recharging business models and is developing a large recharging network. Different charging systems (box station for home charging and pole stations for public charging) with various charging modes (type 2, type 3 and ChaDemo) are also under investigation. Figure 4 shows the ENEL Multistandard Charge Station recently installed in a multi-fuels station of ENI (Italian Oil Company).

The ENEL recharging network is centrally and remotely controlled through the EMM (ENEL Electric Mobility Management) that is able to control the availability and the status of each charging point in real time and manage the energy flux and balances[48]. Up to the end of February 2015, the statistics of the ENEL recharging infrastructure of about 2000 public/private charging points reached a total of 132,022 completed recharges, 720,966 kWh delivered, and a reduction in CO_2 emissions of 746,412 kg.

[48] https://www.eneldrive.it/

Figure 4: ENEL Multistandard Charge Station at ENI Multi Fuels Station near Rome
(Image courtesy of ENEL)

In 2014, the installation of hydrogen infrastructures was also part of demonstration projects partially funded by the EC.

Finally, the Italian national EVSE plan has been formally approved at the end of 2014, with the defined supporting budget, mentioned above, to favor the creation of a national EV recharging infrastructure of public charging points to reach the target of 130,000 by 2020.

Existing charging stations can also have multiple charging points; current statistics do not clearly distinguish between EVSE and charging points[49]. Table 4 gives the number of public EVSE installed as of December 31st, 2013.

Table 4: The number of public EVSE installed as of December 31st, 2013

Type of EVSE	Quantity
Level 2/Standard AC	2,500
DC Fast Charging	< 20
Number of fuelling locations for fuel cells vehicles	15 (only few in operation and accessible)

26.4 EV Demonstration Projects

In Italy many demonstration projects are now running, which can be generally classified in three large categories:

1. Evaluation of the EVs and charging technologies in relation to the needs and mobility habits of selected private customers. These are the projects mostly promoted by electric utilities in collaboration with car manufacturers and often with the support of local authorities.

[49] http://www.colonnineelettriche.it/and http://www.veicolielettricinews.it/mappa-delle-colonnine-di-ricarica/

2. Dedicated demonstrations of charging business models for the analysis of the possible impacts on the electricity grids and the necessity of dedicated regulations
3. Demonstrations of innovative transport vehicles (fuel cells buses and cars), specific property separation uses (car sharing systems), novel associated technologies and their organizational and economic impacts on utility and service fleets. In this category, there are various EC projects for using fuel cells buses in public transport, public and private car sharing systems, electric delivery activities (Italian Post, DHL, and many other utility fleets)

The Italian Authority for Electrical Energy, Gas and Water System (AEEGSI) has financially funded five demonstration projects for comparing three different business models of public electric charging stations. The projects have started in 2010 and will end in 2015 with the installation of about 1,000 charging points. A general result of these projects shows that the public charging covers about 20-25% of the overall charging needs.

To give some examples, some demonstration projects started in 2014 and illustrate the diversification and the different scopes of these evaluation activities.

Two European projects are aimed at evaluating the use of fuel cell buses in different cities throughout Europe:

- The High V.LO-City project, co-financed by the EU Joint Undertaking for Fuel Cells and Hydrogen (FCH JU), aims at facilitating rapid deployment of a new generation of FCH buses in public transport operations in the three project locations: in the Liguria region (Italy), in Flanders (Belgium), and in Scotland (city of Aberdeen). In San Remo city a fleet of 5 Van Hool Fuel Cell buses has been put in operation on two different lines in 2014, partially substituting trolleybuses. Figure 5 shows two of these FC buses.
- The CHIC (Clean Hydrogen in European Cities), also co-funded by the FCH JU, is a major European demonstration project, running from 2010 to 2016, deploying a fleet of fuel cell electric buses and associated hydrogen refueling stations. The Transport Public Utilities of two Italian cities are involved in the project (Milan and Bolzano, with five and three Daimler EVO FC buses, respectively). In particular, the CHIC project in Bolzano is part of a larger programme aimed at transforming the Brennero Expressway into the first "Hydrogen Highway", connecting the city of Munich (Germany) to the city of Modena (Italy) through a zero emission highway, with seven hydrogen refuelling station over a highway route of 650 km. In June 2014, the H2 competence centre and the hydrogen refueling station, shown in Figure 6, was officially inaugurated in Bolzano.

- Finally, new demonstration projects about the use of EVs were launched in 2014 to “green” fleet utilities (such as the introduction of Nissan e-NV200 commercial electric vans in the DHL fleets in various Italian cities) and the taxis in Rome (an initiative of the URI – Radiotaxi Union of Italy and the taxi company)[50], as shown in Figure 7.

Figure 5: Two Van Hool FC buses in service in San Remo, as part of an EC project (Image courtesy of High V.LO-City Project)

Figure 6: Hydrogen competence and refueling station in Bolzano, as part of an EC project (Image courtesy of CHIC Project)

Figure 7: Nissan Leaf Taxi in Rome – S. Peter Square (Image courtesy of Nissan)

[50] www.ecocaronline.it/

26.5 Outlook

The prospects for EVs, PHEVs, and HEVs in Italy are judged positively with a significant growth in medium to long term. The major driving force for all Europe will be the mandatory constraint in the average corporate fleet CO_2 emissions by 2020, which must be contained in the limit of 95 g CO_2/km. In addition to this, in Italy the air quality control will further improve the introduction of low and zero emission vehicles to mitigate the local environmental emergency. Finally, further impulse will also be given by the EU directive for the installation of a clean fuel infrastructure throughout Europe with approved national plans for the implementation by 2020.

27 The Netherlands

27.1 Major Developments in 2014

Electric driving reduces CO_2 emissions, improves energy efficiency and lessens the fossil fuel dependency while increasing energy security. It also reduces noise pollution from traffic while opening up new opportunities for the commercial sector. For these reasons, the Dutch government is eager to realize a critical mass of 200,000 electric vehicles on the roads in the Netherlands by 2020.

Companies, non-governmental organizations, knowledge institutes and governments are working together (inter)nationally to accelerate electro-mobility in the Netherlands and seize the accompanying economic opportunities. The number of electric cars has further increased in 2014, in an overall shrinking car market. The number of entrepreneurs in the field of e-mobility also increased, especially in the areas of custom-made electric vehicles, electric drive techniques, mobility services, and trade. Dutch companies are active in all aspects of the e-mobility value chain.

27.1.1 Sustainable Fuels Vision

Facilitated by the Ministry of Infrastructure and the Environment, more than a hundred experts and stakeholders developed a vision for a sustainable fuel mix for transport[51], as part of the Energy Agreement for Sustainable Growth. This vision aims at 100% zero emission passenger transport in 2050. The vision foresees a big role for electric drive trains and e-mobility in general in future transport and mobility. It serves as a reference framework and provides a basis for an action agenda that will be presented in 2015. For every sustainable “fuel” (in the wider sense, i.e. also including hydrogen and electricity), relevant organizations composed a separate in-depth sub-report. The Formula E-Team, a public-private co-operation between companies, knowledge institutes and governments, contributed to the E-Mobility sub-report.

[51] http://www.energieakkoordser.nl/nieuws/brandstofvisie.aspx

Figure 1: Battery electric moving truck (Aad de Wit Verhuizingen B.V.)

27.1.2 Employment in E-Mobility

Employment in the field of e-mobility quintupled in the Netherlands between 2008 and 2013, according to research in 2014. The number of full-time jobs (FTEs) rose from 300 in 2008 to 1,600 in 2013. Most of these jobs were created in charging infrastructure, powertrain techniques, the development of custom-made vehicles (like e-buses and light electric vehicles), and the development of special software.

Turnover and gross added value also increased. Entrepreneurs active in e-mobility expect that employment, turnover, and exports will rise further in the coming 4 years, resulting in another doubling in 2017.

Research bureau CE Delft calculated that employment in the e-mobility sector could amount to over 10,000 full time jobs in 2020 – on the basis of fulfilling the ambition to reach a total of 200,000 electric vehicles on the road.

27.1.3 Financial and Fiscal Stimulation

One of the drivers behind the increase of electric vehicles is the fiscal stimulation. In addition, a subsidy was given for low emission taxis and commercial cars (vans). Table 1 gives an overview of these instruments.

In addition to these national instruments, there were various regions that subsidized electric vehicles (passenger cars, commercial cars, and/or scooters), and/or the installation of charging points.

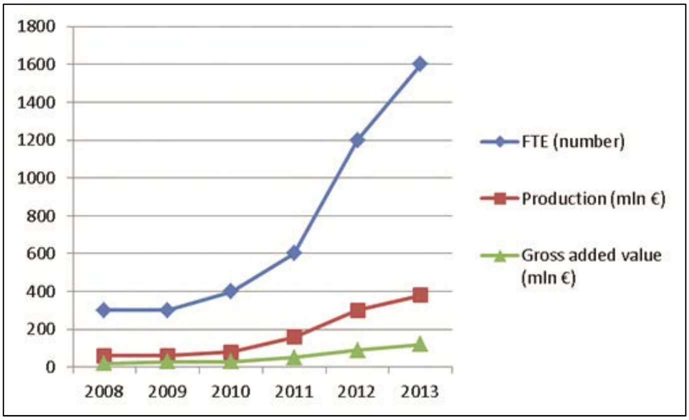

Figure 2: Economic indicators in e-mobility in the Netherlands (CBS/Vereniging DOET/RVO.nl)

Table 1: Financial and fiscal policy instruments in the Netherlands in 2014

Policy	Details
Registration tax exemption	Electric cars are exempt from paying registration tax until 2018. This tax has to be paid at the moment of registering a car. The height of this tax depends on the CO_2 emission and the catalogue price. The exemption for clean vehicles (between 5,000 EUR and 8,000 EUR for mid-size cars) partly compensates for the higher purchase price of EVs.
Road tax exemption	Electric cars are exempt from road tax until at least 2016. 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 petrol car, this is 400 EUR to 700 EUR 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 of 14-25% of the catalogue value on the taxable income. For BEVs the surcharge is 4% of the catalogue value, for PHEVs (1-50 gr CO_2 emissions) the percentage is 7%. This benefit is valid for a period of 60 months.
Tax deductible investments	The Netherlands has a system of facilitating investments in clean technology, by making these investments partially deductible from corporate and income taxes. Electric vehicles are on the list of deductible investments. The Environmental Investment Allowance (MIA) tax relief provides businesses investing in electric vehicles and charging stations with an advantage of up to 36% of the investment, over no more than 50,000 EUR/vehicle.
Subsidy scheme for low emission taxis and vans	A subsidy of 3,000 EUR 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 EUR is given for a BEV (to address specific bottlenecks in air quality).

27.1.4 Market Developments

Car2Go has expanded her fleet of electric Smarts for car sharing in Amsterdam from 300 to 350 vehicles. In 3 years of operation, 8 million electric km were driven. In various other regions electric car sharing projects were opened up as well.

At the end of 2014, a total of 246 electric vehicles were in use as taxis in the Netherlands. 7 of these were PHEVs, the majority BEVs. At Schiphol airport, 167 Tesla Model S cars are being deployed as taxis. A European tender for taxi transport from the airport challenged the market to contribute to Schiphol's sustainability ambitions. An electric powertrain was not required, but those who were tendering could earn extra points by realising more reduction of CO_2 and other emissions.

Non-governmental organisation "Natuur & Milieu" (Nature & Environment) started the first ever private lease action for electric cars. Consumers pay a fixed amount per year and there is no extra cost for maintenance, insurances or reparations. The action is successful.

The Formula E-Team has drawn up a roadmap "consumer market for electric cars". This document makes the chances and barriers visible and transparent.

The foundation "Nationaal Kennisplatform Laadinfrastructuur (NKL)" (Dutch Knowledge Platform on Charging Infrastructure) was established. This co-operation between parties active in the development of e-mobility (such as companies, regional governments, and universities) aims to bring down the costs for public infrastructure, by stimulating collaboration and creating mutual projects.

The number of fast charging points increased rapidly in 2014. This is partly thanks to Fastned, who is building fast chargers along highway corridors, resulting in 201 fast charging locations in a few years.

8 Large and 18 small municipalities have signed a Green Deal[52] on Zero Emission City Logistics. For the next 5 years, the municipalities will deploy as many zero emission vehicles as possible for inner-city distribution, by creating living labs to give an impulse to the development of new technologies. Heineken already distributes its beer in Amsterdam with e-trucks.

More highlights and important milestones in the field of e-mobility in the Netherlands in 2014 can be found here: http://www.nederlandelektrisch.nl/english/

[52] Green Deal: some sustainable initiatives run against barriers, such as laws and regulations. In order to remove these and other barriers, a good co-operation between governments, business and civil society organizations is necessary. Therefore, the Dutch government and society conclude Green Deals that contribute to making the Dutch economy more sustainable.

Figure 3: 167 Tesla-taxis at Schiphol airport (Schiphol airport)

Figure 4: Fastned charging location along Dutch highway (Fastned)

Figure 5: Heineken Hytruck in Rotterdam (Hytruck)

27.1.5 International Co-Operation

With the concept “We are ready to market, are you?” over 30 companies successfully presented Dutch e-mobility solutions at the Holland E-Mobilty House at the Hannover Messe in April 2014. The exhibition had a special theme on “high tech meets energy and automotive”.

Figure 6: Holland E-Mobility House at the Hannover Messe

Special programmes are running to facilitate international collaboration between Dutch and German companies and between companies in the United States and the Netherlands (California and the East Coast). These are expected to contribute to employment and turnover for the companies involved.

27.1.6 Research

Most PHEVs in the Netherlands are leased cars and many of them could do better in using the full electric potential of their vehicle. The Plug-In Coalition set up by the Formula E-Team stimulates “electric share” of the total distance driven by plug-in hybrids, through various measures. To monitor the effects, a system was set up to gain insight in the actual use of PHEVs by collecting and analysing fuelling data, monthly accounts, special driver groups and car types.

The university of Utrecht and the Netherlands Enterprise Agency conducted an analysis of 1 million charging transactions and concluded that e-drivers show routine charging behaviour, with the actual battery level not playing a decisive factor – thus showing potential for smart charging. It was also found that 88% of charging transactions take more than three times the time needed for charging the battery.

More than 50 small and medium-sized companies exchanged an e-mobility innovation voucher at a knowledge institute, thus going forward on a specific scientific item that they needed research on. 56% of these projects will be followed-up after concluding the initial research.

Figure 7: Stella (left) and Nuna (right) at World Solar Challenge in Australia

Dutch students of technical universities and universities of applied sciences are very active in worldwide solar challenges, developing, building, and testing innovative and fuel-efficient cars in close co-operation with industrial partners. Examples are solar car Nuna or Isa, the extremely fuel-efficient city car developed by Delft University and Stella, the world's first solar family-sized car, which won the 2015 Tech Crunch Award – the "Oscar" of Technology and Innovation.

27.2 HEVs, PHEVs, and EVs on the Road

The registered number of BEVs and PHEVs kept increasing steadily in the Netherlands in 2014 (please refer to Figure 7), whilst the total number of newly registered cars decreased compared to 2013. Over the whole year of 2014, 3.9% of newly sold passenger cars were either a BEV or a PHEV. In total, 2,664 BEVs (64% growth compared to the end of 2013) and 12,425 PHEVs (51% growth compared to 2013) were registered in 2014. Just as in 2013, there were more registrations of PHEVs than of HEVs (see Table 3). There were quite a number of different brands and models on the road (see Table 2). Figure 8 shows the top 5 of BEV and PHEV registrations of passenger cars at the end of 2014 (fleet totals):

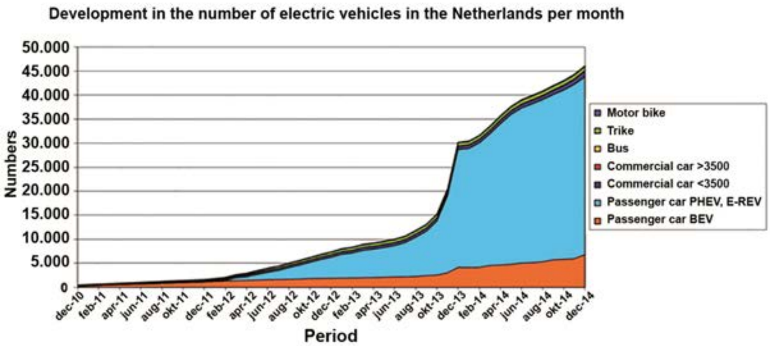

Figure 7: Development of electric vehicles in the Netherlands (Dutch Road Authority, edited by RVO.nl)

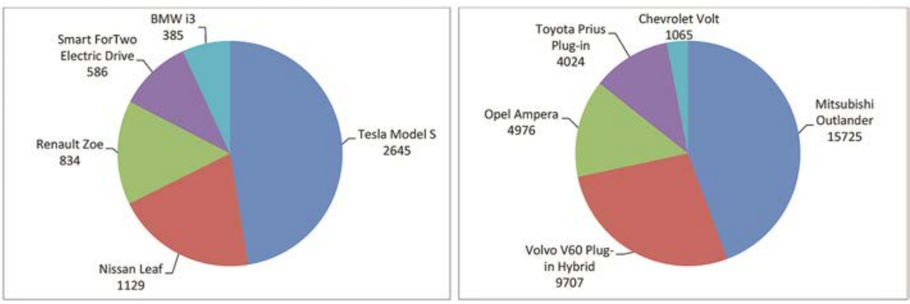

Figure 8: Top 5 BEV registrations (left) and PHEV registrations (right), fleet totals, 31-12-2014 (Dutch Road Authority, edited by RVO.nl)

27.3 Charging Infrastructure or EVSE

The number of public and semi-public charging points more than doubled in the Netherlands in 2014. Please refer to Figure 9. At the end of 2014, there were almost 5,500 public charging points and almost 6,500 semi-public charging points. The number of fast charging points increased by 140%, from 106 in 2013 to 254 at the end of 2014. This includes 3 Tesla superchargers. Next to these publicly accessible charging points, an estimated 28,000 private charging points were in operation. Overall, at the end of 2014, the ratio of charging points to electric vehicle was 0.9 in the Netherlands.

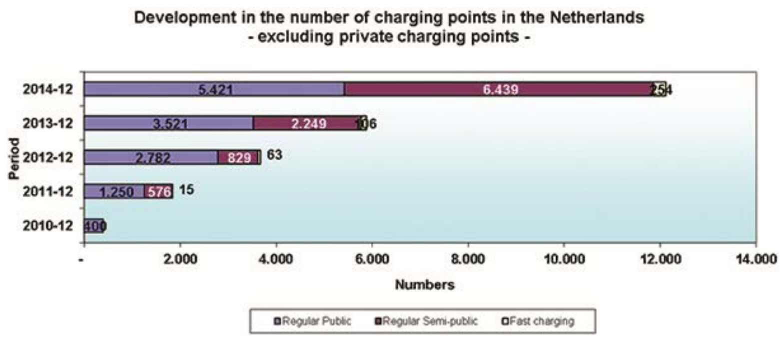

Figure 9: Development of charging infrastructure in the Netherlands (Oplaadpalen.nl, edited by RVO.nl)

The Netherlands counted 2 fuelling locations for FCVs in 2014, one in the Rotterdam area (in the western part of the country) and one in Helmond, in the south. At these fuelling locations both 350 bar (for buses) and 700 bar (for passenger cars) can be tanked.

27.4 EV Demonstration Projects

Several demonstrations projects with both BEVs and PHEVs have been finished 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 at creating 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 9 government-subsidized projects that tried out various EVs, can be found here: http://www.nederlandelektrisch.nl/english/ (see menu on the right). In 2015 a final evaluation report will be published.

Also several Green Deals on e-mobility are being carried out, 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 here: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/praktijkverhalen/green-deals

As far as FCVs are concerned, there is a demonstration project with a hydrogen garbage truck in the city of Eindhoven. Rijkswaterstaat, responsible for the main highways and waterways network in the Netherlands, is testing 2 FCVs (Hyundai). Some other organizations or municipalities are also testing FCV passenger cars.

27.5 Outlook

The national subsidy scheme for low emission vans and taxis has ended per ultimo 2014. Some regions still have subsidy schemes in place. In 2015 the fiscal stimulation policy for electric cars will stay the same as in 2014. From 2017, the system of vehicle taxing will change substantially, with 2016 being a transition year. Of the value of a company car 4% will be added to taxable income for BEVs (no change) and 15% for PHEVs (+8%). Details for 2017 and further are not yet clear.

Figure 10: VDL Citea electric bus (VDL Bus & Coach)

It is expected that the Green Deal on Public Infrastructure will be signed in 2015. One of the elements might be that local and regional governments are eligible for a financial contribution from the central government, under the condition that they themselves contribute as well.

Tesla Motors Europe already based their distribution centre and assembly plant for the European market in Tilburg in the south of the Netherlands and will open up a second assembly location there in 2015.

The province of Brabant will start a pilot project deploying 15 electric buses for public transport. They cooperate with the Dutch company VDL Bus & Coach. The pilot will lead to the formation of an innovation platform focused on the development of electric drive systems, components and associated charging infrastructure.

In 2014, projects were accepted in five regions in the Netherlands to experiment with two fuel cell buses for public transport in each region. In addition two new fuelling locations will be opened. In 2016, 10 hydrogen buses will join the regular bus service in the regions around Arnhem-Nijmegen, Eindhoven, and Rotterdam and the provinces of Groningen and Zuid-Holland.

Table 2: Types of electric vehicles in the Netherlands (not exhaustive)

Most common brands and models on the road in the Netherlands in 2014		
Battery Electric Passenger Vehicles	**Plug-in hybrid and Range-extended Electric Passenger Vehicles**	**Battery Electric Commercial Vehicles**
BMW i3	Audi A3 Sportback e-tron	Citroen Berlingo
BYD E6	BMW i3 (range extender)	Ford Transit Connect
Citroen C-Zero	BMW i8	Mercedes Vito E-cell
Kia Soul	Chevrolet Volt	Nissan E-NV200
Mercedes E-cell	Fisker Karma	Peugeot Partner
Mitsubishi I-MIEV	Mercedes-Benz S500 Plug-in Hybrid	Piaggio Porter E
Nissan Leaf	Mitsubishi Outlander	Renault Kangoo Express Z.E.
Peugeot Ion	Opel Ampera	Citroen Berlingo
Renault Fluence Z.E	Porsche Panamera S-E-Hybrid	Ford Transit Connect
Renault Twizy	Porsche Cayenne S-E-Hybrid	Mercedes Vito E-cell
Renault Zoe	Toyota Prius Plug-in	
Smart Fortwo E	Golf GTE Plug-in Hybrid	
Tesla Model S		
Tesla Roadster		
Th!nk City		
Volkswagen E-Up		
Volvo C30		

Table 3: Distribution, sales, and models of EVs and HEVs in 2014 (Sources: Dutch Road Authority/BOVAG/RAI/RVO.nl)

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	1,227,291[53]	n.a.	n.a.	n.a.	23,625,919[54]
Motorbikes	196	n.a.	n.a.	n.a.	713,917[55]
Quadricycles	769	n.a.	n.a.	n.a.	n.a.
Passenger vehicles	6,825	117,259	36,937	9	8,154,000
Multipurpose	Included in passenger vehicles				

[53] Composed of 1,2 million e-bikes and 27,291 e-scooters
[54] Composed of 22,5 million bikes (2014) and 1,125,919 scooters (2013)
[55] Number per 2013

passenger vehicles					
Commercial cars/vans (<3.5 tons)	1,258	n.a.	n.a.	n.a.	890,000
Buses (public transport)	72[56]	69	n.a.	1	5,000
Trucks	46	n.a.	n.a.	4	69,000
Industrial vehicles	18	25	n.a.	1	16,000

Total Registrations during 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	170,467[57]	n.a.	n.a.	n.a.	1,063,112[58]
Motorbikes	71	n.a.	n.a.	n.a.	10,354
Quadricycles	137	n.a.	n.a.	n.a.	n.a.
Passenger vehicles	2,664	10,341	12,425	6	387,835
Multipurpose passenger vehicles	Included in passenger vehicles				
Commercial cars/vans (<3.5 tons)	589	n.a.	n.a.	n.a.	51,774
Trucks	n.a.	n.a.	n.a.	4	11,032
Industrial vehicles	n.a.	n.a.	n.a.	1	n.a.

n.a. = not available

[56] Including trolley buses
[57] Composed of 166,078 e-bikes and 4,389 e-scooters
[58] Composed of 1 million bikes and 63,112 scooters

28 Portugal

28.1 Major Developments in 2014

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.

28.1.1 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 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.

28.1.2 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 1 are restricted to fully electric vehicles (PHEVs are not included) to maximize the effectiveness and impact of each measure.

Table 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

Figure 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])

28.1.3 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.

28.1.4 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 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.

Today, electric mobility is a core area for Portuguese R&D, and Portugal has many other research projects under way, as shown in Table 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 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 to create a more reliable and efficient end-to-end energy system.	INTELI, CEIIA, Critical Software
MOBILES	To create ICT-based solutions to support electric mobility, in particular mobile-based applications with navigation systems for support.	NDrive, FEUP[a], INTELI, CEIIA, and INESC-Porto[b]
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	MITc-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

[a] FEUP stands for the engineering faculty of the University of Porto
[b] INESC-Porto stands for The Institute for Systems and Computer Engineering of Porto
[c] MIT stands for Massachusetts Institute of Technology

28.1.5 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 looking forward 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.

28.2 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).

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 CO_2/km by 2015. In fact, average car emissions in Portugal's new car market were 127.4 g CO_2/km in 2010, the lowest in the European Union.

28.3 Charging Infrastructure or EVSE

Portugal’s electric mobility program is widely known as MOBI.E, and much of the structure of this program was explained in Section 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 2).

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

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

Figure 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)

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, 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.

28.4 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 EUR 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 EUR 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.

29 Republic of Korea

29.1 Major Developments in 2014

29.1.1 The Supply Status and Future Direction of Domestic EVs

Korea had established a supply strategy of EVs with interagency involvement by the end of 2010. At the first step, the public authorities were intended as buyers of EVs. 3,000 cars were intended in the way of purchase obligation by 2012. As a second step, the designation of EVs leading cities and private pilot supply plan were established in 2013. Despite the effort of the government, the target was not achieved and EVs number counted below 2,000 cars until December 2014. The number of rapid charging facilities was only 237 and both slow and self-charging facilities were a little more than 2,955.

29.1.2 The Supply Status of EVs and Charging Facilities

The government is considering as the next target, a EVs supply number of 8,000 next year and 200,000 cars by 2020. Independently, Jeju city intends to change all ICEV to EVs by 2030 and planned to supply 70,000 EVs under the motto “Zero-Carbon Island”. Seoul also has prepared a plan that spread to 15,000 EVs by 2018. We are also looking to find a solution for charging infrastructure and compatibility of charging system. Especially, the government has been progressively seeking to secure public charging infrastructures in the EVs leading cities. Also, complex multi-type and CHAdeMO + AC 3-phase + DC combo type chargers will be installed to solve the compatibility issue. For the effective operation and management, charging facilities in progress carry out a fee-charge policy and the local government will be intended to expand the charging service. It was intentionally enforced to induce the cost load relaxation of local governments and the participation of businessmen and to increase the slow charging amount at night when there is relatively less electricity demand The fee-charge policy will be based on below 0.41 EUR/kWh. In comparison to gasoline usage for 500 km, the charging price is about 30% less than the gasoline price (Gasoline: 1.53 EUR/l, i.e. 63.6 EUR/500 km).

29.1.3 The Status of Domestic EVs

According to planned new government subsidies, the electric truck scheduled for release in 2015 and PHEV (Plug-in Hybrid Electric Vehicle) will be supported. The target for support and scale of the subsidy will be finally determined at the end of this year. Also, the existing tax benefits such as the individual consumption tax and the sunset regulation of tax reduction are extended to expand the EVs market. In a part of government subsidy, 59.4 million EUR is affirmatively included as the demo project ”EVs battery rental” to break through the largest weakness of EVs such as high EV prices and the shortage of charging infrastructure. This demo project signifies broadscale changes of the key policy from EVs purchase subsidy. The battery rental business will be based on bus and taxi garages for stocking charged batteries and supported for the extra battery purchase (69,500 EUR/bus) and the battery change system will be supposedly 1.5 million EUR per system. These subsidies are not the total price of each part.

Table 1: Domestic EVs status (Note: 1 EUR = 1,210 KRW [won])

Brand	KIA	Renault Samsung	GM Korea	KIA	BMW Korea
Car	 Ray	 SM3	 SPARK	 SOUL	 i3
Highest speed	130km/h	135km/h	145km/h	150km/h	150km/h
Mileage /full charge	91km	135km	135km	150km	126.8km
Battery type	16.4kWh (Lithium-ion)	26.6kWh (Lithium-ion)	21.4kWh (Lithium-ion)	27kWh (Lithium-ion)	21.3kWh (Lithium-ion)
Charging(Slow)	6 hours	6~8 hours	6~8 hours	4~5 hours	6~8 hours
Charging(Rapid)	25 minutes	30 minutes	20 minutes	25 minutes	30 minutes
Battery guarantee	6 years / 120,000 km	5 years / 100,000 km	8 years / 160,000 km	10 years / 160,000 km	8 years / 100,000 km
Price [won]	45 million (Promotion : 35 million)	42.2 million 43.3 million	39.9 million	42.5 million	64.0 million 69.0 million

29.1.4 Gwangju into a Mecca for Hydrogen Car Production

Through an agreement made between Hyundai Motors, the city of Gwangju, and the national government, Gwangju will be transformed into a central hub of hydrogen fuel automobiles in Korea. Government, Industry and University took part in the grand opening ceremony of the Gwangju Creative Economy Innovation Center. With regard to the hydrogen fuel car industry, President Park said the world's one and only automaker of the hydrogen-fueled cars, Hyundai Motors, would invest in developing and promoting the hydrogen automobile industry in the city. In addition, the Gwangju Creative Economy Center will reportedly function to offer local citizens and merchandisers various systematic aids in developing and facilitating a creative economy.

Figure 1: Creative Economy Center in Gwangju

29.1.5 Strategy for Building the Range Extended Electric Vehicle

The "Green RE-EV (Range Extended Electric Vehicle) Car Part Development and Research Infrastructure Project" on transportation systems set its goal to foster car part manufacturing companies specializing in RE-EVs by constructing an R&D infrastructure for core parts, and fortifying the technical development of core components in Ulsan as the center of the national automotive industrial sector. To execute the project, 91 million EUR of national government investments, 13.4 million EUR of local government investments, and 18.6 million EUR of private sector investments for a total of 123.5 million EUR will be invested since September of 2011 through August of 2016. To encourage dissemination of RE-EV transportation, the project set an objective to commercialize 8 types of core components within the 5 year period of the project. The aim is to target components which can contribute to more practical business activities, such as construction R&D and research foundations.

Figure 2: Strategy of the Republic of Korea towards building the range extended EVs

29.2 HEVs, PHEVs and EVs on the Road

According to the Korea automobile Manufacturers Association (KAMA), the diesel cars newly sold and registered were 805,609 and showed an increase of 19.9% compared to last year (672,025 cars). New registrations of cars were totally 1,661,868 and accounted for 48.5% among the whole. This record represented that diesel cars surpassed the gasoline cars (661,919; 39.8%). Gasoline cars showed a 0.9% increase of sales. The sale of hybrid cars decreased 22.5% (34,516 cars) compared to last year. As a result, the proportion dropped below 2%. EVs, however, increased by 114% (1,315 cars) compared to the previous year, which was mainly registered from government offices.

Table 2: The new registration cars in 2014 (Source: KAMA Annual Reports)

Vehicle Item	Number [units]	Growth compared to last year [%]	Ratio [%]
Gasoline	661,919	0.9	39.8
Diesel	805,609	19.9	48.5
LPG	149,014	-15.3	9.0
HEV	34,516	22.5	2.0
EV	1,315	114	0.1
Others	9,495	-2.9	0.6
Total	**1,661,868**	**7.7**	**100.0**

30 Spain

30.1 Major Developments in 2014

Electric vehicles (EVs/PHEVs) and hybrid electric vehicles (HEVs) maintained a firm progression in terms of sales and consumer acceptance in 2014 in Spain due to the following actions and programs:

30.1.1 MOVELE 2014 Program

The MOVELE 2014 Program provided a 10 million EUR budget for incentives to acquire EVs and PHEVs in 2014 (RD 414/2014 normative).

The supported electric vehicles are collected in an EV's catalogue, placed at http://www.movele.es/ including a number of 32 car models, 120 quadricycles, 19 light commercial vehicles, and 2 buses.

Provisional data at the end of the year showed more than 2,000 applications for vehicle incentives of the different categories, realized through 184 sales points all over the Spanish Kingdom.

Table 1: MOVELE 2014 Program: incentives per vehicle, depending on category and range in electric mode

MOVELE 2014 Program: Incentives per vehicle (in EUR)			
Category	15km≤Range≤40km	40km<Range≤90km	90km<Range
Passenger cars & vehicles <3,5t (M1/N1)	3,000	4,500	6,500
Buses <5t & commercial vehicles <12t (M2/N2)			8,000
Buses >5t (M3)			20,000
L6e[59]	1,800		
L7[60]	2,200		

[59] Four wheels vehicle with mass exceeding not more than 350 kg without the mass of batteries.
[60] Four wheels vehicles (others than L6) whose mass is not exceeding 400kg (or 550kg for vehicles carrying goods) not including the mass of batteries.

30.1.2 PIVE Program

The PIVE Program is an incentive program, launched by the Spanish National Government 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 EUR for the purchase of a vehicle.

The PIVE Program is a car scrapping program, oriented at replacing old vehicles by new and more efficient 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. Buyers receive 1,000 EUR per vehicle, which could be increased by a 1,000 EUR additional discount realized by car manufacturers.

The PIVE program started in October 2012 and has been running on different stages, during 2014:

Plan PIVE5: approved on January 24th, 2014, funded with 175 million EUR.

Plan PIVE6: approved on June 26th, 2014, funded with 175 million EUR.

Within the framework of this PIVE Program (from Plan PIVE 1 to Plan PIVE 6) it has been acquired a total of 7,458 HEVs and 304 EVs/PHEVs from a total number of 696.105 conventional vehicles (provisional data at 12/02/2015). Final estimated results of these plans are the replacement of around 711,000 vehicles with a total budget of 715 million EUR.

30.1.3 PIMA Air Program

Another program launched by national government was “Plan PIMA Air”, a car scrapping program for commercial vehicles which has been running from February 2013.

There are incentives of 1,000 EUR for the acquisition of vans up to 2,500 kg weight and of vans over 2,500 kg, the incentives are 2,000 EUR per van. Since October 25th, 2013, electric motorcycles, scooters, and bikes were also included to this incentives program (“Plan PIMA Air 2”), with incentives up to 400 EUR, 250 EUR, and 200 EUR respectively per category.

Incentives of Plan PIMA Air can be added to the MOVELE Program incentives, but not to the PIVE Program.

During 2014, the third edition of the PIMA Air program (“PIMA Air 3”) was running, funded with a budget of 5.5 million EUR, and a number of 2,671 commercial vehicles were renewed and a number of 2,468 electric bicycles were acquired in this frame.

30.2 Charging Infrastructure or EVSE

30.2.1 Normative: Technical Instruction for Installation of Recharging Infrastructure

On December 12th, 2014 a normative was approved (Royal Decree 1053/2014), oriented at promoting and facilitating the deployment of recharging infrastructure of EVs.

This normative includes a Complementary Technical Instruction for the low-voltage electrical normative in Spain (ITC-BT 52).

Also it requires a minimum number of recharging points to be deployed in new public parking facilities and buildings (at least one recharging point per every 40 parking lots). In related parking lots of blocks of flats, it will be due to a principal conduction which enables the electrical branching to individual parking lots.

30.2.2 Charging Infrastructure Available in Spain

After an initial stage characterized by recharging infrastructure for free, in the frame of pilot demonstration projects in cities and regions, public infrastructure service for recharging EVs must be operated by recharging operators at present ("*Gestores de Cargas*", established and defined by national normative Royal Decree 647/2011), officially authorized by the National Government.

The CNMC (Comición Nacional de los Mercados y la Competencia)[61] gathers the relation of recharging operators officially registered in Spain on February 17th, 2015, which were operating more than one hundred public recharging points at the end of 2014.

However, a considerable number of public charging points remain in the frame of demonstration pilot city projects, managed by regional and local governments and not operated by official recharging operators. To keep all of these charging points operating, they need to be managed by officially registered recharging operators once the pilot projects are finished.

Table 2 shows the existing public charging points in Spain at the end of 2014, gathered from the promotors informing the IDAE in the Movele website[62].

[61] https://sede.cne.gob.es/c/document_library/get_file?uuid=8be589c8-9bbc-4881-b05f-baffd8e49afd&groupId=10136
[62] www.movele.es

Table 2: Public-use recharging infrastructure, at the end of 2014 (the total number of public EVSE does not include DC fast charging stations)

Total Public EVSE	761
Level 1	682
Level 2/standard AC	79
DC Fast Charging	11

30.3 EV Demonstration Projects

30.3.1 Balear Islands Pilot Project

This project with the goal of establishing the Balear Islands as an international reference in the electric mobility is running from 2014 to 2020. The proposal is to deploy 2,000 recharging points all over the Balear Islands, which should enable the proper use of around 1,200 EVs. The project is being promoted by the Regional Government of the Balear Islands and IDAE[63], in collaboration with local institutions, rent a car, and companies of the tourism industry. The incentives of IDAE amount to 2 million EUR (2,4 million USD) in total.

30.4 Outlook

The MOVELE Program 2014 was very much focused on promoting the acquisitions of cars and light commercials. In this way, incentives for electric motorbikes were removed from the MOVELE 2014 Program and shifted to the PIMA Air Program, which allowed a much higher budget potentially dedicated to incentives to the acquisition of cars and light commercial vehicles.

During 2014, 1,408 BEV/PHEV passenger cars and 345 light commercials were sold, which represents an increase of 60% and 290% respectively compared to sales of these vehicles in 2013. For HEVs, as is reflected in Figure 2, passenger car sales remain at a similar level within the last years, showing a slight decrease in the year of 2014.

[63] Instituto para la Diversificación y Ahorro de la Energia

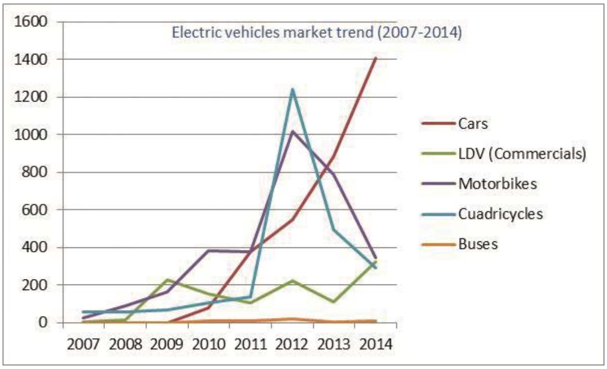

Figure 1: BEVs/PHEVs market trend (annual sales) in Spain

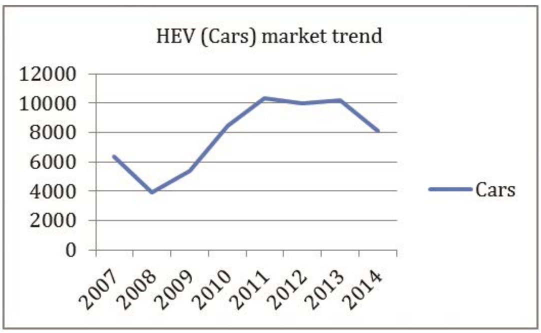

Figure 2: Market trend (annual sales) for HEVs – passenger cars category in Spain

Table 3: Available vehicles and prices before taxes in Spain, given by car manufacturers (data available through MOVELE program)

Market-Price Comparison of Selected EVs and PHEVs in Spain	
Most sold passenger vehicles	**Untaxed, Unsubsidized Sales Price in EUR***
MITSUBISHI OUTLANDER	47,000
Nissan LEAF	24,000
RENAULT ZOE	17,561

*MOVELE 2014 Program most sold passenger cars (data registered at February 24, 2015)

Table 4: Distribution, sales and models of EVs and HEVs in Spain in 2014

Fleet Totals as of December 31st, 2014					
Vehicle type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (assisted pedaling)	2,728	0	0	0	20,000,000*
Mopeds	1,298	0	0	0	2,052,503**
Motorbikes	3,086	8	109	0	2,910,323**
Quadricycles	2,452	0	0	0	69,047**
Passenger vehicles	2,661	62,811	633	0	22,227,173**
Light commercial vehicles (<3.5t)	1,152	0	0	0	4,715,148**
Buses	8	31	45	0	60,234**
Trucks	n.a.	n.a.	n.a.	n.a.	215,576**
Totals with bicycles	**13,385**	**62,850**	**787**	**0**	**52,250,004**
Totals without bicycles	**10,657**	**62,850**	**787**	**0**	**32,250,004**

Total Sales during 2014					
Vehicle type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (assisted pedaling)	2,468	0	0	0	1,034,374*
Mopeds	252	0	1	0	14,754**
Motorbikes	344	8	1	0	92,558**
Quadricycles	292	0	0	0	2,914**
Passenger vehicles	968	8,128	440	0	722,689**
Light commercial vehicles (<3.5t)	322	1	0	0	85,459**
Buses	3	4	5	0	1,719**
Trucks	n.a.	n.a.	n.a.	n.a.	13,150**
Totals with bicycles	**4,649**	**8,141**	**447**	**0**	**1,967,590****
Totals without bicycles	**2,181**	**8,141**	**447**	**0**	**933,216****

n.a. = not available

*Source AMBE (Spanish Association of Bicycles and Brands) estimated data for 2013

**2013 data (in updating process to data of 2014)

31 Sweden

31.1 Major Developments in 2014

For the first time a wide variety of different EV and PHEV models were available at the Swedish market in 2014. This alone did not influence an increase of sales of over 145% compared to 2013, but it is an important factor to explain the rapid growth in sales. The market share of EVs and PHEVs in 2014 was 0.2% and they constitute 1.4% of the new-car sales. The majority of the sales are PHEVs.

31.1.1 New Policies and Incentives

Since 2011, passenger vehicles with emissions levels lower than 50 g CO_2/km have been granted a 4,000 EUR rebate. A total of 21 million EUR where assigned to lower the purchase cost of PHEVs and EVs when the funding ended in July 2014. In December 2014, the new government from the autumn's election prolonged the scheme to include an additional 21 million EUR.

In 2014, the government decided to support the national expansion of the charging infrastructure with 7.5 million EUR per year (a maximum of 4 years and 30 million EUR have been granted). The official construction of the support scheme is not yet finalized.

31.1.2 Funding

The Swedish Transport Administration, the Swedish Energy Agency, and the Swedish Governmental Agency for Innovation Systems together have initiated an innovation/ technology procurement process for the demonstration of electric road systems (ERS). In ERS, the vehicles are continuously supplied with electricity during the whole, 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 the heavy vehicles. In a first stage in 2013, eleven suppliers reported an interest in developing electric road systems, and then they submitted their applications. In 2014, four suppliers moved on and will implement a respective detailed design of the demonstration plant in practice to work. The goal is to have at least two suppliers build demonstration plants in Sweden. The budget is 100 million SEK (approximate 10 million EUR) and the goal is to have two smaller operating systems by 2015.

31.1.3 Research

The Swedish Energy Agency finances research and demonstration projects to support the development of electric vehicles. To illustrate this wide approach, Figure 1 shows some examples of current research programmes.

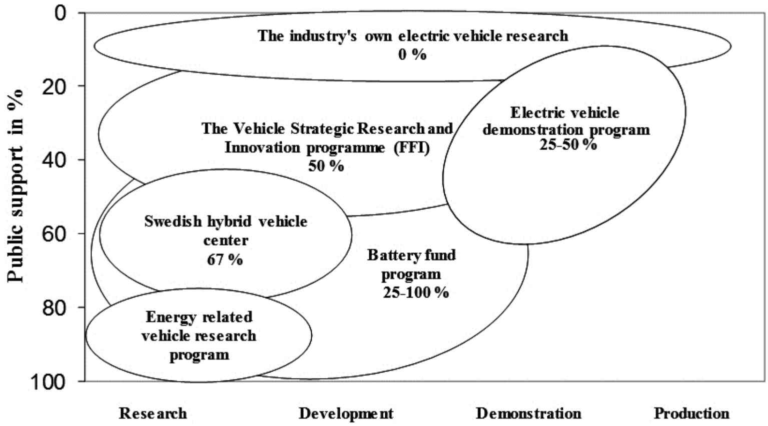

Figure 1: Current research programmes financed by the Swedish Energy Agency

31.2 HEVs, PHEVs and EVs on the Road

At the end of the year 2014, around 5,000 PHEVs, 3,000 EVs (PEVs in total 8,000), and 35,000 HEVs were registered in Sweden. The most common PHEVs are the Mitsubishi Outlander (2,306) and the Volvo V60 (1,127). Among EVs, Nissan Leaf (804) and Renault Kangoo (705) are the most common vehicles.

31.3 Charging Infrastructure or EVSE

In 2014, a EU Directive relating to the expansion of infrastructure for alternative fuels was established. It requires that member countries should submit their plans for the expansion of the infrastructure for charging electric vehicles. The Swedish Energy Agency has initiated the work with the action plan and the Swedish government has been allocated 24 million EUR for the period of 2015-2017 to facilitate the development of the public charging infrastructure.

There are about 3,000 public charging points in Sweden, but many of them are not always as accessible to the public as would be preferred. Information about locations and charging specifications may be found through the website: www.uppladdning.nu.

On the website it is possible to see which types of chargers the places have. As of December 31st, 2014 there were a total of about 100 Tesla superchargers, 50 CHAdeMO, and 40 CCS fast charging outlets in Sweden.

Table 1: Distribution, sales, and models of EVs and HEVs in Sweden in 2014 (the data for 2014 is supposed to be published by Trafa /SCB at the beginning of February 2015).

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	n.a.	n.a.	n.a.	0	n.a.
Motorbikes	n.a	n.a.	n.a.	0	n.a.
Quadricycles	145	n.a.	n.a.	n.a.	n.a.
Passenger vehicles	2,218	35,000	5,043	1	4,585,520
Multipurpose passenger vehicles	827	n.a.	n.a.	0	n.a.
Buses	5-10	n.a.	5-10	0	n.a.
Trucks	n.a.	n.a.	n.a.	0	n.a.
Industrial vehicles	n.a.	n.a.	n.a.	0	n.a.

Total Sales during 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)	n.a.	n.a.	n.a.	0	n.a.
Motorbikes	n.a.	n.a.	n.a.	0	n.a.
Quadricycles	n.a.	n.a.	n.a.		n.a.
Passenger vehicles	1,266	7,053	3,411	1	324,000
Multipurpose passenger vehicles	n.a.	n.a.	n.a.	0	n.a.
Buses	5-10	n.a.	n.a.	0	n.a.
Trucks (< 3,5 t)	282	n.a.	n.a.	0	n.a.
Industrial vehicles	n.a.	n.a.	n.a.	0	n.a.

n.a. = not available

31.4 EV Demonstration Projects

During the summer of 2014, the project Elbilslandet Gotland initiated a rental service with 20 EVs (Leaf, eUp! and Twizy) on the island Gotland, a popular tourist resort, 180 km long and 50 km wide, near the coast in the Baltic sea.

Figure 2: One of the rental Twizies in the UNESCO listed old town Visby in Sweden

The aim was to assess the potential of EVs within the tourism industry. Additionally, the project established 20 public charging points at or close to different tourist sights. Approximately 1,400 people used the vehicles during 3 months. 96 % of the users stated to be positive on renting an EV again.

In Sweden, there is a large interest in electrifying buses in public transport with several different examples, all over Sweden. The degree of electrification varies from a fully electric commuter bus between Ale and Gothenburg, Sweden's second biggest city, to plug-in and hybrid city buses in Gothenburg. In Stockholm, an extensive two-year field-test of plug-in electric buses has started. Eight buses operate an approximately 7 km route (bus 73) with fast-chargers at the end stations.

31.5 Outlook

The number of EVs and PHEVs are expected to increase to 15,500 by the end of 2015. This development may be accelerated by the large investment in public charging infrastructure and the prolonged 4,000 EUR rebate for PEVs.

Table 2: Available vehicles and prices in Sweden

Market-Price Comparison of Selected EVs and PHEVs in Sweden	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (EUR)**
Mitsubishi i-MIEV	29,000
Mitsubishi Outlander PHEV	41,000
Nissan Leaf	34,000
Opel Ampera	38,000
Peugeot iOn	28,100

Porsche Panamera S E-Hybrid	108,500
Renault ZOE	21,000
Renault Kangoo Maxi[a]	27,000
Renault Twizy[a]	6,900
Tesla Model S 60 kWh	65,200
Tesla Model S 85 kWh Performance	86,900
Toyota Prius Plug-in	38,100
VW e-up!	27,000

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

32 Switzerland

32.1 Major Developments in 2014

32.1.1 KORELATION Project – Main Results

By the project name “KORELATION[64]” (German acronym for cost, range, and charging stations), the e’mobile Association evaluated the practical experience of private and commercial drivers of 199 EVs in Switzerland from 2013 to 2014. Results show that the often mentioned disadvantages of electric cars are not as relevant to drivers as stipulated by the media and the general public. Although the purchase price for electric cars is higher than for comparable ICE cars, the corresponding operating costs are significantly lower, mainly thanks to fuel savings of about 63% over all.

The average driving distance of BEVs in this project was 11,500 km per year which compares equally with the average annual mileage of conventional cars in Switzerland. This result refutes the prejudice that electric cars are just suited as second cars. Thanks to an adapted driving style, electric cars offer enough range for everyday use. For longer distances, people choose either public transport or plug-in hybrid cars without missing the advantages of electric driving.

The EV drivers of this project rarely used public charging stations. Business users are satisfied with their private charging solutions. However, some of the private users feel a need for more fast charging stations on public roads.

40% of the private participants of “KORELATION” did not get their electrical installations at home checked by a professional electrician before they bought the EV. For security reasons, the project management highlights the importance that the car dealers should always recommend that their customers have the electrical installation checked at home.

Regarding the type of electricity used, this survey did not reveal a uniform picture. On the one hand, many participants consider it important to produce the required power with their own photovoltaic system. On the other hand, an unexpectedly large number of EV drivers does not buy ecologically produced power. This is contrary to expectations for the preferred choice of the ecological “dream team”

[64] http://e-mobile.ch/index.php?pid=de,3,43

electric car and electricity produced from renewable energy sources. This is an interesting sales potential for energy suppliers.

32.1.2 Watt d'Or

The Swiss Federal Office of Energy (SFOE) awarded two major projects with relevance to E-Mobility with the Watt d'Or prize for their energy saving potential, namely GridSense and AHEAD.

GridSense[65] is a joint venture of Alpiq and the University of Applied Sciences and Arts of Southern Switzerland (SUSPI). The system stabilizes the electricity grid and saves costs. GridSense technology is decentrally installed in buildings, and it anticipates the consumption behaviour as well as the load on the electricity distribution network with artificial intelligence. In doing so, it optimally controls electricity consumption. Load optimization in a building using GridSense takes place across all electricity consumers equipped with this technology, including charging stations for electric vehicles, boilers, heat pumps, and alsophotovoltaic systems and house batteries.

The intelligent technology comprises an algorithm at its core. This constantly measures various parameters in its application environment, such as grid load, electricity consumption and production. It also incorporates weather forecasts as well as electricity prices in the calculations. Furthermore, the algorithm learns the behaviour of its electricity consumers by means of artificial intelligence.

The "Advanced Hybrid Electric Autobus Design" (AHEAD[66]) was developed by Carrosserie Hess AG of Bellach and the Institute for Dynamic Systems and Control of the Swiss Federal Institute of Technology Zürich (ETH).

This project aimed at optimizing the powertrain of a serial hybrid electric bus for public transportation. First, the optimal sizing of the powertrain components (sizes of combustion engine, supercapacitor, traction motor, etc.) were evaluated by using an optimal control theory. Then an optimal energy management was implemented on the vehicle. A standardized on-road test revealed that a serial hybrid electric bus consumes between 17.5-27.5% less fuel than a comparable diesel bus. Running on a public bus line for three weeks, the serial hybrid bus consumed on average 25% less than a comparable diesel bus.

[65] http://www.alpiq-intec.ch/en/energy-efficiency/smart-technologies/gridsense/gridsense.jsp
[66] http://www.idsc.ethz.ch/research-guzzella-onder/research-projects/AHEAD.html

Figure 1: Elements of GridSense: 1 Photovoltaic system | 2 Boiler | 3 Charging station for electric vehicles | 4 House battery | 5 Heat pump | 6 Gateway | 7 Control app/Web (Photo: Alpiq)

Within a couple of years buses with AHEAD-Systems may be operating in Swiss cities. This is possible by configuring tailor-made systems with components from any given supplier.

32.1.3 Waste Disposal System in a Car-Free Resort

Zermatt is one of many Swiss car-free tourist resorts that has restricted access by combustion engine vehicles. In this mountain village more than 500 electric vehicles and buses operate the personal transport, taxi services, and freight distribution.

The air has suddenly become a lot cleaner in Zermatt: the world-famous tourist destination has introduced a brand new method of waste disposal which significantly reduces energy consumption as well as CO_2 emissions and noise levels. The developer of this method, the System-Alpenluft AG[67], has come up with a waste disposal solution that is ideal for a mountain resort like Zermatt. Easily maneuverable energy-efficient electric side-loaders are used for transporting waste, and the electricity that is required for powering these vehicles is obtained from the two hydropower plants operated by Zermatt Electricity Works. Micro-compacting containers compress the waste immediately on site, and thus reduce the number of journeys required for unloading. The result is highly impressive: energy savings of 80% compared to the conventional waste disposal method.

[67] http://www.system-alpenluft.ch/alpenluft-en.html

Figure 2: AHEAD – Advanced Hybrid Electric Autobus Design (Photo: IDSC)

As from May 2015, a fermentation plant will process food wastes and peelings from the restaurants and hotels in Zermatt. Part of the produced electricity will be generated for the local electric transport and waste disposal systems.

32.1.4 "Eco-Vignette"

The label "eco-vignette of naturemade star" stands for ecologically produced electricity in Switzerland, i.e. from 100% renewable sources, and guarantees compliance with strict and comprehensive ecological criteria. The label is available for electric cars, e-scooters and e-bikes. With the purchase of this label, a fixed amount of kilometers per year is guaranteed to be produced by green electricity. The eco-vignettes are marketed by electricity utility providers and car importers.

32.2 HEVs, PHEVs and EVs on the Road

In Switzerland, 396,588 new motor vehicles were registered in 2014. This is 1.4% less than in 2013. Nevertheless, the total stock of road vehicles has grown further and has reached almost 5.8 million vehicles, 75% of which are passenger cars. Statistically every second person in Switzerland owns a car with a distinct trend towards diesel and AWD vehicles. Motorbikes are also very popular. Their number increased fivefold since 1980.

3.2% of the new cars had alternative drive trains in 2014. HEVs (6,205) achieved the highest sales of alternative cars, but their number dropped by 8% compared to 2013. Although lower in absolute numbers, the growth rate of PHEVs (735; +109%), EREVs (296; +61%), and BEVs (1,671; +42%) increased considerably. The best sold models in the PHEV category were the Mitsubishi Outlander (212), Volvo V60 (128), and the Toyota Prius (56) and in the BEV category the Tesla Model S (495), Renault ZOE (380), and BMW i3 (222).

Figure 3: Electric disposal system of System-Alpenluft in Zermatt (Photo: System-Alpenluft)

1,842 new e-scooters were registered in 2014. This was a market share of 3.9%, (2013: 4.7%). The best-selling models were the three-wheeled Kyburz DXP and DXT (1,098), the Renault Twizy (163), and the Segway (92). These vehicles do not correspond to the regular image of classic scooters which seem to become less attractive.

The company Kyburz[68] in Freienstein has been developing and producing electric vehicles for more than 20 years. They first focused on vehicles for persons with reduced mobility. Since 2008, the company supplies the Swiss Post with the three-wheeled DXPs for the delivery service. By the end of 2014, over 80% of the 7,000 scooters of the Swiss Post were electric models and by 2016 all petrol scooters will be replaced.

32.3 Charging Infrastructure or EVSE

The network of public charging stations for electric vehicles is growing fast. By the end of 2014, more than 1,000 charging stations were registered in the first Swiss national database[69]. There were approx. 950 Level 2/standard AC stations with 1-2 EVSEs each and 75 DC fast charging stations (CHAdeMO and CSS stations as well as Tesla Superchargers) with 1-2 EVSEs each. Additionally, there were no public, but three industrial hydrogen filling stations for fuel cell vehicles available.

[68] http://www.kyburz-classic.ch/en/home
[69] http://e-mobile.ch/index.php?pid=de,2,147

Figure 4: The Kyburz DXP continously replaces petrol scooters at the Swiss Post (photo: Kyburz)

The LEMnet.org database was established by the aggregation of the data in a cross-border co-operation from e'mobile and LEMnet Europe. With the merger of the two major directories of charging stations in Switzerland, a national database with uniform data is now available that is also part of the European network. E'mobile takes care of the data updates and LEMnet Europe looks after the maintenance and development of the database. The project is supported by SwissEnergy (SFOE).

There is a trend towards co-operation by local and regional electricity utility providers for networking (MOVE) and standards (EVITE). Additionally, political steps are taken towards fast charging infrastructure at roadhouses along freeways, whereas the Federal Roads Office (FEDRO) is in charge of examining the possibilities for realization.

32.4 EV Demonstration Projects

"Eco-Mobil on Tour[70]" is the program by SwissEnergy, regional partners, the e'mobile Association, gasmobil, and NewRide to promote energy-efficient two and four-wheel-drive vehicles to the Swiss public. Each event consists of at least two days. The professional day is an information and networking event to target groups in the scientific, political, and business environment. On the public day(s), the general population is invited to the exhibition and to test-drives as well as to a panel discussion with owners of eco-mobiles. The personal advice is brand-neutral.

Eco-mobiles belong to cars of the energy efficiency category A. Their CO_2 emissions are limited to 95 g/km. Included are new powertrain technologies such as electric, hybrid, and natural gas cars, as well as energy-efficient gasoline and diesel cars and also small electric cars and e-scooters.

[70] http://www.energieschweiz.ch/de-ch/mobilitaet/fahrzeuge/eco-mobil-on-tour.aspx

Figure 5: Tesla Superchargers alongside EVITE charging station at the Hotel Möwenpick in Egerkingen (Photo: Association e'mobile)

"Electric vehicles for service trips" is a project of NewRide, SwissEnergy, the energy utility provider Energie Wasser Bern (ewb), and Swiss cities. Interested companies are offered the opportunity to test various electric bikes, scooters, and small electric vehicles during four to six months for real life testing. Vehicles are provided by NewRide in collaboration with local dealers for a small fee.

In the town of Berne, e-scooters, e-bikes, and cargo e-bikes have been tested by four companies during a trial period from spring to fall 2014. They were positively evaluated and appreciated for local delivery services. After the test period a participating company decided to buy e-bikes to integrate into their fleet.

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

Table 1: Distribution, sales, and models of EVs and HEVs in Switzerland in 2014

Fleet Totals as of December 31st, 2014						
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**EREVs**	**FCVs**	**Total**
Motorbikes	9,533	n.a.	n.a.	n.a.	n.a.	684,919
Quadricycles	1,142	n.a.	n.a.	n.a.	n.a.	14,300
Passenger vehicles	3,741	40,577	950	744	4	4,384,490
Buses	52	n.a.	n.a.	n.a.	5	62,436
Trucks	390	n.a.	n.a.	n.a.	1	382,281
Industrial vehicles	2,897	n.a.	n.a.	n.a.	n.a.	255,658
Totals without bicycles	**17,755**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**5,784,084**

Total Sales during 2014						
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**EREVs**	**FCVs**	**Total**
Motorbikes	1,619	0	0	0	0	45,969
Quadricycles	223	6	0	0	0	1,552
Passenger vehicles	1,658	6,095	735	294	0	304,083
Buses	3	12	0	0	0	4,167
Trucks	95	2	0	0	0	33,405
Industrial vehicles	270	3	0	0	0	7,412
Totals without bicycles	**3,868**	**6,118**	**735**	**294**	**0**	**396,588**

n.a.= not available

Table 2: Available vehicles and prices in 2014 (currency converted from CHF into EUR on February 24th, 2015)

Market-Price Comparison of Selected EVs and PHEVs in Switzerland	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price* in CHF and EUR, respectively**
BMW i3	39,950; 37,190
BMW i3 REX	46,900; 43,660
Ford Focus Electric	55,500; 51,667
Mia electric	19,900; 18,610
Mitsubishi i-MIEV	24,999; 23,273
Mitsubishi Outlander PHEV	51,999; 48,408
Nissan Leaf	35,690; 33,225
Nissan e-NV200 Evalia	44,570; 41,490
Opel Ampera[a]	46,900; 43,660
Porsche Panamera S E-Hybrid	145,200; 135,173
Renault ZOE[b]	22,900; 21,320
Renault Kangoo Maxi[b]	30,024; 27,950
Renault Twizy[b]	9,700; 9,030
Smart Fortwo Electric Drive[b]	24,500; 22,810
Tesla Model S 60 kWh	71,900; 66,935

Tesla Model S 85 kWh Performance	95,200; 88,625
Toyota Prius Plug-in	45,900; 42,730
Volvo V60 Plug-in Hybrid	68,500; 63,770
VW e-Golf	39,950; 37,190
VW e-up!	32,750; 30,440

[a] EREV = extended-range electric vehicle, FCV = fuel cell vehicle, n.a. = not available
[b] Sales price excludes monthly battery rental fee of 59–103 CHF; 55–96 EUR, depending on brand and model.

33 Turkey

33.1 Major Developments in 2014

Even though the Turkish hybrid and electric vehicle (H&EV) market is still in its early stages, various studies and business plans have been conducted in Turkey in 2014. Turkish policies, legislations and investments are continuing to encourage the market penetration of H&EVs, which is stimulating the research institutes, universities and the industry in the country. During 2014, the government launched major research programs by supporting R&D projects regarding electric vehicles (EVs) and subcomponent technologies. Calls for project proposals in these areas have been announced and executed by TÜBİTAK (The Scientific and Technological Research Council of Turkey). Moreover, significant strategies have been put forth in order to reinforce the associated infrastructure, improve the capacity of the corresponding test centers, and develop a national vehicle brand. The Minister of Science, Industry and Technology has announced that the national vehicle will be a REEV (range-extended electric vehicle) and is expected to have a considerable better fuel economy than most of the conventional vehicles in the market. He stated that TÜBİTAK will be the leader for this operation, especially in terms of design and engineering stages, but the manufacturing will be taken on by the private sector.

In 2014, various studies have been conducted by private institutions and universities to develop H&EV prototypes and technology demonstrators. Among these, Begler Inc. (established in mid 2012 with the sole purpose of electric vehicle production) has continued its efforts on prototype design and production (Figure 1). With the co-operation of academicians, the company has developed different electric vehicle model prototypes/conversions using composite materials. The Uzoq model can accommodate 4 people, has a large internal volume and weighs 850 kg. It has a 73HP motor, is claimed to travel 165 km and to be charged in under 30 minutes. On the other hand the car/motorcycle hybrid concept TR1 accommodates one driver and a single passenger and weighs 600 kg. It has a 13HP motor and can reach a speed of 60-80 km/h with a claimed range of 100-120 km. Moreover, companies such as BD Automotive focused on electric vehicle conversions for light commercial vehicles such as Scudo, Doblo, Ducato, and Renault Kangoo vehicles to achieve fuel efficiency improvements of 15% to be used in cargo applications. These vehicles have claimed electric ranges between 100 and 200 km. The company has manufactured over 400 vehicles, 100 of them being utilized in Turkey.

Figure 1: Electric vehicle prototype developed by Begler Inc. (Image courtesy of Begler Inc.)

Moreover, the Istanbul University has developed an electric vehicle prototype (Figure 2) with 2+1 passenger capacity and a 500 km range using a 30 kWh battery. The vehicle utilizes composite materials that reduces the weight to 500 kg and can reach speeds up to 120 km/h. The university announced that the T-1 can be charged in 4 hours with Level 2 charging and in 8 hours with conventional house plugs. The vehicle won TÜBİTAK's "Electromobility Race" by being the most efficient vehicle among the 30 competitors from universities around the country. In addition, various other electric vehicle prototypes have been developed in Turkish universities with smaller budgets, including "Çinar" from Bursa Orhangazi University that has a claimed 120 km range, and "DEMOBIL" from Dokuz Eylül University with a claimed 80 km range.

In 2014, the taxation system has remained the same in Turkey, both in terms of the tax on an initial new vehicle purchase and on the annual vehicle tax. As of the end of 2014, there is still no separate taxation system for passenger (P)HEVs as they are continued to be taxed with respect to their engine volume (similar to conventional vehicles). In addition, only passenger vehicles and motorbikes are included in the vehicle sale special consumption tax (SCT) reduction; light-duty trucks, trucks, and buses still maintain the same levels of taxation. Table 1 shows the vehicle sales SCT categories for initial new passenger vehicles and motorbikes.

Figure 2: T-1 electric vehicle prototype developed by Istanbul University (image courtesy of Istanbul University)

Table 1: Special consumption tax classification categories for new vehicles in 2014

	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
Motorbikes	<250	8	<20	3
	>250	37	>20	37

33.2 HEVs, PHEVs and EVs on the Road

33.2.1 Fleet

In Turkey, the number of vehicles on the road continued to increase in 2014. However, H&EVs still incorporated a negligible fraction of the total vehicles. Even though the official EV/HEV fleet statistics are not available, EV new sales are collected by the Automotive Distributors Association (ODD) as shown in Table 2.

Table 2: Total vehicle fleet according to the vehicle types between 2011 and 2014 (Source: TURKSTAT Road Motor Vehicle Statistics – 2015)

Vehicle Type	2011	2012	2013	2014
Passenger car	8,113,111	8,648,875	9,283,923	9,754,588
Minibus	389,435	396,119	421,848	426,322

Bus	219,906	235,949	219,885	212,144
Light commercial vehicle	2,611,104	2,794,606	2,933,050	3,040,460
Truck	728,458	751,650	755,950	774,331
Motorcycle	2,527,190	2,657,722	2,722,826	2,833,706
Special purpose vehicle	34,116	33,071	36,148	40,111
Tractor	1,466,208	1,515,421	1,565,817	1,612,310
Total	**16,089,528**	**17,033,413**	**17,939,447**	**18,693,972**

33.2.2 Sales

Passenger car sales in 2014 decreased by 11.6% compared to 2013 with a total of 587,331 units (Table 3). Meanwhile the light-commercial market shrank by 4.4%. Thus, the combined total passenger car and light-commercial market had a 10.04% reduction from 853,378 units in 2013 to 767,681 units in 2014. When the passenger car market was examined according to the engine volumes in 2014, the passenger cars below 1,600 cc received the highest share of sales with 95.17% and 558,995 units due to the lower tax rates (Table 3). In 2014, there were 47 EV passenger cars sold in Turkey compared to 31 in the year before.

Table 3: Passenger car market according to the engine/electric motor size between 2013 and 2014 (Source: ODD Press Summary – 2015)

Engine Size	Engine Type	2013	2014	SCT Tax Rates*	VAT Tax Rates*
≤1,600 cc	Gas/diesel	625,621	558,995	45%	18%
1,601 cc to ≤2,000 cc	Gas/diesel	33,035	22,536	90%	18%
≥2,001 cc	Gas/diesel	5,968	5,753	145%	18%
≤85 kW	Electric	31	22	3%	18%
86 kW to ≤120 kW	Electric	0	0	7%	18%
≥121 kW	Electric	0	25	15%	18%
Totals		**664,655**	**587,331**		

*2014 SCT tax rates

When the passenger car market is examined according to average emission values in 2014, the passenger cars that fell below 140 g CO_2/km limits accounted for more than 80% of vehicle sales (Table 4). This is primarily a result of the lower tax values for the engine volumes ≤1,600 cc, which also helps in reducing the total fleet emissions average of the vehicles in Turkey.

Table 4: Passenger car market according to average emission values in 2014 (Source: ODD Press Summary – 2015)

Average CO_2 -Emission Values of Passenger Cars					
Average Emission Values of CO_2 (g/km)	2013 Cumulative		2014 Cumulative		2014/2013
	Units	%	Units	%	%
<100	56,570	8.51	62,052	10.57	9.69
≥100 to <120	238,896	35.93	232,129	39.52	-2.83
≥120 to <140	215,936	32.49	184,708	31.45	-14.46
≥140 to <160	116,225	17.49	81,103	13.81	-30.22
≥160	37,028	5.57	27,339	4.65	-26.16
Total	**664,655**	**100.00**	**587,331**	**100.00**	**-11.63**

33.3 Charging Infrastructure or EVSE

Various ongoing installation efforts are still underway in Turkey to install EVSE across the country. These efforts are mostly concentrated in Istanbul, since it is the country's most populous city. The charging infrastructure installation projects are mainly conducted individually by a few private companies and increasing at a slow but steady rate. Although statistics have not been kept officially, the total number of charging points is estimated to be over 100 for public units. This number reaches over 500 when the home charging units are included too. Most of the stations are equipped with standard charging; only a few of them are direct current fast-charging stations. However, it is announced that Tesla Motors are planning to install fast charging stations in nine cities in Turkey, starting in Istanbul in 2015 and Anatolian cities in 2016. Despite the lack of an official announcement about new installations, there are plans to increase the number of charging stations over the next years.

A map showing the Esarj charging stations throughout the country can be found in Figure 3.

Figure 3: Map of Esarj charging stations throughout Turkey (courtesy of Esarj Electric Vehicle System Incorporated Company).

34 United Kingdom

34.1 Major Developments in 2014

34.1.1 Policy

The UK government's strategy to drive forward the ultra low emission vehicles (ULEVs) industry was announced in September 2013. The strategy signaled a major change in the way vehicles will be powered in the future and reaffirms the UK government's commitment to provide new opportunities for the motor industry to help grow the UK economy. The strategy is called "Driving the future today – a strategy for ultra low emission vehicles in the UK"[71]. In November 2013 the Office for Low Emission Vehicles launched a *call for evidence*[72], to inform the design of the new policy package to support the ULEV market.

In April 2014 Nick Clegg, the UK's Deputy Prime Minister, announced the main elements of a 500 million GBP package[73] (674 million EUR)of measures to support the development and use of ULEVs from 2015-2020. The overarching aim of the package is to secure the UK's position as a global leader in both the production and use of these vehicles. The associated document[74] provides an overview of the main themes that emerged from the call for evidence and outlines the different elements of the new package.

The UK Government plans the following measures for this period:

- 100 million GBP (135 million EUR) for research and development[75]
- 25 million GBP (34 million EUR) of funding between 2017-2018 and 2019-2020 to support innovation in ULEV manufacturing in the UK
- at least 200 million GBP (270 million EUR) on the continuation of the Plug In Car Grant[76], with the grant staying at 5,000 GBP (6,700 EUR) off the price of a new ULEV (until 50,000 grants or 2017)

[71] https://www.gov.uk/government/publications/driving-the-future-today-a-strategy-for-ultra-low-emission-vehicles-in-the-uk
[72] https://www.gov.uk/government/consultations/measures-to-support-uptake-of-ultra-low-emission-vehicles-from-2015-to-2020
[73] https://www.gov.uk/government/news/deputy-prime-minister-takes-green-cars-up-a-gear
[74] https://www.gov.uk/government/publications/ultra-low-emission-vehicles-in-the-uk-measures-to-support-use-and-development-2015-to-2020
[75] https://www.gov.uk/government/organisations/office-for-low-emission-vehicles/about/research
[76] https://www.gov.uk/government/publications/plug-in-car-grant

- 31 million GBP (42 million EUR) grant support for other ULEV sectors, including vans
- a new 35 million GBP cities scheme[77] (47 million EUR) to support flagship cities in introducing innovative local incentives, such as free parking, access to bus lanes and ULEV car clubs
- 10 million GBP (13.5 million EUR) of funding between 2017-2018 and 2019-2020 to increase ULEVs in London, in support of the ambition to introduce an Ultra Low Emission Zone by 2020
- 20 million GBP [78] (27 million EUR) to encourage a new generation of ultra low emission taxis
- 30 million GBP (40 million EUR) to boost the low emission bus market[79],
- at least 32 million GBP (43 million EUR) on new infrastructure, including rapid chargers
- 4 million GBP (5 million EUR) to ensure the UK has the gas refuelling facilities HGVs needed to support our freight and logistics operators in their efforts to reduce the environmental impact of their business
- 15 million GBP (20 million EUR) for a national network of chargepoints for ULEVs on the Strategic Road Network, as announced in the *Road Investment Strategy*[80]

The UK is also looking to support other technologies as they come to market, and so has not yet allocated all of the 500 million GBP (675 million EUR funding available. The new package builds upon our existing policies to provide one of the most comprehensive, and innovative, support packages for the transition to ULEVs anywhere in the world.

Figure 1: Major car manufacturers like BMW, Nissan, Renault, Toyota, and Vauxhall are backing the Go Ultra Low campaign in a partnership with the government

[77] https://www.gov.uk/government/news/multi-million-pound-fund-for-cities-to-take-driving-seat-in-green-car-revolution
[78] https://www.gov.uk/government/publications/ultra-low-emission-vehicle-taxi-scheme-preliminary-guidance
[79] https://www.gov.uk/government/publications/low-emission-bus-scheme-preliminary-guidance
[80] https://www.gov.uk/government/collections/road-investment-strategy

In what the UK believes is a world first the joint industry/Government Go Ultra Low communications campaign was launched on January 30th, 2014[81]. The aim of Go Ultra Low is to debunk common myths and misconceptions that put drivers off switching to electric or hybrid cars, such as cost and how far the vehicles can travel before being recharged. Following a successful first year, second year activity is now underway.

The UK secured significant ULEV-related inward investment in 2014. For example: in January it was revealed that the new electric car racing formula – Formula E – would be based at Donnington Park in the Midlands; in June, Ford announced that it had chosen Dunton Technical Centre as one of two global hubs for the development of its electric powertrains and; in July Mahindra announced plans to develop their Formula E vehicles in the UK.

34.2 HEVs, PHEVs and EVs on the Road

UK sales of electric cars and other plug-in vehicles continue to rapidly increase, with a record number of people taking advantage of government grants. The UK's Plug-in Car and Van grants reduce the price of ultra low emission vehicles (ULEVs) by up to 5,000 GBP (6,700 EUR) for cars and 8,000 GBP (10,700 EUR) for vans, making them more affordable for the public and businesses[82]. As of the end of January 2015 there were 23 car models and 9 van models eligible for the grant, with many more expected in the months to follow.

As of December 31st, 2014, 22,125 claims had been made for the car grant and 1,013 claims for a van grant. A total of 6,182 grant claims were made in the third quarter of 2014-2015, making it the best quarter yet by a significant margin (22% higher than the previous best quarter). The total Plug-in Car and Van Grants for 2014 were 16,025 (15,416 cars and 609 vans).

In October 2014 Business Minister Matt Hancock announced up to 11 million GBP (15 million EUR) of funding[83] to prepare the UK for the roll-out of hydrogen fuel cell electric vehicles (FCEVs). The funding will be used to help establish an initial network of up to 15 hydrogen refuelling stations by the end of 2015 and also includes 2 million GBP (2.7 million EUR) of funding for public sector hydrogen vehicles. The Programme is called HyTAP (Hydrogen Technology Advancement programme). As a result of the UK commitment to the FCEVs, Toyota has chosen the UK as one of the first markets for their Mirai FCEV which will go on sale later in 2015.

[81] https://www.goultralow.com/ ; https://www.gov.uk/government/news/nick-cleggs-drive-to-make-uk-world-leader-in-electric-cars
[82] https://www.gov.uk/plug-in-car-van-grants/overview
[83] https://www.gov.uk/government/news/multi-million-pound-fund-to-get-hydrogen-cars-moving

Table 1: The number of plug-in car grants made in the UK to December 31st, 2014

Number of Plug-In Car Grants			
Car Make and Model	**Number of Grants Issued**	**Car Make and Model**	**Number of Grants Issued**
Nissan Leaf	6,398	Mitsubishi Outlander	4,354
Toyota Plug in Prius	1,206	Vauxhall Ampera	1,139
Renault Zoe	873	BMW i3 REV	624
BMW i3 BEV	535	Tesla S	515
Peugeot iOn	343	Mercedes Smart Four two	268
Mitsubishi i-Miev	206	BMW i8	194
Citroen C-Zero	193	Porsche Panamera	191
Volvo v60	177	Chevrolet Volt	130
VW eUP	89	Renault Fluence	82
VW e-Golf	46	Audi E-Tron	37
MIA – Mia	1		

The programme follows on from the work undertaken by the UK H_2Mobility project[84] – which brings together leading businesses from the automotive, energy, infrastructure, and retail sectors with the government – to provide a “roadmap” for the introduction of fuel cell vehicles and hydrogen refuelling infrastructure in the UK.

Establishing 15 hydrogen refuelling stations by the end of 2015 will represent a significant first step towards the initial national network of 65 identified by UK H_2Mobility.

34.3 Charging Infrastructure or EVSE

We expect rapid chargers to play an important role in the uptake of electric vehicles, particularly through facilitating longer journeys, by allowing drivers to top up their charge at key locations around the strategic road network. They can also aid the adoption of plug-in vehicle by fleets, by allowing vehicles to quickly top up their charge during natural breaks in their duty cycles. There was a rapid chargepoint at every motorway service station by the end of 2014 and we expect to have a network of over 500 rapid chargers across the UK by March 2015 – the best network in Europe.

[84] http://www.ukh2mobility.co.uk/the-project/

The UK has set aside 32 million GBP (43 million EUR) to support chargepoint infrastructure between 2015 and 2020[85]. Rapid chargepoints are key element in this, but some of the money will be used to support chargepoints in other settings.

This work will build on the progress made in 2014, with the second round of winners being announced in January[86]. This programme will see the installation of part Government funded chargepoints on the street in residential areas, at train stations, and on the wider public sector estate.

In February 2013, the *Office for Low Emission Vehicles* (OLEV) launched a 13.5 million GBP grant scheme (18 million EUR) subsidising householders wishing to install technology to recharge ultra low emission vehicles (ULEVs) at home[87]. Once the original funding for domestic chargepoints had been fully allocated and, to ensure continued support for both consumers and the industry, a new 9 million GBP grant scheme was started in September and will run until March 2015[88]. The new scheme is available for any ULEV owner and also drivers with regular access to one for work who are having a chargepoint installed at their home provide up to 75% of the total cost of the chargepoint and installation, up to a maximum of 900 GBP. To date over 40,000 points have been installed under these schemes.

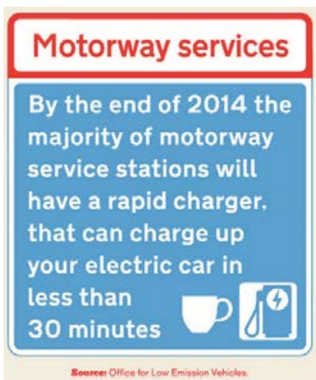

Figure 2: Directive of the UK's Office for Low Emission Vehicles

The *National Chargepoint Registry* is an open source listing of all Government funded and some private sector funded chargepoints in the UK[89]. This has been

[85] https://www.gov.uk/government/news/43-million-for-infrastructure-and-research-and-development-plug-in-vehicle-funding
[86] https://www.gov.uk/government/publications/plug-in-vehicle-infrastructure-grants-second-round
[87] https://www.gov.uk/government/publications/domestic-chargepoint-grant-guidance-for-chargepoint-suppliers
[88] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/389943/evhs-guidance-public.pdf
[89] http://www.nationalchargepointregistry.com/

used by third parties to develop web applications for use by the ULEV driving public in the UK[90].

34.4 EV Demonstration Projects

In July 2014, the UK announced the 5 million GBP (6.67 million EUR) ultra low emission vehicle (ULEV) readiness project as a first step in plans to make electric cars and other plug-in vehicles commonplace in government fleets[91]. The first phase saw 15 central government departments launch reviews of their vehicle fleets and will see around 150 vehicles begin to enter fleets in the spring of 2015.

In January 2015, the second phase of the scheme was launched and will see to 35 public sector organisations receive funding to support the use of up to 200 plug-in vehicles in their fleets. Organisations including the police, fire services, and the National Health Service will be able to test their ULEV-readiness, as part of a drive to get electric and plug-in hybrid vehicles into the fleets of central government.

In June 2014, the UK Government published an executive summary of the progress made in the UK's low carbon truck trial[92]. The trial was launched in 2012 following the government's *Logistics growth review*[93]. 13.5 million GBP (18.2 million EUR) funding from the *Office of Low Emission Vehicles* and the *Technology Strategy Board* was made available, via an open competition, to encourage and assist UK road haulage operators to buy and use low carbon heavy goods vehicles and supporting infrastructure.

34.5 Outlook

Global ULEV market sentiment is generally positive, and potentially ahead of where it might have expected it to be. A number of manufacturers have indicated significant ULEV product plans and some appear to have revised their plans to bring plug-in vehicles to market sooner than anticipated. In the UK, uptake of the Government's Plug-in Car Grant is now doing well with successive record quarters. This is being driven by more models, the technology becoming normalized as well as competitive pricing.

On February 13th, 2015, technical changes to the Plug-in Car grant were announced[94]. These will take effect from April 1st, 2015 and include an increase in

[90] https://www.zap-map.com/
[91] https://www.gov.uk/government/news/electric-cars-for-all-government-fleets
[92] https://www.gov.uk/government/publications/low-carbon-truck-trial-first-year-executive-summary
[93] https://www.gov.uk/government/publications/logistics-growth-review
[94] https://www.gov.uk/government/publications/plug-in-car-grant/plug-in-car-grant-vehicles

the percentage of the grant to 35% (with the cap remaining at its present level) and the introduction of three categories of car.

On February 26th, 2015 the UK announced further detail of its 43 million GBP (58 million EUR) infrastructure policy, which will see a continuation of support for domestic charge points and further funding for rapid and destination chargepoints[95].

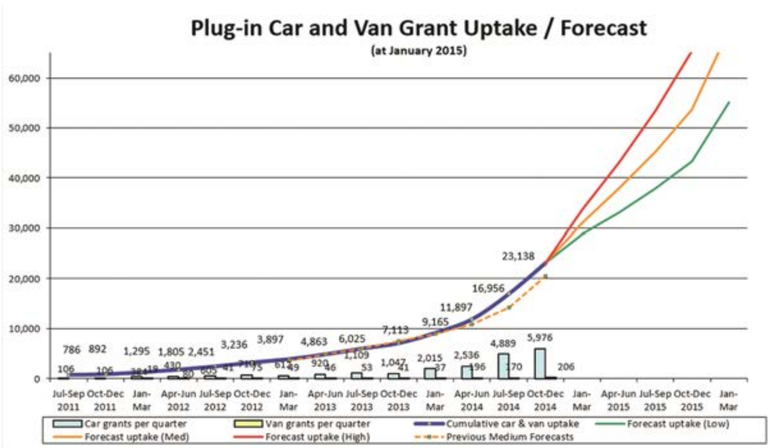

Figure 3: Uptake and forecast for the plug-in car and van grants

Table 2: Distribution, sales, and models of EVs and HEVs in UK in 2014

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Motorbikes	1,013	1	0	0	1,014
Quadricycles	13	0	0	0	13
Passenger vehicles[96]	10,500	171,528	6,318	0	188,346
Multipurpose passenger vehicles	65	2,664	0	0	2,729
Buses	154	1	0	0	155
Trucks	4,501	29	3	0	4,533
Industrial vehicles	3,600	27	0	0	3,627
Totals	**19,846**	**174,250**	**6,321**		**200,417**

[95] https://www.gov.uk/government/news/43-million-for-infrastructure-and-research-and-development-plug-in-vehicle-funding

[96] Category “Passenger vehicles” comprises vehicles with not more than 8 passenger seats in addition to the driver’s seat

Table 3: Distribution, sales, and models of EVs and HEVs in UK in 2014 (the sales table uses data for first registrations in UK during 2014, rather than sales)

Total Sales during 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Motorbikes	243	0	0	0	243
Quadricycles	1	0	0	0	1
Passenger vehicles	6,725	33,380	7,978	0	48,083
Multipurpose passenger vehicles	28	840	0	0	868
Buses[97]	47	0	0	0	47
Trucks	817	3	7	0	827
Industrial vehicles	280	1	0	0	281
Totals	**8,141**	**34,224**	**7,985**	**0**	**50,350**

Table 4: Available vehicles and prices in the UK in 2014 (the currency was converted into EUR on March 12th, 2015)

Market-Price Comparison of Selected EVs and PHEVs in the UK	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price in GBP and EUR, respectively**
Audi A3 Sportback e-tron	28,586; 40,408
BMW i3	24,978; 35,308
BMW i3 REV	27,593; 38,962
BYD e6	39,151; 55,343
Ford Focus electric	27,905; 39,445
Kia Soul EV	24,986; 35,319
Mitsubishi i-MIEV	24,148; 34,135
Mitsubishi Outlander PHEV	35,689; 50,449
Nissan Leaf UK Visia Flex	17,439; 24,651
Vauxhall Ampera Positiv	28,113; 39,740
Peugeot iOn	21,837; 30,868
Porsche Panamera S E-Hybrid	74,109; 104,758
Renault Fluence ZE	18,742; 26,493
Renault ZOE i-Expression	18,986; 26,838
Renault Kangoo Maxi ZE	21,262; 30,055
Smart Fortwo Electric Drive coupe	16,722; 23,638

[97] Numbers of electric and hybrid trucks and buses are probably understated

Tesla Model S 60 kWh	45,731; 64,644
Toyota Prius Plug-in Hybrid	27,401; 38,733
Volkswagen e-Up	20,200; 28,554
Volvo V60	40,125; 56,720

35 United States

35.1 Major Developments in 2014

The decision by Elon Musk in September 2014 to construct the Tesla Gigafactory just outside Reno, Nevada created big headlines and captured the optimism surrounding the electric vehicle market in the United States. The Tesla Gigafactory, when complete, will be the largest lithium-ion battery factory in the world. Tesla and partners plan to invest 5 billion USD in the factory to achieve a target production capability by 2020 of 35 Gigawatt-hours per year (GWh/year) of battery cell output and 50 GWh/year of battery pack output. The goal is a battery cost reduction goal of 30%. The facility is also being designed as a net zero energy one that is powered entirely by solar and wind energy. It will employ approximately 6,500 people.

35.1.1 Overview

The scope and scale of the Tesla announcement captured the optimism surrounding the electric vehicle market in the United States in 2014. Sales for various hybrid and electric vehicle technologies remained strong. The number of all-battery electric vehicles (EVs) on the road increased by over 63,000. For hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs), the corresponding figures were approximately 452,000 and 55,000, respectively. As a result, and for a second consecutive year, the combined sales figure for all three categories was just over half a million vehicles. More detailed information on sales and fleet totals is provided in Section 35.2.

Electric vehicle charging infrastructure also expanded in 2014 led by increases in the numbers of Level 2 and DC Fast Charging Stations. This infrastructure growth helped along by EV manufacturers and the U.S. Department of Energy (DOE) EV Everywhere Workplace Charging Challenge promoted high-quality analysis of the driving habits of plug-in electric (PEV) consumers and ongoing research, development, and demonstration efforts. Additional information on charging infrastructure is given in Section 35.3.

35.1.2 Policy Activities

Policy developments in 2014, in particular at the state and local level, continued to strongly favor development and expansion of the hybrid and electric vehicle market. A significant state-level policy development in 2014 was the May release of the Multi-State ZEV Action Plan as the first promised milestone of a bicoastal collaboration of eight states to put 3.3 million ZEVs on their roads by 2025[98]. The partner states are California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island, and Vermont. These eight states committed to working together on their ZEV programs under a Memorandum of Understanding (MOU) signed by their governors in October 2013. Collectively, these states account for about one-quarter of all new U.S. car sales[99]. Their multi-state effort builds upon California's existing ZEV mandate requiring approximately 15% of all new light duty vehicles sold within the state by 2025 from all manufacturers to be either electric or fuel cell powered.

Many have implemented or are considering implementing incentives to promote hybrid and electric vehicles. According to the National Conference of State Legislatures (NCSL), as of October 2014, 37 U.S. states and the District of Columbia have incentives including rebates, tax credits, or other measures[100]. These are implemented at the state, local, or utility level, or some combination thereof, and they exist in addition to the Federal tax credit. Figure 1 shows the NCSL map as of October 2014.

Policymakers are particularly interested in the impact of direct financial and non-financial incentives and on all-battery electric vehicles (EVs) owing to the observed effect of the latter on the former. A three-year long study[101] found a positive correlation between both financial incentives and the existence of charging infrastructure and the number of all-battery EV registrations. Among the findings:

- On average, a 1,000 USD increase in incentive is associated with a 3% increase in per capita all-battery EV registrations. State-level subsidies promoted registrations of 4,000 all-battery EVs nationwide since 2011.

[98] A copy of the Multi-State ZEV Action Plan is available at http://www.ct.gov/deep/lib/deep/air/electric_vehicle/path/multi-state_zev_action_plan_may2014.pdf
[99] "8 state alliance releases plan to put 3.3 million zero emission vehicles on the road," press release, California Air Resources Board (CARB), May 29, 2014; available online at: http://www.arb.ca.gov/newsrel/newsrelease.php?id=620
[100] "State Efforts Promote Hybrid and Electric Vehicles," by Kristy Hartman, National Conference of State Legislatures (NCSL), Oct. 23th, 2014. Available online at: http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx (accessed February 19, 2015).
[101] Clinton, B., A. Brown, C. Davidson, D. Steinberg. "Impact of Direct Financial Incentives in the Emerging Battery Electric Vehicle Market: A Preliminary Analysis". Presentation. December 2014, Publication Pending.

- Tax credits also have a significant, positive effect. The estimated annual abatement from the use of these BEVs is equivalent to 16,000 tons of carbon dioxide.
- The impact of high-occupancy vehicle (HOV) lane access is less clear. This study showed that the effects of rebates and HOV access are positive but not statistically significant, however a state level incentive evaluation study based on 2013 data does show a significant correlation.

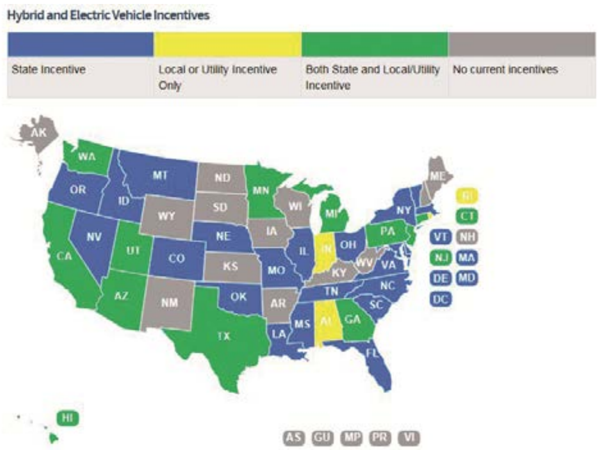

Figure 1: Hybrid and Electric Vehicle Incentives Color-Coded by State (Image courtesy of NCSL)

On the other hand, a few states have instituted fees for electric vehicles on the theory that these vehicles do not pay for road usage and maintenance through the traditional method of gasoline taxes. States that have adopted such fees include Colorado, Nebraska, North Carolina, Virginia, and Washington[102]. A case in point is North Carolina, which in January 2014 instituted a 100 USD annual fee (plus other registration fees) for electric vehicles[103]. While the fee might be lower than what have been charged to conventional vehicles, this reduces or even balances out the benefits for PEV consumers.

35.1.3 Technology Improvements and Standards

[102] "State Efforts Promote Hybrid and Electric Vehicles" by Kristy Hartman, National Conference of State Legislatures (NCSL), Oct. 23, 2014; available online at: http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#fees (accessed Feb. 19th, 2015).
[103] "All-electric vehicles in NC to begin paying special fee," by Holly Henry, WTKR Channel 3 website, Jan. 10, 2014; available online at: http://wtkr.com/2014/01/10/all-electric-vehicles-in-nc-to-begin-paying-special-fee/ (accessed Feb. 19th, 2015).

Developments

The year 2014 witnessed a range of improvements in the technologies supporting electric vehicles as well as continued work on standards development. Technological improvements were facilitated by ongoing demonstration projects such as the vehicle-grid integration (VGI) platform and by more general research, development, and demonstration work in batteries, materials, wireless power transfer, and the alloys used to make the electronics in vehicle motors. Important work in standardization development occurred in areas related to interoperability and wireless power transfer as detailed in Section 35.4.

35.2 HEVs, PHEVs and EVs on the Road

This section provides the number of hybrid and electric vehicles on the road in the United States at the end of 2014 by powertrain technology. It also includes an overview of the prices of the most popular-selling hybrid and electric vehicles.

In 2014, there were 22 plug-in electric vehicle (PEV) models sold in the United States including 13 all-battery EV models and nine PHEV models. These 22 PEV models were sold by 13 distinct manufacturers: BMW, Daimler AG, Fiat, Ford, GM, Honda, Kia, Mitsubishi, Nissan, Porsche, Tesla, Toyota, and Volkswagen[104].

The highest-selling 2014 BEV models included the Nissan Leaf, Tesla Model S, and BMW i3 with annual sales of 30,200, 17,300, and 6,092 respectively[105]. Tesla does not report ongoing sales numbers, but U.S. sales are estimated at 17,300. The leading PHEVs were the Chevrolet Volt with 18,805 sales followed by the Toyota Prius Plug-in with 13,264 sales in 2014[106].

35.2.1 2014 Fleet and Sales Totals

Fleet totals and total sales of all categories of electric and hybrid vehicles as of December 2014 are listed in Table 1. The table also shows the overall fleet size and sales figures for all vehicles including those with regular internal combustion engines.

As the table shows, although the fleet and sales totals for internal combustion engine vehicles dwarf all other technology types, nevertheless, the numbers for all

[104] “December 2014 Dashboard,” HybridCars.com, by Jeff Cobb, Jan. 6, 2015; available online at: http://www.hybridcars.com/december-2014-dashboard/ (accessed Feb. 17th, 2015). Note: BMW i3 is counted once, as a BEV. McLaren P1 is not counted.

[105] “FINAL UPDATE: Plug-In Electric Car Sales Continue Rise In 2014, To 118,500” by John Voelcker, Green Car Reports.com, February 3, 2015; available online at: http://www.greencarreports.com/news/1096120_plug-in-electric-car-sales-continue-rise-in-2014-100000-plus-delivered-this-year (accessed Feb. 17th, 2015); Note: BMW i3 sales from May - December 2014.

[106] “Op-Ed: 2015 Plug In Sales Predictions For America,” by Josh Bryant, Inside EVs.com; available online at: http://insideevs.com/2015-plug-in-sales-predictions/ (accessed Feb. 17th, 2015); See also footnote 7

electric and hybrid vehicle technology types continue to grow. By the end of 2014, the total number of EVs climbed to over 136,000 while the number of HEVs reached 3.5 million and PHEVs rose to just over 150,000. These numbers were reached as a result of combined sales in excess of half a million in 2014.

Table 1: Fleet Totals and Sales of EVs and HEVs in 2014 in the United States

Fleet Totals as of December 31st, 2014					
Vehicle type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)[a]	242,000	n.a.	n.a.	n.a.	n.a.
Passenger vehicles[b]	136,296[c]	3,535,808	150,620	n.a.	258,591,621[d]
Buses	included	included	8,939[e]	n.a.	n.a.
Totals without bicycles	**136,296**	**3,535,808**	**180,633**	**n.a.**	**258,662,378**

Total Sales during 2014					
Vehicle type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Bicycles (no driver's license)[a]	153,000	n.a.	n.a.	n.a.	n.a
Passenger vehicles[f]	63,325	452,172	55,357	n.a.	16,531,070
Totals without bicycles	**63,325**	**452,172**	**55,357**	**n.a.**	**16,531,070**

n.a. = not available

[a] Estimates are from Navigant Research (http://www.navigantresearch.com/research/electric-bicycles) Published 4Q 2014. Fleet totals include 2013 estimate and 2014 estimate. Prior years' data unavailable.

[b] Fleet totals from ANL Transportation Technology R&D Center (http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html) (2014). Note that all BMW i3 sales are counted as EVs. EV, HEV, and PHEV Fleet totals are comprised of cumulative sales.

[c] The EV passenger vehicle Fleet totals for 2014 is based on on-road light duty vehicles and does not include low-speed electric vehicles.

[d] Passenger vehicle fleet totals are based on last year's fleet totals reported plus this year's passenger vehicle sales totals.

[e] PHEV Fleet Buses is based on "electric and hybrid" buses listed in DOE AFDC's "U.S. Transit Bus Fleet by Fuel Type and Year" http://www.afdc.energy.gov/data/10302 (1996-2012).

[f] Sales totals from ANL Transportation Technology R&D Center (http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html) (2014). Note that all BMW i3 sales are counted as EVs.

35.2.2 2014 Prices for Selected Models

Table 2 lists the prices for select hybrid and electric vehicles sold in the United States. The table captures the most popular selling brands. The prices given are in U.S. dollars and reflect the manufactured suggested retail price (MSRP) or some equivalent. The information is current as of February 2015.

Table 2: Prices for Selected EVs and PHEVs in the United States in 2014

Market-Price Comparison of Selected EVs and PHEVs in the United States	
Available Passenger Vehicles	**Untaxed, Unsubsidized 2014 Sales Price in USD**
BMW i3	42,400[a]
Chevrolet Volt	34,185[b]
Chevrolet Spark	26,685[c]
Fiat 500e	31,800[d]
Ford C-Max Energi	31,635[e]
Ford Fusion Energi SE	34,700[f]
Ford Focus Electric	29,170[g]
Honda Fit EV (lease only)	36,625[h]
Mitsubishi i-MiEV	22,995[i]
Nissan Leaf	37,090[j]
Smart Electric Drive (ED)	25,000[k]
Tesla Model S	69,900[l]
Toyota Prius Plug-In	29,900[m]
Toyota RAV4 EV	49,800[m]

All websites and prices as of Feb.19th, 2015

[a] http://www.bmwusa.com/Standard/Content/Vehicles/2015/i3/BMWi3/default.aspx

[b] http://www.newcartestdrive.com/reviews/2014-chevrolet-volt/summary-prices-specs/

[c] http://www.chevrolet.com/2014-spark-ev-electric-vehicle.html

[d] http://www.fiatusa.com/en/lineup/index.html?app=bmo&showslider=false&year=2014

[e] http://www.ford.com/cars/cmax/2014/

[f] http://www.ford.com/cars/fusion/2014/

[g] http://www.ford.com/cars/focus/

[h] http://automobiles.honda.com/fit-ev/specifications.aspx

[i] http://www.mitsubishicars.com/imiev

[j] http://www.edmunds.com/nissan/leaf/2014/

[k] http://www.smartusa.com/Downloads/2013-smart-electric-drive-brochure.pdf

[l] http://www.teslamotors.com/models/design

[m] http://www.fueleconomy.gov/feg/findacar.shtml

35.2.3 Electric Bikes

Although sometimes forgotten in the excitement surrounding hybrid and electric vehicles, the U.S. electric bicycle ("e-bike") market is also doing remarkably well. As shown in Table 1, estimated sales for e-bikes was 153,000 in the United States in 2014. The 2014 sales thus more than doubled the estimated U.S. fleet of 89,000 from a year earlier.

It is against this backdrop that Bosch opened a 4,000 square foot facility in Irvine, California in January 2015 to manufacture e-bikes and drive components. Claudia Wasko, business unit leader of Bosch eBike Systems North America, was very enthusiastic in the accompanying press release on her company's prospects. In that release, she is quoted as saying: "Since Bosch-equipped eBikes first went on sale in the U.S. last summer, we've seen fantastic response to our product. We are expecting a big year in 2015 as even more brands begin to offer eBikes with our technology"[107].

35.3 Charging Infrastructure or EVSE

EV charging infrastructure in the United States continued to expand significantly in 2014. Growth was particularly strong in the numbers of Level 2 and DC Fast Charging Stations. Table 3 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 Vehicle Fueling Locations.

Table 3: Number of public charging stations in the United States by type

Type of Charging Station[a]	Total
Level-1	1,693
Level-2 (Standard AC)	8,376
DC Fast Charging	759
Fuel Cell Vehicle Fueling Locations (excluding private)	12

[a] Data taken from AFDC EVSE Location Database (http://www.afdc.energy.gov/fuels/electricity_locations.html), December 2014. Multiple outlets are available at most EVSE. Total DC Fast Charging total includes Tesla Superchargers.

[107] "Bosch opens North American eBike headquarters in Irvine, Calif.," Bosch Press Release, Business Wire, January 23rd, 2015; available online at: http://www.businesswire.com/news/home/20150123005474/en/Bosch-opens-North-American-eBike-headquarters-Irvine (accessed Feb. 15th, 2015).

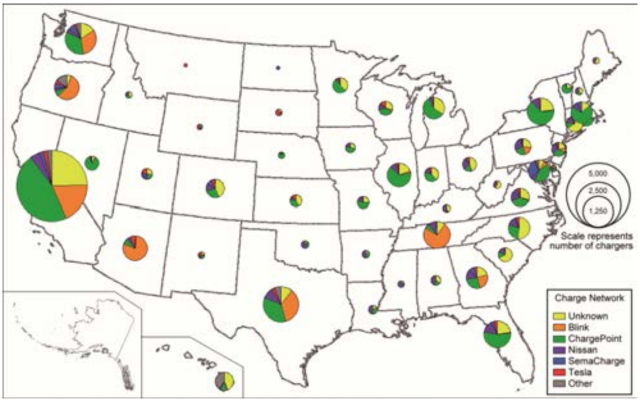

Figure 2: EV Chargers by Network and State (Level 2 chargers, DC Fast chargers and Superchargers)[108]. (Image courtesy of DOE)

Many stations in the table above include multiple charging outlets. There are over 21,000 outlets nationwide. The Alternative Fuels Data Center compiles a database of all electric vehicle (EV) chargers by location and network. As shown in Figure 2 the distribution of charging stations is greatest on the east and west Coasts with California having the largest number of stations.

The total number of public charging stations, however, is only part of the EV charging infrastructure story. Below are some additional highlights of what helped drive the expansion in 2014.

35.3.1 Supercharger Network

Tesla has installed a network of 161 "Supercharger" stations in 38 states as of the time of this report[109]. Using only these superchargers, the official Tesla team completed a 76-hour coast-to-coast trip in February 2014, which covered 3,427 miles with 15 hours of charging time.

35.3.2 Workplace Charging Challenge

DOE through its EV Everywhere Workplace Charging Challenge seeks to raise the profile of the benefits of workplace charging. Workplace Charging Challenge partners commit to assessing employee demand for PEV charging at their workplace and to developing and executing a plan to provide PEV charging access

[108] "Fact #855 January 12th, 2015 Electric Vehicle Chargers by Network and State" U.S. Department of Energy, January 12, 2015; available online at: http://energy.gov/eere/vehicles/fact-855-january-12-2015-electric-vehicle-chargers-network-and-state (accessed Feb. 24th, 2015).

[109] A list of all Tesla Supercharger stations in North America is available online at: http://www.teslamotors.com/en_DK/findus/list?types=supercharger&regions=northamerica (accessed Feb. 17th, 2015).

for employees. As of November 2014, following two years of 40% expansion, 150 employers are partners in the Challenge[110]. Figure 3 shows the cumulative growth in partner workshop locations with charging stations.

Figure 3: Growth in workplace charging locations (Image courtesy of NREL)

35.3.3 The EV Project

Idaho National Laboratory's (INL) ongoing analysis of data collected by The EV Project provides valuable insights into PEV consumers' driving and charging behaviors. Using 124 million miles of data from 8,300 PEVs and 12,500 charging stations, INL has identified how consumers drive their PEVs and their preferences for how, where, and when they charge them and at what power levels they prefer to charge. Infrastructure utilization and costs have also been reported[111]. Figure 4 shows this information for Chevrolet Volt drivers.

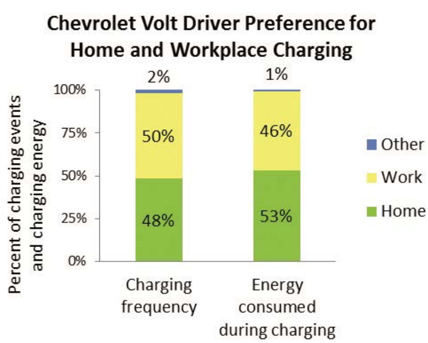

Figure 4: The analysis of charging preferences of Volt drivers who had access to workplace charging in the EV Project demonstrated the importance of workplace charging infrastructure. Analysis by INL (Image courtesy of INL)

[110] Workplace Charging Challenge "Progress Update 2014: Employers Take Charge" Available online at: http://www.nrel.gov/docs/fy15osti/63230.pdf (accessed Feb. 17th, 2015).
[111] The EV Project, Advanced Vehicle Testing Facility, Idaho National Laboratory. Available online at: http://avt.inl.gov/evproject.shtml (accessed Feb. 17th, 2015)

35.4 EV Demonstration Projects

35.4.1 Open VGI Platform

The Electric Power Research Institute (EPRI), along with several auto manufacturers, utilities, and regional transmission organizations (RTOs), have developed and demonstrated an advanced software platform for integrating PEVs with smart grid technologies. The open vehicle-grid integration (VGI) platform facilitates communication with EVs, enabling utilities to take advantage of the built-in smart charging capabilities and to deploy PEVs to support grid reliability, stability, and efficiency. The goal is for a utility to be able to send requests to the PEV – either through a public broadband connection or the vehicle's on-board control system – to turn charging on or off or in order to reduce the charging power level when conditions on the grid require a load reduction to offset peaks in electricity use. Vehicle owners have the option to participate in a demand response and load management program or to opt out[112].

In the next development phase, the EPRI team will be integrating the PEV communications platform with residential, fleet, and commercial facility energy management systems. This will enable testing of its ability to manage local control scenarios such as demand management for commercial and industrial consumers.

35.4.2 Smart Grid Investment Grant

Six Smart Grid Investment Grant (SGIG) Program-funded projects that focused on electric vehicle charging evaluated more than 270 public charging stations in parking lots and garages and over 700 residential charging units in customers' homes[113]. Key findings were in the area of charging behaviors, grid impacts, and technology issues. The review found that most in-home charging occurs overnight during off-peak periods, and that time-based rates were successful in encouraging off-peak charging. Some utilities found residential interoperability communication challenging between smart meters and charging stations. Another common finding across the projects was long capital cost recovery times for public charging stations. Based upon the findings of the review, at present, public charging stations are used to "top off" batteries and overlapped with typical peak periods.

[112] "EPRI, Utilities, Automakers to Demonstrate Technology Enabling Plug-In Electric Vehicles to Support Grid Reliability," EPRI press release, Oct. 14th, 2014; available online at: http://www.epri.com/Press-Releases/Pages/EPRI,-Utilities,-Automakers-to-Demonstrate-Technology-Enabling.aspx (accessed Feb. 17th, 2015)

[113] "Evaluating Electric Vehicle Charging Impacts and Customer Charging Behaviors: Experiences from Six Smart Grid Investment Grant Projects (December 2014)," DOE webpage, available at: http://energy.gov/oe/downloads/evaluating-electric-vehicle-charging-impacts-and-customer-charging-behaviors (accessed February 17, 2015); direct link to report: http://energy.gov/sites/prod/files/2014/12/f19/SGIG-EvaluatingEVcharging-Dec2014.pdf

35.5 Technology Updates

In August 2014, DOE announced the selection of 19 new projects aimed at reducing the cost and improving the performance of key PEV components. Some projects focus on advancing lightweight materials research, developing advanced climate control technologies, and developing and commercializing wide bandgap semiconductors. In the area of advanced batteries, nine projects totaling 11.3 million USD were awarded for beyond-lithium-ion battery technologies including polycrystalline membranes, nanomaterials, high-capacity cathodes, Li-air batteries, Li-sulfur batteries, and electrolyte chemistries.

35.5.1 Batteries

In 2014, DOE's PHEV battery cost reduction milestone of 300 USD/kWh was achieved. DOE-funded research has helped reduce current cost estimates from three DOE-funded battery developers for a PHEV40 battery[114] to an average of 289 USD per kilowatt-hour of useable energy.

35.5.2 Materials

A Multi-Material Lightweight Vehicle (MMLV) concept vehicle was designed by Ford and Magna under a project funded by the DOE's Vehicle Technologies Office. It is a unique concept car which weighs nearly 25% less than the 2013 Ford Fusion, a similar midsized sedan. To better understand how lightweight materials act in real-life situations, Ford subjected the vehicle to the National Highway Traffic Safety Administration's four standard crash tests at Ford's Proving Grounds in Dearborn, Michigan[115].

35.5.3 Motors

Another important technological issue for any vehicles that use a permanent magnet motor in its electric drive system are the constituent metal alloys that are used to develop the alternative rare earth (RE) magnets that they use. Ongoing research has shown progress on the manufacturability of affordable non-rare earth magnet alloys. The Beyond Rare Earth Magnets (BREM) research and development project with The Ames Laboratory has identified two near-term development candidates for gas-atomized aluminum-nickel-cobalt (Alnico) alloys. A new manufacturing process improves performance of the Alnico alloys through

[114] PHEV40 is a plug-in hybrid electric vehicle driven solely by an electric motor for at least 40 miles without consuming any gasoline

[115] "Multi-Material Lightweight Vehicle Hurdles Into the Future", by Reuben Sarkar, DOE Deputy Assistant Secretary for Transportation, DOE/EERE website, Oct. 28, 2014; available online at: http://energy.gov/eere/articles/multi-material-lightweight-vehicle-hurdles-future (accessed Feb. 17th, 2015)

compression molding of gas atomized magnet particles[116]. The BREM researchers focused on refining Alnico alloys. Alnico 8 and 9 showed the most promise for improvement.

35.5.4 Research Facilities

The Energy Systems Integration Facility (ESIF) at DOE's National Renewable Energy Laboratory (NREL) houses an unparalleled collection of state-of-the-art capabilities that supports the development, evaluation, and demonstration of innovative clean energy technologies[117]. EV-focused ESIF efforts are able to core questions involving issues such as:

- Characterizing use cases, performance, and life impacts of grid applications
- Contributing to development of open interface standards
- Identifying and quantifying potential grid integration values

The EV- Smart Grid Interoperability Center at DOE's Argonne National Laboratory (ANL) houses tools to advance charging interoperability and global harmonization for electric vehicles. The Center is able to leverage existing vehicle, battery and powertrain component test facilities at ANL. Research is focused on providing practical applications that enhance market acceptance of plug-in vehicles[118].

35.5.5 Wireless Power Transfer

A number of significant advancements in wireless power transfer (WPT) technologies also occurred in 2014. Of particular importance in the commercial market was the beginning of private sales of an aftermarket wireless charging system that could be retrofitted onto currently available PEVs. This product release significantly raises the awareness of this technology both to the general public and also to industries and communities that regulate and provide commercial standards to products in the interest of public safety. Several companies and research institutions announced new programs in wireless charging technologies for medium and heavy duty vehicles as well as bus/transit systems. This high power

[116] 2014 U.S. DRIVE Highlight "Manufacturability of Affordable Non-Rare Earth Magnet Alloys"; The Ames Laboratory
[117] "Energy Systems Integration Facility," NREL, DOE; website at: http://www.nrel.gov/esif/ (accessed Feb. 17th, 2015)
[118] "EV-Smart Grid Interoperability Center," ANL, DOE; website at: http://www.anl.gov/energy-systems/project/ev-smart-grid-interoperability-center (accessed Feb. 26th, 2015)

WPT activity will require further research and evaluation of the WPT technologies for scalability, interoperability, and safety[119].

Other important activities in 2014 were related to the progress of test and evaluation facilities focused on WPT technologies. Two DOE national laboratories have upgraded equipment capable of evaluating both open air and vehicle integrated WPT systems following testing procedures that are in alignment with planned SAE guidelines for system testing. In a significant step toward standardization, SAE J2954 WPT Standards Development Committee also released the first draft of the J2954 Technical Information Report (TIR) to its members. The committee is presently focusing on alignment, safety, object detection, and interoperability aspects of the standards for the technologies being developed.

35.6 Outlook

The U.S. hybrid and electric vehicle market has many reasons for optimism. These include many state and local policy developments including the Multi-States ZEV Action Plan, strong consumer demands buttressed by a host of financial and non-financial incentives, active and robust research, development, and demonstration (RD&D) and steady improvements in the supporting technologies, and (as was stated at the outset) ambitious private sector plans, most dramatically, the potentially market-transforming Tesla Gigafactory.

For its part, DOE has pledged to continue America's leadership in building safe, reliable, and efficient vehicles to support a strong 21st century transportation system by dedicating 55 million USD to develop and deploy cutting-edge vehicle technologies. The funding will go towards a wide range RD&D projects that aim to reduce the price and improve the efficiency of plug-in electric, alternative fuel, and conventional vehicles. Among the topics addressed are[120]:

- Advanced batteries (including manufacturing processes) and electric drive
- Lightweight materials
- Advanced combustion engine and enabling technologies R&D
- Fuels technologies (dedicated or dual-fuel natural gas engine technologies)

For all these reasons, the U.S. hybrid and electric vehicle market should continue to flourish in 2015 and beyond.

[119] Personal email communication between Perry T. Jones, Oak Ridge National Laboratory; Omer C. Onar, Oak Ridge National Laboratory, and Julie Perez, New West Technologies, U.S. Department of Energy, Feb. 5th and 6th, 2015

[120] An overview of the RD&D projects funded by DOE is available at: http://energy.gov/sites/prod/files/2014/08/f18/FOA%20991%20Selection%20Table.pdf (accessed February 17, 2015)

35.7 Contributors

This chapter has been prepared with the support of Mr. David Howell from the U.S. Department of Energy and Mr. Jake Mello and Mr. Richard Todaro, both from New West Technologies, LLC, United States.

36

Non-Member Countries

36.1 China

36.1.1 Relevant Policies

As one of the first countries implementing incentive policies of new energy vehicles in the world, China established special support for the research and development of new energy vehicles during the “10th five-year plan” period, and started implementing a series of policies such as subsidy for new energy vehicles in 2009. To date, China has established a comparatively optimized policy support system in aspects such as research and development, production, purchase, use and infrastructure, etc., covering research and development industrialization, purchase, use and infrastructure of new energy vehicles, etc. The abstract of main policies is as follows:

In 2009, when the Ministry of Finance and the Ministry of Science and Technology jointly issued a “Notice Regarding Implementation of Experiment Work of Demonstration and Promotion of Energy-saving and New energy Vehicles”, China officially started purchase subsidy for new energy vehicles, determined 13 cities as the first batch of national experiment cities, and supplemented 2 batches totaling 12 demonstration cities successively. During the implementation period of the “demonstration and promotion” policy between 2009-2012, a total of 25 cities participated in the demonstration and promotion work. In 2013, the “Notice on Continuing the Promotion and Application of New Energy Vehicles” was issued, continuing to rely on cities, especially extra-large cities, promotion and application of new energy vehicles. 39 clusters of cities totaling 88 cities were listed as new energy vehicle demonstration and promotion cities. The focus shall be on regions where the need to reduce fine particulate matters is most urgent, e.g. Beijing, Tianjin, Hebei, Yangtze River Delta and Pearl River Delta, where the implementation shall be conducted in selected extra-cities or clusters of cities with higher enthusiasm. Central finance subsidy was granted for battery electric vehicles, plug-in hybrid electric vehicles and fuel cell electric vehicles meeting requirements. The standard of subsidies for promotion and application in 2013 was as follows:

Standard of subsidies for promotion and application of battery electric special vehicles (mainly: the postal service, logistics, sanitation, etc.): 2,000 RMB (322.14 USD) for every 1,000kWh based on the battery capacity, the total amount of subsidy shall not exceed 150,000 RMB (24,163 USD)/vehicle. Subsidy for fuel cell passenger cars is 200,000 RMB (32,212 USD)/vehicle, subsidy for fuel cell commercial vehicles is 500,000 RMB (80,522 USD)/vehicle.

In 2014 and 2015, the standard of subsidies will decrease by 10% and 20% respectively on the basis of the standard in 2013 for battery electric passenger cars, plug-in hybrid passenger cars (including range extended), battery electric special vehicles and fuel cell electric vehicles, but will remain unchanged for battery electric buses and plug-in hybrid buses (including range extended). At present, the government departments are soliciting public comments for 2016-2020 for new energy vehicle promotion and application financial support policy.

Table 1: Standard of subsidies for promotion and application of battery electric passenger cars and plug-in hybrid passenger cars (including range extended) (In 10,000 RMB (1,611 USD)/vehicle)

Type of vehicle	Battery electric range (running mode, km)			
	80 ≤ R < 150	150 ≤ R < 250	250 ≤ R	50 ≤ R
Battery electric passenger car	3.5	5	6	n.a.
Plug-in hybrid passenger car (including range extended)	n.a.	n.a.	n.a.	3.5

Table 2: Standard of subsidies for promotion and application of battery electric buses and plug-in hybrid buses (including range extended) (In 10,000 RMB (1,611 USD)/vehicle)

Type of vehicle	Length of vehicle (m)		
	6 ≤ L < 8	8 ≤ R < 10	10 ≤ R
Battery electric bus	30	40	50
Plug-in hybrid bus (including range extended)	n.a.	n.a.	25

In August 2014, the Ministry of Finance, the State Administration of Taxation and the Ministry of Industry and Information Technology jointly publicized a “Bulletin Regarding Exemption of New Energy Vehicle from Vehicle Purchase Tax”. From September 1, 2014 to the end of 2017, three categories of new energy vehicle approved to be sold (including the imported) in the territory of China should be exempted from vehicle purchase tax, including battery electric vehicle, plug-in (including range extended) hybrid electric vehicle and fuel cell electric vehicle meeting the requirements. As of the end of 2014, the Ministry of Industry and Information Technology and the State Administration of Taxation had publicized three batches of a catalogue of vehicle models exempted from vehicle purchase tax. A total of 377 vehicle models from 57 manufacturers had been listed in the catalogue. According to statistics of the State Administration of Taxation, 29 provinces/cities handled the procedure for exemption from vehicle purchase tax between September and December 2014. A total of 39,400 units of new energy vehicles were exempted from the vehicle purchase tax, including 33,800 units of passenger cars and 5,615 units of commercial vehicles.

In November 2014, four departments (the Ministry of Finance, the Ministry of Science and Technology, the Ministry of Industry and Information Technology, and the National Development and Reform Commission) jointly publicized the "Notice Regarding Incentive for Construction of New Energy Vehicle Charging Facilities". In order to accelerate the construction of charging facilities of new energy vehicles, there are central finance plans to arrange funds to provide an award for the construction of charging facilities in new energy vehicle promotion cities or cluster of cities. The number of promoted new energy vehicles is calculated by taking a battery electric passenger car as standard, and other types of new energy vehicles are converted as per relevant proportion. An incentive of 4 million RMB (644,154 USD) will be granted to each new fuel cell electric vehicle hydrogen filling station that meets the national technical standard and has a daily hydrogen filling capacity not less than 200 kg; and subsidy standard will be appropriately enhanced for the construction of high cost quick-charging facilities serving lithium titanate battery electric vehicles, etc.

Table 3: Rewarding criterion for new energy vehicle charging facilities (2013-2015) (Unit: Vehicle, 10,000 RMB; 1,611 USD)[121]

Regions	2013		2014		2015	
	Quantity of promotion (Q)	Rewarding criterion	Quantity of promotion (Q)	Rewarding criterion	Quantity of promotion (Q)	Rewarding criterion
Cities or cluster of cities in regions such as Beijing, Tianjin and Hebei, Yangtze River Delta and Pearl River Delta	2,500≤Q< 5,000	2,000	5,000≤Q< 7,000	2,700	10,000≤Q< 15,000	5,000
	5,000≤Q< 7,000	3,000	7,000≤Q< 10,000	3,800	15,000≤Q< 20,000	7,000
	7,000≤Q< 10,000	4,500	10,000≤Q< 15,000	5,500	20,000≤Q< 25,000	9,000
	Q≥10,000	7,500	Q≥15,000	9,000	Q≥25,000	12,000
Cities or cluster of cities of other regions	1,500≤Q< 2,500	1,000	3,000≤Q< 5,000	1,800	5,000≤Q< 7,000	2,400
	2,500≤Q< 5,000	2,000	5,000≤Q< 7,000	2,700	7,000≤Q< 10,000	3,400
	5,000≤Q< 7,000	3,000	7,000≤Q< 10,000	3,800	10,000≤Q< 15,000	5,000
	Q≥7,000	5,000	Q≥10,000	6,700	Q≥15,000	8,000

36.1.2 Activities in R&D and Industry

At present, a research and development system of China' new energy vehicles has been formed initially; various complete vehicle products such as battery electric vehicles, plug-in hybrid electric vehicles, and fuel cell electric vehicles have been researched and developed independently; and key technologies such as the designing and manufacturing of complete new energy vehicles and the development of parts/components and the integration of the system have been grasped initially.

In the field of passenger cars, the number of battery electric special passenger car platforms with completely independent intellectual right property has increased gradually. The fuel-saving rate of hybrid electric vehicles has reached 10-40%. Key technologies of BSG hybrid electric cars, ISG parallel middle hybrid electric cars and dual-motor full parallel-series hybrid electric car power system platforms have been grasped. Core technologies of a complete vehicle power system

[121] Vehicles to be promoted must be listed in the "Catalogue of Recommended Vehicle Models for Demonstration Promotion and Application Project of Energy Saving and New Energy Vehicles" publicized by the Ministry of Industry and Information Technology; Vehicles promoted in each year refer to new energy vehicles that have been actually sold and have completed the registration in the traffic administration department in the same year.

matching and integration design and complete vehicle control of battery electric vehicle have been developed. A new generation of battery electric vehicle products such as a mini-car and a large-size bus cover the entire product series. Starting from the second half of 2013, plug-in hybrid electric vehicles such as SAIC Roewe 550 and BYD “Qin”, and battery electric vehicle models such as Roewe E50, BYD Daimler DENZA, BMW Brilliance ZINORO 1E, Venucia Chengfeng, JAC IEV4 and BAIC EV200 have been brought into the market successively, so that products available for consumers have become more and more abundant.

In the field of buses, dominant domestic enterprises have basically grasped core and key technologies of new energy buses, developed a special electric chassis for low-floor public buses, and made substantial progress in core technologies such as lightweight, power economy, high-voltage safety and electromagnetic compatibility. Major bus enterprises such as Yutong, Ankai and Zhongtong have enlarged their investments for research and development of plug-in hybrid electric buses by leveraging an excellent technical base of hybrid electric buses, so that the product system is becoming more and more optimized.

Technologies for homemade traction batteries have developed quickly in recent years, multiple types of high-power batteries for hybrid electric vehicles and high-energy batteries for battery electric vehicles have been researched and manufactured independently, including lithium iron phosphate traction batter, partial nickel metal hydride batteries, and three-element material batteries, covering multiple series of 1.5-200Ah. Batch production lines have been established, prominent progress has been made for key indexes such as safety, power density, energy density, and cycle life, and the cost of batteries have been reduced gradually.

Furthermore, China has developed quickly in terms of control technologies of motors, motor controllers, and electric control systems. At present, China has over 20 driving motor system manufacturers of different scales, which commonly possess a production capacity of 50,000-150,000 sets of driving motors, and the entire industry has embodied characteristics such as diversification of products and the expansion of the production capacity. Functions of electric vehicle control system products from China are comparatively complete, partial complete vehicle manufacturers have performed joint developments with foreign companies such as FEV and Ricardo, so that relevant technologies and experiences have been absorbed, the product integration degree has been gradually enhanced, cost and system complexity have been gradually reduced, and the demand for electric vehicles can be met basically.

36.1.3 EVs, PHEVs and FCEVs

According to data statistics of the “Bulletin of Vehicle Manufacturers and Products” (batch 266) and the “Certificate of Conformity of Complete Motor Vehicle Delivered from Factory”, as of the end of 2014, China has accumulatively registered 1,253 new energy vehicle models in the “Bulletin” (including 872 models of battery electric products, 369 models of plug-in hybrid electric vehicles and 12 models of fuel cell electric vehicles), and has manufactured a total of 119,502 units of new energy vehicles. With the implementation of a new wave of demonstration and promotion work, the output of new energy vehicles from China was 84,884 units in 2014, exceeding the sum of promotion quantity of several previous years, and embodying a quick growth tendency. Statistics data of the bulletin and the certificate of conformity of new energy vehicles from China are as follows:

Table 4: Statistics data of bulletin and certificate of conformity of China’s new energy vehicles

Type	Vehicle model	Number of vehicle models in bulletin (-266)	Output in 2007–2013	Output in 2014	Total output
Battery electric	Passenger car	132	18,151	38,872	57,023
	Bus	487	5,055	12,717	17,772
	Others (Environmental sanitation vehicle / goods vehicle / special vehicle)	253	4,856	3,418	8,274
Plug-in hybrid	Passenger car	27	1,686	16,558	18,244
	Bus	339	4,774	13,313	18,087
	Others*	3	0	0	0
Fuel cell	Passenger car	8	90	6	96
	Bus	4	6	0	6
Total		**1,253**	**34,618**	**84,884**	**119,502**

*Note: Number of vehicle models and output of bulletin exclude joint-venture brands and lead-acid battery vehicle models

Even though new energy vehicles from China developed quickly in 2014, they are still substantially lagging behind the targets of “making every effort to reach an accumulative output/sales volume of 500,000 units of battery electric vehicles and plug-in hybrid electric vehicles in 2015, and a production capacity of 2 million units and an accumulative output/sales volume of 5 million units of battery electric vehicles and plug-in hybrid electric vehicles in 2020”. Therefore, the burden is heavy and the road is long for popularizing new energy vehicles in China.

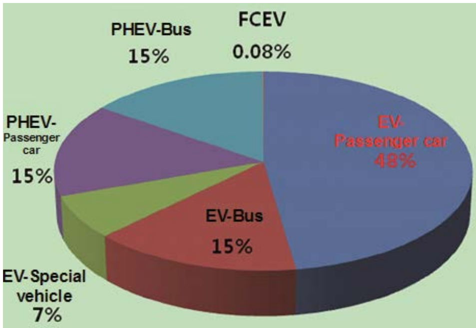

Figure 1: Proportion of production types of China’s new energy vehicles

36.1.4 Charging Infrastructure or EVSE

At present, China has established 723 charging stations and 28,000 charging poles. The construction quantity and layout of infrastructure substantially lags behind the demand for a quick development of electric vehicles. From the point of view of an overall construction scale, the concentration degree of charging infrastructure is high, and the distribution is uneven. At present, charging infrastructures are mainly concentrated in key areas such as Beijing, Jiangsu, Zhejiang, Shanghai, and Shenzhen, accounting for over 60% of the total number, and forming no network of charging facilities.

36.1.5 Outlook

Facing challenges such as tight energy supply, environmental pollution and traffic jam, which are becoming more and more serious day by day, all major vehicle manufacturing countries in the world are taking the development of new energy vehicles represented by electric vehicles as a main strategy, strengthening the support and energetically promoting the research and development of technologies and industrialization.

An output of new energy vehicles from China posted a nearly 400% year-to-year growth in 2014, which is China’s first year of new energy vehicle industry development, and China will enter a quick growth period in 2015.

The introduction of a series of new encouragement and promotion policies for new energy vehicles has paved a smooth road for the development of core technologies of new energy vehicles, the construction of auxiliary infrastructure, and the discussion of a multi-element commercial mode. Meanwhile, a complete policy system is helpful for the formation of an effective compound force of policy and the formation of a uniform promotion/appraisal system and is helpful for accelerating the admittance of new energy vehicles, breaking industrial barriers of local protection, and promotign a better and quicker market development for new energy vehicles.

Table 5: Number of battery charging/swapping infrastructures in demonstration cities (data as of the end of 2013)

Cities	Charging (battery swap) stations	Charging poles	Cities	Charging (battery swap) stations	Charging poles
Shenzhen	82	4,100	Huhehot	5	27
Hangzhou	74	620	Wuhan	4	167
Shanghai	24	1,770	Guangzhou	3	48
Chengdu	14	880	Hebei Province	3	100
Chongqing	12	200	Changsha-Zhuzhou-Xiangtan	3	236
Dalian	10	275	Qingdao	3	n.a.
Hefei	8	2,000	Changchun	2	n.a.
Xinxiang	8	35	Xiangyang	2	30
Beijing	7	1,274	Changzhou	2	110
Tianjin	7	471	Lanzhou	1	82
Taiyuan	7	300	Wuhu	1	461
Fujian Province	7	381	Yancheng	1	n.a.
Shenyang	6	10	Nantong	1	n.a.
Jinan	5	n.a.	Jincheng	1	7
Xi'an	5	60	Kunming	1	150
Linyi	5	150	Zhengzhou	1	500

36.2 India

36.2.1 Relevant Policies

The National Electric Mobility Mission (NMEM) will be implemented in April 2015 for a period of 5 years (initially) to bring the country abreast of global initiatives in electric-drive vehicles. It will have a specific focus on the requirements of the Indian market, which is dominated by small vehicles.

India is the fourth largest consumer of energy in the world, and imports petroleum fuel in large quantities. One third of the imported crude oil is consumed in the Transportation Sector, out of which road transportation constitutes 80% of the demand. Given the price sensitive market, Diesel continues to be subsidized by the Government, while the Petrol prices have been freed up recently to reflect the actual market conditions.

The NMEM will implement specific measures and link up with the activities that the Government of India has already taken for shifting to sustainable development mode – through greater emphasis on renewable energy sources, cleaner environment, and initiatives aimed at mitigating the adverse impact of economic growth on environment and climate change. This includes the National Transport Policy, renewable energy generation programs, and the National Action Plan for Climate Change (NAPCC).

The major activities are:

Scheme for Faster Adoption & Manufacturing of Electric-drive-vehicles (FAME) with three components. The FAME scheme can provide the impetus for the industry to gain the strength and scale by the year 2030, and help to wean some of the road vehicles transport fleets from usage of petroleum fuels.

The three components of FAME are:

- Consumer Demand Incentives for all categories & all variants of electric-drive vehicles (abbreviated as xEVs, below)
- Infrastructure roll-out catalyzed by the Government, with the intent to create a model of entrepreneur/small business driven charging infrastructure
- Supply Side Development, in line with the Make in India objectives

Technology Platform as a Public-Private-Partnership in R&D (PPP-in-R&D) that is jointly supported by the Department of Heavy Industry and the Department of Science & Technology.

This plan is quite similar to that being implemented by at least a dozen advanced economies today.

36.2.2 Faster Adoption & Manufacturing of Electric-Drive-Vehicles (FAME)

Market Analysis

It has been estimated that the potential demand for the full range of electric vehicles in India (mild hybrids to full electric vehicles) will be in the range of 6-7 million units in new vehicle sales by 2020. This will include 3.5-5 million pure electric two wheelers (BEVs), 1.3-1.4 million HEV vehicles (4W, buses, LCVs) and 0.2-0.4 million other pure electric vehicles (4W, buses, LCVs).

The survey jointly carried out by the Government and the industry, in association with a leading consultancy organization has assessed the consumer perception of xEV technology compared to conventional technology, expectations in terms of price, mileage, range, acceleration, payback, etc., and sensitivity to parameters like price, running cost, recharge time. The projections of xEV penetration was prepared considering the total cost of ownership (TCO) model, taking into account the technology trends, price evolution of key components, scale effect due to large scale manufacturing, long term forecast for fuel prices, exchange rates fluctuation, and consumers sensitivities.

Table 1: Incentives scheme in India

Component of the scheme	2015-16 in million INR and USD, respectively	2016-17 in million INR and USD, respectively
Technology Platform (Including testing infrastructure)	700 ; 11.150	1,200 ; 19.112
Demand Incentives	1,550 ; 23.890	3,400 ;54.152
Charging Infrastructure	100 ; 1.592	200 ; 3.185
Pilot Projects	200 ; 3.185	500 ; 7.963
IEC/Operations	50 ; 0.8	50 ; 0.8
Total	2,600 ; 41.410	5,350 ; 81.210
Grand Total		**7,950 ; 126.620**

*Conversion rate is 1 USD = 62 INR

Consumer Incentives Scheme

The demand incentive scheme envisages that support will have to be provided for the next 6 years for various vehicle segments, during which period the industry is expected to gain in strength both in manufacturing capacity and technology ability. The level of demand incentive is calculated as a percentage of the differential of the acquisition cost between a comparable xEV and a representative ICE vehicle in a vehicle-battery-technology segment. The demand incentive is expressed in an easy to comprehend table indicating the amount that will be available for the vehicle models/ category. In general, the differential acquisition cost increases proportionately with the degree of electrification in a vehicle. The cash incentives are intended to be phased out at the end of 5-6 years from the start of the scheme provided the potential sale targets are achieved.

eDIDM (Demand Incentives Delivery Mechanism)

The Indian Banking & Financial Sector has attained excellent capabilities in terms of the back-end technologies, although the spread of retail banking is still continuing as a good portion of the population is still to be covered by the organized banking sector. Even in the vehicle sales network, each company has created their own proprietary electronic networks for sales & services, and a lot of transactions still happen on paper records, particularly for after sales services etc.

The Consumer Demand Incentives will be provided through the manufacturers who would have already passed on the benefits to their customers by way of discounting the price of vehicle to that extent. The demand incentive delivery mechanism, DIDM, will be an e-enabled, transparent, efficient, quick and secure online payment system.

The vehicles must be certified by Government authorized third party certifying agencies to ensure that they meet the NMEM’s Vehicle Parameters and Qualification Criteria (VPQC). The conditions include safety and emission norms under the Central Motor Vehicle Rules (CMVR), proportionate benefit vis-à-vis the demand (cash) incentive, xEV products functions as expected, innovation and value addition.

The transactions will be tracked through a set of identifiers (mentioned below) to enable reimbursement of the incentive expenditure to the vehicle manufacturer.

- Vehicle identification number
- Vehicle registration confirmation and particulars from the registering authority
- Homologation/testing certificate
- Certification of Vehicle Parameters and Quality Criteria (VPQC)
- Sale point confirmation on excise duty payments, VAT payments, etc.

Charging Infrastructure

In Charging Infrastructure Development, the mission will attempt to catalyze a set of entrepreneurial and business activity that will lead to the deployment of an adequate number of charging facilities. A pilot program and studies will be conducted during April to August 2015 for benchmarking trials with available standards & devices, and a techno-commercial viability study involving limited rollout in city conditions, and a distribution grid impact study, and the development of an xEV charging business model, including billing methods, and the development of back-end IT infrastructure for payment gateway, etc. The Mission will specify the national standards, in order to promote the local manufacture of the charging equipment.

New Policies and Regulations

“Frugal Innovations” will be essential for the successful introduction of electric-drive vehicles in the Indian market. The policies will be the frame to assist the industry in this regard, particularly for charging stations, charging sockets and plugs, and metering and billing methods. It will also include regulatory amendments for the commercial business of xEV charging, the location of charging stations like petrol stations, standards and safety precautions, and facilitating the installation of charging equipment by apartment blocks and office buildings.

36.2.3 Technology Platform for Electric Mobility (TPEM)

Specific ”technology platforms” will be developed in energy storage, electrical and electronic subsystems, their mechanical integration with IC engines, and in the thermal management of the complex new systems etc. Research in light-weighting of vehicles and components will also be undertaken. The short term efforts in developing the technology platform will include the acquisition of knowhow, technology acquisitions, R&D consultancy and outsourced R&D abroad.

Systems Research

Electric Mobility System Research: System level innovations will be necessary to overcome the constraints of on-board energy storage in xEV and for a robust interface of xEV fleets with the electricity grid.

Vehicle Systems Integration: xEV architecture and controls are priority topics for research, for arriving at suitable configurations for the Indian conditions. On-road usage data in Indian traffic & weather conditions will be studied to define the requirements of battery, motor, etc., and issues like vehicle health management, safety and Electro-Magnetic Induction and Electro-Magnetic Compatibility (EMI/EMC) aspects will also be part of this activity.

Component Development

Given the numerous variety of vehicle platforms in India, the research focus will be on suitable energy storage technologies and traction motors & controllers for these vehicle types. The R&D Consortium Programs or Public-Private-Partnerships (PPP) will be supported by the Government for the academia-industry collaboration, and for acquiring specific technologies or equipment from abroad.

Long Term Research Capability

4–5 Centers of Excellence (CoE) and 2-3 Testing Facilities would be set up through Government-Industry collaboration. Significant academic participation is expected in these programs, and outsourcing arrangements & collaborations with public funded laboratories within the country or abroad will be encouraged.

36.2.4 HEVs, PHEVs and EVs on the Road

Existing Vehicles

Eight to ten Two Wheeler EV models and the Mahindra Reva's e2o are currently under production (see Figure 1). Tata Motors have run a pilot fleet of half a dozen hybrid buses, and have supplied ten hybrid buses to Madrid, Spain also.

Figure 2: e2o from Mahindra Reva (Image courtesy of Mahindra Reva)

New Launches Expected

Mahindra & Mahindra’s EV “Verito” sedan meant for taxi fleets is expected to launch by June 2015, Kinetic Motors e-auto-ricksha (two versions: low speed and high speed) are expected in November 2015. Tata Motors developed a couple of electric LCVs and is awaiting homologation.

Figure 3: Ricksha from Ampere

Vehicle Types Probable in 2–3 Years

Several vehicle manufacturers are prototyping electric-drive versions of their existing offerings and at least a dozen or more models are expected to be launched in a couple of years. They include Tata Motors (buses, LCVs, cars), Ashok Leyland (EV buses and hybrid buses, see Figure 3), Mahindra & Mahindra (cars, LCV), Maruti-Suzuki (Range Extended EV), TVS Motors (Two-Wheeler-Hybrid), and all two wheeler manufacturers are expected to launch vehicles with a Lithium-ion battery and improved models.

Figure 4: VERSA electric bus from Ashok Leyland (Image courtesy of Ashok Leyland)

Figure 5: 2W EV Photon and Optima from HeroEco, on the left hand side, and YO-EXL 2W EV from Electrotherm with its motor, charger and BMS, on the right hand side.

36.2.5 Outlook

Barriers Expected

- Consumer acceptability, this includes issues relating to low consumer awareness, current price, performance gap, etc.
- Lack of xEV related infrastructure
- Manufacturing investments, includes the existing limited domestic manufacturing capabilities and a non-existent supply chain
- Technology development, the existing low level of R&D in this area in the country, and present limited capabilities are some of the concern areas

Mission Strategy

- Strong measures to provide standardized, low cost and easy access to vehicle charging infrastructure at residences, offices, public building, and through a network of charging stations
- Demand incentives would be accompanied by measures for spurring manufacturing and product development efforts led by the private sector. This will include short-term capability enhancing measures like acquisition of knowhow, technology acquisitions, R&D consultancy and outsourced R&D abroad
- Long term technology platform development activity as per the national roadmap. The directed research efforts will be supported fully by the Government and a significant inflow of private sector investments in R&D is envisaged in the late stages of the Technology Platform program

36.3 Japan

36.1.1 Relevant Policies

Targets

The Japan Revitalization Strategy was revised in 2014 (Cabinet approval on June 24, 2014). It states "(Next-generation automobiles) aim to increase the share of new automobiles accounted for by next-generation automobiles to between 50% and 70% by 2030" (preliminary figure in 2013 was 23.2%). This was followed by "the Next-Generation Vehicle Strategy 2010" of the Ministry of Economy, Trade and Industry (METI).

Table1: Diffusion Targets by types of vehicles (Targets set by the METI), data from the "Next-Generation Vehicle Strategy 2010"

	Year 2020	Year 2030
Conventional Vehicles	**50~80%**	**30~50%**
Next-Generation Vehicles	**20~50%**	**50~70%**
Hybrid vehicles	20~30%	30~40%
Electric vehicles	15~20%	20~30%
Plug-in hybrid vehicles		
Fuel-cell vehicles	~1%	~3%
Clean diesel vehicles	~5%	5~10%

Clean Energy Vehicle Promotion Subsidy

A subsidy of passenger cars is available for Electric Vehicles(EVs), Plug-in Hybrid Vehicles(PHEVs), Clean Diesel Vehicles(CDVs), and Fuel-cell vehicles(FCVs).

- **EVs and PHVs**: up to 850,000 JPY (7,083 USD)
- **CDVs**: up to 350,000 JPY (2,917 USD)
- **FCVs**: up to 2,020,000 JPY (16,833 USD)

Taxation

EVs, PHVs, CDVs, and FCVs are exempt from paying "automobile acquisition tax"(local tax: registered vehicles: 3%; light motor vehicles: 2%) and "motor vehicle tonnage tax" (national tax) and "automobile tax" (local tax: partial exemption).

HEVs are partially exempt from paying "automobile acquisition tax", "motor vehicle tonnage tax", and "automobile tax".

36.3.2 Activities in R&D and Industry

METI is providing 6 billion JPY (nearly 50 million USD) in 2014 to support R&D, with the following targets:

1. Promotion of higher capacity and lower cost of lithium-ion batteries for automotive use
2. Development of new technologies to create innovative batteries technology beyond lithium-ion batteries
3. Development of top level analytical technology for batteries

36.3.3 HEVs PHEVs and EVs on the Road

As of the end of 2014, there were approximately 107,000 EVs and PHEVs on the road in Japan. In 2014 there were about 4.7 million newly registered passenger vehicles in Japan. Of this newly registered total, 1,017,057 were HEVs, 17,212 were EVs, and 16,178 were PHEVs.

Table 2: Distribution, sales, and models of EVs and HEVs in Japan in 2014

Fleet Totals as of December 31st, 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Passenger vehicles	66,000[122]	4,497,037[123]	41,000[124]	n.a.	60,597,550[125]

Total Sales during 2014					
Vehicle Type	**EVs**	**HEVs**	**PHEVs**	**FCVs**	**Total**
Passenger vehicles	17,212	1,017,057	16,178	n.a.	4,699,591
Buses	6	n.a.	n.a.	n.a.	11,983
Trucks	74	n.a.	n.a.	n.a.	851,314

n.a. = not available

Table 3: Available vehicles and prices in Japan

Market-Price Comparison of Selected EVs and PHEVs in Japan	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price in JPY (and USD)**
Mitsubishi i-MIEV	2,094,000 (17,450)
Mitsubishi Outlander PHEV	3,165,000 (26,375)
Nissan Leaf	2,590,000 (21,583)
Porsche Panamera S E-Hybrid	14,609,524 (121,746)
Smart Fortwo Electric Driveb	2,768,519 (23,070)
Tesla Model S 60 kWh	7,620,370 (63,503)
Tesla Model S 85 kWh Performance	10,016,667 (83,472)
Toyota Prius Plug-in	2,714,286 (22,619)

122 Estimated figure
123 Estimate based on 2013 registration data and 2014 sales data
124 Estimated figure
125 Registration data as of November 2014

36.3.4 Charging Infrastructure or EVSE

METI has provided funds to support charging infrastructure by subsidising a "Promotion Project to Develop Charging Infrastructure for Next-generation Vehicles". As of the end of 2014, over 10,000 public charging stations had been installed in Japan, including 2,819 quick charging stations. Many private companies, such as a joint company of four Japanese car manufacturers[126] take an active role in installing quick chargers and normal chargers in response to the government.

36.3.5 Outlook

The Toyota Mirai (Japanese for "future"), which is the first hydrogen fuel cell vehicle in Japan, started to be sold commercially on December 15th, 2014. New types of EVs and PHEVs will be launched on the market by various manufacturers after 2015 in Japan.

Formulating a world-leading, advanced domestic market focusing on global challenges including environmental and energy limitation, as well as encouraging global operational presence, the government promotes next-generation vehicles by creating initial demand and accelerating infrastructure development.

[126] Toyota Motor Corporation, Nissan Motor Co., Ltd., Honda Motor Co., Ltd., and Mitsubishi Motors Corporation jointly established a new company in 2014 to promote the installation of chargers for electric-powered vehicles (PHVs, PHEVs, EVs) and to help build a charging network that offers more convenience to drivers in Japan.

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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.

Table 1: Vehicle Categories

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.

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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