IEA INTERNATIONAL ENERGY AGENCY

HYBRID & ELECTRIC VEHICLE IMPLEMENTING AGREEMENT

IA-HEV

Hybrid and Electric Vehicles

The Electric Drive Commutes

2016

www.ieahev.org

International Energy Agency

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

From 2016 on renamed to
Technology Collaboration Programme on
Hybrid and Electric Vehicles (HEV TCP)

Hybrid and Electric Vehicles

The Electric Drive Commutes

June 2016

www.ieahev.org

IA-HEV, formally known as the Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes, functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of IA-HEV do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries. From 2016 on the IA-HEV has been renamed to Technology Collaboration Programme on Hybrid and Electric Vehicles (HEV TCP).

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Cover Photo: Volvo electric bus. The bus is running on route 55 in Gothenburg (Sweden) as part of the ElectriCity collaboration. Further information about ElectriCity can be obtained over www.goteborgelectricity.se.

(Image courtesy of Volvo Buses)

The Electric Drive Commutes

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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 2015

Hybrid and Electric Vehicles

The Electric Drive Commutes

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* from 2016 on renamed to HEV TCP; in this report the terms IA-HEV and HEV TCP are used as synonyms.

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1 Chairperson's Message

Technology Collaboration Programme on Hybrid and Electric Vehicles HEV TCP of the International Energy Agency IEA enters the 5th phase 2015-2020 – New secretary Dr. James F. Miller elected – 17 member countries work in 12 different working groups – Growth of electric drive trains goes on – Big differences from country to country and from car producer to car producer

Entering the 5th Working Phase

In 2015, the International Energy Agency IEA started rebranding of Implementing Agreements as Technology Collaboration Programmes (TCPs)[1]. From 2016 on, the name IA-HEV is changed to "Technology Collaboration Programme for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV TCP)". Since the end of 2015 the HEV TCP entered its 5th working phase. The mission statement and the strategic objectives of the HEV TCP were developed by the members of the executive committee of all member countries and the operating agents of the different tasks in several preparations meetings since 2013. The strategic objectives for the HEV TCP in the 5th phase from 2015-2020 are:

1. Produce and disseminate objective information for policy and decision makers on H&EV technology, projects and programmes, and their effects on energy efficiency and the environment.
2. Be a platform for reliable information on hybrid and electric vehicles.
3. Collaborate on pre-competitive research projects, and investigate the need for further research in promising areas.
4. Collaborate with IEA transport related IAs, and with specific groups or committees.

The Electric Drive Train Accelerates

This was the motto of our annual report in 2014 and it describes well what was happening at the start of the 5th phase in 2015. The background of the 5th phase is more positive for the electric drive trains than ever before. In the 4th phase we have seen a new class of cars on the market, the "plug-in-hybrid"-concept with the "Opel Ampera/Chevrolet Volt" as the "car of the year 2012". Hybrid cars are more

[1] Presented to the Committee on Energy Research and Technology of the IEA (CERT) and communicated to all the TCP Chairs on 2 March, 2016.

and more common in the product range of all car producers. But still Toyota, the pioneer of the hybrid concept is leading the field with an unmatched range of cars. Toyota profits from the early efforts it started in the last century.

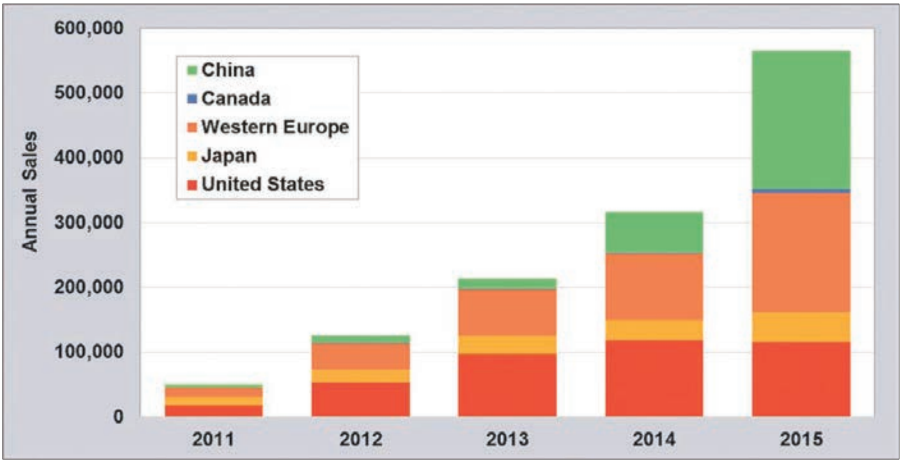


Figure 1: Global plug-in light vehicle sales 2011-2015 (Source: Argonne National Laboratory 2/ 2016)

Sales of battery electric vehicles BEV are still small in most of the countries. But the growing rates look promising. At the end of 2015, we had about 1.3 million EVs and PHVs on the streets. This number has doubled since 2014. The number of different cars is still small and is dominated by small cars as the Nissan Leaf, which is the leader in sales with now over 100,000 EVs in total. This is still remarkable and reflects the status of Nissan as the leader in the BEV segment. Most discussed in the field of BEV is the “Tesla S”. This luxury high performance car is dominating the media and impresses car journalists and car drivers with its acceleration, performance, and new features. “Tesla” is the first new car producer which could enter a market segment and dominates it in some OECD countries. In some countries, the Tesla S is leading the market of luxury cars against all known brands. Tesla has a new sales concept and also solves the recharging problem with its own standard. It will be interesting to see how the other car producers react, especially when the new Tesla models, the SUV “X” and the mass market model “Tesla 3” are entering the market.

The New Car Markets for EVS

China is one of the leaders in e-mobility. The commitment of the government to e-mobility is remarkable. Together with the leading role in the market for renewable electricity with hydro, wind, and PV, the electric car is perfect for China. China has a young and very strong car market. This offers the e-mobility new chances. The HEV TCP will enhance the contact with the EV-specialists of the Chinese government and wants to invite them to the technology collaboration group HEV TCP.

India announced a program for electric vehicles up to 2030. This and new countries from the developing world should be in the focus of the HEV TCP group as well.

Limits of the Combustion Technologies Visible

The "Volkswagen scandal", with the cheated exhaust treatments, demonstrated drastically that the conventional IECVs come to their limits. It can be expected that the emission levels will be more stringent from period to period. To match them, the technical treatment is more and more complicated and has influences on other technical parameters as the consumption. It's a difficult choice when an old technology has to be given up. This problem is well known in the semiconductor industry (see the book from the Intel-genius Andrew Grow "Only the paranoid survive"). But the strong influence in the politics, lead the leaders of the car industry to another more simple solution. All these problems now will foster the electric drive trains.

Many Things Needed Before BEVs and PHVs can Enter the Mass Market

Looking at the success of Tesla we find some weak points of their competitors. Most brands offer only few or no BEV or PHV. Their sales forces are struggling by selling this new car type. – No wonder, they told interested customers for years, how unreliable and expensive such cars would be. They have no or only little expertise in the charging infrastructure. Their technical specialists have no or only little expertise in electric drive trains and their components. Probably they fear the lower service costs in future too. Most of them have no idea about the production of clean, CO_2 free electricity, which is a necessity for a good CO_2 balance of the EVs. An offer for such electricity is a nightmare for a car dealer. – I still remember the discussion about nuclear power with a VW car dealer, which was far from what I wanted to hear from him – I have my own PV plants. Now his brand offers EVs too. I'm wondering, what he is telling now! But also the technology of the BEV is not ready for everyone. This is not a tragedy, as most of the car buyers can't get an EV – the production figures are still too small. Only a small group of car buyers can get such a car. We are still in the "innovative market" and are going slowly to the "pioneer segment". This will be the task for the 5th phase of our TCP. This altogether ranges in the 3-5 % share of the total market. With a total world car market, there is a "2-4 million EVs/year" market within these two buyer groups.

Several Car Concepts in Parallel are Good to Start to the Mass Market

Actually we have three car concepts on the market:

- The hybrid car which acts as a “better ICEV”. This concept will last as long as cars with combustion engines are on the market.
- The “plug-in-hybrids” is a popular concept which takes advantage from the long range capability of gasoline and the high efficiency and torque characteristic of the electric drive train. But two motors are always more complicated and more expensive than one. So the concept will not last forever.
- The battery electric vehicle BEV has all the advantages of the electric drive train. High torque and efficiency and the possibility of the use of local produced renewable electricity. But potential customers fear the limited range. BEV users know how to deal with that limitation.

In the long run, the battery electric vehicle BEV can cover most of the market segments. What is needed are longer ranges, lower prices, and a lot of efforts in the market development. Not to mention, that in the long run, a clean CO_2 electricity production mix and a simple recharging infrastructure is needed.

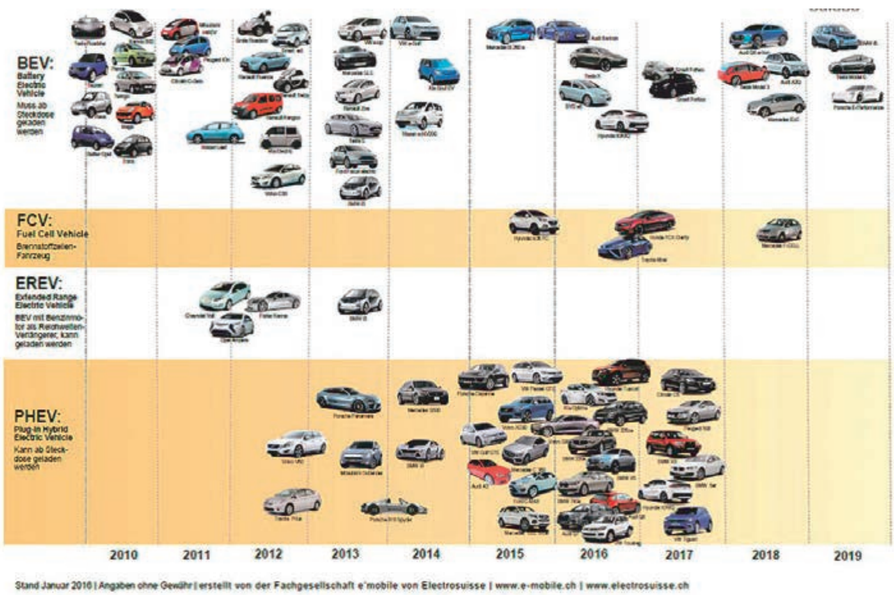
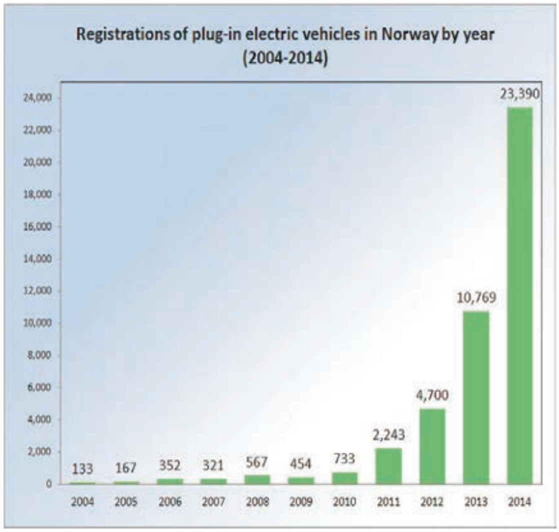


Figure 2: New HEVs on the Swiss market – the picture shows the novelties (e-mobile) – still small numbers of BEV in the next years

Consumers and mainly no EV users are still confused about the range of EVs. For them the new PHVs are a good bridge in the electric drive. So, for the next decades, we will have to live with these three concepts. The BEV can first make the PHV obsolete as the ranges and the fast charging capabilities are going up. To replace all IECVs and the hybrid cars, this needs much more effort and still a long time to go.

An interesting market is Norway with a broad range of incentives for EVs. We should learn more from this successful introduction of EVs in this small country with more than 5 million inhabitants in Northern Europe.



Electric Drive Trains Everywhere

Normally we are focused on private cars. But the electric drive can do more. It brings advantages for small 2-wheelers up to big construction machines. These market niches bring competitive advantages and should be exploited. As e-bikes are well known, I would mention a new tool from the other side of the scale.

In Switzerland a group of engineers from the Eidgenössische Technische Hochschule ETHZ with Prof. Dr. Dyntar, developed a big excavator with 15,400 kg weight and an electric drive train with 115 kW peak power. This device can work the whole day, is quiet and has no exhaust. Over the lifetime of 10 years, it saves 120,000 liter diesel and needs 210,000 kWh electricity. This can be produced with a PV installation of 21 kWp. Only for the gasoline you get savings of more than 600,000 EUR in 30 years. This is an interesting tool not only for such works in cities and villages. The construction company, using the electric excavator, has big PV plants in their workshop. They got the European solar prize for their efforts.

Figure 3: The suncar excavator with 15,400 kg weight and gravel force of 98,700 N is another application for the electric drive

Mission of the HEV TCP

So the surrounding of the electric drive trains is alive. It's time now that the member countries of our transport collaboration group HEV TCP can earn the benefits of these efforts. This is the focus of the mission of the HEV TCP in the 5th phase 2015-2020. Our members expressed the mission:

- Supply objective information to support decision making
- Facilitate international collaboration in pre-competitive research and demonstration projects
- Foster international exchange of information and experience

Target Audience

The target audience of our work is:

- Policy/decision makers in Governmental bodies at national, regional, and city levels
- Automotive industry and component suppliers
- Utilities
- Foster international exchange of information and experience

12 Working Groups

Actually we have 12 working groups with a wide variety of work. The organization in the working groups is quite different. You can find the details in the following descriptions. Don't hesitate to contact the Operating Agent, which leads the working group. There are always meetings of the different working groups going on.

With a new membership system, we could enhance the participation in the working groups. Also we could see a steadily growth in the number of working groups in the last years.

Efforts to Enhance the Number of Member Countries

On our meeting in South Africa we discussed methods to enhance the number of member countries. Actually we have 17 member countries from three continents. We have now special possibilities for developing countries. This should give them the opportunity to cooperate with lower costs. If you are interested, please contact our secretary James F. Miller.

Collaboration with the Electric Vehicle Initiative (EVI)

Since 2012 we collaborate officially with the Electric Vehicle Initiative EVI. More and more often we have the meetings of the EVI in the same venue and on the same date as the meetings of our Executive Committee.

HEV TCP and IEA

Since 2015, the IEA has a new director Fatih Birol. For the first time in the IEA history, he organized a meeting with all the Technology Collaboration Groups. We hope that in future we can collaborate much closer with the IEA headquarters.

Inside HEV TCP

In 2015, we had to find a new secretary-general. Our former secretary-general Martijn van Walwijk informed us, that he will start a new job in a University of Applied Sciences in the Netherlands. Martijn supported our Technology Collaboration Group for nearly 10 years. He lived in France and could help us with his experience in international projects and with his language and management skills. I thank Martijn for his efforts and his work for our TCP. We wish him all the success in the new job and finally also in the new living surrounding.

For the successor we got a lot of very qualified offers from over 10 organizations. The ExCo had to make several rounds for the selection. This expresses the quality and the efforts of the groups for the job. I thank them all for their interest in our organization. We had many candidates, which we could see in the job.

The new elected secretary-general is the experienced researcher Dr. James F. Miller, from the Argonne National Laboratory in the USA. With his background in the battery research of one of the world leading research facilities, he will give us a new and interesting drive. I welcome Jim in our group and I'm happy that we found such a good new secretary-general. For the replacement, we also had the support of the Department of Energy of the US government. We had a very smooth transition from Martijn van Walwijk to James F. Miller. We also could transform the bank account to the Argonne National Laboratory, which makes my life easier.

One of the efforts in the next years is stronger dissemination of activities. This addresses especially new member countries. We want to bring more countries into our group.

Figure 4: Participants from the ExCo meeting in Sandton (South Africa) in November 2015

Finally, I also want to thank the members of the Executive Committee (ExCo). They participate in two meetings per year. This leads to long travels additionally to all of the other obligations they have in their jobs in their home country. Three of them: Carol Burrelle, David Howell, and Mario Conte act additionally as deputy head of the group and have much more work to do. I thank them especially for their commitment to the HEV TCP. The ExCo has the support of two groups: the strategic planning groups (SPG) and the new Technical Committee, which looks at technical trends. Here we have even more members supporting the preparation of the ExCo meetings.

I also want to thank all the Operating Agents who prepare and manage the technical work. They are supported by numerous collaborators. I also thank the technical experts which bring their expertise into the working groups.

Outlook

Electric vehicles got a new push in 2015. They are not only seen as a car with another motor. They are seen more and more as a new system, more an electronic tool, than a car. We could see that EVs are now a topic in electronic fairs, more interesting than on car shows.

The growing interest in autonomous vehicles gives the EV a new touch and also a new perspective. EVs are now seen under a new light by many people.

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2 The IEA and its Technology Collaboration Programme on Hybrid and Electric Vehicles

This chapter introduces the International Energy Agency (IEA) and its Technology Collaboration Programme for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV TCP). In 2015, the IEA started rebranding the Implementing Agreements as Technology Collaboration Programmes (TCPs).

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 1) and beyond to promote reliable, affordable, and clean energy for the world's consumers. IEA countries today account for just under half of the world's energy consumption. The IEA 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

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

Since the 1980s, the IEA is engaged in establishing relationships with countries and international organisations beyond its membership. Particular interest of IEA lies in major energy consuming, producing and transit countries (including the accession candidates Chile and Mexico; the Association countries China, Indonesia and Thailand; and partner countries as Brazil, India, Russia, and South Africa). In this manner, the IEA puts lots of effort towards gathering all stakeholders – from policy makers to business leaders – with a truly international view of the world's energy system.

With the evolution of energy markets, the IEA mandate has also broadened. It now focuses on topics that are well beyond oil crisis management. The 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 as well as opportunities for building resilience to its impacts.

The IEA plays an active role in discussions with producer countries and with the Organization of the Petroleum Exporting Countries (OPEC), particularly within the International Energy Forum (IEF). The IEA also supports energy-related work of the Group of 20 (G20), Group of Seven (G7), and Group of Eight (G8), as well as the Clean Energy Ministerial (CEM). Additionally, the IEA supports and contributes comprehensively to the energy agenda of the Asia Pacific Economic Cooperation (APEC) forum, and regularly advises in expert discussions at the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC).

Statistically, the IEA is a founding partner of the Joint Organisations Data Initiative (JODI), working alongside APEC, the Statistical Office of the European Communities (EUROSTAT), the Gas Exporting Countries Forum (GECF), the Latin American Energy Organization (OLADE), the United Nations Statistics Division (UNSD), OPEC and IEF. The IEA also works closely with the International Renewable Energy Agency (IRENA) to maintain a joint database of renewable energy policies and measures.

Regionally, the IEA also collaborates with multigovernmental organisations such as the Association of Southeast Asian Nations (ASEAN) and the African Union to promote energy co-operation among member states.

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.

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 1).

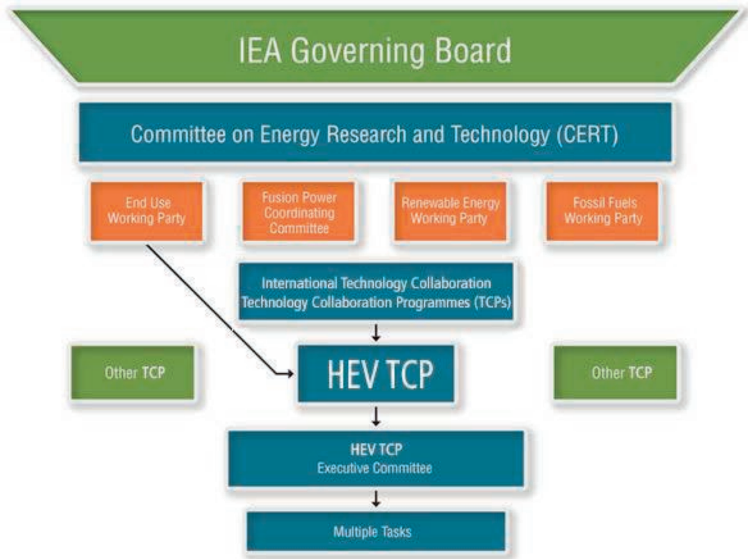

Figure 1: The IEA energy technology network[2]

2.1.3 IEA Technology Collaboration Programmes

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 Technology Collaboration Programmes (TCPs). A TCP may be created at any time, provided that at least two IEA members agree to work on it together. There are currently 40 TCPs 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 TCPs is the Technology Collaboration Programme for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV TCP). HEV TCP reports to the Working Party on Energy End-Use Technologies (EUWP). An overview of the the activities and recent accomplishments of TCPs is available on the IEA web site[3].

IEA TCPs are at the core of the IEA's international energy technology network. This network 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

[2] From 2015, the IEA is rebranding the IAs as Technology Collaboration Programmes - TCPs. Accordingly, IA-HEV was recently renamed to HEV TCP.
[3] http://www.iea.org/publications/freepublications/publication/technology-collaboration-programmes.html

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 the TCPs 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 TCPs. Participants are welcomed from OECD member and OECD non-member countries, from the private sector, and from international organisations.

Participants in TCPs fall into two categories: Contracting Parties and Sponsors. This issue is 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 organisations 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 a TCP.

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

The TCP 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 TCPs focus solely on information exchange and dissemination. The benefits of international co-operation on energy technologies in TCPs are shown in Table 2.

Table 2: Benefits of International Energy Technology co-operation through IEA TCPs

Benefits of International Energy Technology Co-operation through IEA Technology Collaboration Programmes
• 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 TCPs are the responsibility of each TCP. The types of TCP 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 HEV TCP).

Effective dissemination of results and findings is an essential part of the mandate of each TCP. 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 TCPs. HEV TCP 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 TCPs. 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 organising a Transport Contact Group (TCG) workshop for the transport-related TCPs, with the objective of strengthening their collaboration. HEV TCP actively participates in the Transport Contact Group.

2.2 Technology Collaboration Programme 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 TCP dedicated to developing and deploying these vehicles.

The IEA Technology Collaboration Programme for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV TCP) was created in 1993 to collaborate on pre competitive research and to produce and disseminate information. HEV TCP is now in its fifth five-year term of operation that runs from March 2015 until March 2020. 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, United Kingdom, and United States.

Compared to the automotive industry and certain research institutes, HEV TCP is relatively small, in the context of an organisation. Nevertheless, HEV TCP 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 HEV TCP 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 HEV TCP 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 HEV TCP ExCo. The Tasks that were active during 2015 and in early 2016 are described in part B of this report. The activities associated with hybrid and electric vehicles in individual HEV TCP member countries can be found in part C.

The next three subsections briefly report on HEV TCP activities and results in the second, third and fourth terms of its operation (Phase 2, Phase 3 and Phase 4).

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 HEV TCP Phase 2, 1999-2004

Phase 2 of the HEV TCP 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 HEV TCP 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 TCPs: HEV TCP and the Technology Collaboration Programme on Advanced Motor Fuels (TCP-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 TCP, the hybrid vehicle Task, and itself in the field of electrochemical technologies.

2.2.2 Description and Achievements of HEV TCP 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 HEV TCP's mission. Topics addressed during the third phase are shown in Table 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.

HEV TCP'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 HEV TCP (2004-2009)

Topics Addressed in the Third Phase of HEV TCP (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 HEV TCP 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 TCPs (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 HEV TCP 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 HEV TCP Phase 5, 2015-2020

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

In the strategic plan for Phase 5, the participants in HEV TCP 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 and remained more or less on that level through the whole of 2015, 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 prices and lacking charging infrastructure are expected to remain the major hurdles for increased electric vehicle deployment in the coming five years.

The HEV TCP ExCo 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 HEV TCP Contracting Parties, which are representing national governments. The HEV TCP 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 HEV TCP 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 Technology Collaboration Programmes, and to collaborate with specific groups or committees with an interest in transportation, vehicles and fuels.

The existing HEV TCP 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.

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

HEV TCP 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

In addition to the active Tasks, new topics will emerge in the coming five years.

The HEV TCP participants have listed possible topics for Phase 5 (2015-2020) and grouped these in three categories: technology evolution/progress (see Table 5), technology deployment/market facilitation (see Table 6), and environmental protection (see Table 7). Additional topics will certainly emerge, and depending on priorities and resources that can be made available, the HEV TCP ExCo will decide which topics will actually be addressed in Phase 5.

In the 2015, the ExCo approved three new Tasks:

- Task 29 “Electrified, Connected and Automated Vehicles” that will explore possibilities for synergies between connectivity, automation and electrification of vehicles.
- Task 30 “Assessment of Environmental Effects of Electric Vehicles” for collecting and analyzing the environmental benefits of EVs in comparison to conventional vehicles.
- Task 31 “Fuels and Energy Carriers for Transport” that will provide a comprehensive overview of different fuel and drivetrain options.

During 2015 some of the Tasks completed: Task 17 “System Optimization and Vehicle Integration”, Task 19 “Life Cycle Assessment of EVs”, Task 20 “Quick Charging”, and Task 22 “E-Mobility Business Models”. Nevertheless, many of the Task members are still involved in ongoing Tasks. For instance, the OA of completed Task 19, Mr. Gerfried Jungmeier, started a new Task 30 in 2015 and will be involved in upcoming Tasks, too.

To pool resources and to increase the impact of its work, HEV TCP will aim to increase collaboration with other IEA Technology Collaboration Programmes such as TCP-AMF (Advanced Motor Fuels), TCP-AFC (Advanced Fuel Cells), TCP-PVPS (Photo-Voltaic Power Systems) and the co-operative programme on smart grids (TCP-ISGAN). HEV TCP 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 HEV TCP 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 HEV TCP 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 HEV TCP member countries. Other countries are invited to join the Agreement and share the benefits of HEV TCP 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

2.3 IEA Engagement in other Activities Related with Electric Vehicles: the Electric Vehicle Initiative

The Electric Vehicle Initiative (EVI, www.cleanenergyministerial.org/Our-Work/Initiatives/Electric-Vehicles and www.iea.org/evi) is a multi-government policy forum established in 2009 under the Clean Energy Ministerial (CEM), a high-level global forum to promote policies and programmes that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy.

The EVI is dedicated to accelerating the deployment of EVs worldwide with the goal of a global deployment of 20 million electric cars by 2020. It counts today 16 member governments (Canada, China, France, Germany, India, Italy, Japan, Korea, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, the United Kingdom, and the United States). China and the United States are co-chairs of the initiative, and the IEA hosts the EVI secretariat.

The EVI brings together representatives of its member governments and partners twice per year and acts as a platform for knowledge-sharing on policies and programmes that support EV deployment. The EVI has developed a number of analytical outputs over the past years: three editions of the Global EV outlook (2016, 2015 and 2013) and two editions of the EV city casebook (2014 and 2012), with a focus on initiatives taking place at the local administrative level.

The EVI also regularly engages private-sector stakeholders in roundtables to discuss the roles of industry and government in the EV market as well as the opportunities and challenges ahead for EVs. The latest event of this kind is the High-level event on Zero Emission Vehicles (ZEVs), held at the at the 2015 United Nations Climate Change Conference (COP21)[4] .

In 2015, the EVI also supported the preparation of the Paris Declaration on Electro-Mobility and Climate Change and Call to Action[5] announced at COP21 and calling for the global deployment of 100 million electric cars by 2030. This declaration stems from the collaboration of several initiatives active in the promotion of electric mobility (including the EVI and the International Zero Emission Vehicle (ZEV) Alliance). Its development was facilitated by the Governments of France and the United Nations Secretary-General Executive Office, in close coordination with the Paris Process on Mobility and Climate (PPMC), having the lead for the development of all the initiatives related with transport in the Lima-Paris Action Agenda (LPAA). The declaration brings

[4] www.iea.org/workshops/high-level-event-on-zero-emission-vehicles-zevs.html
[5] http://newsroom.unfccc.int/lpaa/transport/the-paris-declaration-on-electro-mobility-and-climate-change-and-call-to-action

together individual and collective commitments to increase electro-mobility to levels compatible with a less-than 2-degree pathway, and builds on current successful experiences worldwide and the converging interest of all transport modes for hybrid/electric solutions. Partners to the Declaration commit to broaden their efforts and call for a decisive joint effort towards sustainable transport electrification – including that at least 20 % of all road vehicles (cars, 2 and 3-wheelers, trucks, buses and others) are to be electrically powered by 2030.

In 2016, the HEV TCP and the EVI worked together on the development of templates for data collection, aligning vehicle category and charger type definitions, taking a first step towards a common data collection process as of 2017. This should allow better alignment of HEV TCP and EVI data analysis and messages throughout their respective publications.

3 Personnel Changes in the IA-HEV

In early 2015, we welcomed Pierpaolo Cazzola as the new IEA Desk Officer for the HEV TCP. He replaces Talli Trigg who served as his predecessor in that role. On 30 June 2015, Martijn van Walwijk stepped down as the Secretary-General for the HEV TCP. He had served in that capacity for eleven years, beginning in 2004.

After a vote of the Executive Committee in May 2015, James Miller was selected as the new Secretary-General. Dr. Miller has worked at the U.S. Department of Energy's Argonne National Laboratory since 1976, and he has over 35 years of experience in batteries, fuel cells, and hybrid and electric vehicle technology. He currently serves as the Deputy Director of Argonne's Energy Systems Division, where he oversees transportation-related activities that include the Advanced Powertrain Research Facility, EV-Grid Interoperability Center, *Autonomie* Vehicle Simulation, Battery Materials Engineering Research Facility, Life-cycle Analyses, and GREET Energy and Environment Modeling. He holds a Ph.D. in physics from the University of Illinois, and an MBA degree from the University of Chicago.

He serves on the International Program Committee of the Electric Vehicle Symposium (EVS). He has been a session organizer and co-chair for battery sessions at the SAE World Congress since 2009. He was a co-organizer of DOE's EV Everywhere Grand Challenge Workshops. He has also served on several committees of the National Research Council.

As Secretary of the HEV TCP, the duties include the following:

- **ExCo Meetings.** Organize two ExCo meeting per year, prepare draft agenda and documents, assist Chair during the meetings, write and distribute minutes. Work with local hosts to secure the meeting venues, arrange working lunches and dinners, and provide supporting information regarding travel and lodging logistics.
- **Support IEA-HEV Tasks.** Provide support the Operating Agents assist in promoting individual Tasks and increasing participation in Tasks. Support the development and implementation of new Tasks. Build contacts with existing and potential new member countries to increase participation.
- **Information Dissemination and Communications.** Provide updates on IEA-HEV activities and upcoming events and distribute this to ExCo members and

Operating Agents. Prepare and disseminate promotional materials. Give presentations on the IEA-HEV at major conferences and meetings. Communicate with and bi-annual reporting to IEA headquarters. Communicate with other Implementing Agreements. Interface with other organizations (e.g., AVERE, WEVA, EDTA) that promote the advancement of hybrid and electric vehicles.

- **Manage Finances of the Secretariat.** Handle invoices after approval by the Chair, prepare and present financial status reports, arrange and report on an annual audit, and develop proposed budget for future years.

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4 Information Exchange (Task 1)

Members: Any IA-HEV member may participate

4.1 Introduction

Information exchange is at the core of IA-HEV's work, enabling members to share key 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 (2015-2020) 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 (2015−2020)
• Produce objective information for policy and decision makers
• Disseminate information produced by IA-HEV (recently renamed to HEV TCP) to the IEA community, national governments, industries, and other organizations
• Collaborate on pre-competitive research
• Collaborate with other IEA Implementing Agreements (from 2016 on, Technology Collaboration Programmes) and groups outside the IEA
• Provide a platform for reliable information

4.2 Objectives

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

Information exchange focuses on these topics:

- Research and technology development;
- Commercialization, marketing, sales, and procurement;
- Regulation, standards, and policies;
- Awareness raising measures, and
- Activities of IA-HEV Tasks.

4.3 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. Since the end of 2014, the responsibility for Task 1 has been 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, 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 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.

4.4 Results

Notable events in 2015 included the following:

- Task 1 Information Exchange meetings were held in Gwangju, Republic of Korea, in May 2015, and in Sandton, South Africa, in November 2015.
- The IA-HEV annual report on 2014 entitled Hybrid and Electric Vehicles – The Electric Drive Delivers was published in 2015.

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

4.5 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 meetings, website, and newsletter topics from members.

4.6 Contact Details of the Operating Agent

For further information, please contact the Task 1 OA:

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5 Electrochemical Systems (Task 10)

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

5.1 Introduction

This chapter represents a final summary of the activities of Task 10 which officially ended at the Executive Committee (ExCo) meeting held in Amsterdam in April 2016. Task 10 addressed topics related to the chemistry and performance of electrochemical energy storage devices (batteries and ultracapacitors) of interest to those working on electric drive vehicles including hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), and electric vehicles (EV). At the ExCo meeting, a proposal for a follow-on Task on Batteries was presented. The follow-on Task will allow a continuation of the discussions of issues related to advanced batteries similar to what was done in Task 10.

5.2 Objectives

Task 10's goal was to advance the state-of-the-art of battery and capacitor science and address issues related to their use in vehicles. The Task accomplished this goal by facilitating information exchange among technical experts from the electrochemical power sources field.

5.3 Working Method

The Task was established in 2000-2001 under the format and budget structure that was standard at the time. After several years, the ExCo determined that it would be appropriate to restructure the way the Task was managed. The current Operating Agent (OA) took over responsibility for the Task at the ExCo meeting held in November 2004; his effort was supported by the United States (U.S.) Department of Energy. After this transition, any IA-HEV member could participate at no additional cost. The OA retired from employment with the U. S. government in 2015; his current address is at the end of this chapter.

The Task addressed selected topics through the use of focused working groups. Each working group met once or twice to discuss a specific topic. Products from the working groups varied depending upon the nature of the discussions and included documents distributed to the participants and summaries published in the Annual Reports. Each working group had unique members; attendees were individuals interested in the specific topic. A country or organization could participate in one working group without making a multiyear commitment to attend every Task meeting. Discussions were on a "no public attribution" basis to encourage candid discussions.

5.4 Results

5.4.1 Workshops

Task 10 sponsored ten working group meetings between 2006 and 2016. Workshops prior to 2016 have been summarized in prior Annual Reports.

A list of the Workshops with one or two brief conclusions from each workshop is as follows:

Safety and Abusive Testing of Batteries, Parts 1 & 2

- Safety tests are complex and can be manipulated.
- Although many standard safety testing procedures and protocols address similar issues, there can be significant differences in the results depending upon subtle differences. For example, some procedures "test to failure" to identify failure mechanisms and "worst case" scenarios; other procedures only "test to a pass/fail point." In these procedures, if a cell or battery reaches the defined "pass" criteria, no further testing is done.

The World's Supply of Lithium

- There is an ample supply of lithium, but some sources of lithium are more expensive to process than others. Production of lithium from brines is normally less expensive than production from ores.

Accelerated Life Testing of Batteries (Especially Lithium-ion Batteries) for Vehicles

- It's not easy, but it can be done.
- As a result of this working group meeting, a new, independent task focusing on Life Testing of Batteries was established.

Government Support for Vehicle Battery Manufacturing Facilities

- Government support can help build an industry, but there will be issues and "failures".
- Several countries had programs to encourage the battery industry.

- No other country had, at the time of this workshop in September 2010, made the same type of large, focused investment that the U.S. had under the Recovery Act.

Battery Recycling (With an Emphasis on Lithium-ion Batteries)

- Most recycling systems in actual use destroy the cell either thermally or physically. What is actually recovered and how it is used is a function of the recycling technology used.
- Recycling is most attractive financially for cobalt systems, because of the value of the recovered cobalt.
- Many materials in a "recycled" battery end up in a slag or waste stream. Some of these slags do have commercial value. For example, the lithium/aluminum oxides in the slag from thermal treatment processes are of value as an additive to cement.
- Recovering "high value" components such as cathode active materials that can be used in new batteries with a minimum of processing is a challenge. Processes that can accomplish this goal are under development, but none were in commercial operation at the time of the workshop in September 2011.

Batteries under Extreme Temperature Conditions

- Cold hurts performance. Some of the suggested methods of extending battery operation in cold weather, such as wearing a very heavy coat and not using the car's heater would not be acceptable to all users.
- Heat hurts battery life.

Safety of Batteries in Electric Drive Vehicles

- The battery is sometimes blamed unfairly.
- Often the problem is poor pack design or poor pack assembly.
- Some battery incidents have involved very complex, multi-step failure scenarios.
- Internal short circuits are a big concern that will be hard to "fix".
- Electrical energy "stranded" in a damaged battery is of significant concern.

Fast Charging of Batteries in Plug-In Electric Vehicles (Joint with Task 20)

- Current versions of "Fast charging" are not that fast.
- Current versions of "Fast charging" should not damage batteries.
- No single standard for charging technology and connection to the vehicle has emerged as dominant.
- The logistical barriers (such as codes, standards, and permitting) to installing a fast charger can be significant.

Suppression of Battery Fires (Joint with the Battery Safety Council)

1. Battery fires are hard to put out, but water will keep them from spreading.
   - In some cases, a battery fire which was "suppressed" with water or another firefighting agent would "reignite" after a passage of time.
   - In many cases, a battery fire was finally "extinguished" only after all reactive materials in the battery had been consumed – i.e. the battery "burned itself out."
   - In some events, a battery failure propagated through multiple cells in one or more modules, but did not spread to adjacent modules. This situation was characterised by the statement, "The car burned up, but much of the battery survived."
2. A car fire is of small concern compared to a fire on an airplane at altitude.
3. The firefighting community is concerned about proposals to install multi-megawatt hour batteries on an upper floor in high-rise buildings.

5.4.2 Attendance Metrics for Workshops

1. Attendance at a given workshop varied from about 18 to 40 individuals.
2. Total attendance for all of the workshops was about 250 people.
   - Some individuals attended more than one workshop, but many experts came to only one workshop on a topic of specific interest to them.
   - Attendees came from about 19 different countries.
3. Workshops were held in four member countries: Belgium, Canada, France, and the United States.
4. Attendees came from a range of organizations, including the following: Universities, Government agencies, National laboratories, Battery materials manufacturers/suppliers, Cell and battery manufacturers, Automotive manufacturers, Defense agencies, Recycling industry, and Independent R&D organisations.

5.5 Next Steps

This Task has ended. At the ExCo meeting held in Amsterdam in April 2016, a follow-on Task on Batteries was approved. The Operating Agent will remain the same.

5.6 Contact Details of the Operating Agent

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6 System Optimization and Vehicle Integration (Task 17)

Members: Austria, Germany, Switzerland, United States

6.1 Introduction

Current trends in energy supply and use are unsustainable, in terms of environment, economy and society. Therefore, low-carbon energy technologies/environmentally friendly mobility will play a crucial role and is one of today's major challenges for the global automotive industry on par with the growing trend towards urbanization, the increasing scarcity of natural resources, the steady rise in the world's population and global climate change. Especially the transport sector is a contributor to many environmental problems due to its dependency on fossil fuels.

In the search for a sustainable solution to these challenges, electrical energy is the key to success, particularly when it comes to mobility. Vehicles driven by an electrified powertrain (also known as xEVs) can significantly contribute to the protection of the environment.

However, penetration rates of EVs are still low, mainly because of the high battery cost, range anxiety, and the still low level of existing charging infrastructure. Research and development play a crucial role in the process of developing alternative power technologies, especially when it comes to the optimization of EVs.

The IEA-IA-HEV, tries to analyze the potentials of these vehicles, by working on different Tasks, including Task 17 – "System optimization and vehicle integration".

This Task analyzed technology options for the optimization of xEV components and drive train configurations which will enhance vehicle energy efficiency performance. After five years of effective networking, it successfully demonstrated the benefits, potentials, technical challenges, but also chances of the overalls vehicle performance.

6.2 Objectives

Electronic systems used to operate and monitor all vehicle types have benefited from substantial improvements during the past few years and have also improved the prospects for xEVs. Improved power electronics have resulted in new opportunities to control and steer the increasingly complex-component configurations. 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 have been analyzed in Task 17 during the last five years.

Member Countries contributing to Task 17 were Austria, Germany, Switzerland, and the United States. Assignment of this Task was to analyze technology options for the optimization of xEVs, which will enhance vehicle energy efficiency and performance.

The **scope of work** has focused on the participant's 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, Task 17 included:

- Overview and analysis of present vehicle components/configurations
- Original Equipment Manufacturer (OEM)s-review of different markets, strategies and technologies for EVs and follow-up of new prototypes
- Analysis of theoretical possible operation and configuration concepts
- Comparison and analysis of different vehicle technologies
- Overview and analysis of different simulation tools
- Analysis of different methods for optimization of components

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

- Improvements in energy efficiency, operational safety and durability
- Integration and control of software solutions
- Reductions in the cost of components
- Reductions in weight and volume
- Configurations for energy storage systems
- Market launch trough international deployment and demonstration projects

6.3 Working Method

Task 17 activities predominantly consisted of preparing a technology assessment report on trends and providing opportunities for member countries to exchange information.

Thus, working methods included:

- Questionnaires, personal interviews and several workshops
- Foresight analyses of future options and opportunities
- Simulation of different component configurations
- International networking
- Information exchange and close coordination with other running Tasks
- 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 was represented by workshops. They enabled the dissemination of information about relevant activities in an international context:

1. Nine workshops took place, covering the following topics:
    - 2010: Vienna – "*Kick Off Meeting and First Steps for System Optimization and Vehicle Integration of EVs*"
    - 2011: Geneva – "*Current status of R&D for EV Components with focus on Energy Efficiency Improvements*"
    - 2011: Chicago – "*Battery Management Systems*"
    - 2012: Santa Monica – "*E/E-Architecture*"
    - 2012: Vienna – "*System Integration and Mass Impact*"
    - 2013: Chicago – "*Innovative Thermal Management for xEVs*"
    - 2013: Vienna – "*Thermal Management Concepts for xEVs*"
    - 2014: Schaffhausen – "*Functional and Innovative Lightweight Structures and Materials in xEVs*"
    - 2015: Berlin – "*Power Electronics and Drive Train Technologies for future xEVs*"
2. In total, 43 speakers from companies, institutes and policy makers participated in these workshops
3. Additionally about 131 participants from eight countries have been participated in these workshops and on several technical visits

6.4 Results

6.4.1 Final Results of Task 17 (2010-2015)

Worldwide industry and government are forced to consider alternative and sustainable solutions for transportation. Vehicles, driven by alternative drivetrain offer a unique advantage concerning energy efficiency, emissions reduction, and reduced petroleum use and have thus become a research focus around the world. Studies – conducted by the IEA – pointed out, that there are approximately 1,000,000 BEVs and PHEVs on the streets (as per the end of December 2015). There are predictions that the EV market will reach 8 % of total car sales by 2020 (2.5 Mio. BEVs, 3.1 Mio. PHEVs and 6.5 Mio. HEVs[6].

Electronic systems involved in the operation and monitoring of such vehicles have been the subject of substantial improvements during the past few years. Further optimization of these components and new concepts for their integration in the overall system tuned to the specific requirements of different vehicle applications is necessary.

From 2010-2015, Task 17 was working on the system optimization and vehicle integration of xEVs to enhance the overall vehicles performance and 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 such a vehicle.

6.4.2 Batteries

During the past decade, there has been a lot of progress, especially in the field of electrochemical storage devices and FCEVs. Beside durability and energy density, cost is one of the main areas where improvements are required to compete with conventional fossil fuels. Within the last years, costs have been falling rapidly and are expected to continue doing so for the next 10 years. The battery's durability is already expected to be sufficient for automotive use, giving ten years calendar life and 150,000 mi. Fuel cell stacks appear to still be falling short of the US DoE's 2009 target of 2,000 hours operation, corresponding to approximately 25,000 miles before a 10 % drop in power output. The next generation of lithium-based chemistries are expected to approach the perennial problem of 'range anxiety'. Currently, 80 % of the total amount of e-drive costs belongs to the battery (see Figure 1), while the 10 % attributable to the e-motor and further 10 % to the power electronics.

[6] Source: Bosch, 2015

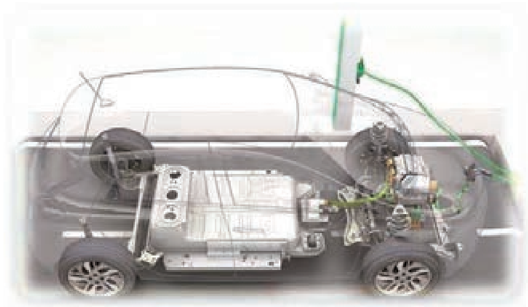

Figure 1: Battery module of Renault ZOE (image courtesy of Renault Austria[7])

6.4.3 Improvements by Thermal and Battery Management

Thermal and battery management is playing one of the most important roles, as it can increase the range and efficiency through optimized system configurations. Knowing the precise thermal interaction of components is necessary for an optimal design as it influences fatigue, energy consumption, noise, emissions, etc.

Workshops of this Task pointed out that:

- Driving at higher speeds, but also aggressive driving will increase the energy consumption in an EV
- Cold start energy consumption is larger than the hot start energy consumption
- The largest energy consumption increase for an EV occurs at -7°C (20°F) and for a conventional one at 35°C (95°F) (compare Figure 2)
- A conventional vehicle has the largest absolute energy consumption penalty on a cold start
- Generally increased speeds and accelerations translate to higher energy consumption except for the conventional due to low efficiency in the city

[7] Renault Austria, Available online at: www.renault.at accessed 11 November, 2015

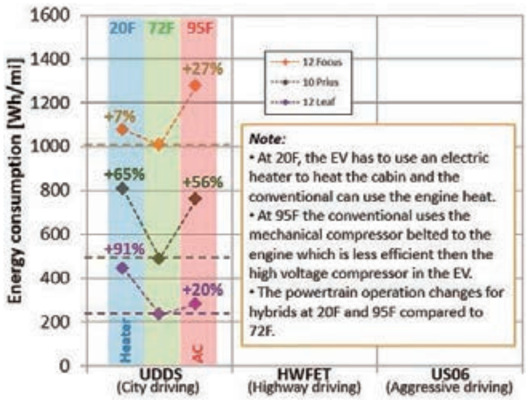

Figure 2: Largest energy consumption increase for an EV occurs at -7°C (20°F) and for a conventional at 35°C (95°F) (image courtesy of ANL[8])

6.4.4 Simulation and Virtual Vehicles

With the introduction of xEVs, the number of components that can populate a vehicle has increased considerably, and more components translate into more possible drive train configurations. In addition, building hardware is expensive. Traditional design paradigms in the automotive industry often delay control-system design until late in the process – in some cases requiring several costly hardware iterations. To reduce costs and improve time to market, it is imperative that greater emphasis has to be placed on modeling and simulation (see Figure 3). This only becomes truer as time goes on, because of the increasing complexity of vehicles and the greater number of vehicle configurations. Thus, the necessary expertise to perform the required sophisticated simulations and calculations becomes more and more complex. Especially predicted future driving information like route based energy management, supported by a mixture between deterministic and stochastic information, will play a key role as they can help to optimize the energy consumption. Task 17 pointed out, that the demand for companies, focusing on simulation tools for EVs, is still increasing. These companies and R&D institutes will play an important role in the future.

[8] ANL. Task 17 workshop, Chicago, United States. 2013

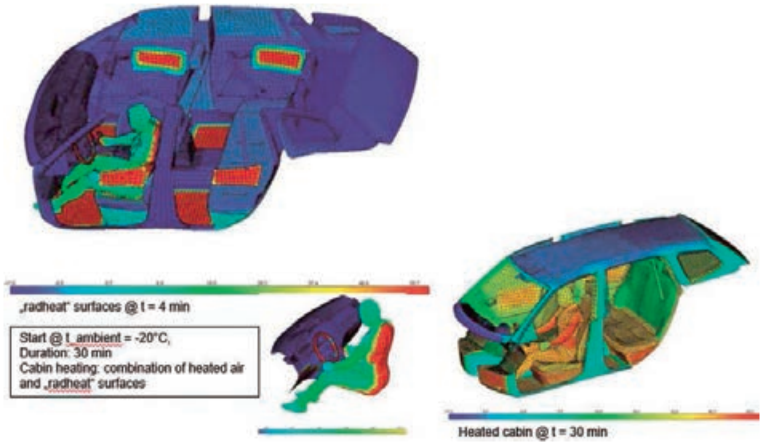

Figure 3: Simulation of the heatable surfaces in an EV (image courtesy of qPunkt[9])

6.4.5 Optimization Trough Lightweight

Vehicle weight and size reduction is one known strategy to improve fuel economy in vehicles, and presents an opportunity to reduce fuel use from the transportation sector. By reducing the mass of the vehicle, the inertial forces that the engine has to overcome when accelerating are less, and the work or energy required to move the vehicle is thus lowered. A general rule of thumb is that for every 10 % reduction in vehicle weight, the fuel consumption of vehicles is reduced by 5-7 %. Vehicle weight reduction can be effective, but is a challenging way to achieve significantly greater fuel economy gains. Especially light weighting the vehicle has a massive impact on the driving range (depending on the driving type cycle).

The light weighting benefits on fuel/energy consumption depends on the driving type.

- In city type driving and aggressive type driving with many and/or larger accelerations, light weighting any vehicle type will reduce the energy/fuel consumption.
- In highway type driving where a vehicle will cruise at relative steady speed light weighting vehicles does not significantly reduce the energy/fuel consumption.
- Light weighting a conventional vehicle will provide the largest improvement in fuel consumption due to the relative lower powertrain efficiency compared to a BEV.

[9] qPunkt. IEA-IA-HEV Task 17 workshop, Chicago, U.S. 2013

Functional integration will play a major role in future vehicles in order to reduce the amount of total parts being used in a vehicle. Functional integration (e.g. CFRP wheel with integrated hub motor (see Figure 4) doesn't only have an impact on reducing weight, it can also help to improve the driving abilities and can lead to a fundamental technology turnaround.

Figure 4: Different solutions for functional integration in terms of lightweight (image courtesy of Groschopp and Fraunhofer[10])

Especially the use of bionic concepts can help to reduce the amount of materials needed. Bionic design can reduce development time, minimize development costs, identify new light weight solutions and help to find efficient concepts in product development. Also the use of new materials as carbon or sandwich materials (combination of different materials in order to improve the total abilities) contributes to light weighting the car. But it should be kept in mind to have a look at the life cycle assessment too. For example carbon has two main advantages: its low weight and its strength. But the increasing use of carbon in xEVs (e.g. BMW i3) requires the need for new recycling processes. Comparing HSS vs. aluminum in lightweight vehicles: HSS is less costly, and has lower production energy demands. However, aluminum remains competitive in select applications.

Future new vehicles are still expected to become steadily lighter, as automakers seek all means to achieve higher fuel economy. Further, the new fuel economy standards for 2016 on will require rapid rates of new and improved vehicle technology deployment. More fuel efficient vehicles, like those with more sophisticated propulsion systems, tend to require more energy during their material processing and production phase. The material production energy demand for a current conventional gasoline car is 5 % of its life-cycle energy impact. The energy expended over its long use-phase in form of fuel use dominates its life-cycle impact at 76 %.

[10] Fraunhofer; Groschopp. IEA-IA-HEV Task 17 workshop, Schaffhausen, Switzerland. 2014

Vehicle light weighting and vehicle downsizing, coupled with efficiency gains in material processing over time can greatly reduce the production energy footprint of new vehicles.

6.4.6 Power Electronics and Drive Train Technologies Require New Software Concepts

The increasing demand for autonomous driving results in an increasing amount of software and electronics within the vehicles. Especially in terms of xEVs the amount of embedded systems and software within the powertrain is rapidly growing. This leads to a fundamental technology turnaround which requires adapted software solutions. Thus, the systems are becoming very complex, which results in required embedded systems and E/E-Architecture in order to process all the data and sources. Power Electronics and adaptive drive train technologies are thus playing an important role and will have a massive impact in the future.
In today’s conventional vehicles, the proportion of electrical, electronic and IT components is between 20 and 35 %. In xEVs, this share will increase to >70 % – including around 70 main control units with more than 13,000 electronic devices.

In the future, every second euro/dollar is spent on the production for electronics. Currently, the share of electronic components to the manufacturing cost is around 30 %, by 2017 it will grow to 35 % and will still increase to 50 % in 2030.

Task 17 pointed out, that today’s manufacturers are focusing very intensely on that field of thematic which indicates the importance on that topic (see Figure 5). Modular drive train topologies could increase the chances for a market breakthrough of xEVs by providing a better opportunity for high production volumes. Future generations of xEVs require a layered, flexible and scalable architecture addressing different system aspects such as uniform communication, scalable/flexible modules as well as hardware and software.

Further, this Task demonstrated that the automotive industry is dealing with two major trends: the electrification of the drivetrain and autonomous driving.

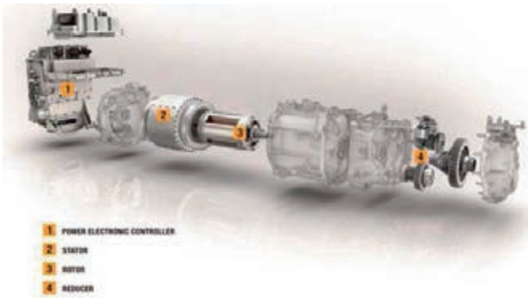

Figure 5: Renault improved the performance of their EV 'ZOE by improvement of the power electronic and electrical architecture[11]

6.4.7 Change Within the Automotive Value Chain

The trend towards e-mobility leads to massive changes along the automotive sector's entire value chain. The new vehicles require a number of technically innovative components and systems to operate. This will impact key parts of the component and vehicle creation value chain, from R&D in specific components like batteries, all the way to integrating and assembling vehicles, down to new fields in the mobility value chain such as new infrastructure and new business models.

While the ICE was almost the component with the highest value within the value chain), the introduction of xEVs are changing the hierarchy. Due to the fact that components like ICE, clutch, exhaust system, etc. won't be needed in xEVs any more, new and additional components as power electronics, e-motor, software will be necessary.

It can be foreseen that the power electronic unit and the e-motor will be on the top of the hierarchy and thus will replace the ICE. This key message has to be transferred to policy makers and representatives of industry in order to aware them of the upcoming change in value chain as well as guarantee qualification and education in that kind of business fields.

[11] Renault Austria, Available online at: www.renault.at accessed 3 May, 2015

6.4.8 The Need to Change

The demand for xEVs is still at a low level and far behind expectations (except in a few countries like Norway). However, in order to reach the various global consumption requirements, further hybridization and thus electrification is inevitable. For conventional cars there is still potential for optimization like through downsizing, use of alternative fuels, etc. Experts from Bosch Engineering are of the opinion that for conventional cars there are still further fuel savings possible (diesel: 10 % and for petrol up to 20 %[12]). However, (partial) electrification is indispensable.

It is predictable that due global trends like interconnectivity, autonomous driving, limited resources and global consumption requirements, the electrified drive train – xEVs – will sooner or later dominate.

6.5 Next Steps

Task 17 was successfully closed in May 2015.

The Task 17 workshop "Power Electronics and Drive Train Technologies" in Berlin 2015 highlighted, that there are still a lot of topics needed to be analyzed.

Thus it was recommended to start a new technological orientated Task, focusing on the benefits of connected and automated EVs.

As a first result, a new Task "Electric, connected and automated vehicles" (Task 29) was initiated in May 2015.

6.6 Contact Details of the Operating Agent

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

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[12] Source: CEA, 2014

7 Life Cycle Assessment of Electric Vehicles (Task 19)

Members: Austria, Germany, Switzerland, United States

7.1 Introduction

Electric vehicles have the potential to substitute for conventional vehicles to contribute to the sustainable development of the transportation sector worldwide, e.g. reduction of greenhouse gas and particle emissions. There is international consensus that the improvement of the sustainability of electric vehicles can be analysed on the basis of life cycle assessment (LCA) including the production, operation and the end of life treatment of the vehicles.

7.2 Objectives

The main goals of this Task were:

- Provide policy and decision makers with FACTS on environmental issues of EVs
- 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 was a networking activity, which means that the experiences from the national projects were fed into the LCA platform and discussed on an international level. The main topics addressed were:

- LCA methodology, e.g. system boundaries, and co-products handling
- frequently asked questions
- overview of international LCA studies
- parameters influencing the environmental performance of electric vehicles
- LCA aspects of battery and electric vehicle production
- end of vehicle life management
- LCA aspects of electricity production, distribution and battery charging
- R&D demand

The activities in Task 19 focused 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 most important networking activity in this LCA platform was the organization of the five workshops in different member countries. – the aim was 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.

These 5 workshops were:

1. The 1st workshop was held on 7 December 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" (see www.elcar-project.eu).
2. The 2nd workshop on "LCA of Vehicle and Battery Production" took place in Chicago, Illinois, United States, on 26 April 2013.
3. The 3rd Task 19 expert workshop on "Recovery of Critical Metals from Vehicles with an Electric Drivetrain" was held in Davos, Switzerland on 9-10 October 2013. The workshop was co-located with the World Resources Forum 2013 (WRF 2013).
4. The 4th workshop "LCA Aspects of Electricity Production, Distribution and Charging Infrastructure for Electric Vehicles" took place in Barcelona, Spain on 15-16 October 2014.
5. The 5th workshop "LCA of Electric Vehicles – Current Status and Future Perspectives" took place in Vienna, Austria on 11 November 2015 and was co-located with the A3PS Conference "Eco-Mobility 2025plus" (www.a3ps.at).

7.4 Overview of Results

Based on the LCA activities in the 18 member countries the Task 19 estimated the LCA based environmental effects of the worldwide electric vehicle fleet in 2014 in 33 countries. In a LCA of these vehicles using the different national framework conditions the environmental effects are estimated by assessing the possible ranges of environmental effects. Based on the emission inventory of CO_2, CH_4, N_2O, CO, NMVOC, SO_2, NO_x, and PM the potential effects on greenhouse effect, acidification, ozone formation, and particles are estimated. The reference case is the substitution of modern conventional ICE vehicles (of which 50 % are gasoline and 50 % diesel). The environmental effects of the electricity for the EVs are estimated on the current national electricity production in the 33 considered countries including grid transmission and distribution, and vehicle charging infrastructure. Additionally, for some selected countries, a scenario with all additional installed renewable electricity from PV and wind is dedicated for use by the EVs.

The details (e.g. data, assumption, methodology) of the following results were published in two conference papers:

1. 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 2014 – 5th Conference Transport Solutions – From Research to Deployment, Paris 14 - 17 April 2014.
2. Jungmeier G., Dunn J., Elgowainy A., Ehrenberger S., Widmer R. (2015): *Estimated Environmental Effects of the Worldwide Electric Vehicle Fleet – A Life Cycle Assessment in Task 19 of the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV)*, Conference Proceedings, EEVC 2015 – European Battery, Hybrid and Fuel Cell Electric Vehicle Congress, Brussels, Belgium, 2 - 4 December 2015.

7.4.1 Methodology

Based on LCA activities in the member countries Task 19 identified the key issues that apply to LCA of EVs & PHEVs in various international case studies and applied it to the EV fleet worldwide. The system boundaries chosen are shown in Figure 1. The following key issues for applying LCA methodology to vehicles with electric drivetrains were identified:

- General issues, e.g. goal and scope, state of technology
- Life cycle modelling approach
- Vehicle Cycle (production – use – end of life)
- Fuel Cycle (electricity production)
- Inventory analysis
- Impact assessment
- Reference system for comparison

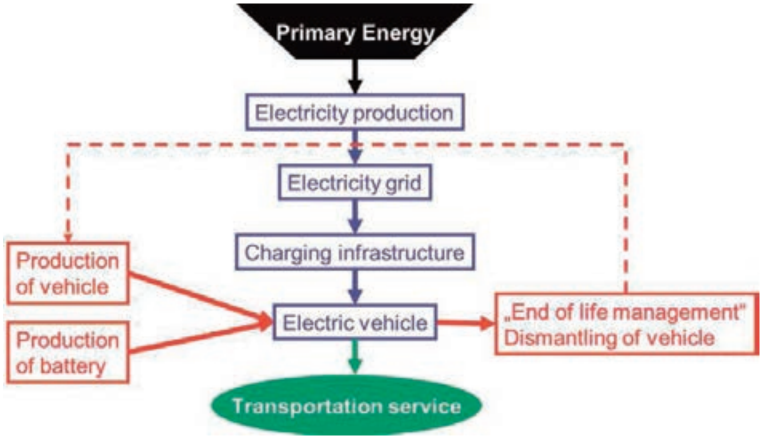

Figure 1: System boundaries

7.4.2 General Issues

In the goal and scope definition of the LCA, it is essential to describe the state of technology of vehicles and batteries including the assumptions for future developments. Here the substitution of new conventional vehicles is assumed, which are released on the market in 2014. In addition, possible rebound effects of substituting conventional vehicles with electric vehicles, e.g. which might result in driving environmentally-friendly vehicles more often, should be discussed or considered, because it is not certain if one kilometer driven by an electric vehicles actually substitutes for one kilometer driven by a conventional vehicle; it can be different, or even another transportation mode, e.g., a bicycle might be the substitution. There is a Norwegian study, that indicates that most users have an equal mileage as before, but about 20 % drive more after they bought an EV. Here it is assumed that the substitution rate is 0.95, reflecting that some additional kilometers driven by EVs do not substitute 100% for the kilometers driven by modern conventional ICEs.

As the key parameters influencing the environmental effects of vehicles with electric drivetrains are the electricity demand per distance travelled and the mix of technology for electricity generation, a sensitivity analysis on these two aspects is recommended. Here the current national electricity production in the considered countries is analysed and the electricity consumption by EV for real world driving cycle (i.e., considering effects of actual on-road driving such as accelerations and heating/cooling, incl. charging losses) is assumed to be in the range of 15-30 kWh/100 km reflecting different vehicle sizes and real life usage.

7.4.3 Life Cycle Modeling

The modeling of the life cycle of fuel and vehicle use is the basis for the assessment of the environmental effects of electric vehicles compared to conventional vehicles. The main issue to be addressed is the choice of an average or marginal approach for assessing the impact of electricity generation on the LCA of EVs. Also, the co-product handling method can influence the LCA results. According to ISO 14040, one preferred way of dealing with co-products is avoiding allocation of energy and emissions burden among all products, but in many cases this is not practicable. For example, heat and electricity from CHP plants and the fate of various components recovered at the end of life can better be handled with different allocation methods, e.g. based on energy, mass, market value or exergy content, or by substitution of (displaced) conventional products. Here for CHP plants the emissions are allocated based on the energy content of the heat and electricity produced.

As the modeling of battery production has a strong influence on the overall results, the following aspects must be documented in detail:

- The influence of battery production in LCA of EVs, including the main environmental impacts and how they might be reduced in a future mass production of automotive batteries
- The (expected/assumed) 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 an efficient recycling of battery materials might significantly reduce environmental impacts of battery production

7.4.4 Vehicle Cycle

The vehicle cycle includes the production, use and end of life of the vehicle components, including its battery. It is generally recognised that the production of electric vehicles has a higher environmental impact compared to the production of conventional vehicles although varying estimates of the energy intensity of battery production create some disparity in estimates of electric vehicle production impacts. The estimates vary because of different approximations of the energy required to assemble the battery from its constituent parts with process-level analyses generally predicting lower energy intensity than top-down studies. Therefore, the details of the battery production and its key technical data (e.g. life time of battery, energy content) must be carefully described in all LCA studies handling this component. For the materials used to produce the vehicle, the main assumptions and data (e.g., types and share of materials, electricity production mix for material production) must also be described in detail. Here it is assumed that the battery capacity of the BEV is in the range of 10-30 kWh, and for PHEV 4-15 kWh, with a vehicle life time of 10 years and annual travel distance of 14,000 km. The “electric driven” annual kilometers with the PHEV is assumed to be 9,000 km.

One of the most influencing factors in the LCA of vehicles is the energy consumption in the operation phase. In particular for vehicles with electric drivetrains, the impact of all auxiliary energy usage for heating and cooling must be incorporated properly.

In Figure 2, an example of the contribution and range of electricity consumption in a battery electric vehicle by activity is shown in ratio “bad” / “good”; e.g., the impact of charging loss ratio of 2-3 means that the highest observed charging losses can be 2 to 3 times higher than the lowest charging losses, whereas in the graph the average absolute charging losses are estimated.

Also the driving behavior (e.g. urban vs. highway driving) is quite relevant for the vehicle’s energy consumption. For plug in hybrid electric vehicles (PHEVs) the share of driving distance on the battery must be specified. The “electricity generated on board” versus “electricity generated off-board” must be carefully distinguished. For battery electric vehicles (BEVs) the possible driving range must be evaluated in real life conditions (see above, including heating and cooling demand). As the driving range of electric vehicles on a single charge is significantly lower compared to conventional diesel or gasoline vehicles, all details for the assumption of the daily, monthly and yearly driving distances must be described in LCA studies.

The end of life management of an electric vehicle can also influence the overall environmental effects significantly. Therefore the details of the dismantling phase must be given, including aspects of material and energy recovery, (e.g. recycling for production “close loop”, which mean that the recycled material is used again in the production of the new material within the system boundaries).

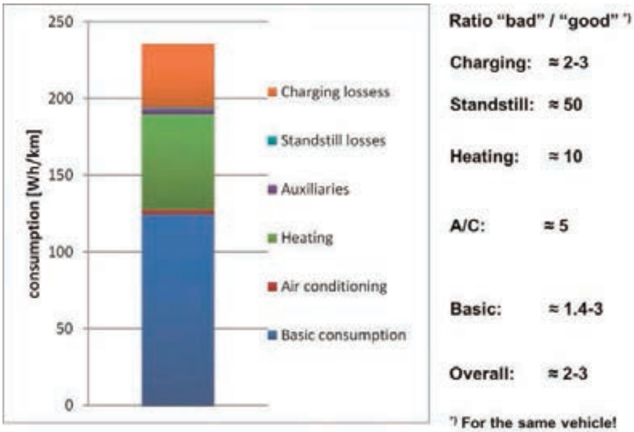

Figure 2: Possible contribution and range of electricity consumption in a battery electric vehicle

7.4.5 Fuel Cycle

The fuel cycle includes the electricity production with the supply of the fuel to power plants, the electricity distribution network and the charging station. The main issue to be addressed is the choice of the electricity generation technology and mixes, e.g. analyzing the time dependent electricity generation mix of a country: choice of the annual average electricity production or mix, or the additionally (marginal) produced electricity for meeting the electric vehicles load. In cases where significant amounts of electricity are stored, e.g. in hydro power pumping plants, the electricity mix of consumption might be more relevant for LCA than the production mix. If fluctuating renewable electricity from wind or solar power is used, the key question is whether the renewable electricity ends up in the battery of the electric vehicle or if other effects are initiated in the grid. In the best case, the production of the renewable electricity needs to be harmonised with the charging of the electric vehicle. In most of the cases, the use of only (fluctuating) renewable electricity or in some specific cases electricity from variable hydro power (not pumped storage) must be combined with an adequate electricity storage system (including storage losses). Otherwise, a realistic share of (fluctuating) renewable electricity from wind and solar along with thermal power generation from biomass or fossil fuels must be considered. Furthermore, it must be ensured that the renewable electricity for the EVs is additional to what would have been produced without the electric vehicles load, as shifting the use of the currently generated renewable electricity from a stationary application to the mobile application (i.e., for EV recharging) brings no additional environmental effects.

Summarizing, it has to be born in mind that the consideration of renewable electricity for the charging of electric vehicles is justified only if this renewable energy is specifically and additionally generated for this purpose.

The four main options of connecting renewable electricity with the loading of the 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, which is not 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.

In this analysis it is assumed that 20 % of the renewable electricity from PV is stored in a stationary battery, and 10 % from wind until an EV is charged. The grid and charger losses are estimated at 5 %.

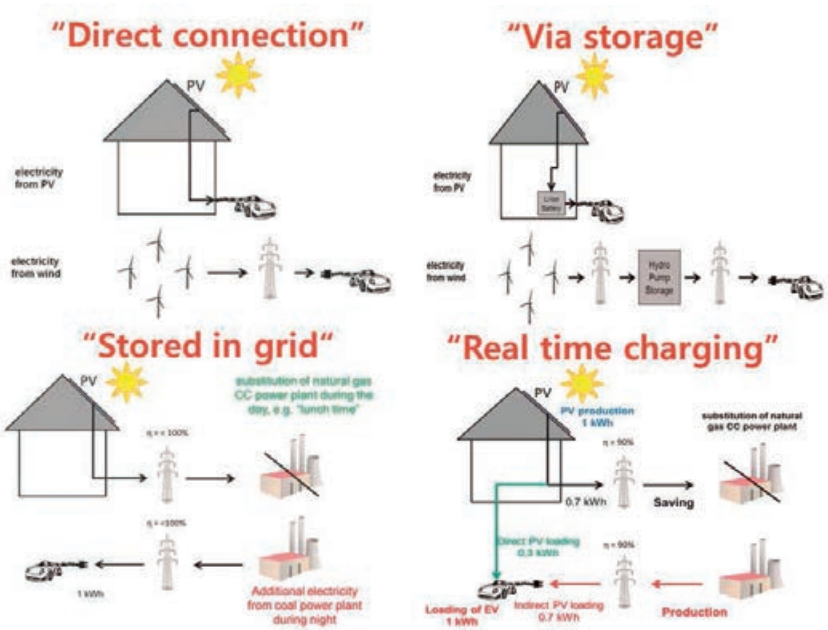

Figure 3: The four options of connecting renewable electricity with the loading of electric vehicles

7.4.6 Inventory Analysis

The basic data for the inventory analysis must be documented with special attention given to the battery production, the vehicle production, the energy consumption of the vehicle in the operation phase, the electricity production, the charging of the vehicle, and the "end of life " treatment of the vehicle with its battery. In general the (assumed) state of technology or its possible future development must be described. The uncertainty range of all data must be indicated properly and discussed in sensitivity analyses. Here new models released mainly between 2010 and 2014 of BEV, PHEV, and ICE are analysed, and the emissions of CO_2, CH_4, N_2O, NO_x, SO_2, NMVOC, CO, and PM are considered in the inventory analysis.

7.4.7 Impact Assessment

The impact assessment might include a wide range of possible environmental effects, but due to limited data availability, most LCA activities concentrate mainly on the greenhouse gas emissions (GHG) and energy resource depletion, e.g., the cumulated primary energy demand. As a minimum requirement, the cumulative primary energy demand must specify the contributing share of fossil, renewable and other energy carriers. In some LCA studies, the material resource depletion, e.g., cumulated material demand and the shares of different materials are calculated, e.g., metallic raw materials and biogenic materials. Also some other impact categories caused by gaseous emissions (e.g., CO, SO_x, NO_x, PM) which impact acidification and ozone formation, are assessed.

Generally it is observed that the mid-point impact assessment is often done for GHG emissions and primary energy consumption with high certainty and robustness. But for the “end point damage assessment” and “single scoring methods”, external costs are still under discussion and/or development due to their high methodological complexity and the lack and uncertainty of data for these impacts. It is recognised that the methodological choices (e.g. modelling approach, system boundaries, determination of relevant electricity generation, etc.) add more uncertainty to mid-point impact assessment results compared to the uncertainties in endpoint modelling. This means that the characterization factors (CF), e.g., toxicity midpoints, are as uncertain as CF for human health damage (i.e. end point).

The following 4 impacts are considered in the assessment:

- Global warming potential (CO_2, CH_4, N_2O)
- Acidification potential (NO_x, SO_2)
- Ozone formation potential (CH_4, NMVOC, NO_x, CO)
- Particulate matters (PM)

7.4.8 Reference System

Generally the reference system, which serves as the baseline for comparison, is directly linked to and dependent upon the goal and scope of the LCA. In most cases, the reference systems for electric vehicles are mainly gasoline and/or diesel ICE vehicles with their current and future technologies. As transportation biofuels become a reality on the fuel market in more countries, e.g., 7 vol-% blending of biodiesel in diesel in Austria, the aspects of biofuels should be integrated in the reference system more often in the future. In some countries, natural gas vehicles (including their new infrastructure) might be part of the reference systems. As described already in section 3.3, when the environmental effects of electric vehicles might be maximized by using renewable electricity, the additional renewable electricity must be generated and not be taken away from base load electricity demand. In such cases, environmental effects associated with this additional renewable electricity production, e.g., building a dam for a hydro power plant, must then be considered for the electric vehicles evaluation.

The fuel demand of conventional new ICE vehicle using 50 % gasoline and 50 % diesel is assumed in the range of 51-63 kWh/100 km. These new average ICE vehicles were sold on the market in 2014.

7.4.9 Database and Results

The main data used is the amount of 700,000 electric vehicles in 33 countries worldwide in 2014, where only Battery Electric Vehicles (BEV) and Plug-in Hybrid Electric Vehicles (PHEV) are considered (Figure 4).

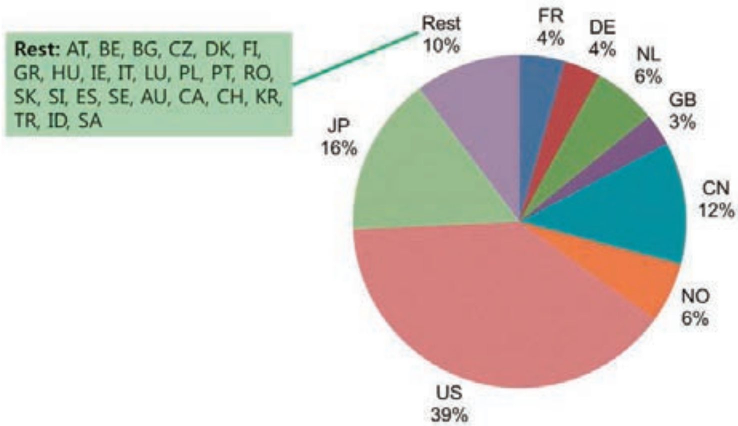

Figure 4: Vehicle Fleet Worldwide 2014

The data for the production and dismantling of the vehicles are based on an Austrian study adopted with results from various case studies in IEA HEV Task 19. The data for the current national electricity production for the considered countries is based on ecoinvent and shown in Figure 5 (GHG-Emissions and PM-Emissions) and Figure 6 (NO_x-, SO_2-, CH_4-, NMVOC-, NO_x- and CO-Emissions). These Figures show that the emissions from electricity production are very different, generally the higher the share of renewable and nuclear electricity, the lower are the considered emissions to air.

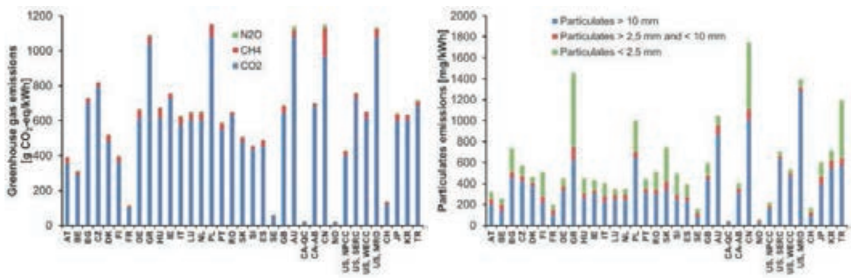

Figure 5: Estimated GHG-Emissions and PM-Emissions of electric production in the various countries

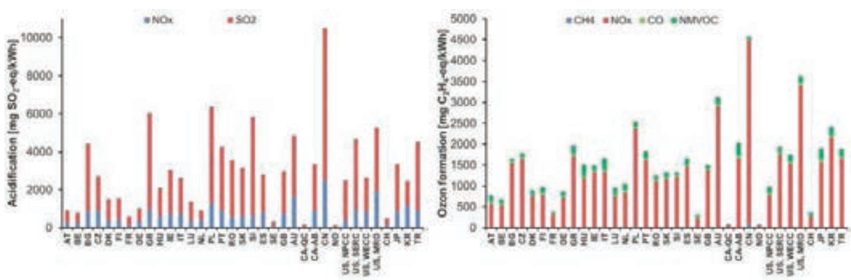

Figure 6: Estimated NO_x-, SO_2-, CH_4-, NMVOC-, NO_x-, and CO-Emissions of electric production in the various countries

The data for the renewable electricity production in selected countries (AT, AUS, FIN, DE) is based on ecoinvent and shown in Figure 7 (GHG- and PM-Emissions) and Figure 8 (NO_x-, SO_2-, CH_4-, NMVOC-, NO_x-, and CO-Emissions). These emissions from renewable electricity mainly derive from the construction and dismantling phases of the power plants, and only a very small part from the operation phase caused by replacement parts.

Compared to the emissions shown above for the current national electricity production the emissions from renewable electricity are significantly lower, but PV is the highest of the renewable energies due to the relative energy intensive production processes.

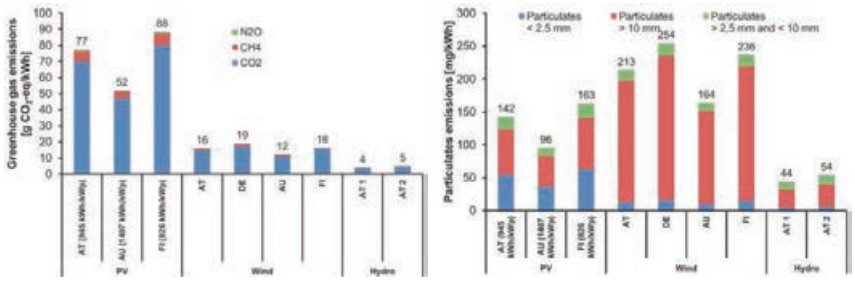

Figure 7: Estimated GHG- and PM-Emissions of renewable electricity production in selected countries

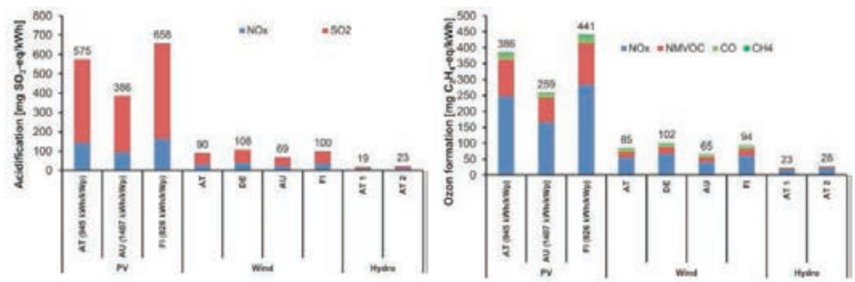

Figure 8: Estimated NO_x-, SO_2-, CH_4-, NMVOC-, NO_x-, and CO-Emissions of renewable electricity production in selected countries

The results of the assessment are shown below, whereas the shown ranges of the estimation are due to variation in:

- Emissions of national electricity production
- Electricity consumption by EVs
- Fuel consumption of substituted conventional ICEs
- Emissions and energy consumption of real world driving cycles
- Data availability, uncertainty and consistency, e.g., PM emissions

The results of the environmental effects of EVs compared to conventional ICEs are shown in Figure 9 (GHG- and PM-Emissions) and Figure 10 (NO_x-, SO_2-, CH_4-, NMVOC-, NO_x-, and CO-Emissions).

Generally it can be observed that the share of fossil produced electricity has a substantial influence on the emissions. In countries with a relative high share of renewable or/and nuclear electricity, the estimated emission reduction is significant (e.g., NO, FR, AT) whereas in countries with a relative high share of fossil electricity, an increase of emissions occur (e.g., PL, CH).

The range of uncertainty in relation to the electricity demand of the EVs is relatively high in countries with a high share of electricity from fossil fuels.

Summing up the 700,000 EVs and PHEV in the considered countries, an average emission reduction is estimated, except for acidification potential where an increase is estimated.

The estimation of the average environmental effects of BEVs and PHEVs substituting diesel/gasoline show

- GHG-reduction: - 20 %
- PM < 10 reduction: - 60 %
- Acidification increase: + 40 %
- Ozone reduction: - 30 %

but the possible range is significant, e.g. GHG emissions from reduction to increase.

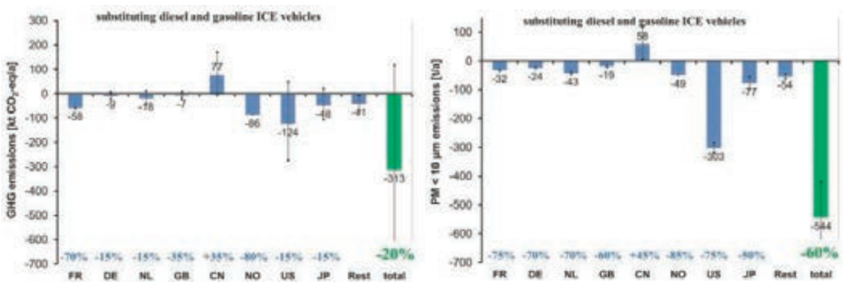

Figure 9: Estimated GHG- and PM-Emissions of Electric Vehicles Worldwide (2014)

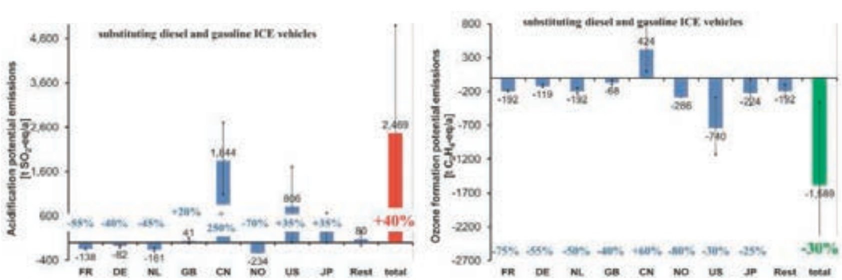

Figure 10: Estimated NO_x -, SO_2-, CH_4-, NMVOC-, NO_x-, and CO-Emissions of Electric Vehicles Worldwide (2014)

In Figure 11, a pure renewable electricity production for EVs is considered, showing that all emission are significantly lower compared to conventional ICE vehicles.

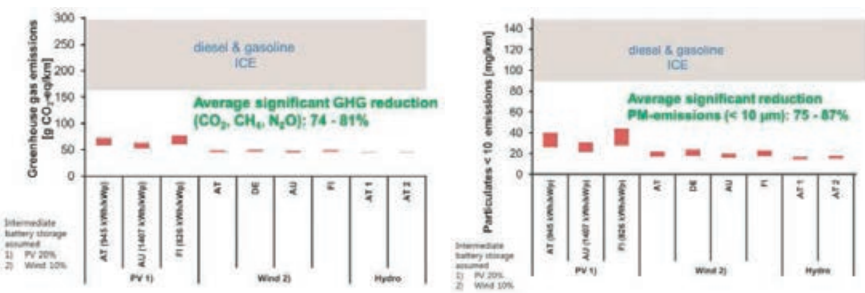

Figure 11: GHG- and PM (< 10 µm)-Emissions of Electric Vehicles - Renewable Electricity

7.5 Conclusions

The main conclusions are:

1. Environmental Assessment of EVs has been conducted based on Life Cycle Assessment compared to conventional vehicles.
2. About 700,000 EVs worldwide are on the road (end of 2014): main countries are US, JP, CN, F, DE, NO.
3. Estimation of average environmental effects substituting diesel/gasoline shows
   - GHG-reduction: - 20 %
   - PM < 10 reduction: - 60 %
   - Acidification increase: + 40 %
   - Ozone reduction: - 30 %
4. Broad estimated ranges are mainly due to variation in:
   - Emissions of national electricity production
   - Electricity consumption of EVs at charging point
   - Fuel consumption of substituted conventional ICEs
   - Data availability, uncertainty and consistency, e.g., PM
5. Additional renewable electricity with adequate charging maximizes environmental benefits.
6. Loading strategies are essential for further significant reductions.

The results show that the environmental effects depend on the national framework condition, e.g., national electricity generation. In most of the countries, a significant reduction of these LCA based emissions of up to 90 % is reached. So there is scientific evidence that under appropriate framework conditions, electric vehicles can substantially contribute to a sustainable transportation sector in the future.

7.6 Next Steps

The Task 19 was finished in 2015 and the cooperation is continued in a new Task 30 “Assessment of Environmental Effects of Electric Vehicles“ (2016-2019).

7.7 Contact Details of the Operating Agent

For further information, please contact the Task 30 Operating Agent:

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8 Quick Charging Technology (Task 20)

Members: Germany, Ireland, Spain, United States

8.1 Introduction

The IEA IA-HEV Task 20 on "Quick Charging Technologies" for plug-in electric vehicles (PEV) was approved on 11 November 2011, at the 35th IA-HEV Executive Committee meeting in Lisbon, Portugal, and run until May 2015. Its main goal was to promote solutions and improvements in order to enable a broad penetration of these technologies.

Specific topics addressed during the lifetime of the task were:

- Quick charging (QC) technology development trends worldwide
- Outcomes from the latest quick charging pilot projects and the issues to be resolved
- Lessons learned from past charging network deployment plans
- Impact of quick charging on PEV battery ageing and behaviour
- Different charging infrastructure options (e.g., specific charging stations that can charge one or many cars in private or public locations)
- Relationship between the energy efficiency and the charge power of the charging station
- Trade-offs between the shortest time to a full charge and the charger cost
- The need for quick chargers and public charging stations to counter range anxiety
- Quick charging solutions that will help to popularize EVs
- Issues in the relationship (technical and socioeconomic) between the PEV and the grid, including power quality, tariffs, regulations, incentives, etc.
- To analyse and propose the best technical solutions for interoperability and the optimum use of the electric infrastructure already in place
- How emerging technologies (smart grids and EVs) can join efforts to accelerate their market penetration
- The requirements and issues of quick charging technology for future smart grid promotion
- Designing and ensuring convenient, safe, and secure handling for consumers,
- Future technology roadmap to help promote vehicle electrification

8.2 Objectives

The specific objectives of Task 20 were:

- Report on the current status of quick charging technology
- Discuss objectively how quick charging technology can contribute to the deployment of electric vehicles
- Share knowledge on quick charging technology deployment developments and trends
- Get consensus and provide joint conclusions to the stakeholders related to the standardization process
- Provide recommendations for setting up a roadmap for quick charging technology development and implementation

8.3 Working Method

Task 20 based 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), the Task organized 3 thematic meetings in Japan, Spain, and France.

Task 20 held its second technical exchange workshop across three cities in Japan on 3-5 June 2013. The goal was to discuss the progress in the development and deployment of DC quick charging technology in Japan, Europe, and the United States (U.S.). Japan's Ministry of Economy, Trade and Industry (METI) helped to organize the meeting. The Japanese government has supported the installation of more than 1,700 QC stations throughout the country.

A total of 39 experts from the U.S., Germany, China, Spain, and Japan participated in the June meetings, representing automotive original equipment manufacturers (OEMs), charging equipment providers, research centres, utilities, and government.

Later in 2013, and again in conjunction with the EVS27, a specific workshop with special focus on interoperability as a trigger for a larger deployment of QC was organized in Barcelona (Spain). More than 30 participants from 6 countries were present representing different entities with key roles in the whole interoperability chain from public and private sides.

The last meeting of the Task was organised together with Task 10 on Electrochemistry in the framework of the International Batteries 2014 congress in Nice on 22-23 September 2014. The workshop focused on the effects of the quick charging on batteries in PEV. The meeting was attended by a number of internationally acclaimed research groups, public authorities, vehicles manufacturers and battery manufacturers.

On the other hand, IA-HEV Task 20, Quick Charging (QC) Technology, posted an online questionnaire to solicit input from the PEV community on the status and future applications of QC technology. The survey covered potential business models for DC QC as well as several issues along its value chain, including charger infrastructure, OEMs and interoperability, the impact of DC QC on the electricity grid, and the anticipated timeframe for developments in technology and regulatory frameworks.

The motivation for the survey was to identify issues that need to be addressed in order to facilitate a more widespread deployment of DC QC technology. Over 50 organizations from more than 10 different countries in Europe, Asia, and America have responded to the survey. These organizations cover all possible QC stakeholders: OEMs, charger providers, utilities, public administrations, academia, etc.

8.4 Results

The information shared by the main stakeholders of the QC technologies worldwide served as a basis of the final report of Task 20, the main deliverable of the Task. This public document, available in the IA-HEV website, described the State of the Art of the different QC technologies, the main challenges (technical, regulatory, market) these technologies faced, their potential and the main trends worldwide – with a special focus on a few case studies. The primary conclusions are summarized below.

CHAdeMO is the most widespread quick charging system in the world: as of May 2015, there were 5,737 CHAdeMO charging points installed all around the world, of which 3,087 in Japan, 1,661 in Europe, 934 in the USA, and 55 in other countries (basically Canada). The evolution of the number of charging stations in Japan and the rest of the world has been very positive, despite the appearance of another competitive and incompatible QC system (CCS) in 2013.

In parallel to CHAdeMO, several American and, particularly, European companies, such as Audi, BMW, Daimler, Ford, General Motors, Porsche, or Volkswagen, started developing a new system for quick charging: the Combined Charging System (CCS) or COMBO. The main goal behind this initiative, strongly supported by SAE and ACEA, was to develop a one “global envelope” that permits the recharging of the vehicle both in AC (slow/medium charging) and DC (quick charging) using two types of charger connectors and only one charging inlet in the vehicle.

This is an important difference with the CHAdeMO standard, since the latter has been only designed for DC quick charging and that is the only charging mode allowed by both the charger connector and the vehicle inlet. An electric vehicle designed to be charged using the CHAdeMO standard needs a separate and differentiated charging socket to be charged using modes 1 to 3 (AC), with the corresponding additional costs that this implies, although it has been a common practice among vehicle manufacturers. Furthermore, the rapid deployment of multi-system chargers in Europe, but also in North America, will change the framework of the competition among OEMs, removing the issue of connection standards and focusing it on vehicle models.

Furthermore, inductive charging is a relatively immature technology that will be ruled by the family of standards IEC/TS 61980, all of which are still under development and not expected to be published before August 2015 (Part 1: General Requirements). However, its important advantages (specially en-route inductive charging) compared to conductive charging have been translated in a big number of research projects and initiatives to further develop this technology.

In spirit of reducing the impact of the fast charging system in the energy grid, there has been an important work on developing advanced PE. Nowadays almost all the chargers available in the market comply with the limits of power quality establish in the standard (IEC 61000-3-12) when charging at nominal power. In any case, DC quick charging produces proportionally less quality distortion to the electrical grid than slow and medium AC charging.

One potential solution is the use of Energy Storage Systems, either using second-life batteries or not, has a wide support from the stakeholders as the most promising to decrease the impact of QC on the grid, along with remote management of the charger (still in an early stage of development).

On the other hand, demand control remains as a very relevant area as well as drivers behaviour to reduce the drawbacks of fast charging. However, modifying the EV driver behaviour is complicated and requires innovative communication and incentive programmes (rewards) to motivate positive behaviours. These strategies are not exclusively designed for reducing the impact of quick charging on the electrical grid, but they take into account all the possible charging options available for the EV drivers in the country or region.

As far as the battery is concerned, it is of vital importance including battery design within 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.

Under this dialogue that took place during the Task 20, as a main conclusion, it appears that there is no clear and unique business model solution. Several on-going projects and deployment activities are taking part across the globe with different approaches: some of them promoting the added value of using QC firstly among the costumers while in other demonstration cases, infrastructure and cars are at the front of the strategy plans. No matter how barriers (both technical and non-technical) are confronted, the full business plan will not be completed before investing and pushing the deployment forward. The model should be flexible and evaluated, adapted to prices and real needs in the hope of enlarging the network and customers. Moreover, a better understanding of the customer behaviour and needs is precisely the starting point to defining the business model, as highlighted by the vast majority of the stakeholders that participated in the survey, especially the private sector. Continuous interaction and support to existing and potential new customers through information programmes, remote assistance, etc. have also been identified as highly important. It is therefore encouraged to establish the system for grasping EV users behaviour/movement and profile of EV users to provide more convenient service in the initial stage after switching from free of charge to charge.

Concerning the key actors around fast charging, the relatively high number of actors involved in the battery recharging process of EV creates a very complex ecosystem, with many different interests and several potential business models depending on who the owner of the EVSE is. There are many possibilities: an independent private service provider, a public foundation, a DSO, private business such as restaurants, retailers, etc. all in all, should be supported by the strong involvement of public authorities in the first stages of the deployment of the quick chargers. According to stakeholders this is essential. Subsidies for the installation, maintenance and operation of the quick charging infrastructure are seen as the most important contribution by the public sector along with other incentives to be progressively decreased when the business model is in place.

Fast charging is moving forward, opening new directions towards more added-value services, among others, V2G. The future of V2G is still uncertain, regardless its potential and despite the fact that the technology is not an issue, but the knowledge about the economic, environmental and grid benefits is underdeveloped, inconsistent or not validate[13]. Indeed, most of the studies conducted on the matter are focused on technical aspects and, although researches have tried to assess the commercial potential of this technology, it is not clear yet how to capture this value, and several business models have been proposed. As highlighted in the business models section for quick charging, in the particular case

[13] California Independent System Operator

of V2G, preferences of the users must be the central point for deriving a business model.

In summary, stakeholders agree on the idea that there is not only one good solution and the adopted approach must be the result of a thorough analysis of the current situation, needs and opportunities in each country, taking into consideration several factors (demographics, cultural aspects, business cases for the different infrastructures, etc.). In addition, governments have a wide variety of options to support the deployment of the EV and they set up measures both in the supply and the demand side. Concerning the EVSE, the most common action is to support their installation through taxes exemptions, financial incentives, and, especially for quick chargers (due to their high cost), direct, partial, or full funding. This last option may include the purchase of the equipment and its installation. Concrete examples of national programmes on deploying EVSE, and particularly, quick chargers are provided within this section.

8.5 Contact Details of 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 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.

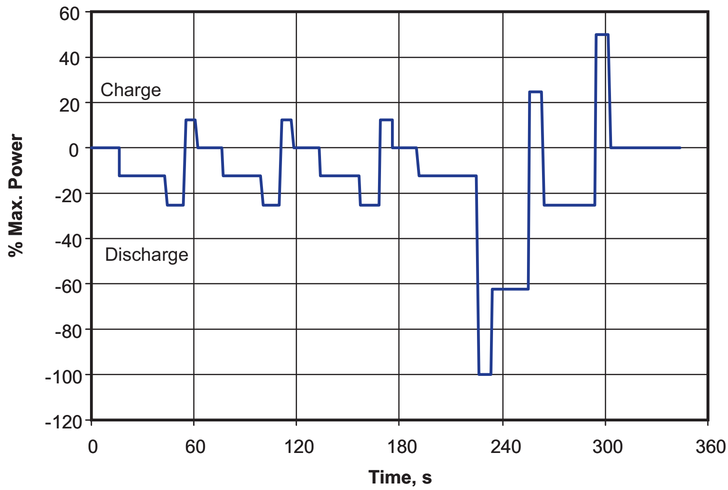

Figure 1: Dynamic stress test profile of the USABC test procedure

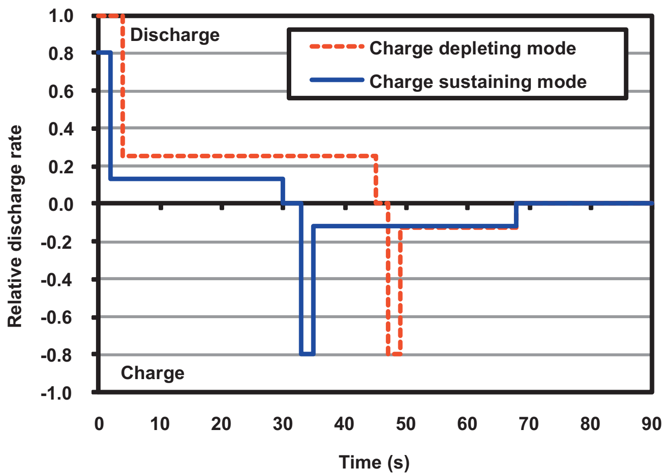

Figure 2: General CLT (Cycle Life Test) profile for PHEV battery developed at Japan Automobile Research Institute – JARI

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

Members: Belgium, Germany, Turkey, Spain

10.1 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 harmonised 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.

10.2 Objectives

10.2.1 Representing the Interests of Local Governments in Standardisation

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 were 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, KTM Motorcycle, Piaggio, BMW Motorcycle, Panasonic Cycle Tech, Shimano, 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 regard 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 German mirror group of the IEC/ISO/TC69/JPT61851-3 committee.

10.2.2 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 the Summer of 2016, 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. The first Version of the public tender blueprint should be presented by November 2016.

10.2.3 Creating Events for Information Exchange on LEV Infrastructure

- Organising events such as expert workshops and conferences, on the subject of LEV infrastructure as well as suitable vehicles.
- Involving governments, city planners, public transportation experts, operating companies, consumer organizations, standardization bodies as well as the vehicle and infrastructure industries.
- Activities have been organized until now at: Taipei (TW), Tianjin (CN), Cologne (DE), Kirchberg (AT), Antwerp (BE), Malbrok (PL), Istanbul (TK), Oslo (NO), Essen (DE), Tanna (DE), Grenoble (FR), Nantes (FR), Frankfurt (DE), Prague (CZ), Shanghai (CN), Chengdu (CN), Rostock (DE) just to name some of them.

10.2.4 Best Practice Sharing Study Trips

- Gathering of experts at locations where local governments have established successful LEV infrastructure systems.
- Sharing of findings and summarizing the positive and negative experiences – distilling the findings into easy-to-follow recommendations.
- In March 2015 an international group traveled around China for 8 Days.
- In June 2015 an international group traveled in Europe (DE, SE, & DK).

10.2.5 Publications with Recommendations on LEV Infrastructure

- Creating publications summarizing key findings and listing recommendations on how to establish the most suitable LEV infrastructure.
- Several lectures have been held during the course of 2015 on the subject of Task 23.

10.2.6 Promoting the Needs to Potential Suppliers

Making joint presentations at relevant trade shows and conferences, and, using suitable methods, explaining the requirements for local governments of potential manufacturers and providers of LEV infrastructure and rental vehicles.

10.3 Working Method

Members of Task 23 can participate in events such as best practice sharing study trips, exhibitions, and conferences. 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.

10.4 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 these are just the most significant. 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 2016.

10.5 Results

A central event for Task 23 was the joint booth within the framework of the G7 Traffic minister meeting held in conjunction to the Frankfurt Auto show IAA on 17 September 2015. The EU Commissioner for Transport Mrs. Violeta Bulc visited the IEA HEV Task 23 special Exhibition presented at IAA with a wide display. There Mrs. Bulc was introduced to the results of the EU Mandate 468 of 2010.

10.5.1 The Charge & Lock Solution for Urban Issues

The Gobike system is station-based, but can also offer free-floating service, and it should not have to pay back the investment in establishing the infrastructure alone. Between the years 2011 and 2013, the first functional version of the EnergyLock was trialled 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 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, in that all electronic components on the pedelec will deactivate themselves in the event of unauthorized disconnection. This would make removing a vehicle that has this safety strategy implemented very unattractive for a thief.

Figure 1: IEA HEV Task 23 Workshop organised for members of local governments during IAA in September 2015

Figure 2: Booth of IEA HEV Task 23 at the IAA conference demonstrating the best sharing pedelecs available on the world market

Figure 3: EU Commissioner of Transport Violeta Bulc visits the IEA HEV Task 23 presentation at Frankfurt International Automobile Exhibition on 17 September 2015

On 18 March 2015, the next generation of the charge & lock cable was presented to the public for the first time as a working model at the Taipei Cycle Show 2015 where 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 as well as transfer of the 12V auxiliary voltage is transferred to an induction-based system which is not sensitive to corrosion.

The female socket would be always 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 4: The Charge & Lock cable sample embedded in a bicycle saddle and its seat post. If not in use it is almost invisible and out of the way.

Figure 5: Different vehicles demonstrating the universal approach for the infrastructure. Such infrastructure would allow for interoperability between different suppliers and all kinds of vehicles.

10.6 Next Steps

Further acquisition of members, cities and regional governments 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.

10.7 Contact Details of the Operating Agent

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

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

11.1 Introduction

The IA-HEV Executive Committee (ExCo) unanimously approved this Task at the 39th Executive Committee meeting in November 2013, held in Barcelona. Task 24 started in 2014 and will run up to and including 2016.

Worldwide, policy makers are implementing supportive measures to facilitate the introduction or implementation of electric mobility in their region for many different 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?

11.2 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 impact it is necessary to have a good view on the local e-mobility sector. 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 on production volume, turnover, employment, export volume, innovations/patents, etc., and in which part of the value chain can we expect further growth? The answer is very region specific, because it depends on the specific activities and competencies of the local stakeholders (industry, research, etc.) and their ambition to become a market player in electric mobility. A SWOT analysis per region on product/service/market combinations can give a better insight in the local situation.

The objective of the task is to get a better view on the value chain of electric mobility in general and more specific on the economic potential in the local e-mobility sector in every participating country in Task 24. This will be done by performing a SWOT analysis and a baseline measurement of some important indicators like turnover/production volume, employment, export volume, innovations/patents, etc.

Important to take into account in this task is the fact that electric mobility is not about vehicles alone, but that it requires a whole “ecosystem” in which electric vehicles are integrated. Beside the vehicles, we need a charging infrastructure that is well integrated in the electricity network (smart grids, financing services, etc.). Electric vehicles can also be integrated in new mobility concepts that are more and more multi-modal and partly based on sharing concepts instead of owning the vehicle. In Belgium we call this “networked and shared mobility”. So we have value chains in different sectors: the mobility sector, the energy sector, and the vehicle sector itself. Also here, Task 24 will not only focus on electric passenger cars, but also on electric bicycles, scooters, trucks busses, and even boats, if that is important in a specific country (like the Netherlands), because every sector has its own economic opportunities.

11.3 Working Method

The working method in Task 24 will be based on task sharing without participation fee.

Task 24 will consist of 3 subtasks: first develop a common methodology for the economic impact assessment, then every country will start collecting data about the agreed indicators in its own country, and finally all results will be analysed and summarized in a final report.

Task 24 will use mainly mail communication and phone conferences to reduce travel costs. However, some meetings/workshops will be organised in conjunction with the ExCo meetings to discuss and present the work-in-progress more in detail.

11.4 Results

It is recognised that data collection and benchmarking of these data within such a complex market as electric mobility is very challenging. Many different organisations collect different types of data and not all indicators can be collected in the same level of detail to feed into the economic impact assessment.

Therefore, Task 24 started with setting up a common methodology as a first important step to set feasible targets and align expectations. During 2014 and 2015, the data collection process has been ongoing and in the beginning of 2016 the different country reports were finalized.

11.5 Next Steps

During 2016, the different country reports will be benchmarked and the final Task 24 end report will be prepared.

11.6 Contact Details of the Operating Agent

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12 Plug-in Electric Vehicles (Task 25)

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

12.1 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.

12.2 Objectives

The topics of the task include vehicle energy consumption, component costs, vehicle costs, total cost of ownership (TCO), and market penetration.
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 & 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, 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

12.3 Working Method

During the last year, comprehensive metrics for ownership cost have been developed to compare the economics of different drivetrain vehicles in different markets.

The Total Cost of Ownership (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 is 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 USD) or, as is done here, in cost per km. The RCO includes the investment cost, 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, maintenance and repair and any annual fees or taxes. Furthermore, a resale or residual value, 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, 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 limited range of the BEV. These might be important influences but 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.

The RCO methodology was applied to a few vehicle powertrains to assess their vehicle energy consumption and economic impact across multiple countries. The latest work has been focused on significantly expanding the vehicles considered for the analysis. Vehicle system simulation was used to assess the impact of multiple component technologies over a wide range of vehicle classes, powertrain configurations and timeframes including uncertainties.

12.3.1 Vehicle Simulations

To evaluate the fuel-efficiency benefits of advanced vehicles, each vehicle was designed from the ground up based on each component's assumptions. The fuel efficiency was then simulated on all the standard driving cycles. The vehicle costs were calculated from each individual component characteristics (e.g. power, energy, weight). Both cost and fuel efficiency will then be used to define the market penetration of each technology to finally estimate the amount of fuel saved.

To properly assess the benefits of future technologies, several options were considered, as shown in Figure 1:

- Fife vehicle classes: subcompact, midsize car, small SUV, medium SUV, and pickup truck.
- Six timeframes: reference (2010), 2015, 2020, 2025, 2030, and 2045. All years are "lab year" with a 5 year delay with production year.
- Five powertrain configurations: conventional, HEV, PHEV, fuel-cell HEV, and BEV.
- Multiple all electric range: 10, 20, 30, and 40 miles for PHEVs, 100, 200, and 300 miles for BEVs.
- Four fuels: gasoline, diesel, ethanol (E85), and compressed natural gas (CNG).
- Three risk levels: low, average, and high. These correspond, respectively, to 10 % uncertainty (aligned with original-equipment-manufacturer [OEM] improvements based on regulations), 50 % uncertainty, and 90 % uncertainty (aligned with aggressive technology advancement). These levels are explained more fully below.

Overall, more than 5,000 vehicles were defined and simulated in Autonomie. The study does not include mild hybrids and does not focus on tailpipe emissions.

Micro hybrid technology is introduced starting in 2030 to replace conventional vehicles. Figure 1 summarizes the options considered.

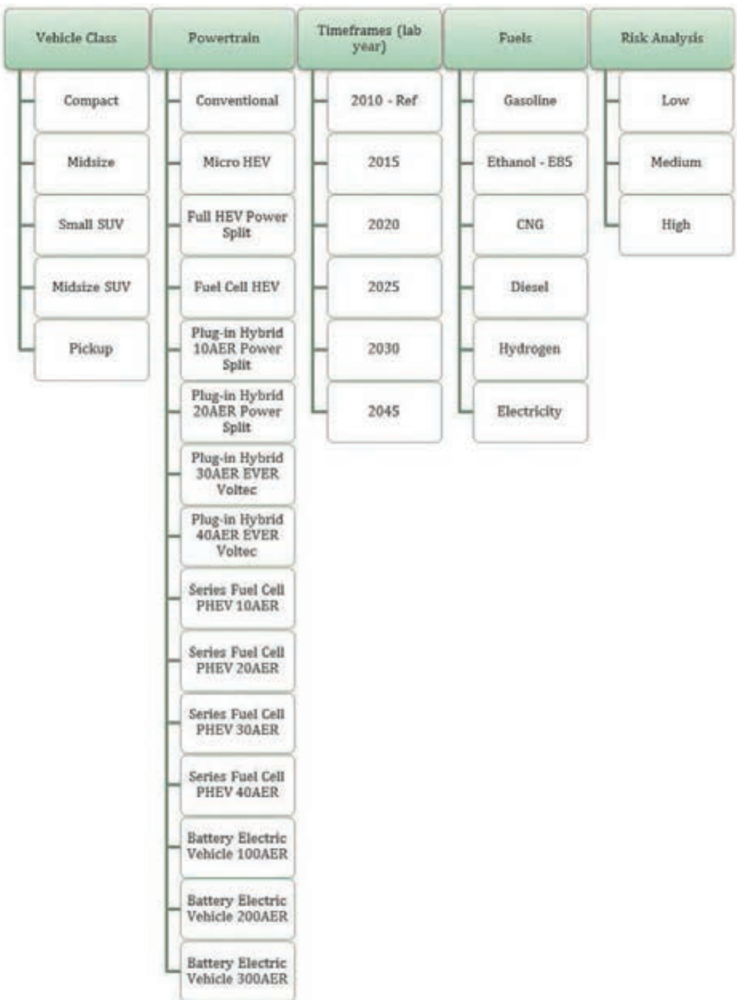

Figure 1: Vehicle classes, timeframes, configurations, fuels, and risk levels

12.3.2 Main Component Assumptions

Assumptions were developed at the component level (e.g. engine, transmission, electric machine, energy storage, fuel cell, etc.) as well as the vehicle level (e.g. glider weight, frontal area, drag coefficient, etc.) in collaboration with experts from government, national laboratories, industry, and academia.

For internal combustion engines, several state-of-the-art technologies were selected as the baseline for the fuels considered: gasoline (spark ignition [SI]), diesel (compression ignition [CI]), E85, and CNG. The engines used for HEVs and PHEVs are based on Atkinson cycles, generated from test data collected at Argonne's dynamometer testing facility. A summary of the high level engine assumptions is shown in Figure 2.

Parameter	2010 lab	2015 lab			2020 lab			2025 lab			2030 lab			2045 lab		
	Low	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Gasoline IC Engine peak eff	36%	37%	38%	40%	38%	42%	45%	39%	44%	46%	40%	45%	47%	42%	47%	50%
Diesel IC Engine peak eff	42%	42%	43%	45%	43%	45%	50%	44%	47%	51%	45%	48%	51%	48%	49%	52%
Flex Fuel IC Engine peak eff	36%	38%	39%	41%	39%	45%	46%	40%	46%	47%	41%	46%	48%	43%	48%	52%
CNG IC Engine peak eff	36%	39%	40%	42%	40%	46%	47%	41%	47%	48%	42%	47%	49%	44%	49%	52%

Parameter	2010 lab	2015 lab			2020 lab			2025 lab			2030 lab			2045 lab		
	Low	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Gasoline Engine eff at 2bar at 2000rpm	24%	23%	24%	25%	25%	27%	29%	27%	29%	31%	29%	31%	32%	30%	32%	34%
Gasoline Engine eff at 20% at 2000rpm	24%	23%	24%	25%	25%	27%	29%	27%	29%	31%	29%	30%	32%	30%	32%	34%
Diesel Engine eff at 2bar at 2000rpm	26%	25%	27%	28%	27%	29%	31%	29%	30%	32%	30%	31%	33%	32%	33%	35%
Diesel Engine eff at 20% at 2000rpm	30%	31%	32%	33%	33%	34%	36%	33%	35%	38%	33%	35%	39%	34%	35%	40%

Figure 2: Engine peak efficiencies (top) and engine efficiency at 2000 rpm – 2 bar, 20 % (bottom)

12.3.3 Vehicle Powertrain Sizing

All the vehicles were sized to meet the same requirements:

- Initial vehicle movement (IVM) to 60 mph less than 9 sec ± 0.1 sec.
- Maximum grade of 6 % at 65 mph at gross vehicle weight (GVW).
- Maximum vehicle speed >100 mph

Several automated sizing algorithms were used to provide a fair comparison between technologies. Each algorithm is specific to a particular powertrain (i.e. conventional, power-split, series, electric) and application (i.e. HEV, PHEV). All algorithms were based on the same concept: the vehicle is built from the bottom up, meaning each component assumption (i.e. specific power, efficiency, etc.) was taken into account to define the entire set of vehicle attributes (i.e. weight, etc.). This process is always iterative in the sense that the main component characteristics (i.e. maximum power, vehicle weight, etc.) are changed until all the vehicle technical specifications are met.

Examples of the rules are provided below for a couple of powertrains:

- For HEVs, the electric-machine and battery powers were determined to capture all the regenerative energy from a UDDS cycle. The engine and the generator were then sized to meet the gradeability and performance requirements (e.g. IVM to 60 mph).
- For PHEV10s and PHEV20s, the electric-machine and battery powers were sized to be able to follow the UDDS cycle in electric-only mode (this control was only used for the sizing; a blended approach was used to evaluate consumptions). The battery-usable energy was defined to follow the UDDS drive cycle for 10 mi or 20 mi, depending on the requirements. The engine was then sized to meet both performance and gradeability requirements (usually, gradeability is the determining factor for PHEVs).
- For PHEV30s and PHEV40s, the main electric-machine and battery powers were sized to be able to follow the aggressive US06 drive cycle (duty cycle with aggressive highway driving) in electric-only mode. The battery-usable energy was defined to follow the UDDS drive cycle for 30 mi or 40 mi, depending on the requirements. The genset (engine + generator) or the fuel-cell systems were sized to meet the gradeability requirements.

12.4 Results

12.4.1 Component Sizing

The following section describes the maximum power, energy, and weight of the different components after sizing. Figure 3 shows an example of battery power sizing for power for the midsize vehicle class.

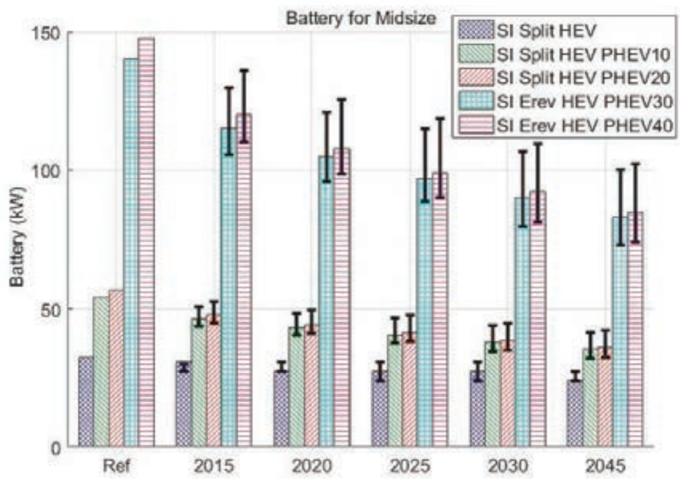

Figure 3: Battery power for midsize gasoline HEVs and PHEVs

Figure 4 shows the evolution of the total battery energy required for multiple PHEV for a midsize car. The graph also shows the evolution of the requirements based on the evolution of vehicle weight and advanced technologies.

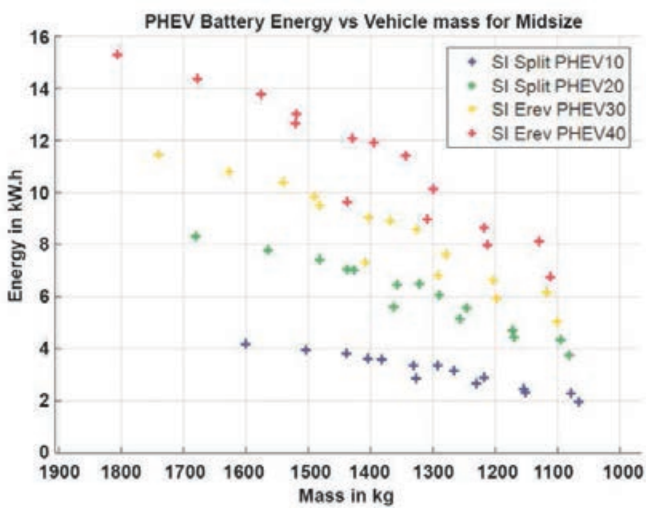

Figure 4: Total battery energy as a function of vehicle mass for gasoline PHEVs for the midsize car across all timeframes and uncertainties

12.4.2 Vehicle Energy Consumption

The vehicles were then simulated on the different worldwide driving cycles to estimate their energy consumption. The following section provides examples of results for midsize vehicles.

Figure 5 shows the fuel consumption relative to the reference gasoline conventional vehicle. In 2045, compared with the gasoline reference case, the ranges of improvement will be as follows: gasoline engine, 28 % to 49 %; diesel-engine, 38 % to 56 %; CNG engine, 23 % to 43 %; and ethanol engine, 39 % to 58 %.

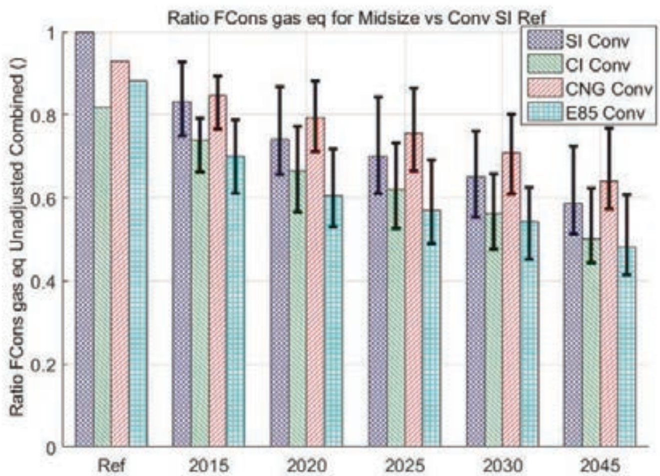

Figure 5: Gasoline-equivalent fuel consumption for conventional midsize cars compared with reference conventional gasoline vehicle

The comparison between power-split HEVs and conventional gasoline vehicles (same year, same case) in Figure 6 shows that the ratios stay fairly constant until 2020 but slowly decrease afterwards. Indeed, the power-split midsize vehicle consumes between 25 % and 45 % less fuel than the conventional gasoline vehicle in 2010 to 2020 versus 40 % to 50 % by 2045. After 2030, the introduction of micro hybrid vehicles does not seem to give conventional vehicles (becoming start/stop systems) an advantage over HEVs.

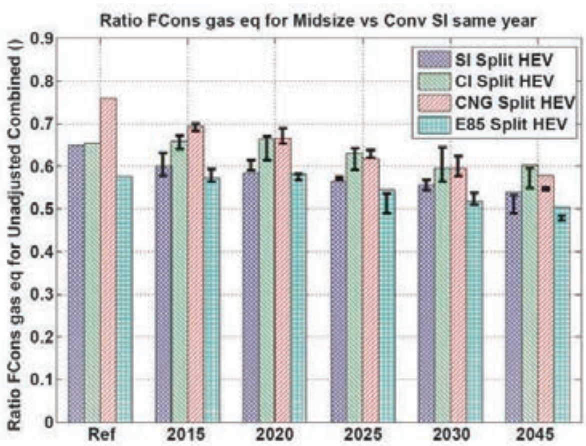

Figure 6: Gasoline-equivalent fuel consumption for midsize power-split HEVs compared with same-year, same-case conventional gasoline vehicles

12.4.3 Conclusions

The results demonstrate significant improvements over time across all powertrain configurations and fuels (see Table 1). When considering the high-uncertainty case across all engines, on the US standard driving cycles, conventional vehicles can achieve a 23 % to 58 % fuel-consumption improvement; engine HEVs, 57 % to 81 %; engine PHEV10s, 65 % to 84 %; and engine PHEV40s, 58 % to 91 %. Fuel-cell vehicles achieve an improvement of up to 81 % for HEVs, 84 % for PHEV10s, and 89 % for PHEV40s.

Table 1: Percentage fuel-consumption reduction of each powertrain by 2045, compared with reference 2010 gasoline conventional powertrain for US CyclesNewly introduced plug-in electric vehicles from German OEMs in 2015

Fuel\Powertrain	Conventional	HEV	PHEV10*	PHEV40*
Gasoline	28–49	61–75	70–81	82–91
Diesel	38–56	57–72	65–78	82–89
CNG	23–43	61–72	69–78	58–62
Ethanol	39–58	65–76	72–81	81–90
Fuel cell		71–81	77–84	83–89

* Electrical consumption is not taken into account for PHEVs

Table 2 shows the 2045 adjusted fuel-consumption reduction on the US combined driving cycle for each powertrain configuration and fuel, compared with each configuration's current status in 2010 (e.g. the diesel HEV in 2045 is compared with the reference diesel HEV in 2010).

The results demonstrate that the maximum improvement expected for each powertrain technology compared with its current status ranges from 17 % to 65 %. The range depends on fuels (i.e. diesel vehicles show less improvement than gasoline vehicles) and powertrain (i.e. conventional engines have a lower maximum improvement than that of PHEV40 engines).

Table 2: Percentage fuel-consumption reduction for each powertrain by 2045, compared with the respective current status (values reflect the uncertainty range) for US Cycles

Fuel\Powertrain	Conventional	HEV	PHEV10	PHEV40
Gasoline	28–49	41–61	42–62	34–65
Diesel	25–46	34–57	35–58	37–63
Ethanol	31–53	39–58	40–59	34–65
CNG	17–38	48–53	49–63	21–27
Fuel cell		35–56	36–56	35–57

12.5 Next Steps

After focusing on the analysis of TCO for a few powertrain configurations within a specific vehicle class (midsize car), the addition of the large number of vehicle technologies will allow us to perform further economic analysis for multiple geographical areas. In addition, the results will be used as inputs to market penetration models.

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

- Database including vehicle energy consumption, component characteristics and cost for multiple powertrain configurations and timeframes on standard driving cycle – completed
- Recommended practice methodology to assess total cost of ownership (TCO) – completed
- Comparison of market penetration methodologies – in progress
- 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, etc.) – in progress
- Analyze results & summarize in a report – in progress

12.6 Contact Details of the Operating Agent

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13 Wireless Power Transfer for Electric Vehicles (Task 26)

Members: Denmark, France, Germany, Spain, Sweden, Switzerland, The Netherlands, United Kingdom, United States

13.1 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.

13.2 Objectives

The task would 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 26 gets underway and narrow in focus as meetings progress. As there is ongoing effort in many of these objective areas, in "bullet" form, 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

13.3 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.

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.

13.4 Results

Task 26 sponsored working groups on two different topics in 2015. The first was a Technical Discussion on Leading Applications and was held in Seoul, Korea on 4 May, 2015. The second was a Discussion of Power Levels. It was jointly sponsored by this task, and Viktoria and was held in Gothenburg, Sweden on 19-20 October, 2015. Workshops were a combination of technology presentations and working group discussions.

13.4.1 Summary of Leading Applications Workshop

The Leading Applications workshop consisted of presentations from Sweden, and the United States and demonstration videos from The Netherlands. The workshop was attended by eleven individuals from seven countries including representatives of industry, academia, governments, and national laboratories.

The United States shared information regarding who was working on wireless technology development within the country and the locations where deployment sites were underway or being considered. The technology is still very much at the prototype stage with no systems available for commercial sale. Deployment costs were discussed and estimates from various studies were compared among workshop members. It was noted that the information on these systems and sites were not well documented and the specifics of the deployments were not well understood.

Sweden shared information about the WiCh and SAWE project. The WiCh project is one of the largest wireless charging demonstrations with 20 EVs in Stockholm and Gothenburg. The SAWE project was focused on human factors associated with exposure to EMF coming from the technology. In addition, there is a future project to study EV pool cars.

As a result of the presentations, it was agreed upon by the task members that the best deliverable from this workshop would be a database of wireless charging project/sites. Based on input from all the task members, criteria was identified that would be useful to have in a database of any existing and proposed deployment sites. The database was populated and distributed to members for their input and correction. The database remains a living document on the task website for members to access.

13.4.2 Summary of Power Levels Workshop

The Power Levels workshop included presentations, site visits to wireless charging demonstrations, and working sessions geared toward further development of the final product. There were a total of eight presentations focused on high power (above 22 kW) and low power (3-22 kW) level systems. Among the presentations were ones discussing demonstration projects in Spain, the United Kingdom, and Ireland. The workshop host secured tours of three different demonstrations including a bicycle pool, an electric road simulator, and a municipal installation of a wireless system. As part of the working session task members reviewed future workshop host proposals and decided on where to hold remaining workshops associated with this task.

Figure 1: Demonstration Site Visit during Power Levels Workshop

13.5 Next Steps

This task plans to hold its third and fourth meetings in 2016. Two workshops a year are planned as shown in Table 1.

Table 1: Draft Meeting Schedule for Task 26

Preliminary Workshop Topics	Anticipated Dates	Host / Location
Interoperability	Summer 2016	PROOV Amsterdam, The Netherlands
Safety Conclusions	Fall 2016	CIRCE Zaragoza, Spain (Tentative)

13.6 Contact Details of the Operating Agent

The operating agent for this task was changed late in 2015. For further information, please contact the Task 26 OA or Task 26 Vice OA.

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14 Electrification of Transport Logistic Vehicles (Task 27)

Members: Austria, Germany, Republic of Korea, The Netherlands, Turkey, United Kingdom

14.1 Introduction

Road freight transport is one of the fastest growing modes of transport and has an increasing share in the total GHG emissions of transport. Worldwide, road-freight activity and energy use have almost doubled in the last two decades [1]. Furthermore, higher gradients are observed for freight emissions compared to passenger travel emissions for most of the IEA countries [2]. 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. Current 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.

14.2 Objectives

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

- Summarize the status of electrified transport logistic vehicles and infrastructure technologies, implementation, and hurdles
- Identify early niche markets and commercialization opportunities for electrified transport logistic vehicles
- 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.

14.3 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.

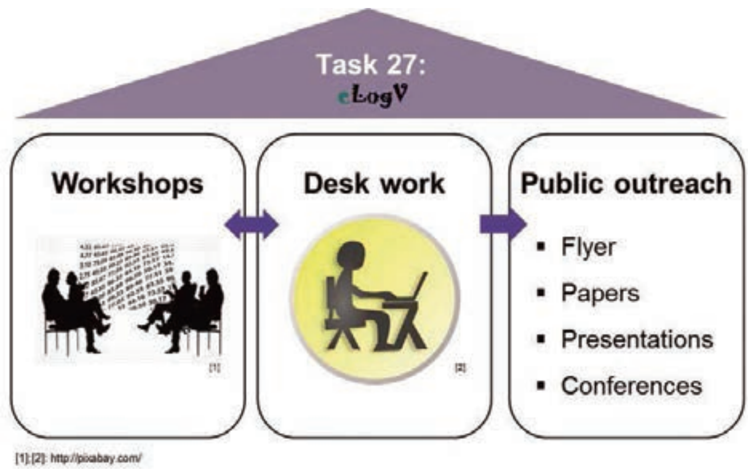

Figure 1: Task 27 working method

For the workshops, external experts are 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 are discussed in workshops and conferences, and published in papers and a final report.

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

14.4 Results

The first Task 27 workshop **“Electric transport logistic vehicle technology and its application”** was held in Stuttgart (Germany) on 19 March 2015. Dedicated topics at the workshop were:

- 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

The participants from industry, research and policy-makers were informed in the first session about the latest developments for batteries and fuel cells. For batteries, economically viable automated production is achieved for the capacity of 20 MWh (ca. 200 units for heavy duty vehicles), which can be upscaled arbitrarily. Furthermore, it is argued that the quality of the battery (e.g. life time, energy density) is decisive for the market penetration of electric freight trucks. For fuel cell systems, it is expected that an automated production for high volume will result in a cost reduction of 50 %. There are already fuel cell systems on the market with an offered warranty of 15,000 operating hours (>10 a).

In the second session, first experiences from pilot projects were presented by two different early adopters of electric freight vehicles. It was stated that maintenance (disuse due to electric powertrain failure) and total cost of ownership were current challenges for the pilot projects. However, the number of trips that could be electrically operated with vehicles which are already available is much higher than estimated (e.g. about 75 % of all truck operations in Rhine-Neckar Region, Germany).

The last session is dedicated to an interactive activity with the participants for discussing “drivers”, “barriers”, “strategies” for electric logistic transport and “expectations from the Task 27”. The results show that vehicle manufacturers are reluctant to produce electrified transport vehicles due to the limited demand from the market. One of proposed solution to this problem is to establish city alliances (for example in Europe) in order to increase the number of vehicles ordered. However, the discussions at the workshop with local authorities and city municipalities showed that there is a lack of information about the status of existing electrified freight vehicles. Furthermore, it could be useful for the local administrations to have an overview about the technical specifications for these vehicles in order to be able to decide about implementing electric vehicles into the fleets [3].

After this lack of information was identified at the first workshop, the Task 27 decided to close this gap by initiating a **database for the electrified transport logistic vehicles** with their detailed technical specifications and a collection of **fact sheets for pilot projects**. Furthermore, as the total cost of ownership was identified to be decisive for the market uptake of electric freight vehicles, the economics of the electric vehicles are also investigated in detail. These activities were presented at the EVS 28 (May 2015 in South Korea) with [4]and at EEVC (December 2015 in Belgium) with [3].

In the first paper, a techno-economic assessment of battery and fuel cell electric transporters (category N1) were presented for Austrian, German, Turkish, British, and South Korean conditions [4]. The results show that the total cost of ownership is strongly depended on the framework of the country, and battery electric vehicles are already economically viable in several countries such as the UK, Austria, and South Korea (see Figure 2). However, in 2015 the total costs of ownership of fuel cell vehicles are significantly higher than for the conventional vehicles for all countries.

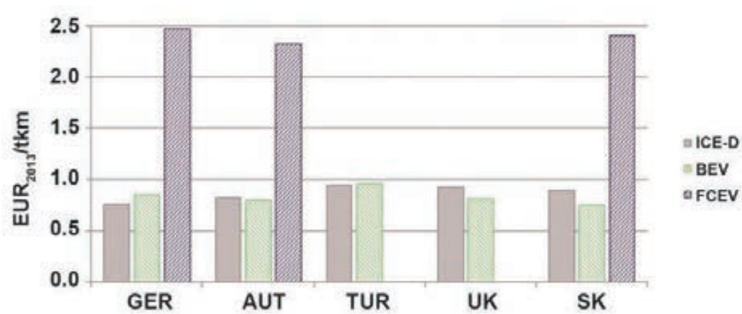

Figure 2: Comparison of country individual total cost of ownership per ton-kilometers for N1 vehicles in 2013 [4] [14]

In the second paper, the developed vehicle database with more than 95 vehicles and their technical features were presented in South Korea [3]. The analyses showed that only very few vehicles (only three) are powered by fuel cells. The reason is probably the disadvantages about the total cost of ownership as identified by [4]. It is also concluded that the number of electrified vehicles is decreasing as the payload increases (see Figure 3). Furthermore, all vehicle concepts with more than 150 km electrical range or with more than 2 tons of payload are powered by Li-Ion technology. This result indicates that Li-Ion technology is utilized if the requirements of the electric vehicle are considerably high.

[14] GER: Germany, AUT: Austria, TUR: Turkey, UK: United Kingdom, SK: South Korea

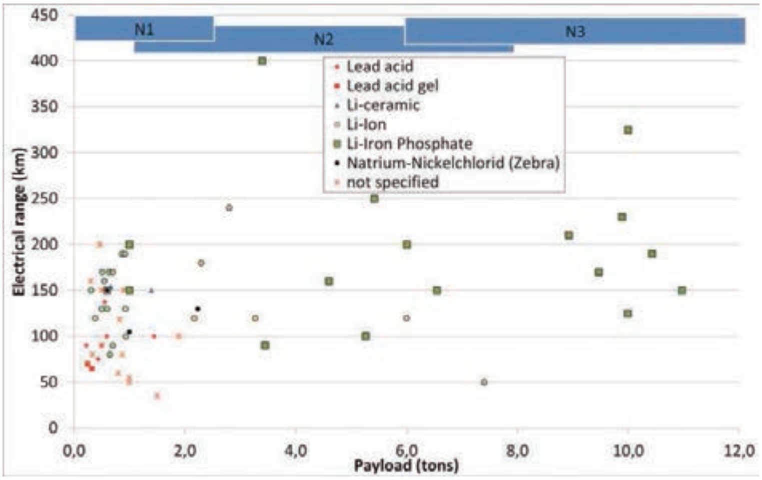

Figure 3: Comparison of electric range and payload of electrified logistic vehicles according to their battery type [3]

14.5 Next Steps

The next workshop *"Experiences and prospects of electric freight vehicles – from city to distributor to transport company, including infrastructure technology"* will be organized on 12 April 2016 in Amsterdam. Dedicated topics of the Dutch workshop are:

- best practice experiences of pioneer cities
- experiences from early adopters of electric freight vehicles
- current status of charging infrastructure technologies for heavy duty vehicles
- panel discussion about activities needed to get out of niche into mass market

The workshop series will continue with the event planned in Austria for October 2016, which is targeted to policy makers and stakeholders from vehicle manufacturers, technology suppliers, research, and entrepreneurs around the globe.

Participation is by invitation only and free of charge for all Task 27 workshops.

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[4] Kleiner, F., Özdemir, E.D., Schmid, S.A., Beermann, M., Çatay, B., Moran, B., Lim, O.T., Friedrich, H.E., Electrification of transport logistic vehicles: A techno-economic assessment of battery and fuel cell electric transporter, EVS28 KINTEX, Korea, May 3-6, 2015

15 Home Grids and V2X Technologies (Task 28)

Members: Denmark, France, Germany, Ireland, Republic of Korea, Spain, Switzerland, United States

15.1 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 until April 2017. 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 customer 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 that 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 emergency.

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.

15.2 Objectives

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

The initial task objectives are the following:

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?
   - Which are the potential synergies with self-generated electricity in households?
   - Which 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?
   - Which 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 on-site renewable energy generation capacity while improving security and quality of supply.

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

15.3 Working Method

The overarching objective of Task 28 is to investigate the means to overcome 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 are programmed on different strategic topics. 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 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.

15.4 Results

In 2015, Task 28 held two expert workshops:

- **Workshop II: V2X Technologies and the Power System.**
  The workshop was held in Burgdorf (Switzerland) on 15-16 April, 2015. It included panels on home grids, communication and protocols and on opportunities of V2X integration into power and energy markets.
- **Workshop III: V2X Flexibility Aggregation, BEMS and Bidirectional Chargers.**
  The workshop was held in Copenhagen (Denmark) on 26-27 October, 2015. It included panels on aggregation and regulatory framework, bidirectional chargers, grid codes and building energy management systems.

The main conclusions from each workshop are detailed in the following subsections.

15.4.1 PEVs and Home Grids

Regarding V2H, Japan has become the first real market for V2H technologies as a backup emergency power in 2015. A number of prefectures incentivize its usage in order to reduce peak power demand and increase power supply reliability after the shutdown of a number of nuclear power plants in 2011. Degradation effects on the EV battery for V2H applications have been proved to be similar as the effects from fast charging operation.

V2G could help to smooth peaks in demand; reducing electricity cost and increasing energy reliability. Denmark and Germany represent an attractive market for V2G due to the high share of renewable energy sources in their electricity mix.

Distribution system operators (DSO) are interested in analyzing the potential for different V2G applications. In countries such as Switzerland the relevancy and opportunities of distributed energy resources and smart grid solutions are already recognized to tackle distribution congestion issues; a centralized control (demand side management) by the distribution system operator (DSO) is carried out; in the future, demand response (DR) strategies are to emerge.

15.4.2 Communication and Protocols in V2X

Standards are needed to harvest V2X properties such as the fast response time, high power load, possibility of V2X support, and high degree of flexibility.

Regarding standards from EV to EVSE, ISO 15118 includes a F5 sub-case on V2G but, in 2015, further developments are needed. CHAdeMO has become the *de facto* protocol for V2X projects and has been used in over 3,000 bidirectional chargers in Japan. Currently available communication protocols can be used for V2X applications, but real time control (i.e. those controls required by TSO/DSO services) are not so well supported (e.g. ISO 15118 delay between seconds-minutes).

Between EVSE and back office system, the enabling protocol is the OCPP 2.0. Some new features of OCPP 2.0 compared to OCPP 1.2/1.5 have been introduced, such as pricing, smart charging, and monitoring.

In accordance to the general view of the experts attending the workshop, standardization should be in place by 2017 when the business model for V2X will be clearer. It was agreed that it might be useful to focus on guidelines and use cases instead of full standards. Standardization bodies have the risk to be too slow while product development cycles are too fast.

15.4.3 Aggregation and Regulatory Framework

In 2015, aggregation of V2X applications are mainly focused on V2G services for transport system operators (TSOs). A regional transmission organization in the US is currently operating and providing ancillary services regulation (in October 2015, 300 kW tested, registered from EVs). In Denmark, aggregated EV with V2G capabilities operating experimentally are providing frequency-controlled disturbance reserves (pre-commercial, not yet registered, but following rules and providing reserves). Results so far show that V2X technology (bidirectional charging) is eight times the value of unidirectional (controlled charging) although more complex.

Regarding the regulatory framework, TSO rules were historically designed for large thermal power plants and that poses a challenge to qualify distributed storage.

Markets designed for slow thermal do not allocate full value to very fast-responding resources.

A potential third-party aggregator will be in charge of gathering small flexibility providers (V2X enabled EVs together with other flexibility sources) in order to sell their services in the electricity markets. This scheme has possibilities in the electricity markets, however regulatory schemes need to be clarified (e.g. currently flexibility activation is blocked by intermediary players).

So far V2X applications for DSOs have been only tested at research level. However, there is a huge potential for these services (voltage control & congestion management in the short, medium, and long term). Combination of TSO/DSO V2X market applications should be considered to maximize the value of V2X. Its optimal combination and potential saturation should be further investigated. Further coordination between DSO/TSO is essential for ensuring the creation of a common marketplace and regulatory framework which guarantees a transparent, secure and cost-effective flexibility services provision.

15.4.4 Bidirectional Chargers

In 2015, there is not a real mass market for bidirectional chargers. Subsidies could help the uptake of this technology, but proper cost-benefit analyses including positive externalities would be required in advance. In Europe there is an existing market development, but it could always be faster. A key limiting factor is the fact that no two markets are alike: different legal markets, bound of difficulties when entering the public grid.

Synergies among V2X bidirectional chargers, EV fast chargers, local DERs, and local energy storage systems can improve the business models and therefore empower the market uptake for V2X technology.

Still, there are plenty of open questions to be addressed regarding bidirectional chargers:

- Should the structure be placed on or off-board?
- How to integrate customer requirements?
- How to respect electricity standards from DSO/TSO on EV side?
- How to respect charge point operators requirements?
- How to prepare an electricity market environment?

15.4.5 Grid Codes and Building Energy Management Systems

In 2015, there are no clear standards for bidirectional chargers connection to distribution networks. As a first step photovoltaic generation modules standards can be extrapolated together with other more general micro-generation connection rules. So far, standards outside Europe and the US are lagging behind with less or no focus on grid support mechanisms; there are lower levels of penetration, so fewer issues are experienced.

Existing network design rules and congestion management mechanisms should be adapted and an active role of the DSO on V2X chargers operation should be required.

Energy management systems are key tools for V2X chargers and the interaction with DSO. They are also required for V2H applications such as peak shaving, renewable energy sources integration, and energy arbitrage applications.

The available communication protocols in 2015 should be adapted in order to increase the number of parameters to be included (charging time, amount of energy, V2X authorization, tariff, power limits, etc.). The EMS – EVSE architecture should also be reviewed, currently there are too many gateways that make real-time applications realization difficult.

15.5 Next Steps

The work in Task 28 may continue until April 2017. The following subtasks, corresponding to the next workshops, focus on the technical challenges that V2X technology may face:

1. **Workshop IV: V2X enabled EVs** to be held in Denver (US) in May 2016 with the following panels:
   - Effects of usage profiles on battery lifespan
   - Improved models of battery degradation for V2X
   - Market potential as a function of mobility patterns
2. **Workshop V: Updated on Business Models and regulatory framework** to be held in France in autumn 2016.

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16 Electrified, Connected and Automated Vehicles (Task 29)

Members: Austria, Germany, United States

16.1 Introduction

The convergence of technologies for connectivity and automation with the electrification of road vehicles may offer a multitude of synergies in both performance of the technical systems and added values for users and businesses. Interdependencies between the development and innovation processes in automation and electrification are likely, due to similarities in the electronic architecture both technologies rely on. Furthermore, functional complementarities as well as commonalities in the systematic character of the operating environment enlarge synergetic effects. Thus, the combination of the three technologies may define novel products, designs and services and, along these lines, new market opportunities for the merging automotive and IT sectors. The synergetic effects can be expected to contribute to higher customers' acceptance of electrified vehicles. On the other hand, concerns exist over potential rebound effects: High-degree automation of vehicles may lead to a more intense use of them and thus increase the energy needs even though the technology is more efficient. In order to discuss opportunities and challenges of electrification in combination with connectivity and automation of road vehicles, Task 29 was launched by the IA-HEV.

16.2 Objectives

The Task 29 will focus on following objectives:

- Analyze the potential technological synergies of electrification, connectivity and automation of road vehicles and derive research, development and standardization needs.
- Study the business models by combining electrification and connectivity/automation of road vehicles and identify action fields for companies and/or governments.
- Assess the impact of user/driver behavior on the combination of electrification, connectivity and automation and conclude on needs for measures in awareness and legislation.

16.3 Working Method

Task 29 will organize a series of expert workshops scheduled in conjunction with dedicated conferences and IA-HEV Executive Committee (ExCo) meetings. The workshops will gather a variety of stakeholders coming from academia, industry and public authorities. The purpose is to identify trends and scenarios, to analyze challenges and opportunities, and to deliver conclusions for future actions. The final list of topics will be defined considering the interests of the Task participants, including the member state representatives, as well as the industries and R&D centers involved in the Task. The results of the Task 29 meetings will be presented in form of a report and a roadmap. It shall be made available to the community as a book.

16.4 Financing and Sponsorship

Becoming a member of Task 29 is free of charge. Please contact the Operating Agent for more information.

16.5 Benefits of Participation

Task 29 will offer a platform for sharing information about the results and future strategies for research and development programs, implementation measures and actions e.g. in legislation, or standardization regarding electrified, connected and automated road transport.

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17 Assessment of Environmental Effects of Electric Vehicles (Task 30)

Members: Austria, Germany, Spain, United States

17.1 Introduction

Electric vehicles have the potential to substitute for conventional vehicles to contribute to the sustainable development of the transportation sector worldwide, for example, in the reduction of greenhouse gas (GHG) and particle emissions. There is international consensus that the improvement of the sustainability of electric vehicles can only be analysed on the basis of life cycle assessment (LCA), which includes the production, operation, and the end-of-life treatment of the vehicles and the fuel cycle. All environmental impacts must include the whole value chain and – if relevant – interactions from recycling in the dismantling phase to the production phase, if recycled material is used to produce new vehicles.

17.2 Objectives

The aim of Task 30 is to analyse and assess environmental effects of electric vehicles (EVs) on water, land use, resources and air based on life cycle assessment in a cooperation of the participating countries in the International Energy Agency (IEA).

Task 30 is using the results of the completed Task 19 "Life Cycle Assessment of Electric Vehicles"[15] as a foundation to subsequently examine the environmental effects – benefits and impacts – of vehicles with an electric drivetrain (EVs), based on life cycle assessment (LCA). With an eye on the three phases of LCA, such as production, operation, and dismantling of EVs, various environmental effects of EVs on water, land use, resources and air, among others, will be analysed and assessed. Thereby a strong accent is put on the comparison of environmental effects between pure battery EVs (BEV) and Plug-in hybrids (PHEVs) on one hand and conventional ICE vehicles using gasoline, diesel, and natural gas on the other side.

[15] 2011-2015, www.ieahev.org/tasks/task-19-life-cycle-assessment-of-evs/, led by JOANNEUM RESEARCH

In Task 19 the focus of the activities was on the analyses of the process chain and in Task 30 the focus is on the environmental effects on water, land use, air resources and waste (Figure 1).

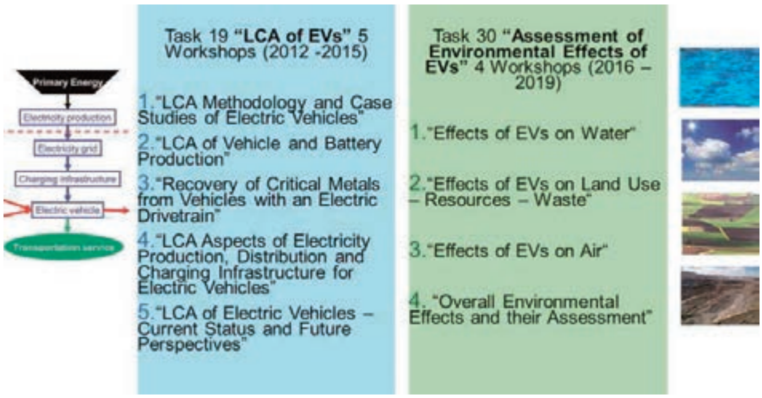

Figure 1: From process chain analyses (Task 19) to environmental effects (Task 30)

Task 30 will focus on the following topics covering methodologies, data, and case studies:

- Effects of EVs on water (emissions to water, waste water, "Water Footprint" of EVs)
- Effects of EVs on land use-resources-waste (land use, occupation and degradation, demand of renewable and fossil resources, recycling)
- Effects of EVs on air (local emissions and effects of NO_x, PM, and C_xH_y, human health effect and non-energy related emissions from tires and brakes)
- Overall environmental effects and their assessment (comparing and assessing different impact categories, single score methodologies, stakeholder involvement)

17.3 Working Method

Within the task, methodologies for helping countries implement EVs by identifying possibilities to maximize the environmental benefits will be developed. Besides, various case studies will be analyzed and networking combined with information exchange will be supported within the task's frames (Figure 2). For the purpose of research, the extension of the international "Research Platform for Life Cycle Assessment (LCA) and End-of-Life Management for Electric Vehicles", that was already established in Task 19, will be considered.

The task will proceed by holding a series of workshops addressing the following objectives:

- Methodologies on assessment of environmental effects
- Analyses of necessary and available data
- Overview of international studies/literature
- Analyses of current knowledge and future challenges
- Overview of key actors and stakeholders and their involvement
- Communication strategies to stakeholders
- Summarizing further R&D demand

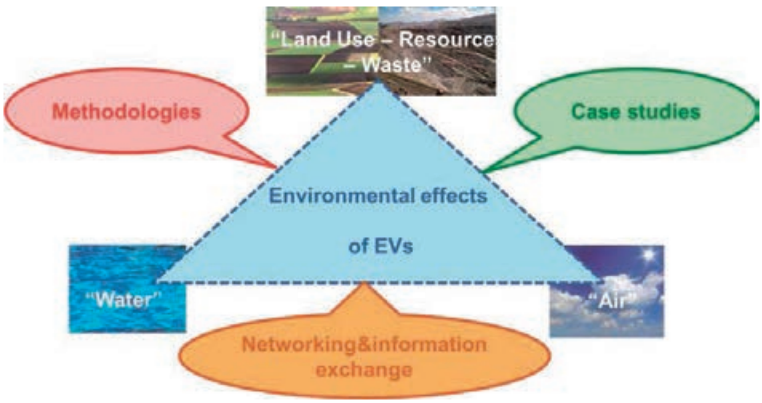

Figure 2: Working method in Task 30

17.4 Results

Members in this task will compile a list of environmental benefits and impacts of EVs with the goal to increase their overall acceptance by providing facts and figures on the environmental effects of EVs. Thus, numerous advantages of EVs compared to conventional vehicles will be shown. These results should help the industry and government to support further development and employment of EVs in all transport modes. The results will document and summarize the state of current knowledge and future challenges (incl. methodologies and case studies) on:

- Effects of electric vehicles on water
- Effects of electric vehicles on land use – resources – waste
- Effects of electric vehicles on air
- Overall environmental effects and their assessment of EVs
- R&D demand

In addition to these technical and scientific results a glossary on "Frequently asked questions" (FAQ), a framework for Communication strategies to stakeholders, and dissemination activities (e.g. proceedings, reports, papers, notes, presentations) will be available.

17.5 Next Steps

Based on an already ongoing survey and summary of literature, Task 30 organizes its first Workshop "Effects of electric vehicles on water" in autumn 2016.

17.6 Contact Details of the Operating Agent

For further information, please contact the Task 30 OA:

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18

Fuels and Energy Carriers for Transport (Task 31)

Members: Denmark, France, The Netherlands

18.1 Introduction

IEA IA-HEV aims to create an objective review / assessment, based on state-of-the-art, independent studies, to inform policy makers on the key environmental aspects of electric vehicles (EVs) in comparison to conventionally fueled vehicles (Internal Combustion Engine Vehicles, ICEV). Scenario analysis on a vehicle level will give insight in the consequences of e.g. a changing electricity mix, or of an increasing average battery size and range of electric vehicles.

18.2 Objectives

The goal of the Task 31 is to:

- Provide policy makers with an independent, state-of-the-art environmental evaluation of vehicles and their use, comparing electric and plug-in hybrid vehicles with vehicles running on conventional motor fuels and a limited range of alternative motor fuels
- Inform policy makers about the impact of future developments on this comparison of environmental impacts

The present work will answer questions such as:

1. How do BEVs and ICEVs compare on environmental impacts if not only direct emissions are taken into account, but also the indirect emissions from energy production chains and vehicle production and decommissioning?
2. Is the environmental impact comparison between BEV, ICEV and PHEV different for different market segments with corresponding use pattern?
3. How may future developments influence the comparison between electric vehicles and combustion engine vehicles, in terms of greenhouse gas emissions and air pollutant emissions:
    - Efficiency improvement of combustion engine vehicles
    - Trend towards more sustainable electricity mix
    - Developments in battery capacities and life span

- Changes in driving behaviour: autonomous driving, intelligent traffic systems, platooning

Currently, many reports, studies and LCA’s are available on this topics as well as many biased “lobby” documents and it is very difficult for policymakers to distinguish between these sources and to draw the right conclusions.

18.3 Working Method

Information necessary for the task will be collected through three different channels and subsequently analysed.

Firstly, recent scientific literature will be collected:

- Scientific journals
- Conference proceedings
- Studies commissioned by central and regional governments
- Other independent studies

Secondly, key independent groups in this field will be identified and contacted in order to discuss their view on the environmental balance between ICEVs and EVs, and to find possible additional sources. Among these groups will be the Department of Civil and Environmental Engineering of the Carnegie Mellon University in Pennsylvania (Costa Samaras), the VUB Brussels MOBI and the Industrial Ecology Group of the Norwegian University of Science and Technology (Anders Hammer Strømman, in particular).

An option is to ask one or more of these groups to review the report (dependent on the available budget). This might further improve the credibility and stature of the report.

Finally, the literature sources collected will be sorted. In general, it is important to be aware of a possible bias in the results presented in each of the publications. To judge the independence of the information found, we will try to find out in which way the studies have been funded. Next, the assumptions will be judged by our team of experts to see if these are realistic or are suspect to having a bias. Furthermore, the information (literature) sources that have a large influence on the outcome of the work presented in the publications will be requested and researched. Subsequently cross checks among the papers/reports will be done, where relevant.

It is not yet clear how many studies will be found, or what their quality is. It is attempted to cover the complete chain of processes in equal detail, thus being representative for Europe.

The outcome of the study will be a high level, credible and "understandable for all" short summary comparing the impacts of the current dominating fuels (gasoline and diesel) with electricity for selected vehicle types. The summary will also provide scenarios for the impacts in 2030 and as such provide an assessment on how the impacts will evolve in time.

18.4 Duration and Financing

Duration of the task is about 1 year. The Task will start in February 2016 and will be continue until February 2017. As several countries may join the task, also at a later stage in 2016, the task may be extended if needed.

The task is based on a work sharing principle and in kind contribution is expected. The Operating Agent will get financed on the standard per country contribution.

18.5 Contact Details of the Operating Agent

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19

Overview of Hybrid and Electric Vehicles in 2015

The sales of EVs and PHEVs increased significantly in several countries. For instance, within just one year the Netherlands doubled the PHEV fleet which reached almost 1 % of the total fleet for passenger vehicles. In the US, the fleet of EVs and PHEVs reached 0.15 %. This is quite an impressive result if one considers that there are approximately 260 million passenger cars in the US, only. The top three countries with the greatest increases in sales of EVs and PHEVs were the United States, the Netherlands, France, Sweden, and Canada. Worth mentioning is the rapid increase of EV popularity in Norway. In just one year, the fleet of EVs in Norway reached remarkable 70,000. Further information on EV development and incentives in Norway are given in Chapter 38.

On the other hand, the sales level for HEV remained the same as in previous years in many countries.

Table 1 shows the fleet totals for passenger vehicles[16] of HEVs, EVs, and PHEVs over the last three years. The numbers for 2013 and 2014 have been taken from the previous IA-HEV reports. Data for 2014 have been additionally corrected due to the fact that some of the member states delivered verified statistics after the report was published in April 2015. The country chapters provide numbers for 2015 sales and fleet totals for EVs, PHEVs, and HEVs.

[16] UNECE category M1 – please refer to vehicle defintions given at the end of the annual report.

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

	HEVs			EVs and PHEVs		
Country	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
Austria[a]	10,504	12,823	14,350	2,070	3,386	6,544
Belgium	25,553	31,579	n.a.	4,446	6,700	8,586[c]
Canada	130,823	143,917	163,269	5,712	10,778	18,451
Denmark	2,599	3,706	3,799	2,083	3,393	8,059
Finland	3,915	11,772	14,054	489	945	1,580
France	130,785	173,520	229,550[b]	19,561	30,121	54,640
Germany	85,017	107,754	119,556	22,698	18,948	36,311
Ireland	7,745	8,746	10,474	393	550	1,215
Italy	*34,439*	*68,960*	25,661	*3,378*	*7,152*	4,616
Netherlands	106,918	117,353	131,011	30,229	46,121	87,531
Portugal	n.a.	n.a.	3,000	n.a.	n.a.	2,117
Rep. of Korea	n.a.	n.a.	n.a.	n.a.	*2,000*	*10,267*
Spain	54,683	62,811	64,169	1,886	3,294	4,746
Sweden	n.a.	35,000	42,737	2,594	7,261	14,541
Switzerland	34,883	40,577	46,261	2,433	4,691	9,021
Turkey	n.a.	n.a.	n.a.	715	n.a.	n.a.
UK	n.a.	171,528	n.a.	n.a.	16,818	46,978[c]
United States	3,087,892	3,535,808	3,804,630	225,375	286,916	406,536
Totals IA-HEV	**3,715,756**	**4,525,854**	**4,672,521**	**324,062**	**449,074**	**721,739**

n.a. = not available
[a] Austria started to make a difference between the statistics for HEVs and PHEVs from 2015 on. The statistics for EVs and PHEVs refer to EVs as passenger vehicles, only (UNECE category M1)
[b] Added HEV sales for France in 2015 to the fleet totals for passenger vehicles in 2014
[c] Data from EAFO (European Alternative Fuels Observatory), www.eafo.eu

20 Austria

20.1 Major Developments in 2015

Pushing the e-mobility forwards in Austria is done by two main steps: the exposure through R&D deployment funding and promotions programs and the increase of the attractiveness of mobility by regulatory (legal) measures. Since 2007, the Austrian government has more than tripled their 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.

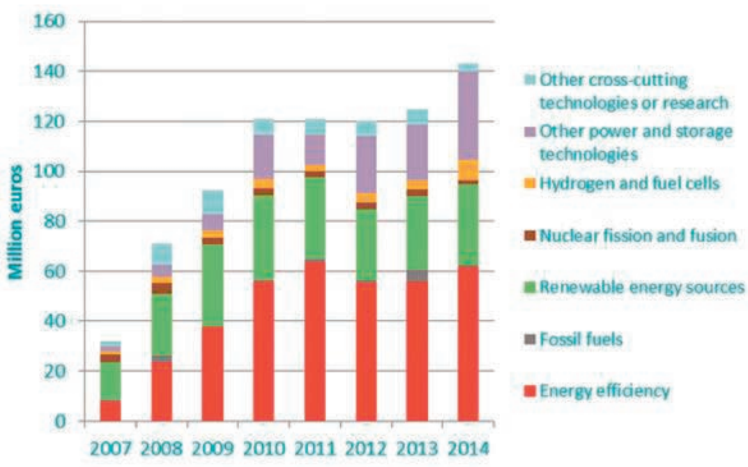

Figure 1: Austria's public expenditure for energy-related research and development in 2014 (image courtesy of bmvit, 2014[17]). The 10 subcategories with the highest expenditures in 2015 in million EUR were: efficient residential and commercial buildings (about 17.8); electricity transmission and distribution (21.5); photovoltaics (11.5); energy efficiency in industry (8.1); communities, smart cities (13.4); bioenergy (9.4); **hybrid and electric vehicles (8.5)**; energy storage (11.5) and FCH (5.1). 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 %.

[17] www.nachhaltigwirtschaften.at/iea_pdf/201512_energieforschungserhebung_2014_praesentation_en.pdf

In 2014, Austria's public expenditures for energy-related research and development amounted to 143,100,718 EUR, increasing the expenditures of 2013 by 15 % and reaching an all-time high (see Figure 1).

20.1.1 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 2015 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 for 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 cooperation between industry, research institutions, and the Ministry with the common goal to develop and launch alternative propulsion systems and fuels.

"Mobility of the Future"[18] 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 in Austria creating a transport system designed to meet future mobility and social challenges by identifying and refining middle-to long-term technology developments. 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 propulsion systems, 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 for around 15 million EUR.

[18] www.bmvit.gv.at/en/service/publications/downloads/mobility_of_the_future.pdf

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”** program[19], which issued its latest call at the end of 2014 with a budget of 3 million EUR – focusing on Low-Emission Electric Vehicles. Further calls focus on: Low-Emission Electric Fleets (2015), Low-Emission/ Low cost Industrial Production for Electric Vehicles (2016), and Low-Emission Electric Vehicle and Infrastructure Design (2017).

20.1.2 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 by 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.

20.1.3 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 system, 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.

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

[19] www.klimafonds.gv.at/foerderungen/aktuelle-foerderungen/2013/leuchttuerme-der-e-mobilitaet-5-as

The results showed that an upgrade of the existing taxi operation to BEVs could be easily realised 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 increase the number of e-taxis to 250 e-taxis until 2018.

Train operators have already realised 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 utilisation, 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 driven by a synchronous motor with an output of 11 kW, an empty weight of 178 kg, and a top speed of 120 km/h. The batteries used (12.7 kWh) enable a range between 150 and 200 km. The fast charging time amounts to 2.5 hours (80 %). In 2015, 150 units 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 Austria – in 2014, every 9th-selling bike was an e-bike.

20.1.4 Logistics

A few Austrian projects focusing 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 reorganisation of logistic structures and the concomitant reorganisation 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 un-coupled for loading and unloading operations. Every vehicle is ‘driving’ itself, led by electronic signals to follow the trajectory of the first one and 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 at 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

20.1.5 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 10-20 % for EVs. For companies, associations and non-profit organisations, 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 +0.04 EUR/l for gasoline and +0.05 EUR/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 sulphur max. of 10 mg/kg, for 482 EUR (otherwise 515 EUR) and diesel, with a content of min. 66l biofuel and sulphur max. of 10 mg/kg, for 397 EUR (otherwise 425 EUR).

In 2008, the **Normverbrauchsabgabe (NoVA)**, a uniquely bonus/malus system for CO_2 and NOx emissions as well as 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. Owners of new cars which cause < 90 g CO_2/km, don't 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 g 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 1 January 2013, the motor-dependent insurance tax for HEVs and range extender has to be paid for the engine power of the combustion engine only, BEVs are exempt from the motor-dependent insurance tax.

20.2 HEVs, PHEVs and EVs on the Road

As of 31 December 2015, 8.6 million people were living in Austria and 4.7 million passenger vehicles were on Austrian roads. According to Statistics Austria, a total of 6,545,878 vehicles (including 4,748,108 passenger cars) were registered in Austria, as of 31 December 2015. 401,039 motor vehicles were newly registered in 2015 – a decrease of 1.4 % in comparison to 2014. The number of newly registered passenger cars was 308,555 – a decrease of 1.7 % compared to 2014. A study conducted by a Vienna insurance group about consumers' preferences for buying a new car, pointed out that 44 % of all car owners plan to buy a new car within the next two years, but 80 % of them would not pay more for eco-mobility[20]. The preferences are diesel (50 %) and gasoline (30 %), followed by HEVs (15 %) and BEVs (5 %). Thus, there is a significant trend towards increasing usage of public transport systems and car sharing models.

[20] www.generali.at/fileadmin/media/pdf/Presse/user_upload/20150522_Grafiken_Autostudie_2015.pdf

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.

However, an ongoing trend towards advanced propulsion systems can be seen in the numbers of vehicles on Austrian roads in 2015 (see Figure 6). The majority of these vehicles are flex-fuel vehicles (FFVs, powered by gasoline or ethanol - E85) and HEVs (with a gasoline or diesel engine and an electric motor). Because of the significant progress in the electrification of the drivetrain it is foreseeable that the number of HEVs will strongly increase within the next years.

In addition to HEVs, BEVs are very popular in Austria. In numbers, there are 15,862 (P)HEVs in total, which feature an e-motor via an internal combustion engine (93 % gasoline/7 % diesel). The number of BEVs increased to 5,032 in 2015. The number of vehicles driven by compressed natural gas (CNG) or liquefied petroleum gas (LPG) (inclunding bivalent ones) rose to 5,087. The number of vehicles driven by Hydrogen rose to 6.

Taking into account the absolute number of new registrations based on alternative drivetrains (5,901 vehicles), their proportion of the total registration counts for 1.9 % of all new registered vehicles. Table 1 illustrates the development of the fleet distribution of passenger cars by drive trains between 2013 and 2015.

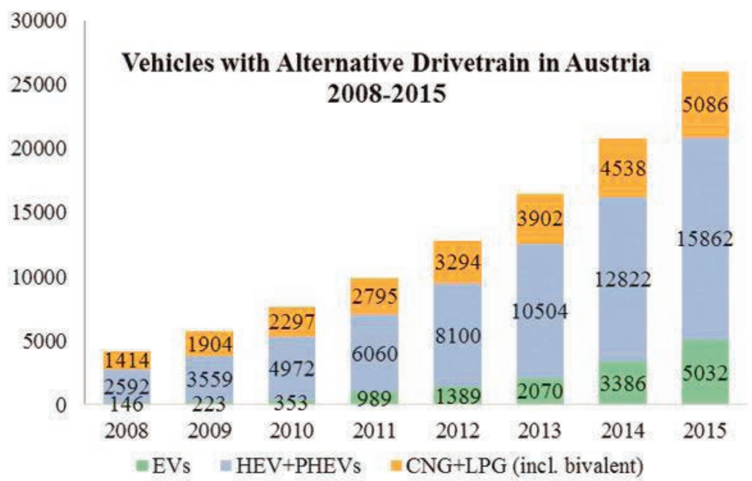

Figure 6: Development of vehicles with alternative drivetrain in Austria

Table 1: Fleet distribution of passenger cars regarding the drivetrain in Austria (Data source: Statistics Austria, KFZ Bestand as of 31 December of the years 2013-2015[21])

Drivetrain	2013	2014	2015
Gasoline	1,997,302	2,004,724	2,012,885
Bivalent gasoline/ethanol (E85)	6,397	6,380	6,254
Diesel	2,621,133	2,663,063	2,702,922
Electric	2,070	3,386	5,032
LPG	1	1	1
CNG	2,219	2,397	2,475
H2	0	3	6
Bivalent gasoline/LPG	250	279	311
Bivalent gasoline/CNG	1,432	1,865	2,300
Hybrid gasoline/electric (including plug-in)	10,049	12,232	14,785
Hybrid diesel/electric (including plug-in)	455	591	1,077
Totals	**4,641,308**	**4,694,921**	**4,748,048**

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Data source: Statistik Austria)

<table>
<tr><th colspan="5">Fleet Totals on 31 December 2015</th></tr>
<tr><th>Vehicle Type</th><th>EVs</th><th>PHEVs</th><th>HEVs</th><th>FCVs</th></tr>
<tr><td>2-Wheelers[a]</td><td>4,416</td><td colspan="2">10</td><td>n.a.</td></tr>
<tr><td>3- and 4-Wheelers[b]</td><td>908</td><td colspan="2">7</td><td>n.a.</td></tr>
<tr><td>Passenger Vehicles[c]</td><td>5,032</td><td>1,512</td><td>14,350</td><td>n.a.</td></tr>
<tr><td>Buses and Minibuses[d]</td><td>138</td><td colspan="2">13</td><td>n.a.</td></tr>
<tr><td>Medium and Heavy Weight Trucks[e]</td><td>1,070</td><td colspan="2">7</td><td>n.a.</td></tr>
<tr><td>Totals</td><td>11,564</td><td colspan="2">15,899</td><td>n.a.</td></tr>
</table>

n.a. = not available
[a] UNECE categories L1e,L3e
[b] UNECE categories L5e + L7e = 608; L2e + L6e = 300
[c] UNECE categories M1
[d] UNECE categories M2-M3
[e] UNECE categories N1-N3
Statistik Austria doesn’t differentiate between PHEVs and HEVs (except for passenger cars), lightweight 3 and 4-wheelers and different truck types.

[21] www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/verkehr/index.html

Table 3: Prices of some of the most popular PHEV and BEV passenger models (Data source: topprodukte.at in February/March 2016)

Market-Price Comparison of Selected EVs and PHEVs in Austria	
Available Passenger Vehicles	**Sales Price incl. Tax (in EUR)**
BMW i8	137,000
Opel Ampera	38,400
Porsche Panamera S E- Hybrid	104,340
Porsche Cayenne S	85,410
Toyota Prius Plug-in Hybrid	37,920
Volvo V60 Twin Engine	30,350
BMW i3	35,700
Kia Soul EV	31,990
Mercedes B-Klasse Electric Drive	33,167
Nissan Leaf	22,661
Renault Kangoo	24,576
Renault Zoe	21,690
Smart Fortwo electronic drive	24,590
Tesla Model S 85	93,300
VW e-up!	26,210

20.3 Charging Infrastructure or EVSE

Regarding the development of diesel and gasoline prices, Austria is one of the cheapest countries within the EU. Thus, December 2015 was the cheapest month for refilling a conventional car in Austria since February 2010[22]. By 7 December 2015, as an average at Austrian petrol stations Eurosuper cost 1.128 EUR/l (EU average is 1.328 EUR/l) and diesel cost 1.041 EUR/l (EU average is 1.161 EUR/l) including taxes[23]. By 31 December 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/station) and Romania at the low end (9,811 person/station).

Beside conventional petrol stations, the number of alternative filling stations has increased in recent years (see Table 4). Today, there are approximately 171 public filling stations in Austria with CNG dispensers. Remarkably, in 2015 Austria was the absolute champion in terms of number of CNG filling stations compared with

[22] http://www.bmwfw.gv.at/EnergieUndBergbau/Energiepreise/Seiten/MonitorTreibstoff.aspx?Report=9
[23] http://www.ots.at/presseaussendung/OTS_20151211_OTS0207/treibstoffpreise-eurosuper-ist-um-20-cent-pro-liter-und-diesel-um-12-cent-pro-liter-billiger-als-im-eu-schnitt

the size of the country (best CNG coverage in Europe). Due to the fact that there is no “official” map of electric charging stations (EVSE) available in Austria, it is difficult to represent the exact number of EVSE. One EVSE can host several individual charging points. In Austria, EVSE’s are counted by the number of stations rather than the number of plugs in a charging station. There were 3,400 in total and 1,705 public charging stations (18 DC fast charging) installed as of December 2015.

Table 4: Filling stations for alternative fuels and conventional gas stations in Austria (Data source: Fachverband der Mineralölindustrie, Mineralölbericht 2015[24])

Filling Stations	2012	2013	2014	2015
CNG (public)	146	175	174	171
LPG	32	36	38	38
Biogas	1	3	3	3
E85	28	33	33	29
Electric vehicle (Public charging station - Level 2 AC)	1,060	1,160	1,449	1,705
Hydrogen (Public station)	1	1	1	3
Vegetable oil	19	20	20	20
Conventional (Public)	2,575	2,515	2,640	2,622

[24] www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/verkehr/index.html

21 Belgium

21.1 Major Developments in 2015

21.1.1 Electric Mobility in Belgium

The vehicle industry in Belgium is in a transition to a clean and smart mobility industry. The vehicle industry has always been an important industrial sector in Belgium, but especially the car assembly has been under severe pressure for the past years. With the closure of the Ford Genk factory in 2014, we lost 10,000 direct and indirect jobs. 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 this factory closure. For future job creation, our industry has to make the right choices and has to be very efficient and innovative. Within the automotive sector, it is not only about making and selling vehicles anymore. It is about offering a clean, comfortable and cost-efficient mobility service to the end customer. Electric vehicles can play an important role, especially when we combine this with the growth of renewable energy sources in our energy supply. The transport and energy sector will get more and more interlinked and this creates new economic opportunities for companies in this new e-mobility value chain (vehicles, charging infrastructure, ICT, mobility and energy services). For more information see the chapter on Task 24 "Economic impact assessment of e-mobility" on page 87.

Today, Belgium still hosts two car assembly plants: Audi in Brussels and Volvo Cars in Ghent. Both OEMs are active in the field of electric mobility.

Volvo Cars has been producing cars in Ghent since 1965. 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. The number of jobs at Volvo Cars Ghent has been growing above 5,000 employees.

After successful testing of the pure electric Volvo C30 prototype, Volvo Cars is now moving ahead with its electrification program. The existing Volvo V60 plug-in hybrid, which is currently built in Volvo's assembly plant in Gothenburg, will move to Volvo Car Ghent in early 2016. After the phase out of this model, Volvo will further expand its hybrid program, with estimates to 10 % of the model range being hybrid or pure electric vehicles. Electrification is planned for both the compact and the large cars.

Figure 1: Electrification program moving ahead at Volvo Cars (Source: Volvo Cars)

Audi Brussels made a big announcement related to electric vehicles. Up to now it produces about 115,000 cars (Audi A1) per year and has 2,500 employees. But Audi is also preparing its international production network for the mobility of the future. Large series production of the first purely electric driven SUV from Audi will begin at the site in Brussels in 2018. The plant will also produce its own batteries. The company will transfer the production of the Audi A1 from Belgium to Martorell in Spain.

Figure 2: Audi e-tron quattro concept study at Frankfurt Motor Show 2015 (Source: Audi)

As of 2018, Audi Brussels will exclusively produce the first battery-electric SUV from Audi for the world market. The Audi e-tron quattro concept study that was presented at the Frankfurt Motor Show in 2015 provides a clear indication of the final production version. The Brussels plant will also have its own battery production. The site in Belgium will thus become a key plant for electric mobility at the Volkswagen Group.

Besides car assembly, Belgium has a lot of other activities in the automotive sector. Toyota Motor Europe has its European headquarter, logistics centres, and technical R&D centre in Belgium and the country has about 300 local automotive suppliers. There are assembly plants for trucks (Volvo Europa Trucks) and for buses (Van Hool and VDL Bus Roeselare) in Belgium.

Busworld Europe Kortrijk 2015[25] proved that the market of electric buses is in full expansion. Belgian bus companies Van Hool and VDL Bus Roeselare are very active in this field.

Van Hool presented its inductively charged electric buses driving in the city of Bruges during the Busworld 2015 (for more information see chapter EV Demonstration Projects). With EquiCity, Van Hool developed an innovative concept for sustainable public transport in which hybrid, battery electric, or fuel cell powertrain can be integrated. Van Hool is also the coordinator for important European projects like 3EMotion, in which 21 Fuel Cell Buses will be introduced used in Rotterdam, London, Antwerp, Cherbourg, and Rome.

VDL Bus Roeselare, part of VDL Bus and Coach, is going to deliver approximately 40 Citeas SLFA Electric buses in 2016 for the Zuidoost-Brabant concession. The tender was issued by the Province of Noord-Brabant in the Netherlands with the objective of transitioning to entirely zero emission public transport in the period of 2016-2025.

Figure 3: Citeas SLFA Electric bus (Source: VDL Bus Roeselare)

The VDL Citea SLFA Electric is an electric articulated bus with a length of 18.1 metres built in an updated, futuristic BRT (Bus Rapid Transit) design. The buses will be operated in high-frequency lines under the name ‘Evolans’. Charging will

[25] www.busworld.org

be done at the bus stops via a quick charging system on the roof. VDL Bus Roeselare is also delivering 120 hybrid buses to the Flemish public transport operator De Lijn and electric buses to cities in Germany. Development and production of the electric buses is taking place in Belgium at VDL Bus Roeselare.

We also see developments in other types of electric vehicles like electric cargo-bikes (TheOpportunityFactory), city distribution vehicles (E-trucks, Addax Motors), or light electric vehicles (Green Urban Mobile, Altreonic).

Figure 4: Green Urban Mobile (Source: Flanders' MAKE)

Belgium has a large group of suppliers to the automotive industry. A lot of the innovations in the automotive sector are taking place on the suppliers side. In Belgium we have suppliers like e.g. Umicore, LMS International, Melexis, PEC, Leclanché, DAF, and Punch Powertrain. Most of these companies are active in electric mobility.

More information about the Belgian vehicle industry can be found on following websites:

- **www.beautomotive.be** is the homepage of the Belgian vehicle industry. The sector represents about 300 companies and 70,000 employees, or 10 % of the Belgian export. Beautomotive.be brings together information on relevant companies, events, job opportunities, and news items from the sector, covering the topics innovation, technology, talent, investments, and internationalisation.
- **www.asbe.be** is the Belgian section of the European AVERE network for manufacturers, suppliers, importers and distributors of electrically propelled vehicles (battery, hybrid, fuel cell) and accessories. The purpose of the

association is to promote the use of battery-electric, hybrid, and fuel cell electric vehicles and supporting scientific and technological developments.

21.1.2 Research Related to Electric Mobility in Belgium

The Belgian automotive industry is ready for a transition to a green and smart mobility industry.

Many new research and demonstration projects related to electric mobility have been set up in 2015 together with research partners like e.g. Flanders' MAKE, VUB-MOBI, and VITO/EnergyVille.

The list of projects is too long to summarize in the country report, so we recommend taking a look at following websites:

- VUB-MOBI: **mobi.vub.ac.be**
- Flanders' MAKE: **www.flandersmake.be**
- VITO/EnergyVille: **www.vito.be** and **www.energyville.be**

21.1.3 Policy Framework Alternative Fuels in Belgium

An important introduction of alternative fuels (not only electricity but also gas (CNG/LNG), hydrogen, etc.) in our transport sector could generate significant opportunities for Belgium and Europe, for example: the reduction of our oil dependence, the integration of renewable energy in the transport sector, the strengthening of our economy and additional employment, the improvement of air and sound quality, and the fight against climate change.

Regardless of all these opportunities, a significant introduction of alternative fuels such as electricity and gas for vehicles is still lacking in Belgium. This is mainly due to some persisting barriers that are difficult to overcome, such as:

- higher purchase price of electric vehicles (and to a lesser extent gas vehicles)
- the lack of charging infrastructure
- the lack of objective and correct information (which causes prejudices among consumers)

Moreover, there are many scattered initiatives throughout Belgium (federal and regional level). The Federal Public Service of Economy's current task is to coordinate them in order to converge towards a common goal, i.e., a goal which is in line with the initiatives taken by Europe.

In that respect – and as stipulated by the EU Directive 2014/94 regarding the deployment of alternative fuel infrastructure – Belgium is currently developing a national policy framework regarding alternative transport fuels/infrastructure (electricity, CNG/LNG, hydrogen), as stipulated in the Directive 2014/94 on the deployment of alternative fuels infrastructure. The national policy framework will be communicated to the European Commission, at the latest on 18 November 2016.

The Regions of Belgium (i.e. Flemish Region, Walloon Region and Brussels-Capital Region) are competent for most aspects of the Directive (focus on infrastructure). The Federal Public Service of Economy and the Federal Public Service of Mobility and Transport (federal government of Belgium) are coordinating the national concertation and development of the Belgian policy framework.

A mixed government steering group (Energy-Transport) was created in 2013. All concerned energy and transport departments (regional and federal) are represented in this group.

21.1.4 Policy Framework Alternative Fuels in Flanders

At the end of 2015, the Flemish government approved an action plan “Clean Power for Transport” to stimulate the use of alternatively fueled vehicles and related infrastructure.

The action plan starts from the point of view that electrification of transport, combined with renewable energy, has the best perspective at the moment to reach a carbon-free environment friendly transport system. Therefore, the action plan aims in the first place at supporting the break-through of electric mobility (BEV, PHEV, FCEV) but also offers changes for the use of more natural gas in transportation on the road and on the water.

Table 1: Action plan announced by the Flemish government at the end of 2015

Action plan	
Vehicle Targets 2020	**Infrastructure Targets 2020**
• Battery electric vehicles: 60,500 • Plug-in hybrid vehicles: 13,600 • CNG: 41,100	• EV charging points: 7,400 • CNG: 300H • Hydrogen: 20

The most important actions want to stimulate the market by removing barriers like the high purchase cost, an appropriate public charging infrastructure and objective information on electric mobility. All communication related to this action plan can be found on the following website: **www.milieuvriendelijkevoertuigen.be**.

This website contains a lot of valuable information for existing and potential end users of electric vehicles. A TCO simulation tool gives the end users the chance to compare lots of different vehicles by taking all costs and incentives into account.

Related to the action plan a lot of new measures have been set-up for electric vehicles:

- Zero emission bonus for people buying an electric vehicle: max. 5,000 EUR and digressive in time (2016-2019)
- Exemption from registration tax
- Lowest rate of tax under the circulation tax
- Measures for an improved public charging infrastructure: more public charging points in 2020, an open and interoperable network (via “code-of-conducts”), a database for a centralised overview, new market model strategies like the role of market players like DSO’s for a basic public charging infrastructure, new services to owners of electric vehicles without their own garage to ask for a charge point under certain conditions (“Station follows Car” concept)
- Multi-stakeholder working groups

In the next chapters you can see that these measures already have had a first effect on the market of electric mobility.

21.1.5 Low-Emission Zones in Flanders (LEZ)

Cities in Flanders can introduce low-emission zones starting from March 2016. This is a new police measure to give cities an extra alternative to improve the local air-quality by keeping polluting vehicles outside certain areas in the city. the first city to introduce a low-emission zone will be Antwerp starting in February 2017.

Figure 5: Green Urban Mobile (Source: Flanders' MAKE)

21.1.6 Electric Vehicle Deployment Plan

The Brussels Capital Region is also developing an electric vehicle deployment plan. Currently, EV infrastructure scenarios are developed based on VUB-MOBI's GIS-based optimal charging location analyser.

21.2 HEVs, PHEVs and EVs on the Road

The number of electric vehicles in Belgium has been growing quickly during 2015 and especially at the beginning of 2016. A combination of the new policy measures mentioned above and the Brussels Motor Show in January 2016, led to a big sales increase.

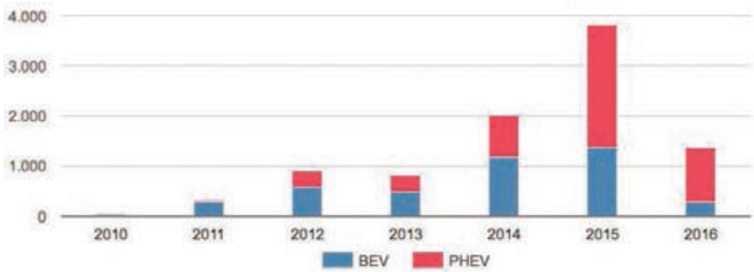

Figure 6: PEV (M1) market share in Belgium (Source: EAFO).

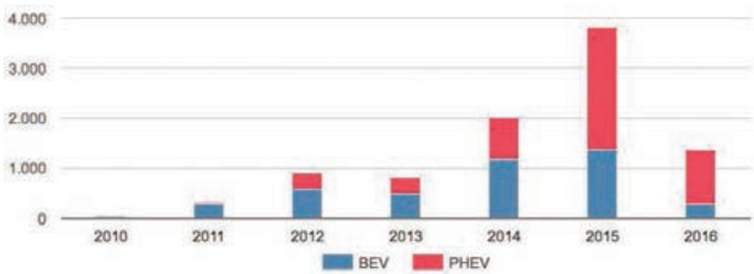

Figure 7: New registrations for PEV (M1) in Belgium (Source: EAFO; the statistics for 2016 in both Figures 7 and 8 contain data for January and February, only)

We see that the sales of 2015 almost doubled compared to 2014 and in the first two months of 2016 more electric vehicles have been sold than in e.g. the whole of 2013. Most sold electric vehicles since 2015 are PHEV's with top sellers like Volvo XC90, BMW X5 40e and Porsche Cayenne. Within the BEV's the top sellers are Tesla Model S and Nissan Leaf.

For more information on the number of electric vehicles on the road in Belgium we refer to the website of the European Alternative Fuels Observatory: **http://www.eafo.eu**. The European Alternative Fuels Observatory has been launched in 2016 and will collect information about the electric vehicles market in Europe. The geographical scope consists of all EU Member States plus the EFTA members (Iceland, Norway, Switzerland, and Liechtenstein) and Turkey. The update frequency for the statistics will be: monthly for passenger cars; quarterly for all other vehicles and infrastructures (if data available). Legislation and incentives will be updated upon changes. Consortium Partners of EAFO are: AVERE, the European Association for Electromobility as project coordinator and data collection; POLIS - a leading association of cities; the VUB and TNO as research and analysis partners and Tobania as IT provider.

21.3 Charging Infrastructure or EVSE

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. For previous annual reports, we collected this information via a survey sent to the different market players in Belgium. But this only gave a rough idea of how this charging infrastructure market is growing and which companies are active in this market.

Drivers of an electric vehicle need much more detailed real-time information on the charging infrastructure: location, ways of access, availability, prices, etc. There is still a long way to go, because all information at the moment is scattered over different databases/websites/apps and not always up-to-date and certainly not available in a standardised way. Thus, big improvements are needed in user-friendly access to charging infrastructure information.

Triggered by the end customer needs and by the European and national/regional governments, the market for charging infrastructure is trying to organize itself at aiming for an open and interoperable charging network. In Belgium, this process started already in the Flemish Living Lab Electric Vehicles (2011-2014) within the interoperability working group. Afterwards, different initiatives like EVORA and OpenChargePoint.be continued this huge effort of bringing the different stakeholders together to set-up a “code-of-conducts”.

21.3.1 EVORA: the Flemish Platform for Public Charging (2014-2015)

Electric vehicles are eminently city vehicles. At the end of 2014, the EVORA platform was initiated by the car importers Audi/Volkswagen, BMW, Nissan, and Renault, the cities of Antwerp, Hasselt, Leuven, Mechelen, and Sint-Truiden, the distribution network operators Eandis and Infrax, Blue Mobility, and The New Drive. The EVORA platform is an action and discussion platform for all Flemish based actors in the public charging value chain, which aims at creating a solution for public charging in a city context in 2015, and applying it in real life in 2016. The base question of EVORA is: how can city inhabitants without their own garage or driveway charge electric vehicles in a sustainable way?

EVORA is unique as an EV platform, since it created a multi-stakeholder coalition of the willing that developed a consensus on multiple models on how public charging in a city context should be addressed. Instead of launching pilots in several cities, which was the original set-up of EVORA, private and public stakeholders co-created multiple policy plans, on how to create a sustainable roll-out of public charging stations in five major Flemish cities. These plans include local government policy, roll-out strategy, business cases and financing options, and the charging market model. The main three pillars of these plans are “Station follows Car”, the “Ladder of Charging”, and “Public charging Uniformity”.

Firstly, “Station follows Car” means that Flemish cities will follow a reactive roll-out strategy, meaning that charging stations will mostly be installed based on market demand. In reality, this means that a charging station will be installed in the neighborhood of a citizen, when the citizen buys an electric vehicle. During the nights the public charging infrastructure is used by the inhabitants, during the day by the city visitors. The consequence is that charging infrastructure is effectively used, and that a business case may be possible. Apart from a reactive roll-out strategy some strategically positioned stations can be placed in a proactive roll-out, especially for visitors.

Secondly, the “Ladder of Charging” means that when a citizen requests a charging station, certain steps (of the Ladder) will be followed. First, the city or charge point operator (CPO) will check whether the citizen can charge on their own terrain. If this is the case, the citizen has to organize infrastructure for himself. If not, the city or CPO checks the availability of nearby charging infrastructure, within a range of 250 meters. If no infrastructure is available, infrastructure will be organized in publicly accessible terrain on private grounds (e.g. parking lots, retail stores, apartments or leisure buildings). If this is not possible, the infrastructure will be placed in the public domain, which is the most expensive option.

Figure 8: Handover EVORA "Public Charging Code" to Flemish Minister of Energy (Source: EVORA)

Finally, more than 30 public and private stakeholders co-developed a "Public Charging Code", in which the main and basic conditions for public accessible charging are described. This Code will be used as a standard in Flanders, as it was also referred to in the Flemish EV policy. The Code covers topics such as charging definitions, conditions for accessibility, payment standards and interoperability.

21.3.2 OpenChargePoint Belgium

A new sector organisation of charge point operators active in Belgium has been set-up during 2015. The founding members (Allego, Blue Corner, Eneco Belgium, EV-Box Belux, EV Point, and The New Motion) signed the "code-of-conduct" during an event at the Brussels Motor Show 2016 in the presence of the Flemish Minister of Energy Annemie Turtelboom.

Figure 9: Press event OpenChargePoint Belgium at Brussels Motor Show (Source: OpenChargePoint Belgium)

The organisation is open for other charge point operators and aims at creating an open, reliable and interoperable charging network in Belgium. This initiative supports the policy plans within the Flemish government related to the “clean power for transport” directive.

21.3.3 Statistics on Charging Infrastructure in Belgium

For the statistics on charging infrastructure in Belgium we refer to the website of EAFO[26]. For more details on electric vehicles charging points and CNG/hydrogen filling stations we also refer to the databases on the website related to the Flemish action plan – clean power for transport[27].

21.4 EV Demonstration Projects

21.4.1 E-Taxis

“From 2020 all taxis in Flanders will drive electric”. At least that’s the premise of a unique research project of the Association for a Better Environment (BBL) and the National Grouping of Enterprises with Taxi and Location vehicles with driver (GTL).

Figure 10: E-taxi type Mercedes B-Class Electric Drive in Antwerp (Source: DTM Taxi)

The examination includes a test phase with two Flemish e-taxis in Antwerp and a comprehensive survey of the entire taxi sector. The project is in collaboration with The New Drive, research institute MOBI of the Brussels University, taxi company DTM and with the financial support of FIDO, the Federal Institute for Sustainable Development. This e-taxi project will be examined on how feasible it is to make the taxi fleet electric in Flanders by 2020 and what the economic and ecological

[26] www.eafo.eu/content/belgium#country_charging_plugs_graph_anchor
[27] www.milieuvriendelijkevoertuigen.be

impact is. At the end of the project, BBL will communicate the results and recommendations to the appropriate authorities.

In Brussels, the taxi sector made its first steps in introducing electric vehicles in its fleet already at the end of 2014. The operation seems to be successful. However, while waiting for the next client, electric taxis have to make use of fast charging infrastructure and there is a lack of fast chargers. Therefore, today these electric taxis in Brussels have to rely on the fast chargers at VUB-MOBI and Engie Electrabel.

21.4.2 Inductive Charging of Electric Buses in Bruges

Within the framework of the Flemish Living Lab Electric Vehicles, the first project with inductive charging for electric busses in daily operation started up in the city of Bruges. Since October 2015, three electric buses built by Van Hool with batteries from Leclanché (previous Trineuron) are in use by public transport operator De Lijn. The buses are being quick charged via an inductive charging station, Primove, from Bombardier.

Figure 11: Electric bus inductively charged in the city of Bruges (Source: www.benweyts.be)

21.4.3 Automated Fast Chargers to Power Electric Buses in Namur's Public Transport System

Eleven new Volvo electric buses will run within a new zero-emissions zone inside Walloon region's capital city Namur. The new bus service is planned to be operational by the end of 2016.

The electric buses will be charged via two new automated fast charging systems from ABB. The fast charger modular design, with powers of 150 kW, 300 kW, or 450 kW, accommodates any electric bus system. The fast-charging solutions are based on IEC 61851-23, the international standard for fast charging electric vehicles. This ensures that the appropriate safety systems are in place, the electrical design is in accordance with regulations, and the systems architecture and working principles are supported by a wider automotive community in the future.

Such automated fast chargers play an important role in opportunity charging, where instead of returning the bus to a depot to connect to an individual charger, the bus is recharged in minutes each time it arrives at an end station. This allows the bus to have a smaller, lighter battery pack which increases passenger capacity. Because they are not returned to the depot for charging, the buses are able to run more routes, improving service for commuters. These benefits reduce the total cost of ownership for the city. The quiet and clean Volvo 7900 buses are designed for zero-emission areas and silent or safety zones. The buses extend their reach and flexibility when needed with a small diesel engine. They create possibilities to open new routes and stops in areas that were not possible before.

21.4.4 Swap2driveE

Another option to recharge an electric vehicle is by swapping the empty battery with a full battery. Within Belgium, a first demonstration project is being set-up with the development of the Swap2drivE concept. A first prototype has been built at the Vives Highschool in Kortrijk. More recently, together with Bubble Post (see also the project with electric trikes, below), a Zero Emission Cold Chain Logistics Supply model (e.g. for supply of food, etc.) has been conceived, where the energy for the cooling element comes from swappable batteries.

21.4.5 City Distribution Based on Electric Trikes

Companies like CityDepot and Bubble Post are continuously improving its activities in Belgium to use electric vehicles for the “last-mile” deliveries of goods in cities.

Bubble Post invested in the development of urban trikes for city distribution. The electric tricycles (trikes) are capable of transporting up to 2 m^3 – 250 kg. As they are legally bikes, they can deliver goods in city centers in the most efficient, flexible and sustainable way.

Besides trikes also electric vans and small trucks are being used for the delivery of goods in city centers.

Figure 12: City deliveries with electric trikes (Source: Bubble Post)

21.5 Outlook

GEAR 2030: Belgium is represented by Flanders' minister of innovation, Mr Muyters in the High Level Group on Automotive Industry GEAR 2030, that started its activities in early 2016 to make recommendations to reinforce the competitiveness of the European automotive value chain, in particular developing a roadmap for the connected and automated vehicles. Within the context of AVICA, Flanders' MAKE is working on the realisation of self-driving buses that consider other road users and are able to participate in public road transport. This is a logical next step following the self-driving vehicles that are already in use for instance in agriculture fields.

The use of electric vehicles in new mobility services, the improvement of important components like batteries, higher end user comfort/trust and the seamless integration of electric vehicles in a smart grid environment are still high on the research agenda within Horizon 2020. Research centres like VUB-MOBI, Flanders' MAKE and VITO/EnergyVille are therefore setting up a lot of new research projects on these topics in close collaboration with the industry/governments to further improve the ecologic and economic benefits from electric mobility for society.

22 Canada

22.1 Major Developments in 2015

22.1.1 National Developments

Canada's federal government, elected in October 2015, is committed to taking action on climate change and in investing in clean technologies. Canada signed onto Mission Innovation, a global partnership announced during the first day of the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21). Mission Innovation seeks to double government investment over the next five years in clean energy research and development, and to spur private sector investment in clean technology[28].

As part of the Government of Canada's efforts to promote a clean environment and a strong economy, Canada is committed to investing an additional 77.2 million USD each year in clean technology producers and tackling Canada's most pressing environmental challenges. The Government of Canada will also invest an additional 154.4 million USD each year to support innovation and the use of clean technologies in the natural resources sector. Clean energy research and development will be one of the areas of focus[29].

Also at COP 21, the Government of Canada, as a member of the Clean Energy Ministerial – Electric Vehicles Initiative (EVI), supported the Paris Declaration on Electro-Mobility and Climate Change. Partners to the Declaration, including governments at all levels, businesses, and other organizations, commit to broaden their efforts towards sustainable transport electrification. This includes a commitment to electrify 20 % of all road vehicles (cars, 2 and 3-wheelers, trucks, buses and others) by 2030. EVI is a multi-government policy forum established in the framework of the Clean Energy Ministerial and dedicated to accelerating the introduction and adoption of electric vehicles worldwide. In particular, EVI seeks to facilitate the global deployment of 20 million electric vehicles, including plug-in hybrid electric and fuel cell vehicles, by 2020.

[28] http://pm.gc.ca/eng/news/2015/11/30/prime-minister-announces-action-clean-jobs-and-energy
[29] http://pm.gc.ca/eng/news/canadas-participation-mission-innovation

22.1.2 Federal Budget 2016

Investing in Electric Vehicle and Alternative Transportation Fuels Infrastructure. The government recognized that early action is needed to support the transition to low-carbon transportation fuels, as vehicle choices made today will determine the mix of technologies on the road in 2030, and committed to increase spending on Green Infrastructure by 3.8 billion USD over the next five years, including on technologies such as electric vehicle charging infrastructure.

Budget 2016[30] invested 48.3 million USD over two years, starting in 2016-2017, to Natural Resources Canada to support the deployment of infrastructure for alternative transportation fuels, including charging infrastructure for electric vehicles and natural gas and hydrogen refueling stations. The Government will advance these objectives by working with provinces and territories, municipalities and the private sector. These resources will also support technology demonstration projects that advance electric vehicle charging technology.

22.1.3 Expanding Tax Support for Clean Energy

The income tax system encourages businesses to invest in clean energy generation and energy efficiency equipment by providing accelerated capital cost allowance (CCA) rates. CCA Classes 43.1 and 43.2 provide accelerated CCA rates (30 % and 50 % respectively on a declining balance basis) for investments in specified clean energy generation and conservation equipment. The assets in these classes include eligible equipment that generates or conserves energy by using a renewable energy source, using a fuel from waste or making efficient use of fossil fuels.

The government proposes to add electricity storage technologies and electric vehicle charging stations to the list of investments that are eligible for accelerated CCA, meaning the assets can be fully depreciated for tax purposes within a reduced time period. The budget proposes to expand Classes 43.1 and 43.2 to include electric vehicle charging stations based on whether they meet certain power thresholds. Class 43.1 will include those charging stations set up to supply more than 10 kilowatts but less than 90 kilowatts of continuous power. Class 43.2 will include electric vehicle charging stations set up to supply at least 90 kilowatts of continuous power.

22.1.4 Moving to a Cleaner Transportation Sector

The transportation sector represented 23 % of Canada's greenhouse gas emissions in 2013, and is the second largest source of emissions in Canada. It is also a significant source of air pollution.

[30] www.budget.gc.ca/2016/docs/plan/budget2016-en.pdf

Budget 2016 proposes to provide 44 million USD over two years, starting in 2016-2017, to Transport Canada and Environment and Climate Change Canada to support the transition to a cleaner transportation sector, including through the development of regulations and standards for clean transportation technology. Funding will also support Canada's continued participation in the development of international emissions standards for emissions from the international aviation, marine and rail sectors, including through the International Maritime Organization and the International Civil Aviation Organization.

22.1.5 Electric Vehicle Deployment Roadmap

Under a mandate from Natural Resources Canada, Electric Mobility Canada (EMC) developed an update to the 2010 Electric Vehicle Technology Roadmap for Canada[31]. This new document entitled "Roadmap for Accelerating the Deployment of Electric Vehicles in Canada 2016-2020"[32] recommends high-priority strategies and concrete actions to increase the share of EVs in Canada over the 2016-2020 time period. This roadmap was developed in consultation with EMC members and various stakeholders, and it outlines a number of recommendations that address the following areas: public awareness, incentives, infrastructure, research and development (R&D), codes and standards, car-sharing, and public transit. EMC is a national not-for-profit organization dedicated to the electrification of transportation in Canada.

22.1.6 Provincial Policies and Incentives

British Columbia. The Province of British Columbia's Clean Energy Vehicle (CEV) Program[33] Phase 2 was introduced in April 2015 and is based on the success of Phase 1 and public requests for additional funds. The first phase of the incentives program ended when allocated funds were exhausted in February 2014. The second phase of the program received 8.1 million USD from the Innovative Clean Energy (ICE) Fund, and provides for the following components: 5.8 million USD for vehicle point-of-sale incentives, 1 million USD for charging infrastructure incentives and investments in Level 2 and DC Fast Charging infrastructure. It also provides 0.23 million USD for one new public hydrogen fuelling station, 0.73 million USD for investment bonuses for the CEV fleet program, and finally 0.4 million USD for research, training and public outreach.

Due to tremendous uptake of the newly reintroduced vehicle purchase incentives, the province of BC injected an additional 5.32 million USD into the CEV program

31 https://emc-mec.ca/wp-content/uploads/ElectricVehicleTechnologyRoadmap_e.pdf
32 https://emc-mec.ca/wp-content/uploads/EMC-EV-Roadmap_Final-Report.pdf
33 British Columbia Clean Energy Vehicle Program

in early 2016. The program offers the same level of incentives, namely 3,850 USD off the pre-tax sticker price for qualifying new BEVs and PHEVs, and up to 4,650 USD for hydrogen fuel cell vehicles. The B.C. Scrap-It Program enhances these policies by providing a 2,500 USD incentive to scrap an aging gasoline powered vehicle in favour of a more efficient one. This incentive can be stacked with the EV purchase incentives.

The CEV Program vision is to stimulate the market such that by 2020, 5 % of new light duty vehicle purchases in British Columbia are clean energy vehicles[34]. BC has also signed the Pacific Coast Collaborative Agreement[35], with the states of Alaska, California, Oregon, and Washington in October 2013. This agreement established a non-mandatory target for EV sales to make up 10 % of new vehicles purchases in public and private fleets by 2016.

Ontario. The province of Ontario's Climate Change Strategy[36] released in December 2015 acknowledges that EVs and PHEVs will play an essential role in the province's GHG emissions reduction strategy, which aims to reach reductions of 80 % below 1990 levels by 2050, and build a prosperous low-carbon economy. Based on the positive experience from their previous efforts, the province made changes to the Electric Vehicle Incentive Program (EVIP)[37] in February 2016. In an effort to modernize the program, the objectives include: making EVs more affordable; providing additional incentives for EVs with large batteries, as well as for those with greater passenger capacity for carpooling; and introducing a cap on the incentive for luxury vehicles. The Green Licence plate program, which had been set to expire on 30 June, 2015, was extended for an additional year. The Green Investment Fund also made a commitment in late 2015 to provide 15.4 million USD for the development of public-private partnerships that would deploy a growing EV charging network in the province through the Electric Vehicle Chargers Ontario (EVCO) Program[38]. The partnerships emphasize the importance of installing chargers in cities, along highways and at workplaces, apartments, condominiums, and public places across Ontario. Over 200 applications to the EVCO Program were received between 21 December, 2015 and 12 February, 2016, totalling more than 127.3 million USD in grant requests[39]. A total of 27 public and private sector partners will share the 15.4 million USD in provincial funding to build a total of 280 Level 2 and 213 DCFC - EV charging stations across Ontario[40].

[34] www.cevforbc.ca/clean-energy-vehicle-program
[35] Pacific Coast Collaborative - Climate Action Plan
[36] Ontario Climate Change Strategy
[37] www.mto.gov.on.ca/english/vehicles/electric/electric-vehicle-incentive-program.shtml
[38] www.mto.gov.on.ca/english/vehicles/electric/electric-vehicle-chargers-ontario.shtml
[39] https://news.ontario.ca/mto/en/2016/04/ontario-building-more-electric-vehicle-charging-stations.html
[40] https://news.ontario.ca/mto/en/2016/04/funding-for-electric-vehicle-charging-stations.html

Québec. As part of Québec's Transportation Electrification Action Plan 2015–2020, *Propelling Québec Forward with Electricity*[41], the province has put in place a robust suite of electric vehicle policies aimed at reaching 100,000 BEV and PHEV registrations in the province by 2020. Leading by example, the government has also committed to adding 1,000 EVs to its own fleet. Québec's abundance of clean hydroelectricity, which is both highly reliable and low-cost, provides a strong basis for the deployment of EVs within the province. A large-scale rollout of EVs using Québec's renewable energy will significantly help reduce greenhouse gas emissions related to personal transportation.

Figure 1: Nissan LEAF on Canadian roadway (Image courtesy of L. Wilkens)

The Action Plan centres on the three following reinforcing policy directions, each supported by a series of measures.

- Promoting Electric Transportation: uses incentive mechanisms and infrastructure investments to promote increasingly electrified public transit, light passenger vehicle, and freight transportation. This includes the flagship Roulez Electrique[42] (Drive electric) rebate program that provides up to 6,200 USD on the purchase or lease of EVs. A key aspect of this policy direction is the development of partnerships for charging infrastructure.
- Developing the Industry: supports innovation, market development, and foreign investment in the Québec EV sector. Part of this includes introducing a college certificate and university graduate level education programs in transportation electrification.
- Creating a Favourable Environment: involves the development of modern policies with regard to motor vehicles, including proposing regulatory changes and supporting urban planning, such that EV investment becomes more favourable. Measures include the introduction of free access to certain toll bridges and ferries as of 1 January, 2016, changes to the Construction Code for the installation of EV charging stations, and changes to the Highway Safety Code to regulate access to parking spaces equipped with charging stations.

[41] www.transportselectriques.gouv.qc.ca/en
[42] http://vehiculeselectriques.gouv.qc.ca/english

Table 1: Direct Policy Support for EVs or Charging Infrastructure

Province	Policy Instrument
British Columbia 	**Purchase Incentives** • As of 1 April 2015, rebates of up to 3,850 USD will be available for the purchase or lease of new BEVs and PHEVs, and up to 4,650 USD for hydrogen FCVs. • As of 2 March, 2016, vehicles with an MSRP of over 60,000 USD shall not be considered eligible for the incentive rebate. • Scrap-It Program provides an incentive of up to 2,500 USD to scrap your older gasoline powered vehicle, which can be stacked with EV incentives. **HOV lane / EV permit and decal** • EVs displaying an official decal are allowed in high occupancy vehicle (HOV) lanes in British Columbia regardless of the number of passengers in the car, unless a sign is posted indicating otherwise.
Ontario 	**Purchase incentives** • New suite of incentives announced in February 2016 • Rebate for BEV and PHEVs increased to 4,650-7,750 USD; based on the battery capacity between 5-16 kWh • 2,300 USD add-on incentive for batteries 16kWh or larger • 750 USD add-on incentive for vehicles with 5 or more seats • Incentives for vehicles with MSRP of 58,000-116,000 USD restricted to 2,300 USD • 50 % of the total purchase and installation cost of home Level 2 EV charger, up to a maximum of 390 USD **Green licence plates** • Until 30 June, 2016, EVs with green licence plates will be granted access to HOV lanes on 400-series highways and the QEW, even if there is only one person in the car. **Green Investment Fund** • 15.4 million USD grant program to develop partnerships for a network of fast-charging electric vehicle stations in cities, along highways and at workplaces, apartments, condominiums and public places across Ontario.
Québec 	**Transportation Electrification Action Plan 2015 –2020** Several major initiatives, representing 325 million USD in investments are under way, including: • Electric public transport incentives • EV infrastructure investment (e.g. charging stations) • Freight electrification • RD&D for electric vehicle technology • Marketing/foreign investment incentives • New policy frameworks to support deployment **Drive Electric Program** • Purchase rebate on eligible EVs of up to 6,200 USD • Purchase rebate for Level 2 EV charging stations up to 270 USD for equipment and 195 USD for installation **Green License Plates** • Free access to certain highway lanes, toll bridges and to ferry services, as of 1 January, 2016.
New Brunswick	**Free Public Charging Network** NB Power, the province's electric utility, has installed 7 smart EV chargers in urban centers that are accessible to the public, free of charge[43]
Newfoundland	**Green Fund** Announced 40,000 USD in 2015 to help pay for the installation of 5 residential and 14 commercial Level 2 EV chargers across the province[44].

[43] www.nbpower.com/en/smart-habits/smart-grid/electric-vehicles
[44] www.releases.gov.nl.ca/releases/2015/env/0218n08.aspx

22.2 HEVs, PHEVs and EVs on the Road

Canadian EV sales showed a positive trend with a 32 % increase in sales from 2014. This is lower than the increase from the previous years, which was approximately 67 %, however, there is still a strong interest from Canadian consumers considering the negative sales trend happening in the United States (-5%). As in the previous years, EV purchases continued to be concentrated within provinces offering direct incentives. As discussed in section 20.1.3, 2015 saw British Columbia re-introduce an EV purchase incentive in April, and Québec update its EV and EVSE support program and policies; the impact of these actions resulted in notable increases in EV uptake from roughly 1 % of total vehicle sales to over 2 % of total vehicle sales by year-end, while Ontario's market share remained flat over the same period[45]. A 2014 case study published in the Green Car Reports[46] evaluated the impact the lapsing of funds in Phase 1 of the Clean Vehicles Program had on the EV sales share for BC: it was estimated that though EV sales continued during this period, the sales share for BC compared with Québec and Ontario was lower by 30-50 %. One conclusion of the report is that purchase incentives can have a significant impact on the rate of uptake of EVs.

It is interesting to note that BEVs now represent 54 % of the total Canadian EV fleet, which historically has been an even split with PHEVs. Similarly to 2014, three models make up 72 % of EVs sold in Canada in 2015: the Tesla Model S (29 %), the Chevrolet Volt (22 %), and the Nissan LEAF (21 %). At the end of 2015, Québec had 46 % of all of Canada's EVs, at 8,456.

HEV sales decreased slightly from 20,762 to 17,238 in 2015. The total HEV fleet for Canada was an estimated 163,269 vehicles by the end of 2015.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Data source: DesRosiers Automotive Consultants).

Fleet Totals on 31 December 2015					
Vehicle Type	EVs	PHEVs	HEVs	FCVs	Totals[a]
Passenger Vehicles	10,034	8,417	163,269	n.a.	23,628,081

Total Sales during 2015					
Vehicle Type	EVs	PHEVs	HEVs	FCVs	Totals[a]
Passenger Vehicles	2,378	2,579	17,238	n.a.	1,898,485

n.a. = not available

[a] Including non-electric vehicles, estimates

[45] www.fleetcarma.com/ev-sales-canada-2015/

[46] Green Car Reports: When Electric Car Incentives Expire: a Case Study in Canada

Table 3: Available vehicles and prices

Market-Price Comparison of Selected EVs and PHEVs in Canada	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in USD)**
BMW i3	33,975
Chevrolet Spark	25,458
Ford Focus Electric	23,999
KIA SOUL	26,246
Mitsubishi i-MIEV	20,998
Nissan LEAF	24,523
Renault Twizy	12,750
Smart Fortwo Electric Drive	20,242
Tesla Model S 70 kWh	71,475
Tesla Model S 85 kWh Performance	109,500
Audi A3 Sportback e-tron	29,400
BMW i3 REX	37,125
BMW i8	114,000
Cadillac ELR	55,533
Chevrolet Volt	28,792
Ford C-MAX Energi	19,499
Ford Fusion Energi	21,561
Hyundai Sonata Hybrid	22,237
Porsche Cayenne S-E-Hybrid	65,775
Porsche Panamera S E-Hybrid	79,500
Porsche 918	845,000
Toyota Prius Plug-in	19,496
Volvo XC90 T8 Plug-in	55,612

22.3 Charging Infrastructure or EVSE

In 2015 has seen the expansion of charging infrastructure in multiple jurisdictions, including provinces, municipalities, and businesses. Provinces like Newfoundland and New Brunswick, which have eschewed direct EV support, have begun making investments in public charging networks. A number of companies, such as IKEA Canada, St-Hubert, and Tim Hortons, have also installed or are planning to install chargers at select Canadian locations. By the end of 2015, there were approximately 3,513 EVSEs, of which 3,360 were Level 2 (240V AC) chargers, 51 were DC Fast Chargers, and 102 were Tesla Superchargers. This is an increase of 13 % from the previous year, which saw 3,117 EVSEs installed across Canada. It is important to note that, as there are no requirements for EVSEs to register with respective jurisdictions; tracking of operational Level 2 and DC Fast Charge (including Tesla Superchargers) stations is performed through voluntary reporting by charging network owners and managers, as well as end users. Level 1 (120V AC) charging infrastructure is not reported since this typically relates to residential charging through a regular wall outlet.

Table 4: Information on charging infrastructure in 2015 (Data source: http://www.plugshare.com).

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	n.a.
AC Level 2 Chargers	3,360
Fast Chargers	51
Superchargers	102
Inductive Charging	n.a.
Totals	**3,513**

n.a. = not available

There has been a substantial amount of activity around charging infrastructure more recently and based on announced provincial policies, which include clean vehicle strategies and electrification plans depending on the jurisdictions, significant infrastructure is expected to be deployed over the 2016-2017 period. Listed below are a few highlights from some of the EVSE networks operating in Canada.

Figure 2: The underground parking at the Bell Campus, in Île des Soeurs (Montréal) consists of 27 Level 2 charging stations installed with support from the 'Branché au travail' provincial government incentive (Image courtesy of AddÉnergie)

Québec's Electric Circuit

The Electric Circuit is the largest public charging network in Québec. It is a major initiative in the implementation of the infrastructure required to support the adoption of EVs in Québec. The network comprises over 600 public charging stations, including 30 fast-charge stations, in operation across 16 Québec regions. Since its launch in March 2012, 135 private and institutional partners have joined the Electric Circuit, and the network now has over 6,500 members. The Electric Circuit will offer 800 charging stations by the end of 2016, including 60 fast-charge stations.

Electric Circuit users have access to a 24/7 telephone help line run by the Canadian Automobile Association of Québec (CAA-Québec), as well as a charging-station locator service. The Electric Circuit web site theelectriccircuit.com and the mobile app for iOS and Android are updated as new stations are commissioned. The Electric Circuit card also allows users access to an additional 150 Québec charging stations through AddÉnergie's national network (VERnetwork).

In February 2016, it was announced that AddÉnergie, a Québec based EVSE manufacturer, supplier and network operator won the tender call launched by Hydro-Québec, on behalf of the partners of the Electric Circuit. This will allow AddÉnergie to supply 1,500 Level 2 (240V) charging stations throughout the province. The four-year contract will come into effect in April 2016[47].

The Electric Circuit will make its first expansion outside Québec. The Ontario government will pay Hydro Québec to install 22 charging stations for EVs along the corridor between Ottawa and the Québec border, with more than a dozen stations to be installed in Ottawa[48].

22.4 EV and EVSE Demonstration Projects

The following are a sample of some EV-related demonstration projects that are taking place or have taken place in various jurisdictions across Canada.

22.4.1 Nova Scotia Share Ready Program

ShareReady[49] was a pilot program run by Nova Scotia power that ran from 2011 to 2015. The aim was to better understand the use of EVs in the Nova Scotia (NS) context through the sharing of 10 Nissan LEAF EVs across partner organizations. Each partner organization installed a charging station where the vehicle would typically be parked. One of the vehicles was used by Avis Rent-a-Car as their first

[47] Hydro-Québec: AddÉnergie Wins Tender Call
[48] www.cbc.ca/news/canada/montreal/electric-cars-montreal-ottawa-1.3562444
[49] www.nspower.ca/site/media/Parent/ShareReady%20v4.pdf

100 % electric rental, as well as a low-cost customer shuttle vehicle when the vehicle was not rented to customers. Following the pilot, Avis purchased the vehicle in order to maintain the usage pattern. In addition to acclimatizing the participants, the pilot program collected critical data on the practical usage of EVs in the Nova Scotia context. One of the program findings is that publicly available charging infrastructure was lacking to allow day trips and longer distance travels throughout the province. One of the project partners has worked with NS organizations to install a number of Level 2 stations during 2015. With only one DCFC installed in the province, and a program that has shown that EVs can work in Nova Scotia, there is an opportunity to further develop the DCFC network throughout the province.

Figure 3: DCFC station in Halifax, owned by NS Power and connected to AddÉnergie's VERnetwork (Image courtesy of AddÉnergie).

22.4.2 Sun Country Highway and Petro-Canada Pilot Project

BC-based EVSE manufacturer and operator Sun Country, along with five Petro-Canada gas stations have teamed up for a pilot project located in Ontario to evaluate the use of co-located fossil fuel and electric charging stations. The locations are along one of Canada's busiest highways, the 401, between Kingston and Toronto, and the charging stations are all Level 2 type[50].

22.4.3 Téo - Electric Taxis in Montreal

A taxi fleet pilot program called Téo (short for Transport Écologique Optimisé) consisting of 50 EVs including Nissan LEAF, Kia Soul EV, and Tesla Model S, has been operating throughout Montreal towards the end of 2015. The plan is for Téo to eventually deploy 2,000 EVs on the streets of Montreal and 350 DCFC

[50] https://suncountryhighway.com/en/Blog/Petro-Canada-Pilot-Project-in-Ontario

stations by 2019[51]. The project is supported by the fund XPNDCROISSANCE, which brings together the expertise, network, and capital of some of Canada's most renowned technology entrepreneurs. The fund is part of the portfolio of XPND Capital, a private equity firm focused on growth investments in exceptional Québec-based companies. It reached a 40.2 million USD capitalization in 2015, and the fund gained the support of the Caisse de dépôt et de placement du Québec (11.6 million USD) and Investissement Québec (7.7 million USD) during 2015. The fund supports the pilot and eventual full rollout of Taxelco's all-electric taxi fleet.

22.4.4 Commercial Demonstration of a Management System for EV Charging Station Networks[52]

With funding from Natural Resources Canada's ecoENERGY Innovation Initiative, AddÉnergie deployed 1,778 Level 2 charging stations and 35 DCFC stations throughout Canada between the start of the project in 2011 and 28 April, 2016. These will enable the company to improve, test and demonstrate the performance of its centralized charging station management system, the Charging station network management system (CSNMS™).

Figure 4: Level 2 and DCFC charging stations installed in front of AddÉnergie's headquarters in Québec City (Image courtesy of AddÉnergie).

22.4.5 The British Columbia EV Smart Infrastructure Project[53]

Since 2012, the Government of Canada, through Natural Resources Canada's ecoENERGY Innovation Initiative, has provided funding support to British Columbia Hydro for the purchase and installation of 300 Level 2 charging stations

[51] www.investquebec.com/quebec/fr/salle-de-presse/nouvelle/Des-taxis-100-pour-cent-electriques-a-Montreal.html
[52] www.nrcan.gc.ca/energy/funding/current-funding-programs/eii/16157
[53] www.nrcan.gc.ca/energy/funding/current-funding-programs/eii/16387

and 30 DCFC stations throughout the province. All 300 of the Level 2 stations are now in operation in numerous municipalities throughout the province of British Columbia, while 27 of the fast charging stations were operational on interurban highways linking major municipalities. The remaining three fast charging sites are currently under development.

Figure 5: BC Hydro EV Charge Park at Powertech Labs – Multi-DC Fast Charger Station for Advanced Operations Testing (Image courtesy of BC Hydro).

23 Denmark

23.1 Major Developments in 2015

With over 4,500 new EV registrations in 2015, the Danish EV stock has more than doubled. The growth in sales was particularly strong in the last quarter of the year after the Danish government announced its plan to terminate the tax exemption on EVs (see Section 23.1.2). During November and December more than 2,100 EVs were sold, which is more than the accumulated sales total in 2014. In 2015, EV sales constituted approximately 2 % of the overall car sales in Denmark, with Tesla Model S the most sold car in Denmark in the final month of the year (see Section 23.2).

There has also been a considerable expansion of the fast charger network thanks to the major private e-mobility providers: CLEVER, E.ON, CleanCharge Solutions, and Tesla (see Section 23.3). The number of fast chargers has increased from 24 chargers (72 outlets) in 2014, to 123 chargers (291 outlets) in 2015. Finally a number of EV projects have been launched to familiarize companies, public bodies, and private consumers with EVs (see Section 23.1.3) and strengthen Denmark's position as an important green transport corridor in Northern Europe (see Section 23.5).

23.1.1 Framework for the Electrification of Transport

The electrification of the transport sector plays a significant role in fulfilling the Danish goal of being 100 % independent of fossil energy in 2050, and with electricity being based 100 % on renewables in 2035. In 2015, wind power made up 42.1 % of the Danish electricity consumption, which is a world record. In 2020, approximately 55 % of the electricity will be generated from windmills. Thus, integration of renewable energy into the energy system and also the transport sector will be a very important issue in the coming years.

The Danish Energy Agency has analyzed a range of scenarios to meet the national 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, minimal pollution, low CO_2-emissions, the flexibility that comes with the capability of car batteries to store excess capacity of wind-power, and the ability to balance the grid.

Following the EU's Renewable Energy Directive, Denmark must have a 10 % share of renewables in the transport sector by 2020. While the vast majority of this will come from biofuels, an analysis by the Danish Energy Agency shows that electrification can contribute with a 2.4 % share of renewables in transport by 2020.

Denmark has been a member of the Electric Vehicle Initiative (EVI), which is a signatory of the Paris Declaration on Electro Mobility and Climate Change & Call to Action at the COP21 in Paris.

Denmark participates in two tasks under the International Energy Agency's Hybrid and Electric Vehicle Implementing Agreement: Task 24, which focuses on the economic impact of the introduction of e-mobility, and Task 28, which focuses on the means for facing the technical, economic, and policy challenges of V2X technology.

23.1.2 Danish EV Regulation and Incentives

As of 1 January 2016, EVs are no longer exempt from the Danish registration tax for passenger cars, which is very high (150 %) and based on the value of the car. Following the new legislation the registration tax will gradually be phased in over a five-year period. In the phase-in period the EVs are due a registration tax of 20 % in 2016, 40 % in 2017, 65 % in 2018, 90 % in 2019 and 100 % 2020. This effectively means that in 2020, the buyer of an EV must pay a registration tax that corresponds to 150 % of the value of the EV.

It is, however, a condition in the legislative agreement that 24,100 EVs are sold by 2020, beginning with 1,800 EV sales in 2016. If necessary, the parties to the agreement have committed to revise it in order to ensure that this condition is met. The first follow up meeting will take place in August 2016.

Danish EV incentives
• In 2016 and 2017, small EVs are granted the basic allowance for the registration tax of up to 10,000 DKK (1,470 USD). • Until the end of 2016, 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. • Tax rebate on installation of EV home chargers of up to 18,000 DKK (2,646 USD). • 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. Municipalities can differentiate charging payments for parking lots up to 5,000 DKK (735 USD) per year.

23.1.3 Public Funds to Support EVs

The Danish Energy Agency (DEA) administrates a number of funds to support the deployment EVs in the Danish transport sector. The funds are used to support projects that allow companies, public bodies, and private consumers to familiarize themselves with EVs, develop synergies between relevant stakeholders and support the deployment of alternative fuel infrastructure. These funds and programs all end in 2015.

The funds are divided into three categories: Alternative fuel infrastructure, Grants for electric buses, and Pilot schemes for EVs. In 2015, private companies and public entities applied for funding towards 27 different projects worth a total of 47 million DKK (6.9 million USD). 30 million DKK (4.4 million USD) have been awarded.

Here, the four examples of selected projects:

“The Partnership for purchase of EVs” was allocated funds that contribute towards participants’ purchase of 870 EVs in 2016. Moreover the partnership will ensure that public and private stakeholders join forces in order to develop a strategy on alternative infrastructure and to come up with a national joint procurement strategy.

“The Partnership for increased use of e-mobility in Northern Jutland” was allocated funds to support the deployment of 40 new public charging stations in the region. The new public charging stations will help ensure that EV users have a nearby charging station all over the Region.

The project **“Electric buses at Copenhagen Airport”** was allocated funds to buy 2 electric buses that will operate in Copenhagen Airport’s regular bus fleet. This allows Copenhagen Airport to gain practical experience with electric buses for their specific needs.

The project “**Testing of buses under normal operating conditions”** was allocated funds that allow one of Denmark’s transport authorities to add electric buses to its fleet in order to gain practical experience with them on parameters such as operational reliability, economy, and general utility. During the project period the buses are expected to cover up to 960,000 km.

It is estimated that in total 500 million DKK (73 million USD) public funds have been invested to promote EVs, while private investment amounts to approximately 2 billion DKK (292 million USD).

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Source: DBI IT A/S)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
Passenger Vehicles[a]	7,567	492	3,799	52	2,371,786
Buses and Minibuses[b]	3	0	0	0	8,782
Light commercial vehicles[c]	520	99	641	0	390,264
Medium and Heavy Weight Trucks[d]	7	0	0	0	40,953
Totals without bicycles	**8,097**	**591**	**4,440**	**52**	**2,811,785**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
Passenger Vehicles[a]	4,262	359	2,356	37	207,556
Buses and Minibuses[b]	0	0	0	0	550
Light commercial vehicles[c]	262	85	288	0	32,461
Medium and Heavy Weight Trucks[d]	0	0	0	0	4,756
Totals without bicycles	**4,524**	**444**	**2,644**	**37**	**245,323**

n.a. = not available
[a] UNECE categories M1
[b] UNECE categories M2-M3
[c] UNECE categories N1
[d] UNECE categories N2-N3
[e] Including non-electric vehicles

23.2 HEVs, PHEVs and EVs on the Road

The Danish EV stock more than doubled in 2015 from 3,282 units to 8,097 units. The number of new EV registrations almost tripled from 1,616 in 2014 to 4,524 in 2015. The sale was particularly strong in November and December where more than 2,100 EVs were sold, which is more than the accumulated sales total in 2014.

The most sold electric passenger car was Tesla Model S with 2,737 units, followed by BMW i3 with 492 units, Renault Zoe with 330 units, and Nissan LEAF with 224 units. The most sold light commercial vehicle was Nissan e-NV200 with 243 units.

Fleet totals and total sales during 2015 are displayed in Table 1.

Table 2: Available vehicles and prices

Market-Price Comparison of Selected EVs and PHEVs in Denmark	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in DKK and USD)**
BMW i3	225,600 ; 30,241
BMW i3 REX	268,480 ; 35,989
Citroen Berlingo Electric	199,990 ; 26,808
Nissan E-NV200	221,080 ; 29,635
Nissan Leaf	198,552 ; 26,615
Peugeot Partner Electric	199,990 ; 26,808
Renault Zoe	131,920 ; 17,683
Renault Kangoo Maxi	158,900 ; 21,300
Renault Twizy	46,720 ; 6,262
Tesla Model S 70 kWh (rear weel)	488,757 ; 65,517
Volvo V60 Plug-in Hybrid	796,000 ; 106,702
VW E-golf	229,198 ; 30,723
WV e-up!	149,052 ; 19,980

23.3 Charging Infrastructure or EVSE

Denmark has a very well developed public charging infrastructure, thanks to four major private e-mobility providers: CLEVER, E.ON, CleanCharge Solutions, and Tesla. Combined, the four companies provide publicly accessible recharging networks countrywide. The total size of the public EVSE in Denmark by the end of 2015 is summarized in Table 3.

In 2015, there has been a significant expansion of the network of both medium and fast chargers in Denmark. The number of AC Level 2 Chargers has increased from

106 chargers (212 outlets) in 2014, to 666 chargers (1332 outlets) in 2015. The number of Fast Chargers has increased from 24 chargers (72 outlets) in 2014, to 123 chargers (291 outlets) in 2015.

The Danish Road Directorate conducted a tender to establish 10 public charging infrastructures at rest stops on Danish highways. By the end of 2015, E.ON and CLEVER had deployed combined fast chargers on all the sites.

Business Models

E.ON 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).

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.

Tesla has developed a network of Supercharger stations in Denmark where drivers can fully charge their Tesla vehicles for free. The networks consist of 8 Supercharging stations with a total of 54 superchargers. In 2015, the largest station in Europe (at the time) was opened 30 kilometers outside of Copenhagen. This supercharging station has the capacity to charge 12 Tesla vehicles simultaneously.

Table 3: Information on charging infrastructure in 2015 (Sources: CLEVER, EON and Tesla)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	13 (13 outlets)
AC Level 2 Chargers	666 (1332 outlets)
Fast Chargers	123 (340 outlets)
Superchargers	64 (64 outlets)
Totals	**866 (1,749 outlets)**

23.4 EV Demonstration Projects

23.4.1 The GREAT Project

The Green Region for Electrification and Alternatives fuels for Transport project (GREAT) aims to development a green transport corridor connecting Norway, Sweden, Denmark, and Germany.15 fast chargers will be set up in Denmark.

Project partners include E.ON, Nissan, Renault, and the Technical University of Denmark (DTU). The latter is partially responsible for conducting studies on learning experiences from the new corridor.

The estimated cost of action is 14 million EUR (15.5 million USD). The Connecting Europe Facility covers 50 % of the finance.

Figure 1: The transport corridor (Source: GREAT)

23.4.2 The MECOR Project

The Multimodal e-mobility connectivity for the Oresund Region project (MECOR) aims to promote multimodal e-mobility by installing 30 semi-fast charging sites in both Denmark and Sweden. The charging sites will be located in transport "hotspots" such as bus and train stations in order to underpin multimodal e-mobility solutions. The project is in line with the Oresund Regional development strategy, which calls for development of "green corridors". CLEVER is a key project partner. The estimated cost of action is 2.9 million EUR (3.16 million USD). The Connecting Europe Facility covers 50 % of the finance.

23.4.3 Platform for E-mobility in ÖKS Region

The project aims to increase the share of environmentally friendly transport services in the ÖKS region (Öresund-Kattegat-Skagerrak) by helping the municipalities in the region adapt to e-mobility. The project establishes a common platform that delivers expertise to municipalities to help them increase the deployment of EVs in public fleets and among private citizens. The platform also establishes a publically available hotline for EV related questions. The platform is established by The Danish EV Alliance (DK), Power Circle (SWE), and Elbilforening (NOR). It is established under the EU Interreg program, which covers 50 % of the finance of the project.

23.4.4 The Nikola Research Project

Nikola is a Danish research and demonstration project that analyses how to integrate EVs in the distribution grid. It has a particular focus on the economic viability of participation in the current market and the development of new technologies. The project runs from 2013 to 2016 and has a total budget of 15.1 million DKK (2.3 million USD). 10.3 million DKK (1.6 million USD) are financed by ForskEL (a PSO-financed research program). It is supported by EUDP.

23.5 Outlook

With over 4,500 new EV registrations in 2015, the Danish EV stock has more than doubled. However, as of 1 January 2016, EVs are no longer exempt from the Danish registration tax for passenger cars, which is very high (150 %) and based on the value of the car. Following the new legislation the registration tax will gradually be phased in over a five-year period. When the registration tax is fully phased in in 2020, the buyer of an EV must pay a registration tax that corresponds to 150 % of value of the EV.

There are two contrasting official forecasts for EV sales until 2020. On the one hand the Danish Energy Agency (DEA) has released a report that forecasts a total Danish EV stock of only 6,000 in 2020 and 10,000 in 2025. It should be noted however, that this forecast was made before the significant sales growth in the last quarter of 2015. On the other hand the Ministry of Taxation forecasts that by 2020 the Danish EV stock will increase by 24,000 units, which will bring the total stock to approximately 32,000 units. This forecast is the underlying assumption of the agreement to phase in the registration tax. It has been signed into the agreement that it can be revised if the assumption does not hold. This is to prevent a severe stagnation of the EV market. The first follow up meeting will take place in August 2016.

While the forecast for EV sales in Denmark remains somewhat blurry, it is clear that a number of projects will ensure the continued evolvement of the Danish EV market: **The Partnership for purchase of EVs**, which is supported by the Danish Energy Agency, is expected to help bring 870 new EVs on the road. The Danish

Energy Agency also supports two projects that will allow transport providers to gain hands on experience with electric buses. Other projects worth mentioning are **the GREAT project** that will develop a green transport corridor connecting Norway, Sweden, Germany, and Denmark; **the MECOR project** that will increase the multimodal e-mobility connectivity in the Oresund Region; and **the Platform for E-Mobility in the ÖKS Region**, which will ensure that best practices are shared among the relevant stakeholders in the Scandinavian countries.

Finally, Denmark's Smart Grid **Strategy and the Nikola Research Project** should help Denmark fulfil its ambition to be at the forefront in the development of synergies between the EV and the power system (V2G). Nissan and Enel's decision to start their pilot program on V2G technology up in Denmark should underpin this development.

24 Finland

24.1 Major Developments in 2015

Finland’s governmental policies are tied to greenhouse gas (GHG) reduction targets and currently do not favor or subsidize electric vehicles (EVs). At the moment, the overall targets for GHG reduction can be met by using biofuels, which are already supplied from Finland’s vast forests. There were no national hybrid-related or EV-related policy announcements or legislation changes during 2015.

Current Finnish fuel taxes are based on energy content, carbon dioxide (CO_2) emissions, and the impact on local air quality. The accepted target for average CO_2 emissions for new cars sold in 2020 will be 95 g/km. The average level of new cars sold in 2011 was 144.8 g/km. This CO_2-based taxation system was launched in 2011 and remains in effect. The system favors hybrid vehicles and EVs, along with many biofuels.

Below, some developments in Finland in 2015 are given.

24.1.1 First Fast Charging E-Buses in Traffic in Espoo

The first two HSL[54]-owned electric buses[55] started their operation in the end of 2015 in line 11 in Espoo. HSL will purchase a total of 12 buses from Linkker and they will be running next year in Helsinki lines. Around 10 % of HSL's bus fleet is expected to be electric by 2020 and reach 30 % in 2025. HSL is committed to sustainable development measures aiming to carbon neutrality in 2050. Electric buses support of HSL's strategic objective of increasing the share of low-emission transport public transportation.

The buses are part of an ePeli project, that was launched a year ago as a spin-off of VTT Technical Research Centre coordinated and Tekes – the Finnish Funding Agency for Innovation supported ECV network’s eBus project.

[54] Helsinki Regional Traffic
[55] Manufactured by the Finnish start-up company Linkker

24.1.2 The Development of Electric Mobility in Finland Visualized

Even though the total number of EVs is still modest in Finland the data collected from vehicles participating in EVE (Electric Vehicle Systems programme of Tekes) show how electric vehicles have spread gradually to the whole country. Lately, the traffic has been growing north of Jyväskylä and Oulu. The visualization of Haave Oy that depicts the volume growth can be seen on youtube-channel[56].

The video shows nicely how the electric mobility volumes have increased, where the main routes of electric cars are, and how the use of electric vehicles has increased with the development of the fleet and charging infrastructure.

24.1.3 Linkker Wins Copenhagen Electric Bus Contract

The city of Copenhagen purchases two electric buses and charging solution from a consortium of Linkker, a Finnish e-bus start-up, and Heliox, a Dutch charger manufacturer. The buses will be operating on one of the city central bus lines. The contract value is 1.3 million EUR and the delivery will take place in June 2016.

The Linkker buses have a lightweight aluminum structure, and the 2-3 minute charging time enable a high daily mileage. Copenhagen's aim is to be CO_2 neutral by 2025, and will operate the Linkker buses alongside its current fleet of buses. Linkker claims the combination of lightweight buses, quick charging and an efficient driveline can add up to 10-20 % savings in the total cost of ownership compared to diesel buses.

24.1.4 Electric Vehicles for Rent from EkoRent

EkoRent Ltd.[57], founded in 2014, introduced a car rental service where all the leased cars are electric. The company has more than ten Nissan Leaf electric vehicles and the rent price of just 8 EUR for an hour, the cheapest. The cars are retrieved from and returned to five different service points in the Helsinki metropolitan area. The reservation and unlocking of the vehicles is done with a smart phone or text message, and the invoicing is hourly-based.

24.1.5 Tampere to Electrify the First Bus Line

Tampere, the largest inland city in the Nordic countries, will be acquiring four battery electric buses and an automatic charging station to be placed at the end stop. The aim is to electrify the first bus line in order to gather experiences for a significant electrification of other bus services.

[56] www.youtube.com/watch?v=toy30ug7Y6g
[57] http://ekorent.fi/en

Tampere has ordered the buses and the necessary charging stations from the Polish Solaris Bus & Coach. Buses are scheduled to be operational towards the end of next year.

24.1.6 TankTwo Combines Mobile Technology with Electric Vehicle Batteries

Finnish-American start-up TankTwo[58], introduced a completely new type of electric vehicle battery solution. In the solution the built-in battery-pack has been replaced with a container filled with large number of smart individual cells, connected to each other and the management system. According to TankTwo, the swapping of the cells in the container can be done in three minutes. The idea targets to revolutionizing of electric vehicles charging.

24.1.7 Light EVs on Roads from 2016

Light electric vehicles and walking assist devices, which were not allowed in public areas before, became legitimate as means of road transport from the beginning of 2016. Lightweight electric vehicles and walking assist devices include the so-called senior scooters and balanced single- or multi-wheeled people movers type Segway. Also, more efficient engines are allowed for electric bicycles. Usage of such equipment does not require a driver's license, registration or vehicle inspection.

In connection with EVE (Electric Vehicle Systems programme of Tekes) an incentive system was launched in 2012 for company EVs and charging infrastructure. A prerequisite for the incentive of a vehicle was the measurement of the driving behavior and vehicle technology for the use of EVE. The support for a company vehicle was 30 % of the capital share of the leasing fee for three years and 35 % of the charger investment. For this purpose the Ministry of Employment and the Economy granted 10 million EUR, reserving 50 % of the sum for vehicles and 50°% for the infrastructure. The money reserved has been well used but no new incentive system has been decided.

24.2 HEVs, PHEVs and EVs on the Road

The growth rate of the EV fleet in Finland in 2015 was a handsome 70 %, however the total number of EVs and PHEVs remained modest with 1,580 vehicles (see Table 1). The market share of plug-in vehicles was under 1 % in 2015. In the absence of consumer incentives the growth of the EV fleet in Finland has not yet

[58] www.tanktwo.com

boosted. The market share of HEVs reaches 3 %, the total size of the fleet being 14,000 at the end of 2015.

Of over 600 EVs on the roads, Nissan and Tesla cover 80 % of the fleet with an equal share of about 40 %. In 2015 sales Tesla's market share grew to 60 % with 146 sold vehicles, while Nissan dropped down to 30 %. With Volkswagens additional 7 % share there's not much left for the other brands.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Data source: www.trafi.fi/tietopalvelut/tilastot/tieliikenne)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	778	6	n.a.	n.a.	412,843
Passenger Vehicles[b]	614	966	14,054	1	2,612,922
Buses and Minibuses[c]	5	2	n.a.	n.a.	12,455
Light commercial vehicles[d]	129	1	n.a.	n.a.	307,706
Medium and Heavy Weight Trucks[e]	1	5	n.a.	n.a.	95,250
Totals without bicycles	**1,527**	**980**	**n.a.**	**n.a.**	**3,441,176**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	n.a.	n.a.	n.a.	n.a.	10,774
Passenger Vehicles[b]	243	414	3,269	0	108,817
Buses and Minibuses[c]	0	0	n.a	n.a.	526
Light commercial vehicles[d]	33	0	n.a	n.a.	11,431
Medium and Heavy Weight Trucks[e]	1	0	n.a.	n.a.	2,707
Totals without bicycles	**277**	**414**	**3,269**	**0**	**134,255**

n.a. = not available
[a] UNECE categories L1-L5
[b] UNECE categories M1
[c] UNECE categories M2-M3
[d] UNECE categories N1
[e] UNECE categories N2-N3
[f] Including non-electric vehicles

For PHEVs, the sales leader in 2015 was Mitsubishi with a 25 % share followed by 21 % for Porsche, and Volkswagen (model GTE), Audi (A3 E-Tron) and Mercedes (several model) with 15 % each. Former favourites like Volvo, Toyota and Opel suffered from the launch of new models by competitors. In HEVs segment, Toyota was the bestseller with a market share of more than 97 % (including the sales data of 7 % for Lexus). Thus, there is practically only small room left at the Finnish market for other HEV manufacturers.

Prices for the vehicles available in Finland are listed in Table 2.

Table 2: Available vehicles and prices (Data source: web pages of the local representatives/importers of each vehicle brand)

Market-Price Comparison of Selected EVs and PHEVs in Finland	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Mitsubishi Outlander PHEV (model 5P)	36,340
Nissan Leaf (24 kWh Visia)	27,050
Porsche Panamera S E-Hybrid	90,300
Tesla Model S 70 kWh	70,100
Tesla Model S 90 kWh Performance	101,000
Toyota Prius Plug-in (1.8 Active)	30,000
VW e-up!	22,360
VW e-Golf	31,850
VW Golf GTE	31,180

24.3 Charging Infrastructure or EVSE

There are two major operators of the charging network in Finland, Virta and Fortum Charge & Drive. Both are also active elsewhere in Europe for instance, Charge & Drive being a major player in the Nordic countries and Virta in Central Europe[59]. A half of over 300 chargers in the country are Level 1 types, around 100 are Level 2 and about 50 are fastchargers (see Table 3). Tesla installed 2 superchargers in 2015 and a third one in the beginning of 2016. The chargers are placed mostly in the south of Finland but the infrastructure is also developing alongside main roads, in western Finland, in Oulu region, and in Lapland.

[59] charging networks are available at app.virta.fi and map.chargedrive.com

Table 3: Information on charging infrastructure in 2015 (Data source: for level 2 and fastchargers over map.chargedrive.com and app.virta.fi; number of Level 1-chargers is estimated)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	150 (est.)
AC Level 2 Chargers	104
Fast Chargers	47
Superchargers	2
Inductive Charging	n.a.
Totals	**303**

est. = estimated
n.a. = not available

24.4 EV Demonstration Projects

EVE (Electric Vehicle Systems programme of Tekes) ended in December 2015 and no new EV demonstration projects have been decided for the period after 2015. Many of the projects initiated within EVE will continue in 2016 though. Also, Tekes will be financing new electric mobility projects within the frame of its usual funding possibilities.

In the following, a short presentation of the three EVE projects that were active during the latter part of the programme, in 2014 and 2015, is given[60].

24.4.1 Electric Traffic

The number of electric vehicles has practically doubled each year since 2011 exceeding 1,500 at the end of 2015. Besides, hundreds of charging points have been installed. A free application and a website for locating the chargers have been created to make things easier for EV drivers. New commercial solutions are on their way. Together with nearly 40 partners, the Electric Traffic consortium, coordinated by Eera Oy, has brought EVs on the streets in Finland.

New charging business models have been created within Electric Traffic consortium towards enabling the future commercial activities. Finnish charging systems and related infrastructure have been introduced to key international EV markets by companies like Virta Ltd.[61] and Fortum Charge & Drive.

[60] For further information, please see the report EVE - Electric Vehicle Systems 2011-2015.
[61] An innovation leader in consumer driven smart energy services, and a spin-off of Electric Traffic consortium

New technologies that are still to be introduced within Electric Traffic include a commercially scalable solution for EV charging network participation in frequency controlled demand response market along with price demand solution services allowing private charging point owners to minimize their electricity bill and reduce their CO_2 emissions. These new services will cut CO_2 emissions of charging, make the energy system smarter and more flexible and enable new possibilities for international collaboration.

24.4.2 Electric Commercial Vehicles

The Electric Commercial Vehicles (ECV)[62] focused in the electrification and development of business in the area of commercial vehicles creating extensive testing and development environments for heavy duty electric vehicles and their components. Testing and research as well as modelling and simulation have been the core themes of ECV. A large number of industrial companies, research institutes and universities, and public stakeholders have participated in the project entity coordinated by VTT Technical Research Centre of Finland.

ECV projects concentrate on electric bus technology, hybrid-electric working machine, system engineering, electrochemical energy storages, power grid and charging. International projects like ZeEUS (Zero Emission Urban Bus System) and EBSF_2 (European Bus System of the Future 2) have been tightly linked to ECV context.

An added value for the ECV test environment and the ECV participants came from networking and sharing the test expertise, competent purchasing of required components, and expanding the competence base due to training and recruitment.

24.4.3 Electric Vehicles Goes Arctic

The Electric Vehicles Goes Arctic (EVGA)[63], was coordinated by Centria University of Applied Sciences and preceded by WintEVE[64]. The consortium was targeting the development of vehicle testing in arctic conditions.

The EVGA projects have included the development of metering and safety system for the testing of EV's, which was later commercialized by Northern Engineering Oy, owner of Lapland Proving Ground[65], one of the biggest testing facilities in Scandinavia. Moreover, the University of Oulu has been developing information safety of the vehicles and a modular battery solution. Significant enterprise projects

[62] ECV at www.ecv.fi/in-english
[63] http://evga.winteve.fi
[64] http://winteve.fi
[65] http://laplandpg.fi

were run by Kemppi Oy, developing quick charging stations and SataVision Oy with its 3D presentation solution for vehicle retailers.

The development projects within EVGA and WintEVE had a decisive role in launching the electrification of transport in Northern Finland. New charging stations have been installed in Oulu region as well as in several positions above the polar circle. Participating has also opened collaboration channels for EVGA's network to European research institutes and enterprises.

24.5 Outlook

With no special incentives for electric vehicles the size of the fleet in Finland is expected to grow only gradually. However, with the launch of new models by OEMs, the consumer interest for new technology will increase. The Ministry of Transport and Communications has appointed a working group for the implementation of the EU directive for the distribution of alternative fuels.

The government of Finland has decided to lower the taxation of cars with CO_2 emissions under 140 g/km. The tax decreases on the average totally 50 % during four years, beginning 2016. The tax cuts are the biggest for low-emission cars with carbon dioxide emissions of less than 65 g/km. The tax of plug-in hybrids decreases by up to 52 %, for zero-emission cars the tax reduction is 46 % from the current level. The Finnish car tax rate is determined solely on the basis of nominal CO_2 emissions of the vehicle regardless of the technology.

Tekes – the Finnish Funding Agency for Innovation launched in 2011 the EVE– Electric Vehicle Systems programme of program that has contributed in many ways to the development of electronic transport and its infrastructure in Finland. The five-year program ended at the end of 2015.One of the objectives of EVE was to increase the net sales of Finnish electric transportation solutions and services from 200 million EUR in 2010 to 2 billion EUR by 2020. According to Martti Korkiakoski, the programme manager of EVE, the results achieved so far suggest that in five years the target can be achieved. EVE contributed to the creation of dozen new growth companies in Finland, including, Virta and Linkker which have been able to quickly establish the business abroad.

Heavy machinery enterprises accounted for a significant share of the 200 million sales in 2010 in Finland and the situation in the future is assumed to be similar. Mobile machinery manufacturing companies, such as Kalmar, Sandvik and Rocla, have developed their own electronic solutions and have been able to strengthen their position on the international markets. Component manufacturers like ABB and Visedo are gaining on the global market. The breakthrough of electronic solutions in heavy vehicles is believed to be close.

25 France

25.1 Major Developments in 2015

COP21

In 2015, France was chairing the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21/CMP11), which was held in Paris in late 2015. This Conference was a crucial event. Its objective was to achieve a new international agreement on the climate, applicable to all countries, with the aim of keeping global warming below 2°C.

In order to respond to the warnings of the Intergovernmental Panel on Climate Change (IPCC) scientists concerning the human responsibility for climate change, France provides strong support for national climate policies and the two legal instruments adopted by the international community: the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

France's considerable reduction in greenhouse gases emissions (-13 % compared to 1990) has contributed to the commitment of the European Union and its Member States under the Kyoto Protocol (-8 % in 2008-2012 compared to 1990).

For several years, France has been stepping up its international climate action, by making use of technical operators including the Institute of Research for Development (IRD), and the Environment and Energy Management Agency (ADEME).

France's efforts will continue to contribute during the second commitment period of the EU to Kyoto (-20 % in 2020 compared to 1990). France is making many political and economic efforts for climate change mitigation and adaptation at international, European, national, and local levels. Combating climate change is a cross-cutting priority of its development policy.

The Energy Transition for Green Growth Act and its attendant action plans are designed to give France the means to make a more effective contribution to tackling climate change and reinforce its energy independence while striking a better balance in its energy mix. Development of electromobility is a clearly identified target in those action plans for reducing CO_2 emissions in France.

25.2 Energy Transition for Green Growth Act

In 2015, the French Parliament has adopted the law on energy transition. The law and its related action plans are designed to give France the means to further contribute to tackling climate change while reinforcing energy independence by diversifying the energy mix.

The law includes a reduction of the share of nuclear power in the French power mix, a reduction of the final energy consumption (-20 % by 2030), an increase in renewable power generation and a reduction in GHG emissions by 40 % by 2030.

Action plans for "Clean transport" are tailored toward reaching the goal of developing green transport to improve air quality and protect public health. It includes stepping up efforts to combat air pollution, reducing dependency on hydrocarbons, speeding up the replacement of car and bus fleets with low-emission vehicles, and offering 7 million recharging points for electric vehicles by 2030.

In order to strengthen the efforts to combat air pollution and to reduce dependency on hydrocarbons, the energy transition for the green growth act aims at providing universal access to plug-in vehicles in France, funding clean transport, leading by example in the public sector and supporting business, research and innovation.

Concrete actions in favor of electromobility development are given below.

25.2.1 Bonus Malus System

In 2015, the bonus malus system remains generally unchanged. For the Ministry of Ecology, Sustainable Development and Energy "the bonus malus system is designed to reward buyers of new cars with the lowest CO_2 with a bonus, and penalise, via a penalty, those opting for the most polluting models".

The amount of the penalty is unchanged. If in 2014 all the slices penalty had advanced with a maximum threshold reached 8,000 EUR for cars emitting more than 201 g/km of CO_2, the scale has not changed in 2015. The thresholds and amounts applicable therefore remain the same.

The neutral zone extends further. In 2015, the neutral zone extends from 91 to 130 g/km of CO_2 to rejecting combustion vehicles between 61 and 130 g/km of CO_2.

A 2015 bonus adjusted for green vehicles. The new amounts of the bonus came into force by decree in January 2015. The latter establishes that vehicles emitting more than 60 g/km CO_2 are no longer eligible to obtain a bonus. An added bonus is available for environmentally friendly vehicles that are not 100 % electric, though it amounts to 4,000 EUR.

Moreover, these bonuses are indexed to the price of the vehicle itself, or within the limit of 27 % of the acquisition cost for an electric vehicle and a limit of 20 % of the acquisition cost for a vehicle rejecting from 21 to 60 g CO_2/km.

Figure 1: Bonus malus system in France in 2015

25.2.2 Car Conversion Bonus

The bonus for purchasing an electric vehicle has been extended and increased since April 2015 when accompanied by the scrapping of a polluting vehicle. The total bonus may be worth as much as 10,000 EUR.

25.2.3 Aid for the Installation of Recharging Points

In 2015, a 30 % tax credit has been introduced for the installation of recharging points for electric cars by private individuals.

25.2.4 Vehicle Fleets

The Energy Transition for Green Growth Act imposes to the French State and its public bodies to conform to a minimum share of 50 % of vehicles with low CO_2 and air pollutants emissions, such as electric vehicles when renewing their fleets.

Local authorities are subject to the same requirement concerning 20 % of their fleet.

All new buses and coaches that shall be acquired for public transport services from 2025 onwards must be low-emission vehicles.

25.2.5 Car Hire and Taxis

The Energy Transition for Green Growth Act also forces car rental firms, operators of taxis and transport vehicles with drivers renewing their fleets to acquire at least 10 % of low-emission vehicles.

25.2.6 Restricted Traffic Areas

The Energy Transition for Green Growth Act gives the possibility for local authorities to implement traffic restriction measures in areas affected by poor air quality.

25.2.7 7 Million Recharging Points

In mid-2015, 10,000 publicly accessible recharging points were operational. The Energy Transition for Green Growth Act states that new car parking provision shall be equipped with charging points, which will also be installed as part of car park renovation work in existing buildings. Charging points must also be installed in car parks at existing shopping centres.

25.2.8 New Road Uses

In addition to the public transport development policy, the Act provides new tools for developing new road uses for clean vehicles, such as differentiated subscriptions proposed by motorway concession-holders, bus lanes, taxis, car-pooling, and car-sharing.

25.3 HEVs, PHEVs and EVs on the Road

25.3.1 EV Sales

2015 was a record year for the electric vehicle market in France. With strong public incentives and a consolidated offer of models available, 22,187 Electric Passenger Vehicles and Electric Light Commercial Vehicles were registered in France last year. The passenger vehicles segment shows the most spectacular progress, with a growth of 64 % compared to 2014.

The electric vehicle market had a very positive year with 22,187 registrations in 2015, marking an increase of 47.5 % compared to 2014. According to the website Automotive and Enterprise, 7,470 of them (or 33.67 %) concern companies' vehicles in fleets.

Just like last year, December brought a new sales record with 3,036 registrations of electric passenger cars and light commercial vehicles, and a 1.2 % market share.

17,268 electric passenger vehicles were registered in 2015 in a market of 1.91 million units, according to statistics released by the CCFA. Electric passenger vehicles represented 0.9 % of the sales in 2015.

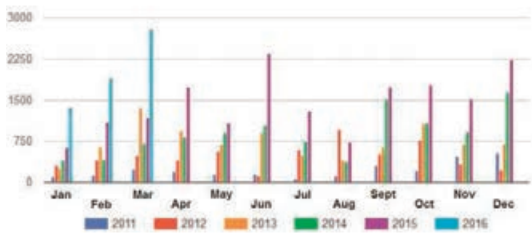

Figure 2: EV passenger vehicles sales by month in France (Source : Automobile-propre.com)

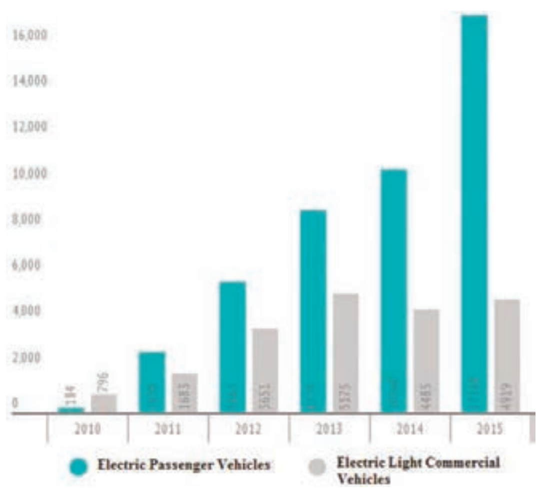

Figure 3: EV sales evolution from 2010 to 2015 (Source: AVERE)

Sales have therefore increased by 64 % compared to 2014 when 10,560 vehicles were registered in this segment. Those very positive results demonstrate the impact of the 10,000 EUR superbonus as BEV has become more accessible, especially to households.

The top seller, with 10,407 units registered, is the Renault ZOE which ended the year with a 60 % market share. The Nissan LEAF and Bolloré Bluecar arrive behind with 2,222 and 1,191 registrations, respectively. The segment of the electric light commercial vehicles has also ended the year with a 9.6 % growth compared to 2014. 4,919 units were registered compared to 4,485 in the previous year. The Renault Kangoo ZE is the most sold professional model with 2,836 registrations before the Goupil G3 (445) and the Nissan e-NV200 (343).

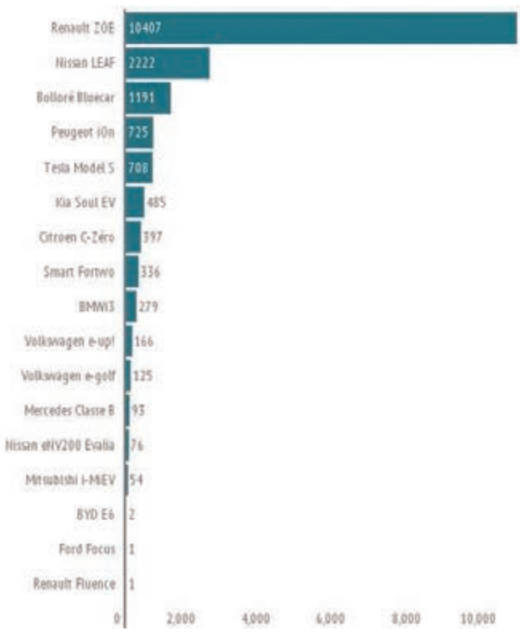

Figure 4: 2015 EV passenger vehicles sales by models (Source: AVERE)

25.3.2 HEV and PHEV Sales

In 2015, HEV sales fell by 10 % while the number of PHEVs rose sharply.

In 2015, the PHEV market has exceeded 8,000 cumulated registrations since its launch in 2012. The plug-in hybrid vehicle market continued to grow in 2015 with 5,583 registrations, including 543 BMW i3 with a range extender. Within a year, sales have almost tripled thanks to the introduction of the car conversion bonus.

The leading models are the Volkswagen Golf GTE with 1,695 registrations, the Audi A3 e-tron (1,129) and the Mitsubishi Outlander PHEV (913). Luxury models such as the sport BMW i8 (95) or the C-Class Mercedes 350e (77) were also successful.

However, the growth in PHEV sales could experience a slowdown in 2016 as the environmental bonus has been limited to 1,000 EUR for all vehicles emitting between 21 and 60 g of CO_2 per kilometer.

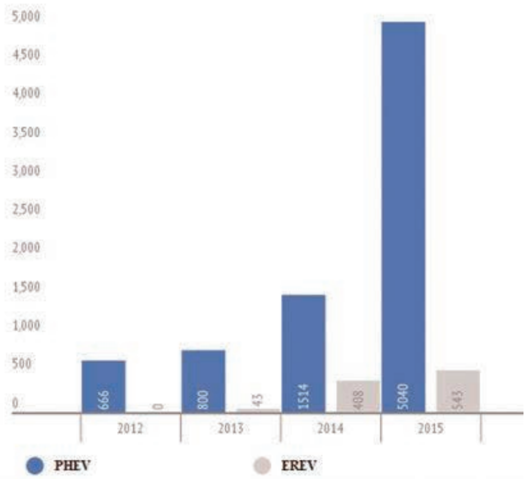

Figure 5: PHEV sales evolution from 2010 to 2015 (Source: AVERE)

25.4 Charging Infrastructure or EVSE

In order to develop PHEV and EV sales, France is investing in a network of charging spots available to the public. The development of private charging infrastructure is also seen as important and must therefore also be facilitated.

In general, France aims to massively install charging points: 7 million recharging points for electric cars are planned for 2030 (10,000 public charging spots in service in 2014).

The law on the energy transition to green growth provides a tax benefit to encourage charging stations installed in private homes. In addition, all new parking spaces will be equipped with EV charging stations.

Finally, large-scale deployment projects of charging stations lead by local authorities are eligible to the “investment for the future” program, a fund with a budget of 50 million EUR.

For private charging infrastructure, the Advenir program aims at installing more than 12,000 private charging stations for electric and rechargeable hybrid vehicles. Advenir will fund private charging points in France with energy savings certificates. The French Energy Savings Certificates is a private funding scheme based on an obligation set on energy suppliers in proportion of their sales. Energy suppliers must either implement energy savings programs, trade (buy) certificates on the Energy Savings Certificate market, or pay a penalty. Advenir is funded with 9.75 million EUR by EDF. This agreement paves the way to finance new charging points for electric and rechargeable hybrid vehicles in residential buildings and businesses.

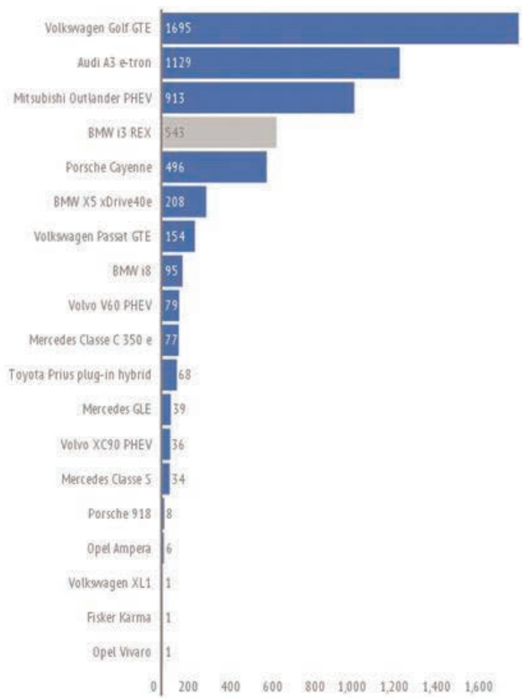

Figure 6: 2015 PHEV passenger vehicles sales by models (Source: AVERE)

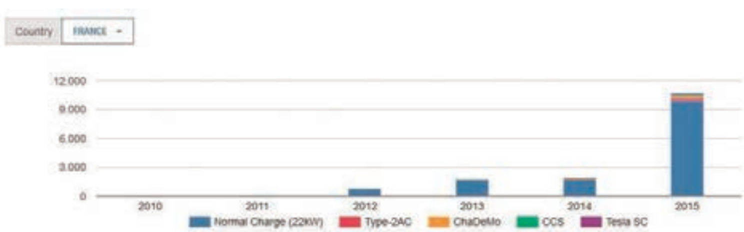

Figure 7: Number of publicly available charging positions (Source: EAFO)

Table 1: Information on charging infrastructure in 2015 (Sources: EAFO and ADEME)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	1,973
AC Level 2 Chargers	7,892
Fast Chargers	800
Superchargers	31
Inductive Charging	n.a.
Totals	**10,696**

n.a. = not available

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Sources: ADEME and CCFA)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
2- and 3-Wheelers[a]	n.a.	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles[b]	43,959	10,681	229,550	10	31,800,000
Buses and Minibuses[c]	220	n.a.	n.a.	n.a.	92,268
Light commercial vehicles[d]	n.a.	n.a.	n.a.	n.a.	5,965,000
Totals	**44,179**	**10,681**	**229,550**	**10**	**37,857,268**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
2- and 3-Wheelers[a]	2,764	n.a.	n.a.	n.a.	243,937
Passenger Vehicles[b]	17,268	5,587	56,030	10	1,917,223
Buses and Minibuses[c]	n.a.	n.a.	n.a.	n.a.	6,724
Light commercial vehicles[d]	4,974	11	703	1	427,866
Totals	**25,006**	**5,598**	**56,733**	**11**	**2,595,750**

n.a. = not available
[a] UNECE categories L1-L5
[b] UNECE categories M1 (estimated data)
[c] UNECE categories M2-M3
[d] UNECE categories N1
[e] Including non-electric vehicles

Table 3: Available vehicles and prices

Market-Price Comparison of Selected EVs and PHEVs in France	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Renault ZOE	22,400
BMW i3	35,490
Bolloré Bluecar	18,300 (+ 80 EUR/month)
Bolloré Bluesummer	24,000
Mitsubishi I-Miev	23,350
Nissan e-NV200	20,610 (+ 73 EUR/month)
Nissan Leaf 2.0	30,290
Nissan Leaf 30 kWh	35,255
Venturi Fetish	358,800
Citroën C-Zero	26,900
Ford Focus Electric	39,900
Kia Soul EV	35,400
Mercedes Class B Electric Drive	41,100
Smart Fortwo Electric Drive	24,250
Tesla Model S	71,760
VW e-Golf	34,900
VW e-up	26,250
Audi A3 e-tron	40,000
BMW 225xe Active Tourer	38,950
BMW 330e	46,950
BMW i3 REx	39,700
BMW i8	136,800
BMW x5 xDrive 40e	72,450
Chevrolet Volt	38,000
Fisker Karma	102,300
Mercedes S500 PHEV	108,944
Mitsubishi Outlander PHEV	43,900
Opel Ampera	38,000
Porsche Cayenne S-E Hybrid	84,038
Porsche Panamera S-E Hybrid	112,309
Toyota Prius PHV	37,150
VW Golf GTE	38,500
VW Passat GTE	47,360
Volvo V60 PHEV	61,150

26 Germany

26.1 Major Developments in 2015

Electric mobility is seen as a major driver in order to reach Germany's climate goals for 2020[66]. The political framework is given in the "Federal Program Electric Mobility" and the R&D activities are bundled in the "National Platform for Electric Mobility" with representatives from industry, science, and politics along the value creation chain. The showcase program with regional demonstration and pilot projects due to run until mid-2016 is seen as one of the central elements, being funded with 180 million EUR. According to the current plan of action, Germany has entered the market development phase in 2015, lasting until 2017. In order to reach the goal of one million electrified vehicles on German roads in 2020, several programs have been established covering the topics research and development, training and education, charging infrastructure, and tax/financial incentives. According to Sigmar Gabriel, the German minister of economic affairs, charging infrastructure development and customer friendly charging and billing are important next steps[67].

Complementary, the Federal Ministry for Economic Affairs and Energy, the Society of the Automobile Industry (VDA), and the trade union IG Metall have started an initiative "Branch dialogue with the Automotive Industry", stating that tax incentives, R&D, the build-up of battery cell production, and a charging infrastructure set-up are the key activities to be one of the global leading markets and suppliers[68].

Several new measures have been decided in 2015: the electric mobility act came into force in June; in September the German Bundestag issued a draft law concerning tax incentives. In addition, digitalisation and automation were other important parts of the political agenda in 2015, established via a number of announcements and initiatives: the "Digital Test Field" on the Highway No 9, the "Cooperative ITS Corridor", linking Rotterdam via Frankfurt am Main with

[66] www.bmub.bund.de/presse/pressemitteilungen/pm/artikel/uba-emissionsdaten-fuer-2015-zeigen-notwendigkeit-fuer-konsequente-umsetzung-des-aktionsprogramms-klimaschutz-2020/
[67] http://2015.konferenz-elektromobilitaet.de/konferenzunterlagen.pdf
[68] www.igmetall.de/docs_Gemeinsame%20Erklaerung_Fahrzeugindustrie_3cc56da6b14ee18312fb14c1100547905079403f.pdf

Vienna[69], the “Automated and Connected Driving Strategy”[70], the “Branch Dialogue with the Automotive Industry”, and the R&D program “New Vehicle and System Technologies”[71] of the Federal Ministry for Economic Affairs and Energy.

26.1.1 New Policies

In 2015, the German government passed the electric mobility act, which allows municipalities to privilege electric vehicles. The Federal Council drafted a law concerning tax incentives for electric vehicles, which is actually debated in the German Bundestag. Additionally, the government selected new flagship project in order to emphasize their importance and success (see Section 26.4.1).

26.1.2 New Legislation for Electric Mobility in Germany

The electric mobility act (EmoG[72]) came into force on 12 June 2015. Privileges are granted to electric vehicles that belong to one of the following categories: battery electric vehicles, fuel cell electric vehicles, and plug-in hybrid vehicles (emitting a maximum of 50 g CO_2/km or having a minimum electric range of 30 km until 31 December 2017 and 40 km thereafter). The electric mobility act empowers municipalities to give one or more of the listed privileges to EVs:

- Free and/or dedicated parking lots,
- Use of lanes that are reserved for special purposes,
- e.g. bus lanes, and
- Access to restricted areas.

Indication of privileged vehicles is implemented by a number plate that contains an “E” for German vehicles or by a sticker for foreign vehicles. Foreign number plates or stickers for electric vehicles are equivalently admissible[73].This law is especially important for Germany, since there was no jurisdictive foundation to give privileges to EVs previously.

[69] www.bmvi.de/SharedDocs/DE/Anlage/VerkehrUndMobilitaet/Strasse/flyer-eurokorridor-cooperative-its-corridor-in-deutsch.pdf?__blob=publicationFile
[70] www.bmvi.de/SharedDocs/DE/Publikationen/StB/broschuere-strategie-automatisiertes-vernetztes-fahren.pdf?__blob=publicationFile
[71] www.bmwi.de/DE/Themen/Technologie/Schluesseltechnologien/verkehrstechnologien.html
[72] Bundesgesetzblatt, “Gesetz Zur Bevorrechtigung Der Verwendung Elektrisch Betriebener Fahrzeuge“ (Elektromobilitätsgesetz - EmoG).
[73] BMVI, “Fünfzigste Verordnung Zur Änderung Straßenverkehrsrechtlicher Vorschriften“.

26.1.3 Tax Incentives for Electric Vehicles

The Bundesrat issued a draft law concerning tax incentives for electric mobility[74] in September 2015. The draft proposes the following measures:

- If an employer provides free charging infrastructure for employees, the monetary benefit of charging electric vehicles should be tax-free.
- Investments for electric vehicles and charging infrastructure should be promoted by special depreciation.

The law might also include a buyer's premium of up to 5,000 EUR for the purchase of electric vehicles and a simplified legal situation for the admission to install charging infrastructure.

26.1.4 Support of Municipal Concepts for Electric Mobility

In June 2015, the Federal Ministry of Transport and Digital Infrastructure issued a directive[75] concerning financial support for

- The purchase of electric vehicles and the installation of charging infrastructure. Subsidies are determined corresponding to additional investment costs. A minimum of 5 vehicles per funding request is normally required and parties entitled to submit an application may also unite to reach the required number.
- The preparation of environmental studies for municipal mobility concepts.
- Research and development that supports a higher market share of electric vehicles.

Presently, 35 municipalities in Germany receive financial support to install an electrical vehicle fleet with corresponding charging infrastructure and to develop procurement and transportation concepts based on electric mobility[76].

26.1.5 Automotive Industry

At the end of 2015, 22 PEV models were available at the dealerships of German manufacturers. The 2015 newly introduced models are listed in Table 1. Eight PEV models that are ready to go into production were shown at the 66th IAA Motor Show in Frankfurt. All of the eight models are PHEV and cover almost all segments and varieties. Additionally, Audi and Porsche (see Figure 1) have unveiled their concepts of a sporty, long-range and suitable for daily use full size BEV. Both models (the Audi Q6 e-tron quattro and the Porsche Mission E) provide

[74] Bundesrat, "Entwurf Eines Gesetzes Zur Steuerlichen Förderung Der Elektromobilität, Drucksache 18/5864."
[75] Bundesministerium für Verkehr und digitale Infrastruktur, "Förderrichtlinie Elektromobilität".
[76] "NOW: Now-Gmbh.de | Fachkonferenz in Aachen Und Förderaufruf."

a 95 kWh traction battery to achieve an all-electric range of at least 500 km. The Mission E concept also shows an 800 V system voltage and inductive charger. With Borgward, a new brand is entering the market that offers solely PHEV SUVs.

Bosch has entered a joint venture with GS Yuasa and Mitsubishi Corp. to develop improved battery cells. In order to achieve the self-set goal to double the energy density of current battery systems by the end of this decade, Bosch has also bought the Californian start-up Seeo that specialises on solid-state lithium-ion batteries.

Table 1: Newly introduced plug-in electric vehicles from German OEMs in 2015

Brand	Model	Type	Electric range (km)	Minimum list price (EUR)
BMW	225xe	PHEV	41	39,600
BMW	330e	PHEV	35	45,050
Mercedes-Benz	C 350 e	PHEV	31	51,051
Mercedes-Benz	GLE 500 e 4MATIC	PHEV	30	74,197
Volkswagen	Passat GTE	PHEV	50	44,250

Figure 1: Mission E (Image courtesy of Porsche AG)

26.2 HEVs, PHEVs and EVs on the Road

In 2015 3.21 million new cars were registered in Germany, a 5.6 % year-on-year increase. It remains the largest market in Europe. BEV sales increased by 45.1 % year-on-year to 12,363. HEV sales grew by 22.6 % to 33,630 of which 11,101 are PHEV (see Table 2). Despite the scandal of Volkswagen admitting to have falsely achieved emission standards, the shares of diesel and gasoline car sales remain at a high level of 48 % and 50.3 %, respectively. The average CO_2 emission of the newly registered car fleet decreased by 4 g/km to 129 g/km.

As of 1 January 2016, 54.6 million motorised vehicles were on the road in Germany, including 45.1 million passenger cars, 4.2 million motorbikes, 2.8 million trucks, and 78,000 buses. The stock of BEV amounted to 25,502, that of HEV to 130,365. This corresponds with a year-on-year growth of 34.6 % and 21 %, respectively. With 3,842 sold units, the Kia Soul EV was the most popular BEV in 2015. It is followed by the BMW i3 (2,271) and the Renault Zoe (1,787). The most popular PHEVs were the Mitsubishi Outlander PHEV (2,128), the Volkswagen Golf GTE (2,109), and the Audi A3 e-tron (1,839)[77].

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Data source: Kraftfahrtbundesamt www.kba.de)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
2- and 3-Wheelers[a]	7,300	n.a.	239	109	4,228,238
Passenger Vehicles[b]	25,502	10,809	119,556	241	45,071,209
Buses and Minibuses[c]	137	n.a.	321	15	78,345
Medium and Heavy Weight Trucks[d]	4,367	1	116	7	2,800,780
Totals without bicycles	**37,306**	**10,810**	**120,232**	**372**	**52,178,572**

n.a. = not available
[a] UNECE categories L1-L5 (without e-bikes)
[b] UNECE categories M1
[c] UNECE categories M2-M3
[d] UNECE categories N2-N3
[e] Including non-electric vehicles

[77] E-mobility-dashboard: www.electrive.net.

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
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

26.3 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 fastchargers. This charging infrastructure is also referred to as EV supply equipment (EVSE). As of 31 December 2015, there were 665 Level 1 charging points, 4,497 Level 2 charging points, and 153 fast chargers on about 2,567 publicly accessible sites in Germany. Table 4 provides an overview of the EV charging infrastructure.

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

Within the Showcase program, further charging infrastructure deployment and its expansion to region/corridors with the integration of fast charging points took place. Further projects aim at the development and demonstration of rapid charging systems in urban environment and at the build-up of fast charging points along motorways.

Table 4: Number of charging points installed in Germany as of December 31, 2015 (all publicly accessible, data source: German Energy and Water Association BDEW 2015)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	665
AC Level 2 Chargers	4,497
Fast Chargers	153
Totals	**5,315**

26.4 EV Demonstration Projects

26.4.1 Flagship Projects

Since 2012, the German Federal Government chooses flagship projects[78] in order to emphasize their importance and success. In 2015, the following projects have been selected:

Hamburg – Wirtschaft am Strom – testing of up to 740 electric vehicles in companies and municipalities, focus on port industries, logistics, aviation, small and medium-sized companies and vehicle fleets of Hamburg's administration.

Das 3E-Mehrfamilienhaus – Eigenerzeugung, Eigenverbrauch, Elektromobilität combination of electric mobility and decentralised sustainable electricity generation in buildings (photovoltaic systems and mini block-type cogeneration plants), usage of vehicle batteries and stationary batteries.

Schnellladenetz für Achsen und Metropolen (SLAM) – fast-charging infrastructure along traffic axes and in metropolises.

Adaptive City Mobility (ACM) – (e-Taxi) development of a new lightweight electric taxi vehicle concept, with a weight of 550 kg and a maximum speed of 80 km/h, providing emission-free electric transportation in urban areas.

Systemintegrativer Multi-Material-Leichtbau für die Elektromobilität (SMILE) – development of a lightweight vehicle concept adapted to the special requirements of electric vehicles, focus on innovative materials, according production processes and products that can be standardised.

[78] Bundesministerium für Verkehr und digitale Infrastruktur, "Bundesregierung Nominiert 7 Leuchtturmprojekte Elektromobilität."

Fertigungs- und Recyclingstrategien für die Elektromobilität zur stofflichen Verwertung von Leichtbaustrukturen in Faserkunststoffverbund-Hybridbauweise (ReLei) – development of an innovative production and recycling process for body structures of electric vehicles, focus on recovery of carbon fibres and thermoplastics of fibre-reinforced plastics.

Ein Elektromotor mit direkt integrierter Leistungselektronik (EMiLE) – development of an electric drive with integrated power electronics unit with the goal to reduce installation space and weight and to improve electromagnetic compatibility (EMC), size and costs should be halved while simultaneously increasing energy efficiency.

26.4.2 Electric Mobility Showcase Program

Since 2012, 130 electric mobility projects were funded by federal and state governments within six showcase projects in the four showcase regions Baden-Württemberg, Bavaria-Saxony, Berlin-Brandenburg, and Lower Saxony. The goals of these projects were to bundle the competencies in electric vehicles, energy supply and transportation system in regional demonstration and pilot projects. Most of these projects, which addressed for example research, building up of charging infrastructure, new mobility concepts, urban development or information and communication technology (ICT), were concluded by the end of 2015. Within this period, 2,500 passenger cars (90 % BEV), 1,000 pedelecs, 20 e-bikes, and 8 lightweight cars as well as 65 busses, 71 commercial and 15 municipal vehicles where used. To ensure the usage, 1,990 AC, 105 DC and 3 inductive charging points have been installed[79].

26.4.3 Results of Accompanying Research and Impact Research

Additionally to the electric mobility projects, accompanying research was initiated. The aim is to examine the impacts and effects of the funding program and to find answers to key questions concerning the electric mobility in Germany[80].

As an overarching result it can be noted that electric mobility is suitable for daily use and economical in many applications, even today.

More detailed results concerning the users are:

- Only very few people are willing to pay more for an EV.

[79] Harendt, Bertram (2016) Ergebnisse der Begleit- und Wirkungsforschung zum Schaufenster Elektromobilität. Forum Elektromobilität, Berlin. 02.03.2016.
[80] Begleit- und Wirkungsforschung Schaufenster Elektromobilität (2016). Ergebnispapier 16 – Fortschrittsbericht 2015. Frankfurt am Main.

- German customers wish for a higher assortment of EV vehicle models.
- While most vehicles are charged at home, at the work place or at semi-public charging points, a sufficient and visible public charging infrastructure is an important psychological factor.
- Driving pleasure and comfort are important issues for buying an EV.
- The majority of users who have tried electric mobility are (very) satisfied.

Beside private users, commercial transport can be an important part for supporting a successful market launch, in spite of an inadequate supply. Low operating costs are essential. Here, mixed fleets with conventional vehicles, PHEV and BEV can bring benefits concerning environment, operating costs as well as range reliability. Public charging is often billed per time. Hence, parking on charging spots shall be avoided. But at the same time, it leads to a great effort for the customer to move the car after finishing the charging process. Many of the public charging stations run on green electricity.

26.4.4 Funding Program for Market Introduction

In 2013, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety announced a funding program “Erneuerbar Mobil” (“Renewable Mobility”) for the market introduction of electric vehicles in private and commercial fleets. The aim of the program is the support of the acquisition of 1.600 electric vehicles[81]. Six projects started in January 2014: InitiativE-BB, InitiativE-BW, PREMIUM, HELD, ePowered Fleets Hamburg, Emissionsfreier Nahverkehr für Hannover (Emission-free local transport in Hannover)[82]. Within the projects, the leasing rates of the electric vehicles are reduced by 45 % of the added costs against a comparable conventional vehicle. In addition, 45 % of the component costs of the charging infrastructure are borne. Four projects focus on passenger cars while HELD and Emissionsfreier Nahverkehr für Hannover use electric and plug-in hybrid buses in the public transport in Hamburg and Hannover.

The range of vehicles is wide. From minicars (Renault Twizy) to luxury cars (Tesla Model S), every segment is represented. With the Renault Kangoo, the Citroen Berlingo and the Nissan e-NV 200, box vans for the commercial use are available.

[81] www.erneuerbar-mobil.de/de/projekte/vorhaben-im-bereich-der-elektromobilitaet-von-2013/markteinfuehrung-mit-oekologischen-standards

[82] www.emo-berlin.de/de/initiative/ ; http://www.initiative-bw.de/; www.erneuerbar-mobil.de/de/projekte/vorhaben-im-bereich-der-elektromobilitaet-von-2013/markteinfuehrung-mit-oekologischen-standards/PREMIUM ; www.erneuerbar-mobil.de/de/projekte/vorhaben-im-bereich-der-elektromobilitaet-von-2013/markteinfuehrung-mit-oekologischen-standards/HELD ; www.erneuerbar-mobil.de/de/projekte/vorhaben-im-bereich-der-elektromobilitaet-von-2013/markteinfuehrung-mit-oekologischen-standards/EcoFleet ; www.erneuerbar-mobil.de/de/projekte/vorhaben-im-bereich-der-elektromobilitaet-von-2013/markteinfuehrung-mit-oekologischen-standards/E-Busse%20Hannover

26.4.5 Preliminary Results from InitiativE-BW

Within InitiativE-BW, based in the German federal state of Baden-Württemberg, over 300 EV (89 % BEV and 11 % PHEV) were brought into the market, the majority of users being commercial fleets e.g. in social services, car sharing, IT-services and municipalities[83]. So far, experiences show that public relations management is one key role for a successful market introduction of EV.

More than 44 BEV have been equipped with data loggers, intended to run until the end of 2016. Data includes hours of operation, state of charge (SoC), mileages driven, speed statistics, and GPS information. First results show that varying ambient temperatures have a significant influence on the BEV energy consumption (Figure 2). Average energy consumption is up to 45 % higher during winter months.

Among all participants of InitiativE-BW, expectations and experiences with leased EVs are repeatedly evaluated through questionnaires. The questionnaires aim at user costs, electricity tariffs, expected mileages, and predicted needs for electric ranges. So far, survey results indicate that EV technical benefits such as their pronounced acceleration are not commonly known (Figure 3).

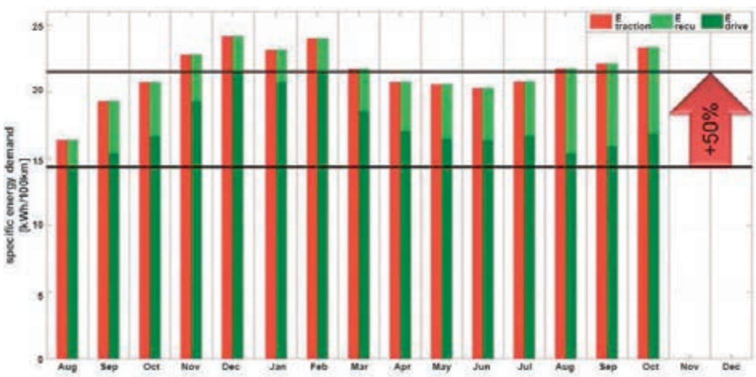

Figure 2: Real driving patterns of BEV in Baden-Württemberg: measured average specific energy demand (08/2014-10/2015)[84]

[83] www.initiative-bw.de

[84] Kugler, U., Ehrenberger, S., Dittus, H., Schmitt, M., Özdemir, E.D., Brost, M. (2015): Real-world driving, energy demand and emissions of electrified vehicles. Abstract submitted to the 21st International Transport and Air Pollution Conference (TAP 2016)

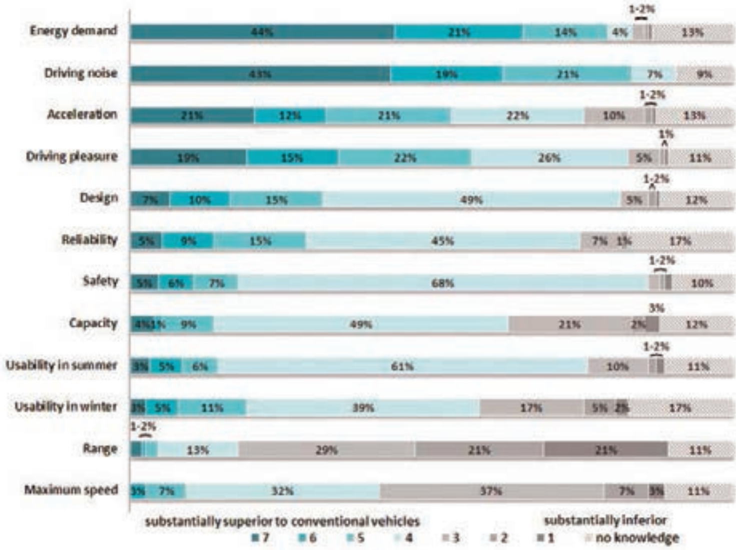

Figure 3: Survey results: attitudes towards EV in comparison to conventional vehicles (150 users)

27 Ireland

27.1 Major Developments in 2015

EV sales grew by 100 % from 2014 to 2015. The underlying growth for conventional passenger car sales increased by 30 % which indicated that interest in the EV market strengthened significantly. The Nissan Leaf dominated the market with sales of the Leaf weakening in the second half of the year as customers anticipated the new 250 km 30 kWh Leaf in the following year.

The charging infrastructure in the country has been paid for mainly by a charge on all electricity customers bills with some funding also provided by ESB and the EU. At present, there is no cost for the EV drivers to use this charging infrastructure (i.e. On-Street and Fast Chargers). Towards the end of 2015, ESB proposed introducing a subscription and usage charge to all users of this infrastructure. However, this was met with a negative reaction from EV users as the energy cost saving plays a significant element in the cost of ownership consideration for owners in Ireland. Plans to introduce pricing for use of the infrastructure have been postponed for the time being and will be reconsidered in 2016 following discussions with the Energy Regulator.

Approximately 23 % of Ireland's electricity is produced from renewable sources which is expected to reach 40 % by 2020. The average CO_2 intensity of the electricity produced is 457 g/kWh which would give indirect emissions of 70 g/km for a typical EV. This number will progressively improve as Ireland steadily increases its renewable electricity generation levels. By comparison, CO_2 emissions for new cars in Ireland are estimated to be on average 117 g/km based on manufacturer's data. It is expected that this performance level would then progressively deteriorate as the combustion engine ages and wears. NO_X estimates for an EV operating on Ireland's electricity mix would result in indirect NO_X emissions of 0.05 g/km for an EV which is better than the current Euro standards for cars.

Policies and Incentives

The primary support mechanisms for the EV market include a capital grant of up to 5,000 EUR and Vehicle Registration Tax relief of up to 5,000 EUR for BEVs. PHEVs receive the same grant amount but only receive VRT relief of up to 2,500

EUR. Accelerated Capital Allowances are provided to commercial purchasers of EVs.

Domestic charge points are currently being installed free of charge for the first 2,000 EV customers by ESB ecars (a company which belongs to the same group as the Distribution System Operator). The charge point is valued at 1,000 EUR and is expected to expire in 2016 as the number of new EVs purchased exceeds the number of EVs.

27.2 HEVs, PHEVs and EVs on the Road

The cumulative number of Passenger and Light Commercial EVs (BEV and PHEV) on Irish roads was 1,306 as of the end of 2015. EV sales doubled from 2014 to 2015. 80 % of the EV cars sold in Ireland are BEVs and approximately 17 % of the vehicles are sold to commercial entities. The market is dominated by the Nissan Leaf, however, in 2015 a large number of PHEV vehicles were introduced for the first time by different manufacturers. There are now 18 EV models available to the Irish consumer (see Table 3).

27.3 Charging Infrastructure or EVSE

Table 1 indicates the current number of chargers available at publically accessible locations in the Republic of Ireland. Charging infrastructure is also available in Northern Ireland and drivers may roam between and readily access the infrastructure in both parts of Ireland.

Table 1: Information on charging infrastructure in 2015 (Data source: ESB ecars)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers[a]	107
AC Level 2 Chargers	714
Fast Chargers[b]	81
Superchargers	0
Inductive Charging	1
Totals	**903**

[a] Level 1 includes publically accessible non-domestic chargers only
[b] AC Fast Charger may be used in parallel with CHAdeMO or CCS

27.4 EV Demonstration Project

The Rapid Charge Network project involved the development of a multi-standard, rapid charge network for electric vehicles throughout the UK and Ireland (see Figure 1). ESB was a partner in this project. 74 rapid charge points have been installed in total including three in both Ireland and Northern Ireland.

The project was co-financed by the European Union through the Trans-European Transport Network (TEN-T) program. The project will have a major impact on the adoption of electric mobility. Partners in the project included ESB, Nissan, BMW, Renault, Volkswagen, Zero Carbon Futures and Newcastle University.

Figure 1: Rapid Charge Network co-financed by the EU (image courtesy of ESB)

27.5 Outlook

The Alternative Fuels Infrastructure Directive must be transposed into national legislation by the end of 2016 and sets minimum levels of coverage for charging infrastructure for EVs and other low emission vehicles such as CNG and Hydrogen vehicles. It is likely that the EV will dominate the passenger and light commercial markets as the leading low emission vehicle technology for the near to medium term. There is some prospect for electric city buses when used in conjunction with fast charging technology. CNG and Hydrogen Fuel Cell technologies may offer strong prospects for heavier vehicles in the near to medium term.

Tesla is yet to sell EVs in Ireland so it is hoped that they may start operations in Ireland in 2016 and introduce their own supercharging network together with vehicle sales locations. This would eventually allow the Model 3 to become available to the Irish consumers.

Subject to availability, it is planned that the Hyundai Ionic BEV (250 km range) and PHEV will enter the Irish market towards the middle of 2016 which should offer real competition to the Leaf. Dealers believe that once 2,000 examples of a particular model exist on the road in Ireland, consumers become very familiar with the vehicle leading to increased sales rates. The second half of 2015 saw the introduction of many new PHEV models to Ireland particularly in the luxury brand sector which will gain traction in the 2016 market sales. More PHEVs are expected to arrive in the market in 2016 which will continue the trend of an ever widening product range for motorists to choose from.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Data source: Department of Transport, Tourism & Sport, SEAI)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	43	0	0	n.a.	36,974
Passenger Vehicles[b]	1,089	126	10,474	n.a.	2,054,432
Buses and Minibuses[c]	0	0	0	n.a.	21,133
Light commercial vehicles[d]	91	0	204	n.a.	329,316
Medium and Heavy Weight Trucks[e]	28	0	5	n.a.	127,493
Totals without bicycles	**1,251**	**126**	**10,683**	**n.a.**	**2,569,348**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	5	0	0	n.a.	1,244
Passenger Vehicles[b]	478	122	1,232	n.a.	121,453
Buses and Minibuses[c]	0	0	0	n.a.	418
Light commercial vehicles[d]	12	0	48	n.a.	28,173
Medium and Heavy Weight Trucks[e]	2	0	0	n.a.	2,562
Totals without bicycles	**497**	**122**	**1,280**	**n.a.**	**153,850**

n.a. = not available
[a] UNECE categories L1-L5
[b] UNECE categories M1
[c] UNECE categories M2-M3
[d] UNECE categories N1
[e] UNECE categories N2-N3
[f] Including non-electric vehicles

Table 3: Available vehicles and prices (Data source: SEAI - basic entry level price show for each model)

Market-Price Comparison of Selected EVs and PHEVs in Ireland	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Mitsubishi i-MIEV	28,095
Mitsubishi Outlander PHEV	35,137
Nissan Leaf 30kWh	30,073
Nissan ENV200	23,411
Renault Fluence	20,139
Renault Kangoo Van ZE	20,000
Renault Zoe	15,514
Citroen C-Zero	25,183
BMW i3 BEV	30,668
BMW i8 PHEV	101,342
BMW 225xe PHEV	35,131
BMW 330e PHEV	33,880
VW eGolf	30,216
VW Golf GTE PHEV	33,431
VW Passat GTE PHEV	34,349
Audi A3 E-Tron PHEV	33,431
Volvo V60 PHEV	47,807
Volvo XC90 PHEV	58,045

28 Italy

28.1 Major Developments and Legislation in 2015

In 2015, the major national measures to promote and financially support the introduction of cleaner vehicles were continued, according mainly to the national law n° 134 approved in August 2012 and partially revised in October 2014. This national law made financial incentives available 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 effects of this law are evident in the inversion of the declining trend of passenger cars, started in 2007 with respect to 2014 the passenger car market increased for about 16 %, with beneficial impact also on the cleaner vehicles market with various lower carbon fuels, including NG (Natural Gas) and LPG (Liquefied Petroleum Gas), electricity and hydrogen. The main scope of the law was to reduce CO_2 emissions in the transport sector by giving incentives to vehicles of various categories, and relating the incentives to three levels of CO_2 emissions: lower than 120 g/km, 95 g/km, and 50 g/km. The complete statistics of the subsidy law and advancement is reported on a dedicated website[85]. 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 26.1 summarizes details of the purchase incentives schemes.

The approved law also aims to create a set of clear and simplified rules, to be agreed with 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. Additional developments came from the further implementation of the national plan for electric charging stations, which approved and supported various local projects to start the installation of charging stations in many cities.

A dedicated fund of 50 million EUR in the same law is also available at 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

[85] www.bec.mise.gov.it/site/bec/home.html

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 realisation of the charging infrastructure. To accelerate the start of the process, an initial bid with a limited fund of about 4.5 million EUR has been reserved for regions with projects approved in November 2014.

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

	2013		2014		2015	
CO_2 emissions	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 in "car-free" days

28.1.1 Taxation

A cost reduction for major taxes on EVs and HEVs is still in place. 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 2015, some regions have also extended the property tax exemptions to these vehicles (including also, in some cases, those fueled with hydrogen) for short periods after the first registrations.

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

28.1.2 Incentives

Various regional and municipal authorities are financing the introduction of EVs and HEVs:

- The city of Milan is heavily assisting financially the use of Car-sharing networks with 100 EV 2-seats passenger vehicles (Share'ngo, shown in Figure 1): an electric bike sharing system with 1,000 p.a. bikes plus 3,600 conventional bikes is also in operation in the city with very promotional tariffs.
- The Emilia-Romagna Region, as part of the Agreement on the Air Quality is financing the i-Moving project with 2.4 million EUR, the introduction of 103 EVs of various categories in 15 cities (LDV, passenger cars, quadricycles, shown in Figure 2).

Figure 1: EV-car sharing system in the city of Milan: (Image courtesy of Share'ngo Sharing system)

Figure 2: Electric quadricycles in the I-moving Project financed (Image courtesy of Emilia-Romagna Region)

- In 2015, the full implementation of a financial supporting scheme of the national plan for electric charging infrastructure was carried out:A total of more than 4.5 million EUR was distributed to 18 regional projects, approved in November 2014 for the creation of an electric recharging infrastructure cover about 50% of the total costs of the projects. In some casesin the Lombardia Region, the funding was open to private recharging points. At the moment the total number of recharging points funded with these projects is not yet known.

28.1.3 Research and Industry

In 2015, the EV research has been prosecuted and/or completed in various projects in national programs (Industria 2015, PRIN-Research Projects of National Interests) and as part of the final year of the EU (European Union) 7th Framework Program, with the participation of Italian industries and research organizations and with some very valuable results. These projects covered EV technologies from components research and development like 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 3 shows the innovative electric motor inverter under test, which can be reversibly converted in the battery charge: one device for two key EV functions. This electronic device was developed by ENEA, as part of the National Research Program for the Electrical System.

In various European projects novel and improved batteries (Lithium-ion, Lithium-air, Lithium-Sulphur) and advanced supercapacitors have been investigated, with interesting results, while various categories (from large buses up to small 2-wheel motorbikes) of new hybrid and battery-powered electric vehicles with new configurations and applications (for private and commercial uses) are being researched and developed. Figure 3 shows the equipment for abuse testing on aged Li-ion modules for second life analysis and Figure 4 reports some results.

ENEA, as part of the Electromobility project included in the National Research Program for the Electrical System has been heavily investigating the effect of fast charging on battery behavior and the impact on the electricity grid. Figure 5 presents the testing station for Fast Charging with a Nissan Leaf connected to a CHAdeMO fast charger.

Figure 3: Second-life abuse testing equipment for aged Li-ion modules (Image courtesy of ENEA)

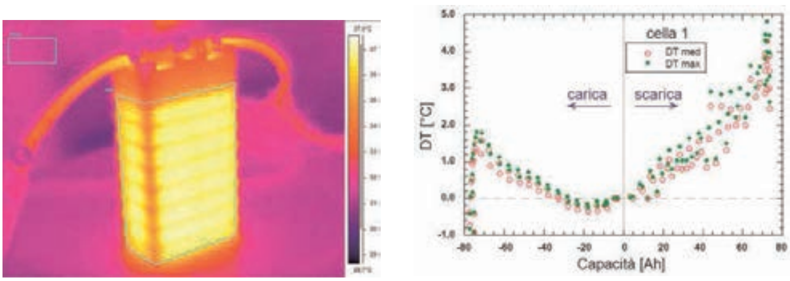

Figure 4: Some results of Second-life abuse testing for aged Li-ion modules (Image courtesy of ENEA)

Figure 5: Integrated testing station for fast charger characterization and static compensator for evaluating the impact on the electricity grid (Image courtesy of ENEA)

The EV manufacturers (national and international) have significantly increased their presence in Italy and their efforts to better promote the introduction of EVs and HEVs of any category (buses, passenger cars, commercial vans, two-wheel motorbikes and mopeds, and quadricycles). Large car companies (Renault, Toyota and Honda) have introduced more types of electric vehicles to the market, while national small manufacturers have encountered financial difficulties related to the late start of the public subsidies and the enlargement of the National Recharging Infrastructure. Tesla has created a network of 48 superfast charging stations distributed in various regions in Italy with the rationale to have an average distance of less than 300 km between each charging point.

Large utilities and industries such as ENEL (the largest Italian electric utility) and ENI (Italian Oil Company) are developing a joint program to install recharging stations in the country. In the beginning of 2015, they have reached an agreement to collaborate in installing fast charging stations in conventional fueling stations along the Italian Expressway network. Figure 6 shows the ENEL fast charging station opened at the beginning of 2015 at the Pomezia, south of Rome, at the ENI refueling station.

Figure 6: Fast Charge Plus Station at Pomezia ENI fueling station (Image courtesy of ENEL-ENI)

28.2 HEVs, PHEVs and EVs on the Road

In 2015 the Italian vehicle market inverted the negative trend of the last 8 years in major market segments: overall passenger car sales have increased for about 16 % with respect to 2014, reaching a total of 1,575,898. In addition, the 2015 market situation for cleaner passenger cars (vehicles fueled with natural or liquefied gas, EV and HEV) was further improved with an overall share of 5.7 % with respect to 2014 of the overall passenger car market.

HEV/PHEV/EV sales during 2015 continued to slightly increase, despite the economic crisis and the uncertainties related to the subsidy scheme, which was modified and stopped a few times during the year 2015. However, the HEV market share in the passenger car sector reached 1.6 % of the overall passenger car market, more than at the same level of 2014 with a numerical decrease of about 25 %, while the EVs share remained stable (0.1 %) with a numerical increase of 22.4 %. The reasons for such good results for cleaner vehicles are mostly related to the financial incentives, the governmental strategy aimed at assisting park renewal in private and commercial fleets; a larger availability of vehicle offers from national and international car companies; local (regional and municipal) initiatives and promotional actions, 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 with 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 Tables 1 and 2 were estimated and updated at February 2016, based on publicly available data. The data for EVs and HEVs (and PHEVs) on overall fleets were mostly adapted from CEI-CIVES (Italian EV Association) analyses and from different sources of official automobile and governmental organizations (ACI, ANCMA, ANFIA, UNRAE, Ministry of Transportation), and are also based on interviews of manufacturers and importers in the last years.

28.3 Charging Infrastructure or EVSE

The national effort for the preparation of the electric charging infrastructure 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 more than 2,000 normal charging points (in public areas and in private ones open to public usage) with just about a significant increase in one year of fast charging stations, but with a foreseen outstanding acceleration in the next two years. The superfast-charging stations, thanks to the Tesla effort are significantly augmented, and the initiatives of electric utilities and central and local authorities, with current focus on demonstration activities. For example, ENEL (the largest Italian electric utility) and ENI (Italian Oil Company) have reached an agreement to collaborate in installing fast charging stations in conventional fueling stations along the Italian Expressway network. Recently the Minister of Transport has announced the Ministry's intention to install 20,000 electric charging stations in less than three years.

In 2014, hydrogen refueling stations have been installed as part of the European demonstration projects High V.LO-City project, CHIC and HyFIVE (Hydrogen for innovative vehicles).

Table 2: Information on charging infrastructure in 2015 (Data source: Source: CEI-CIVES Italian EV association survey)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	1700[a]
AC Level 2 Chargers	300[b]
Fast Chargers	10
Superchargers	48 (Tesla charging points)
Inductive Charging	n.a
Totals	2058

n.a. = not available
[a] Charging points in public areas
[b] Charging points for dedicated categories (2-3 wheelers and quadricycles)

28.4 EV Demonstration Projects

Several of the world's leading car manufacturers, including all of those in the HyFIVE an EC project, involving more than 180 FCEV and 15 participants and 5 FCEV manufacturers, of which 10 are used in the city of Bozen, and one of the project participant have been developing hydrogen fuel cell concept vehicles during the past 20 years and have matured the technology to the point where the first production models will be coming to market within the next few years. Their priority will be the introduction of vehicles in markets where a strategy is in place to support their use with an appropriate infrastructure for hydrogen fuel supply, distribution and sales.

28.4.1 The High V.LO-City Project

The High V.LO-City project, co-financed by the EU Joint Undertaking for Fuel Cells and Hydrogen (FCH JU), aimed at facilitating rapid deployment of a new generation of FCH buses in public transport operations, will continue until 2018 in various European locations: in Italy, in Flanders (Belgium) and in Scotland (city of Aberdeen). San Remo city has a fleet of 5 Van Hool Fuel Cells buses being put in operation in 2014 on two different lines, partially substituting trolleybuses.

28.4.2 The CHIC

The CHIC (Clean Hydrogen in European Cities), also co-funded by the FCH JU, is a major European demonstration project, involving a total of 58 FC buses of 5 different manufacturers, from 2010 to 2016, deploying a fleet of Daimler EVO fuel cell electric buses and associated hydrogen refueling stations. Two 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 program aimed at transforming the Brennero Expressway in the first "Hydrogen Highway", connecting the city of Munich (Germany) with the city of Modena (Italy) through a zero emission highway, with seven hydrogen refueling stations over a highway route of 650 km. In June 2014, the H_2 competence centre and the hydrogen refueling station in Bolzano was officially inaugurated, shown in Figure 8.

Figure 7: The FC buses in service in Milan (3 in total), as part of the EC High V.LO-City project (Image courtesy of High V.Lo-City Project)

28.4.3 The HyFIVE

The HyFIVE (Hydrogen for innovative vehicles) is another EC project, involving more than 180 FCEV and 15 participants and 5 FCEV manufacturers, of which 10 Hyundai ix35 FC are used in the city of Bolzano. The Korean Hyundai, one of the project participants has been developing hydrogen fuel cell concept vehicles during the past 20 years and have matured the technology to the point where the first production models will be coming to market within the next few years. Their priority will be to introduce vehicles into markets where a strategy is in place to support their use with an appropriate infrastructure for hydrogen fuel supply, distribution and sales. Figure 9 shows all the FC vehicles passenger cars and the bus in service in Bolzano.

Figure 8: Six 700 bar Hydrogen refueling stations in Bolzano, as part of the CHIC EC project (Image courtesy of CHIC Project)

Figure 9: Hydrogen FC vehicles and bus in Bolzano, as part of an CHIC and HyFIVE EC projects (Image courtesy of CHIC Project)

28.5 Outlook

The prospects for EVs, PHEVs and HEVs in Italy are judged positively and with a significant growing trend in the medium to long term with higher attention from media general public and authorities. The major driving force for most countries and car makers in Europe will be the mandatory constraints 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, the air quality control in Italy will further improve the introduction of low and zero emission vehicles to mitigate the local environmental emergency, also thanks to the initiatives of regional and municipal authorities integrating the initiatives of the central government and various Ministries. Finally, a 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 implementation by 2020 and beyond for hydrogen refueling stations.

The Italian Government has already prepared and approved the National Plan for Electric Charging Infrastructure, and that for liquid natural gas and another one for hydrogen refueling infrastructure is under preparation by the Ministry of Economic Development.

Table 3: Distribution and sales of EVs, PHEVs and HEVs in Italy in 2015 (data are estimates from car associations UNRAE (association of foreign car manufactures, ACI = ANCMA, Automobile club of Italy, Elaborations of CIVES = Italian EV association)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	370,834	n.a	n.a.	n.a.	8,105,620
Passenger Vehicles[b]	4,160	456	25,661	n.a.	38,656,651
Buses and Minibuses[c]	471	n.a.	35	13	100,341
Light commercial vehicles[d]	3,900	182	n.a.	n.a.	483,603
Medium and Heavy Weight Trucks[e]	n.a.	n.a.	n.a.	n.a.	3,919,013
Totals without bicycles	**379,365**	**647**	**25,696**	**13**	**51,265,228**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	58,829	n.a.	n.a.	n.a.	58,829
Passenger Vehicles[b]	1,460	456	25,661	1	1,575,898
Buses and Minibuses[c]	n.a.	n.a.	n.a.	n.a.	135,138
Light commercial vehicles[d]	479	n.a.	77	n.a.	132,711
Medium and Heavy Weight Trucks[e]	n.a.	n.a.	n.a.	n.a.	15,155
Totals without bicycles	**60,768**	**456**	**25,738**	**1**	**1,917,731**

n.a. = not available
[a] UNECE categories L1-L5
[b] UNECE categories M1
[c] UNECE categories M2-M3
[d] UNECE categories N1
[e] UNECE categories N2-N3
[f] Including non-electric vehicles

Table 4: Available vehicles and their prices in Italy (Data source: websites and national car magazine Quattroruote)

Market-Price Comparison of Selected EVs and PHEVs in Italy	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Fisker Karma	105,600
Mia electric	25,218
Mitsubishi i-MIEV	32,214
Mitsubishi Outlander PHEV	44,900
Nissan Leaf	23,790
Opel Ampera (EREV)	45,500
Peugeot iOn	30,689
Porsche Panamera S E-Hybrid	113,417
Renault Fluence	28,500
Renault ZOE	22,100
Renault Kangoo Maxi	22,650
Renault Twizy	6,800
Tesla Model S 60 kWh	80,240
Tesla Model S 85 kWh Performance	100,840
Toyota Prius Plug-in	29,250
VW e-up!	27,400
VW e-Golf	38,000
Hyndai ix35 fuel cell	66,000
Mercedes B class 250 executive	41,680
Mercedes B class 250 sport	43,440
Volvo XC 90 Hybrid	80,550
BMW i3	36,500
KIA Soul EV	36,000

29 The Netherlands

29.1 Major Developments in 2015

The Netherlands stimulate the electrification of transport, because it contributes to climate objectives, energy transition, and the quality of life in cities. Moreover, the development of an e-mobility sector strengthens the economic position of the Netherlands, thus realizing green growth.

The vision on Sustainable fuels for transport, as developed by the government in close co-operation with experts and important stakeholders, states that in 2035 all newly sold vehicles should be capable of driving emission-free. The Formula E-team, a public-private co-operation between companies, research institutes, the government, and local authorities, leads the way in achieving these goals.

Figure 1: Picture from the RVO.nl-brochure "We are the Netherlands, your partner in E-mobility!"

The number of electric cars in the Netherlands has grown in the past few years. In fact, the Netherlands is one of the global leaders in EV sales. The target for 2015 was to have 15,000 to 20,000 EVs on the road. With over 90,000 EVs on the road at the end of 2015, this target was met and easily exceeded.

The frontrunner position is also illustrated by the number of foreign EV-companies investing in the Netherlands. Tesla and BYD have both expanded their Dutch activity centres, for example.

29.1.1 Employment in E-Mobility Sector

The number of companies active in the sector is also increasing, as are their export activities. Research published in 2015 reported on the economic size of the EV-sector in the Netherlands. Figure 2 shows indicators on the development of (direct) employment (in fte), production volume and gross added value.

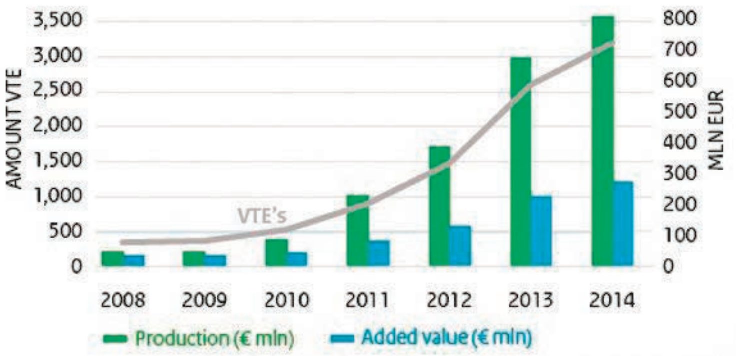

Figure 2: E-mobility economic indicators (Source: CBS Statistics Netherlands)

Direct employment in e-mobility has almost increased by tenfold since 2008; from 350 fte in 2008 to 3,200 fte in 2014. Although growth has slowed down a bit last year, the number of jobs still increased by 25 % compared to 2013.

A breakdown of these data in market clusters shows that employment is highest in the services sector (financing, payment, mobility and other services) and in the manufacturing and retrofitting of vehicles. In terms of percentage, the highest increase in jobs in 2014 was realized in the segment of charging infrastructure and smart grids. Production and added value follow this trend.

In early 2015, the research company CE Delft estimated the number of jobs in electro-mobility in 2020, using various scenarios, to reach between 5,400 and up to 18,850 jobs – the average being around 10,000 jobs in 2020.

29.1.2 Financial and Fiscal Incentives

One of the main drivers behind the increase of electric vehicles is fiscal stimulation. Starting 1 January 2015 there is more focus on stimulating zero emission vehicles, with an even stronger focus since 1 January 2016. For the period of 2017-2020 fiscal incentives for PHEVs will gradually be reduced to the same level as for regular cars. Table 1 provides an overview of the incentives that were in place in 2015.

Table 1: Fiscal incentives in the Netherlands 2015

Policy measure	Details
Registration tax	Zero emission cars are exempt from paying registration tax. For other cars the system is progressive, with 5 levels of CO_2 emissions and amounts of registration tax. Plug-in hybrid cars go to level 1, 1-82 g CO_2/km and pay 6 EUR per gram. For level 2, 83-110 g CO_2/km the extra tariff for those emissions is 69 EUR per gram CO_2. The final level is 434 EUR per gram for 180 g CO_2/km or over.
Road tax	Cars < 51 g CO_2/km are exempt from paying road taxes, compared to 400 EUR to 1,200 EUR otherwise (depending on fuel, weight and address).
Surcharge on income tax for the private use of company cars	In the Netherlands, income tax has to be paid on the private use of a company car. This is implemented by imposing a surcharge of 4-25 % of the catalogue value on the taxable income. For zero emission cars this percentage is 4 %. For most plug-in hybrids the percentage is 7 % (< 51 g CO_2/km), the next level (51-82 g CO_2/km) is 15 %, increasing to 25 % for CO_2 emission over 110 g/km.
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. Zero emission and plug-in hybrid (and not with a diesel engine) cars are on the list of deductible investments, as are the accompanying charging points.

In addition to these national instruments, there are various regions that subsidise electric cars (passenger cars, commercial cars, trucks and/or scooters) and/or the installation of charging points.

As part of the Green deal on public charging infrastructure (please refer to Chapter 29.1.3 for more information), the national government committed 5.7 million EUR to contribute during three years to the installing of public charging points. In the period of mid-2015 to mid-2018 a gradually decreasing contribution per pole can be granted, provided that a municipality contributes the same amount and a market party also contributes. In 2015, the national contribution was 900 EUR per charging pole.

29.1.3 Green Deal on Public Charging Infrastructure

Frontrunner regions such as the Province of Brabant and the Metropolitan Region of Amsterdam and large cities such as Amsterdam, Rotterdam, The Hague, and Utrecht are organising tenders for the installation and operation of public charging infrastructure. Since most public charging stations are still not commercially viable, public authorities and the business community have used shared financing to create new charging stations. The national government is helping to remove financial barriers in the form of a Green Deal.

Through Green Deals, the Dutch government helps local authorities, citizens, companies and organisations to stimulate environmental initiatives. Several Green Deals on e-mobility have been signed in recent years. In June 2015, a Green Deal was signed on public charging infrastructure. The national government has made 7.3 million EUR available for this project. The Green Deal aims to enlarge the public charging network in the Netherlands and to bring down the cost, through the foundation of the National Knowledge Platform for Charging Infrastructure and a contribution for public charging poles. Additional financing will come from local governments and private entities (please refer to Chapter 29.1.2 for financial details).

The *National Knowledge Platform for Charging Infrastructure*[86] aims at bringing down the cost for public charging infrastructure, through research and innovation projects.

29.1.4 Market Developments

At the end of 2015, 453 electric taxis were in operation in the Netherlands, many of them Tesla Models S's driving at Schiphol airport. Several other cities have electric taxis as well. In the city of Utrecht for example, 20 electric Kia Soul taxis are being used for transporting school children.

The Ministry of Infrastructure and the Environment (after consultation with the European Commission) have decided to stretch the concession term for electric buses for public transport from 8 to 10 years to 12 to 15 years. This is favourable, because the vehicles and infrastructure can be amortized over a longer period, thus making the total costs of ownership comparable to diesel buses.

Amsterdam Airport Schiphol also has started the deployment of 35 electric buses that transport passengers from aircraft to gate. Charging is done on the basis of solar energy and every bus has its own charging point at the airport, making Schiphol the biggest charging station for electric buses in Europe.

The rapid growth in fast chargers in the Netherlands is partly attributable to Fastned's new stations, now 50 in number. Their goal is to have more than 200 fast-charging stations along highways, creating a geographically comprehensive national network.

[86] www.nklnederland.nl

Figure 3: Schiphol taxi (Source: RVO.nl-brochure “We are the Netherlands, your partner in E-mobility!”)

Figure 4: Fastned charging station (Source: RVO.nl-brochure “We are the Netherlands, your partner in E-mobility!”)

Electric car sharing is gaining ground. Car2Go’s 350 electric Smarts in Amsterdam remain popular. The corporate E-car sharing project eCARSHARE in the south of the Netherlands has expanded its fleet. As of October 2015, 250 users had driven over 75,000 electric kms for both business and private use.

An association for electric drivers was established, the Vereniging Elektrische Rijders[87] (VER). It has 15,000 members and will function as information and linking platform. VER will regularly research its members to highlight ideas, wishes, and problems.

29.1.5 Innovation and Research

Most PHEVs in the Netherlands are leased cars and many of them could make better use of their electric potential. The Plug-in Coalition set up by the Formula E-team stimulates the increase of electric kms through various measures. A monitoring system was set up to keep track. The first report was published in 2015. It appeared that 25 % of PHEVs drive 60 % electrically (1 out of 4 PHEVs maximise their e-potential) and 50 % of PHEVs drive 50 % electrically. It was recognised, however, that the fast increasing number of PHEVs helped a lot in increasing the number of public charging points.

The municipality of Amsterdam and the University of Applied Sciences of Amsterdam have analysed the use of charging poles in the city. The data provide interesting insights in when and where new charging points should be installed, leading to information on the most efficient way to install charging infrastructure.

Collaboration between universities and industry is on the rise. Especially striking is the presence in the Netherlands of nearly 20 student racing teams with electric vehicles. Cooperating with Dutch companies, they design highly innovative e-vehicles (cars, motor bikes, even a boat) that compete very successfully in electric student races, such as the World Solar Challenge in Australia or the Formula 1 Student in Germany.

Figure 5: Examples of innovative e-vehicles designed by Dutch students

29.2 HEVs, PHEVs and EVs on the Road

The number of plugged-in electric vehicles grows steadily in the Netherlands (please refer to Figure 6 and Table 2). Registrations of plugged-in electric passenger cars doubled in 2015. At the end of 2015, 87,531 electric passenger cars

[87] VER, www.verenigingelektrischerijders.nl

were registered in the Netherlands. Of these almost 11 % were Battery Electric Vehicles (BEVs), the majority consisting of Plug-in Hybrid Vehicles (PHEVs or E-REVs). When compared to the end of 2014, BEVs increased by 37 % and PHEVs by 112 %. There were 131,011 HEVs on the road at the end of December 2015. In the year 2015 the number of registered HEVs increased by almost 12 %.

In 2015, 276,000 e-bikes were sold in the Netherlands, versus 983,000 new bikes sold in total in 2015. Thus, 28 % market share for e-bikes compared to an overall sum of bikes were sold. The fleet total of e-bikes at the end of 2015 was more than 1.2 million (no exact figure is traceable). The total bike fleet at the end of 2015 was 22.7 million[88].

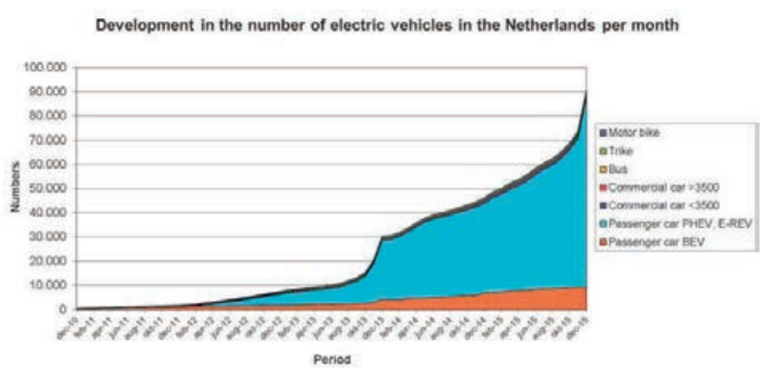

Figure 6: Development of plugged-in electric vehicles 2010-2015 in the Netherlands (Source: Dutch Road Authority, edited by RVO.nl)

At the end of 2013 and the end of 2015, the effect of upcoming changes in fiscal incentives is clearly visible. Section 29.1.2 gives an overview of Dutch incentives. Over the year 2015, 9.7 % of new registrations were BEVs or PHEVs. In 2014 this percentage was 3.9 %, and in 2013 it was 5.3 %. At the end of 2015 about 1 % of the total passenger car fleet was electric (BEV and PHEV). The most popular models in the Dutch fleet for PHEV and BEV are shown in Figure 7.

[88] Source of the data is the Rabobank Cijfers en Trends, Tweewielerspeciaalzaken Branche-informatie. Their quoted source is BOVAG, Detailhandel.info, edited by Rabobank.

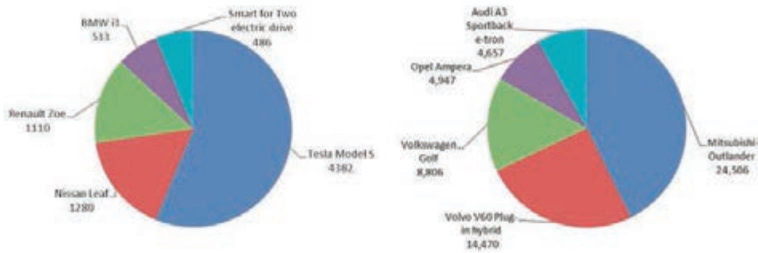

Figure 7: Top 5 registrations in fleet BEV (left) and PHEV (right), 31-12-2015 (Source: Dutch Road Authority, edited by RVO.nl)

29.3 Charging Infrastructure or EVSE

At the end of 2015, there were over 7,300 public charging points and more than 10,300 semi-public charging points in the Netherlands. The number of fast chargers increased by 80 %, from 254 at the end of 2014 to 465 at the end of 2015. This includes 7 Tesla Supercharger locations with 51 chargers in total. Next to these publicly accessible charging points an estimated minimum of at least 55,000 private charging points were in operation. Please refer to Table 2 and Figure 8.

Overall, at the end of 2015, the ratio of public charging points to electric passenger vehicles was 0.8.

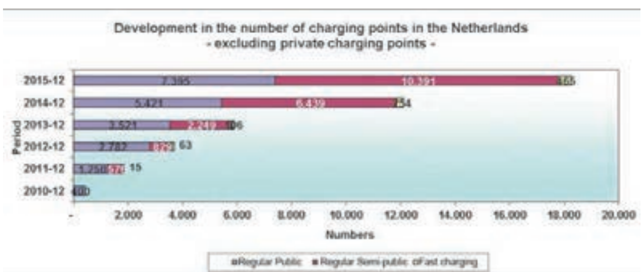

Figure 8: Charging infrastructure development in the Netherlands, 2010-2015 (Source: Oplaadpalen.nl, edited by RVO.nl)

The Netherlands have made national agreements on interoperability, corresponding to European standards. Many charging systems in use in the Netherlands have been interoperable since the beginning of 2011.

The recently developed Open Charge Point Interface (OCPI) protocol, an independent roaming protocol for providers of charging infrastructure and services, was designed in the Netherlands for this purpose. It provides information about location, real-time availability, prices, real-time billing, as well as mobile access of chargers.

Table 2: Information on charging infrastructure in 2015 (Source: Oplaadpalen.nl, edited by RVO.nl)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 & 2 Chargers	17,786
Fast Chargers	414
Superchargers	51 (7 locations)
Inductive Charging	Pilot projects only
Totals	**18,251**

29.4 EV Demonstration Projects

A living lab in Utrecht's Lombok district is concerned with V2G (vehicle-to-grid) energy storage. Lomboxnet smart charging stations can both charge and discharge, establishing the foundation for a local energy system based on local energy sources and local storage.

Ngo's Natuur & Milieu and Friends of the Earth together ran Project A15 from 2012 up to and including 2015, aiming at accelerating electric driving with locally generated green energy. They strived to create the first really sustainable highway in the world, with electric (shared) cars using local sustainable energy. Valuable experiences were gained in the project and important lessons were learned for the further roll-out of e-mobility.

An innovative project on the second-life of discarded EV batteries is running on the self-sufficient island of Pampus. A set of these batteries has been installed in a test configuration at an off-grid location in order to monitor the changes in power over time.

Figure 9: Opening of V2G-charging point Lomboxnet in June 2015 (photographer: O. Timmers)

Figure 10: Pampus battery configuration (Source: RVO.nl-brochure ‘We are the Netherlands, your partner in E-mobility!’)

Several green deals are carried out in the field of electric driving, some focusing on a specific region and others on specific themes. The Green Deal on Zero Emission City Distribution, for example, runs several living labs on city logistics. These may include new vehicle technologies, new ways of utilizing and loading trucks and the introduction of innovative logistics processes, as well as solutions for removing obstacles in the area of legislation and the promotion and implementation of changes for regulations.

Rijkswaterstaat, responsible for the main highways and waterways network in the Netherlands, is testing some fuel cell passenger cars. Five demonstration projects with fuel cell buses are being developed in five specific regions (Arnhem-Nijmegen, Eindhoven, Rotterdam, Groningen, and Zuid-Holland).

29.5 Outlook

Starting from 2016 on, the fiscal incentives will focus more on battery electric vehicles. For the period of 2017-2020 fiscal incentives for PHEVs will gradually be reduced to the same level as for regular cars. It is expected that this will affect PHEV sales.

It is expected that a green deal will be signed in 2016, enabling the Formula E-team to keep active in stimulating e-mobility until 2020. The next stage in Dutch EV collaborations will focus on:

- Development of consumer market for electric vehicles
- Storage capacity of renewable energy in electric cars and charge and discharge capacities with the grid
- Innovative solutions for charging infrastructure

Also it is expected that an agreement among public authorities will be signed to reach zero emission public transport ultimately in 2030.

The vision on Sustainable fuels for transport will be implemented in 2017. In 2016 the instruments needed to facilitate the implementation process will be developed.

At the end of 2015, the Dutch parliament carried a motion on the high energy tax for (public) charging poles. Therefore the installation of a separate tariff of energy tax for charging poles will be investigated.

Table 3: Distribution and net registrations of EVs, PHEVs and HEVs in 2015 (Source: Dutch Road Authority, edited by RVO.nl and totals: BOVAG/RAI via www.bovag.nl and www.raivereniging.nl)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
Bicycles (assisted pedaling)	1,503,291	n.a.	n.a.	n.a.	24,608,919
2- and 3-Wheelers[a]	33,428	n.a.	n.a.	n.a.	1,861,978
Passenger Vehicles[b]	9,368	78,163	131,011	21	8,193,000
Buses and Minibuses[c]	94*	n.a.	n.a.	1	10,000
Light commercial vehicles[d]	1,460	n.a.	n.a.	3	885,000
Medium and Heavy Weight Trucks[e]	50	n.a.	n.a.	2	134,000
Totals without bicycles	**44,400**	**78,163**	**131,011**	**27**	**11,083,978**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
Bicycles (assisted pedaling)	276,000	n.a.	n.a.	n.a.	983,000
2- and 3-Wheelers[a]	5,000	n.a.	n.a.	n.a.	22,142
Passenger Vehicles[b]	2,543	41,226	13,752	21	449,350
Buses and Minibuses[c]	14*	n.a.	n.a.	1	309
Light commercial vehicles[d]	202	n.a.	n.a.	2	57,707
Medium and Heavy Weight Trucks[e]	0	n.a.	n.a.	2	14,111
Totals without bicycles	**7,759**	**41,226**	**13,752**	**26**	**543,889**

n.a. = not available
[a] UNECE categories L1-L5
[b] UNECE categories M1
[c] UNECE categories M2-M3
[d] UNECE categories N1
[e] UNECE categories N2-N3 ;
[f] Including non-electric vehicles

Table 4: Available vehicles and prices (Source: internet in the period March/April 2016)

Market-Price Comparison of Selected EVs and PHEVs in the Netherlands	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Mia electric	24,505
Mitsubishi i-MIEV	25,990
Mitsubishi Outlander PHEV	41,990
Nissan Leaf	30,735
Opel Ampera	34,900
Peugeot iOn	29,990
Porsche Panamera S E-Hybrid	110,100
Renault ZOE	20,990
Renault Kangoo Maxi	27,825
Renault Twizy	7,790
Smart Fortwo Electric Drive	15,890
Tesla Model S 60 kWh	66,200
Tesla Model S 85 kWh Performance	88,700
Toyota Prius Plug-in	34,450
VW e-up!	25,925

30 Portugal

30.1 Major Developments in 2015

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 3,000 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.

30.1.1 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:

4. **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.

5. **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).
6. **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.

30.1.2 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])

30.1.3 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.

30.1.4 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	MIT[c]-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

30.1.5 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.

30.2 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.

30.3 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.

30.4 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.

31 Republic of Korea

31.1 Major Developments in 2015

Hyundai Motor has announced the name of its advanced, alternative-fuel compact vehicle due for launch in 2016: the Hyundai IONIQ. The car will be available with electric, plug-in gasoline/electric hybrid, or gasoline/electric hybrid powertrain – the first car from any manufacturer to offer customers these three powertrain options in a single body type. Based on an exclusive new platform, made specifically for the car's multi-powertrain options, the IONIQ chassis is optimised to deliver responsive handling while remaining efficient in each of its three powertrain configurations. In its fully-electric (EV) form, the IONIQ is powered by a high capacity, ultra-efficient lithium ion battery. The plug-in hybrid (PHEV) version combines a fuel-efficient energy with battery power obtained by charging the car with electricity, boosting its range while cutting its emissions. Finally, the hybrid (HEV) utilises the gasoline engine and motion of the car to charge the on-board battery, which returns enhanced efficiency by supplementing the engine's power. The powertrain to be made available will be the hybrid. Comprising a 1.6-liter Kappa GDi engine that produces a peak of 103 bhp and 15 kgm of torque, and a lithium-ion battery-powered, permanent magnetic electric motor, which contributes a maximum of 43 hp and 17 kgm of torque, the hybrid is claimed to have a thermal efficiency of 40 %.

Figure 1: New Hyundai IONIQ hybrid (Image source: http://globalpr.hyundai.com/prCenter/newsView.do?dID=5696)

This efficiency is possible thanks to the combustion engine's use of optimised cooling and a 200 bar six-point direct fuel injection system, while the electric motor benefits from declination coils that allow it to work with a claimed 95 % efficiency. Drive is sent to the front wheels via a six-speed DCT dual clutch transmission that has been optimised for the hybrid to offer as much as 97.5 % efficiency – another class leading feature, according to Hyundai. Below, some of the technical details have been summarised.

Engine		Motor		Battery	
Type	1.6 GDI Atkinson Cycle	**Type**	Interio-Permanent Magnet Synchronous Motor	**Type**	Lithium-ion Polymer
Materials	Aluminum block and head	**Output**	32kW	**Voltage**	240V
Horsepower	104hp@5700rpm	**Horsepower**	43hp@2500rpm	**Capacity**	1.56kWh
Torque	15kgm@4000rpm	**Torque**	17kgm@1798rpm		

*FUEL CONSUMTION : 22.4km/L

31.1.1 EV Rapid Charger Fee

It was decided for the EV rapid charger fee to be 313.1 KRW/kWh (2.35 EUR/kWh) and making the transition from government-led to market-driven through private sector participation.

- Only slow charger electric fee was levied, but an electric vehicle pay/rapid charger electric fee has also been installed since the beginning of April.
- Previously the government used to install electric car chargers, but now it is the intention to switch to a market-driven approach with utilizing private capital and skills.
- When Rapid charger electric fee compare to an internal combustion engine fuel cost, the electric fee is 44 % of gasoline and 62 % of diesel vehicles.
- When a slow charger is compared to a rapid charger, the electric fee is 33 % of gasoline and 47 % of diesel vehicles.

Table 1: Comparison with electric fee and an internal combustion engine fuel cost (all prices given in KRW)

	An internal combustion engine fuel cost		Electric vehicle charge fee (C)			An internal combustion engine fuel cost / Electric vehicle charge fee	
Classifi-cation	Gasoline (A)	Diesel (B)	Using 30 % of rapid charger	Using slow charging only	Using rapid charging only	Comparison with gasoline (A:C)	Comparison with diesel (A:B)
Fuel Cost	132	94	44	30	58	1:0.33	1:0.47

31.1.2 Promoting EV Battery Leasing Business (Starting Jeju Corporation)

1. Provision of electric vehicle industry foundation through spontaneous creation of private electric cars.
2. Reduce consumer’s burden for battery management and provide customer-oriented services.
3. Promotion details:
   - Promotion period: 2015-2017 (3 years)
   - The total project cost: 96,585 million KRW (72,000 EUR; government expenditure 13,200 KRW, city expenditure 13,200 KRW, private capital 70,185 KRW)
   - 2016 Business: input 23.5 billion KRW (17.6 million EUR, 333 vehicles supply (buses 33, taxis 200, rental car 100)
4. Promotion Strategies:
   - EV battery leasing company (SPC) selection complete
   - Buses, taxis, car rental companies purchase vehicle excluding batteries

Figure 2: Overview of Korea’s e-mobility projects

31.1.3 Provision of Electric Vehicle Safety Inspection Standards

1. Electric vehicle safety inspection standards for electric vehicles to prevent accidents and raise professional safety center construction operations.
2. Using secure electric safety, electric home activation and associated industries.
3. Promotion overview:
   - Promotion period: 2015-2018 (4 years)
   - Project cost: 11.7 billion KRW (8.8 million EUR)
4. Contents:
   - A qualified electric vehicle safety inspection and standardisation
   - Electric test equipment and inspection system, research and development

- EV Inspection and Test Management Operations Center established operations

5. Promotion schedules:
    - A qualified electric vehicle safety inspection and standardization
    - Electric test equipment and inspection system, research and development
    - EV Inspection and Test Management Operations Center established operations

31.1.4 EV Battery Recycling Projects

1. EV battery recycling industries support construction operations.
2. Waste battery R&D and technology commercialisation support.
3. Promotion overview:
    - Promotion period: 2016-2019 (4 years)
    - Project cost: 16.6 billion KRW (12.5 million EUR)
4. Contents:
    - Supports EV battery recycling industries center building, performs recyclable battery diagnostic tests
    - The remaining battery capacity and valuation, recycling batteries and perform ESS Application performance testing
    - It provides qualified testing and test reports for safety certification, product commercialisation empirical
5. Promotion schedules:
    - Battery recycling business planning research projects (2015), manual and establish standardised research (2016)
    - Battery recycling industries support center building infrastructure, battery device health assessment and re-packaging technology development support (2017)
    - Empirical research supports product development and commercialisation (2018)
    - Performance and safety assessment of the recycling batteries, commercialisation business support (2019)

Figure 3: Image of an EV battery

31.2 HEVs, PHEVs and EVs on the Road

In 2016, The Ministry of Environment's supply plans of Eco-friendly car are 8,000 EVs, 30,400 HEVs, 3,000 PHEVs, and 70 FCEVs. On theirs vehicle subsidy budget, EVs' subsidy is 12 million KRW (9,000 EUR), 4 million KRW (3,000 EUR) on Installation charges of slow charger, 4 million KRW on tax support, and a maximum of 800 million KRW (600,000 EUR) is supported by region. HEVs' subsidy is 1 million KRW (750 EUR) on vehicle and 2.7 million KRW (2,000 EUR) on tax cut. PHEVs' subsidy is 5 million KRW (3,750 EUR) on vehicle subsidy, 2.7 million KRW on tax cut. Supporting target is that CO_2 emissions are lower than 50 g/km and the per-charge range is longer than 30 km and displacement is lower than 2,000 cc. FCEVs only supply to local governments, public institutions, and corporations. Subsidy for purchasing is 27.5 million KRW (20,500 EUR). The Ministry of Environment plans to have a conference with the relevant authorities for the same tax cut with EVs. Moreover, a person who wants to purchase an EV, first has to put a supply announcement to the local government. And then the buyer should apply to the agent appointed by the vehicle company. A firm buyer is determined by a lot or order of come. Before the delivery of an EV, the determined buyer has to set up a slow charger.

32 Spain

32.1 Major Developments in 2015

32.1.1 Alternative Energy Vehicles Strategy "VEA Strategy"

On 26 June 2015, the Spanish National Government approved an Agreement of knowledge about a new National Strategy to promote Energy Alternative Vehicles in Spain for the period of 2014-2020 (VEA Strategy).

The VEA Strategy stablishes 30 key actions to place Spain as a reference country for the alternative energies applied to the transport sector: electric, LPG, natural gas, biofuels and hydrogen vehicles, focusing on industrial development and to meet energy and environmental challenges.

Three main guidelines are considered in the VEA Strategy:

- Industry: to promote R&D and industrialization measures regarding vehicles, components, and infrastructure.
- Market: actions to promote the demand of alternative vehicles and communication and training campaigns.
- Infrastructure: actions to promote recharging and refueling networks to allow an adequate use of alternative vehicles.

The VEA Strategy is congruent with the objectives of the Directive 2014/94/EU of 22 October 2014, relative to promotion of infrastructure of alternative fuels and technologies and also congruent with the National Frame to be developed in the frame of that directive, which should gather actions and programs focused on the promotion of alternative vehicles in Spain, with the Horizon 2020.

32.1.2 MOVELE 2015 Program

The MOVELE 2015 Program provided a 7 million EUR budget for incentives to acquire BEVs and PHEVs in 2015 (RD 287/2015 normative). These incentives could be complemented with additional incentives given in other programs at a regional scale.

Electric vehicles were collected in a catalogue, including a total number of 216 models and versions for the different categories, as follow: 39 cars, 143 quadricycles, 30 light commercials vehicles, and 4 bus models.

According to the requirements of the MOVELE 2015 Program of incentives for EVs acquisition, car dealers who participate in the program had to facilitate the installation of recharging points to beneficiaries of the incentives before the registration of the vehicle, assuming a maximum cost of 1,000 EUR before taxes (except for quadricycles, where the maximum cost assumed by car dealers was 150 EUR per vehicle).

In the frame of this program and attending to its provisional results, more than 1,100 vehicles will be successfully acquired through 184 car dealers, placed all over the Spanish Kingdom.

Table 1: Incentives per vehicle, depending on category and range in electric mode in the MOVELE 2015 Program

MOVELE 2015 Program - Incentives per vehicle		
UNECE Vehicle Category	**Range**	**Incentive (EUR)**
M1	15 km ≤ Range ≤ 40 km	2,700 (3,200*)
	40 km < Range ≤ 90 km	3,700 (4,200*)
	90km < Range in electric mode	5,500 (3,200*)
M2/N1/N2	60 km < Range	8,000
M3	60 km < Range	20,000
L6e	No restriction	1,950 (2,250*)
L7e	No restriction	2,350 (2,650*)

* Incentives increased for large families and disabled beneficiaries

32.1.3 Normative: Technical Instruction for Installation of Recharging Infrastructure (ITC-BT 52)

On 12 December 2014 it was approved a normative (Royal Decree 1053/2014, 12 November) aimed at supporting 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), which establishes technical and safety requirements for the recharging infrastructure at a national scale.

RD 1053/2014 also stablishes a minimum number of recharging points to deploy in new public parking facilities and buildings (at least one recharging point per each 40 parking lots).

32.2 HEVs, PHEVs and EVs on the Road

As it can be seen in the Figure 1, BEVs/PHEVs registrations in Spain maintained in 2015 a steady increase, at rates of more than 20 % in the particular case of cars and light commercials, supported by national incentives programs for BEVs/PHEVs acquisition (MOVELE 2015 Program) and other incentive programs at regional scales.

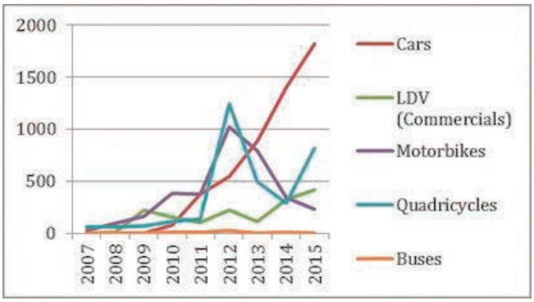

Figure 1: BEVs/PHEVs market trend (annual sales) in Spain, 2015

Regarding conventional hybrid vehicles (HEVs), as it is reflected in Figure 2, passenger car sales remain at similar levels within the last years, very close to 10,000 units sold per year and with a slight decrease during the last two years. It is remarkable that, at a national scale, there are not any incentives programs running for the acquisition of these vehicles over the last years.

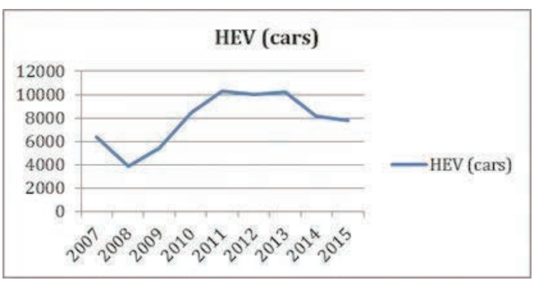

Figure 2: HEVs – passenger cars category – market trend (annual sales) in Spain, 2015

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Data source: Spanish Traffic Authorities)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[g]**
Bicycles (assisted pedaling)	87,656	0	n.a.	n.a.	30,000,000
2- and 3-Wheelers[a]	4,807	36	29	n.a.	4,987,871
Quadricycles[b]	2,491	22	1	n.a.	114,803
Passenger Vehicles[c]	3,619	1,127	64,169	n.a.	22,355,549
Buses and Minibuses[d]	59	43	29	n.a.	60,252
Light commercial vehicles[e]	1,629	3	3	n.a.	3,990,149
Medium and Heavy Weight Trucks[f]	47	0	4	n.a.	861,369
Totals with bicycles	**100,308**	**1,231**	**64,235**	**n.a.**	**62,369,993**
Totals without bicycles	**12,652**	**1,231**	**64,235**	**n.a.**	**32,369,993**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[g]**
Bicycles (assisted pedaling)	22,952	n.a.	n.a.	n.a.	1,140,000[h]
2- and 3-Wheelers[a]	310	1	2	n.a.	152,309
Quadricycles[b]	809	6	n.a.	n.a.	3,147
Passenger Vehicles[c]	1,172	645	7,759	n.a.	1,094,117
Buses and Minibuses[d]	2	2	25	n.a.	2,954
Light commercial vehicles[e]	417	3	1	n.a.	130,375
Medium and Heavy Weight Trucks[f]	n.a.	n.a.	2	n.a.	29,598
Totals with bicycles	**25,662**	**657**	**7,789**	**n.a.**	**2,552,500**
Totals without bicycles	**2,710**	**657**	**7,789**	**n.a.**	**1,412,500**

n.a. = not available
[a] UNECE categories L1-L5
[b] UNECE categories L6-L7;
[c] UNECE categories M1
[d] UNECE categories M2-M3
[e] UNECE categories N1
[f] UNECE categories N2-N3
[g] Including non-electric vehicles
[h] Estimated data at the end of 2015 (Source AMBE - Spanish Association of Bicycles and Brands-)

Table 3: Most sold vehicles: models and prices (before taxes) in 2015

Market-Price Comparison of Selected EVs and PHEVs in Spain	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)***
Renault KANGOO	16,274**
Renault ZOE	16,363**
BMW i3	34,855

* Attending to data registered in the MOVELE 2015 Program

** Most of these vehicles include battery renting services (around 80% of the total sales for each model)

Table 3 shows the most sold BEV/PHEV vehicles in Spain, in the frame of MOVELE 2015 Program. It is remarkable that imaginative solutions for financing the acquisition of electric vehicles and reducing the risk of technical obsolescence of batteries have a very positive effect on the demand of electric vehicles.

In this way, battery renting services are a key tool for reducing technical obsolescence of batteries, which also allow the reduction of the initial payment amount of the vehicle.

Table 4: Medium price and electric range

Price and electric range (data registered in MOVELE Program 2015)				
Category of the vehicle	**L6e**	**L7e**	**M1**	**N1**
Medium market price in EUR (before taxes)	6,971	9,474	26,302	18,679
Medium range on electric mode (km)	101	95	161	164

32.3 Charging Infrastructure Available in Spain

After an initial stage characterized by recharging vehicles for free, in the frame of pilot demonstration projects in cities and regions, public infrastructure service for recharging EV's must be operated by authorized recharging operators at present (which are called "Gestores de Cargas" in Spain), established and defined by the national normative -Royal Decree 647/2011).

The updated list of authorized recharging operators, which were operating more than one hundred public use recharging points at the end of 2014 is publicly available[89].

[89] Publicly available under the link: http://sede.cnmc.es/Portals/2/Documentaci%C3%B3n/Procedimientos/Gestores%20de%20carga/201512_Listado%20Gestores%20de%20Cargas_CNMC.pdf

However, a considerable number of public-use charging points remain in the frame of demonstration pilot city projects, managed by regional and local governments and are still not operated by authorized recharging operators. Once these pilots are finished, and in order to keep all of these charging points operating, they would need to be managed by authorized recharging operators.

Considering all the public-use charging points installed and declared in Spain at the end of 2015, there was a total number of 1,665 public-use recharging points in Spain, which accounts to a ratio of eight recharging points per electric vehicle running in Spain.

Attending to the VEA Strategy, there are currently around 1,000 public-use recharging points available and working, and also an important number of recharging points are installed in the frame of pilot demonstration projects, before the publication of the Directive 2014/94/UE of the European Parliament and Council, related to infrastructure of alternative vehicles and technical specifications for the recharging points of EVs, which should be technically updated to this normative, with a minimum transformation needed to keep them working.

33 Sweden

33.1 Major Developments in 2015

Both the sale of EV and PHEV increased rapidly while sales of HEV have slowed down. The sale of ethanol cars, which were the most common environmental cars for several years, has fallen from 65 % in 2007 to only 2 % in 2015. The expansion of the charging infrastructure has previously had very little public funding, but in 2015 two public programs Climate Stride “Klimatklivet” and Urban Environment Agreements “Stadsmiljöavtal” were introduced, which both include public funding for charging infrastructure. For city buses EV and PHEV options became more common with the Swedish municipalities procure bus services.

33.1.1 EV Bus Premium

The Swedish Energy Agency has been tasked by the Government to distribute a new premium for electric buses. In 2016, there are 5.6 million EUR allocated for this premium, and for 2017-2019 a proposed 11.2 million EUR to be added annually to the new allocation. The premium will be regulated in a new regulation, which at present has been referred by the Department of energy and the environment. The proposed regulation specifies that the size of the premium shall be determined by the maximum transport capacity. Buses classified in emission category electricity and trolley buses are proposed to get a great premium, between 33,000-78,000 EUR per bus, depending on transport capacity in accordance with the proposed regulation. Buses that are classified in emission category plug-in hybrid get half the premium, provided that the bus runs on electricity at least 70 % of the mileage and otherwise only on fuel that is sustainable fuel under the law on sustainability criteria for biofuels and renewable liquid fuels. The premium will cover a part of the additional costs for the electric bus in comparison to a conventional bus.

33.1.2 Super Green Car Rebate “Supermiljöbilspremie”

Anyone who buys a so-called super-green car can get up to 4,100 EUR in purchasing subsidy from the state. The aim is to encourage the purchase of primarily electric cars. Both private cars and company cars can get the super green car rebate.

A super green car is a car that meets emissions requirements of 5 EUR and emits a maximum of 50 grams of carbon dioxide per kilometer. For individuals, the premium is 40,000 SEK (approx. 4,350 EUR) for an electric car, and from 2016 it will be lowered to 2,050 EUR for a plug-in hybrid car. For a business, the premium is equivalent to 35 % of the price difference between the purchased super eco-car and the nearest comparable car. However, the premium does not exceed 4,100 EUR for EVs and 2,050 EUR for PHEVs.

In 2015, the Government gave the Swedish Energy Agency the mission to coordinate the energy transition in the transport sector and the development of the charging infrastructure. The mission will build on the Swedish investigation fossil-free vehicles on the road.

33.2 HEVs, PHEVs and EVs on the Road

The number of new “Super green vehicles (environment cars)” (EV and PHEV) doubled for the fifth year in a row and today Sweden is the world’s third best electric car country after Norway and the Netherlands in terms of the percentage of the total car fleet. After a record strong increase in December, the Swedish fleet of rechargeable vehicles cars was 15,962 by the end of 2015, representing an increase of 101 % during the year. For HEV sales, however, the increase was only just over 10 %. With regard to electric-powered city buses, several municipalities have shown great interest, and both EV and PHEV buses are now tested in several Swedish cities. Electric buses, from the Swedish bus manufacturers Volvo and Hybricon are the most common ones. During 2015, Scania also started selling HEV-buses.

33.3 Charging Infrastructure or EVSE

Sweden has provided a relatively limited support for the development of charging infrastructure in recent years. The background for this position is that the charging stations built in the 1990s were used relatively little, and there are relatively many electrical outlets in Sweden used for parking heaters. In 2015, however, public funding opportunities described in the following opened for electricity infrastructure.

33.3.1 Climate Stride Program ”Klimatklivet”

The Swedish environmental protection agency, in co-operation with other central authorities and provincial governments provide support to local climate investments. In 2015, the funding amounted to 14 million EUR. A further 67 million EUR per year will be awarded for climate investment for 2016, 2017 and 2018. For 2015, about 6.7 million EUR of the funding was allocated to the development of charging infrastructure. The following is required to gain support/funding for charging infrastructure from the Climate stride program.

- The base station should be prepared for electricity metering and billing of electricity cost.
- The charging station should be equipped with at least the socket or connector for vehicles of the type 2 that is described in the standard EN 62196-2 or type Combo 2 described in standard EN 62196-3, but they can also have different connectors.
- The base station is placed so that it can be considered to contribute to an effective distribution of charging stations in the area in question.
- The charging station should only refer to charging for electric vehicles.

33.3.2 Urban Environment Agreement ”Stadsmiljöavtal”

The aim of the initiative is to promote sustainable urban environments by creating the conditions for a larger share of passenger transport in cities using public transport. The measures should lead to energy-efficient solutions with low greenhouse gas emissions and contribute to achieving the environmental quality objective, a good built environment. The initiative should in particular promote innovative, strong capacity and resource-efficient solutions for public transport. The budget is 223 million EUR for the period of 2015-2018. Some of these funds may be used for example, for the construction of charging infrastructure.

Table 1: Information on charging infrastructure in 2015 (Data sources are www.uppladdning.nu and www.laddinfra.se)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	800
AC Level 2 Chargers	500
Fast Chargers	250
Superchargers	100
Inductive Charging	n.a.
Totals	**1650**

n.a. = not available

33.4 EV Demonstration Projects

Following are two examples of demonstration project supported by the Swedish State.

33.4.1 Autonomous Electric Gravel Pit

The aim of the project is to demonstrate operations with autonomous electrified vehicles/machines, which, from an operational perspective, can produce rock materials with near-zero emissions of CO_2. In this demonstrator a wired full electric excavator is included, a mobile crusher, a conveyor belt and 6-7 autonomous fully electrically powered load carriers, and a PHEV wheel loader. The project is carried out by Volvo Construction Equipment and Skanska, with support from the Swedish Energy Agency.

33.4.2 ERS Tests in Sweden

Sweden is testing an electric road system (ERS) in a virtual environment (ERS-procurement). Two solutions for electric road systems will be tested in the vicinity of the Stockholm airport and outside Gävle on respectively two test routes. The aim is a knowledge base for electric road systems, and to find out if the technology can be used in the future. Development Rosersberg AB is testing a technical solution in which an electric rail in the road surface powers and charges the vehicle while running. Gävleborg region test a solution in which a pantograph on truck cab roof feeds down power to a HEV-trucks electric engine.

33.5 Outlook

For 2016 a proper development of electricity infrastructure was expected to take place with the support of the new public spending. During 2016 a substantial expansion of the electric infrastructure is expected due to new public support.

At first reduction of PHEV sales is expected when Public support is reduced by 50 % at the end of the year 2015.

In 2016 Sweden is producing an action plan under the EU infrastructure directive.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Data source: public authority; www.trafa.se/vagtrafik/fordon/; http://svenskcykling.se/2015/10/05/cykelforsaljning-fortsatter-oka-elcyklar-och-motionscyklar-rekordokar/)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	n.a.	n.a.	n.a.	0	365,000
Passenger Vehicles[b]	4,765	9,776	42,737	4	4,669,063
Buses and Minibuses[c]	20	10*	70*	0	14,114
Light commercial vehicles[d]	1,224	7	50	0	516,168
Medium and Heavy Weight Trucks[e]	0	0	23	0	80,046
Totals without bicycles	**6,009**	**9,793**	**42,880**	**4**	**5,279,391**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	30,000	n.a.	n.a.	0	54,000
Passenger Vehicles[b]	2,916	5,752	8,769	1	361,932
Buses and Minibuses[c]	9	5*	15*	0	1,423
Light commercial vehicles[d]	321	7	10	0	45,868
Medium and Heavy Weight Trucks[e]	n.a.	n.a.	1	0	6,329
Totals without bicycles	**3,246**	**5,764**	**8,795**	**1**	**415,552**

n.a. = not available
* Only data for PHEVs and HEVs together
[a] UNECE categories L1-L5
[b] UNECE categories M1
[c] UNECE categories M2-M3
[d] UNECE categories N1
[e] UNECE categories N2-N3
[f] Including non-electric vehicles

Table 3: Available vehicles and prices in Sweden (Data source: www.facit.com)

Market-Price Comparison of Selected EVs and PHEVs in Sweden	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Mitsubishi i-MIEV	27,000
Mitsubishi Outlander PHEV	49,000
Nissan Leaf	32,400
Opel Ampera	39,000
Peugeot iOn	37,200
Porsche Panamera S E-Hybrid	106,000
Renault ZOE	23,800
Renault Kangoo Maxi	24,700
Renault Twizy	6,300
Tesla Model S 85 kWh Performance	89,100
Toyota Prius Plug-in	44,000
VW e-up!	28,500
Volvo V60 PHEV	56,900
BMW i3	35,000

34 Switzerland

34.1 Major Developments in 2015

34.1.1 Swiss Federal Council Presents Report on E-Mobility

The Swiss Federal Council has approved the master plan for e-mobility in May 2015 and assumes that e-MIV (electric motorized individual transport) will play an important role in the future[90]. The market penetration is based upon renewable energies and it is set to play an essential part in reducing fossil fuel consumption by traffic. In the context of the New Energy Policy 2050 (NEP) of the Swiss Federal Office of Energy corresponding measures were already identified, e.g. contributions for research and development as well as pilot, demonstration, and flagship projects, but also information and consulting programs. Establishing a specific strategy for an additional action plan “electro-mobility” is not considered necessary. There are no plans to introduce subsidies for electric vehicles at a federal level.

34.1.2 Swiss Trolley+

The project SwissTrolley+ aims to replace the diesel auxiliary power units in standard trolley buses with high performance traction batteries[91]. This offers major advantages: existing trolley bus lines can be extended without expensive infrastructure, bus stops outside the grid can be served by electric traction and there are reduced noise and pollutant emissions during the off-grid operations. Energy consumption decreases by approximately 15 % due to regenerative braking and an active peak load balancing in the electricity grid.

This project is a cooperation of Carrosserie HESS AG, Zurich Public Transport (VBZ), Bern University of Applied Sciences (BFH), and ETH Zurich. It is sponsored by the Swiss Federal Office of Energy (SFOE) and the Swiss Competence Center for Energy Research (SCCER).

[90] www.e-mobile.ch/pdf/2016/Bericht_Motion_12.3652.pdf
[91] www.idsc.ethz.ch/research-guzzella-onder/research-projects/SwissTrolleyPlus.html

34.1.3 TOSA Buses to Start Line Operation

ABB's innovative electric bus charging technology was one of the highlights of the show of sustainable transport systems in Paris in November 2015, where world leaders met to seek a global agreement on climate change. The TOSA system (Transport with Optimized Power Supply System) was the only all-electric solution for an articulated bus among the vehicles on display.

The TOSA technology[92] was launched in 2013 in Geneva, where it connected the airport with the city's main venue for trade fairs. Designed for high-capacity urban transport, the articulated bus can be charged in just 15 seconds while passengers board at selected stops along the route and with longer top-ups at each terminus. The TOSA e-bus stores its energy in compact batteries on the roof, thus increasing passenger space on board. The e-bus recovers energy while braking thus reducing the total energy consumption. The bus has a capacity of 143 passengers and a length of 18.75 meters.

Figure 1: Trolley bus of Zurich Public Transport (Photo: VBZ)

Figure 2: ABB's TOSA in Paris (Photo: ABB)

[92] www.climatesolutionsplatform.org/solution/tosa-the-first-large-capacity-electric-bus

34.1.4 E-Rentals in the City of Berne

ElectroDrive weShare[93] is the EV car sharing service of Energie Wasser Bern (ewb). It is based upon the online platform sharoo.com[94] and combines electric mobility with car sharing: four Renault ZOE cars can be rented centrally at the parking of the main station and booked and opened by Smartphones. Easy parking is guaranteed thanks to tickets for all "blue parking" zones in Berne.

Figure 3: ElectroDrive weShare (Photo: Beat Mathys / Berner Zeitung)

In September 2015 the Mobility Academy together with its partners Migros, City of Berne, and BLS launched the world's first public e-cargo bike-sharing[95] in Berne. Users can reserve their electric cargo bikes via the platform carvelo2go.ch[96] and collect them from various locations. After registration users can select one of 18 available cargo bikes and can rent them on an hourly base for up to three days. Cargo bikes are well suited for transporting e.g. small children or goods in the city.

34.1.5 E-Scooter on the Test Bench

On behalf of NewRide[97], the Berne University of applied Sciences tested six e-scooters in order to gain an overview of the model range and to assess the latest developments. The overall efficiency of the vehicles from plug-to-wheel and the range at constant speed were measured and the reliability of the range indications verified.

[93] www.ewb.ch/de/angebot/mobilitaet/electrodrive/electrodrive-weshare.html
[94] http://sharoo.com
[95] www.tcs.ch/de/der-tcs/sektionen/bern/bern-mittelland/carvelo.php
[96] www.carvelo2go.ch
[97] www.newride.ch

The efficiency of the six scooters from plug-to-wheel is in the range of 50-60 % with small differences between the tested models. This favorably compares with conventional scooters with efficiencies of only 20 %. All scooters also report low charge levels of their batteries at an early stage that reduces the chances of stranding on the way. The test results confirm the positive trend of concurrent development of scooter technology.

Furthermore, NewRide has tested the handling and quality of eight e-scooters on a round course and has assessed their overall impression. The conclusion was that the model offer allows for an appropriate choice of vehicles for virtually all needs.

Figure 4: Launch of the e-cargo bikes project in Berne (Photo: TCS)

Figure 5: E-scooter tests near Bienne (Photo: NewRide)

34.1.6 Market and User Monitoring for Electric Mobility

The project "Electro-Mobility Market and User Monitoring" (MANUEL) was run by the Mobility Academy[98] and supported by the Swiss Federal Roads Office (FEDRO) between 2011 and 2014. It provides an insight into the determinants of e-mobility and shows the prospects for the development of plug-in automobiles in Switzerland.

MANUEL shows how the future price trend for batteries, vehicles, and infrastructure enables investments, how it influences operating costs for users and how flanking measures such as subsidies by public authorities could accelerate the development of the market. The successive installation of public charging points and the development of a new e-mobile service market help Swiss motorists to accept e-mobility without limitations. But the potential user also needs more support. Information deficits and range anxiety must be addressed. This is done best by means of a "genuine electrical experience".

People in Switzerland will only accept and buy an electric vehicle, if it can be used everywhere and with the same ease, range, and performance as their conventional car. In that case some 70 % of conventional drivers could turn to electrical vehicles. Assuming that charging is enabled on the way this proportion would increase to around 80 % and on 80 % of days of the year – that is MANUEL's rule of thumb for the potential electrification of mobility in Switzerland.

34.2 HEVs, PHEVs and EVs on the Road

In 2015, a total of 427,168 new motor vehicles were registered in Switzerland[99]. This is 7.7 % more than in 2014. The total stock of road vehicles has increased to almost 5.9 million vehicles (+ 1.8 %), 75 % of which were passenger cars. In particularly high demand were cars with engine sizes below 1,000 cubic centimeters (+ 44.6 %). 39.1 % of newly registered passenger cars accounted for diesel cars, slightly more than in the year before (37.3 %).

Sales of HEVs (6,118) increased by 0.4 % compared to 2014. Although they were lower in absolute numbers, the growth rates of PHEVs (2,331 cars, + 217 %), EREVs (646 cars, + 118 %) and BEVs (3,265 cars, + 97 %) were impressive. However, despite the growth rates the total numbers of electric passenger cars with 6,366 units remained tiny in 2015. Their share accounted to just 0.2 % of the entire stock of 4.5 million passenger cars.

[98] www.mobilityacademy.ch
[99] Swiss Federal Statistical Office (FSO)

The best sold PHEV models were the Audi A3 e-tron (688 cars), the VW Golf GTE (624), and the Mitsubishi Outlander (340). In the BEV category the Tesla Model S (1560), the Renault ZOE (478), and the BMW i3 (303) sold best. The range extender version of the BMW i3 was sold 583 times.

1,482 e-scooters were sold in 2015, which is even less than in the year before. Their market share dropped from 3.9 % to 2.9 %. Other best-selling e-models of last year also lost ground: 952 three-wheeled Kyburz DXP (2014: 1,098 vehicles), 133 quadricycles Renault Twizy (2014: 163), and 27 Segway (2014: 92).

66,332 new e-bikes were sold in 2015 including 19,687 e-mountain bikes[100]. One in five sold bicycles were e-bikes. This is an increase of 15 % compared to 2014. The rapid rise of e-bikes and their ongoing popularity is due to the excellent cost-benefit ratio in Switzerland.

34.3 Charging Infrastructure or EVSE

By the end of 2015, close to 1,400 public charging stations with 3,200 charging points were registered in the Swiss national database[101]. There were 1,260 Level 1 and 2 AC-stations with 1-3 EVSEs each and 120 fast charging stations (CHAdeMO, CSS, Tesla Superchargers and 43 kW AC) with 1-3 EVSEs each. Additionally, there were no public, but four industrial hydrogen filling stations for fuel cell vehicles available.

In 2015, two new partners joined the MOVE[102] network of public charging stations. In western Switzerland the electricity utility provider Romande Energie offers technical assistance and the national automobile club TCS offers its breakdown service for electric vehicles.

Easy4you[103] by Alpiq, Siemens, Swisscom, and Zurich Insurance Group is the new access and accounting system for charging stations in Switzerland. The four companies have jointly developed a standardised payment and access package with an integrated mobility guarantee as a turn-key solution for operators of charging stations, e.g. for companies, public institutions or private persons. The payment and access package combines all the elements required for a network of electric vehicle charging stations. Most of the existing charging stations can easily be retrofitted with the system launched late in 2015.

The project partners are expecting the standardised access and accounting system to be a prime mover for the expansion of the Swiss network of charging stations.

[100] www.velosuisse.ch
[101] http://e-mobile.ch/index.php?pid=de,2,147
[102] www.groupe-e.ch/de/news/20151208/romande-energie-und-tcs-neu-partner-des-move-netzes
[103] www.alpiq-intec.ch/en/news-stories/media-releases/media-releases.jsp?news=tcm:122-139220-1

They calculated that, if the CO_2 reduction target for Switzerland in the field of passenger transport is to be met, 700,000 cars on Swiss roads will have to be electrically powered by 2020. The project partners estimate that 80,000 charging stations at workplaces, 23,000 stations in towns, and 250 fast charging stations at major traffic junctions will be necessary.

Table 1: Information on charging infrastructure in 2015 (Data source: LEMnet.org)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	800
AC Level 2 Chargers	460
Fast Chargers	110
Superchargers	10
Inductive Charging	0
Totals	**1,380**

Figure 6: The partners from Easy4you are committed to electro-mobility (Photo: Alpiq)

34.4 EV Demonstration Projects

34.4.1 SUNCAR E-Digger

In addition to the Swiss Solar Prize, the e-digger team has received the European Solar Prize 2015 in Prague. The e-digger was realized by the construction company Affentranger Bau AG, the machinery manufacturer Huppenkothen, and the Interstate University of Applied Sciences of Technology Buchs (NTB) within the scope of ETH Zurich’s SUNCAR project.

The SUNCAR e-digger[104] is low-noise, energy-efficient and emits no pollutants. Its performance of 75 to 167 kW is significantly higher than that of a comparable diesel model. The converted Takeuchi digger requires only 30,000 kWh/a compared to 150,000 kWh/a of a diesel digger. This energy is provided by photovoltaic installations of the construction companies participating in the project. The battery capacity of 190 kWh allows for a 9-hour day operation. Compared to a diesel model the solar digger emits 40 t of CO_2 less per year and it saves approximately 19,000 EUR in fuel costs per year.

34.4.2 Move – Mobility of the Future

Sustainable mobility means reducing the use of fossil energy as well as CO_2 emissions. One option is to convert surplus, renewable electricity into storable energy carriers that are suitably low in CO_2, such as hydrogen or synthetic methane. They can be used as fuels for individual mobility and transport. The federal research institute Empa in Dubendorf near Zurich has teamed up with partners from research, industry, and the public sector for the project "move"[105]. It aims to demonstrate how the mobility of tomorrow might work without fossil energy.

According to the "New Energy Policy" (NEP) of the Swiss Federal Office of Energy (SFOE), almost 50 % of the automobile mileage is to be covered by electric vehicles by 2050 and at least 50 % by vehicles with combustion engines. The energy consumption of the vehicles is to be reduced and it should mainly originate from renewable sources. For electro-mobility, the priority is the electrochemical storage of surplus electricity in grid or vehicle batteries and the electrolytic conversion into hydrogen for fuel cell vehicles. For combustion engine vehicles, surplus electricity is to be converted into synthetic fuels such as methane.

Move shows the pathway of using and converting surplus renewable electricity for mobility – first in form of hydrogen and later on as synthetic methane and grid batteries. In the case of hydrogen, its use as a fuel for fuel cell vehicles as well as the use as an admixture to natural gas/biogas for CNG vehicles is investigated. The vehicles that are used within the scope of various projects are equipped with state-of-the-art powertrain concepts and technologies. Besides the optimization of energy conversion and storage technologies, the move project aims to demonstrate which technology is best suited for which "mobility type".

[104] www.sccer-mobility.ch/aboutus/sccer_events/Again-a-price-for-E-digger-European-Solar-Prize-2015
[105] www.empa.ch/web/s604/move-inauguration

Figure 7: SUNCAR's low-noise and energy-efficient e-digger (Photo: NTB)

Figure 8: Move station at Empa (Photo: Empa)

34.4.3 First Test Runs of Autonomous Shuttles in Switzerland

PostBus Switzerland Ltd and its partners (City of Sion, the Canton of Valais, and the ETH Lausanne) plan to test two autonomous vehicles in Sion over two years[106]. This is the first time that a transport company in Switzerland will use this type of technology in public areas to transport passengers.

As a provider of integrated mobility solutions, PostBus wants to find out whether these intelligent vehicles can provide new types of mobility in regions that cannot currently be served by public transport. However, the objective is not to replace buses on existing routes with autonomous vehicles, but rather to diversify the modes of transport in order to cover as many passenger mobility needs as possible.

The two electric vehicles – 4.80 m long and 2.05 m wide – are developed by the French company Navya. If the tests are approved by the federal authorities, the two shuttles will transport up to nine people at a maximum speed of 20 km/h through

[106] www.post.ch/en/about-us/company/media/press-releases/2015/first-test-runs-of-autonomous-shuttles-in-switzerland

the streets of Sion. There will be specially trained personnel on board, but the vehicles will run fully automatically without a steering wheel, accelerator or brake pedal. A program developed by the Swiss start-up BestMile will monitor and control the two autonomous vehicles.

Figure 9: Autonomous shuttle in Sion (Photo: Claude Coeudevez)

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Swiss Federal Statistical Office). In Switzerland, the fleet totals are available only as of 30 September, whereas total sales were reported for the entire calendar year (1 January through 31 December).

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	10,085	n.a.	n.a.	n.a.	694,982
Quadricycles[b]	1,339	n.a.	n.a.	n.a.	15,040
Passenger Vehicles[c]	6,366	2,655	46,261	4	4,458,069
Buses and Minibuses[d]	54	n.a.	n.a.	5	65,720
Medium and Heavy Weight Trucks[e]	544	n.a.	n.a.	1	393,598
Totals without bicycles	**18,388**	**2,655**	**46,261**	**10**	**5,627,409**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	1,482	0	0	0	49,968
Quadricycles[b]	198	0	1	0	1,819
Passenger Vehicles[c]	3,265	2,331	6,118	0	327,143
Buses and Minibuses[d]	3	0	26	0	4,995
Medium and Heavy Weight Trucks[e]	164	0	5	0	35,290
Totals without bicycles	**5,112**	**2,331**	**6,150**	**0**	**419,215**

n.a. = not available
[a] UNECE categories L1-L5
[b] UNECE categories L6-L7
[c] UNECE categories M1
[d] UNECE categories M2-M3
[e] UNECE categories N2-N3
[f] Including non-electric vehicles

Table 3: Available vehicles and prices

Market-Price Comparison of Selected EVs and PHEVs in Switzerland	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Audi A3 e-tron	44,400
BMW i3	33,500
BMW i3 REX	39,200
Hyundai ix35	60,900
Kia Soul	33,500
Mitsubishi i-MIEV	22,700
Mitsubishi Outlander PHEV	45,500
Nissan Leaf	26,300
Nissan e-NV200 Evalia	40,500
Opel Ampera	42,600
Renault ZOE*	19,100
Renault Kangoo Maxi*	25,800
Renault Twizy*	8,800
Smart Fortwo Electric Drive*	22,300
Tesla Model S 60 kWh	62,200
Tesla Model S 85 kWh	70,500
Toyota Prius Plug-in	37,600
Volvo V60 Plug-in Hybrid	62,300
VW e-Golf	33,600
VW e-up!	27,300

* Sales price excludes monthly battery rental fee of 45–94 EUR, depending on brand and model

35 Turkey

35.1 Major Developments in 2015

In the past year, the Turkish government has taken significant steps to gain and accumulate experience associated with the underlying electric vehicle technologies in the country. Thus, various policies, legislations and investments have been made to encourage the research and development of H&EVs and their subcomponents (especially battery, electric motor and driver and ECU) in research institutes, universities, and the industry. During 2015, the government also launched major research programs by supporting R&D projects related with these 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, enhance the capacity of the corresponding test centers, and develop a national vehicle brand. An Automotive Excellence Center and Motor Excellence Center is currently being built to provide the necessary support in this roadmap.

Figure 1: First prototypes of the Turkish National Car (Image courtesy of TÜBİTAK MRC)

Moreover, TÜBİTAK MRC has displayed the first demonstrator vehicles for the Turkish National Car (TNC) brand (shown in Figure 1), which is currently developed on the Saab 9-3 Platform. TNC is expected to be launched initially as a REEV (range-extended electric vehicle) before 2020. The vehicle is aimed to be competitive with most of the conventional vehicles in the market in terms of safety, comfort and performance. TÜBİTAK will be leading this process, especially in terms of design and engineering stages, but the manufacturing is expected to be taken on by the private sector.

Taxation

In 2015, 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 2015, 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.

Table 1: Special consumption tax classification categories for new vehicles in 2015

	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

35.2 HEVs, PHEVs and EVs on the Road

35.2.1 Fleet

In Turkey, the number of vehicles on the road continued to increase in 2015. However, H&EVs still incorporated a negligible fraction of the total vehicles. The EV new sales are collected by the Automotive Distributors Association (ODD) as shown in Table 2.

35.2.2 Sales

Passenger car sales in 2015 increased significantly when compared to 2014. Meanwhile the light-commercial market also had a slight increase. When the passenger car market is examined according to the engine volumes in 2015, the passenger cars below 1,600 cc received the highest share of sales with 95.9 % and

696,076 units due to the lower tax rates (see Table 3). In 2015, there were 120 EV passenger cars sold in Turkey compared to 47 in the year before.

Table 2: Total vehicle fleet according to the vehicle types between 2011 and 2015

Vehicle Type	2011	2012	2013	2014	2015
Passenger car	8,113,111	8,648,875	9,283,923	9,857,915	10,589,337
Minibus	389,435	396,119	421,848	427,264	449,213
Bus	219,906	235,949	219,885	211,200	217,056
Light commercial vehicle	2,611,104	2,794,606	2,933,050	3,062,479	3,255,299
Truck	728,458	751,650	755,950	773,728	804,319
Motorcycle	2,527,190	2,657,722	2,722,826	2,828,466	2,938,364
Special purpose vehicle	34,116	33,071	3,6148	40,731	45,732
Tractor	1,466,208	1,515,421	1,565,817	1,626,938	1,695,152
Totals	**16,089,528**	**17,033,413**	**17,939,447**	**18,828,721**	**19,994,472**

Data source: TURKSTAT Road Motor Vehicle Statistics (2016)

Table 3: Passenger car market according to the engine/electric motor size between 2014 and 2015 (Data source: ODD Press Summary)

Engine Size	Engine Type	2014	2015	SCT Tax Rates* (%)	VAT Tax Rates* (%)
≤1,600 cc	Gas/diesel	558,995	696,076	45	18
1,601 cc to ≤2,000 cc	Gas/diesel	22,536	23,108	90	18
≥2,001 cc	Gas/diesel	5,753	6,292	145	18
≤85 kW	Electric	22	38	3	18
86 kW to ≤120 kW	Electric	0	0	7	18
≥121 kW	Electric	25	82	15	18
Totals		**587,331**	**725,596**		

* 2015 SCT tax rates

When the passenger car market is examined according to average emission values in 2015, the passenger cars that fell below 140 g CO_2/km limits accounted for more than 80 % of the vehicle sales (see Table 4). This is primarily a result of the lower tax values for the engine volumes ≤1,600 cc, which also helps with the reduction of the total fleet emissions average of vehicles in Turkey.

Table 4: Passenger car market according to average emission values in 2015

Average Emission Values of CO_2 (g/km)	2014 Cumulative		2015 Cumulative		2015/2014
	Units	%	Units	%	%
<100 g/km	62,052	10.57	82,122	11.32	32.34
≥100 to <120 g/km	232,129	39.52	304,901	42.02	31.35
≥120 to <140 g/km	184,708	31.45	206,474	28.46	11.78
≥140 to <160 g/km	81,103	13.81	104,622	14.42	29.00
<160 g/km	27,339	4.65	27,477	3.79	0.50
Totals	**587,331**	**100.00**	**725,596**	**100.00**	**23.54**

Source: ODD Press Summary (2016).

35.3 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 shopping centers, hotels, restaurants, public buildings and auto-dealers 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 officially kept, there are 117 public destination chargers in cities (22 kW Type-2) by the largest charging infrastructure provider (Esarj). 87 of those belong to ChargeNow in collaboration with BMW. Moreover, 90 further public stations are built/planned by other EVSE providers. In terms of fast chargers (CHAdeMO), less than a handful of units currently exist in the country. However, it is announced that Tesla Motors is planning to install fast charging stations in nine cities in Turkey, starting from Istanbul and reaching towards the 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 2.

Figure 2: Map of Esarj charging stations throughout Turkey (courtesy of Esarj Electric Vehicle System Incorporated Company)

36 United Kingdom

36.1 Major Developments in 2015

In May 2015 a new UK Government was formed by the Conservative party who had included in their manifesto:

"Our aim is for almost every car and van to be a zero emission vehicle by 2050 – and we will invest 650 million EUR over the next five years to achieve it."

This was followed by the announcement of a comprehensive spending review. In November the outcome of the review stated:

"The government will spend more than 780 million EUR between 2015-2016 and 2020-2021 to support uptake and manufacturing of ultra-low emission vehicles (ULEVs) in the UK, maintaining the global leadership that has seen 1 in 4 of all European electric vehicles built here and keep the UK on track for all new cars to be effectively zero emission by 2040. This investment will save 65 million tonnes of carbon and help deliver the Long Term answer on urban air quality."

This set the overall financial envelope for UK policy and there have been a number of announcements that have added detail to how policy would develop that are laid out in the relevant sections below. Figure 1 shows the key measures for the period to 2020, with further details to be announced in 2016.

The UK's programme of Government support is one of the most comprehensive in the world. The market is growing well and the UK is at the forefront of the global transition – but there is much more to do. Last year the UK was one of the largest global markets for ultra low emissions (second largest in the European Union behind the Netherlands). The low emission vehicle industry supports over 18,000 UK jobs and is a key aspect of the Government's ambition for a low carbon, high tech economy.

In December 2015 the UK became one of the founding members of the International Zero Emission Vehicle Alliance (ZEV Alliance)[107]. The UK, along with like-minded countries, US States, and Canadian Provinces, agreed to make all passenger vehicle sales zero emission vehicles by no later than 2050.

[107] www.zevalliance.org/content/participants

Figure 1: Table of Office for Low Emission Vehicle programmes

The Go Ultra Low Communications Campaign

The "Go Ultra Low" campaign, launched in January 2014, aims to build awareness of the Office for Low Emission Vehicles' Plug-in Grant scheme and the wider benefits of ULEVs. The campaign was developed in response to the clear insight that "category-level" consumer information barriers needed to be overcome if ULEVs were to gain traction in the UK. Uniquely, vehicle manufacturers came together with the government to joint fund Go Ultra Low to promote the concept of ULEVs as they recognised, that while they had clear skills in selling cars individually, joint activity was required across government and industry combining messages about the vehicles with wider messages about infrastructure to overcome consumer barriers.

The campaign's key objective, informed by insight and developed in partnership with marketing experts in the vehicle manufacturers, is simple: to establish ULEVs as 'normal' not 'novel', by raising awareness and addressing common misconceptions. The current industry partners are, Audi, BMW, Kia, Mitsubishi, Nissan, Renault, Toyota, and VW.

The campaign addresses misconceptions about how far electric cars can drive on one charge, and demonstrates that owning an electric car is easier than you think.

The 2016 creative campaign will feature on on-demand TV[108] radio, print, and online, including social media. The new TV advert challenges the idea that electric cars are weak and boring to drive by positioning them as unexpectedly exhilarating. There will be print advertising an example of which can be seen in Figure 2.

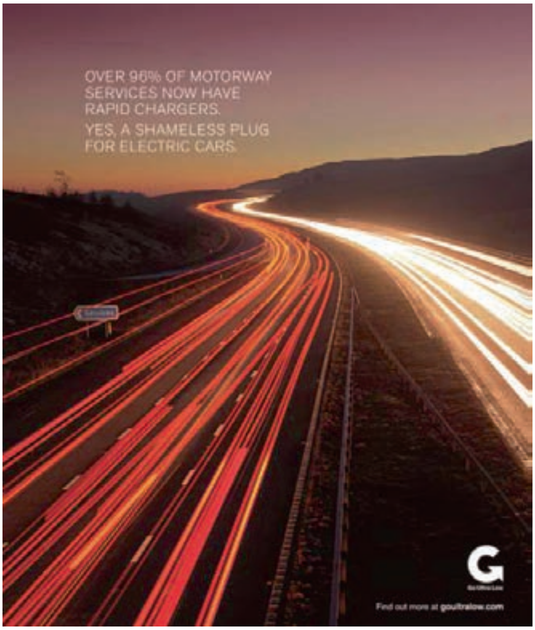

Figure 2: Example creative work for Go Ultra Low Campaign

36.2 HEVs, PHEVs and EVs on the Road

36.2.1 Plug-in Car Grant

The Plug-in Car Grant[109] offers a grant towards the purchase of a qualifying ultra low emission vehicle, paid directly to vehicle manufacturers to reduce the price paid by consumers. For 2015 the grant was 35 % of the list price capped at a maximum of 6,500 EUR per car.

On 13 February 2016 the Office for Low Emission Vehicles (OLEV) announced[110] that there would be three new car categories under the Plug-in Car Grant. This was in recognition that different cars provided different environmental benefits and had different performance characteristics (see Figure 3).

[108] www.youtube.com/watch?v=1dKsF1gSnJA
[109] www.gov.uk/plug-in-car-van-grants/what-youll-get
[110] www.gov.uk/government/news/take-up-of-plug-in-car-grant-continues-to-rise

On 17 December 2015 the UK Government announced[111] new rates of grant for each of these three categories. Category 1 models attract a grant of 5,850 EUR and categories 2 and 3 would benefit from a grant of 3,350 EUR. It was also announced that category 2 and 3 models with a list price of over 78,000 EUR would not be eligible for the grant, but all category 1 vehicles will be eligible for the full 5,850 EUR grant. The new grants came into effect on 1 March 2016.

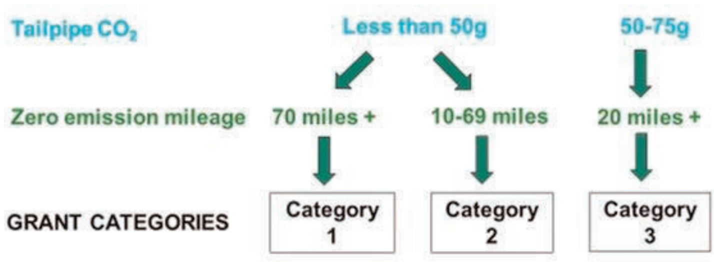

Figure 3: Plug-in Car Grant Categories

Throughout 2015 and the early part of 2016 there was strong growth in the uptake of the grant, as shown in Figure 4. The UK has seen over 70,000 claims for their Plug-in Car Grant since it was introduced in 2010. Sales quadrupled between 2013 and 2014 and in 2015 totalled to more than the previous four years combined (28,188). In December 2015 nearly 2 % of all new cars registered were ultra low emission cars.

There are now around 30 types of ultra low emission cars available in the UK and 10 more are expected to be launched in 2016. These include vehicles from Audi, BMW, BYD, Citroen, Ford, Kia, Mercedes-Benz, Mitsubishi, Nissan, Peugeot, Renault, Smart, Tesla, Toyota, Vauxhall, Volkswagen, and Volvo.

[111] www.gov.uk/government/news/new-plug-in-grant-will-treble-number-of-greener-cars-on-britains-roads

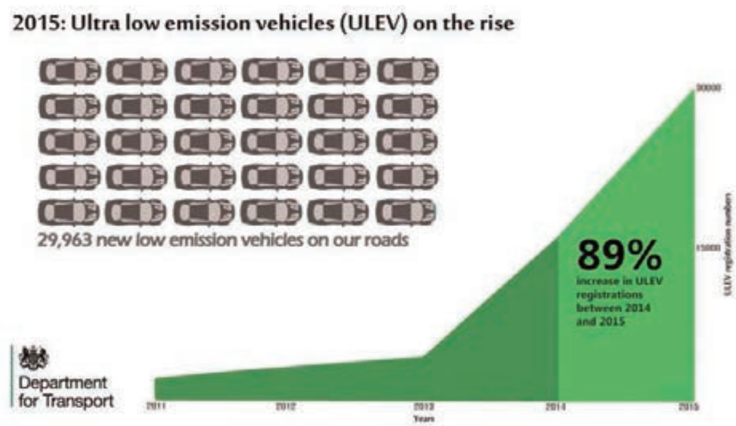

Figure 4: Plug-in Car Grant uptake

Table 1: Selected ultra low emission car registrations in 2015

Number of ultra low emission cars registered in the UK in 2015			
Car Make and Model	**Cars registered in 2015**	**Car Make and Model**	**Cars registered in 2015**
Audi A3	1198	Porsche Panamera	198
BMW i3	2207	Renault Zoe	2053
BMW i8	849	Smart Fortwo	20
Citroen C-Zero	2	Tesla Model S	1470
Ford Focus	4	Toyota Mirai	4
Kia Soul	128	Toyota Prius	270
Mercedes B-Class	178	Vauxhall Ampera	109
Mercedes S-Class	163	Volkswagen E-Golf	76
Mitsubishi Outlander	11686	Volkswagen Golf	1384
Nissan E-NV200	97	Volkswagen E-Up	31
Nissan Leaf	5238	Volvo V60	58
Peugeot iON	23		

36.2.2 Plug-in Van Grant

The Plug-in Van Grant[112] offers 20 % off the price of a qualifying van up to a maximum of 10,500 EUR. There are currently 9 eligible models.

Table 2: Selected ultra low emission van registrations in 2015

Number of ultra low emission vans registered in the UK in 2015			
Van Make and Model	Vans registered in 2015	Van Make and Model	Vans registered in 2015
Citroen Berlingo	9	Nissan E-NV200	639
Mercedes Vito	9	Peugeot Partner	36
Mitsubishi Outlander	98	Renault Kangoo	103

36.2.3 Taxi Scheme

It was announced in April 2014[113] that the Office for Low Emission Vehicles (OLEV) would make at least 26 million EUR available for an Ultra Low Emission Taxi Scheme. The scheme will be open to local authorities UK-wide and funding will be made available through a competitive process in which local authorities will submit bids which will be evaluated against a published set of defined criteria.

OLEV will provide funding to successful bidders for these elements:

Feasibility Phase

- Feasibility studies for local areas, to identify how funds can be used strategically and in a cost-effective way to best suit taxi and private hire drivers, users and the local population

Delivery Phase

- Taxi top-up Grants to provide funding above the level of the Plug-in Car Grant towards eligible, purpose-built, ultra low emission taxis in winning local areas, to support the purchase of vehicles
- Infrastructure for ultra low emission taxis and private hire vehicles, to support drivers and fleets in the local area

The feasibility studies will be assessed and then a call for bids will be announced in 2016 for consortia to submit proposals. All bids will be assessed against published criteria.

[112] www.gov.uk/plug-in-car-van-grants/what-youll-get
[113] www.gov.uk/government/uploads/system/uploads/attachment_data/file/382190/taxis-preliminary-guidance.pdf

36.2.4 Bus Scheme

In March 2016 the Office for Low Emission Vehicles announced the low emission bus scheme[114]. This scheme will be run as a competition, with 39 million EUR made available for local authorities and operators in England and Wales through a competitive bidding process. This new scheme will build on the success of the Green Bus Fund[115], which ran from 2009 to 2013 and delivered around 1,250 low emission buses onto England's roads.

The low emission bus scheme has these primary objectives:

- Increase the uptake of low and ultra low emission buses
- Speed up the full transition to an ultralow emission bus fleet in England and Wales and thereby reducing the need for subsidy support
- Support the improvement of local air quality – buses are a significant contributor to the UK's air quality problems on some of its most polluted roads
- Support OLEV's commitment of attracting investment to the UK

Once the bids have been assessed an announcement will be made detailing the consortia that will receive funding, as well as details of the numbers of buses and recharging infrastructure supported.

36.2.5 Low Carbon Truck Trial

The low carbon truck trial was launched in 2012 to support UK road haulage operators in buying and using low carbon heavy goods vehicles. 14.7 million EUR funding from the Office of Low Emission Vehicles and Innovate UK (formerly the Technology Strategy Board) has been awarded via competition. A number of the successful projects commenced vehicle trials in 2013 and 2014. A report[116] was released in July 2015 to update on how the trial had been progressing.

36.2.6 Go Ultra Low City Scheme

Following a competitive bid process in 2015, in January 2016 the UK announced[117] the creation of four "Go Ultra Low" Cities – Bristol, London, Milton Keynes, and London. They will receive funding to turn them into global exemplars of ultra low emission vehicle uptake. The scheme is also providing 6.5 million EUR of

[114] www.gov.uk/government/uploads/system/uploads/attachment_data/file/413022/Low_Emission_Bus_Scheme_bidding_guidance.pdf
[115] www.gov.uk/government/collections/background-to-the-green-bus-fund
[116] www.gov.uk/government/publications/low-carbon-truck-trial-executive-summary-2014
[117] www.gov.uk/government/news/40-million-to-drive-green-car-revolution-across-uk-cities

development funding for specific initiatives in Dundee, Oxford, York, and the North East England region. Total scheme funding is 52 million EUR.

The winning cities will deliver a rollout of cutting edge technology, such as rapid-charging hubs and street lighting that double as charge points, along with a range of innovative proposals that will give plug-in car owners extra local privileges such as access to bus lanes in city centres. Around 25,000 parking spaces will also be opened up for plug-in car owners.

Figure 5: The UK's Go Ultra Low cities and their headline policies

36.3 Charging Infrastructure

With the growing number of EVs in the UK more chargepoints will be needed. The UK is strategically reviewing its support for infrastructure for the spending period to 2020, with announcements due later in 2016. These announcements will build on the work of previous years which has seen Government funding deliver over 11,000 publicly available chargepoints, including over 850 rapid chargepoints and over 60,000 home chargepoints.

As well as part-government funded chargepoints there have been many chargepoints installed by the private sector. The National Chargepoint Registry[118] is an open source database listing all Government funded and some private sector funded chargepoints in the UK. This has been used by third parties to develop web applications for use by the ULEV driving public in the UK.

The UK is continuing with some of its infrastructure offerings with the Electric Vehicle Homecharge Scheme[119] providing 650 EUR towards the cost of installing

118 www.national-charge-point-registry.uk
119 www.gov.uk/government/publications/electric-vehicle-homecharge-scheme-guidance-for-customers-2016

a homecharger for EV drivers with off street parking. This is particularly important as evidence shows that drivers do most of their charging at home. In addition Highways England have committed[120] to ensuring there is a chargepoint every 20 miles, rapid where possible, across 95 % of the Strategic Road Network.

The Go Ultra Low City (52 million EUR), ultra low emission taxi (26 million EUR), and low emission bus schemes (39 million EUR) will all contain provision of funding to install recharging infrastructure across the UK.

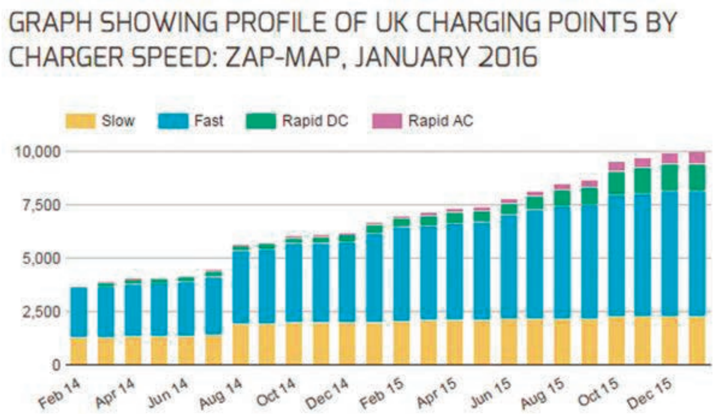

Figure 6: Growth in publically available chargepoints in the UK

36.4 EV Demonstration Projects

36.4.1 Hydrogen Technology Advancement Project (HyTAP)

The UK has been identified by manufacturers as a lead market for the roll-out of hydrogen fuel cell electric vehicles and the Government is supporting the provision of refueling infrastructure. An initial network of 12 publicly accessible hydrogen refueling stations will be operational by the end of 2016 under the HyTAP imitative. This is the first step towards a national network of 65 stations which the UKH2Mobility[121] project identified as needed to provide a base level of support nationwide. This 7.1 million EUR scheme will see hydrogen refueling stations being opened around London, Swindon, Sheffield, South Wales and the provision of two mobile refuellers.

Up to 2.6 million EUR funding will also be provided to public and private sector fleets for the deployment of FCEVs. This money will provide support for the

[120] www.gov.uk/government/collections/road-investment-strategy
[121] www.gov.uk/government/uploads/system/uploads/attachment_data/file/192440/13-799-uk-h2-mobility-phase-1-results.pdf

purchase of M1 and N1 vehicles (cars and vans) for over three years of operation. Announcements on how this will work will be provided in 2016.

36.4.2 Government Procurement

In the UK 6.5 million EUR has been invested in a large scale ultra low emission and zero emission vehicle readiness programme for government and public sector fleets[122]. 140 plug-in cars and vans have been joining vehicle fleets in the Foreign and Commonwealth Office, Ministry of Defence and the Home Office amongst others, whilst the wider public sector is deploying a further 200 ultra low emission vehicles into service. In addition to the vehicles OLEV is providing funding for recharging infrastructure.

36.5 Outlook

The UK is committed to supporting the development of a flourishing market for ULEVs. It will not be easy, there are challenges in helping to bring technologies to market that are affordable, accepted by consumers and with the necessary infrastructure in place to enable them to be used to their full potential. A mass market shift to ULEVs will also bring challenges and opportunities for the energy sector, which will need to be prepared for and managed.

Efficient transport is vital to the UK's economic wellbeing and road transport remains the dominant transport mode in the UK. Increasing use of ultra low emission vehicles therefore has a very important role to play in supporting mobility while reducing the carbon and air quality impact of road transport.

[122] www.gov.uk/government/news/government-departments-sign-up-to-green-revolution

37 United States

37.1 Major Developments in 2015

U.S. vehicle usage in the first half of 2015 reached a historic high of 1.54 trillion miles driven[123], highlighting the need for widespread affordable electric vehicle technology for reducing petroleum consumption and green-house gas (GHG) emissions. The availability of plug-in electric vehicles (PEVs) continued to grow – several new models were either announced (e.g., Chevrolet Bolt, 2nd Generation Chevrolet Volt, Hyundai IONIQ, Tesla Model X, and Tesla Model 3) or became commercially available (e.g., Mercedes S550 Plug In, Volvo-XC90 Plug-In, Tesla Model X, BMW X5, Hyundai Sonata Plug-In, Audi A3 Plug-In). Both the Model 3 and the Bolt claim a 200-mile electric range, and cost 30,000 USD or less after a federal incentive of 7,500 USD. (The estimated average transaction price for a new U.S. vehicle was 34,112 USD[124].) Hybrid electric vehicle (HEV) numbers continued to expand across vehicle types. Almost all manufacturers offer a HEV in the vehicle line-up. This occurred in spite of historically low gas prices which would presumably reduce the appeal of HEVs and PEVs. Other major developments included:

- Two manufacturers announced future releases of affordable (30,000 USD after incentives) 200-mile PEVs. GM's Chevy Bolt will be built in GM's Orion Assembly facility near Detroit, and will go into production by the end of 2016[125]. Tesla's Model 3 will begin production in late 2017[126].
- President Obama signed the Fixing America's Surface Transportation Act (FAST Act), which mandates the U.S. Department of Transportation (DOT) to designate corridors for alternative fueling stations (including PEV chargers) to

[123] "U.S. Driving Hits Historic High in Year's First Half" U.S. FHWA. 20 Aug. 2015; Web. 11 Mar. 2016; www.fhwa.dot.gov/pressroom/fhwa1557.cfm.
[124] "New-Car Transaction Prices Rise Nearly 3 Percent in January 2016, According to Kelley Blue Book" Kelly Blue Books Press Release, 2 Feb. 2016; Web. 22 Mar. 2016 ; http://mediaroom.kbb.com/new-car-transaction-prices-rise-nearly-3-percent-january-2016
[125] "Chevrolet Commits to Bolt EV Production" GM Media. 12 Feb. 2015; Web. 18 Mar. 2016; http://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2015/feb/chicago/0212-bolt-ev.html.
[126] "Tesla Motors: Model 3 Planned For 2018 (Update – Tesla Re-Confirms 2017 Production)" InsideEVs. 22 June 2015; Web. 18 Mar. 2016; http://insideevs.com/tesla-motors-model-3-pushed-back-2018/

be chosen based on demand, road strategic importance, and a pre-existing infrastructure[127].

- BMW and Nissan announced a partnership to deploy 120 dual 50 kW fast chargers across 19 states[128]. This parallels Tesla's Supercharger strategy. It will also enable charging of non-Tesla EVs (the chargers will have both CHAdeMO and CCS Combo connectors). This is in addition to BMW's partnership with VW and Chargepoint earlier, aimed at building DC fast charging corridors on U.S. coasts[129].
- A newly-announced EV company, Faraday Future, was said to have plans to invest 1 billion USD in a U.S. manufacturing facility, with the first ground-up vehicle design release targeted for 2017[130]. Its global employee team exceeds 400 automotive professionals, many from BMW i3 and i8, Tesla Model S, and Chevy Volt, etc.

37.1.1 Policy Activities

The International Council on Clean Transportation (ICCT) assessed EV promotion and uptake in the top 25 U.S. metropolitan areas[131]. The study found that the top PEV markets represent over 42 % of the population, 46 % of auto sales in the U.S. (2014) are characterized by a combination of more PEV promotion action, greater charging infrastructure per capita, greater consumer incentives, and greater model availability thus providing evidence that effective policy plays an important role in increasing consumer acceptance of PEV technology.

Most policy developments in 2015 at the state and national level continued to favor the further expansion of the HEV and PEV markets. Seven states (California, Connecticut, Maryland, Massachusetts, Oregon, Rhode Island, and Vermont), in partnership with Canada, the Netherlands, Norway, and the United Kingdom, founded the International ZEV Alliance, which aims to accelerate global adoption of zero-emission vehicles (ZEVs)[132]. It plans to increase ZEV deployment through

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127 "Final Transportation Bill: Electric-Car Fans Get MORE Reasons To Rejoice" Green Car Reports. 28 Dec. 2016; Web. 18 Mar. 2016; www.greencarreports.com/news/1101546_final-transportation-bill-electric-car-fans-get-reasons-to-rejoice

128 "BMW and Nissan partner to deploy dual fast chargers across the US" BMW. 21 Dec. 2015; Web. 11 Mar. 2016; www.press.bmwgroup.com/usa/article/detail/T0248223EN_US/nissan-and-bmw-partner-to-deploy-dual-fast-chargers-across-the-u-s-to-benefit-electric-vehicle

129 "BMW, Volkswagen and ChargePoint Announce Initiative to Create Electric Vehicle Express Charging Corridors on the East and West Coasts." Press Release. 22 Jan. 2015; Web. 11 Mar. 2016; www.chargepoint.com/news/2015/0122/

130 "What is Faraday Future Up To?" HybridCars. 21 Dec. 2015; Web. 11 Mar. 2016; www.hybridcars.com/what-is-faraday-future-up-to/

131 "Assessment of Leading Electric Vehicle Promotion Activities in U.S. Cities" ICCT. July 2015; Web.14 Mar. 2016; http://theicct.org/sites/default/files/publications/ICCT_EV-promotion-US-cities_20150729.pdf

132 "International Alliance on Zero-Emission Vehicles Grows to 11 Partners" CARB. 09 Sep. 2015; Web. 11 Mar. 2016; www.arb.ca.gov/newsrel/newsrelease.php?id=761

exchanging best practices and jointly encouraging policies that drive ZEV adoption.

California's Air Resources Board (CARB) initiated a retire-and-replace program to help low income citizens replace older, higher-pollution vehicles with cleaner, more fuel-efficient ones. It provides eligible consumers an incentive between 2,500 USD and 12,000 USD depending on income and the replacement vehicle under consideration[133].

In 2015, Connecticut implemented the Connecticut Hydrogen and Electric Automobile Purchase Rebate Program (CHEAPR). It offers up to 3,000 USD to Connecticut residents, businesses, and municipalities who purchase or lease an eligible PEV. CHEAPR is geared to help the state meet its commitment to the 8-state ZEV Action Plan, which aims to put 3.3 million ZEVs on the road by 2025[134].

Businesses and individuals remain eligible for federal tax credits worth 30 % of the qualifying EVSE cost. Twenty states offer grant funding, tax exemption, tax credits, and/or rebates for business EVSE, while twelve offer it for home EVSE installations[135].

37.1.2 Continued Research, Development, and Deployment Funding

Several different electric vehicle R&D funding opportunities were released in 2015 by both federal and state entities. The federal funding initiatives from 2015 included:

- The U.S. Department of Energy (DOE) awarded 55 million USD in September 2015 for 24 different projects, over half of which support the "Critical Technologies to meet the *EV Everywhere* Grand Challenge" thrust area[136]. The relevant projects cover both design and manufacturing of power electronics and battery technologies. An additional 4.5 million USD was awarded to 4 different battery and power electronics research projects in August 2015[137]. An

[133] "California providing incentives up to 12,000 USD to help low-income families afford the cleanest cars" Green Car Congress. 28 May 2015; Web. 11 Mar. 2016; www.greencarcongress.com/2015/05/20150528-arb.html

[134] "Connecticut providing up to 3,000 USD cash rebate for buyers of BEVs, FCEVs, and PHEVs while funding lasts" Green Car Congress. 20 May 2015; Web. 11 Mar. 2016; www.greencarcongress.com/2015/05/20150520-ct.html

[135] "Take Credit for Going Green" ChargePoint. 2016; Web 14 Mar. 2016; www.chargepoint.com/station-incentives

[136] "DOE awards nearly 55 million USD to advance fuel efficient vehicle technologies in support of EV Everywhere and SuperTruck" U.S. DOE. 17 Sep. 2015; Web. 14 Mar. 2016; http://energy.gov/articles/energy-department-awards-nearly-55-million-advance-fuel-efficient-vehicle-technologies

[137] "Energy Department Announces $12 Million to Advance Efficient, Environmentally-Friendly Highway Transportation Technologies" U.S. DOE. 26 Aug. 2015; Web. 14 Mar. 2016;

additional funding of 56 million USD for vehicle technologies was announced in December 2016.

- DOE continued funding its Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs, covering 162 projects (26.6 million USD) in 2015. The projects cover a wide range of PEV and hydrogen fuel cell technology R&D[138]. Topics were released for the 2016 programs as well.
- DOE also awarded 6.6 million USD to solid-state battery research through its Advanced Research Projects Agency – Energy (ARPA-E)[139], and announced 11 million USD in funding which would be partially available to medium- and heavy-duty vehicle powertrain electrification[140].
- U.S. DOT announced the availability of 22.5 million USD to support "low or no emissions bus deployment" (LoNo)[141]. The LoNo Program focuses on the commercialization of the cleanest and most energy-efficient U.S.-made transit buses. Also, 55 million USD was awarded to 10 projects earlier in the year, both PEV and fuel-cell powered buses.
- 2015 also marked a large increase in California's Funding Plan for Low Carbon Transportation Investments and the Air Quality Improvement Program, to 373 million USD (150 million USD higher than in FY2014-2015). This will cover zero-emission vehicle incentives, the state's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project, large-scale commercialization projects, and a range of other ZEV development and deployment efforts[142].

These programs will continue to improve vehicle electrification technology, availability, and awareness in the U.S.

http://energy.gov/eere/articles/energy-department-announces-12-million-advance-efficient-environmentally-friendly

[138] "SBIR/STTR FY15 Phase 1 Release 2 Awards Announced" U.S. DOE. 28 May 2015; Web. 14 Mar. 2016; http://energy.gov/eere/fuelcells/articles/sbirsttr-fy15-phase-1-release-2-awards-announced-includes-fuel-cell-battery

[139] "ARPA-E awards 6.6 million USD to two projects for electrolytes for solid-state batteries for EVs" Green Car Congress. 1 Dec. 2015; Web. 14 Mar. 2016; http://www.greencarcongress.com/2015/12/20151201-solidstate.html

[140] "DE-FOA-0001349 Medium and Heavy Duty Vehicle Powertrain Electrification and Dual Fuel Fleet Demonstration " Grants.gov. 8 Sep. 2015; Web. 14 Mar. 2016; http://www.grants.gov/web/grants/view-opportunity.html?oppId=278892

[141] "U.S. Department of Transportation Announces $22.5 Million to Put More Low and No-Emission Vehicles into Service Across America" Federal Transit Administration. 25 Sep. 2015; Web. 14 Mar. 2016; www.fta.dot.gov/newsroom/news_releases/12286_16576.html

[142] "California ARB approves 373 million USD funding plan for advanced vehicle technologies in FY2015-2016; up from 150 million USD last year" Green Car Congress. 26 Jun. 2015; Web. 14 Mar. 2016; www.greencarcongress.com/2015/06/201506.html

37.2 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 2015 as well as price overview of the highest selling models.

Hybrid electric vehicles (HEVs) continued to increase in both variety and performance in 2015. There were 47 total models available and 25 models with annual sales over 1,000. The range of Original Equipment Manufacturers (OEMs) offering HEVs included: BMW, Daimler AG, Ford, GM, Honda, Kia, Nissan, Porsche, Subaru, Toyota, and Volkswagen. The highest selling models were the Toyota Prius Liftback, Toyota Prius C, Toyota Camry, Toyota Prius V, Ford Fusion, and Hyundai Sonata, with respective annual sales of 113,829, 38,484, 30,640, 28,290, 24,681, and 19,908 units. The Prius line-up continued to predominate and controlled 46 % of the U.S. HEV market in 2015. Figure 1 shows the annual sales of the most popular models.

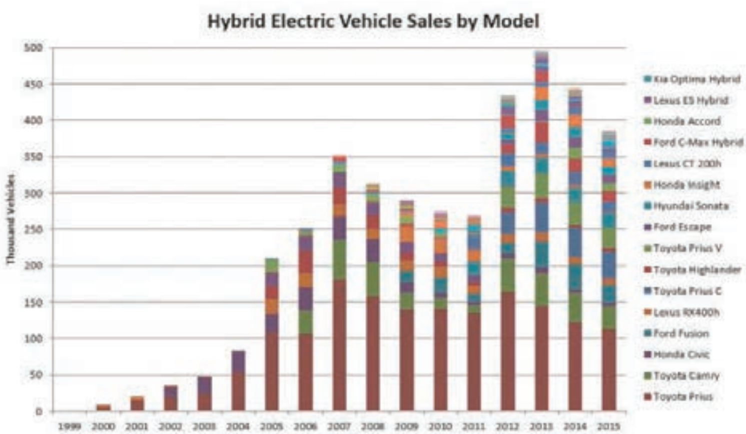

Figure 1: HEV Sales by Model (Source: U.S. DOE AFDC; www.afdc.energy.gov/data)

In 2015, there were 26 plug-in electric vehicle (PEV) models sold in the United States, including 12 all-battery EV models and 14 PHEV models. The range of manufacturers offering PEVs included: BMW, Daimler AG, Fiat, Ford, GM, Honda, Kia, Mitsubishi, Nissan, Porsche, Tesla, Toyota, Volkswagen, and Volvo[143]. Announcements from Hyundai indicated that it will be releasing a modular line-up which includes HEV, PHEV, and full-EV variants, in 2016[144].

[143] "December 2015 Dashboard." December 2015 Dashboard. 06 Jan. 2016; Web. 09 Mar. 2016; www.hybridcars.com/december-2015-dashboard/; Note: BMW i3 is only counted once, as a BEV
[144] "2017 Hyundai Ioniq Hybrid, Electric: More Notes from Geneva Motor Show." Green Car Reports; Web. 09 Mar. 2016; www.greencarreports.com/news/1102653_2017-hyundai-ioniq-hybrid-electric-more-notes-from-geneva-motor-show

Several existing PEV manufacturers plan to release additional PEVs in 2016 as well, including the highly-anticipated Chevrolet Bolt and Tesla Model 3.

The highest-selling 2015 models included the Tesla Model S, Nissan LEAF, Chevrolet Volt (including both Gen I and Gen II), and BMW i3, with respective annual sales of: 26,566, 17,269, 13,413, and 11,024 units. A total of 17 models sold over 1,000 units in 2015.20 Figure 2 shows the annual sales of the most popular models.

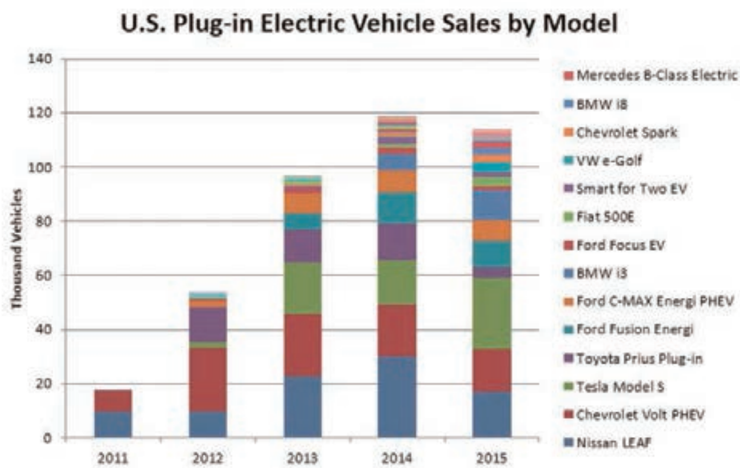

Figure 2: PEV Sales by Model (Source: U.S. DOE AFDC; www.afdc.energy.gov/data)

Table 2 lists the prices for select hybrid and electric vehicles sold in the U.S. The prices given are in U.S. dollars and reflect the manufactured suggested retail price (MSRP). The information is current as of March 2016.

While several e-bike manufacturers are producing and selling e-bikes in the U.S., the market has not taken off quite as successfully as in China or Europe. The recent efforts of the Light Electric Vehicle Association and the Electric Bike Expo[145] have led to more e-bike technology visibility in the U.S., and will likely continue to do so via several roadshow events scheduled throughout 2016. According to LEVA, "Sales of low priced e-bikes seem to have declined steeply, probably due to Currie withdrawing their popular low priced models from mass merchant channels, combined with low gasoline prices. However, high priced e-bikes and pedelecs (a type of e-bike) sales were dramatically up"[146].

[145] "About Electric Bike Expo" Electric Bike Expo; Web. 10 Mar. 2016; www.electricbike-expo.com/about-us/
[146] Email correspondence with the Light Electric Vehicle Association.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2015

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[8]**
E-Bikes	600,000[a]	0	0	0	n.a.
Passenger Vehicles[b]	214,610	191,926	3,804,630	n.a.	258,000,000 (est)[c]
Buses and Minibuses	n.a.	n.a.	n.a.	n.a.	864,549[d]
Medium and Heavy Weight Trucks	n.a.	n.a.	n.a.	n.a.	10,597,000[e]
Totals without e-bikes	**214,610**	**191,926**	**3,804,630**	**n.a.**	**269,461,549**

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[h]**
E-Bikes	130,000[a]	0	0	0	n.a.
Passenger Vehicles[b]	72,303	42,959	382,636	57[f]	17,500,000[g]
Buses and Minibuses	n.a.	n.a.	n.a.	n.a.	n.a.
Medium and Heavy Weight Trucks	n.a.	n.a.	n.a.	n.a.	449,505
Totals without e-bikes	**72,303**	**42,959**	**382,636**	**57**	**17,949,505**

n.a. = not available

[a] Correspondence with Light Electric Vehicle Association. www.LEVAssociation.com

[b] Estimated fleet size and annual sales calculated using data from HybridCars.com's history of monthly sales dashboards. E.g.: www.hybridcars.com/december-2015-dashboard/

[c] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." U.S. Energy Information Administration (EIA); Web. 09 Mar. 2016; www.eia.gov/forecasts/aeo/data/browser/#/?id=49-AEO2015

[d] Most recent data is from 2013. www.rita.dot.gov/

[e] ORNL Transportation Energy Data Book. Most recent available data is 2013. http://cta.ornl.gov/data/tedb34/Edition34_Chapter05.pdf

[f] www.greencarreports.com/news/1101338_portable-hydrogen-fuelers-go-to-six-toyota-mirai-dealers-as-stations-lag

[g] www.wsj.com/articles/u-s-car-sales-poised-for-their-best-month-ever-1451999939

[h] Including non-electric vehicles

Table 2: Available vehicles and prices (Data source: websites; only vehicles that are available and that sold over 1,500 units in 2015 are listed)

Market-Price Comparison of Selected EVs and PHEVs in the United States	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in USD)**
Average for new, conventional vehicles	34,112[147]
BMW i3	42,400
BMW i8	140,700
Chevy Spark EV	25,995
Chevy Volt	33,220
Fiat 500e	31,800
Ford C-Max Energi	31,770
Ford Fusion Energi	33,900
Ford Focus Electric	29,170
Mercedes Benz B-Class	41,450
Nissan LEAF	29,010
Tesla Model S	75,000
Volkswagen e-Golf	28,995

37.3 Charging Infrastructure or EVSE

EV charging infrastructure in the United States continued to expand significantly in 2015. 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, Fast Chargers, and Tesla Superchargers, and Figure 3 gives an overall picture of the geographical distribution of charging stations in the U.S. This information is all continuously collected by the U.S. Department of Energy's Alternative Fuels Data Center, and placed on their website[148].

[147] "New-Car Transaction Prices Rise Nearly 3 Percent in January 2016, According to Kelley Blue Book" Kelly Blue Books Press Release, 2 Feb. 2016; Web. 22 Mar. 2016; http://mediaroom.kbb.com/new-car-transaction-prices-rise-nearly-3-percent-january-2016
[148] "Alternative Fuels Data Center" U.S. DOE; Web. 10 Mar. 2016; www.afdc.energy.gov/

Table 3: Information on charging infrastructure in 2015 (excl. private chargers), showing number of stations with number of available outlets, in parentheses (Data source: U.S. DOE Alternative Fuels Data Center, accessed March 9, 2016; www.afdc.energy.gov/fuels/electricity_locations.html)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	1,567 (2,972)
AC Level 2 Chargers	10,599 (23,996)
Fast Chargers	1,564 (3,277)
Superchargers (incl. in Fast Chargers)	253 (1,603)
Totals	**13,730 (30,245)**

Figure 3: Electric vehicle charging stations in the United States (Source: http://maps.nrel.gov/transatlas)

37.3.1 Workplace Charging Challenge

The DOE *EV Everywhere* Workplace Charging Challenge seeks to promote benefits of workplace charging. Its partners assess employee demand for PEV charging at the workplace and develop/execute a plan for it. As of November 2015, following three years of rapid expansion, 255 employers are partners in the Challenge. Over 600 workplaces installed a total of over 5,500 charging stations accessible to nearly one million employees. Figure 4 shows the cumulative growth in workshop locations with charging stations, and Figure 5 their geographic distribution[149]. In addition to the official partners, more than 200 other employers

[149] "Workplace Charging Challenge Mid-Program Review." Dec. 2015; Web. 10 Mar. 2016; www.energy.gov/sites/prod/files/2015/12/f27/105313-5400-BR-0-EERE%20Charging%20Challenge-FINAL_0.pdf

also offer charging, showing how the Challenge has acted as a catalyst for workplace charging growth even beyond Challenge participants.

37.3.2 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.

Figure 4: Cumulative growth in partner workplace locations with charging stations

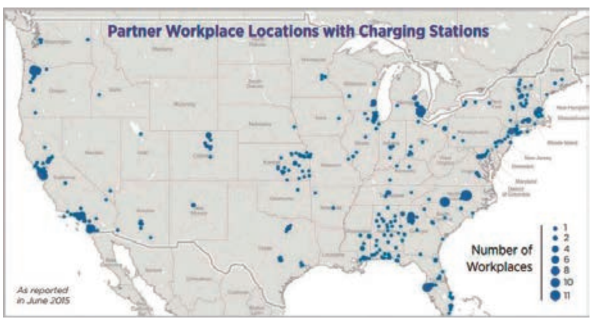

Figure 5: DOE Workplace Charging Challenge participants

In 2015, INL focused on infrastructure utilization by region and area type, as well as analysis of charging infrastructure effects on the electricity grid. These analyses resulted in a total of 30 Lessons Learned White Papers, which are available for download the EV Project website, as well as a Final Report[150].

[150] "Plug-in Electric Vehicle and Infrastructure Analysis." Sep. 2015; Web. 14 Mar. 2016; http://avt.inel.gov/pdf/arra/ARRAPEVnInfrastructureFinalReportHqltySept2015.pdf

37.4 EV Demonstration Projects

In addition to the PEV charging infrastructure analysis (mentioned above) INL also released its findings from several EV demonstration projects. These projects deployed approximately 8,700 PEVs across the U.S., including Chevrolet Volts, Nissan Leafs, Chrysler Ram PHEV Pickups, Car2Go Smart EVs, and Via Motors PHEV vans and pickups. Over 130 million miles of driving data was captured, the analysis of which resulted in the extended Final Report mentioned above.

37.5 Technology Updates

37.5.1 Batteries

The 2015 DOE PEV battery cost reduction milestone of 275 USD/kWh has been accomplished. DOE-funded research has helped reduce the current cost projection (from three DOE-funded battery developers) for a 40-mile range PHEV battery (PHEV-40 battery) to an average 264 USD per kilowatt-hour (of useable energy) (see Figure 6). This cost projection is derived by using the value for material costs and cell and pack designs as provided by those developers, using the ANL model "Battery Production and Cost (BatPaC)", assuming a minimum production volume of 100,000 batteries per year. DOE's goals are to continue to drive down battery cost to 125 USD/kWh by 2022[151].

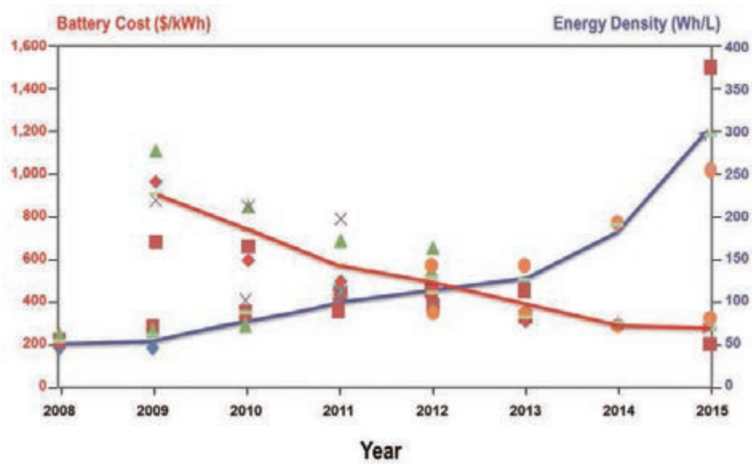

Figure 6: Battery R&D Progress: Cost Reduction & Energy Density Trends[152]

[151] Vehicle Technologies Office, Energy Storage R&D, Fiscal Year 2015 Annual Progress Report, U.S. Department of Energy, Washington, DC, March 2016.
[152] Vehicle Technologies Office, Battery R&D Progress: Cost Reduction & Energy Density Trends U.S. Department of Energy, Washington, DC, March 2016.

37.5.2 Materials

DOE-funded research completed the prototype design, build, and testing of a multi-material lightweight vehicle (MMLV) demonstrating more than 23 % weight reduction versus a conventional baseline (see Figure 7). It also developed/deployed Aluminum friction stir welded tailor welded blank process technology with weight reduction of up to 60 % versus conventional techniques. This technology is now implemented in production at the TWB facility in Monroe, MI with capacity of up to 250,000 parts per year. It also developed and demonstrated new high strength, exceptional ductility advanced steel with greater than 1,200 MPa tensile strength and greater than 30 % elongation to failure[153].

Figure 7: Multi-material Lightweight Vehicle Mach I Design[154]

37.5.3 Vehicle Systems

INL Published PEV and Infrastructure Analysis Report addressing driving and charging behavior throughout the U.S and five multi-year demonstrations of PEVs and charging infrastructure. This study represented an analysis of the largest PEV and charging infrastructure demonstrations ever conducted (2010-2015)[155].

37.6 Outlook

Global sales of light, medium, and heavy duty PEVs are estimated to continue growing, according to Navigant Research reports published in 2015[156]. ICCT estimates that full-function hybrid systems are likely to drop 50 % in cost before 2025, pushing mild electrification into the U.S. fleet at ever-increasing levels[157].

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[153] Vehicle Technologies Office, Lightweight Materials R&D, Fiscal Year 2015 Annual Progress Report, U.S. Department of Energy, Washington, DC, March 2016.
[154] Vehicle Technologies Office, Multi-Material Lightweight Vehicles, Annual Merit Review Presentation #LM072, U.S. Department of Energy, Washington, DC, June 2015.
[155] Vehicle Technologies Office, Vehicle Systems R&D, Fiscal Year 2015 Annual Progress Report, U.S. Department of Energy, Washington, DC, March 2016.
[156] "Navigant forecasts 29.3% CAGR growth for electric-drive and electric-assisted commercial vehicles to nearly 160,000 units in 2023" Green Car Congress. 28 Jan. 2015; Web. 14 Mar. 2016; www.greencarcongress.com/2015/01/20150128-navigant.html; and "Navigant forecasts global annual sales of LDVs of 122.6 million by 2035, up 38 % from 2015" Green Car Congress. 6 July 2015; Web. 14 Mar. 2016; www.greencarcongress.com/2015/07/20150706-navigant.html
[157] "Hybrid Vehicles: Technology Development and Cost Reduction" ICCT. July 2015; Web. 14 Mar. 2016; http://theicct.org/sites/default/files/publications/ICCT_TechBriefNo1_Hybrids_July2015.pdf

Lithium-ion battery costs are estimated to drop 35 % by 2025[158]. Many state and local policy developments, including the Multi-State ZEV Action Plan, federal/state/local incentives, and increasing investment in research, development, and demonstration, as well as ambitious private sector plans such as Tesla's Gigafactory and Faraday Future's manufacturing facility, will continue to fuel an optimistic outlook for the U.S. PEV market.

[158] "Crossing the Line: Li-ion Battery Cost Reduction and Its Effect on Vehicles and Stationary Storage" Lux Research. 31 Mar. 2015; Web. 14 Mar. 2016; https://portal.luxresearchinc.com/research/report_excerpt/19123

38 Non-Member Countries

38.1 China

In recent years, China issued a lot of policies to promote the industrialization of new energy vehicles. Electric vehicles free from purchase tax, 2016-2020 promotion and application financial support policy, product oil price subsidy for urban public transportation and operation subsidy for electric vehicle public transportation are issued successively. “Provisions on Administration of Newly Established Pure Electric Passenger Vehicle Enterprises” implemented in July 2015 encourages social capital and technical innovative enterprises that mastering core technologies of pure electric passenger vehicles enter into R&D and manufacturing of new energy vehicles to form high-level market competition.

In 2015, the new energy vehicle industry maintained rapid growth. By the end of December 2015, as many as 39 demonstration cities/ regions promoted 383,285 vehicles in total. From January 2015 to January 2016, the nation-wide production of new energy vehicles was 395,100 vehicles, in which pure electric passenger vehicles are 150,800 with a 278 % increase; the number of plug-in hybrid passenger vehicles is 68,500 with a 261 % increase. The production of pure electric commercial vehicles is 150,300 with a 782 % increase and the production of plug-in hybrid commercial vehicles is 32,900 with a 46 % increase.

The construction of charging infrastructure achieved a remarkable progress. In October 2015, “Guiding Opinions on Accelerating the Construction of Electric Vehicle Charging Infrastructure” was issued. It stipulates the general idea of China’s electric vehicle charging infrastructure development, and the implementation mode. By the end of January 2016, as many as 58,758 charging piles in total with 38,312 AC charging piles, 12,101 DC charging piles, and 8,345 AC & DC integrated charging piles were built.

The fuel cell vehicle industry develops steadily as well. In July 2015, a 12-meter electric-electric hybrid fuel cell urban bus developed by Yutong Bus was listed into the Ministry of Industry and Information Technology’s Announcement of “Road Motor Vehicle Production Enterprise and Product (No. 274)”. In 2015, SAIC a self-developed China’s fourth generation fuel cell electric car was manufactured with a Roewe 950 model platform and equipped with a middle-capacity power storage battery, a small pressurized fuel cell system, and plug-in technology. At present, China has four hydrogen refueling stations in operation.

38.1.1 Subsidy Standards in China

Various examples of subsidy standards available for vehicles and buses are given in Tables 1-3. The data was being provided through the Notice of the Ministry of Finance, the Ministry of Science and Technology, the Ministry of Industry and Information Technology, and the National Development and Reform Commission on Continuing on "Promotion and Application of New Energy Automobiles" and the "Notice on Further Conducting the Promotion and Application of New Energy Automobiles". In Table 3, the data was available due to "Beijing Detailed Rules for Administration of Subsidy Funds for Demonstration Application of New Energy Cars".

Table 1: Information on subsidy standards of Chinese Central Government in 2015 (1 EUR = 7.4 CNY)

2015 Subsidy Standard of Chinese Central Government		
Vehicle Type	**Range (Mileage)**	**Subsidy (10,000 CNY/ Vehicle)**
Pure electric passenger vehicle	80 ≤ R < 150	3.15
	150 ≤ R < 250	4.5
	R ≥ 250	5.4
Plug-in hybrid passenger vehicle (extended range included)	R ≥ 50	3.15
Pure electric special vehicle	1800 CNY/KWh; not exceeding 135,000 CNY/vehicle	
Fuel cell passenger vehicle	18	
Fuel cell commercial vehicle	45	

Table 2: Information on subsidy standards for new energy buses in 2015 (1 EUR = 7.4 CNY)

2015 Subsidy Standard for New Energy Buses		
Vehicle Type	**Bus Length (m)**	**Subsidy (10,000 CNY/Vehicle)**
Pure electric bus	6 ≤ L < 8	30
	8 ≤ L < 10	40
	L ≥ 10	50
Plug-in hybrid bus (extended range included)	L ≥ 10	25
150,000 CNY (20,000 EUR) / vehicle for super-capacity and lithium titanate fast-charging pure electric bus.		

Table 3: Information on subsidy standards for Beijing in 2015 (1 EUR = 7.4 CNY)

2015 Beijing Subsidy Standard		
Vehicle Type	**Range (Mileage)**	**Subsidy (10,000 CNY/Vehicle)**
Pure electric passenger vehicle	80 ≤ R < 150	3.15
	150 ≤ R < 250	4.5
	R ≥ 250	5.4
Fuel cell bus		18

38.1.2 Main Policies in China in 2015

Requirements of Industry Standards for Automotive Power Storage Batteries was issued in March 2015 by the Ministry of Industry and Information Technology. The goal of the policy is to implement the "Notice of the State Council on Issuing the Planning for the Development of the Energy-Saving and New Energy Automobile Industry (2012-2020)", guide and regulate the healthy development of China's automotive power battery industry, according to the requirements of "Guiding Opinions of General Office of State Council on Accelerating Promotion and Application of New-energy Automobiles". "Requirements of Industry Standards for Automotive Power Storage Batteries" are formulated.

Made in China 2025 is the first 10-year action guideline of the Chinese government to implement the strategy of becoming a powerful manufacturing country. The policy was issued by the General Office of the State Council in May 2015. It raises the basic policy of "innovation driving, quality prior to everything, green development, structure optimization and talent-oriented" and the basic principle of "market-orientation, government guidance, standing from the present and having future in mind, advancing comprehensively and emphasizing on key issues, self-development and boosting opening and cooperation".

To achieve the goal of becoming a powerful manufacturing country "Made in China 2025" points out three steps:

1. Listed into powerful manufacturing countries by 2025
2. reaching middle-level of the powerful manufacturing countries by 2035
3. ranked among top of the strong manufacturing countries

The **Preferential Vehicle and Vessel Tax Policies for Energy-saving and New-energy Vehicles and Vessels** policy was issued by the Ministry of Finance, the Ministry of Industry and Information Technology, and the State Administration of Taxation in May 2015. The goal of the policy is to promote saving energy, according to "Vehicle and Vessel Tax Law of the People's Republic of China" and its implementation provisions, "Preferential Vehicle and Vessel Tax Policies for Energy-saving and New-energy Vehicles and Vessels" is approved and issued by the State Council.

Provisions on Administration of Newly Established Pure Electric Passenger Vehicle Enterprises was issued by the National Development and Reform Commission, Ministry of Industry and Information Technology in June 2015 with the goal to promote the development of a new energy vehicle industry, give full play to the market and support social capital and enterprises with technical innovative capability to participate in the R&D and manufacturing of pure electric passenger vehicles, according to "Administrative License Law of the People's Republic of China", "Administrative Measures for the Government Confirmation of Investment Projects" and "Automotive Industry Development Policy", "Provisions on Administration of Newly Established Pure Electric Passenger Vehicle Enterprises" is formulated and issued.

38.1.3 HEVs, PHEVs and EVs on the Road

In 2014, the production of new energy vehicles was 83,900. In 2015, the production was 379,000 with a 4-time's increase. Table 5 provides information on various types of vehicles produced in China in 2014 and 2015.

Table 4: Available vehicles and prices (Data source: official website of the corresponding enterprise; prices converted on May 2nd, 2016; 1 EUR = 7.4 CNY)

Market-Price Comparison of Selected EVs and PHEVs in China	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in CNY and EUR)**
BMW i3	416,800 ; 56,200
Mercedes-Benz Smart For two	235,000 ; 31,700
Denza Lifestyle	369,000 ; 50,000
BAIC EV200	226,900 ; 30,600
Venucia (3.6KW)	242,800 ; 32,800
BYD- Yuan	80,000 ; 10,800
BYD- Qin	209,800 ; 28,300
BYD- Song	96,900 ; 13,100
BYD- Tang	251,300 ; 33,900
BYD- e6	309,800 ; 41,800
BYD- F3DM	43,900 ; 6,000
JAC iEV4	152,800 ; 20,600
JAC iEV5	180,800 ; 24,400

Table 5: Production of New Energy Vehicles in China in 2014 and 2015 (Data source: Website release of Ministry of Industry and Information Technology)

Vehicle Type	2014	2015
Pure electric passenger vehicle	37,800	142,800
Plug-in hybrid passenger vehicle	16,700	63,600
Pure electric commercial vehicle	15,700	147,900
Plug-in hybrid commercial vehicle	13,800	24,600

38.1.4 Charging Infrastructure or EVSE

Two guiding policies on charging infrastructures were issued in 2015:

- Guiding Opinions on Accelerating the Construction of Electric Vehicle Charging Infrastructure (General Office of the State Council)
- Guidelines for the Development of Electric Vehicle Charging Infrastructure (2015-2020, National Development and Reform Commission, National Energy Administration, Ministry of Industry and Information Technology, Ministry of Housing and Urban-Rural Development)

By the end of January 2016, the China Electric Vehicle Charging Infrastructure Promotion Alliance published the data of public charging piles reported by its members: 58,758 charging piles in total with 38,312 AC charging piles, 12,101 DC charging piles and 8,345 AC & DC integrated charging piles.

In 2015, as many as 3,600 charging/replacing stations were built with a 362 % increase.

Table 6: Top 10 of China's provincial administrative regions on charging piles built by the end of January 2016 (Data source: China Electric Vehicle Charging Infrastructure Promotion Alliance)

City	Quantity
Guangdong	11,670
Beijing	8,764
Jiangsu	7,080
Shanghai	4,680
Anhui	3,879
Shandong	3,720
Liaoning	2,318
Tianjin	2,122
Hubei	1,960
Sichuan	1,728

38.1.5 EV Demonstration Projects

From 2013-2015, there were two batches of demonstration cities involving 39 cities or regions, including 88 cities. By the end of September 2015, as many as 181,000 new energy vehicles were promoted in which five regions exceeding 10,000 vehicles each with a total of 99,000, taking up 54.8 % of all. As many as 13 regions exceed 4,000 vehicles each with a total of 147,000, accounting for 81.1 % of all.

Table 7: List of EV demonstration cities in China (Data source: Website release of Ministry of Industry and Information Technology)

Demonstration Cities				
Beijing	Guangzhou	Shanghai	Shenzhen	Tianjin
Chongqing	Hefei	Chengdu	Dalian	Luzhou
Wuhu	Qingdao	Ningbo	Xi'an	Zhengzhou
Lanzhou	Xinxiang	Shenyang	Wuhan	Changchun
Xiangyang	Harbin	Taiyuan	Zibo	Jincheng
Linyi	Liaocheng	Weifang	Haikou	

Table 8: List of EV demonstration city clusters in China (Data source: Website release of Ministry of Industry and Information Technology)

Demonstration City Clusters	
Chang-Zhu-Tan	Changsha, Zhuzhou, Xiangtan
Zhejiang	Hanghzou, Jinhua, Shaoxing, Huzhou
Jiangsu	Nanjing, Changzhou, Suzhou, Nantong, Yancheng, Yangzhou
Guangdong	Foshan, Dongguan, Zhongshan, Zhuhai, Huizhou, Jiangmen, Zhaoqing
Hebei	Shijiazhuang, Tangshan, Handan, Baoding, Xingtai, Langfang, Hengshui, Cangzhou, Chengde, Zhangjiakou
Fujian	Fuzhou, Xiamen, Zhangzhou, Quanzhou, Sanming, Putian, Longyan, Ningde, Pingtan
Jiangxi	Nanchang, Jiujiang, Fuzhou, Yichun, Pingxiang, Shangrao, Ganzhou
Inner Mongolia	Hohhot, Baotou
Guizhou	Guiyang, Zunyi, Bijie, Anshun, Liupanshui, Qiandongnan Prefecture
Yunnan	Kunming, Lijiang, Yuxi, Dali

38.1.6 Outlook

With the improvement and implementation of China's charging standards of electric vehicles, the sales of new energy vehicles in 2016 is expected to continue growing rapidly with a forecasted sales of exceeding 700,000 vehicles.

China will seize the opportunities and speed up cultivating energy-saving and the new energy vehicle industry. Enterprises will become more self-determined and the support policies will be put in place orderly so as to build a sound development environment for enhancing the innovative capability of energy-saving and the new energy vehicle industry. With the ongoing optimization and upgrade of the automotive industry, China aims at transforming itself from a big automotive country to a strong automotive country.

38.2 Japan

38.2.1 Targets

The Japan Revitalization Strategy Revised in 2015 (Cabinet approval on June 30th, 2015) 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". This was followed by the "2014 Automobile Industry Strategy" of the Ministry of Economy, Trade and Industry METI.

Table 1: Diffusion Targets by types of vehicles (Targets set by the METI)

	2015 Results	2030 Targets
Conventional Vehicles	**73.5 %**	**30 ~ 50 %**
Next-Generation Vehicles	**26.5 %**	**50 ~ 70 %**
Hybrid Vehicles	22.2 %	30 ~ 40%
Electric Vehicles	0.27 %	20 ~ 30 %
Plug-in Hybrid Vehicles	0.34 %	20 ~ 30 %
Fuel-Cell Vehicles	0.01 %	~ 3 %
Clean Diesel Vehicles	3.6 %	5 ~ 10 %

A new target was set, to increase the number of disseminated EVs and PHVs (ownership basis) to up to one million vehicles by 2020. The total sales of EVs and PHEVs as of the end of February 2016 were approximately 140,000 (From "the Road Map for EVs and PHVs toward the Dissemination of Electric Vehicles and Plug-in Hybrid Vehicles").

38.2.2 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 (6,964 USD)
- **CDVs**: up to 350,000 JPY (2,868 USD)
- **FCVs**: up to 2,020,000 JPY (16,551 USD)

38.2.3 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 at 1st & 2nd inspection) and "automobile tax" (local tax: partial exemption).

HEVs are partially exempt from paying "automobile acquisition tax" and "motor vehicle tonnage tax" and "automobile tax".

38.2.4 Research

METI has provided approximately 6 billion JPY to support for R&D in 2015, 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

38.2.5 HEVs, PHEVs and EVs on the Road

As of the end of 2015, cumulative EVs/PHVs/FCVs sales were over 135,000 in Japan. In 2015, there were about 4.22 million newly registered passenger vehicles in Japan. Of this newly registered total, 937,595 were HEVs, 10,910 were EVs, 14,188 were PHEVs, and 388 were FCVs.

Table 2: Sales of EVs, PHEVs and HEVs in 2015

Vehicle Type	EVs	PHEVs	HEVs	FCVs	Totals
Passenger Vehicles[a]	10,910	14,188	937,595	388	963,081
Light commercial vehicles[b]	1,436	n.a.	n.a.	n.a.	1,436

n.a. = not available
[a] UNECE categories M1
[b] UNECE categories N1

38.2.6 Charging Infrastructure or EVSE

METI have provided to support charging infrastructure by a subsidy of the "Promotion Project to Develop Charging Infrastructure for Next-generation Vehicles". As of the end of 2015, more than 20,000 public charging stations, including 5,971 quick chargers were installed in Japan. Many private companies such as four Japanese car manufacturers' joint company take an active role in installing quick chargers and normal chargers in response to the government.

The four car makers' joint company – 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 who can use associated majority of public chargers by one membership cards in Japan.

Table 3: Information on charging infrastructure in 2015

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	16,120
AC Level 2 Chargers	n.a.
Fast Chargers	5,971
Superchargers	19
Inductive Charging	n.a.
Totals	**22,110**

Table 4: Available vehicles and prices

Market-Price Comparison of Selected EVs and PHEVs in Japan	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in JPY and EUR)**
Mitsubishi i-MiEV	2,094,000 ; 17,157
Mitsubishi Minicab MiEV	1,666,000 ; 13,650
Mitsubishi Minicab MiEV truck	1,465,000 ; 12,003
Mitsubishi Outlander PHEV	3,330,000 ; 27,284
Nissan Leaf(24kwh)	2,466,000 ; 20,205
Nissan Leaf(30kwh)	2,891,000 ; 23,687
Nissan eNV200	3,593,000 ; 29,439
Toyota Prius Plug-in	2,714,286 ; 22,239
Toyota MIRAI	6,700,000 ; 54,896
Honda Accord Plug-in Hybrid	4,761,905 ; 39,016
Smart Fortwo Electric Drive	2,768,519 ; 22,683
Audi A3 Sportback e-tron	5,222,223 ; 42,788
BMW i3	4,620,370 ; 37,856
BMW i8	18,203,704 ; 149,150
BMW X5 xDrive40e	8,583,333 ; 70,326
Tesla Model S 60 kWh	7,620,370 ; 62,436
Tesla Model S 85 kWh	8,638,889 ; 70,782

38.3 Norway

In 2015, electric vehicles (BEV and PHEV) had a 22 % market share in Norway. This is due to a substantial package of incentives developed to promote zero emission cars.

38.3.1 Incentives

The Norwegian EV success is due to a substantial package of incentives developed to promote both hydrogen and zero emission electric cars. Since the early 1990's, the incentive package has been gradually introduced by a broad coalition of different political parties.

The zero emissions incentives include:

- No purchase/import taxes (1990)
- Exemption from 25 % VAT on purchase (2001)
- Low annual road tax (1996)
- No charges on toll roads or ferries (1997 and 2009)
- Free municipal parking (1999)
- Access to bus lanes (2005)
- 50 % reduced company car tax (2013)
- Exemption from 25 % VAT on leasing (2015)

The incentive package will be revised and adjusted parallel with the market development in coming years. The tax incentives will stay in place until 2018 and then be revised. From 2017 on the local governments will decide on the local incentives such as access to bus lanes and free municipal parking. Free toll roads will be replaced with a new system with differentiated prices depending on CO_2 and NOx emissions.

The overall signal from the majority of political parties is that it should always be economically beneficial to choose zero and low emission cars over high emission cars. This is obtained with the "polluter pays principle" in the car tax system – high taxes for high emission cars and lower taxes for low and zero emission cars.

Introducing taxes on polluting cars can finance incentives for zero emission cars without any loss in revenues.

38.3.2 HEVs, PHEVs and EVs on the Road

By the end of 2015 there were close to 75,000 BEV and about 12,000 PHEV registered in Norway. Nissan LEAF is the bestselling EV model with over 21,000 Norwegian registered cars bought by the end of 2015, followed by the Volkswagen e-Golf with about 10,800 registered vehicles and the Tesla Model S with about 9,800 registered vehicles.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2015 (Data source: ofv.no)

Fleet Totals on 31 December 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals**
Passenger Vehicles[a]	70,700	12,136	n.a.	20	n.a.

Total Sales during 2015					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals**
Passenger Vehicles[a]	25,799	7,982	10,748	9	n.a.

n.a. = not available
[a] UNECE categories L1-L5

38.3.3 Charging Infrastructure or EVSE

Table 2: Information on charging infrastructure in 2015 (Data source: www.nobil.no)

Charging Infrastructure on 31 December 2015	
Chargers	**Quantity**
AC Level 1 Chargers	n.a.
AC Level 2 Chargers	5,185
Fast Chargers	1,083
Superchargers (Tesla)	190
Inductive Charging	n.a.
Totals	**6,458**

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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
2-Wheelers or "2- and 3- Wheelers"	This category includes e-bikes (two-wheeled vehicle with an electric motor and an appearance similar to that of a conventional bicycle and moped), pedelecs, e-mopeds and e-motorcycles (including e-scooters) running on two or three wheels. UNECE categories L1-L5.
Passenger Cars	Vehicle with a designated seating capacity of not more than 8 seats (in addition to the driver's seat). UNECE category M1.
Buses and Minibuses	Vehicle with a designated seating capacity of more than 8 seats in addition to the driver's seat. UNECE categories M2 and M3.
Light Commercial Vehicles	Commercial carrier vehicle with a gross vehicle weight of not more than 3.5 tons. This category includes commercial vans, pickup trucks and three-wheelers for goods or passenger transport. UNECE category N1.
Medium and Heavy Freight Trucks	Vehicle designed primarily for the transportation of property of equipment. UNECE categories N2 and N3.
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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