IEA INTERNATIONAL ENERGY AGENCY
HYBRID & ELECTRIC VEHICLE TECHNOLOGY COLLABORATION PROGRAMME

HEV TCP

Hybrid and Electric Vehicles

The Electric Drive Chauffeurs

2017

www.ieahev.org

International Energy Agency

Technology Collaboration Programme on
Hybrid and Electric Vehicles (HEV TCP)

Hybrid and Electric Vehicles

The Electric Drive Chauffeurs

September 2017

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Technology Collaboration Programme on Hybrid and Electric Vehicles (HEV TCP) functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of HEV TCP do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries. HEV TCP was previously known as the Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). The labelling changed in 2016.

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Cover Photo: Electric taxi by Chinese automaker BAIC BJEV. Beijing's fleet of 70,000 taxis will gradually be replaced by EVs.

(Image Courtesy: private)

The Electric Drive Chauffeurs

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International Energy Agency

Technology Collaboration Programme on
Hybrid and Electric Vehicles (HEV TCP)

Annual Report Prepared by the Executive Committee
and Task 1 over the Year 2016

Hybrid and Electric Vehicles

The Electric Drive Chauffeurs

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1 Chairperson’s Message

As chairman of the Technology Collaboration Programme Hybrid and Electric Vehicles (HEV TCP) of the International Energy Agency (IEA) I have the pleasure to introduce you to the Annual Report 2017. The report is part of our Task 1 “Information Exchange” and is produced by our member from Germany, VDI/VDE Innovation + Technik GmbH. I thank them for their efforts.

This report gives you an overview on the status of our working groups (Tasks) and the member countries. All together we provide our member countries with reliable information about the status of the electric, hybrid and fuel cell technologies. Probably even more important is the collaboration in the working groups (Tasks) of our technical experts. Here the experts work together and profit from their colleagues.

Hybrid- and Electric Vehicles – the Long Run to the Mass Market

Hybrids and EVs developed differently in the last 30 years. But they had a hard way into the market place. Now they are in a different position in the market. The hybrid car was mainly pushed into the marketplace by one company – Toyota. This was at a time when the “EV hype” of the nineties with fleet tests in Europe like Rügen (D), La Rochelle (F), and Mendrisio (CH) lost their momentum. Attractive EVs like the EV1, the electric Toyota RAV4, Citroen AX/ Saxo etc. disappeared from the market. After the stop of the ZEV act in California the interest was gone. Light EV producers like “mini el/ city el (DK)” and TWIKE (CH) struggled hard to survive.

Figure 1: Big fleet test in Mendrisio – replacing 8 % cars with EVs in 1995 (Source: private)

In HEV TCP, we lost many member countries. The interest on hybrid and especially electric vehicles went down the drain. Exhaust and efficiency problems could be solved with the diesel engine and “a nice software…”.

Only Toyota went further and further and their commitment (and success) with this technology brought the hybrid technology into the market in industrialized countries. In the meantime the electric drive entered the market from the bottom. After decades of efforts electric bikes “went through the roof”. Here also, pioneers with a strong lung (and several capital infusions) brought the success. E-bikes are established in the marketplace. Their success in China is a signal from a new strong player in the field of the electric drive.

EVs also entered the market from the top. Electric and hybrid busses are on the move. Special vehicles as caterpillars, construction machines, fork lifts etc. are filling some market niches. Light trains are entering new market segments in the public transport sector. Trolley busses and trolley hybrids with batteries and fast charging capability give city planners new possibilities.

Learning From the Best

In the last years a new wave of EVs entered the market. In most of the countries, we are still in the market niche of pioneers and opinion leaders. Either EVs are very expensive like the Tesla models or they are both expensive and have limited range and usability. If we study the classical Rogers’ curve of innovation we can see that we are still in the area of the innovators and pioneers. For them the characteristics of EVs are mostly satisfactory. Several models offer interesting features – and for all the others there are many plug-in-hybrids or Tesla models.

To be frank, only one country, Norway has entered the market segment of the early majority. This gives us the chance to learn from Norway. Norway is a small but rich country with a very high production (and consumption) of clean electricity, mainly from hydro. Their tax import system gives them the opportunity to support the import of electric vehicles. Norway has no car industry and this gives them the opportunity to cooperate with the most innovative producers. HEV TCP invited Norway to work within our group. I'm sure we can learn and profit from each other.

Another country with an interesting market penetration is the Netherlands. More than 100,000 EVs are in use there now. I was very impressed about the pragmatic installation of EV charging stations in the streets of Amsterdam. This is important for peoples living in rental and multi-level houses.

Figure 2: Sent the old postal vehicles into the museum (Source: Swiss Kyburz DTX postal EV)

Looking into our member countries, we see interesting initiatives and the use of all kinds of EVs on the local level and in market segments. In my home country Switzerland, the Swiss postal service put the last postal service vehicle with an ICE motor into the museum. They now only use electric three wheelers for that service.

Going over our member countries we see new players outside of the IEA (OECD) countries. The most interesting country is China. China made tremendous efforts in technology, production and use of cars. China is still the market leader in electric bikes, photovoltaic and wind energy. With the new credit system for EVs and

PHEVs China requests a market share of these technologies. Car producers have to reach a certain market share with EV and PHEV or have to limit their car production or have to buy credits. This request from big car producer production numbers in the range of 100,000 cars per technology. China gives the EV community a strong push. – Another country we have to visit and to learn from!

Please take a look in the country chapters of this Annual Report 2017 for other examples. Many initiatives are going on in many of our member countries.

Looking for Synergies Into Zero CO_2 Emission

EVs need electricity from renewable energies. Leading countries in the sector of the renewable energies (30 % new renewable electricity in the last 10 years), like Germany, are looking around, to use more of the clean electricity. The combination of “PV and EV” gives a leverage effect for both. It also helps these countries to lower the burden of the expansion of the electric grid. EVs will be one of the few technologies which can do that.

For decades critics against the electric vehicles have been telling us that EVs are ”dirty” due to of the electricity mix. The result can be seen in Table 1.

Table 1: CO_2 emissions for various types of vehicles using different source of primary energy (Source: own research)

Model	CO_2-emiss.	TWIKE	BMW i3	Renault ZOE	Tesla	Renault Clio 1.2	BMW X5 3l
Electric consumpt. per 100 km [kWh]		5	12	14	20	Gas.	Gas.
Energy source [kWh]	[kg/kWh]	gr/km					
Brown coal (lignite)	1.23	61.5	147.6	172.2	246		
Stone coal (anthracite)	1.08	54	129.6	151.2	216		
Gas	0.64	32	76.8	89.6	128		
PV	0.03	1.5	3.6	4.2	6		
Wind	0.01	0.5	1.2	1.4	2		
CO_2 EU-Mix (only emissions)	0.46	23	55.2	64.4	92		
CO_2 (GE-Mix)	0.48	24	57.6	67.2	96		
CO_2 EU- LCA Mix (with plant etc.)	0.578	28.9	69.36	80.92	115.6		
CO_2 CH-Mix certified (Frischknecht 2012)	0.014	0.7	1.68	1.96	2.8		
Petrol/gasoline	---	0	0	0	0	137	197

Legal obligation for fleets EU CO_2-emissions: 95 gr/ km in 2020

When I was a member of the parliament of the state of Bern, I started an initiative for the use of EVs. For the transport of our seven ministers they should only use vehicles with locally produced clean energy. In our state this could only be something with an electric drive. We had an interesting discussion in the parliament with all the opinions against EVs. This ended when a respected member of a conservative party entered the podium and explained to the parliament how well his Tesla works. He was an opinion leader in the best way. My initiative passed the parliament.

A public discussion started in Switzerland about the new personal vehicle of our minister for energy Doris Leuthard. Instead of a black big limousine from our northern neighbour country – like her colleagues – she uses a big black limousine with a plug. An intensive discussion in the public started about all the aspects of the use of electric vehicles. She is another opinion leader. The question about how clean the electricity mix is, was a very important one. That motivated me, to calculate the link between the electricity mix and some car models.

Crossing the Chasm

Finally we have to convince users to buy HEVs, PHEVs, EVs or even a FCVs. From the marketing theory it is known that the move into the "early majority" is entering a "new world". It is called the "Chasm". A new approach is needed to enter the mass market.

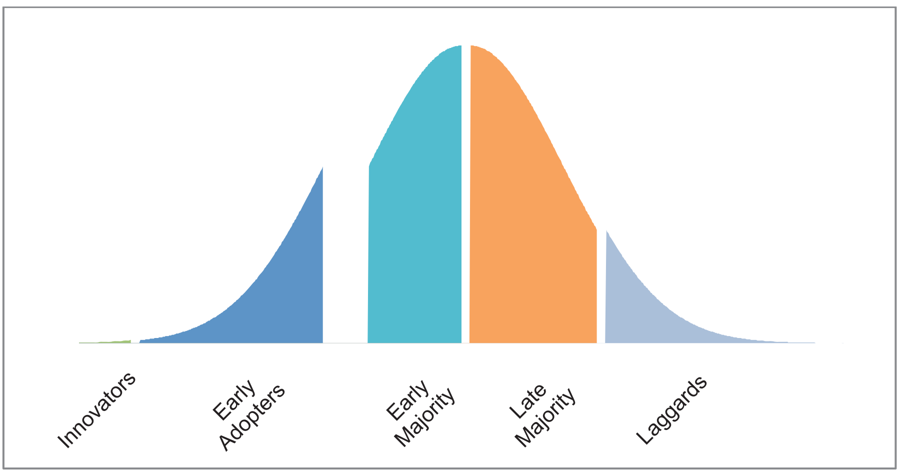

Figure 3: Phases of selling and marketing innovative products to mainstream costumers – the chasm

Bridging the Gap to the EV Mass MarketT

For the early majority we have to answer questions like:

- Why are EVs (and PHEVs/ FCVs) so expensive?
- Why is the range so low?
- What about the battery life time?
- What about recharging?
- Do we have a possibility to recharge the car near our house?
- Etc.

Finally we need competitive advantages for the customer driving an electric drive train compared to ICEVs.

A main problem will be to bring the user into the EV for test rides. Too strong are the resistances for the new technology. A positive image on the driver level will support the market breakthrough into the "early majority" market segment. For this the existence of the opinion leaders is important. They show that it works!

Give People What They Want…

No one needs an electric vehicle. People want a car to transfer themselves from point A to B. Well, and some folks need a car for their own prestige…! But that is not the mass market. Instead of educating people to use an electric car, it is better and faster to serve them with a car, similar to what they have now. Or as the British rockband "Kinks" expressed: "… give the people what they want…"! Later the EV user will learn, that some of the problems imagined do not exist – like the "range anxiety".

Considering these requirements, the price and the range of these vehicles, we need a new kind of cars. With the new models of Tesla (like model 3), the Opel Ampera-e (Chevrolet Bolt), Renault Zoe etc., and ranges of about 400 km, we will come close to the point. Finally these vehicles should have prices lower than ICE's. For the car producers a lot of problems have to be solved. It ends with sales and service concepts. As more of these cars are on the road, new questions will arise. This goes up to the regulations and tax systems which are not compatible to electric cars. The user of the EV later learns quickly that it is more fun to drive an EV. He learns to recharge the car at home or at work, similar to the mobile phone. He enjoys the acceleration and the simple use of the car. Satisfied EV users then will ask for an EV again, that's the car they want in future...!

The Paris CO_2 Commitment Helps EVs

A new strong push for the electric drive is the battle to lower the CO_2 emissions and the “climate change”. The political commitment will help us to promote EVs. From country to country, region to region and city to city this can be very different.

The IEA started a new initiative, the “Mission Innovation” action. The idea is that some technologies are near to the mass market and therefore it makes sense to support them more than other technologies. 20 countries from inside and outside the IEA collaborate in this effort. China and India are some of the members in the “Mission Innovation”.

The 15 Working Groups of the Technology Collaboration Programme Hybrid and Electric Vehicles (HEV TCP)

Such problems have to be solved on an international level. The Technology Collaboration Programme works on many of the open questions. The practical work in the Technology Programme Hybrid and Electric Vehicles is done in so called “Tasks”. Two or more countries can start such a Task. With the implementation of a new founding scheme for new Tasks we could shorten the time to the start. Countries can bring new questions and Tasks to the Executive Committee (ExCo) meeting and look for collaborators for the new topic. This works better and better. Soon, we will have 15 tasks in parallel. This is interesting for everyone. Our active tasks are:

- Task 1: Information Exchange
- Task 23: Light Electric Vehicle Parking and Charging Infrastructure
- Task 25: Plug-in Electric Vehicles
- Task 26: Wireless Power Transfer for EVs
- Task 27: Electrification of Transport Logistic Vehicles (eLogV)
- Task 28: Home Grids and V2X Technologies
- Task 29: Electrified, Connected and Automated Vehicles
- Task 30: Assessment of Environmental Effects of Electric Vehicles
- Task 31: Fuels and Energy Carriers for Transport
- Task 32: Small Electric Vehicles
- Task 33: Battery Electric Buses
- Task 34: Batteries
- Task 35: Fuel Cell Electric Vehicles
- Task 36: Consumer Adoption and Use of EVs
- Task 37: Ultra Fast Charging

The collaboration of researchers goes via the member country experts, which are the member of the executive committee of the HEV TCP. Their addresses can be found in the address list.

Benefit of Participation in the Technology Collaboration Programme TCP HEV

Working together in a period of market development makes sense. Collaboration makes also sense if a technology should go into the worldwide marketplace. Participants in the Technology Collaboration Programme Hybrid and Electric Vehicles profit from:

- Obtaining information on the best practices for the promotion and deployment of hybrid and electric vehicles.
- Sharing the results of in-depth projects that focus on special topics in hybrid and electric vehicles.
- Access to objective, world-wide data and information for governmental decision makers.
- Transfer of the latest knowledge and experiences among government officials responsible for automotive research during semiannual HEV TCP meetings.
- Use of the best public-sector laboratories in the world.
- Exchanges between experts from member countries.
- A well-informed overview of the future automotive technology.
- Sharing of best practices for implementing alternative drive vehicle fleets.

Collaboration in the TCP 2016

2016 was the first year of our new secretary Dr. James Miller from the Argonne National Laboratory (ANL). James did a fantastic job and my life as chair is easier than ever. This is also a compliment to my deputy chairs Carol Burelle (CA) and David Howell (USA). It is also a compliment to the Operating Agents running their tasks and all the collaborators in the tasks.

My thanks go to the DOE, which supported us again with the service of the secretary. My thanks also go to the VDI/VDE-IT and Gereon Meyer’s team. They maintain our website, lead the work of the Task 1 “Information Exchange” and produce this Annual Report.

Unfortunately, we had to accept the loss of our founding member Dr. Mario Conte from ENEA Italy. He passed away in September 2016. My compliment goes to him and his family. We honor our good friend Mario, an outstanding expert in the field of the electric drive, in the following pages of this Annual Report.

In our ExCo meeting in Berkeley we could welcome Professor Dr. Ock Taeck Lim from South Korea as the new deputy chair of our TCP. I wish Dr. Ock Taeck Lim a fruitfull and productive work in our group.

Professor Urs Muntwyler, HEV TCP Chairman, Burgdorf, Switzerland

Figure 4: Chairman IEA HEV TCP Professor Urs Muntwyler

Mr. Urs Muntwyler
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Dr. Mario Conte, 1953-2016

Born in Barano d'Ischia (Naples) as the fourth of five brothers, Dr. Mario Conte graduated with honours in nuclear physics at the University Federico II of Naples in 1978. Afterwards he worked for three years in the physics faculty as a researcher. Until 1984 Dr. Conte was employed by Conpheobus, an ENEL S.p.A. company with focus on renewable energy. Thereafter, he worked with the ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development.

Dr. Conte started as a researcher and thanks to his theoretical and managerial talents his responsibilities increased. He lead the energy storages research group of ENEA and at the end he was appointed Head of the Technical-Strategic Support Unit of the Energy Technologies Department at ENEA. He managed countless national and international research projects on batteries, supercapacitors, hydrogen storage for mobile and stationary applications, among them the European founded project ILHYPOS (Ionic Liquid-based HYbrid POwer Supercapacitor).

For that project he won the Best Paper Award at the EVS24 (2009) and the TRA Visions Senior Researcher Award (2016). In the last years, he was advisor for energy policies for various Italian ministries. He held the secretary post of the Italian EV association (CIVES) and he was board Member of AVERE.

Mario Conte was one of the founding members of the IEA Implementing Agreement on Electric and Hybrid Vehicles (IA-HEV) in 1992. He organized the first IA-HEV meeting parallel to the EVS11 in Florence. He also acted as an organising member of this conference. Mario Conte was the delegate on behalf of the Italian government and a very active member of our Implementing Agreement, and finally he acted fas deputy chair.

On the private side, he married Maria, also originating from Barano. They lived in Manziana, close to the ENEA headquarter. They got two kids, Stella and Marco, which are actually only 13 and 9 years old. Mario got a diagnosis of cancer almost eight years ago. At the beginning he won the battle, also because he underwent, without any kind of complains, all the not comfortable chemo and radiotherapy with admirable courage.

Time passed fine, but about four years ago the pathology came back, stronger. Mario started again a tenacious battle, for himself and for his beloved family, as he confided to me. In the meanwhile, he worked tirelessly, arranging with discretion the business meetings in between the chemotherapy applications.

Until the end he enjoyed a relatively high life quality, and limited pains (or at least he did not complain). Mario lost his war and he passed away in Manziana on the 10th of September 2016 after an unexpected worsening of his conditions. During this big step he was surrounded by his beloved family and best friends.

With Mario Conte we have lost not only a valuable researcher but also a good friend of us all.

Text: Urs Muntwyler with help from Valerio Conte, Mario’s nephew. Valerio is an associate professor in energy storage technology today, because at the age of eight he found a booklet on the Lorentz’s transformation on Mario’s desk. Thanks to Mario being one of the organizers of the EVS11 symposium in 1992, Valerio was allowed to participate as a teenager.

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 – 2016			
Australia	Finland	Luxembourg	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).

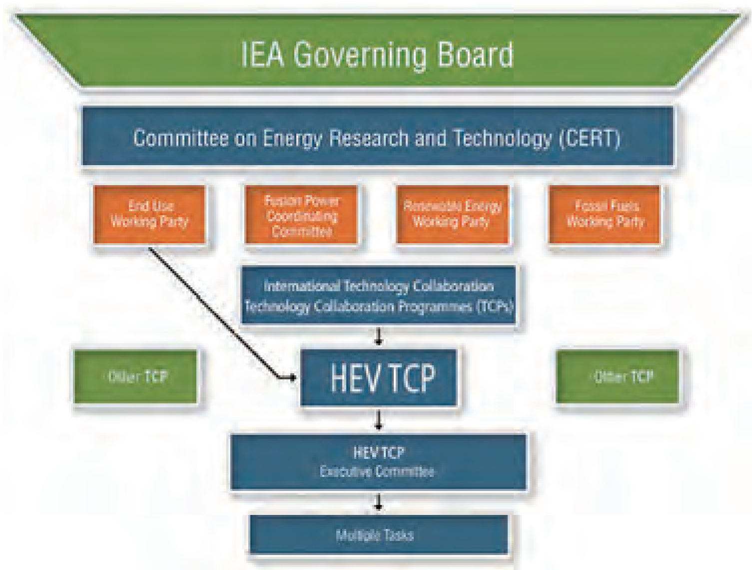

Figure 1: The IEA energy technology network[1]

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[2].

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

[1] From 2015, the IEA is rebranding the IAs as Technology Collaboration Programmes - TCPs. Accordingly, IA-HEV was recently renamed to HEV TCP.
[2] 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 17 active Contracting Parties (member countries) as of May 2014 are Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, The Netherlands, 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 2016, the ExCo approved three new Tasks:

- Task 35 “Fuel Cell Electric Vehicles”
- Task 36 “Consumer Adoption and Use of EVs”
- Task 37 “Ultra Fast Charging”

During 2016 some of the Tasks completed: Task 10 “Electrochemical Systems” and Task 24 “Economic Impact Assessment of E-Mobility”. Nevertheless, many of the Task members are still involved in ongoing Tasks. For instance, the OA of completed Task 10, Mr. James A. Barnes, started a new Task 34 in 2016 “Batteries”.

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
• 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)[3] .

In 2015, the EVI also supported the preparation of the Paris Declaration on Electro-Mobility and Climate Change and Call to Action[4] 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

[3] www.iea.org/workshops/high-level-event-on-zero-emission-vehicles-zevs.html
[4] 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 Information Exchange (Task 1)

Members: Any HEV TCP member may participate

3.1 Introduction

Information exchange is at the core of HEV TCP's work (formerly IA-HEV), 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 HEV TCP in 1993 and continues as the main forum and portal for announcing news and results to the broader International Energy Agency (IEA) community.

The HEV TCP 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

HEV TCP Phase 5 Objectives (2015−2020)
• Produce objective information for policy and decision makers • Disseminate information produced by HEV TCP to the IEA community, national governments, industries, and other organizations • Collaborate on pre-competitive research • Collaborate with other IEA Technology Collaboration Programmes and groups outside the IEA • Provide a platform for reliable information

3.2 Objectives

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

Information exchange focuses on these topics:

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

3.3 Working Method

Experts from member countries serve as delegates at Task 1 meetings held every six months in conjunction with the HEV TCP Executive Committee meetings. Country delegates also write country-specific information for HEV TCP 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 HEV TCP 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 HEV TCP 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 HEV TCP 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 HEV TCP participants. This is a valuable source for keeping up to date with worldwide developments.

3.4 Results

Notable events in 2016 included the following:

- Task 1 Information Exchange meetings were held in Amsterdam, The Netherlands, in April 2016, and in Berkeley, USA, in November 2016.
- The HEV TCP annual report on 2015 entitled Hybrid and Electric Vehicles – The Electric Drive Commutes was published in 2016.

Figure 1: Home page of the HEV TCP website (www.ieahev.org), which includes comprehensive information on hybrid and electric vehicles in all member countries, updates on activities of the Tasks, and links to national organizations working to promote vehicle electrification

3.5 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.

3.6 Contact Details of the Operating Agent

For further information, please contact the Task 1 OA:

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

Members: Belgium, Germany, Turkey, Spain

4.1 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, as well as sharing bikes (electric and non-electric) requires addressing issues related to parking and charging infrastructure. This includes the development of harmonized charging standards which are embedded in a public parking space management solution. Task 23 seeks to ensure that these issues are addressed at a governmental level, so that the outcome is as applicable as possible to both local and global policies. Task 23 will also encourage the development and establishment of both bicycle, e-scooter, pedelec sharing schemes and private usage (parking and charging) of such vehicles.

Table 1: Listing the Task “new phase” objectives

LEVs 1992	LEVs 2007	LEVs 2042
5000 Units	250 Million Units	1,6 Billion Units

4.2 Objectives

A key objective of Task 23 is to discuss the specific requirements from the governmental side (especially at the local level) LEV charging and parking infrastructure, and deliver these requirements to the IEC TC69-WG10 committee. This is to be done by the operating agent EnergyBus.org, which is also leading the German mirror group of the IEC TC69-WG10 61851-3-1-7 Series committee. Besides, Task 23 counts following activities:

- Representing the interests of local governments in standardization
- Following the IEC TC69-WG10 61851-3-1-7 Series, the standardization group on Light Electric Vehicle standardization (system architecture, infrastructure, communication and standard batteries), as well as the IEC SC23h which is defining the connectors used for the future parking and charging infrastructure

- Since May 2016 also being active in the newly formed ISO 4210-10 which is defining the pedelec internationally within a harmonized standardization body for the first time. Here the key activity is to ensure that there are no indifferences within the technical infrastructure defined by the IEC and that the standard would be an acceptable basis for international GTRs (Governmental Technical Regulations) defining that pedelecs may still be considered equally to a bicycle

In 2016, the EN 50604-1 was published as the first Battery Safety standard by the European standardization body CENELEC and is globally setting the lead followed by the ISO 18243, referencing also to the IEC SC23h defined interface connector and the IEC TC69-WG10 defined communication protocol. This means that when the EN 50604-1 will be published within the Machinery directive and/or the Battery Directive of the European Union. It will not only define the technical state of the art, it will become mandatory by law, enabling easy infrastructure interconnection down the road.

Figure 1: Publication of the EN 50604-1 by the CENELEC. The milestone in safe lithium batteries and safe harmonized safe charging for LEVs (Source: private)

4.2.1 Target a Blueprint for Public Tenders for LEV Infrastructure

After the complete publication of the IEC TS 61851-3-1/7 (to be expected until July 2018) as TS (Technical Specification of the IEC), the next step will be to create a blueprint for public tenders, which reference to standard sets for the acquisition of public infrastructure, for parking, space management of LEVs and sharing bicycles two-wheelers, and for charging infrastructure. Such tenders would also include a section on the requirements and specifications of bicycles, pedelecs and electric scooters for public use. The need especially for the management of non-moving traffic just became totally obvious in China due to the extreme popular sharing bikes which literally flooded the city sidewalks and streets in a way that they became a serious hurdle creating traffic blocks and urging local governments to regulate this effectively (Figure 2).

Figure 2: Beijing bike share success has its downside (Source: private)

As a result, the city government stopped new players in the sharing schemes to enter the market in September 2017, after 15 players are already active and after about 2.4 million sharing bikes are already placed in the city. A key consideration is to find a solution on how to regulate the parking of these bikes. On the other hand the Chinese central government stated in a meeting in April 2017 that they would be in favor of LEVs being introduced into the sharing schemes as well.

Here the Charge-and-Lock-Cable-System is perfectly suited to free dense urban areas from uncontrolled flooding with sharing as well as private vehicles. Japan has the longest history in parking management of bicycles and other mobility devices since the extreme dense space usage in Japan has forced governments early to deploy strict regulations.

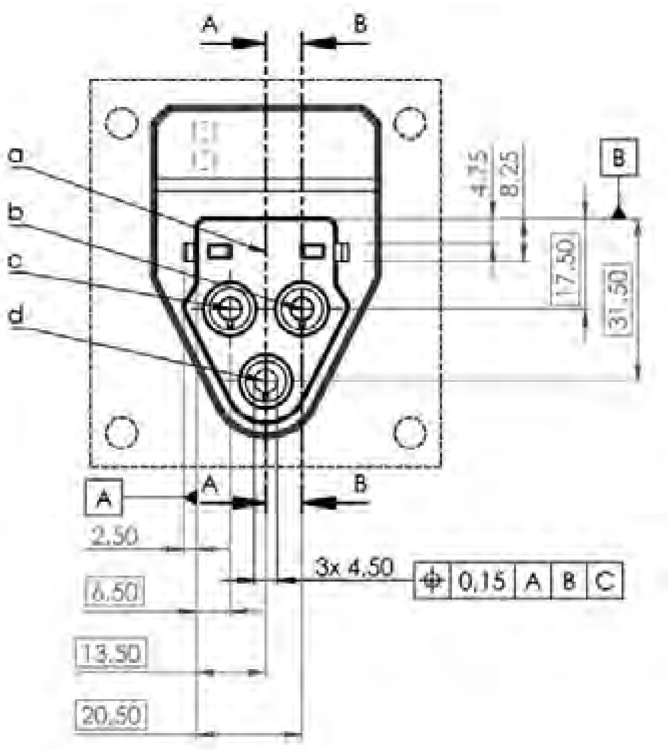

Figure 3: The IEC standardized socket which will be used around the world by all kinds of privately owned as well by shared LEVs and bicycles to park them in accordance to public interests regulated by non-moving traffic management regulations (Source: own research)

4.2.2 Creating Events for Information Exchange on LEV Infrastructure

- Organizing 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), Istambul (TK), Oslo (NO), Essen (DE), Tanna (DE), Grenoble (FR), Nante (FR), Frankfurt (DE), Prague (CZ), Taipei (TW) Shanghai (CN), Chengdu (CN), Rostock (DE), Osaka (JP) Beijing, Shenzen, Tianjin (CN) Zürich (CH) just to name some of them.

Figure 4: Workshop with users, manufactures and developers of Cargo Pedelecs at Tanna reviewing the testing data and together considering about better ecosystems to enable the cargo and family pedelec segment to be more widely accepted (Source: private)

4.2.3 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). In 2016 an international group of journalists and opinion leaders traveled to see key Chinese industry and city environments. In spring 2017 a Chinese government and industry delegation traveled to Europe for the ISO 4210-10 meeting (PT) and traveled to France, the Netherlands, Germany, and Austria for best practice sharing visits.

Figure 5: Example of Japanese public non-moving traffic management scheme at Kyoto Train Station (Source: private)

4.2.4 Publications with Recommendations on LEV Infrastructure

One of the missions of Task 23 is to create publications that summarize key findings and list recommendations on how to establish the most suitable LEV infrastructure. Several lectures have been held during 2016 about Task 23 activities.

4.2.5 Promoting the Needs to Potential Suppliers

- Making joint presentations at relevant trade shows and conferences, and explaining the requirements for local government of potential manufacturers and providers of LEV infrastructure and rental vehicles using suitable methods.
- In 2016 such presentations have been on BtoB and BtoC Tradeshows in Germany, Taiwan and China.

Figure 6: EU Commissioner of Transport Mrs. Violeta Bulc visits the IEA Task 23 presentation at Frankfurt International Automobile Exhibition on 17 September 2015 (Source: private)

4.2.6 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 about 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.

4.2.7 Task 23 Membership

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 and Bregenz (Austria), Indonesia, Delhi (India), Munich, Frankfurt, Cologne, Münster, Rostock, Hannover, Berlin, Merseburg, Tegernsee (Germany), Grenoble

(France) – and these are just the most significant talks. To date, the active phase including the preparation of the blueprints for tenders to acquire LEV infrastructure has not yet started. This is expected to happen during summer 2018.

4.3 Results

A central event for Task 23 in 2015was 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, where the EU Commissioner for Transport Mrs. Violeta Bulc visited the IEA HEV TCP Task 23 special exhibition. There Mrs. Bulc was introduced to the results of the EU Mandate 468 of 2010. In 2016 the publication of the EN 50604-1 was a major milestone and in 2017 the finalization of the Connector Standard by the IEC SC23h group will be another one. By 2018 the long-postponed finalization of the IEC Technical Specifications on the Standard Series IEC TS 61851-3-1/2/3/4/5/6 and 7 defining all communication necessary as well as safety relevant procedures. Standards secure safe and interoperable technical ecosystems.

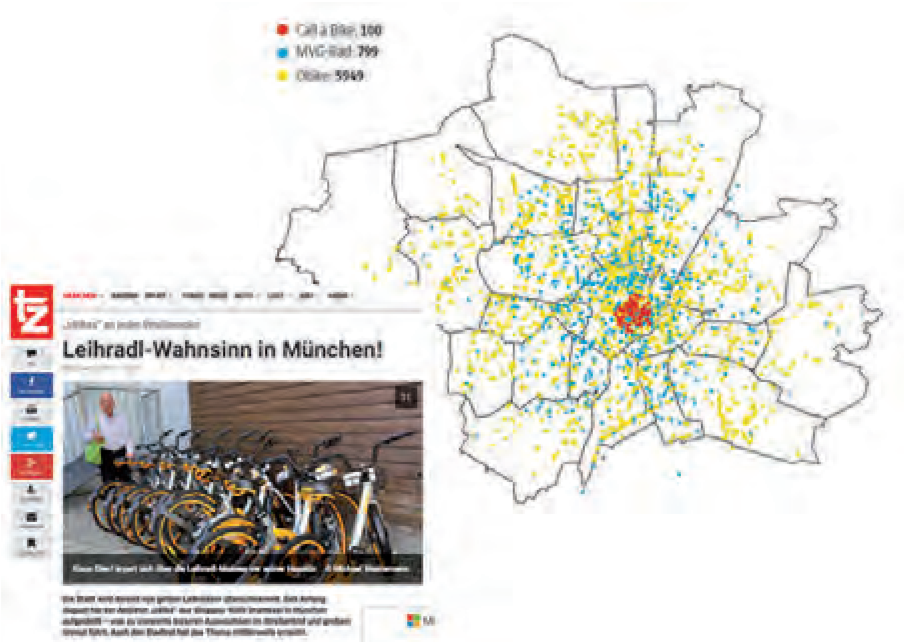

Figure 7: Picture of locations of sharing bikes offered by 3 suppliers in Munich/Germany. 100 Call a Bikes by Deutsche Bahn (the oldest System in Munich for sharing bikes) are all located in a very central area where they are only offered and allowed to be dropped-off, the 799 MVG Bikes provided by the city owned public transport

company and the just recently introduced 5949 Obikes by a Singapore based sharing bike provider offering the rides. Causing a lot of discussions since the free-floating bikes sometimes also block pedestrian areas since users may not consider so much about the drop-of spot when parking the shared bikes at the end of their ride (Source: tz online)

4.4 The Charge-and-Lock Solution for Many Urban Issues

The Copenhagen Go-bike pedelec share system is station-based but can also offer free-floating service, and it should not have had to pay back the investment in establishing the infrastructure alone. Between 2011 and 2013, the first functional version of the EnergyLock was trialled in the Tegernsee region, Germany. The idea was proven to be working but a clear finding was that the locking system, based around a heavy duty locking mechanism and steel-reinforced cable, was considered to be too heavy by the 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 fully implementing this safety strategy very unattractive for a thief. 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. 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 always be of a universal shape. But the male plug attached to the vehicle would be available in 3 different versions, catering appropriately to the specific needs of all 3 types of two-wheelers. This would allow a single infrastructure to cater for all types of two-wheelers: the system can be used both to manage the use of public space for two-wheeler parking, and to provide free two-wheeler electrical charging. Charging power can be up to 6000 Watts in the case of the 3 pin 120V/60A connector version intended for large electric scooters and electric motorcycles.

The Minister President of the German County of Baden-Württemberg stated recently in an interview with a newspaper: “It is important to be sure, that a Pedelec will not be stolen. Who worries about theft, will either not ride a bike, or even not buy one at all. This means that we need safe parking facilities and intelligent solutions to protect the vehicles”.

4.5 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
- In 2018, a field test is considered by a Chinese operator of sharing pedelecs in Sichuan province
- Currently several industrial companies are digging into this area for further industrialization options

4.6 Contact Details of the Operating Agent

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

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

Figure 1: From the cover of the Task 24 final report, published in 2016

5.1 Introduction

The IEA HEV-TCP 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 ended in December 2016. In total the project lasted 30 months.

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 June 2013, Cambridge Econometrics published its research, Fuelling Europes Future[5], which stated that by 2030, over 1 million jobs could be created by auto-sector innovation in advanced hybrid, battery-electric and fuel-cell vehicles.

[5] www.camecon.com/how/our-work/fuelling-europes-future

In this Task we focused 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?

5.2 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 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. So we have value chains in different sectors: the mobility sector, the energy sector, and the vehicle sector itself.

Task 24 mainly focused on electric passenger cars, but also reported some data on electric bicycles, scooters, trucks busses, and even boats if that was important in a specific country. Every sector has its own economic opportunities.

5.3 Working Method

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

The project consisted of three subtasks:

1. Development of a common methodology for economic impact assessments
2. In each participating country, collection of data on the agreed indicators
3. Analyses of results summarized in a final report

The work of Task 24 was executed mainly by mail and phone conferences to reduce travel costs. Physical meetings were organized in conjunction with the HEV TCP ExCo meetings.

5.4 Results

The final report of the Task was delivered at the end of 2016. This paragraph gives a short summary of the main results that were achieved.

All deliverables can be downloaded from the HEV TCP website.

5.4.1 Framework

One of the problems encountered while starting work on the Task was the difficulty in comparing the data amongst different countries. A set of key indicators was identified to help participants gather comparable data on the economic impact of e-mobility in their country:

- Number of jobs (FTE) in e-mobility, total and, if known, by specific segments of the value chain, indicating whether these are direct or indirect jobs
- Production volume/turnover (in EUR) related to e-mobility, total and, if known, by specific segments of the value chain
- Export volume (in EUR or %) related to e-mobility

Each participant could add other relevant data for their country to these indicators. Examples of other indicators used are the development of the actor network, or the impacts associated with specific components like advanced batteries.

Common value chains for the manufacturing of electric vehicles, charging infrastructure, energy and mobility services were developed as part of the work, and the number of requested patents in the e-mobility sector for each Task 24 country was researched as well.

Initially, we attempted to have one method used by all member countries to be able to evaluate and benchmark the results. However, that proved to be impossible. The Task also intended to use existing country data as much as possible, and as such, a variety of methods were used by the participants to determine the economic impact of e-mobility in their country. The final report describes the various methods used.

5.4.2 Patent Analysis

An overview of requested patents gives an indication of developments in R&D and innovation in a country, and gives some insight into the strengths and key innovation aspects of a specific industry.

A patent query was performed by the patent department of the Netherlands Enterprise Agency in June 2015, in which the sector of e-mobility was divided into eight subsections:

- Drive train technology
- Battery information systems
- Battery management
- Batteries
- Fuel cells
- Charging infrastructure
- Navigation
- Smart grids

The query involved international patent requests filed at the European Patent Bureau or the World Intellectual Property Office (WIPO).

The year 2013 was not fully complete in the base statistics at the time the query was done, so the data gave an incomplete overview of 2013. Patents have a secrecy period of 18 months, followed by some processing time before becoming visible in the statistics.

Tables were produced stating the number of patents in the different subsectors for the years 2005 – 2013 for Task 24 member countries. These were visualised for the years 2005, 2010 and 2013 to identify trends:

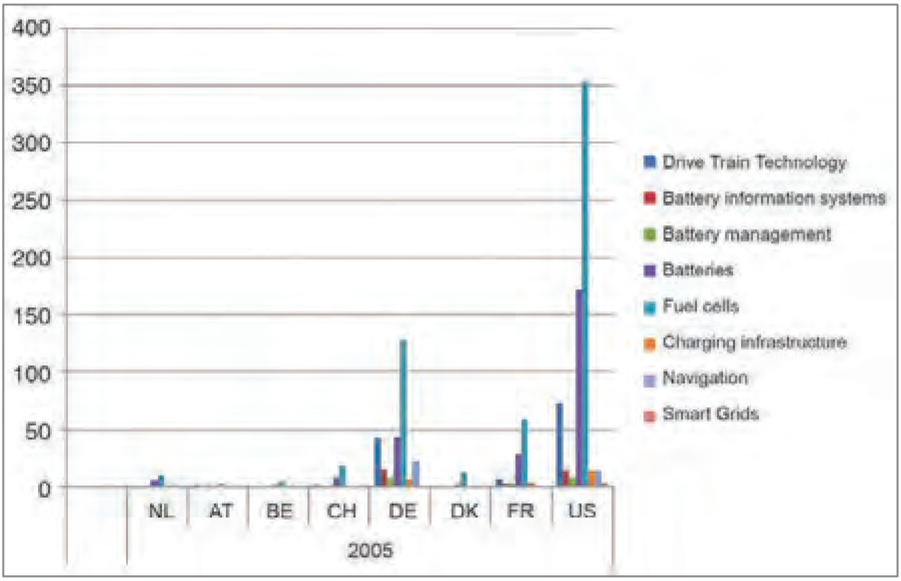

Figure 2: Number of patents in Task 24 member countries in 2005

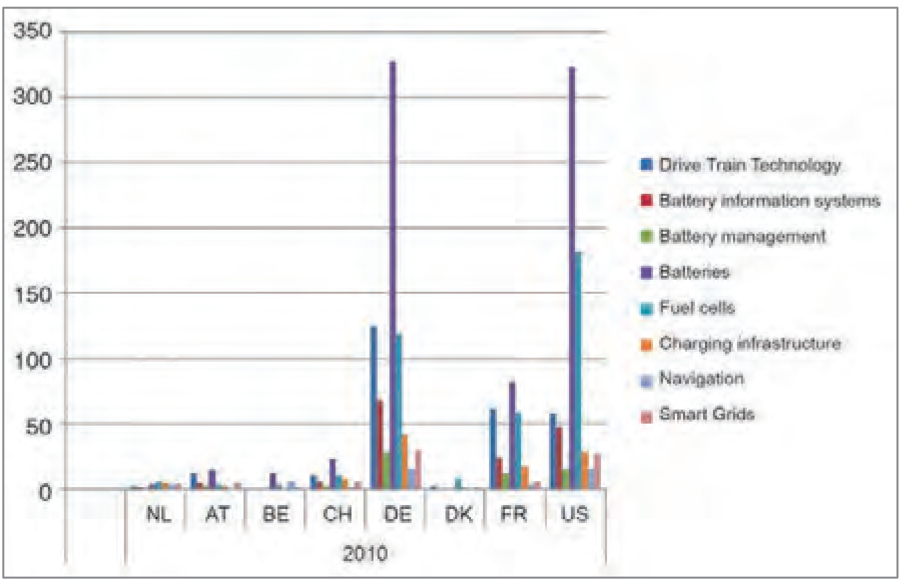

Figure 3: Number of patents in Task 24 member countries in 2010

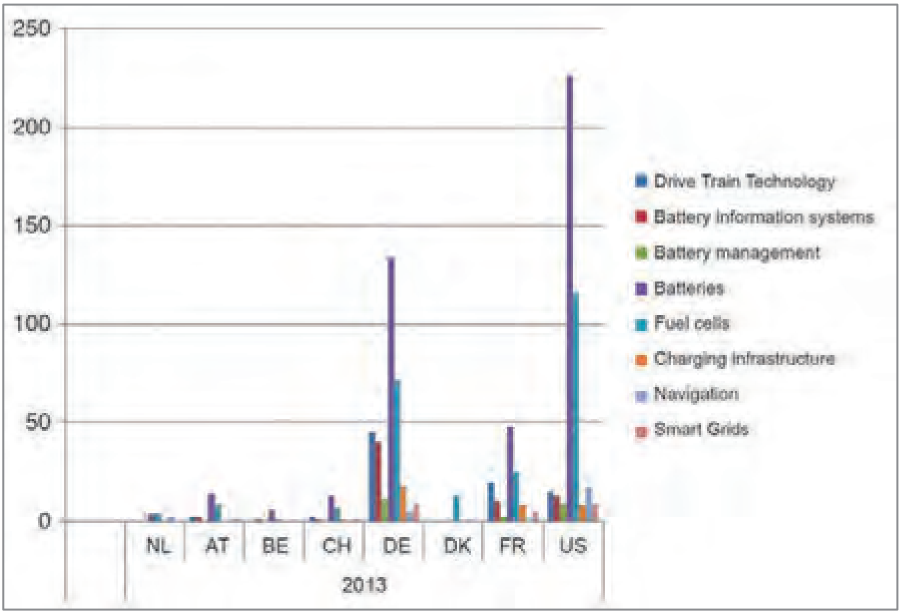

Figure 4: Number of patents in Task 24 member countries in 2013

The query included all countries that have applied for patents, which also made it possible to look at the trend per subsection and the division amongst countries in the world. Because of the size difference in Task 24 member countries and the difference in patents in e-mobility, though, data were hard to compare. Countries with large OEMs have much higher numbers of patents than others.

5.4.3 Country Reports

Each participant produced a full country report on the economic perspective in their own country. These country reports are Annexes to the final report which summarises and analyses the work that has been done in the Task, and includes 2-pagers on the country reports.

Figure 5: Title pages of all 8 country reports delivered in Task 24

5.4.4 Conclusion

We initially intended to benchmark the results of the individual country reports. Although similar trends were identified in the participating countries, actual benchmarking proved to be impossible. It is difficult to compare the various data on the industry and the value of the e-mobility sector because of the different backgrounds from which data were collected, the different methods used to collect and analyse the data, and the timescale for which data were collected or available or estimates were made.

What the project made clear though, is that employment growth can be substantial when the local EV market really takes off. For example, the US country report shows that employment associated with PEV deployment rises from roughly 55,000 in 2015 to 110,000 in the AEO Scenario and 600,000 in the ZEV Scenario, both for 2030. In the German region of Baden-Wuerttemberg, the realistic market development scenario indicates 18,000 additional jobs in 2025 compared to 2013. In the Netherlands, a study estimated a mean potential of 10,000 jobs in e-mobility in 2020 (compared to 3,200 jobs in 2014).

One thing to realise is that investigation of the economic impact needs to take into account both the gains in turnover and jobs by e-mobility and related businesses, as well as the loss of turnover and jobs in the combustion engine sectors. Most country reports do not yet address this issue.

The most important key messages that could be noted from the work done are displayed in the figure below. They are described in further detail in the final report of the Task.

Figure 6: Summary of key messages of the IEA HEV TCP Task 24

5.5 Contact Details of the Operating Agent

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6 Plug-in Electric Vehicles (Task 25)

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

6.1 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 (HEV TCP). 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.

6.2 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 EREVs 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, and 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 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

6.3 Working Method

During the last two years, 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 are relevant to a consumer's purchase decision. This cost measure is termed as relevant cost of ownership (RCO). The RCO may be reported as a cost (net present value e.g,, in dollars) or, as is done here, in cost per km. The RCO includes the investment cost, 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 (CRCO) 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.

In addition, a large number of vehicle simulation models were developed and simulated over different standard driving cycles both in Europe and in the US.

The results demonstrate significant improvements over time across all powertrain configurations and fuels (Table 1, below). 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 Cycles

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

6.3.1 New Cost Benefit Analysis Tool

A new benefit cost analysis tool was developed (BEAN) to quickly analyze the economic impact of different cost assumptions (e.g., components, fuel, etc.) on different powertrain technologies in the US and in Europe. The tool will be released to the public once the copyright process has been completed.

As shown in Figure 1, the results from the vehicle energy consumption are directly entered into a specific Tab (“Autonomie Out”), including fuel and electrical energy consumption but also component technologies, power and energy. The user can then enter the cost assumptions (“Assumption” Tab). From there, all the main economic metrics (vehicle cost, RCO, TCO, NPV, LCOD, etc.) are automatically calculated.

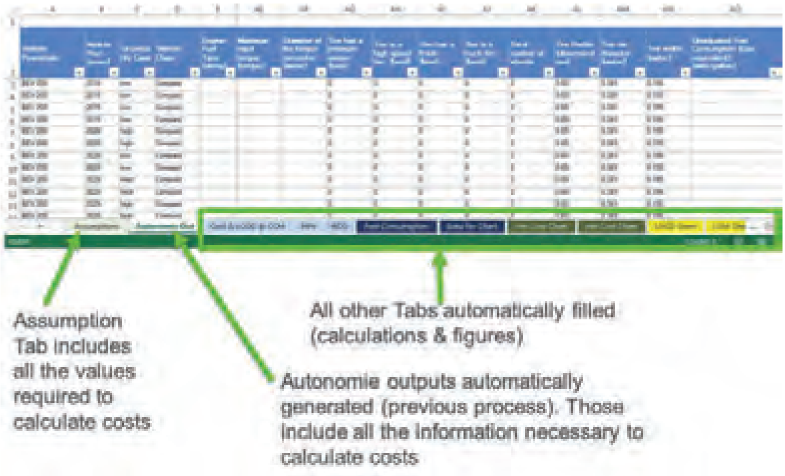

Figure 1: BEAN - Benefit Analysis Tool (Source: own research)

6.3.2 Main Component Assumptions

The need to reduce CO_2 emissions and petroleum use from the transport sector forces the automobile industry, researchers and policy makers to think about the diffusion of plug-in electric vehicles (PEVs). For this purpose, a variety of models has been set up to analyze factors that influence market diffusion and ways to accelerate it, e.g., by subsidies or restrictions (USEPA/NHTSA 2010, EU 2014).These models differ greatly in structure, internal logics and input factors, resulting in different diffusion results. A comparison of these models can have at least two benefits – explaining the modeling reasons for the result differences so that the probability of these different results misleading and obstructing policy discussion can be mitigated; and exposing the underlying wisdom in designing the model structure, formulating the internal logics and choosing the input factors so as to advance the state of art in diffusion modeling.

Al-Alawi and Bradley (2013) reviewed market diffusion models for PEVs in the US and compared the various model approaches used (agent-based, discrete choice, diffusion models, etc.) to make recommendations for improved approaches. Daziano and Chiew (2012) also compared PEV market diffusion models for the US. They discussed relevant factors influencing PEV adoption in the US and identified additional data needed for developing improved models. There remains a need for a broader review of recent models comparing approaches, input factors and findings from markets worldwide. Comparing models developed for different markets as well as models for specific markets provides new understanding of what factors are (or thought as) important and how they have been represented in models. For this reason, we compared recent research papers on PEV market diffusion to determine general conclusions and to address the following research questions:

- What factors do current models include and what data do they use?
- What factors influence market diffusion the most according to the papers?
- Are there important factors that are not well modeled or not included in models at all?

We focused on papers on at least a national or state level (no local models) and compare only those where a PEV market diffusion model is explicitly described. Expert estimates or very simple calculations are not considered here. For those models that are used in multiple publications, we focused on the main publications and discuss results of the most recent one. The present work differs from previous studies in several respects. First, we compare models for different geographical regions: Europe, U.S., and other countries. Second, we compare input factors and projected market shares from a wide range of models at a high level without a detailed evaluation of model algorithms or mathematical formulations. This provides a broad perspective of PEV market diffusion.

6.4 Results

6.4.1 Vehicle Energy Consumption

Fuel and electricity consumption of some powertrains (conventional, PHEV, and BEV) are compared in Figure 2.

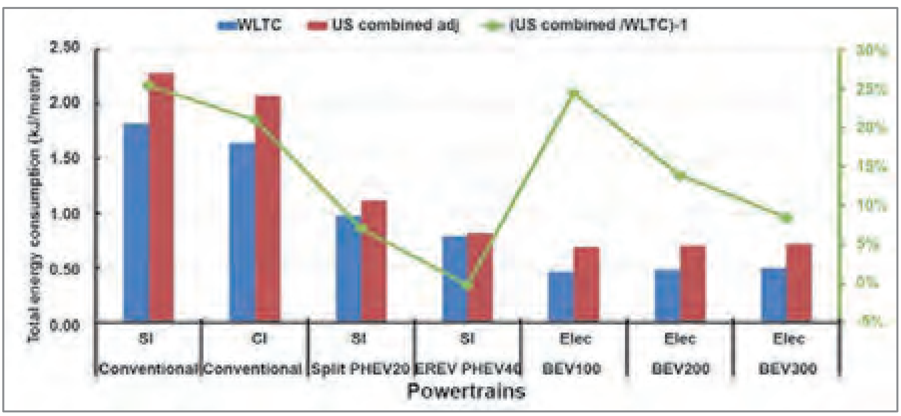

Figure 2: Energy consumption by powertrains and driving cycle (left axis), and the percent increase in energy consumption on the U.S. combined cycle over that on the WLTC (right axis)

The WLTC leads to higher vehicle energy consumption, especially for electrified vehicles, even if the U.S. driving cycle is actually less aggressive than the WLTC due to the real-world adjustment factor on the U.S. cycle.

6.4.2 Ownership Costs

Figure 3 shows the vehicle ownership cost metric RCO across powertrains for Germany and the U.S. for a 10 years ownership period. As one notices, despite the fact that the U.S. driving cycle leads to higher energy consumption for electrified vehicles compared to the WLTC, fuel savings by PEVs are higher in Europe than in the U.S. due to the high fuel price.

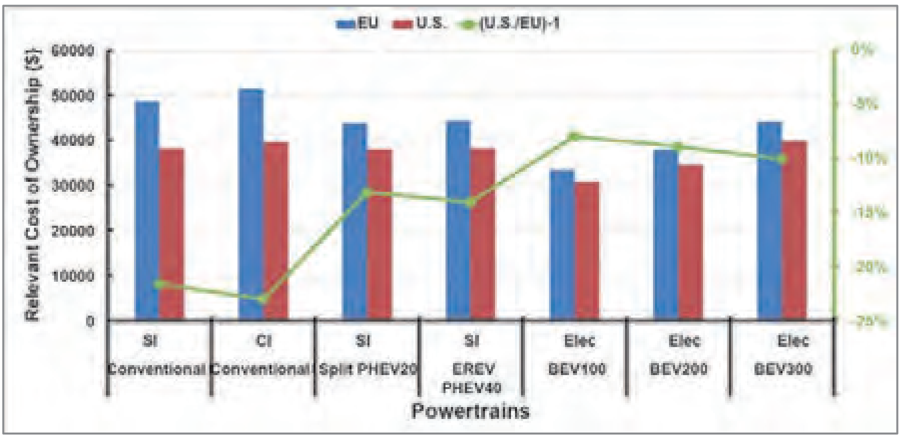

Figure 3: RCO (left axis) for U.S. and EU for 10 years of usage, and percent difference (left axis) in RCO between the two (right axis)

6.4.3 Impacts of Additional Factors

We evaluated the impact of different factors on the PEVs competitiveness on the U.S. and EU market in order to evaluate what is required for the PEVs to be competitive. The battery manufacturing cost for instance has a direct impact on the purchase price of the vehicle and therefore on the RCO. The heat-map bellow (Figure 4) displays the RCO, according to the powertrain and the manufacturing battery cost. We assumed a period of 10 years of ownership again, and we assumed no battery pack replacement during this period. U.S. energy prices, incentives, and the U.S. combined adjusted driving cycle were assumed for this calculation.

One can notice in Figure 4 that the BEV200 with 300 USD_2015/kWh Battery cost becomes competitive with the conventional car and becomes even more economical at lower battery costs.

		Powertrains						
		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
		SI	CI	SI	SI	Elec	Elec	Elec
Battery costs {USD_2015/kWh}	500	38,157	39,531	39,935	42,651	40,574	50,850	65,147
	400	38,157	39,531	38,825	40,633	37,487	45,740	57,205
	300	38,157	39,531	37,715	38,615	34,401	40,630	49,264
	200	38,157	39,531	36,605	36,596	31,314	35,520	41,322
	100	38,157	39,531	35,973	35,327	28,227	30,410	33,381

US Energy price	
Fuel	Cost
Gasoline {USD_2015/L	0.677
Diesel {USD_2015/L}	0.727
Electricity {$/kWh}	0.116

Figure 4: RCO according to the battery cost and powertrains – 10 years ownership in U.S., US combined adjusted driving cycle as reference

For Germany, largely due to the higher fuel price, and despite the higher electricity price, the BEV200 becomes competitive at higher battery prices than in the U.S (Figure 5).

		Powertrains						
		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
		SI	CI	SI	SI	Elec	Elec	Elec
Battery costs {USD_2015/kWh}	500	48,664	51,329	46,078	49,792	45,219	57,517	74,669
	400	48,664	51,329	44,746	47,370	41,515	51,385	65,139
	300	48,664	51,329	43,414	44,948	37,811	45,253	55,609
	200	48,664	51,329	42,083	42,526	34,106	39,121	46,079
	100	48,664	51,329	41,324	41,002	30,402	32,989	36,550

EU Energy price (Germany)	
Fuel	Cost
Gasoline {USD_2015/L	1.819
Diesel {USD_2015/L}	2.024
Electricity {$/kWh}	0.397

Figure 5: RCO according to the battery cost and powertrains – 10 years ownership in Germany, WLTC as reference

In the full report, we will compare various combinations of fuel consumption, fuel prices, vehicle prices, annual distance travelled, daily charging frequency and other parameters. We will also examine the influence of the different incentives in U.S. and Germany.

6.4.4 Market Diffusion Models

The results consist of a comparison of the 40 papers mentioned before and are divided into four parts.

Models Approaches

When comparing model approaches, there are many possible classifications (see e.g. Al-Alawi and Bradley 2013, Jochem et al. 2017, Daziano and Chiew 2012 and Gnann and Plötz, 2015, Section 3.1, for a discussion). In this model comparison, we choose a simple classification, since many models cannot be categorized well according to the above mentioned categorizations. We classify them with respect to their level of aggregation to highlight the general detail of the models: (1) Very aggregated models that consider only the vehicle stock for their analysis; (2) more disaggregated models that model the vehicle sales and differentiates multiple market or customer segments; (3) the most disaggregated approaches model on the level of individuals and combine them for vehicle sales afterwards. The numbers of each type of published models per year of publication are shown in Figure 6.

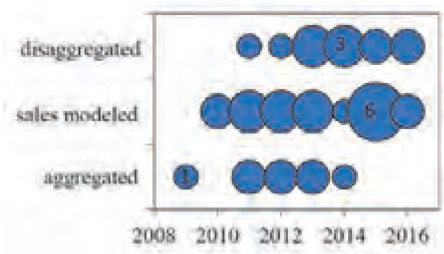

Figure 6: Model type and year of publication

Attributes Included

We analyzed four groups of attributes that are considered in the models: (1) factors directly related to the purchase decision, (2) attributes of vehicles that are considered in the models, (3) attributes to describe consumer characteristics and (4) factors especially important for PEVs.

To model the consumer choice, ownership costs are often used which contain vehicle cost and energy prices. Furthermore, a common differentiation in the consumer choice is the number of decision alternatives that is presented to the consumer. Almost all models cover the purchase price (37/40) as a simple factor for vehicle cost. Also fuel costs are taken into account by 33 models. However, operating costs apart from fuel cost (e.g. operations and maintenance, insurance or vehicle registration tax) are not so often covered (20/40) and the inclusion of resale prices is very rare (5/40). While these other costs are hard to determine, the difference in O&M can play an important role in the operating cost and should not be neglected (see e.g. Propfe et al. 2012 for a good approach).

Apart from the drive trains, the vehicle attributes considered in this review included vehicle registration attributes, which are: vehicle size class, diversity of makes and models within a powertrain type, and car holder (private, company or commercial fleet ownership). We also reviewed technological improvements in battery technology or energy consumption, vehicle availability and other vehicle attributes such as comfort, power or emissions. We find three main differentiations in vehicle registration attributes in the models which are also evident in Figure 7.

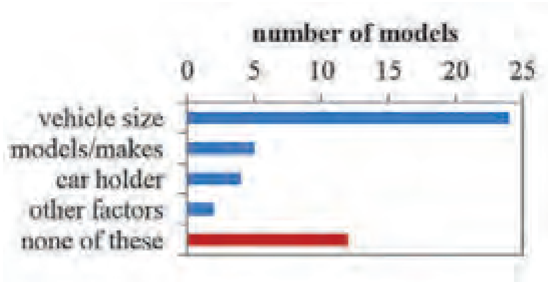

Figure 7: Vehicle registration attributes covered in models

Several consumer characteristics are considered in the models: differentiation or segmentation of consumers by different characteristics, and the interaction between consumers. The most important attributes for the characterization of certain consumer groups are shown in Figure 8.

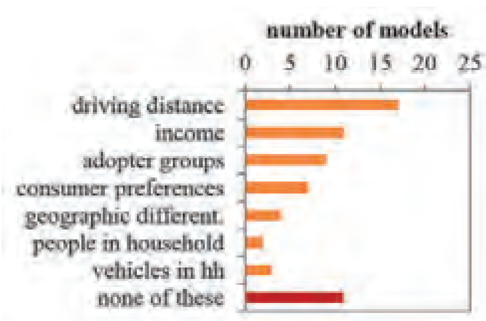

Figure 8: Consumer attributes used in models

The factors especially important for the PEV market diffusion comprise factors related to vehicle range, charging infrastructure and which type of policy measures are included. The majority of models considers the limited range of BEVs (24), yet there are still quite a few models that do not. When projecting short to medium term PEV market diffusion, this is an obligatory factor to consider and together with cost, the main factor preventing many consumers from buying BEVs (NRC 2015). A few authors try to include the range anxiety (5) or the charging times (5) explicitly in their models. Since this will remain an issue for some years, a consideration in future models could be useful. Charging infrastructure is also decisive for the market diffusion of PEVs. Yet, 15 models do not contain charging infrastructure at all. In 18 papers, the authors model charging infrastructure without a differentiation between private, semipublic and public charging infrastructure (LIT) while seven models do. An endogenous infrastructure evolution with a rising number of PEVs is considered in eleven models. Although, we believe that the differentiation in different types of charging infrastructure is helpful to also consider the benefits of plug-in electric vehicles, the inclusion of any kind of charging infrastructure should be a prerequisite for PEV market diffusion modeling.

Comparing Model Projections

Results are at the heart of each scientific publication. However, a comparison of results from the papers is very difficult since their assumptions are often different and the influence of different input factors is investigated while a comparison with the same input factors may be a valuable comparison (e.g. Stephens 2014). The absolute number of PEVs is not the only and most of the time not the most important outcome. Nevertheless, there are some outputs that may be compared, e.g. the sales shares of PEVs in different years distinguished by battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) in Figure 9. Here, we only show the results from the base scenarios of the papers and only those where a distinction of these PEV types is clearly shown for the vehicles sales. We show these results for the years 2020, 2030 and 2050.

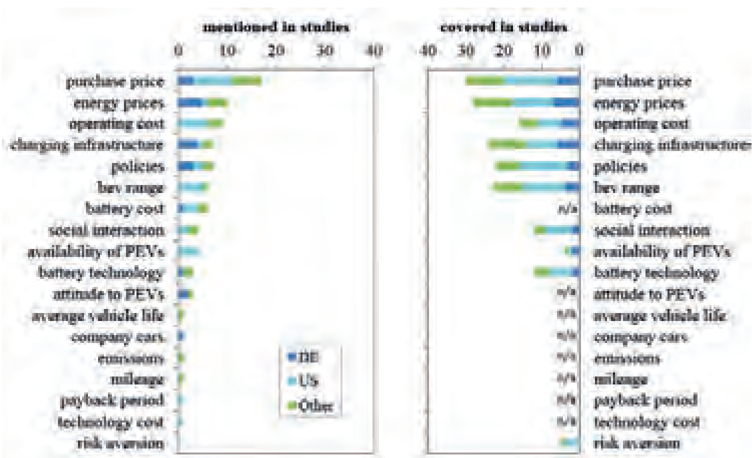

Figure 9: Left panel: Most important factors for PEV market diffusion stated by the authors of the models; Right Panel: Factors covered in the studies (factors with “n/a” were not investigated)

The first observation in these graphs is that market diffusion results are extremely uncertain and the market shares in 2020 vary between 0.4 % (in Propfe at al. 2013) and 16.8 % (in Eggers and Eggers 2011) for the German market. This range is even higher when looking to 2050 where Liu and Lin (2016) derive a 60 % market share for the US market while Pasouglu et al. (2015) determines 23 % for the EU in

2050. Yet again, the absolute market shares should not be in focus of market diffusion model results, this just shows the great deal of uncertainty.

6.4.5 Conclusions

Based on our findings, we conclude the following: Important factors vary between countries but could indicate future evolutions. Currently, there is a focus on purchase prices and vehicle attributes in the US and more weight is put on energy prices in Germany. Yet, this could change for the US if energy prices rise. Models should not be interpreted beyond the focus of their research questions. Only some results can be compared between models, e.g. PHEV vs. BEV shares. Models cannot predict exact market shares, but they help to understand the influences on market diffusion (drivers and barriers). A large variety of results and heterogeneity of research questions is found. Different changeable factors (e.g. vehicle attributes) and external input factors (which can’t be influenced directly, e.g. energy prices) influence them and a large variety of these factors are observed (16 in total).

For future research and PEV market diffusion models, several key points stand out: Future models for PEV market diffusion should cover more attributes than purchase price and operating cost. Several models lack the important PEV-specific features (limited range of BEVs: 16/40, Charging infrastructure: 15/40, technological and cost improvement of batteries over time 15/40). Some segmentation is helpful since not all vehicle buyers are equal (e.g. both product and consumer segmentation) and is especially important when early markets are modeled. Current (and future) policies should be integrated in model development. Future models should be capable of incorporating policy regulations (CAFE standard or CO_2 limits on vehicle sales). Also, the incorporation of indirect (non-monetary) incentives should be considered, although it is difficult (since they often apply on a local level or apply to suppliers rather than to consumers), but could largely influence PEV market diffusion. Authors of future papers should mention important factors for PEV market diffusion especially if they have some quantitative evidence. One may interpret some of the papers that they overestimate the importance of factors they integrate instead of mentioning and discussing other important factors. An objective evaluation and quantitative assessment of the modeled and missing factors would contribute even more to this field of research.

6.5 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 – completed
- 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 and summarize in a report – in progress

6.6 Contact Details of the Operating Agent

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7 Wireless Power Transfer for Electric Vehicles (Task 26)

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

7.1 Introduction

Wireless charging of electric vehicles (EVs) has the potential to untether EVs from their charger cables and possibly reduce the size of EV batteries or extend their range for the same size battery 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 is developing 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, interoperability, 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.

7.2 Objectives

The Task coordinates a study of various country-based standards, technical approaches, grid interactions, regulatory policy and safety codes for WPT for EVs and addresses interoperability, power levels, alignment, and safety. In addition, there are many fields of interest in WPT that this Task may address. Areas considered will be broad as Task gets underway and narrow in focus as meetings progress. As there is ongoing effort in many of these 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

7.3 Working Method

The Task conducts bi-annual workshops and supporting conference calls, which include visiting 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 operates 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;
- Summarize safety issues arising from misalignment, leakage fields, and debris tolerance and response
- Establish a repository for the data collected and links to other activities available to the members of the Task

7.4 Results

Task 26 sponsored workshops on two different topics in 2016. The first, a Workshop on Standards and Interoperability, was jointly sponsored with PROOV and held in Rotterdam, The Netherlands on June 28-29, 2016. The second was a Workshop on Safety of WPT Systems. It was jointly sponsored by this Task, and IEEE Power Electronics Society Workshop on Emerging Technologies: Wireless Power (2016 WoW) and took place in Knoxville, Tennessee, United States on October 5-6, 2016. Both workshops were a combination of technical presentations, site demonstrations and working group discussions.

Based on the working group discussions, members strongly felt that the Task should continue in order to address all the pertinent topics on this technology. In November 2016, Task leadership presented to the ExCo on the Task activities and requested a two-year extension. The ExCo granted the extension request.

7.4.1 Summary of Interoperability and Standards Workshop

The Interoperability and Standards workshop consisted of presentations from Germany, Italy, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States. The workshop was attended by 20 individuals from eight countries including representatives of industry, governments, standards group and national laboratories. The following table summarized the presentations that were part of this workshop.

Table 1: Presentations of the Interoperability and Standards Workshop

Title	Presenter	Country
Interoperability concerns and solution ideas	Conny Borjesson, Viktoria	Sweden
Recent ORNL Progress on Wireless Power Transfer Systems: Stationary and Dynamic Wireless Charging	Burak Ozpineci, Oak Ridge National Laboratory	United States
Wireless power transfer system testing for interoperability standard development	Shawn Salisbury, Idaho National Laboratory	United States
Addressing interoperability challenges for High Power HRWPT Systems	Morris Kesler, Witricity	United States
Vehicle Pad design that address existing and known future requirements for WEVC	Daniel Kürschner, Qualcomm	Germany
Current status of 100 Kw system and the work on standardizing	Mathias Wechlin, IPT Technologies	The Netherlands
SAE Wireless Power Transfer Standardization through SAE J2954	Jesse Schneider, BMW, Chair SAE J2954	Germany
Extending electric operation of hybrid buses through opportunistic inductive charging	Denis Naberezhnykh, TRL	United Kingdom
Wireless Power Transfer for Electric Vehicles: Interoperability and Standards the critical factors towards mass adoption	Giampiero Brusaglino, ATA - Associazione Tecnica dell’Automobile	Italy
Actual state of the standardization landscape and possible harmonization strategies	Faical Turki, Paul Vahle GmbH & Co. KG	Germany
Important aspects to be successful in a global WPT market	Kurt Hug, BRUSA	Switzerland

Workshop presentations are available on the members site for HEV TCP members. Additionally, a summary report of this workshop was developed and shared with the attendees of the workshop. This summary report will provide input into the final Task deliverable.

In addition to the presentations, members visited two pilot project sites. The first site belonged to the City of Rotterdam and was meant to explore the usability of a wireless charging system in a semi-public space with real passenger electric vehicles. HEVO Power and EV-Box provided the wireless charging system, mobile app and back office payment system. The wireless charging system was installed on a Nissan Leaf electric vehicle. A picture of the HEVO Power ground assembly and EV-Box system is shown in the following figure. The second site was in Utrecht where three Optare electric buses that are part of the Qbuzz fleet were outfitted with wireless charging capabilities. While at the depot the buses used conductive charging, however they performed wireless opportunity charging at certain stations along their route.

Figure 1: City of Rotterdam pilot site visited during Interoperability and Standards Workshop

7.4.2 Summary of Safety of Wireless Power Transfer Systems Workshop

The Safety of Wireless Power Transfer Systems Workshop was held as a special session within the WoW2016 conference. Because of this arrangement, there was a much broader audience for the presentations. In order to have this larger audience understand the Task activities, the objectives of the Task and the past workshops were explained.

The presentations within the safety session were from Germany, Japan, and the United States. The following table summarizes the presentations that were part of this workshop.

Table 2: Presentations of the Safety of Wireless Power Transfer Systems Workshop

Title	Presenter	Country
Pareto Fronts for Coils' Efficiency Versus Stray Magnetic Field in Inductive Power Transfer	Ming Lu and Khai Ngo, Virginia Tech	United States
Characterisation of Influencing Factors on the Magnetic Leakage Field of a 7 Kw Wireless Electric Vehicle Charging System	Leandro Percebon, Qualcomm	Germany
The Reality of Safety Concerns Relative to WPT Systems for Automotive Applications	Andrew Daga, John Miller, Bruce Long, and Peter Schrafel, Momentum Dynamics Corporation	United States
Development of an Exposure System of 85 Khz Magnetic Field for Evaluation Biological Effects	Keiji Wada and Yukihisa Suzuki, Tokyo Metropolitan University, and Akira Ushiyama, National Institute of Public Health	Japan
Field Decay Characteristics of Wireless Power Transfer Emissions Over Earth Sites and in Semi-Anechoic Chambers	Nevin Altunyurt, Ford Motor Company	United States
ORNL Experiences and State-of- the-art Practices for Foreign Object Detection and Shielding	Omer C. Onar and Madhu Chinthavali, ORNL	United States
INL's Wireless Charging Testing Supports Code and Standards Development	Barney Carlson, INL	United States
Magnetic and Electric Field Emissions of IPT and CPT Systems in Electric Vehicle Charging Applications	Chris Mi, San Diego State University and Fei Lu, University of Michigan	United States

Workshop presentations are available on the members site for HEV TCP members. Additionally, a summary report of this workshop was developed and shared with the Task member attendees. This summary report will provide input into the final Task deliverable.

In addition to the presentations, experts from different parts of the transportation industry were recruited to serve on a panel. The panel addressed safety issues from their various perspectives. The panelists are shown in the following table.

Table 3: Panelists of the Safety of Wireless Power Transfer Systems Workshop

Panelist Name	Company
Ted Bohn	Argonne National Laboratory
John Miller	Momentum Dynamics
Khurram Afridi	University of Colorado
Veda Galigekere	Oak Ridge National Laboratory

Figure 2: Demonstration of static wireless charging of a Toyota RAV4 with Oak Ridge's wireless charging system (Source: ORNL)

7.5 Next Steps

In 2017, this Task plans to hold an additional two workshops. The following table provides possible topics and locations for remaining workshops.

Table 4: Schedule for remaining workshops

Workshop Topics	Anticipated Dates	Host / Location
Installations & Alignment	April 25-26, 2017	VEDECOM Versailles, France
TBD	Fall 2017	CIRCE Zaragoza, Spain
Dynamic Systems	Spring 2018	TRL London, UK
TBD	Fall 2018	TBD
Summary Report Generation	Spring 2019	TBD

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8 Electrification of Transport Logistic Vehicles (Task 27)

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

8.1 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[6]. Furthermore, higher gradients are observed for freight emissions compared to passenger travel emissions for most of the IEA countries[7]. 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.

8.2 Objectives

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

- Light commercial vehicles, medium and heavy freight trucks

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[6] International Energy Agency, Energy Technology Perspective 2012, Pathways to a Clean Energy System, OECD/IEA, Paris 2012.
[7] Eom, J.; Schipper, L.; Thompson, L.: We keep on truckin': Trends in freight energy use and carbon emissions in 11 IEA countries, Energy Policy 45 (2012) 327-341, 2012.

- 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

8.3 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.

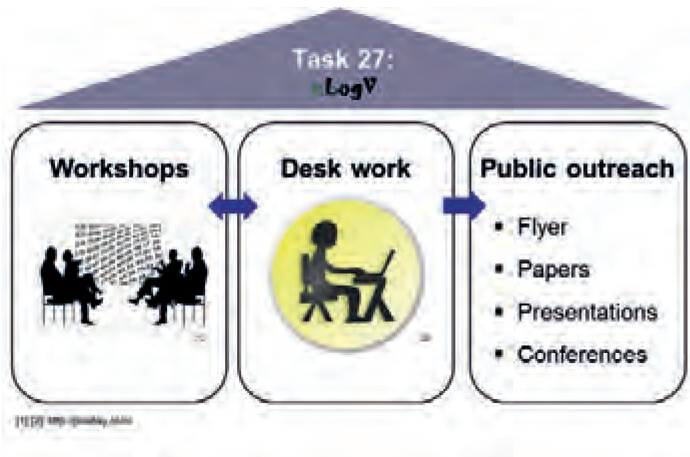

Figure 1: Task 27 working method

Workshops:
External experts are invited from industry, research organizations, and technology policy institutions around the world to refer and discuss about the topics of consideration.

Desk work:
Review of documents and data, providing information and assistance to pre- and post-processing operations.

Public outreach:
Working results will be published and discussed for example on conferences, within papers and within a final report.

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

8.4 Results

The **first Task 27 workshop** "Electric transport logistic vehicle technology and its application" was held in Stuttgart (Germany) on March 19th, 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 **second Task 27 workshop** "Experiences and prospects of electric freight vehicles" was held in Amsterdam (the Netherlands) on April 12th, 2016. Dedicated topics at the Workshop were:

- City and country perspectives
- Early adopters of electric freight vehicles
- Infrastructure for charging

The **third Task 27 workshop** "Electric freight vehicles - out of niche into mass market" was held in Vienna (Austria) on October 19th, 2016. Dedicated topics at the Workshop were:

- Electric freight vehicles as pillar of sustainable logistics
- Governmental perspectives and implementation plans for electric freight vehicles
- Performance and limits of electric freight vehicles
- eDrive system designs for electric freight vehicles

All presentations are available for download: www.ieahev.org/tasks/e-logistics-task-27.

Results from the workshops:

- High investment costs for electric trucks (about three times higher compared to conventional diesel trucks) appears the main barrier for application.
- Reaching cost-effectiveness of trucks is difficult due to low profit margins within the transport sector.
- Reliability of electric trucks is highly volatile.
- The lack of technical support for electric trucks leads to longer downtimes compared to conventional diesel trucks.

- The lack of experience along with technical issues generate “organizational range anxiety“: overcautious route planning and dispatching.
- A better way to support the mass adoption of the alternatively fueled technology is to give them a long-term competitive advantage like rewarding frontrunners e.g. via privileges (subsidies, parking and loading spaces, time windows for loading-unloading zones, etc.) for electric vehicles and build platforms for sharing knowledge.
- A supportive government policy is still of high importance for the wider uptake of electric trucks.
- A strong appeal to develop an integral European vision on electrical distribution.
- The majority of fleet managers declare a period of three to four years as the period of amortization in which they expect to recover the purchase price of an electric vehicle.

The **28th International Electric Vehicle Symposium** (EVS), KINTEX, Korea, May 3-6, 2015: *“Electrification of transport logistic vehicles: A techno-economic assessment of battery and fuel cell electric transporter”*. A techno-economic assessment of battery and fuel cell electric transporters (category N_1) were presented for Austrian, German, Turkish, British and South Korean conditions[8].

- Battery electric vehicles are (almost) competitive throughout the countries of investigation and that fuel cell electric vehicles are by far currently not an economic solution mainly based on high costs of the fuel cell system and the high hydrogen prices per MJ energy carrier in comparison to the electricity and diesel fuel prices.
- Purchase tax, energy prices and residual value are identified as main influencing factors of the relevant cost of ownership calculation.

European Battery, Hybrid and Fuel Cell Electric Vehicle Congress (EEVC) Brussels, Belgium, 2nd - 4th December 2015: *“Status and trends for electrified transport logistic vehicles”*. The developed vehicle database with more than 95 vehicles and their technical features were presented[9].

- The results show that most electrification efforts are expended for the vehicles within the smaller vehicle classes.

[8] 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.
[9] Özdemir, E.D., Kleiner, F., Beermann, M., Çatay, B., Beers, E., Moran, B., Lim, O.T., Schmid, S.A.,: Status and trends for electrified transport logistic vehicles, EEVC - European Battery, Hybrid and Fuel Cell Electric Vehicle Congress Brussels, Belgium, 2nd - 4th December 2015.

- Most of the electrified vehicles, especially battery electric vehicles, belong to the vehicle category N_1.
- For most of the vehicles (with only a few exceptions), the electric range is shorter than 250 km, independent of the payload.
- Only very few vehicles (only three) are powered by fuel cells.

8.5 Next Steps

- Full parallel session at the upcoming European Battery, Hybrid and Fuel Cell Electric Vehicle Congress (EEVC) in Geneva, Switzerland, 14th - 16th March 2017
- Fourth workshop in the United Kingdom (UK) “Experiences and prospects of electric freight vehicles in the UK” on April 26th, 2017 in Coventry
- The preparation of a final report

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9 Home Grids and V2X Technologies (Task 28)

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

9.1 Introduction

The HEV TCP Executive Committee (ExCo) unanimously approved this Task at the Executive Committee meeting in May 2014 held in Copenhagen. It was expected to continue until December 2016 but it has been extended until the end of 2018.

This Task explores 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) or vehicle-to-vehicle (V2V). The main 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 electric vehicle applications are known as Vehicle to Everything (V2X), a term that represents the strategic technology for ensuring sustainable, secure, and cost-effective deployment of electric mobility. Note that although the possibilities are multiple, most of the research and the demonstration projects are focused on V2G and V2H applications which have shown further grid benefits and higher revenue potential. In particular 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.

9.2 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 were 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.

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.

9.3 Working Method

The overarching objective of Task 28 is to investigate the means to overcome the technical, economic, and policy challenges of the 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 HEV TCP framework, Task 28 provides 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 TCP Tasks (such as Task 10, 20, 22, and 30) 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.

9.4 Results

During 2016, Task 28 organized the following two expert Workshops:

- **Workshop IV: V2X enabled EVs**
  This Workshop was held in Denver (United States) during 18-19 May, 2016. It included panels on interoperability standards, V2G participation in US demand response market, battery degradation models and market potential as a function of mobility patterns.
- **Workshop V: V2X User's perception, business models and regulatory framework**
  The Workshop took place in Paris (France) during 26-27 October, 2016. The topics of discussion included business models, V2X challenges for field implementation, V2G experiments and internal diffusion and user's engagement.

The main conclusions derived from the multiple expert contributions within these Workshops are detailed below.

9.4.1 V2X Grid Services Standards

One main conclusion is that standards for ease the participation of PEVs in grid services through V2X face different challenges around the world. Experts from Europe and the United States analyze the difference in V2X standards:

- Challenges on V2X Standards in US: the main challenge is the lack of standards versus the need of them. On one hand, the SAE (Society of Automotive Engineers) has its recommended practices but not standards. On the other hand, regulatory bodies and utilities do not accept recommended practices. Specifically, utilities need to certify equipment sending power to the grid and require that the equipment comply with Underwriter Labs (UL) standards. Additionally, utilities have traditionally dealt with stationary hardware but PEVs could plug-in anywhere and pose a challenge on the portion of interconnected equipment that should be approved.
- Challenges on V2X Standards in EU: in EU there are some already defined and used standards; EVs are providing grid services using IEC61851 and CHAdeMO, although security aspects are still weak. IEC15118 is the only standard used from the EV to the EVSE (Electric Vehicle Supply Equipment), including TLS (Transport Layer Security) encryption, however this ISO (International Organization for Standardization) has a slow response time (i.e. order of magnitude of 60 s). From the EVSE to the back-end, the standard used is IEC61850 which only includes technical parameters (missing identification, billing, etc.); OCPP version 1.6 does not include V2G features although it is expected that version 2.0 will do (with some further details included such as SOC (State of Charge), identification and higher security requirements). Standards developments run behind pilot projects.

9.4.2 V2X Business Models

Since the beginning of the Task, an important issue to be analyzed has been the V2X business models. V2X economics depend on the integration with other components: the payback time can be considerably reduced when increasing the penetration of solar panels (strongest market) and optimized charge/discharge cycles. According to some US experiences, revenues for the end-user are quantified as 1,800 USD for grid services; 600 USD for peak shifting and 0 USD for emergency backup a year. Nevertheless current models are not sustainable since compensations have been estimated at 20 times expected aggregator revenue.

The participation of a PEV aggregation in days ahead and reserve electricity markets needs to quantify the amount of energy that could be required. Also, other approaches for massive PEV's management could be the PEVs fleet clustering based on departure time or maximum power.

Business model innovation/value proposition reconfiguration can help to compensate for technological inferiorities and create a more attractive value proposition (discharge technologies) to enhance customer engagement. V2X technologies have the potential to reshape the EV value proposition: EVs have points of superiority to exploit V2X technology better than the incumbent ICE technology. Besides, there are actually opportunities to expand the V2G value proposition to other vehicle fleets such as school buses.

All markets are trying to adapt themselves to enable distributed energy sources to participate. Until 2016, there was no country using distributed resources to deliver large regulation reserves.

9.4.3 Effects of Usage Profile on Battery Lifespan and Battery Degradation Models for V2X Applications

Some interesting conclusions on battery lifespan and battery degradation have been presented during 2016 workshops.

One important novelty from the analysis presented is that calendar fade represents the most significant factor for battery degradation; physical reality cannot be ignored. Previously identified important factors such as time, temperature and SOC at which the battery sits have been proven to be high significant factors in battery degradation. Actually, maintaining the SOC close to 50 % is crucial for battery degradation mitigation.

Therefore, the impact of V2G services on PEV battery life depends mainly on how the PEV is used in regular driving and recharging and not in V2G services. An extreme case of daily discharging the full PEV battery for V2G purposes results in 3 or 4 years lifespan reduction. Moreover, if we take into account pros and cons of V2G services in terms of battery degradation, frequency regulation market results to be the most interesting market given that it requires lower energy transfers.

Battery degradation is a real concern among the potential EV consumers and it poses a challenge for the roll out of EVs and more specifically for V2G services development. It is therefore convenient to keep devoting resources to continue the research around this topic.

9.4.4 V2X Experiments

By 2014, 3.15 billion EUR had been invested on smart grid projects in Europe. Several world-wide projects have been presented during the workshops whose main goal is to demonstrate the potential and benefits of the EV integration into energy systems. The IEA expects a further 600 billion EUR of smart grid investment in Europe from 2014 to 2035.

Following one of its objectives, this Task is building a catalogue on V2X experiments and projects around the world. Table 1 represents a summary of the first version of the catalogue.

Table 1: V2X international projects catalogue

Project name	Topic	Country	Starting year
e-DASH	The e-DASH project aims at the harmonization of electricity demand in Smart Grids for sustainable integration of electric vehicles.	DE, DK, ES, FR, IT, SLO	2011
Smart V2G	Its major target is the connection of electric vehicles to the grid by enabling controlled flow of energy and power through safe, secure, energy efficient and convenient transfer of electricity and data.		2011
Los Angeles Air Force Base Vehicle to Grid Pilot Project	Technical challenges of V2G participation and potential financial benefit.	US	2012
Grid on Wheels	Vehicle to grid demonstration project	US	2012
Nikola Project	Danish research and demonstration project with a focus on the synergies between the electric vehicle (EV) and the power system.	DK	2013
Cotevos	Concepts capacities and methods for testing EV systems and their interoperability within the Smart Grid	9 EU countries	2013
Smart Grid V2X Energy & Mobility Project	The project puts an open mobility services platform on which services can be developed as V2X. Among other innovative new hardware and operating software for fast (dis) charge for V2X developed and tested in Amsterdam New-West.	DK	2013
PlanGridEV	Distribution grid planning and operational principles for EV mass roll-out while enabling DER integration	9 countries	2013
Vehicle2Grid	This pilot will help move forward the large scale implementation of electric vehicles, the use of solar energy and the energetic independence of households.	DK	2014
Canadian V2X project	Investigate the impact of V2X on EV battery life, the potential to mitigate this impact using a smart supercapacitor module and the economics of V2X	CA	2014
EnergyLab Nordhavn	The project utilizes Copenhagen’s Nordhavn as a full-scale smart city energy lab and demonstrates how electricity and heating, energy-efficient buildings and electric transport can be integrated into an intelligent, flexible and optimized energy system	DK	2015
Parker	Seeks to prove that series-produced electric vehicles, as part of an operational fleet, can support the Danish power system through power and energy services.	DK	2016
SEEV4-City	SEEV4-City supports the transition to a low-carbon economy in Europe’s Cities, combining electric transport, renewable energy and smart energy management.	DK	2016

Some of the conclusions presented in the experts' workshops as results of world-wide demonstration projects investigating topics related to V2X technologies are the following:

- When practice is applied, complexity regarding sub-metering and charge-based metering requirements, physical production of suitable chargers and aggregation testing has been observed.
- Revenue potential of bidirectional chargers has been proven to be more than 10 times higher than for unidirectional ones.
- In general, pilot projects have shown that technical barriers are less important than social and regulatory issues.

9.4.5 User's Engagement

How to motivate people to participate in the market? The decision to plug-in is dependent on different factors: inconvenience, benefits regarding using gasoline, battery space, environmental issues, etc. In order to encourage people to plug-in some actions could be taken such as increasing the battery size, decreasing transaction costs or increasing the gasoline cost. Incentivizing users per plug-in event would also certainly stimulate the willingness to plug-in.

PEVs with small capacity batteries can only ever generate small financial returns and plugging in tends to fade away over time. They require additional incentives. End users prioritize upfront discounts or a pay-as-you-go contract (rather no obligations).

In one workshop, an interesting analysis from Germany was presented. In the case of Germany there is not yet a real electric mobility take off. This has been attributed to political and economic reasons, path dependencies and behavioral inertia. Another possible reason could be a weak offer from car manufacturers. The project carried out in Germany wanted to encourage people to plug-in their vehicles when arriving at home enabling smart charging showed that they trusted the system and agreed on the suitability and effectiveness. Reliability, flexibility, smarter systems and financial incentives emerged as key elements in user behaviour.

9.4.6 Final Remarks

During 2016 expert workshops, there have been detected challenges on the V2X market for all stakeholders: the low EV sales volume does not seem to justify investment in technology for utilities and battery degradation costs. Equipped EVS with bidirectional capabilities are not obvious for OEMs (Original Equipment Manufacturers) and there is a need to clearly identify compensation for grid services to the owners. The development of these technologies has been also slowed down due to the scarcity of political and economic support.

9.5 Next Steps

The work within the Task 28 will continue until the end of 2018. As it was the case up to 2016, the aim still is to organize biannual expert workshops. The next one in March 2017 in Jeju Island (South Korea) is taking advantage of the 4th International Electric Vehicle Expo (IEVE 2017) venue.

The partners contributing to Task 28 activities also expressed their interest to be present in other multitudinous European electric mobility events such as the European Battery, Hybrid & Fuel Cell Electric Vehicle Congress (EEVC 2017) in Geneva (Switzerland) or the 30th International Electric Vehicle Symposium & Exhibition (EVS 30) in Stuttgart (Germany), both events to be hold during 2017. Including presentations around the V2X topic or a parallel “Home Grids and V2X Technologies” Workshop in the course of these events will be considered.

Task 28 members have the ambition to develop a V2X Technology roadmap as one of the main outputs of the Task. The roadmap will capture all the knowledge shared during the multiple expert Workshops since Task 28 started with the aim of identifying the main barriers that prevent the roll out of the V2X technology and gathering best practices to help on a faster deployment. The topics to be covered will include: V2X status, technology development (standardization, harmonization and battery degradation), regulation and policies, market and business cases and project’s dissemination among others.

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10 Electrified, Connected and Automated Vehicles (Task 29)

Members: Austria, Germany, United States

10.1 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 these technologies may define novel products, designs and services contributing 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. Along these lines, concepts from sharing economy not just provide new market opportunities for the merging automotive and IT sectors, but also offer ways to compensate negative effects of a higher mobility demand.

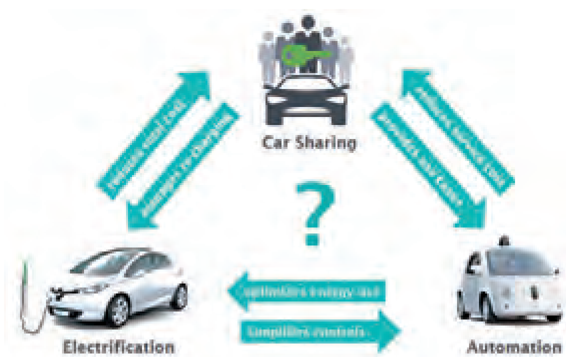

Figure 1: Synergies of electrification, automation and car sharing (Source: G. Meyer, S. Beiker, Road Vehicle Automaton 3, Springer, 2016)

In order to discuss opportunities and challenges of electrification in combination with connectivity and automation of road vehicles, and particularly to exchange information about the implementation of related innovation funding programs, Task 29 was launched by the HEV TCP.

10.2 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 with concepts of sharing economy 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.

10.3 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 as a book.

10.4 Financing and Sponsorship

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

10.5 Contact Details of the Operating Agent

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

Members: Austria, Canada, Germany, Spain, United States

11.1 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 analyzed 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.

11.2 Objectives

The aim of Task 30 (2016 – 2019) is to analyze 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” (2011 – 2015, available at www.ieahev.org and led by JOANNEUM RESEARCH) 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 analyzed 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 and diesel on the other side.

In recent years the focus in environmental assessments of electric vehicles was on global warming and primary energy consumption (see Figure 1). But now it is recognized that other impacts gain additional relevance and must be addressed by life cycle based comparisons like water, land use, resource consumption, local particle matter (PM) and NO_x-emissions. Therefore Task 30 will focus on following topics covering methodologies, data and case studies:

- Effects of EVs on water (emissions to water, waste water, “Water Footprint” of EVs)
- Effects on EVs on land use-resources-waste (land use, occupation and degradation, demand of renewable and fossil resources, recycling)
- Effects on 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)

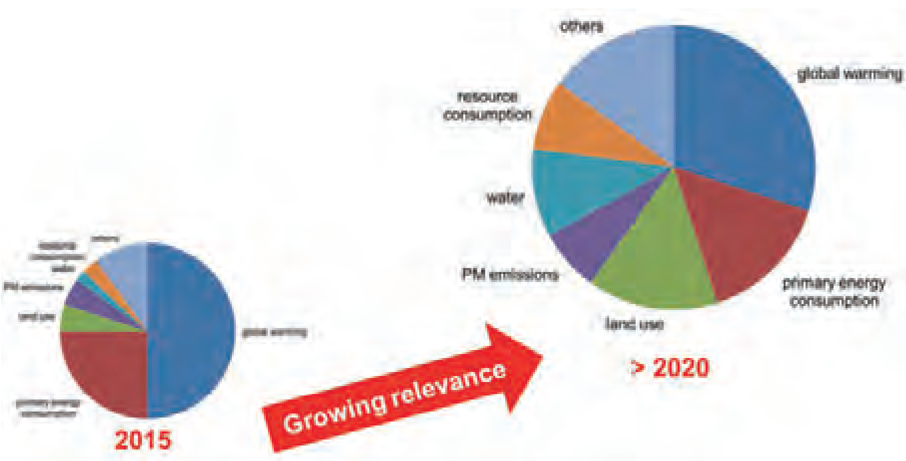

Figure 1: Growing relevance of environmental impacts of EVs compared to ICEs

11.3 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 already in Task 19 established and international "Research Platform for Life Cycle Assessment (LCA) and End-of-Life Management for Electric Vehicles" will be challenged. 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: Scheme of the working method in Task 30

11.4 Results

11.4.1 Expected Final 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.

11.4.2 First Results on Water Issues

In January 2017, Task 30 held an expert workshop on the environmental effects of electric vehicles (EVs) on water, energy consumption and air emissions based on life cycle assessment in Graz/Austria.

The aim of the workshop "Environmental Effects of Electric Vehicles (EV) – Water Issues and Benefits of EV-Fleets on Energy Consumption and Air Emissions " was to present and discuss the current status and the future perspectives of the environmental performance of electric vehicles in comparison to conventional vehicles with an internal combustion engine (ICE) in a life cycle perspective. The main focus is on Battery Electric Vehicles (BEV) and Plug in Hybrid Electric Vehicles (PHEV).

The two topics for the workshop were:

1. Water issues
2. Benefits of EV-fleets on energy consumption and air emissions

The format of the workshop was based on presentations, discussion and group work with focus on

- Data requirements
- Case studies
- Identification of main issues in LCA of EVs and ICE
- Identification of "hot spots" on water issues of EVs, PHEVs and ICEs
- Communication of LCA results to stakeholders, e.g. Fact Sheet
- Findings and Recommendations

In an interactive group work the following key issues were discussed, summarized and documented:

- Main drivers
- Water inventory
- Most relevant water issues for LCA of EV and ICE
- "Water footprint"
- Water issues in electricity production
- Water issues in value chain of EVs and ICE
- Research questions on water issues & EVs
- Possible activities of IEA HEV Task 30

Main drivers

The key drivers to work on water issues are:

- Water is a key factor for sustainable development goals
- Agriculture (incl. biofuels)
- Electricity production in thermal power plants and hydro power plants
- Waste water from industry and population as a pollution of rivers, lakes and seas

Water inventory

The starting point of an LCA on water issues is a water balance for the most relevant processes of EVs and ICE. Ideally the water balance of each process is closed, as all inputs equal the outputs incl. the transformation of hydrogen into water, e.g. due to a chemical reaction. The water inventory must include the water inputs and water outputs by providing the data on process level with its geographical location:

- Input water: source, volumes, temperature, quality
- Discharge water: sink, volumes, temperature, quality
- Emissions to water: specifically amounts of N, P, heavy metals and organic loading

For a proper impact assessment the inventory data including uncertainties are needed by:

- Region
- Timeframe (current, future)
- State of technology
- Data source: original, secondary and tertiary data

Most relevant water issues for LCA of EV and ICE

1. Inventory
    - Water evaporated (blue water use)
    - Water flow alteration (for hydro power)
    - Water emissions (impurities that affect water quality)
    - Thermal emissions
2. Impact assessment
    - Water consumption factor (WCF)
    - Water scarcity
    - Water Stress Index or kind of such an index number
    - Water eutrophication and
    - Water toxicity

"Water footprint"

Water Scarcity Footprint = Water Consumption * Water Scarcity Index

in analogy to

Carbon Footprint = Greenhouse Gas Emissions * Global Warming Potential

The commonly often used wording of "*water footprint*" gives only information on the amount of water and is, as such, on an LCA inventory basis, e.g. water consumption. Carbon footprint, on the other hand, is an LCA impact category. An LCA on water issues requires the water footprint but also water scarcity, eutrophication and toxicity.

Water issues in LCAs should be considered because water is a relevant part of the sustainable development goals and will in future play an increasingly important role. As a result water LCA and carbon footprint should be combined to create DALYs (disability/disease-adjusted life years lost) for impact categories "Human health" and "Ecosystem quality".

Water issues in electricity production

The water consumption is mainly relevant for thermal power plants and hydro power plants. For thermal power plants the water consumption mainly depends on the type of cooling technology, whereas for hydro power the allocation of the water consumption to the different purposes of a hydro dam (e.g. electricity, flood control, navigation, recreation, and irrigation) is most influencing.

The total environmental damage (e.g. "Eco-Indicator 99" - Ei 99+) comparing different electricity generation systems might lead to two findings:

1. Water is most relevant for hydro power.
2. The total environmental damage of hydro power is significantly lower compared to natural gas and coal.

Water issues in value chain of EVs and ICE

The following processes are most important in the value chain of EVs and ICE:

1. ICE (incl. blending of biofuels):
   - Fossil fuel extraction and refining (e.g. tar sands, oil shale or traditional oil)
   - Cultivation of feedstock for biodiesel and bioethanol (e.g. for B5, E10)
   - Vehicle production
2. EV (only BEV and PHEV):
   - Electricity generation (e.g. thermal open cycle, closed cycle, or hydro power)
   - Battery production (specifically because of pollutants for mineral extraction and refining)

The comparison of water issues of EV and ICE shows that the life cycle based water consumption of EV might be higher than from ICE. Main reason is the electricity production from hydropower and thermal power plants. For ICE the most relevant influence on water consumption depends on the amount of biofuel blended (biodiesel in diesel or bioethanol in gasoline), as the agricultural production of the feedstock for biofuels is most relevant for water issues, e.g. most of the water consumption for E10 gasoline ICE vehicle in the USA derives from corn cultivation for bioethanol.

The comparison of water withdrawal and consumption for fuel supply show that

- For the ICE about 50 % of the water withdrawal and about 80 % of the water consumption is needed for the gasoline supply.
- For the EV about 90 % of the water withdrawal and about 80 % of the water consumption is needed for the electricity supply.

Research questions on water issues & EVs

- How to reduce the water impacts of EVs?
- Reduction of uncertainties in assessment. This requires basic data for the inventory at the regional level and improved data of water inputs and emissions in the construction and dismantling of the EVs.
- How a broader use of EVs impacts water stress in a given region?
- Preparedness for the possibility that water becomes a “show stopper”. This requires a proper communication strategy of results and uncertainty of results.
- Including water vapour as a climate forcing.

Possible activities of IEA HEV TCP Task 30

The Task 30 might work on the following activities:

- A report giving a summary of the current state of knowledge on water issues in the LCA of EVs covering methodological aspects, data issues, case studies comparing EVs and ICEs and further R&D demand.
- Collection and compilation of water consumption (WCF) of global electricity production to analyse and assess water consumption of current global EV fleet. This might then be included in the FACT SHEETS for the IEA HEV TCP countries and worldwide.
- Screen methodologies, data and case studies to expand analyses and assessment to include stress index (or other kind of index) by region/scenario and impact assessment (e.g. water quality, thermal pollution, etc.).

11.4.3 Estimated Environmental Effects of Worldwide EV Fleet

Based on the LCA activities in the 18 member countries Task 19 estimated the LCA based environmental effects of the worldwide electric vehicle fleet in 2014 and 2015 in 35 countries. In the LCA of these vehicles using the different national framework conditions, the environmental effects are estimated by assessing the possible ranges of greenhouse gas emissions (CO_2, CH_4, N_2O), acidification (NO_x, SO_2), ozone formation (NO_x, CO, NMVOC, CH_4), particle matter (PM) emissions and primary energy consumption (total, fossil, nuclear, renewable) in comparison to conventional ICE vehicles. The system boundaries chosen are shown in Figure 3.

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. Here the current national electricity production in the considered countries in 2014 and 2015 is analyzed 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. The fuel demand of a conventional new ICE vehicle is assumed in the range of 50 – 75 kWh/100 km.

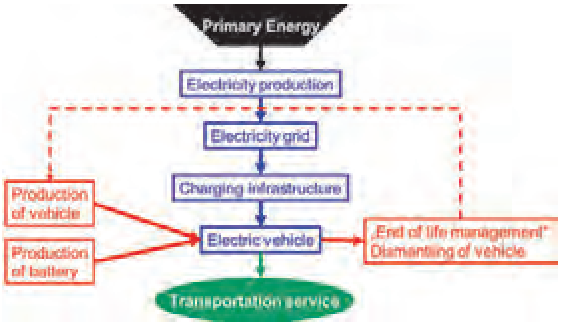

Figure 3: System boundaries

The analysis is done for each of the 35 countries separately and the main country specific results are summarized in a "Country Factsheets on Estimated Environmental Impacts of Current EV-Fleet" documenting (see Figure 4).

- "BASIC DATA" on electricity and electric vehicle fleet, e.g. share of national electricity production, estimated environmental effects of electricity at charging point, development national electricity market (incl. import & export), and electric vehicle fleet: number of BEV and PHEV
- "Estimation of LCA based ENVIRONMENTAL EFFECTS" by substituting conventional ICE (absolut annual change or relative annual change)

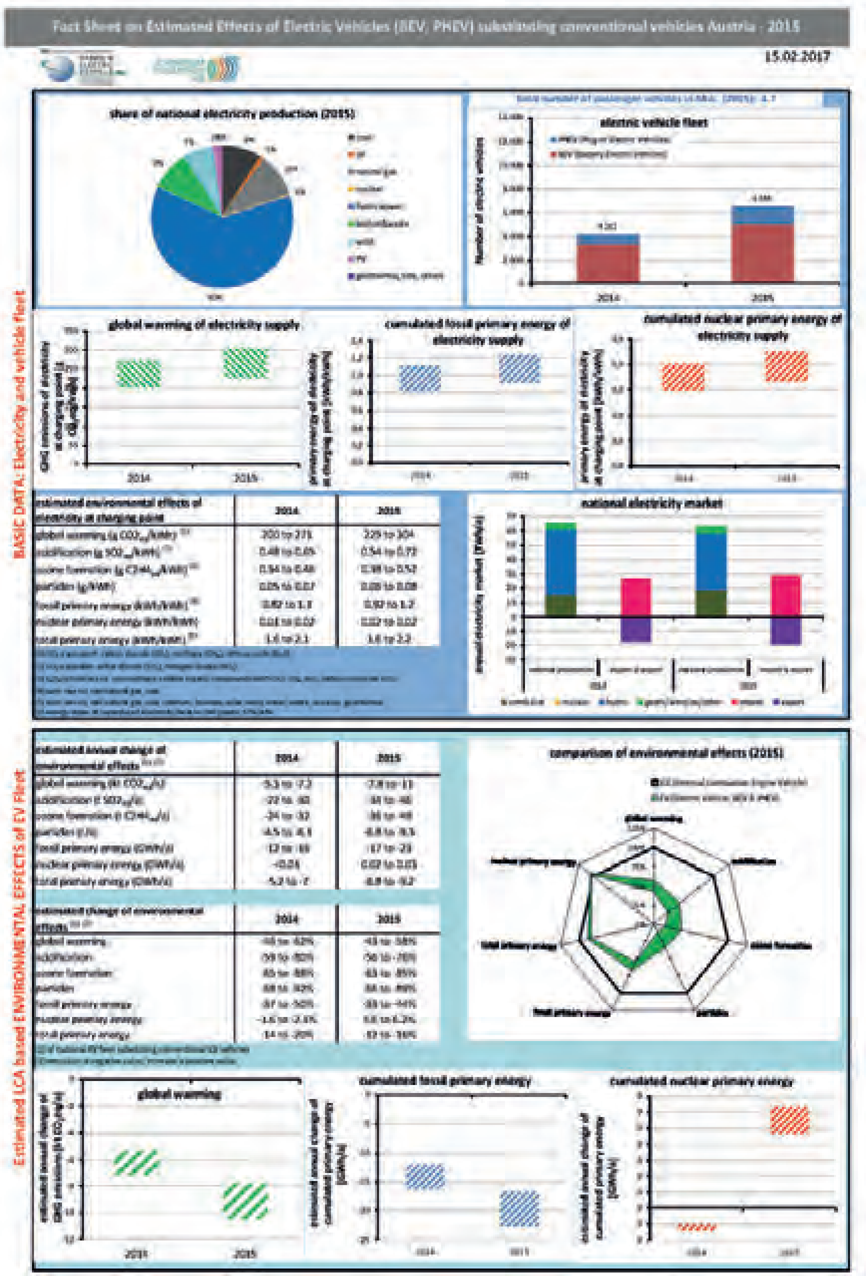

Figure 4: Country fact sheet – example Austria

The main data used are the amount of about 1.3 million electric vehicles in 35 countries worldwide in 2015, of which there are about

- 0.75 million Battery Electric Vehicles (BEV) and about 0.55 million Plug-in Hybrid Electric Vehicles (PHEV)
- 30 % in the USA, 25 % in China and 10 % in Japan (Figure 5) and
- 0.8 million in the 17 IEA HEV TCP countries and 0.5 million in the 18 non-IEA HEV TCP 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 range of the estimated environmental effects of the current national electricity supply at the charging point for the IEA HEV TCP countries are shown in Figure 6 (GHG-Emissions) and Figure 7 (cumulated fossil and nuclear primary energy).

The results of the estimated environmental effects of EVs compared to conventional ICEs are shown in relative and absolute terms for 2015 in Figure 8 to Figure 11, whereas the main difference between the countries is the mix of the national electricity consumption.

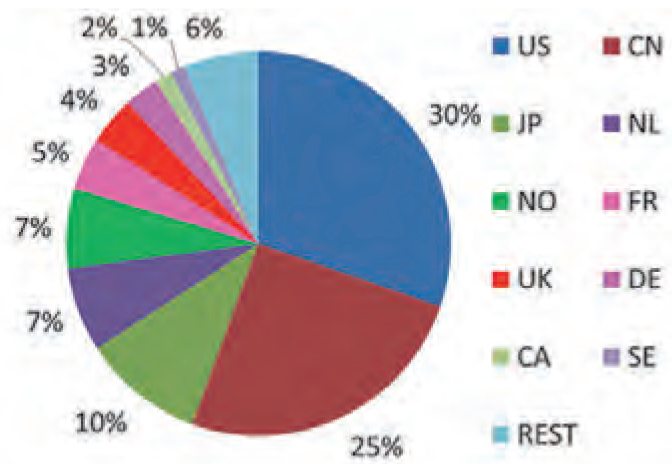

Figure 5: Vehicle fleet worldwide 2015

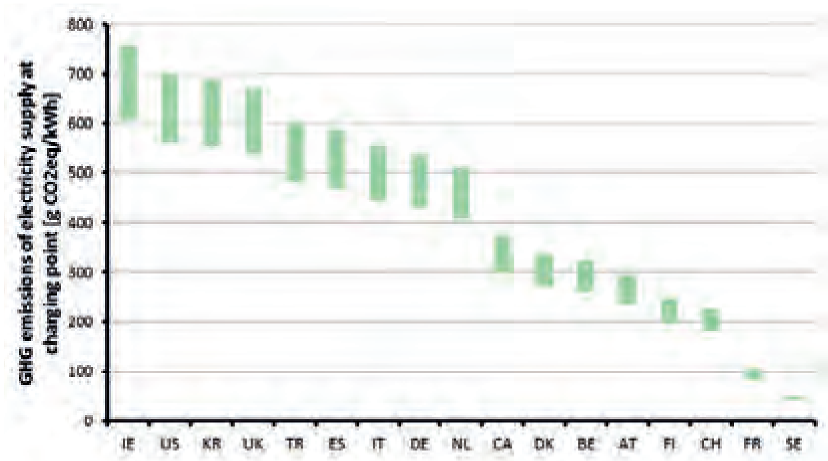

Figure 6: Estimated range of GHG emissions of electricity at charging point in IEA HEV TCP countries in 2015

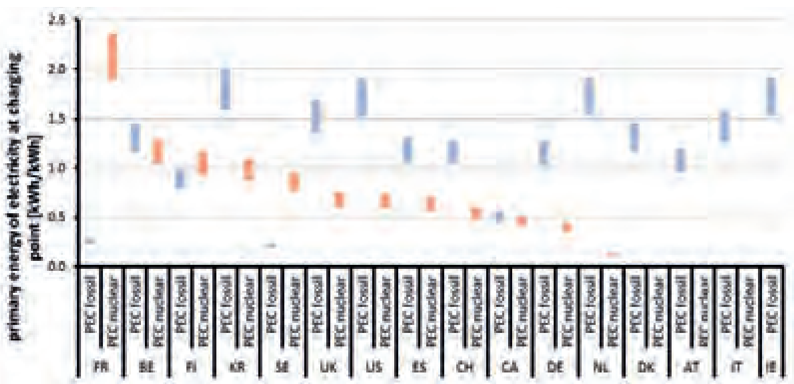

Figure 7: Estimated range of cumulated fossil and nuclear primary energy of electricity at charging point in IEA HEV TCP countries in 2015

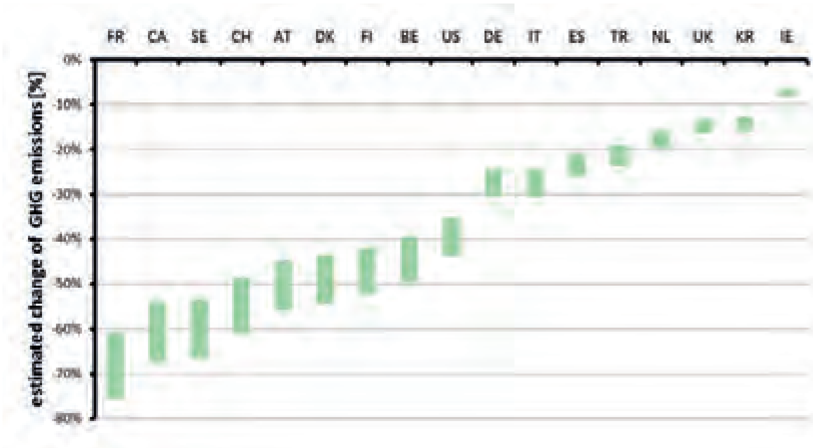

Figure 8: Estimated range of GHG reduction of EVs substituting ICE in IEA HEV TCP countries in 2015

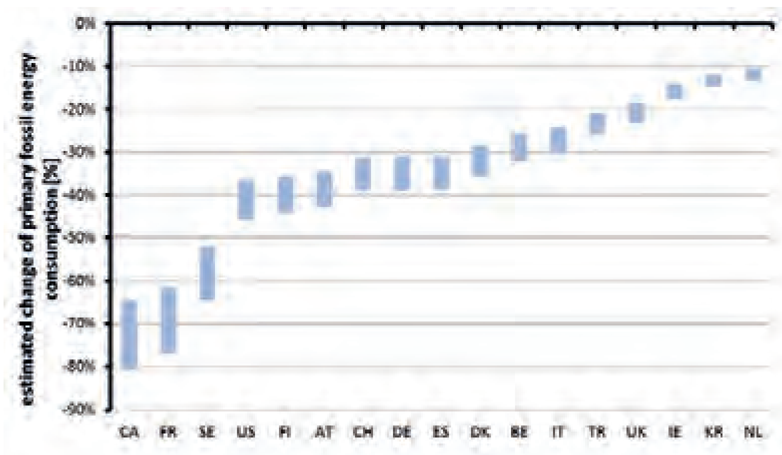

Figure 9: Estimated range of fossil primary energy reduction of EVs substituting ICE in IEA HEV TCP countries in 2015

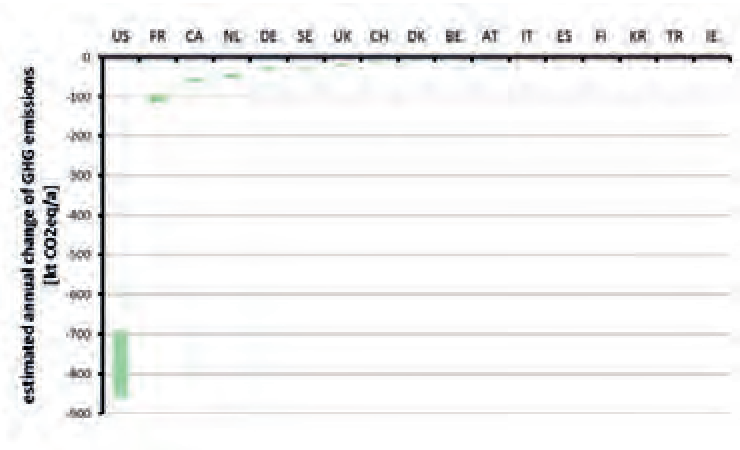

Figure 10: Estimated range of annual GHG reduction of EVs substituting ICE in IEA HEV TCP countries in 2015

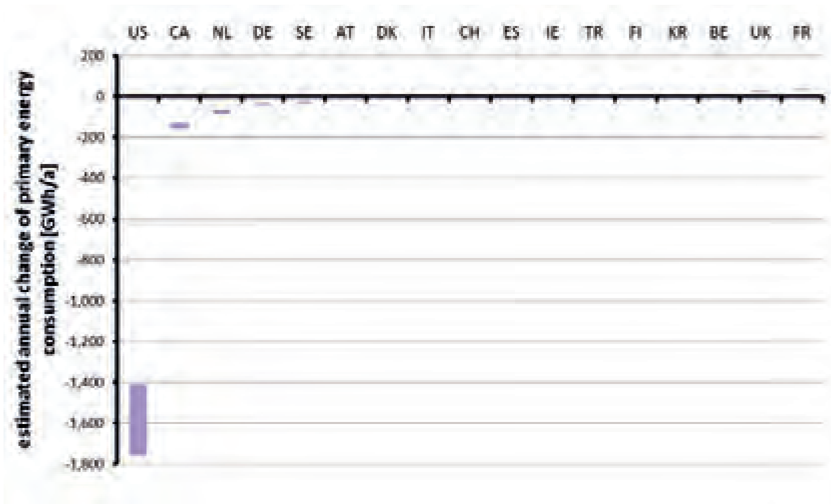

Figure 11: Estimated range of annual primary energy changing of EVs substituting ICE in IEA HEV TCP countries in 2015

Finally the total global environmental effects in 2015 of the 1.3 million EVs are estimated. In Figure 12 the total reduction of GHG emissions is shown with a range between 1.0 – 1.3 million t CO_2-eq, mainly deriving from the EVs fleet in IEA HEV TCP countries. In Figure 13 the estimated change in acidification is shown, which shows globally a slight increase due to electricity production in non

IEA HEV TCP countries, and in Figure 14 the cumulated primary energy with a reduction between 1,900 – 2,400 GWh/a.

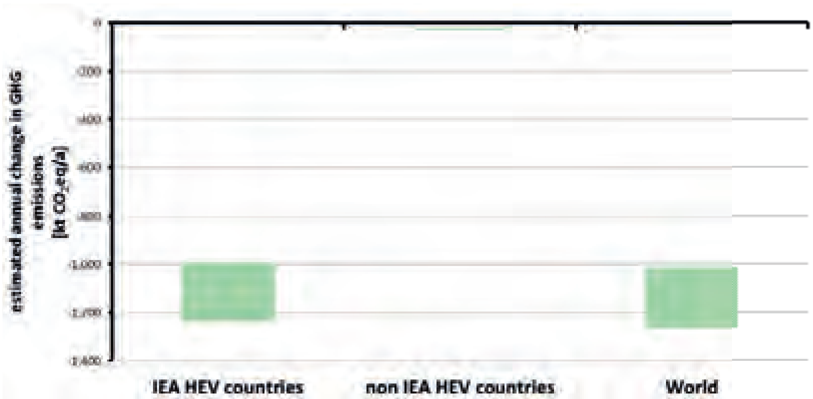

Figure 12: Estimated range of change in GHG emission of EVs substituting ICE globally in 2015

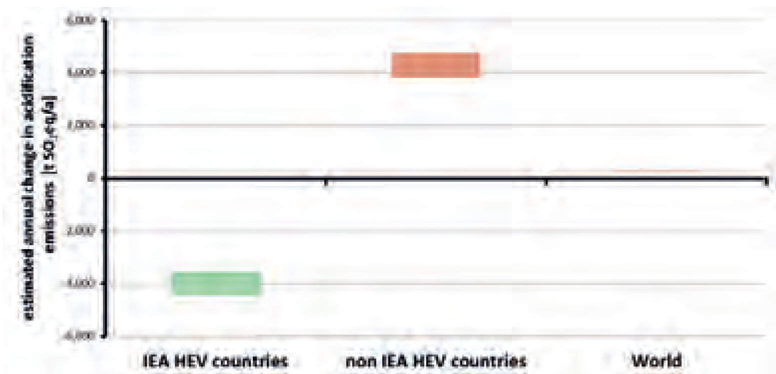

Figure 13: Estimated range of change in acidification of EVs substituting ICE globally in 2015

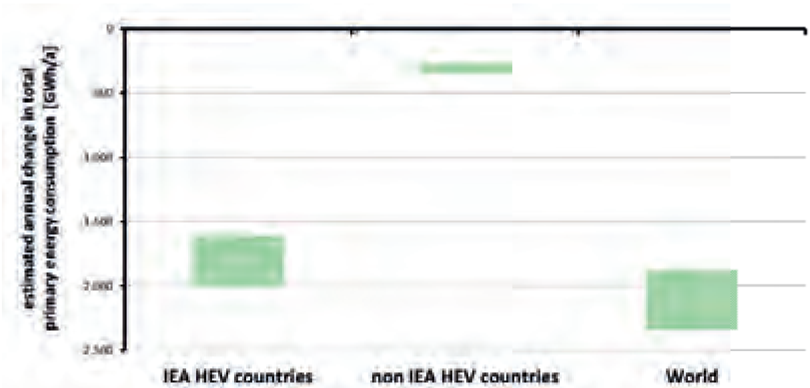

Figure 14: Estimated range of change in cumulated primary energy consumption of EVs substituting ICE globally in 2015

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

The estimation of the average environmental effects of BEVs and PHEVs substituting diesel and gasoline globally shows

- GHG-reduction: - 25 % to – 30 %
- PM < 10 reduction: - 40 % to – 50 %
- Acidification: 0 % to – 5 %
- Ozone reduction: - 50 % to – 60 %
- Fossil primary energy reduction - 25 % to – 30 %
- Renewable primary energy increase + 10 % to +15 %
- Nuclear primary energy increase + 600 % to + 800 %
- Total primary energy reduction - 15 % to – 20 %

The main conclusions of the environmental assessment of EVs based on Life Cycle Assessment compared to conventional vehicles are:

1. 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.

2. The 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
3. Additional renewable electricity with adequate charging maximizes environmental benefits.
4. Adequate loading strategies to optimize the use of renewable electricity are essential for further significant reductions.
5. So there is scientific evidence that under appropriate framework conditions, electric vehicles can substantially contribute to a sustainable transportation sector in the future.

11.5 Next Steps

The next workshops are scheduled as follows:

- „Effects of EVs on Air“, January 2018, Stuttgart (Germany) organized by DLR
- „Effects of EVs on Land Use/Resources/Waste“, June 2018, collocated with the Annual Merit Review in Washington DC (USA) organized by ARGONNE
- “Overall Environmental Assessment of EVs”, April – May 2019, Barcelona (Spain) organized by IREC.

The dissemination activities are:

- Presentation: *The Carbon Footprint of E-Mobility – A Comparison Between Countries*, Mobility for the Future Low-Carbon Economy and Society, JOANNEUM RESEARCH Zukunftskonferenz 2017, March 1, 2017, Graz, Austria
- Presentation and conference paper: *Environmental Effects of 1.5 million Electric Vehicles worldwide*, Fuels – Conventional and Future, 11th International Colloquium Fuels, June 27 – 29, 2017, Stuttgart/Ostfildern, Germany
- Abstract submission: *Life-cycle Based Environmental Effects of 1.5 million. Electric Vehicles on the Road in 35 Countries – Facts & Figures from the IEA Technology Collaboration Program on Hybrid & Electric Vehicles*, EVS30 – Electric Vehicle Symposium, Stuttgart, Germany, October 9 – 11, 2017

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12 Fuels and Energy Carriers for Transport (Task 31)

Members: Denmark, France, The Netherlands

12.1 Introduction

1. Authorities are promoting the transition of transport to non-oil based fuels and increasingly zero emission vehicles (ZEV) are the (long term) target for cars.
2. Transparency of the impact of the different drivetrain options on the CO_2 emissions and other pollutants is missing, making it difficult for policymakers to link policies with impacts -
   - Information is often limited, biased and outdated
   - Technologies, cost structures and (perceived) impacts of the different fuel and drive-train options are changing rapidly
3. High quality data is available from academic peer reviewed studies, multi-actor national level analysis on details -
   - But not always accessible in a comprehensive form
   - Most of these are not dealing with all the relevant issues
   - Mostly it is a fixed set of data examples with limited practical use

12.2 Objectives

The aim is to provide policy makers with an independent, objective and state-of-the-art evaluation of well-to-wheel energy chains for transport, comparing electric and plug-in hybrid vehicles with vehicles on conventional motor fuels (gasoline and diesel).

- Provide an objective alternative for studies that are funded or largely carried out by interest groups representing specific energy production sectors
- Results to be reported in a concise format for policy makers

Scope of work

Impacts:

1. WTW GHG emissions and energy efficiency
    - GHG emissions including CO_2 and other GHGs expressed as CO_2-equivalents with latest GWP factors
2. To be included:
    - Life-cycle GHG emissions of vehicle manufacturing, and decommissioning
    - Energy security / dependence on imported oil

Current situation and future trends (2020, 2030):

- E.g. decarbonisation of electricity generation, increased WTW emissions for petrol / diesel due to higher share of unconventional oil, etc.

Approach:

- Based on evaluation of available recent literature, no new in-depth assessments
- Compare battery-electric and plug-in hybrid vehicles with petrol, diesel

12.3 Working Method

Inventory of state-of-the-art literature

Collection of recent scientific literature on WTW impacts of various energy chains. Used sources include: scientific journals, national and other independent studies and references contained therein.

Methodological issues

1. How to assess emissions from electricity generation and how to attribute these to end users?
    - System boundaries?
        - Average / marginal emissions
        - Production mix / delivery mix (overall or for small end-users)
        - How to deal with imports and exports?
    - How to deal with end-users that buy green electricity?
2. How to estimate WTT impacts for a future year?
3. Investigate to what extent it is possible to include other impacts than GHG emissions and energy consumption.

- Life-cycle GHG emissions of vehicle manufacturing and decommissioning:
  - Have a significant impact on comparison
  - How to estimate future developments? (e.g. of WTW emissions of electricity used in China for battery manufacturing will be taken into account)
- Pollutant emissions: OUT OF SCOPE but can be added later
- Noise: OUT OF SCOPE but can be added later
- Energy security / dependence on imported oil: the amount of “eliminated / displaced” oil will be calculated

4. How to define comparable real-world TTW energy consumption figures for vehicles running on different energy carriers?
   - Take account of regional differences in vehicle specifications
   - See also WP 4

Assessment of available WTT data

1. Current situation (2010/2016) and modelling of future emissions
   - Assess available literature with respect to consistency of methodology and underlying data
   - Assess developments in upstream emissions and provide projections of future WTT impacts
   - Time horizon: 2016, 2020, 2030
   - A model will be build to facilitate future projections and evaluate impacts of vehicle characteristics and fuel characteristics as well as battery manufacturing

Assessment of TTW energy consumption

1. Focus on passenger cars only.

2. Appropriate dimensioning of vehicles
   - Define comparable vehicles for all energy chains and assess TTW energy consumption
   - Energy consumption of BEVs and PHEVs depends on range / size of battery (Assumptions and possibly scenario variants needed)
   - Modelling will allow for an in principle infinite number of different vehicles and use cases

3. Based on real-world energy consumption
   - Take account of gap between real-world and type approval data (For EVs electricity consumption depends strongly on speed profile, temperature

conditions (impact depending also on way in which cooling / heating is done in the vehicle, etc.)

- For PHEVs also the share of electrically driven kilometers is a parameter influencing real world fuel consumption (Real world data for electric drive versus fossil fuel drive will be used)

Reporting

1. Summarize findings of WP 1 to 4 in a high level document for policy makers:
    - Part of results presented in graphs
    - The model will have a user friendly interface for parameter input

12.4 Results

The data has been collected, the modelling is operational in a test environment.

12.5 Next Steps

Cross check inputs, validate model, finalise model. Subjects that need attention: auxiliary energy consumption of EV, future changes in efficiency.

Write report (timing Q2, 2017).

12.6 Contact Details of the Operating Agent

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13 Small Electric Vehicles (Task 32)

Members: Belgium, Germany, Republic of Korea, Switzerland, United Kingdom

13.1 Introduction

Pressure on reconsidering transport options is increasing. Growing global population, a global motorization rate that rose by 21 % between 2005 and 2013[10], increased urbanization, problems related to climate change and limited resources result in the need to use available space, material and energy most efficiently. Global emission targets quantify the need to reduce emissions and require innovative mobility solutions. Small electric cars (SEV) could effectively support fulfilment of targets. Model variety of SEVs achieved a considerable number within the last year, including few models from established OEMs (Renault Twizy, Peugeot e-Vivacity) as well as many models offered by small companies (Tazzari EV Zero City, Clean Motion Zbee, etc.). However, SEVs still constitute a very low share of the existing vehicle fleet and vehicle registrations.

Small electric vehicles considered in this task shall include three- and four wheel small electric vehicles that are propelled by a locally emission free technology and belong to one of the L-categories L2, L5, L6 and L7 according to UNECE Regulation[11]. The Task should additionally comprise locally emission free vehicles that do not exceed 3.50 m, a maximum drive power of 55 kW and an unladen weight up to 1200 kg. Examples for that type of vehicle would be the smart ED or Mitsubishi i-MiEV.

13.2 Objectives

The objective of this Task is to promote a broader commercialization, acceptance and a further development of small electric vehicles (SEVs) by collecting and sharing pre-competitive information, exchange about framing conditions, best practices and ideas, how to develop the market conditions and mobility concepts further. In this sense, the objectives in short are twofold:

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[10] "The Automobile Industry Pocket Guide. 2015-2016" European Automobile Manufacturers Association (ACEA), June 2015, p. 41.

[11] UNECE, Inland Transport Committee, World Forum for Harmonization of Vehicle Regulations, Consolidated Resolution on the Construction of Vehicles (R.E.3) Revision 4, 2016.

1. Increased safety, comfort and usability at lower costs for SEVs due to technological progress
2. Better market perspectives for SEVs due to a change in surrounding conditions like e.g. regulations, transport policies and mobility concepts

The Task addresses the SEVs concepts, status of technologies and needs for research as well as the conditions to put them on the market. Apart from the vehicles themselves, the Task addresses also the potential future role of SEVs in advanced mobility concepts, including e.g. their role in concepts of sharing, increased automation and new public transport.

13.3 Working Method

The main approach of the Task is to collect and exchange information in workshops. The workshops aim to attract professionals from research, enterprises and policy makers, depending on the individual topics. The topics and the individual orientation of the workshops will be decided by the Task partners. The concept of having invited presentations from individual stakeholders together with more interactive parts has proven to be attractive. Individual meetings/workshops might be handled confidentially if asked for by participants.

In addition to the workshops, the Task may benefit from conducting a survey and/or organize a special session at conferences to bring together interested stakeholders.

While the Task partnership could constitute from academic institutions, NGOs or policy makers, contributions from industry and the participation in workshops is explicitly welcomed.

The results of the Task are shared with the public as agreed with the workshop participants. The presentations and discussions within the workshops are shared by the participants. Literally citations of companies’ representatives might be excluded by gentleman’s agreement. Publications about the Task and about results are in the interest of the participating researchers. The papers and presentations will exclude confidential and/or non-official statements. A final report summarizing the overall results of the Task will be prepared by the operating agents with the contributions from the Task partners.

Workshops:

Two workshops are organised with a focus on “vehicle concepts and technologies of SEVs”, one in Europe, one in Asia or North America. One or two workshop(s) are organised with a focus on “market conditions for SEVs”. One workshop will be organised with a focus on “mobility concepts and SEVs”.

Public outreach:

A flyer is prepared which presents the Task. Results will be published by writing papers, providing presentations, offering webinars or attending conferences, according to individual expectations of the Task partners. A final report will provide a compilation of material elaborated during the three years project duration: presentations and conclusions of the workshops, conference contributions and scientific publications.

The Task is based on a work sharing principle and in kind contribution is expected.

13.4 Results

A **first Task 32 workshop** “Differences in worldwide regulations for SEV: problems and options for improvements” (Focus L7) was held in Rüsselsheim (Germany) on 1st December 2016 at the Opel Training Center. Experts from OEM and research institutions from Germany, Switzerland, Belgium, the United Kingdom and South Korea joined the Workshop. Topics presented and discussed at the Workshop were:

- RAK-E: A concept LEV from Opel
- EU regulations relevant for small 4-wheeled road vehicles
- Kyburz – company and concept presentation
- Twike – company and concept presentation
- Safety aspects of SEV
- Homologation of L7 in South Korea

Participants discussed and exchanged knowledge in a workshop session with the following topics:

- Main difficulties in homologation
- Options for improvement

13.5 Next Steps

- Development of a database with L-category regulation
- Next workshop about “vehicle concepts and technologies of SEVs”

13.6 Contact Details of the Operating Agent

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14 Battery Electric Buses (Task 33)

Members: Austria, interested to join: Canada, Ireland, Germany, Spain, USA

14.1 Introduction

Battery Electric Bus Systems are getting increased attention in recent years. Several cities and urban bus operators aim to electrify bus fleets partially/completely in the near future. Recent developments show that new charging strategies and advanced energy storage technologies enable full-day operations of electric buses, e.g. using the opportunity of fast charging concepts. Significant cost reductions are expected due to technology standardization and economies of scale. More than 20 bus producing companies in Europe already offer various types of electric buses. Main bus companies intend to start electric buses in serial production soon, because battery electric bus systems have the potential to substitute diesel buses in the (near) future.

Numerous innovative projects were initiated in recent years, especially in central European countries, from pilot projects towards commercial use (e.g. Geneva, Vienna, Maastricht, Graz). They are testing and demonstrating various types of electric buses, charging methods and strategies as well as energy storage systems. Based on the daily collection of experiences in operating battery electric buses, an evaluation and analysis of key aspects from 60 electric bus projects worldwide (e.g. charging strategies, electric energy storage systems) is currently taking place. Urban public transport is the promising sector for the implementation of electric buses due to its structured system layout, professional line management and synergies to existing electric infrastructure.

Figure 1: Electric bus at charging station in Graz (Source: Graz Holding Linien)

The rapid development to prepare the broad rolling out of electric buses is underlined by the following press-releases of the industry:

- *"Volvo and the European bus manufacturers Irizar, Solaris and VDL have agreed to ensure the interoperability of electric buses with charging Infrastructure provided by ABB, Heliox and Siemens. The objective is to ensure an open interface between electric buses and charging infrastructure and to facilitate the introduction of electric bus systems in European cities" (15.03.2016).*
- *"The public transport community is preparing for electric buses in Europe and standardization activities have started via the European body (CEN-CENELEC) and via the international organization for standardization (ISO/IEC). European standards are expected to come in place 2019 and international standards in 2020" (23.03.2016).*

14.2 Objectives

The objective of the Task 33 (2016-2018) is to analyze and assess the current state of technology & demonstration experiences of battery electric buses. On the one hand this covers the bus technology e.g. battery or capacitor system, and on the other hand the charging infrastructure, e.g. fast charging stations at the bus stop and its optimal integration in an urban infrastructure, e.g. synergies with trams, metro or trolley bus systems. The task work is done based on an analysis of ongoing demonstration projects of battery electric buses worldwide. Based on this, the future perspectives and challenges for battery electric buses are analysed and described. This includes the identification of major challenges e.g. technology, costs, public acceptance and the necessary R&D demand. Finally the key aspects for a successful broad introduction of battery electric buses and the necessary frame work conditions are concluded.

The work is done in a close cooperation of the relevant stakeholder from the three focus groups:

1. Providers of public transportation services
2. System and technology providers
3. Research institutions

The results are continuously documented and disseminated via presentations, workshops, conference contributions and publications.

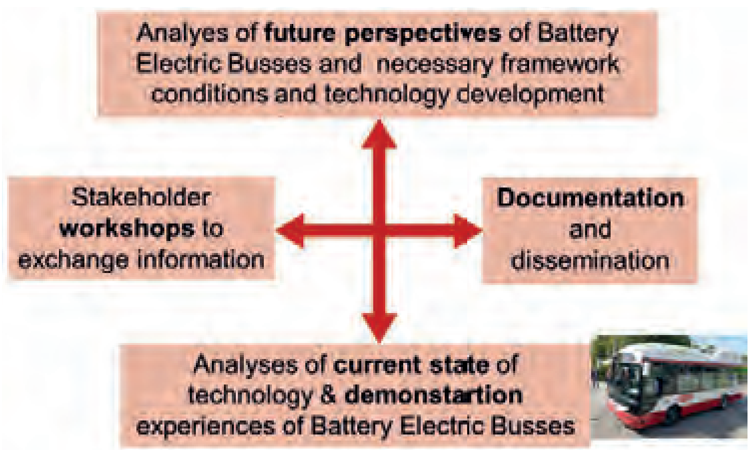

Figure 2: An overview of objectives in Task 33

The major activities are

- Identify &analyze state of technology and systems of battery electric buses
- Collect and document „International Success Stories“ in a common format
- Give overview of systems &technology providers with characteristic data

- Stakeholder involvement in 2 - 3 Workshops in combination with site visits
- Analyze combination of trolley and battery bus systems
- Integration and use of existing infrastructure of trams, trolleys and metro
- Identify success factors, e.g. size of bus, distances between bus stops
- Define loading strategies
- Analyze sustainability issues – economic, environmental &social aspects
- Identify R&D demand
- Conclude and summarize future perspectives
- Publish IEA HEV glossy Brochure of results
- Presentations and contribution at conferences

14.3 Working Method

The most important activity of the working method is the organization of workshops in different member countries to involve the stakeholders in the value chain of battery electric buses, e.g. providers of public transportation services, system and technology providers, and research institutions. The organization of workshops with the participation of the industry, research organizations, technology policy experts, and governmental institutions provides an international basis for the exchange of information on the relevant activities. The focus of the expert workshops is to analyze, discuss and document the

1. State of technology for battery electric buses
2. Future perspectives of battery electric buses

The workshops are combined with a site visit to an ongoing demonstration of battery electric buses in daily life applications.

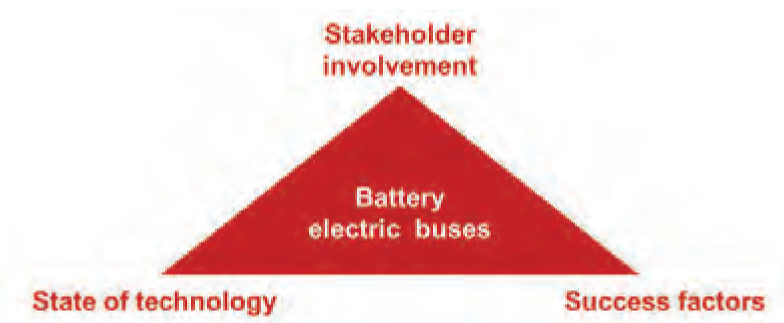

Figure 3: Working method

14.4 Results

Numerous innovative projects have been initiated in recent years, especially in central Europe, from pilot projects towards commercial use (e.g. Cologne, Maastricht, Graz). An assessment of current demonstration projects worldwide was initiated to initially analyze the state of technology, economic aspects and identify key implementation issues for battery electric buses and their necessary charging infrastructure[12].

The evaluation and analysis of key aspects from 60 electric bus projects worldwide (e.g. charging strategies, electric energy storage systems) was done covering battery, plug-in hybrid- and trolley hybrid electric buses. Urban public transport represents a promising sector regarding the implementation of electric buses due to its structured system layout and scheduled line management. In recent years, various types of electric buses, charging methods and strategies as well as energy storage systems are tested in daily operation in numerous projects worldwide. A comprehensive overview of electric bus projects worldwide was made to identify the initial key aspects for a broad successful implementation and to describe the state of technology.

Figure 4: Fact charging integrated in bus station and grid connection in Graz (Source: Holding Graz Linien)

[12] Landerl. P., Jungmeier G. (2016): Status and Future Perspectives of Electric Busses in Urban Public Transport – An Assessment of Current Demonstration Projects, State of Technology and Economic Aspects, Graz, Austria

The analysis is based on literature, expert interviews, case studies and life cycle cost analyses (LCC). In total the evaluation is based on 38 electric bus manufacturers and 58 electric bus projects worldwide (Figure 5). In these electric bus projects especially in central and northern Europe innovative charging strategies are used and highly developed electric energy storage systems have emerged in the last three years. The analysis shows that electric buses are up to three times more energy efficient than conventional diesel buses, however, their life cycle costs are up to 25 % higher. The most influential life cycle cost factors are:

- Number of buses operating on a particular route
- Investment costs of the bus
- Energy consumption
- Service lifetime of the bus

Figure 5: Initial analysis of 58 electric bus demonstration projects worldwide

In the detailed analysis of five selected demonstrations of electric bus systems in urban areas the following drivers for a successful implementation are identified:

- Further technological development of electricity storage systems
- Standardization of charging infrastructure
- An accurately planned electric bus system design to achieve an optimal trade-off between battery/passenger capacity and charging power/time
- An adequate financing strategy (e.g. funding programs)
- A broad stakeholder support

Summing up the actual assessment indicates that battery electric bus systems using an „opportunity“ fast charging strategy seem to be most promising to significantly substitute conventional diesel buses in future.

14.5 Next Steps

The expert workshop „State of Technology of Battery Electric Buses” will take place in Austria, a date will soon be fixed and made available via the IEA HEV TCP webpage.

A data base to collect and document the electric bus demonstration projects will be established and partners are encouraged to provide input. Based on this a common format is developed to collect and document „International Success Stories on Battery Electric Buses”.

The dissemination activities are:

- Presentation & Conference paper: *Status and Future Perspectives of Battery Electric Buses in Urban Public Transport*, IEWT 2017 - 10th International Energy Economic Conference “Climate Goals 2050 – Opportunity for a Paradigm Change”, Vienna, Austria, February 15 – 17, 2017
- Abstract submission: *Challenges of Battery Electric Buses – Assessment of Demonstration Activities in the IEA Technology Collaboration Program on Hybrid&Electric Vehicles*, EVS30 – Electric Vehicle Symposium, Stuttgart, Germany, October 9 - 11, 2017
- Abstract submission: *Battery Electric Buses – Perspectives for Commercialization based on an Evaluation of 60 Demonstration Projects Worldwide*, UITP – BUSWORLD: International Bus Conference, Kortrijk, Belgium, October 20 - 25, 2017

14.6 Contact Details of the Operating Agent

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15 Batteries (Task 34)

Members: Canada, Germany, Sweden

15.1 Introduction

Task 34 is a follow-on to Task 10, Electrochemistry, which was active from 2001 until 2016. Task 34 was formally approved by the Executive Committee (ExCo) at its meeting in Amsterdam in April 2016. At that meeting about six countries said that they planned to join, and a similar number expressed strong interest in the Task. Dr. James A. Barnes was Operating Agent (OA) for Task 10. In 2015, he retired from government service and now serves as OA of Task 34 on an independent basis. 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). Task 10's focus did not extend to issues related to the integration of batteries in vehicles or infrastructure issues, but the Task did collaborate with other Tasks on topics that spanned both battery technology and system issues. The potential scope of Task 34 remains broad, but its focus is on issues related to safety. Within the area of safety, it expects to address topics ranging from basic cell phenomenon to battery safety issues in vehicular systems.

15.2 Objectives

Task 34's goal is to encourage the sharing and dissemination of current information about battery topics of interest to the vehicle community with a focus on safety.

15.3 Working Method

There are a large number of public meetings on batteries held every year. Most of these meetings follow the same general format: A series of speakers address the audience using set presentations. There may be time for short questions at the end of a presentation or a set of presentations. There is little or no time for an in-depth discussion of a topic by all of those present. Because these meetings are public, speakers tend to avoid preliminary information. Presentations rarely include negative data or mention experimental problems. Unfortunately, for the battery community to improve the safety of battery systems and to avoid multiple, similar incidents, there must be an opportunity for experts in the field to candidly discuss accidents, potential accidents, and safety concerns. These discussions must be honest and candid. These discussions must allow participants to express differences of opinion. To speak candidly, individuals must be comfortable that their comments will not be mis-quoted.

The working method of Task 34 has been chosen to encourage honest and candid discussions of a type that are unlikely to occur in large, public meetings. The Task identifies a topic that is of interest to the technical community and that would benefit from an active discussion. A small group (about 25) of experts in the field are invited to a meeting focused on this topic. Attendance at the meeting is limited to allow all those present to participate in the discussions. Presentations are used to spark the exchange of ideas, but do not dominate the meetings. Meetings are conducted on a not-for-attribution basis to encourage individuals to report important, but perhaps embarrassing, data and experiences. Because the participants in a discussion may have strong, and potentially differing, opinions on a topic, the goal of the meetings is to foster discussion and the exchange of ideas, not to force a consensus.

The output or products of the Task will be guided by the nature of the discussions. The OA will prepare a summary of each meeting for publication in the Annual Report, posting on the HEV TCP website, and/or available for public distribution. Some participants may have publications or documents that they are willing to share with others. Based on the experiences in Task 10, some documents will be released for public sharing without further restriction; some presentations will be cleared for sharing with other attendees but not released for public distribution; and some presentations will not be released. Those presentations that have been released will be distributed to all participants and made available on the website as appropriate.

Because the range of possible topics is quite varied and each topic may be associated with a unique group of experts, each topic will be addressed in a single meeting or set of meetings. A participant in a one meeting is not required to attend future meetings on different topics; although individuals with broad interests may choose to attend multiple meetings.

Meeting locations are determined by the OA in conjunction with experts in member countries who are interested in hosting a meeting. Given that some experts may be very interested in a topic but be unable to attend a meeting at a distant location, the OA will be willing to consider arranging multiple meetings on similar topics in multiple locations if requested to do so by member countries. The OA is also investigating ways for individuals to participate in a meeting from a remote site (i.e. by telephone or video conferencing). Unfortunately, if most of the participants in a discussion are collected in one room, it is hard for someone who is not present to gain maximum value when participating remotely.

15.4 Results

The Task organized a set of two meetings in December 2016 and January 2017 to discuss issues related to internal short circuits in lithium-ion cells. Both meetings were held in the Washington, DC, USA area. The December meeting focused on an in-depth discussion of three specific questions and brought together about 25 experts in the field. The January meeting touched on these three questions but also addressed many broader aspects of internal short circuits and brought together almost 50 participants with a wide range of backgrounds including transportation companies and fire fighters. Both meetings attracted participants from government, national laboratories, industry, and academia.

Internal short circuits were chosen as the focus of these meetings because they are of great concern to anyone using lithium-ion batteries. A short can result in thermal runaway with significant safety issues. The three questions addressed in December were as follows:

1. Since internal short circuits occur relatively rarely in state-of-the-art cells, how can internal shorts be provoked or simulated in a laboratory setting? Data from appropriate tests can be used to help identify the way a short forms and propagates, to help a user identify cells that are less likely to fail violently if a short were to occur, and validate the predictions of a mathematical model. What laboratory methods are now in use or development to simulate an internal short? Specific approaches discussed included versions of the nail penetration test, versions of the “pinch” and “dimple” tests, shorts initiated by the introduction of foreign material, and shorts caused by the “activation” of a component incorporated into a cell.
2. How can modeling inform our understanding of how shorts behave inside a cell and how the characteristics of the short and the cell affect the ultimate outcome? Violent failure or quiet discharge? Presentations discussed models that have been developed and what predictions they can make.
3. What methods exist or are in development to identify the formation of an internal short in a cell in order to allow remedial action before the short results in thermal runaway? Any method to identify a short as it forms must be validated experimentally.

In addition to these three topics, the January meeting also addressed issues related to manufacturing quality controls for preventing and screening shorts at beginning of Life (BOL). Different methods have been used by manufacturers and users to screen or detect internal shorts. Cell and battery screening for any type of defect that could lead to an internal short are common with the top tier cell and battery manufacturers. However, with the use of billions of commercial cells in millions of commercial batteries, cost-effective screening every cell and battery can be a challenge. Specific issues mentioned included processes to minimize the production of metal shards and particles during manufacturing, processes to remove metal shards and particles from components (especially powders) before cell fabrication, processes to inspect for flaws and foreign object debris (FOD) during manufacture. Processes to test or inspect cells after manufacture but before shipment include high pot tests, X-ray examination, monitoring during formation, and charge retention testing.

The discussions of how to simulate an internal short circuit in the laboratory concluded that there was no technique that would allow one to provoke a realistic short circuit in a production cell without modification. Penetration and pinch tests have been standard techniques used by many testing organizations for many years. The techniques have been refined with respect to the way the penetration, dimple, or pinch is done. These tests can be conducted on an unmodified cell and do cause short circuits, but the nature of the shorts provoked by these techniques is not a realistic simulation of the failures observed in the field. Many organizations still use these tests on a regular basis, but others are reducing their use of these tests in cell evaluations. Penetration techniques (i.e. nail penetration) do have use as a method to provoke cell failure, especially in a battery pack, without adding extra energy to the system by a technique such as heating. The ability to provoke a cell failure is important when assessing the tendency of a cell failure to propagate through a battery.

Very realistic internal shorts can be caused by introducing an appropriate metal particle into a cell and then cycling the cell. During cycling, the particle will be oxidized and dissolved and then reduced and precipitated as a solid. This cycling process can cause the particle to be transformed into a dendritic, conductive pathway that results in a short circuit. The disadvantage of this technique is that it requires introducing the material into a cell either during manufacture or by a post-manufacture process that disassembles the cell. Once the particle is in place, cycling to produce a dendrite is not a precise process. The short may form after a relatively few cycles, or it may require a large number of cycles, or a short may never form.

Internal shorts can also be caused by incorporating into a cell a device that, when activated, will cause a short. Several devices/techniques that have been used to cause a short when the device is activated. In one technique, two metal disks are separated by a layer of a wax with a low melting point. When the cell is gently heated, the disk melts, the two metal pieces touch, and the short is formed. Another technique introduces a very fine heating wire into a cell. When current flows through the wire, it gets hot enough to melt the separator and allow a short to form. Neither of these techniques result in a short that is identical to those observed in the field, but both approaches can help a manufacturer or user understand some of the processes that occur when a short forms. Both techniques have the disadvantage that they require a non-standard part to be introduced into a cell during the manufacturing process.

A full, multi-dimensional cell model can allow one to mathematically simulate a wide variety of internal shorts. If the model is sophisticated enough, one can investigate the effects of shorts with different resistances, shorts in different locations in a cell, cells with different heat capacities and heat conduction pathways, and shorts in different electrical environments (fully charged cell vs. fully discharged cell vs. a cell receiving energy from an external source during charging). Unfortunately, to develop a model that is complete enough and detailed enough to allow realistic simulations is a very demanding task. And once a model has been developed for a given cell design and chemistry, it is not a trivial task to adapt it for a different cell design and chemistry. Using an appropriate model, one can investigate a variety of conditions that would be difficult or impossible to do in real cells. Modeling investigations can allow one to better understand the dynamics of an internal short. But no attendee could identify any user who was willing to rely on modeling as a complete replacement for testing actual cells and batteries.

Several organizations have developed techniques that purport to detect internal shorts in a cell before they result in thermal runaway. Some of these techniques are now being reduced to practice in developmental equipment. Test results in controlled settings are promising. In order to be adopted for use in practical batteries, all of these approaches will require additional work to reduce the size and cost of the devices and to refine how they might be incorporated into a battery. Progress is being made. Some developers reported that they are now working with battery manufacturers or users to incorporate their technology into practical systems.

It was agreed that internal short circuits remain one of the most challenging issues for battery developers and users. Experienced designers believe that they can address failures such as overcharging, over discharge, and unbalanced cells through appropriate electrical controls. In a similar manner, they believe that an appropriate battery housing can protect against reasonable crush and penetration incidents. But they are concerned that they do not yet have a practical, cost effective way of insuring that an internal short will never result in a cell or battery failing.

15.5 Next Steps

The OA, in conjunction with other colleagues in the field, is planning the next discussion meeting. The issues related to the propagation of a failure from a single cell to other cells in a battery will be the subject of this meeting. The tentative schedule and location are June 2017 in the United States.

The OA is working with representatives from the member countries to identify topics and locations for future meetings. Assuming that the other countries who expressed an intention to join the Task are able to confirm that intention, the OA hopes to hold an average of two discussion meetings a year for the duration of the current phase of the HEV TCP.

15.6 Contact Details of the Operating Agent

For further information, please contact the Task 34 OA:

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16

Overview of Hybrid and Electric Vehicles in 2016

Member countries of the HEV TCP regularly report the sales of HEVs, EVs and PHEVs.

Table 1 shows the fleet totals for passenger vehicles[13] of HEVs, EVs, and PHEVs over the last three years. The numbers for 2014 and 2015 have been taken from the previous HEV TCP Annual Reports. The country chapters provide more detailed numbers for 2015 sales and fleet totals for EVs, PHEVs, and HEVs.

[13] 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 HEV TCP member countries, as of December 31 of each year that is shown (exceptions are noted)

	HEVs			EVs and PHEVs		
Country	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**
Austria[a]	12,823	14,350	17,746	3,386	6,544	11,360
Belgium	31,579	n.a.	n.a.	6,700	8,586[c]	17,268[c]
Canada	143,917	163,269	186,057	10,778	18,451	29,270
Denmark	3,706	3,799	n.a.	3,393	8,059	8,373
Finland	11,772	14,054	18,732	945	1,580	3,285
France	173,520	229,550[b]	283,670	30,121	54,640	84,150
Germany	107,754	119,556	167,552	18,948	36,311	61,465
Ireland	8,746	10,474	13,637	550	1,215	2,053
Italy	*68,960*	*25,661*	*117,898*	*7,152*	*4,616*	8,822
Netherlands	117,353	131,011	141,559	46,121	87,531	112,008
Rep. of Korea	n.a.	n.a.	58,596	*2,000*	*10,267*	11,210[d]
Spain	62,811	64,169	94,771	3,294	4,746	8,562
Sweden	35,000	42,737	55,770	7,261	14,541	29,320
Switzerland	40,577	46,261	53,159	4,691	9,021	14,103
Turkey	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
UK	171,528	n.a.	215,053	16,818	46,978[c]	89,339[c]
United States	3,535,808	3,804,630	4,267,157	286,916	406,536	560,885
Totals HEV TCP	**4,525,854**	**4,669,521**	**5,691,357**	**449,074**	**719,622**	**1,051,473**

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 source: EAFO (European Alternative Fuels Observatory), www.eafo.eu

[d] Data source: Global EV Outlook 2017

17 Austria

17.1 Major Developments in 2016

In 2016, 3,826 new BEVs were registered in Austria. That's an increase of 128 % compared to 2015. Additionally, 1,237 PHEV and 4,613 HEV passenger vehicles were registered in 2016, +12 % and +34 % compared to 2015, respectively. From 1 January 2016 electric vehicles which are used as company cars are eligible for deduction of input tax and are exempted of non-cash compensation regulations. With this reform EVs became much more attractive for companies and self-employed persons.

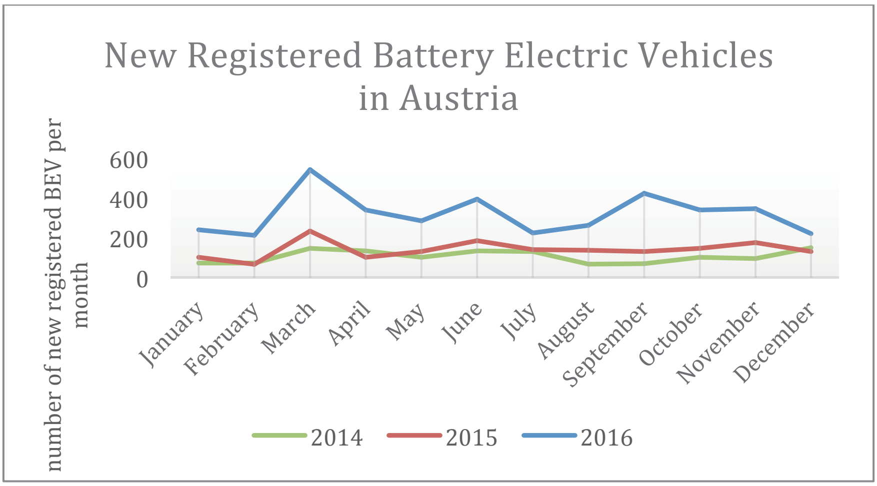

Figure 1: Absolute number of new registered BEV in Austria from 2014 until November 2016

On 8 July 2016 the international agreement on the climate – which had been decided on at the 21st session of the *Conference of the Parties to the United Nations Framework Convention on Climate Change* (COP21/CMP11) in Paris in 2015 – was ratified by the Austrian National Council. Austria was among the first 20 countries who ratified this agreement.

17.1.1 New Policies and Strategy

In November 2016, the Austrian Minister of Transport, Innovation and Technology (bmvit) and the Minister of Agriculture, Forestry, Environment and Water Management (BMLFUW) presented together with the spokesman of the Austrian automobile importers a package of measures to support electric mobility with 72 million EUR. It includes incentives for buying EVs, installation of charging stations, and a particular number plate for electric vehicles. From March 2017 a bonus for the purchase of electric vehicles is available.

On 6 December 2016 the national strategy framework was introduced to the Ministerial Council by the Federal Ministry for Transport, Innovation and Technology (bmvit), the Ministry of Science, Research and Economy (BMWFW) and the Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) and approved. With the national strategic framework "*Saubere Energie im Verkehr*"[14] (Clean Energy in Transportation) Austria fulfilled an obligation of the 2014/94/EU directive of the European Parliament and Council about the installation of an infrastructure for alternative fuels, such as electricity, CNG, LNG, and hydrogen.

17.2 HEVs, PHEVs and EVs on the Road

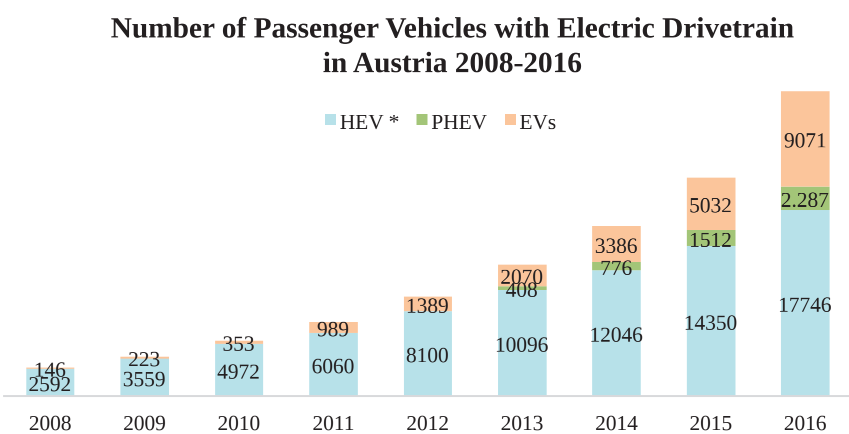

Figure 2: Electric passenger vehicle statistics 2008 – 2016 (Data source: Statistik Austria)
* until 2012 numbers for HEV include PHEV

As of 31 December 2016, 8.6 million people were living in Austria and 4.8 million passenger vehicles were on Austrian roads. 430,648 motor vehicles (+7.4 %

[14] www.bmvit.gv.at/verkehr/elektromobilitaet/downloads/strategierahmen.pdf

compared to 2015) and 329,604 passenger cars (+6.8 % compared to 2015) were newly registered in Austria in 2016. The share of passenger EVs registered in 2016 increased to 1.2 % (compared to 0.5 % in 2015), the share of passenger HEV and PHEV increased to 1.4 % (compared to 1.1 % in 2015). Even though their share is still relatively small, an ongoing trend towards vehicles with alternative drivetrains can be observed. Figure 2 displays the development of the number of hybrid, plug-in hybrid, and battery electric vehicles on the road in Austria. The number of fuel cell hydrogen vehicles (not shown in figure 2) increased to 13 in 2016, compared to 6 in 2015.

17.3 Charging Infrastructure or EVSE

Since no official map of electric charging stations (EVSE) is available in Austria, it is difficult to represent the exact number of EVSE. One EVSE can host several charging points. In Austria, EVSEs are counted by the number of stations rather than by the number of plugs in a charging station. In Table 1 the number of Level 2, ChAdeMO and CCS charging stations are shown.

Table 1: Information on charging infrastructure in 2016 (Data source: e-tankstellen-finder.com)

Charging Infrastructure on 31 January 2017	
Chargers	**Quantity**
AC Level 1 Chargers	n.a.
AC Level 2 Chargers	2,174
ChAdeMO	137
CCS	127
Inductive Charging	n.a.
Totals	**2,438**

n.a. = not available

Statistic data originates from *E-Tankstellen-Finder*, a website provided by KELAG (*Kärntner Elektrizitäts-Aktiengesellschaft*) which is a regional energy service provider in Austria. It is collected by offering EVSE operators to add their stations to the map. Therefore, this website might not represent the whole electric charging infrastructure. Within the 2,438 charging stations shown in Table 1, 2,119 allow a charging capacity up to 22 kW. 129 are accelerated charging stations (22 – 45 kW) and 190 offer fast charging above 45 kW.

Most public charging stations are operated and/or owned by regional energy service providers and many operators require a kind of registration in order to be able to charge a vehicle at their stations. In order to facilitate charging in the whole country, the project “ÖHUB” was initiated. 11 regional energy service providers connect their existing charging infrastructure which represents about 80 % of the public Austrian charging infrastructure a superordinate hub called ÖHUB. With ÖHUB only one contract is needed for charging at any station of these 11 energy service providers.

As a full service provider, SMARTRICS provides a large customer-oriented network with public charging and high-speed charging stations in Austria. Shareholders of SMARTRICS are Verbund, Austria's biggest energy service provider, and Siemens. The charging network includes more than 400 charging points all over Austria. Some 200 of these are high-speed points with 43 or 50 kW output, located about every 60 km along motorways and in urban centers. All charging points are supplied with 100 % renewable energy. SMARTRICS offers different contracts depending on the charging profile of their customers and allows EV drivers who are not yet customers to charge their vehicle immediately after activation via mobile phone with internet access.

17.4 EV Demonstration Projects

*"klima**aktiv** mobil*"[15], the national action program for mobility management, is undertaken by the Austrian *Federal Ministry of Agriculture and Forestry, Environment and Water Management* (BMLFUW) and supported by the Austrian *Chamber of Commerce*, the Austrian *Association of Cities and Towns* and the Austrian *Association of Municipalities*. It is part of the implementation of the *Austrian Climate Strategy* and the *EU Climate and Energy Package*. *klima**aktiv** mobil* provides a national framework to motivate and support various stakeholders to develop and implement measures to reduce CO_2 emissions from related transport activities, to promote environmentally friendly and energy efficient mobility and to stimulate new innovative business opportunities and green jobs. Between 2007 and 2016 more than 6,600 green mobility projects have been initiated. This made annual savings of 610,000 tonnes of CO_2 possible. In 2015, the BMLFUW allocated approx. 9 million EUR for *klima**aktiv** mobil* funding and about 2 million EUR for consulting, information and education programs, provided by the ministry, the *Climate and Energy Fund* and the *National Environmental Support Scheme*.

In 2006, the Austrian *Federal Ministry for Transport Innovation and Technology* (bmvit) founded the "***Austrian Association for Advanced Propulsion Systems (A3PS***)"[16] in order to support an active technology policy of the ministry and to strengthen Austrian research and development activities. A3PS is a strategic public-private partnership, serving as a reliable partner for the ministry as well as

[15] www.klimaaktiv.at/mobilitaet.html
[16] www.a3ps.at

for the partner companies and scientific institutions. A3PS addresses all advanced power train and vehicle technologies such as advanced ICE technologies, hybrid, battery electric and fuel cell vehicles as well as advanced fuel technologies including bio fuels and active safety measures such as ADAS and supports the whole innovation cycle including research, development and deployment.

The research program "***Mobilität der Zukunft***"[17], (*Mobility of the Future)* is an Austrian national transportation research funding program for the period of 2012 – 2020. The program was developed by the Austrian *Federal Ministry for Transport Innovation and Technology* (bmvit) based on experiences 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. The mission-oriented program focuses on the search for integrated solutions designed to help build the mobility system of the future, a system that must balance social, environmental, and economic needs. It includes four complimentary thematic fields addressed to different challenges and targets, respectively. These thematic fields are *Personal Mobility*, *Mobility of Goods*, *Vehicle Technology*, and *Transport Infrastructure*. The annual budget of *Mobilität der Zukunft* is between 13 and 19 million EUR.

The Program "***Leuchttürme der Elektromobilität***"[18] (Electric Mobility Flagship Projects) is a funding program within the *Climate and Energy Fund* and has created an opportunity for stakeholders from all kinds of areas such as automotive engineering, software development, usability optimization and even transport planning to tackle the issue of electric mobility together and in a highly focused manner. In the course of a realignment in 2014 a strategic perspective for several years was determined. In four calls until 2017 technologies which increase the range and decrease the cost of electric vehicles shall be developed. Main focus are topics such as production and design of vehicles, infrastructure, recycling, and reuse of vehicle components. This program has a budget of 5 million EUR.

The number of EVs in Austria increased by 44 % in 2016 compared to 2015. While light electric vehicles and buses show only small increases, the number of electric passenger vehicles increased by 80 % compared to 2015. Table 2 shows the fleet totals and sales of EVs, PHEVs, HEVs, and FCVs as of 31 December 2016 and during 2016, respectively.

Electric bikes, e-bikes or pedelecs (pedal-electric-vehicles) are defined as bicycles with assisting pedaling in Austria. The electric motor turns on automatically as one starts to pedal. When a speed of 25 km/h is reached, the motor turns off

[17] www.bmvit.gv.at/innovation/mobilitaet/mobilitaetderzukunft.html
[18] www.klimafonds.gv.at/foerderungen/aktuelle-foerderungen/2016/leuchttuerme-der-elektromobilitaet

automatically. The power of these vehicles must not exceed 600 watts. While these e-bikes are not counted by *Statistik Austria* and don't appear in Table 2, electric cycles with a power exceeding 600 watts are counted as mopeds and appear as part of the 2-wheelers in the table.

In 2016, the VCÖ (Verkehrsclub Österreich, a group which represents the interests of transport users) reported that Austria was third in terms of sold e-bikes per inhabitant in Europe[19]. In total, 77,220 e-bikes were sold in Austria in 2015 what means about 8,980 e-bikes per million inhabitants. In total, more than 300,000 e-bikes are expected to exist in Austria. For 2016, the VCÖ expected sales of about 90,000 e-bikes and about 900 electric mopeds.[20]

[19] www.vcoe.at/news/details/vcoe-oesterreich-bei-e-fahrrad-verkaeufen-an-dritter-stelle-in-europa
[20] www.vcoe.at/publikationen/infografiken/e-mobilitaet

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2016 (Data source: Statistik Austria)

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- Wheelers[a]	4,894	9		0	781,379
3-Wheelers and Quatricycles[b]	1,013	6		0	35,098
Passenger Vehicles[c]	9,073	2,287	17,746	13	4,821,557
Buses and Minibuses[d]	149	6		0	9,825
Trucks[e]	1,468	9		0	457,214
Totals without bicycles	**16,597**	**20,063**		**13**	**6,105,073**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- Wheelers[a]	1,352	0	0	0	44,664
3-Wheelers and Quatricycles[b]	126	0	0	0	3,219
Passenger Vehicles[c]	3,826	1,237	3,474	5	329,604
Buses and Minibuses[d]	22	0	0	0	39,958
Trucks[e]	449	0	0	0	4,106
Totals without bicycles	**5,775**	**1,237**	**3,474**	**5**	**421,551**

n.a. = not available
[a] UNECE categories L1 and L3
[b] UNECE categories L2 and L5-L7
[c] UNECE categories M1
[d] UNECE categories M2-M3
[e] UNECE categories N1-N3
[f] Including non-electric vehicles

Table 3: Available vehicles and prices (Data source: ÖAMTC; status as of September 2016)

Market-Price Comparison of Selected EVs and PHEVs in Austria	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Audi A3 e-tron	39,900
BMW i3	34,950
BMW i3 Rex	40,399
Citroen Berlingo	27,750
Citron C-Zero	19,490
Ford Focus Electric	34,900
KIA Soul EV AC	31,990
Mercedes Benz B-Klasse Electric Drive	39,600
Mercedes Benz S 500 Plug-In Hybrid	86,750
Mitsubishi i-MIEV	23,990
Mitsubishi Outlander PHEV	39,900
Nissan E-NV200 Evalia	31,800
Nissan Leaf	28,560
Opel Ampera	38,400
Peugeot iOn	26,640
Peugeot Partner	29,869
Porsche Panamera S E-Hybrid	109,218
Renault ZOE	21,390[1]
Renault Kangoo Z.E.	24,360[2]
Renault Twizy	7,180[3]
Smart Fortwo Electric Drive	19,420[4]
Tesla Model S 70 kWh	78,600
Tesla Model S 85 kWh Performance	116,000
Tesla Model X 75 kWh	99,700
Toyota Prius Plug-in	37,920
VW e-Golf	36,730
VW e-up!	26,210
VW Golf GTE	39,140

Data source: www.oeamtc.at/portal/elektrofahrzeuge-in-oesterreich+2500+1393831

[1] in addition rental rate for battery: from 49 EUR per month

[2] in addition rental rate for battery: from 73 EUR per month

[3] in addition rental rate for battery: from 50 EUR per month

[4] in addition rental rate for battery: from 65 EUR per month

Table 3 shows a selection of electric vehicles available in Austria in 2016. In 2016, as in 2015 and 2014, Renault Zoe was the most popular electric vehicle in Austria. Figure 3 represents newly registered battery electric passenger vehicles. Only those EVs which were registered as passenger vehicles are shown, but vehicles such as Renault Kangoo Z.E. or Nissan E-NV200 can be registered either as passenger vehicle or truck and therefore, are not counted here if registered as trucks. In December less EVs were registered compared to the month before – probably since the new EV purchase bonus for private individuals only becomes effective for EVs purchased after 1 January 2017.

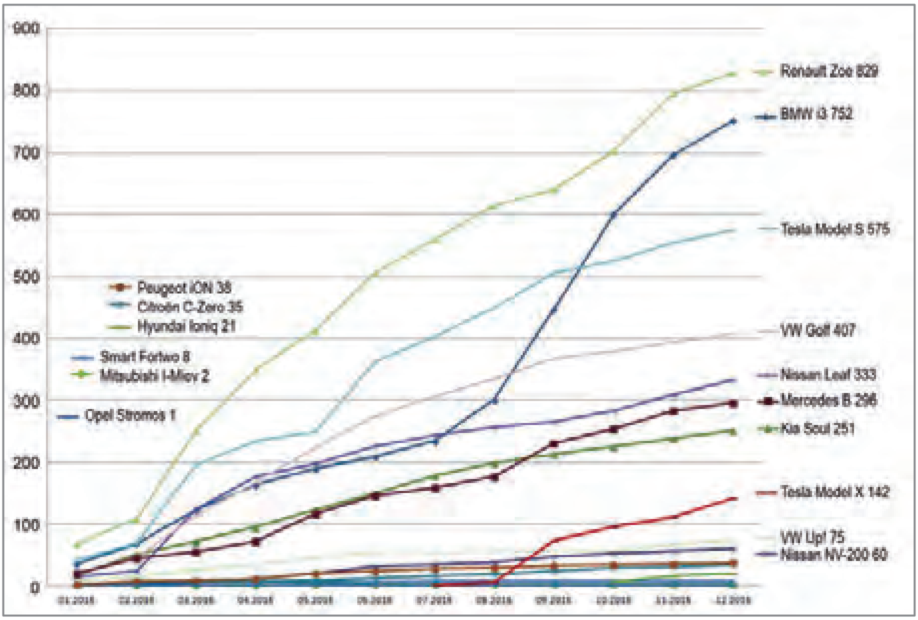

Figure 3: Newly registered electric passenger vehicles in Austria in 2016. (Source: https://myampera.wordpress.com/statistik/; based on Statistik Austria data)

17.5 Outlook

Several funding programs and incentives mainly focus on electric mobility at the moment. With the package of measures to support electric mobility with 72 million EUR presented in November 2016, which becomes effective in 2017, further increases of EV sales are expected. Several new car models will become available on the Austrian automobile market and the charging infrastructure is going to be developed further. Austria is also planning further development of the H_2 infrastructure linked to the market development of vehicles running on H_2.

18 Belgium

18.1 Major Developments in 2016

18.1.1 Electric Mobility in Belgium

Introduction

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 is under severe pressure in 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). A dedicated study on these economic opportunities has been concluded at the end of 2016 and was a cooperation between the following countries: Austria, Belgium, Denmark, France, Germany, the Netherlands, Switzerland, and USA. All results can be found in the chapter on Task 24 “Economic impact assessment of e-mobility” (see Chapter 5).

Since the beginning of 2016 the number of electric vehicles on the road in Belgium has grown significantly. Within the national action plan “clean power for transport”, new policy measures have been set up to stimulate the use of alternative fueled vehicles and related infrastructure. But also the local research and industrial activities on electric mobility are growing. Many interesting announcements were made in 2016 by different OEMs and suppliers in the e-mobility value chain. More electric vehicles on the road means more services like sales, maintenance and after-service, but more and more charging infrastructure, energy and mobility-related services are also possible. An important trend to mention is that we not only see growth in electric passenger cars. The market share of electric passenger cars in Belgium was 1.82 % in 2016 (source: www.eafo.eu/content/belgium). In addition, the interest in electrification of freight vehicles and vehicles used for public transportation such as electric buses is growing fast. The fastest growing market within electric mobility is that of pedelecs, which are becoming more and more popular for younger people and for commuting, and which already have a market share of more than 23 %.

Passenger cars

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.

The site of **Audi Brussels** in Belgium will become a key plant for electric mobility in the Volkswagen Group. Up to now it produces mainly Audi A1cars and has 2,500 employees. Audi Brussels assembled 105,205 units of Audi A1 and S1 in 2016 and for the 6th time in a row reached its goal in terms of production, that means assembling more than 100,000 units a year. The Top Employer Institute awarded Audi Brussels recently also as “Top Employer 2017”.

Figure 1: German Federal President Joachim Gauck and the Belgian royal couple visit the Audi plant in Brussels (Source: Audi)

Audi is preparing its international production network for the mobility of the future. As of 2018, Audi Brussels will exclusively produce the first battery-electric SUV from Audi for the world market. The Brussels plant will also have its own battery production.

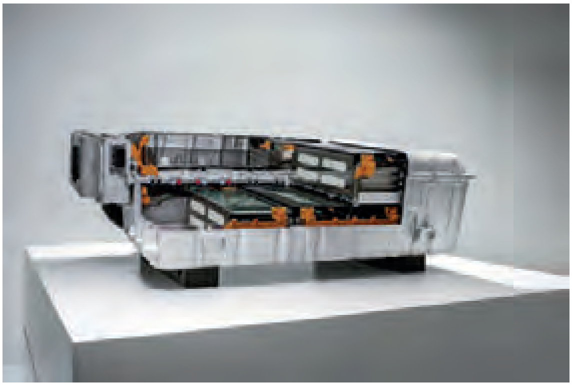

Figure 2: Audi e-tron quattro concept Pouch cell battery modul (Source: Audi)

The preparations for the new model Audi e-tron quattro are ongoing. At the end of 2016, Audi Brussels transformed line 1+2 in the assembly shop and pushed forward the new building for the body shop. The first prototypes of Audi e-tron were build up in the factory and Audi Brussels started the first trainings for the operators. 2017 will be a very challenging year for Audi because the transformation process has to go on whereas the assembly of the Audi A1/S1 must be guaranteed with the required quality and planned production-volume. But all projects are right on track and Audi Brussels is confident to reach its goals.

Volvo Cars Gent is producing cars in Ghent since 1965. In 2014, Volvo Cars Gent 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 Gent has been growing above 5,000 employees.

Figure 3: Employees training program Volvo V60 plug-in hybrid (Source: Volvo Cars, Gent)

After successful testing of the pure electric Volvo C30 prototype, Volvo Cars is now moving ahead with its electrification programme. The existing Volvo V60 plug-in hybrid, which is currently built in Volvo's assembly plant in Gothenburg, will move to Volvo Car Gent in early 2017 and will be the first plug-in hybrid car being built in Ghent. Volvo Cars Gent will spend a lot of attention to the training program of its employees for working with electric vehicles in the production line. This is a good preparation for the Volvo XC40 which will be the next model produced in Ghent and which will also be available in a plug-in version.

Training and lifelong education of employees plays a crucial role for companies to stay competitive, especially when new technology gets introduced. Audi Brussels and Volvo Cars Gent were both recognized for their personnel management. Volvo Cars Group has been recognised by the Ethisphere Institute, a global leader in defining and advancing the standards of ethical business practices, as a 2017 World's Most Ethical Company®. Audi Brussels was rewarded by the Top Employer Institute as "Top Employer 2016" and "Top Employer 2017" for creating excellent working conditions and development opportunities for its employees.

Besides car assembly, Belgium has a lot of other activities in the automotive sector. **Toyota Motor Europe** has its European headquarter, logistics centers, and technical R&D center in Belgium. Belgium has about 300 local automotive suppliers (for more details see below). There are assembly plants for trucks (**Volvo Europa Trucks**), heavy-duty vehicles (**MOL CY**) and for buses (**Van Hool** and **VDL Bus Roeselare**) in Belgium.

Electric Buses

Belgian bus companies Van Hool and VDL Bus Roeselare are very active in this field.

Van Hool, a Belgian independent manufacturer of buses, touring coaches and industrial vehicles, is very active in electric and fuel cell busses. Van Hool presented its inductively charged electric buses driving in the city of Bruges during Busworld 2015 (more information see chapter EV Demonstration Projects).

Figure 4: EquiCity Articulated Trolleybus with battery APU for TPG Geneva (Source: Van Hool)

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 coordinator of important fuel cell electric bus European projects like “High VLO City” and “3Emotion”, in which a total of 49 Fuel Cell Buses are being introduced in San Remo, Aberdeen, Cologne, Rotterdam, London, Antwerp and Rome.

VDL Bus Roeselare, part of VDL Bus and Coach, has put 43 Citeas SLFA Electric buses in operation at the end of 2016 in Eindhoven 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 2016-2025.

Figure 5: VDL Citeas SLFA Electric bus fleet in Eindhoven (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 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.

Freight logistics

We see also developments in other types of electric vehicles like electric cargo-bikes (**TheOpportunityFactory**) and city distribution vehicles (**E-trucks**, Addax Motors).

Addax Motors (www.addaxmotors.com) is convinced that, in the future, mobility in towns and cities will rely on small personalized, electric commercial vehicles. These vehicles will ensure cost and energy efficient, silent and environmentally friendly transport. Addax Motors is offering a full service solution which includes the technical, financial and administrative aspects – mobility as a service. The Addax Motors vans are electric and 100 % “Made in Belgium”.

Figure 6: Electric light commercial vehicles for green transport in cities (Source: Addax Motors)

Rhenus SML manufactures the Addax Motors electric vans on the suppliers’ park of the former Ford plant in Genk. The Belgian SML used to supply Ford Genk, and now builds suspensions for Audi Brussels. SML has shifted up a gear, and recently began making complete vehicles. In 2017, SML expects to produce a volume of 150 Addax MT 10 and 15 vans mainly for the BeNeLux market. In 2018, this could rise to 300 following interest from Sweden, France and the Netherlands. The vans don’t make any noise, neither do they release harmful emissions.

Consequently, they are ideal vehicles to bring goods from the edge to the center of cities, as well as for recreational and holiday parks and even for green waste collection. The light vans weigh 600 kg and can take a payload of up to 1,000 kg. They have a maximum range of 110 km on a fully charged battery.

Altreonic's aim is to bring solutions to the market that fulfill the promise of sustainable Mobility as a Service (MaaS) in urban environments. Their main contribution is the KURT lightweight electric vehicle platform (http://kurt.mobi) invented and developed by Altreonic. KURT is an enabler for urban electric mobility. Its modular and scalable architecture solves many issues that prevent light weight electric vehicle from taking off. With a low empty weight, it provides a much better load capability and better energy efficiency. It can be easily customised for a wide range of applications by adapting the superstructure. The result is a unique platform that allows Altreonic to develop new vehicle variants in a short period of time in a cost-efficient way. Also available under an Open Technology License.

Light electric vehicles

As for light electric vehicles, the electric bicycle has become the most successful vehicle in Belgium in the past few years. The trend was confirmed in 2016, with sales of 186,000 electric bikes, a 25 % increase compared to 2015. In 2016, more than 39 % of all newly sold bicycles were electric as opposed to 33 % in 2015. Their average value was 2,260 EUR, i.e. 4 % more than in 2015. The electric bike market in Belgium has a turnover of 420 million EUR, which is three times more than the market of full electric cars (Source: AVERE – Annick Roetynck).

There are a considerable number of Belgian electric bicycle assemblers, whereas all international leading brands are available as well. On average the quality of the electric bikes on offer is high and consumers have easy access to service. All bicycles are equipped with lithium-ion batteries offering a range that increases every year. Besides electric bicycle assemblers and resellers, we also see new market players focusing on new services like the easy and safe parking/charging/storage of expensive products like electric bicycles (www.gridbox.be). See also Task 23 for more details related to “Light-Electric-Vehicle Parking and Charging Infrastructure”.

The market of electric scooters/mopeds and motorcycles is still very limited in Belgium. The offer is restricted to a few brands only and prices are not competitive (yet) with those of ICE two-wheelers.

Suppliers

Belgium hosts about 300 suppliers to the automotive industry. A lot of the innovations in the automotive are taking place on the suppliers side. In Belgium we have renowed suppliers like e.g. Umicore, Siemens PLM Software, Melexis, PEC, Leclanché, DAF and Punch Powertrain. Most of these companies are active in electric mobility.

Umicore, the Belgian materials technology and recycling group, announced in April 2016 investments of some 160 million EUR over a period of three years at the company’s existing rechargeable battery cathode materials facilities in Cheonan (South Korea) and Jiangmen (China), as well as greenfield investments on adjacent land in both locations. These investments will enable the company to triple existing capacity by the end of 2018 across a broad range of material grades. The expansion is required to meet a surge in demand for materials used in hybrid and electric vehicles.

Figure 7: Demand for battery cathode materials growing significant (Source: Umicore)

One of the key elements in cathode materials is cobalt (Co). In December 2016, Umicore obtained third party validation for its sustainable procurement framework for cobalt. Umicore was the first company in the world to have introduced such a framework for cobalt supply and the first to obtain external validation for its ethical procurement approach in this area. In order to cope with the needs for Co for rechargeable battery materials, Umicore invested 25 million EUR in its Co refining and recycling plant in Olen, Belgium (http://rbm.umicore.com).

Punch Powertrain continued its efforts in 2016 to develop its first hybrid application with the customer. The hybrid electric powertrain has a transmission based on the VT2/3 CVT and uses a PMAC motor. The Switched Reluctance Motor developed earlier was not market ready for PHEV applications. The market launch of the first hybrid application is expected for 2018. In parallel, additional application projects are targeted with other customers.

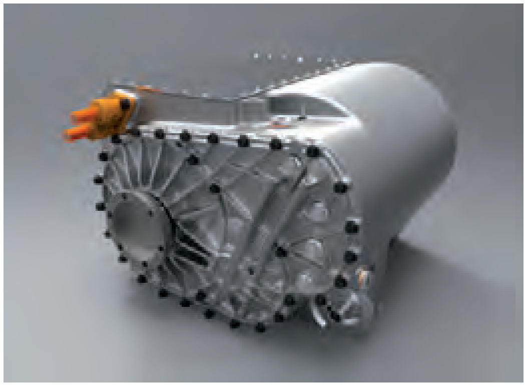

Figure 8: Fully integrated electric powertrain ARMEVA (Source: Punch Powertrain)

2016 was also the final year of the ARMEVA project (EU-FP7, project 605195). Punch Powertrain was project coordinator and together with the other partners (Siemens, TeKshift, Technical University Cluj-Napoca, Prodrive Technologies and Technische Universiteit Eindhoven) an EV demonstrator with a fully integrated electric powertrain was built and demonstrated. The powertrain contains a newly developed powerful and silent Switched Reluctance Motor.

Figure 9: Junior electric single seater (Source: Punch Powertrain)

Punch Powertrain also elaborated an electric trike demonstrator and started the preparation of an electric powertrain for an electric race car which had its world premiere on EEVC (Geneva).

PEC (www.peccorp.com) delivers the building blocks for the development and manufacturing of large format cells and modules used in electric mobility. In 2016, PEC released a new generation of battery cell testers, the ACT0550 and CT0550, specifically designed for materials research, life cycle testing and simulation of

Hybrid and Battery Electrical Vehicles applications, supporting currents up to 4,000 Amps.

Figure 10: Automated cell finishing lines improve battery cell cycle life and performance (Source: PEC)

In 2016, PEC continued the delivery of its automated cell finishing lines to cell makers all over the world. Recent customer research showed that battery cells produced on PEC's automated cell finishing lines have a much better cycle life and show an improved consistency in cell capacity and impedance due to a more homogenous forming of the SEI layer in the battery cell.

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 internationalization.
- **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, etc.) 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.

Research Institutes

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 2016 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 to take a look at the following websites:

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

VUB-MOBI: The Mobility, Logistics and Automotive Technology Research Centre (MOBI) is nested at the Vrije Universiteit Brussel (VUB) and is a leader in electric and hybrid vehicles and in socio-economic evaluations for urban mobility and sustainable logistics. It delivers social, economic and environmental impact studies, decision-making support, modelling and simulation, engineering and standardization. The centre has a strategic role in the strategic research center for the manufacturing industry in Flanders (Flanders' MAKE). It is heading the Virtual Department VD1 Power Electronics and Energy Storage (formed by VUB-MOBI, KULeuven-ELECTA and UGent-EEDT), responsible for the research priority “Clean and energy efficient motion”.

Flanders' MAKE: Flanders Make is the strategic research centre for the manufacturing industry and works together in a structural way with research departments of the 5 Flemish universities. The aim is to realise a top-level research network in Flanders that delivers full support to the innovation projects of manufacturing companies to contribute to new products and processes that help to realise the vehicles, machines and factories of the future.

VITO/EnergyVille: EnergyVille is an association of the Flemish research institutes KULeuven, VITO, imec and UHasselt in the field of sustainable energy and intelligent energy systems. EnergyVille provides expertise to industry and public authorities on energy-efficient buildings and intelligent energy networks for a sustainable urban environment. Electric vehicles will play an important role in energy networks based on more and more renewable energy sources. EnergyVille is performing research on batteries (stationary and vehicles), battery management systems, grid integration, demand side management, energy management systems, business models, etc.

18.1.2 National Policy Framework – “Alternative Fuels Infrastructure”

In response to the Directive 2014/94/EU of the European Parliament and of the Council of October 22, 2014 on the deployment of alternative fuels infrastructure, Belgium has developed a policy framework regarding alternative transport fuels/infrastructure.

The introduction and roll out of alternative fuels in the Belgian transport sector could contribute significantly to the following objectives: the reduction of our oil dependence, the integration of more renewable energy in the transport sector, the strengthening of our economy and the creation of additional employment, the improvement of air and sound quality and the fight against climate change. However, a significant introduction of alternative fuel vehicles has progressed relatively slowly over the past few years in Belgium. This is mainly due to some persisting barriers that are difficult to overcome, such as for example: higher purchase prices of alternative fuel vehicles, the lack of recharging infrastructure, limited driving range and the lack of objective and correct information (which causes prejudices among consumers).

Given the complex institutional context in Belgium (both regional and federal entities are directly involved) and the various involved policy areas (such as economy, mobility, energy, environment, finances), an interdepartmental transversal government working group (Energy-Transport) was created.

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. However, the Regions of Belgium (i.e. Flemish Region, Walloon Region and Brussels-Capital Region) are competent for most aspects of Directive 2014/94.

Also the cooperation with neighboring countries is taken into account e.g. via the Benelux recommendation M(2015)10 on cooperation regarding the deployment of infrastructure for alternative fuels which was signed in October 2015 by the three Benelux countries. This cooperation aims to strengthen the exchange of knowledge and best practices on the deployment of infrastructure for alternative fuels in the territories ensuring a minimum coverage by the end of 2020, 2025 and 2030.

Underlying regional and federal policy frameworks aim at providing an overview of the current and/or planned policies and measures in favor of the development of alternative fuel infrastructure and vehicles in Belgium. Moreover, specific targets have been determined regarding the roll-out of alternative fuels infrastructure in Belgium.

Table 1: Division of competences regarding alternative fuels in Belgium (Source: National Policy Framework Belgium)

	Federal	Regional	Local (municipalities)
Fiscal measures	• Tax reduction motorcycles, tri- or quadricycles; • Deductibility of clean company cars; • System of taxable benefits of all kinds (company cars); • Excise duties.	• Purchase premium for electric vehicles (private individuals); • Car registration tax; • Annual circulation tax; • Kilometer based road charge.	/
Mobility and Transport	• Highway code; • Registration of vehicles; • Technical standards of vehicles.	• Public road infrastructure (highways and regional roads); • Availability of alternative fuels on rest areas along highways; • Public refueling and charging infrastructure; • Vehicle inspection; • Homologation vehicles; • CNG/LNG/Shore Power installations in ports and along inland waterways; • Public transport (bus/tram); • H2 installations.	• Public road infrastructure (local roads); • Parking facilities on municipal territory.
Energy	• Access to transmission network; • Security of supply.	• Regulation of gas and electricity retail markets; • Access to distribution networks; • Distribution tariffs; • Renewable energy sources (except offshore wind energy); • Energy R&D (except nuclear).	/
Economy and other	• Standardisation/ normalisation; • Price indication of energy products and inspection of price indications.	• Integration of refueling and charging points in petrol stations; • Development of public network of refueling and charging infrastructure; • Spatial planning.	/

Table 2: Number of targeted recharging points in Belgium (2020) (Data source: National Policy Framework Belgium)

Targeted recharging points (2020)	TOTAL	Flemish Region	Walloon Region	Brussels Capital Region
Normal and high power recharging points (Public)	86,641	74,100	9,903	2,638
Shore-side electricity supply in maritime and inland ports	42,584	41,000	1,344	240

Flemish policy framework

The Flemish policy framework regarding alternative fuels infrastructure for transport in response to Directive 2014/94/EU is based on the Action Plan on the deployment of alternative fuels infrastructure as adopted by the Flemish Government on December 18, 2015. With this Action Plan, the Flemish Government wants to accelerate the transition towards the roll out of an alternative fuels vehicle market in Flanders and to support the European dimension regarding this topic, e.g. in rolling out cross-border infrastructure for alternative fuels. As observed in other countries, multiple actions will be set up simultaneously in order to achieve the maximum effect. Market support for green vehicles must be accompanied by the development of charging and refuel infrastructure while at the same time informing the stakeholders concerned, including the early adopter-drivers of Clean Power vehicles. In conclusion, the implementation of the actions as defined in the Action Plan should operate as a driving force during the period of 2015-2020, stimulating future Clean Power development.

The Action Plan focusses on four-wheelers and integrates 2020 objectives for electric vehicles and vehicles on natural gas as well as objectives for charging and refueling infrastructure. Long-term goals (horizon 2025 and 2030) are to be further explored and examined. The main actions stimulate the market uptake for Clean Power vehicles and aim for a fast expansion of the infrastructure required. The actions should remove the main barriers as experienced by current users, more specifically the purchase price, the lack of charging infrastructure and the limited user knowledge regarding Clean Power. A well-organized coordination structure with working groups for the implementation, including feedback and reporting mechanisms, ensures the transversal character and the involvement of all stakeholders concerned in the policy development. Key concerns are clear consumer information, visibility and user friendliness.

In order to reach the targets set forward in the Flemish Action Plan, the following policy measures will be implemented:

- Fiscal incentives for Clean Power vehicles (exemption from registration and annual circulation taxes);
- A zero-emission premium of 5,000 EUR maximum for individuals when purchasing battery-electric or hydrogen vehicles
- The obligation for the Distribution Grid Operators (DGO's) to make sure that 5,000 publicly accessible charging points are installed through public procurement in 2020
- The introduction of a notification requirement for publicly accessible charging points
- The setup of a website dedicated to Clean Power and an accompanying communication campaign
- The development and provision of a tool to compare the total cost of ownership (TCO) of Clean Power vehicles to one another and other vehicles
- The deployment of the first publicly accessible hydrogen refuelling stations
- The setup of actions to encourage the use of shore power for vessels on inland waterways
- The design of an electric mobility guide for local governments
- The mobilization of funds (1 million EUR each year) to support studies (e.g. light electric vehicles) and Clean Power projects
- The 2 year prolongation of the financial support provided under the ecology subsidy to companies for the installation of electric charging infrastructure
- The initiation of projects regarding niche market fleets, e.g. taxis
- The exploration of potential deployment of public electric busses

The first results from some of these policy measures can be found here below and in the other chapters of this country report.

Electric mobility guide for local governments

Flemish Minister of Energy Bart Tommelein presented the “Electric mobility guide for local governments” on December 10, 2016 at the start of the information campaign “Week of Clean Vehicles”.

Figure 11: Electric mobility guide for local governments (Source: The New Drive)

The purpose of the guide is to inform, inspire and especially activate the local authorities to get started with electric driving. Besides an introduction about electric driving, the guide will give practical advice and inspiration to local governments since they play a very important enabling role in the roll-out of electric mobility.

TCO comparison web tool

In 2016, the Flemish government launched an easy-to-use, visual attractive web tool to allow companies, governments and individuals to compare electric, plug-in hybrid and conventional cars in terms of Total Cost of Ownership. The web tool user is able to fill out 5 questions and select two individual cars in a certain segment. The tool then compares the two individual cars and offers a TCO comparison on multiple components such as purchase price, insurance, repair and maintenance, and fiscal incentives. The TCO tool was introduced during the Brussels Motor Show and is available on **www.milieuvriendelijkevoertuigen.be**.

Walloon policy framework

Wallonia has decided to put forward a fair balance between the rapid technological developments in the sector and the opening-up of the market, on the one hand, and the fragile budgetary context which has to be optimized in order to offer real opportunities for each alternative fuel without being too burdensome for the region and the community as well as for individuals.

The objectives set up in the plan were taken on a basis of a “business as usual” scenario which provides a fairly optimistic growth of the number of vehicles and infrastructures within four years. The rapid technological evolution regarding the electric mobility sector has led to the choice not to set up objectives in 2025 and 2030. Wallonia is convinced that major breakthroughs are going to occur in between that can lead to a major and more rapid slide to BEV/PHEV after 2020.

At this point, Wallonia has decided not to favor one or another technology in order to keep the market in a fair competition. On the other hand, this choice must lead to a more controlled growth that may avoid major congestions on the electricity grid mainly.

As we have already noticed, the deployment of the infrastructures, i.e. electric charging points, has already followed growing curves in major cities and in more densely populated regions of Wallonia and the trend will be reinforced in the coming years. A major attention will be kept on more fragile rural regions of the southern part of Wallonia.

Brussels policy framework

The Brussels Capital Region (BCR) is facing important challenges in improving local air quality and reducing road congestion. Especially the numerous diesel vehicles daily entering and circulating the roads contribute strongly to the emissions of particulate matter and nitrogen oxydes, causing important health problems, as well as damage to ecosystems and cultural heritage. Changing the way of transportation towards more sustainable modes of transport (walking, cycling, public transport) is the main driver in the regional mobility policy and is translated in the region’s objective to reduce motorized traffic by 20 % by 2018, compared to 2001.

In order to reach the BCR’s targets regarding air quality and climate change, additional actions are necessary. These actions have been defined by the ‘Air-Climate-Energy Plan’ (ACE plan), adopted on June 2, 2016 by the Brussels’ regional government. Besides rationalizing the transport demand and encouraging a modal shift, the plan includes several measures to improve the environmental performance of vehicles. The introduction of a Low Emission Zone (excluding the most polluting diesel and petrol cars, vans and buses) on the complete BCR territory as of January 2018, is one of the most important measures which have been decided upon. The vehicle taxation (annual circulation tax and registration tax) will also be reformed, as part of the ACE plan, giving an advantage to environmentally friendly vehicles.

Alternatively fueled vehicles form an interesting solution for the nuisance caused by conventional diesel and petrol vehicles, although these vehicles will not resolve the congested roads. Seen the urban context of the BCR and the fact that on average only 5 kilometers are travelled inside the region per trip, electric vehicles are considered as the most promising alternative vehicle technology. This is especially the case for captive fleets, such as taxis, car sharing, public fleets, etc.

To stimulate the transition towards electric transport, the BCR has already taken different measures, e.g. quota on electric cars in the public fleets, financial support for small and medium enterprises to purchase hybrid, electric and fuel cell vehicles, electric taxis, etc. The public transport company in the BCR (STIB – MIVB) is also preparing the transition towards electric buses, following a test period with three fully electric bus lines.

In 2017, the deployment of a public charging infrastructure network will take a lead, with an objective to have 200 recharging points by 2020 for 2,000 electric cars and 600 light duty vehicles. Currently, only one public CNG station is operational in the BCR, which will be expanded towards three public stations by 2020.

The port of Brussels (an inland port, part of the TEN-T core network) will also start the transition towards alternative fuels for vessels with the installation of three shore-side electricity supply points by 2020, as well as one LNG refueling point by 2030.

The urban context and limited presence of motorways on the BCR territory directs the objectives of the Brussels policy framework strongly towards electric recharging infrastructure. Infrastructure for hydrogen or LNG for heavy duty vehicles is currently not included in this policy framework due to safety considerations within our densely populated region.

Federal policy framework

The main elements with regard to Directive 2014/94 can be found in the policy frameworks of the three regions being mainly competent for aspects regarding alternative fuels infrastructure.

The federal part of the Belgian policy framework describes the main federal policy measures/competences which directly or indirectly regard alternative fuels / vehicles / infrastructure. The federal part goes beyond the scope of Directive 2014/94.

The federal government of Belgium however played an important role in support actions like the coordination of the national policy framework. The Federal Public Service of Economy and the Federal Public Service of Mobility and Transport coordinated the national concertation and development of the Belgian policy framework. In the ENOVER-Transport working group, all regional and federal energy and mobility related policy makers work together. Input from industry and research is collected via stakeholder meetings and communication has been done via the “Belgian Platform Alternative Fuels”.

The federal government also plays a coordinating role in Belgium related to the cooperation with the other policy levels: Benelux, EU Sustainable Transport Forum, IEA TCP Hybrid and Electric Vehicles, etc.

Main federal policy measures/competences are related to federal fiscal measures (see Table 1: Division of competences regarding alternative fuels in Belgium (Source: National Policy Framework Belgium), economy and employment (see Audi Brussels), mobility and transport (networked and integrated transport) , energy and environment (synergy electric mobility and renewable energy), federal government fleet, standardization (CEN – NBN) and security.

18.1.3 Other Policy / Incentives

Low-emission zones in Flanders (LEZ)

Cities in Flanders can introduce low-emission zones starting from March 2016.

Figure 12: New road signs for low-emisision zones in Flanders (Source: Flemish Government – Environment, Nature and Energy Department)

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. Other cities in Belgium will follow.

Green Deal Shared Mobility

Inspired by the Dutch Green Deal on car-sharing, Autodelen.net, The Shift, The New Drive and Taxistop took the initiative to launch a Green Deal Shared Mobility with the Flemish Government.

The aim of the Green Deal is to accelerate the growth of shared mobility (car-sharing, carpooling and bike-sharing) in Flanders. The Green Deal is a partnership of many different organisations who are willing to undertake actions and to remove barriers to provide alternatives to car ownership.

The Green Deal, launched on March 27, 2017, is an engagement between several parties and the Flemish government. At the moment of the kick-off, 80 organisations have signed the deal with three Flemish Ministers: Bart Tommelein (Energy), Ben Weyts (Transport and public works) and Joke Schauvliege (Environment). The signing organisations have chosen their own actions to contribute to the four objectives of the green deal, with 2020 as horizon.

Speed Pedelec

Last year marked the breakthrough of the fast electric bike, the so-called speed pedelec with a motor that assists up to 45 km/h. This new type of light electric vehicle convinces people who live 30 km and more away from work to swap their car for a bicycle.

The speed pedelec is still subject to a lot of confusion and uncertainties, especially in relation to its terms of use. Speed pedelecs look like conventional bicycles and function as their 25 km/h counterparts: the cyclist should pedal to engage the motor. As soon as he stops pedaling, the motor stops assisting. Despite this, speed pedelecs fall in the scope of type-approval legislation for L-category vehicles. They have been categorized as L1e-B “mopeds”. Whilst type-approval is a European harmonized system, the terms of use for the L-category vehicles (such as helmet obligations, insurance, traffic code), are still largely national competence.

Belgium is one of the first member states that has taken clear-cut decisions on most of the terms of use for speed pedelecs. First, in the traffic code, a new vehicle category specifically for speed pedelecs has been created. Secondly, Belgium allows the use of bicycle helmet instead of motorcycle helmets. Finally, it has created the possibility for road authorities to allow speed pedelecs on cycle paths and to grant them the same privileges as conventional and "slow" electric bikes, such as riding both ways in one-way streets, turning right at red traffic lights, etc. Also a specific licence plate starting with the letters 'S-P' has been introduced. Some issues are not yet clear like whether speed pedelecs are subject to a motor insurance or not.

18.2 HEVs, PHEVs and EVs on the Road

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

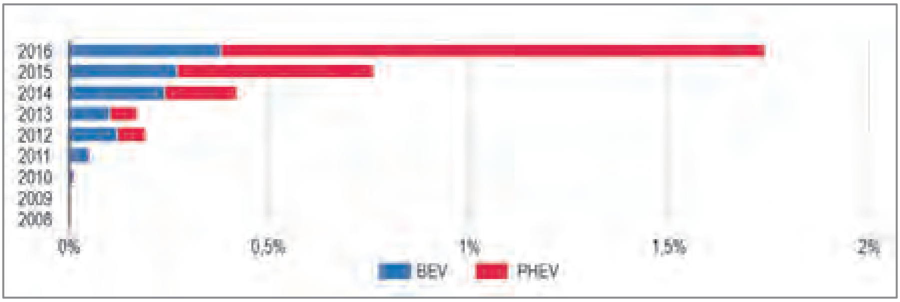

Figure 13: PEV (M1) market share in Belgium (Source: EAFO)

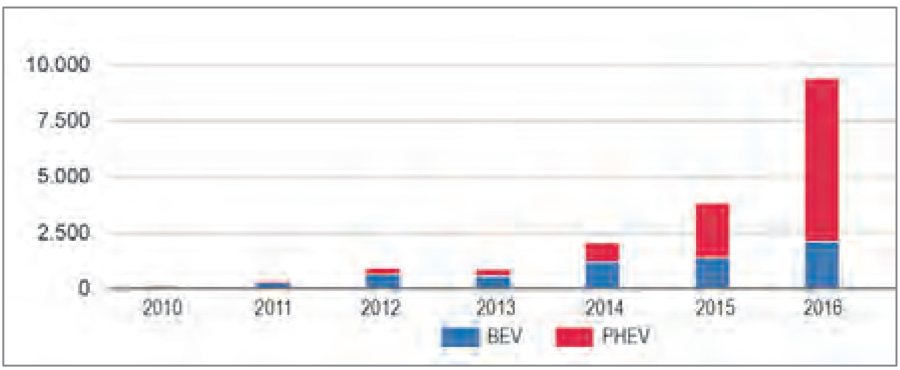

Figure 14: New registrations for PEV (M1) in Belgium (Source: EAFO)

Most sold electric passenger cars in 2016 are PHEVs with as top sellers Volvo XC90, BMW X5 40e and Porsche Cayenne. Within the BEVs segment, the top sellers in 2016 are Tesla Model S, Nissan Leaf and BMW i3.

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: www.eafo.eu.

The European Alternative Fuels Observatory has been launched in 2016 and collects information about the electric vehicles market in Europe. The geographical scope consists of all EU Member States, the EFTA members (Iceland, Norway, Switzerland, and Liechtenstein) and Turkey. The update frequency for the statistics: monthly for passenger cars; quarterly for all other vehicles and infrastructures (if data is 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.

18.3 Charging Infrastructure or EVSE

18.3.1 Introduction

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 standardized way. Thus, big improvements are needed in user-friendly access to charging infrastructure information.

Triggered by these end customer needs and by the European and national/regional governments, the market for charging infrastructure is trying to organize itself to aim 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 “code-of-conducts” 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.

Within the National Policy Framework “Alternative fuels infrastructure” extra policy measures have been taken to stimulate the market for charging infrastructure. Some examples from the Flemish policy framework are:

- The obligation for the Distribution Grid Operators (DGO’s) to make sure that 5,000 publicly accessible charging points are installed through public procurement in 2020
- The introduction of a notification requirement for publicly accessible charging points
- The setup of a website dedicated to Clean Power and an accompanying communication campaign
- The design of an electric mobility guide for local governments
- The 2 year prolongation of the financial support provided under the ecology subsidy to companies for the installation of electric charging infrastructure

These measures aim for having more publicly accessible charging points and for giving the potential EV drivers more accurate information. All information will be centralized on the following website: **www.milieuvriendelijkevoertuigen.be**.

18.3.2 Statistics on charging infrastructure in Belgium

For statistics on charging infrastructure in Belgium we refer to the website of EAFO (www.eafo.eu/content/belgium) and to the databases on the website related to the Flemish policy framework “Alternative fuels infrastructure” (www.milieuvriendelijkevoertuigen.be). Below you can also find the number of charging points as mentioned in the National Policy Framework Belgium.

Table 3: Number of current recharging points in Belgium (Data source: National Policy Framework Belgium)

Current recharging points	Totals	Flemish Region (June 2016)	Walloon Region (31/12/2015)	Brussels Capital Region (31/12/2015)
Normal power recharging points (Public)	522	251	212	59
High power recharging points (Public)	84	70	3	11
Normal power recharging points (Private)	2,667	2,348	237	82
High power recharging points (Private)	1,030	1,013	17	0
Shore-side electricity supply for inland vessels in maritime and inland ports (Terminals)	329	285	44	0
Shore-side electricity supply for sea-going vessels in maritime and inland ports (Terminals)	9	9	n.a.	0
Electricity supply for stationary airplanes	Present	Present	Present	n.a.

18.4 EV Demonstration Projects

18.4.1 ECAR

ECAR (www.ecar333.be) was shown as a concept on the Brussels Motorshow 2015. Since then business angels have provided funds through three consecutive capital increases and a regional subsidy has been obtained to develop and homologate the first rolling vehicles. This will be achieved by March 2017 and final prototypes were shown at the Brussels Motorshow in January 2017 creating a lot of interest of regional and national government. Target sales for 2017 is 50. Industrial partners have been identified who will industrialize the whole concept.

Figure 15: ECAR (Source: Xavier Van der Stappen)

ECAR is an L5 category fully electrical vehicle aiming at being different than a traditional car and affordable through its simplicity. It is a 3-wheel category simplifying the homologation track but also light weight product whilst still seating three people and reaching 130 km/h speeds. With one battery set an autonomy of 150 km can be reached and 300 km with two battery sets. These batteries will be rented as a second life is planned as home battery stretching overall life of the battery to over 20 years, time at which recycling will generate a surplus versus its cost.

18.4.2 Zen Car

Zen Car (www.zencar.eu) started in Brussels with Car Sharing of Electric Vehicles in Brussels in 2011. After a slow start to obtain spaces in the public domain, the benefits of EV Car Sharing are becoming a part of City Policies.

Figure 16: Car Sharing in Brussels (Source: Zen Car)

In 2016, Zen Car has reached 100 cars (Renault Zoe, BMW i3 and others) parked on the public domain on triple A locations and with the appropriate charging infrastructure. In 2017, Zen Car will reach 200 cars in Brussels and achieve financial break even. This means the time is right to roll out to other cities with priority on Antwerp, Liège and Luxembourg.

18.4.3 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). 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. By this the e-taxi project will be examined about how feasible it is to make the taxi fleet electric in Flanders by 2020 and what the economic and ecological impact is.

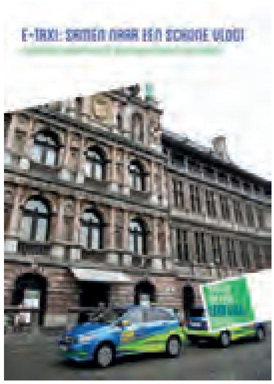

Figure 17: Brochure with results from E-taxi pilot project (Source: BBL)

This project will be continued by the project **"Clean Power for Taxis"** led by BBL and GTL with support from the Flemish government. The scope of the project is to have at least one out of ten taxi's driving electric in 2020. The "Clean Power for Taxis" builds further on the pilot projects in Antwerp and Louvain and will roll-out also in Bruges, Ghent and Mechelen.

In Brussels, the taxi sector made its first steps in introducing electric vehicles into its fleet already by 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, so today these electric taxi's in Brussels have to rely on the fast chargers at VUB-MOBI and Engie Electrabel.

18.4.4 E-Buses

ZEB Platform and ZeEUS

Projects like ZeEUS (http://zeeus.eu) and events like Busworld Europe (www.busworld.org) prove that the market of electric buses is in full expansion worldwide. The ZeEUS project produced in 2016 a very comprehensive overview of the electric buses being used in Europe today and gives information about 61 European cities and 27 bus manufacturers. From Belgium, input was foreseen from the city of Bruges and from bus manufacturers Van Hool and VDL Bus and Coach. VITO gave support in creating the ZeEUS eBus Report. An update from the report is foreseen in 2017.

Figure 18: ZeEUS eBus Report (Source: UITP – the International Association of Public Transport)

At the end of 2016, a new initiative in Flanders has also been approved: **ZEB Platform** (www.platformzeb.be). The Zero Emission Bus project aims to accelerate the transition to zero emission bus transport in Flanders, by improving the cooperation and knowledge sharing between the different stakeholders.

Figure 19: FBAA Symposium on electric public transport (Source: FBAA)

The ZEB platform will also work closely together with the ZeEUS project, to translate the huge amount of knowledge build up by ZeEUS on the European level to the local situation in Flanders. The ZEB platform had his first symposium at FBAA (available at www.vimeo.com). The public transport authorities and operators were informed about the barriers and opportunities of introducing electric buses in operational use. The next event of the ZEB platform will be on Busworld 2017.

TEC Group ordered 90 electric hybrid buses and 12 charging stations for Charleroi and Namur

TEC Group has very ambitious plans in the electrification of its bus fleet.

Figure 20: Volvo 7900 Electric Hybrid charging in Namur (Source: TEC Group)

The Belgian cities of Charleroi and Namur are to receive 90 **Volvo 7900 Electric Hybrid buses** and **12 ABB charging stations** as part of a complete solutions contract with Volvo Buses. Charleroi will introduce 55 Volvo 7900 Electric Hybrids and 4 ABB charging stations. This order comes on top of the previous order for Namur and brings the total for both cities to 101 Volvo electric hybrids and 15 ABB charging stations! This will be the largest single network of electric buses and bus charging systems in Europe.

TEC Group previously ordered 11 Volvo 7900 Electric Hybrids along with charging stations for Namur, a system that became operational in January 2017. Once the 35 extra electric buses for Namur are on the roads, 90 percent of Namur's public transport will be electrified!

Figure 21: Opportunity charging station in Namur (Source: ABB)

In January 2017, ABB inaugurated the first two OppCharge bus charging stations ordered in February 2016, to power eleven electric hybrid buses running within a new zero-emissions zone in the city center of Namur. The charging stations will fully charge the electric hybrid buses with 150 kW of charging power in three to six minutes during layover times at the bus route's end points. ABB's fast chargers are compliant with the open Interface **OppCharge** (www.oppcharge.org), which means that buses from other manufactures can also be charged. The scope of ABB's second contract is a complete turnkey project to charge the additional 90 Volvo Electric Hybrid buses and includes 12 150 kW charging stations, substations, switchgear, civil works, installation and a service contract. ABB's fast charger connectivity includes remote diagnostics and management, and over-the-air software upgrades to ensure a fast response and high availability. With over 5,000 web-connected DC fast chargers sold around the world, ABB's connectivity solutions have delivered industry leading uptimes.

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.

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.

Figure 22: Electric bus inductively charged in city of Bruges (Source: www.benweyts.be)

Since October 2015, three electric buses built by Van Hool with batteries packaged in Belgium by Emrol (now Leclanché) are in use by public transport operator De Lijn. The buses are being quick charged via an inductive charging station (Primove) from Bombardier.

18.4.5 Light Electric Vehicles

Last year, the Department for Environment, Nature and Energy has launched a tender for a study of the potential of LEVs. This study will be carried out in 2017 by VUB, KULeuven and ASBE. The same department has granted funding for a project comprising six EV and LEV-roadshows. These initiatives are part of the National Policy Framework – "Alternative fuels infrastructure".

18.5 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 early 2016 its activities 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 strategic research centre smart manufacturing gets support for its research program 'Autonomous Vehicle and Infrastructure Cooperative Architecture'. The objective is to create a demonstration environment for automated vehicle technologies to facilitate the take up in public transport in the coming years.

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.

19 Canada

19.1 Major Developments in 2016

19.1.1 National Developments

Pan-Canadian Framework

In March 2016, Canada's First Ministers issued the Vancouver Declaration[21] on clean growth and climate change. The First Ministers agreed to develop a pan-Canadian Framework to achieve Canada's international commitments in the Paris Agreement. They agreed to implement policies in support of meeting or exceeding Canada's 2030 target of a 30 % reduction below 2005 levels of greenhouse gas emissions and transitioning Canada to a stronger, climate- resilient, low-carbon economy. A made-in-Canada plan to tackle climate change and grow the economy will cut across all sectors of Canada's economy through a variety of measures, including putting a price on carbon pollution, seeking energy-efficient solutions for our buildings and vehicles, and making our electricity cleaner. Four working groups, comprised of federal, provincial and territorial officials were established to develop options, considering the following: How and where to reduce emissions, ideas for new innovation, technology and job creation, pricing carbon pollution, and preparing for and responding to the impacts of climate change.

In December 2016, the Government, along with provinces and territories, worked with Indigenous partners and adopted the Pan-Canadian Framework on Clean Growth and Climate Change[22]. The Framework follows commitments made in the Vancouver Declaration of March 2016 and in the United Nations Paris Agreement on climate change. It builds on provincial and territorial measures to reduce greenhouse gas emissions, and identifies ways that governments, business and civil society can seize the many economic opportunities afforded by the global clean growth economy.

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[21] Office of the Prime Minister, "Communiqué of Canada's First Ministers," http://pm.gc.ca/eng/news/2016/03/ 03/communique-canadas-first-ministers, March 3, 2016, accessed May 2, 2017.
[22] Climatechange.gc.ca, "Clean Growth and Climate Change Working Group Reports," www.climatechange.gc.ca/default.asp?lang=en&n=64778DD5-1, accessed May 2, 2017.

COP22

The Government of Canada, as a member of the Clean Energy Ministerial – Electric Vehicles Initiative (EVI), signed a Government Fleet Declaration[23] during a Zero Emissions Commercial Vehicles session at the Marrakech Climate Change Conference (COP22), in November 2016. The Declaration emphasizes the renewal of government fleets and showcases specific and voluntary commitments of the endorsing countries to accelerate the introduction of low-emission vehicles in their vehicle fleets. Through this Declaration, the eight signatory governments are taking a leadership role in this movement and sending a strong signal for the need to speed up the transition to low-carbon transportation. The 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 (EVs) worldwide. In particular EVI seeks to facilitate the global deployment of 20 million EVs, including plug-in hybrid and fuel cell vehicles, by 2020.

Investing In Electric Vehicle and Alternative Transportation Fuels Infrastructure

The 2016 federal budget allocated 48.3 million USD over two years to Natural Resources Canada to support the deployment of infrastructure for alternative transportation fuels, including charging infrastructure for EVs, as well as natural gas and hydrogen refueling stations. The funds also support technology demonstration projects that advance EV charging technology.

Calls for proposals for the Electric Vehicle and Alternative Fuel Deployment Initiative, as well as for the Energy Innovation Program – Electric Vehicle Infrastructure Demonstrations component were launched in May 2016 and, as of March 31, 2017, two projects have been announced. The funding available under this initiative is entering its second and final year, therefore, many developments in terms of infrastructure deployment and technology demonstrations are planned to take place throughout 2017.

A first deployment project[24] of 25 electric vehicle fast-charging stations at Canadian Tire Gas+ locations across Ontario was announced in December 2016, and is led by AddÉnergie, a Québec-based EVSE manufacturer and network operator. The charging stations will be installed at strategic locations along some

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[23] Clean Energy Ministerial, "Major Countries Commit to Increasing the Share of Electric Vehicles in Government Fleets," www.cleanenergyministerial.org/News/major-countries-commit-to-increasing-the-share-of-electric-vehicles-in-government-fleets-76834, November 21, 2016, accessed May 2, 2017.
[24] CNW, "AddÉnergie powered by Natural Resources Canada to expand FLO, its electric vehicle charging network in Ontario," www.newswire.ca/news-releases/addenergie-powered-by-natural-resources-canada-to-expand-flo-its-electric-vehicle-charging-network-in-ontario-604794046.html, December 5, 2016, accessed May 2, 2017.

of Ontario's busiest highways and the charging infrastructure at each location will consist of a direct-current fast charger (DCFC) compatible with vehicles equipped with CHAdeMO or SAE Combo charging ports, as well as dual Level 2 curbside charging stations. The announced stations will expand AddÉnergie's FLO Network, which is discussed in more detail later in this Chapter. The project value is estimated at 1.35 million USD and includes a repayable financial contribution of 628,000 USD from Natural Resources Canada.

A first demonstration[25] project was announced in February 2017, to develop innovative charging technologies for residential, commercial and public applications at various locations in Canada. The project value is estimated at 12.7 million USD, which includes a repayable financial contribution of 5 million USD from Natural Resources Canada. This support will allow AddÉnergie to develop the next generation of fast-charging stations for EVs, to serve the greater variety of EV models that will be available to consumers in the next five years. It will also enable AddÉnergie to continue developing a new and innovative business model that will help Canadian consumers and businesses access charging services on a monthly subscription basis, much like cable television service. This formula will address the cost barrier involved in acquiring and installing charging infrastructure in both the residential and commercial markets. Finally, AddÉnergie will use the Federal funding to install charging stations designed especially for curbside use in five major Canadian cities, using the expertise developed during the rollout of several hundred such stations in Montréal in partnership with the City of Montréal and Hydro-Québec.

19.1.2 Federal Budget 2017

The Federal Budget 2017 was announced March 22. It included a number of initiatives that relate to transportation, as described below.

Investing In Electric Vehicle and Alternative Transportation Fuels Infrastructure

Federal Budget 2017[26] proposes to provide an additional 90 million USD in funding to this initiative, which was launched in Budget 2016 and managed by Natural Resources Canada. It will support the deployment and demonstration of EV charging infrastructure and of refueling stations for natural gas and hydrogen. Funds will be made available in 2018 for a 4-year period.

[25] CNW, "AddEnergie to develop the future of electric vehicle charging with a $6.7 million contribution from Natural Resources Canada," www.newswire.ca/news-releases/addenergie-to-develop-the-future-of-electric-vehicle-charging-with-a-67-million-contribution-from-natural-resources-canada-614868674.html February 27, 2017, accessed May 2, 2017.
[26] Government of Canada, "Budget Plan," www.budget.gc.ca/2017/docs/plan/toc-tdm-en.html, accessed May 2, 2017.

Mission Innovation

In November 2015, Prime Minister Trudeau announced Canada's participation in Mission Innovation, a global initiative of countries working together to accelerate clean energy innovation. As part of this initiative, countries agreed to double their national investments in clean energy innovation over five years, while encouraging greater levels of private sector investment in transformative clean energy technologies.

The Government of Canada has made a commitment under Mission Innovation to double its 2014–15 baseline expenditures of 290 million USD for clean energy and clean technology research, development and demonstration by 2020. Budget 2017 proposes a number of measures, including in the areas of green infrastructure and clean technology that will help to meet this commitment while generating a larger number of well-paying jobs in the clean growth economy.

Pan-Canadian Framework - A More Energy Efficient Transportation Sector

In 2014, Canada's transportation sector accounted for nearly a quarter of Canada's greenhouse gas emissions. To help reduce these emissions, Budget 2017 proposes under the Pan-Canadian Framework (PCF), to develop greenhouse gas regulations in the marine, rail, aviation and vehicle sectors. These efforts will be led by Transport Canada, with a proposed investment of 42.7 million USD over four years, starting in 2018–19. Budget 2017 also proposes to provide 12.9 million USD over five years, starting in 2017–18, to Environment and Climate Change Canada and Transport Canada to develop and implement heavy-duty vehicle retrofit and off-road regulations, as well as a clean fuel standard to reduce emissions from fuels used in transportation, building and industrial sectors.

Also under the PCF, in order to ensure a coordinated, whole-of-government approach to climate change, Budget 2017 proposes to provide 101.6 million USD over four years, starting in 2018–19, to Environment and Climate Change Canada and Natural Resources Canada. This investment touches on many technology sectors, including transportation. As such, it will be used to enhance action on short-lived climate pollutants, decarbonize the transportation system, and maintain policy and coordination capacity, as well as to develop a legislative framework for offshore renewable energy projects.

Investing in Research and Development for Clean Energy and Transportation

Clean energy and transportation research and development (R&D) maintains economic competitiveness and contributes to lower-cost emissions reductions in the energy and transportation sectors. The Government proposes to provide 171.8 million USD over four years, starting in 2018–19, to Natural Resources

Canada and Transport Canada to continue R&D activities through their core clean energy and clean transportation innovation programming.

Accelerating Innovation through Superclusters

Budget 2017 proposes to invest up to 712.5 million USD over five years, starting in 2017–18, to be provided on a competitive basis in support of a small number of business-led innovation "superclusters" that have the greatest potential to accelerate economic growth.

Clusters, dense areas of business activity that contain large and small companies, post-secondary institutions and specialized talent and infrastructure, energize economies and act as engines of growth. They create jobs, encourage knowledge sharing, drive business specialization and help to attract "anchor" companies from around the world. Successful clusters like the ones in Silicon Valley, Berlin, Tel Aviv and the Toronto-Waterloo corridor contribute significantly to both regional and national economies.

The competition will launch in 2017 and focus on superclusters that enhance Canada's global competitiveness by focusing on highly innovative industries such as advanced manufacturing, agri-food, clean technology, digital technology, health/bio-sciences and clean resources, as well as infrastructure and transportation.

Encouraging Innovation with the Smart Cities Challenge

Canadians who live in urban communities face many challenges, from traffic congestion that takes time away from family and friends to poor-quality air that can make it difficult to enjoy all that cities have to offer. Smart infrastructure investments can help to address current problems while helping Canada's cities prepare for the challenges ahead. To encourage cities to adopt new and innovative approaches to city-building, the Government proposes to provide Infrastructure Canada with 225 million USD over 11 years to launch a Smart Cities Challenge Fund.

Modelled on a similar competition in the U.S., the Smart Cities Challenge would invite cities across Canada to develop Smart Cities Plans, together with local government, citizens, businesses and civil society. Participants will create ambitious plans to improve the quality of life for urban residents, through better city planning and implementation of clean, digitally connected technology including greener buildings, smart roads and energy systems, and advanced digital connections for homes and businesses.

Winning cities will be selected through a nationwide, merit-based competition, facilitated by the Government's new Impact Canada Fund. To accelerate innovation further, infrastructure and transportation will also be eligible sectors under the Government's commitment to support business-led innovation "superclusters" that have the greatest potential to accelerate economic growth.

Modernizing Canada's Transportation System

Budget 2017 proposes to provide Transport Canada with 57.5 million USD over five years starting in 2017–18, to develop regulations for the safe adoption of connected and autonomous vehicles and unmanned air vehicles, working with industry, provinces, territories and municipalities to establish pilot projects, and to increase Transport Canada's ability to establish and provide the standards and certification that industry will need to safely use these new technologies.

19.1.3 Provincial Policies and Incentives

British Columbia

The government of British Columbia announced the Multi-Unit Residential Building Charging Program[27] in early 2016, a component of the Clean Energy Vehicle (CEV) Charging Infrastructure Program. The program's objectives are to support the purchase and installation of EV charging stations in multi-unit residential buildings (MURBs) in B.C., and to assist in reducing the barriers for current and future EV adoption. The program provides a rebate of up to 3,375 USD or 75 % of total costs per Level 2 charging station. The program performed well and due to high interest and uptake, the MURB program ended applications in May 2016. In early 2017, B.C. announced nearly 525,000 USD in additional funding for the MURB program, and a new round of applications will be considered starting at the end of March 2017.

The Fleet Champions Program[28] was announced in 2016 to assist fleets within the province in their efforts toward deploying clean energy vehicles. The program offers technical and financial assistance in performing an EV fleet business case, a free assessment (approximately 26,000 USD value) to determine potential savings by adopting EVs, or by performing vehicle telematics to gain insights on best ways to improve vehicle performance. Applications for this component closed on January 27, 2017. In addition, the program assists by providing a rebate of 33 %, up to 1,500 USD, on the purchase and installation of a Level 2 EVSE as well as free site assessments to understand charging needs and options. Applications will close on May 1, 2017.

[27] Plug in BC, "MURB Charging Program," http://pluginbc.ca/charging-program/murb, accessed May 2, 2017.
[28] Plug in BC, "Fleet Champions Program," http://pluginbc.ca/charging-program/incentives-for-fleets, accessed May 2, 2017.

Also, in early 2017, the provincial government announced[29] 30 million USD to further support the deployment of clean energy vehicles. The funding will be aimed at electric and hydrogen vehicle purchasing, charging and refueling infrastructure, and outreach programs. Of this amount, 20.2 million USD will augment the existing CEVforBC Program[30], which provides up to 3,750 USD for the purchase of qualifying new BEVs and PHEVs, and up to 4,500 USD for hydrogen fuel cell vehicles. The CEVforBC Program vision is to stimulate the market such that 5 % of new light duty vehicle sales in B.C. are clean energy vehicles by 2020. The remaining 9.8 million USD will be directed towards fast-charging, multi-unit residential infrastructure (as discussed above), and workplace charging infrastructure, as well as outreach efforts. The BC Scrap-It[31] program provides an incentive of 2,500 USD to scrap an aging fossil fuel powered vehicle in favor of a more fuel efficient one. The program has been refurbished earlier this year to increase the incentives to 4,500 USD when scrapping an older vehicle and purchasing a new EV, and 2,250 USD when purchasing a used EV. Cash incentives of up to 750 USD, based on the CO_2 emission reduction between the old and replacement vehicles, are also provided when purchasing a more fuel efficient fossil fuel vehicle. Other financial incentives in the form of rebates, credits and cash are available; these apply to options such as public transit passes, new bicycle purchases or ride share programs. The BC Scrap-It Program incentives will remain stackable with those offered by the CEVforBC Program of up to 3,750 USD to receive a total incentive of up to 8,250 USD for the purchase of a new EV.

Manitoba

The Manitoba Government and City of Winnipeg Joint Task Force on Transit Electrification undertook and completed a report during 2016, examining the prospect for increasing the implementation of electric buses within the transit system of the City of Winnipeg, this beyond the current pilot already underway. Release of a public version of the final report is pending.

Ontario

In June 2016, Ontario released its Climate Change Action Plan[32] (CCAP) 2016-2020, which builds on the Ontario Climate Change Strategy[33] released in November 2015, and whose objectives are to reduce greenhouse gas emissions to 80 % below 1990 levels by 2050, and build a prosperous low-carbon economy.

[29] Plug in BC, “$40 Million in New Funding for Clean Energy Vehicles,” http://pluginbc.ca/40-million-new-funding-evs, February 3, 2017, accessed May 2, 2017.
[30] www.cevforbc.ca.
[31] https://scrapit.ca.
[32] Ontario, “Ontario’s five year Climate Change Action Plan 2016 – 2020,” /www.ontario.ca/page/climate-change-action-plan, 2016, accessed May 2, 2017.
[33] Ontario, “Ontario’s Climate Change Strategy,” www.ontario.ca/page/climate-change-strategy, November 24, 2015, accessed May 2, 2017.

The CCAP is a requirement of the Climate Change Mitigation and Low-carbon Economy Act[34], also enacted in 2016. This plan is to establish the long-term framework for action on climate change to ensure greenhouse gas pollution is reduced while boosting low-carbon innovation. The legislation also requires that the province specify how cap and trade proceeds will be used to reduce or support the reduction of greenhouse gas by investing in green projects.

The CCAP five year plan to fight climate change, reduce greenhouse gas pollution and transition to a low-carbon economy identified a number of action areas over a broad spectrum including Transportation: Becoming a North American leader in low-carbon and zero-emission transportation. The action plan establishes a province-wide electric and hydrogen passenger vehicles sales target of 5 % in 2020. This target will be reviewed and increased appropriately every 5 years thereafter. The government's approach to reach the stated objective is to closely work with automakers, unions, the not-for-profit sector and with academia to ensure that all stakeholders are taking the most effective steps to get electric and hydrogen vehicles on the province's roads. To support the increased use of EVs, the province is planning to implement 7 measures, including maintaining the current EV purchase incentives of up to 10,500 USD until 2020, working with utilities to offer a four-year program to decrease overall electricity bills for homes that charge vehicles by providing free overnight EV charging for residential and multi-unit residential customers, and offering rebates to low- and moderate-income households to replace old cars with new or used EVs or plug-in hybrids. The province also intends to ensure charging infrastructure is widely available by investing in the deployment of charging stations in workplaces, multi-unit residential buildings (MURBs), as well as public charging, by requiring that all new homes and townhomes with garages to be constructed with a 50 amp, 240 Volt receptacle in the garage for EV charging purposes, and by requiring that all newly constructed commercial office buildings and workplaces must provide charging infrastructure.

Under the CCAP, the EV Charging Incentive Program[35] has been updated to provide 50 % or up to 750 USD in financial assistance for the purchase and installation of new Level 2 charging stations for residential or business use. Eligible participants are individuals and organizations who have previously purchased an EV and received a rebate through Ontario's Electric Vehicle Incentive Program (EVIP). Participants can request one charging rebate for each vehicle rebate received.

[34] Legislative Assembly of Ontario, "Bill 172, Climate Change Mitigation and Low-carbon Economy Act, 2016," www.ontla.on.ca/web/bills/bills_detail.do?locale=en&BillID=3740, 2016, accessed May 2, 2017.
[35] Ontario Ministry of Transportation, "Electric vehicle charging incentive program," www.mto.gov.on.ca/english/vehicles/electric/charging-incentive-program.shtml, accessed May 2, 2017.

Québec

Following the implementation of the Transportation Electrification Action Plan 2015-2020, the Québec government put forward various measures, including a new incentive for the school bus market, as well as a new legislation aimed at the light vehicle market.

In March 2016, the Québec Government adopted the *Programme de soutien au déploiement des autobus scolaires électriques au Québec*[36], a program to support the deployment of electric school buses in the province. This program allows school boards and private educational institutions that provide student transportation, as well as carriers who have contracts with either of these organizations, to obtain financial assistance of up to 93,750 USD for the purchase of a new battery electric school bus. The program, which will be in effect for 5 years, has an overall budget of 22.5 million USD, funded through the amendment of a measure to compensate school carriers for the increase in the price of diesel fuel. The province of Québec has at least one electric school bus manufacturer, Autobus Lion, who manufactures and markets the eLion bus. As of December 31, 2016, 50 electric school buses were given a total incentive of 4.7 million USD through this program.

In October 2016, the Government of Québec adopted zero emission vehicle (ZEV) legislation[37] *(Loi visant l'augmentation du nombre de véhicules automobiles zéro émission (VZE) au Québec afin de réduire les émissions de gaz à effet de serre (GES) et autres polluants)* in order to provide Québec consumers with an increased offering as well as increased availability of plug-in EVs. Similarly to 10 American states, amongst which California and several northeastern States, Québec has provided itself with the power to adopt regulations that encourage automakers to improve their ZEV supply.

Starting with model year 2018, the regulation will establish a ZEV sales target for each reporting vehicle manufacturer. This target, determined by the government and transposed in the form of credits, will take into consideration the total number of light vehicles sold by each manufacturer in Québec. With this new measure, the car market will be motivated to develop more models and to use low-carbon technologies. This is one of the concrete measures under this regulation to support the overall target set out in the Transport Electrification Action Plan 2015–2020,

[36] Ministère des Transports, de la Mobilité durable et de l'Électrification des transports, "Soutien au déploiement des autobus scolaires électriques," www.transports.gouv.qc.ca/fr/aide-finan/electrification/soutien-deploiement-autobus-scolaires/Pages/autobus-scolaires.aspx, accessed May 2, 2017.

[37] MDDELCC, "Loi visant l'augmentation du nombre de véhicules automobiles zéro émission au Québec afin de réduire les émissions de gaz à effet de serre et autres polluants," www.mddelcc.gouv.qc.ca/changementsclimatiques/vze, accessed May 2, 2017.

which includes the registration of 100,000 fully electric or plug-in hybrid vehicles by 2020.

19.2 HEVs, PHEVs and EVs on the Road

Canadian EV sales were strong in 2016, displaying an increase of 56 % in sales over 2015 sales to reach 11,000 units during the year[38]. By comparison, sales increased by 32 % from 2014 to 2015. The total number of EVs in Canada on December 31, 2016 was almost 30,000, driven by sales in the three provinces offering EV purchase incentives, British Columbia, Ontario and Québec. Milestones were reached in BC and QC, where EV sales exceeded 1 % of all motor vehicle sales. By December 31, 2016, QC, ON and BC were home to respectively 46 %, 31 % and 18 % of EVs, therefore totaling 95 % of the total Canadian EV fleet.

Similarly to the previous years, a trio of models made up the majority of sales. The Chevrolet Volt regained first place with 32 % of total sales, while the Nissan Leaf had the second highest portion with approximately 14 %, and Tesla Model S having the third highest sales with 13 %. The proportion of sales allocated to these three models decreased to 59 % from 72 % in 2015, which indicates a diversification in consumer selection, from existing EV models or from the additional 9 new models available on the Canadian market.

The number of HEVs sold in 2016 increased slightly from 17,238 in 2015, to 22,788 vehicles, which resulted in an estimated fleet total of 186,057 HEVs.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2016 (Data source: Statistics Canada and FleetCarma)

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs[a]**	**FCVs**	**Totals[b]**
Passenger Vehicles	14,910	14,360	186,057	n.a.	25,907,551

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[b]**
Passenger Vehicles	5,130	5,930	22,788	n.a.	1,983,745

n.a. = not available
[a] Estimates
[b] Estimates, including non-electric vehicles, minivans, sport-utility vehicles, light and heavy trucks, vans, buses, and motorcycles

[38] Matthew Stevens, “Electric Vehicle Sales in Canada: 2016 Final Update,” www.fleetcarma.com/ev-sales-canada-2016-final, fleetcarma, February 8, 2017, accessed May 2, 2017.

Table 2: Available vehicles and prices (Data source: Information based on Auto manufacturers' websites)

Market-Price Comparison of Selected EVs and PHEVs in Canada	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in USD)**
BMW i3	35,625
Chevrolet Bolt	32,096
Ford Focus Electric	23,623
KIA Soul	26,546
Mitsubishi i-MIEV	20,998
Nissan LEAF	24,523
Renault Twizy	12,750
Smart Fortwo Electric Drive	20,242
Tesla Model S 75D kWh	84,225
Tesla Model X 75D kWh	101,450
Audi A3 Sportback e-tron	34,425
BMW i3 REX	37,125
BMW i8	112,350
BMW 330e	39,075
BMW 740e	82,923
BMW X5 xDrive40e	58,023
Chevrolet Volt	28,868
Chrysler Pacifica	42,371
Ford C-MAX Energi	21,996
Ford Fusion Energi	24,066
Hyundai Sonata Plug-In Hybrid	33,000
Mercedes GLE550e	62,250
Porsche Cayenne S-E-Hybrid	67,050
Porsche Panamera 4 E-Hybrid	85,050
Porsche 918	845,000
Volvo XC90 T8 Plug-in	55,612

19.3 Charging Infrastructure or EVSE

As a result of investments by federal, provincial and municipal governments, as well as businesses, the number of charging stations installed across Canada in 2016 grew by 20 % from 2015. There were approximately 4,215 EVSEs, of which 3,900 were Level 2 (240 V AC) chargers, 135 were Level 3 (DC Fast Chargers), and 180 were Tesla Superchargers. The majority of new installed charging capacity was located in British Columbia, Ontario, and Québec, provinces that offer varying degrees of direct financial incentives for the purchase of Level 2 and Level 3 charging stations.

It is important to note that, as there are no requirements for EVSEs to register with respective jurisdictions, tracking of operational Level 2, Level 3, and Tesla Supercharger stations is performed through voluntary reporting by charging network owners and managers, as well as end users. Level 1 (120 V AC) EVSEs are not reported since this infrastructure typically relates to charging via a residential wall outlet.

Figure 1: Level 2 and Tesla Supercharger stations at a tourism office in St-Alexis-des-Monts, Québec (Source: RP Allard)

Table 3: Information on charging infrastructure in 2016 (Data source: Plugn'Drive)

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	n.a.
AC Level 2 Chargers	3,900
Fast Chargers	135
Superchargers	180
Inductive Charging	n.a.
Totals	**4,215**

n.a. = not available

There has been a sustained amount of growth in the charging infrastructure across Canada during 2016–2017. Listed below are highlights for some of the EVSE networks.

FLO Network

Launched in May 2016 by AddÉnergie, the FLO Network[39] connects members to nearly 2,000 EVSEs in British Columbia, Ontario, Québec, New Brunswick, and Nova Scotia, along with interoperability capabilities that can extend the network to systems in other provinces. The FLO Network is expected to offer a seamless transition between charging at home, at work and during travels. Network members will benefit from connectivity tools and support such as a smart phone application that enables an EV driver to easily identify the nearest available charging station, and pay for its charging session with a tap of a finger; the ability to consult consumption-related data at any time; and access to 24/7 live operator support and a technical support team that ensures network reliability and addresses charging issues in real time.

Figure 2: Flo Network urban charging design (Source: AddÉnergie)

AZRA Network

In April 2016, AZRA announced that it would invest 30 million USD in transportation electrification in Canada[40]. The Québec-based company is planning to deploy 2,000 new charging stations over 18 months, as well as deploy the

[39] AddÉnergie, „AddÉnergie launches FLO, the largest and most reliable electric vehicle charging network in Canada," http://blog.addenergietechnologies.com/en/addenergies-news/addenergie-launches-flo-the-largest-and-most-reliable-electric-vehicle-charging-network-in-canada, May 15, 2016, accessed May 2, 2017.

[40] CNW, "AZRA invests $40 million Canadian in transport electrification," www.newswire.ca/news-releases/azra-invests-40-million-canadian-in-transport-electrification-575871501.html, April 15, 2016, accessed May 2, 2017.

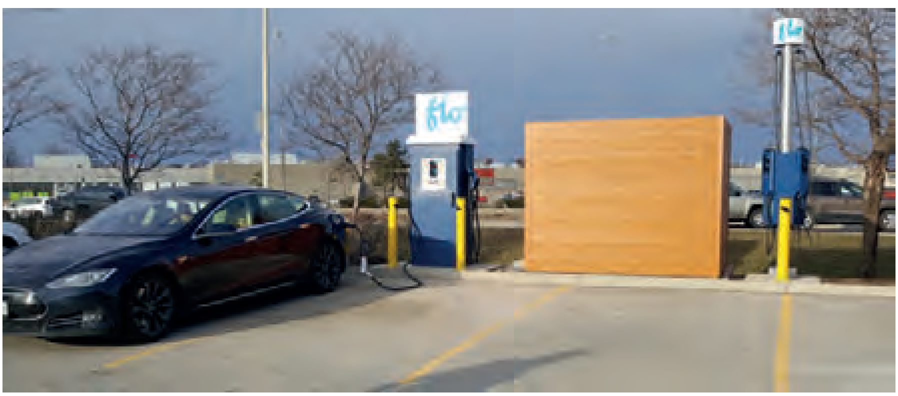
Twizy, Renault's first 100 % EV in Canada. The Twizy is a low-speed vehicle, which is capped at 40 km/hr, and it will be available for lease on a monthly basis at 75 USD, including registration and insurance.

19.4 EV and EVSE Demonstration Projects

A number of demonstration projects are taking place or have taken place across Canada. A brief description and update on some of these projects is offered in the following paragraphs.

19.4.1 Commercial Demonstration of a Management System for Electrical Vehicle Charging Station Networks

Natural Resources Canada provided 3.4 million USD in funding to AddÉnergie through the ecoENERGY Innovation Initiative from 2011 to March 2017, for a project[41] that tested and demonstrated the performance of its centralized charging station management system. The Charging Station Network Management System (CSNMSTM) successfully monitored and managed the operation of 3,000 Level 2, and 85 DCFC stations in various locations across Canada. The demonstration project was successful in that it met its stated objective to demonstrate the operational viability of a network of different charging levels for electric vehicles in multiple locations. In order to achieve this, the project needed to demonstrate that the base architecture of the data network as well as that of the telecommunications network architecture was able to support the growth of the charging infrastructure, in a Canadian climate, and that the business model was viable.



[41] Government of Canada, "Commercial Demonstration of a Management System for Electrical Vehicle Charging Station Networks," www.nrcan.gc.ca/energy/funding/current-funding-programs/eii/16157, October 28, 2016, accessed May 2, 2017.

Figure 3: A retail parking lot in Milton, Ontario, with Level 2 and Level 3 charging stations (Source: AddÉnergie)

19.4.2 Winnipeg Transit – Electric Bus Demonstration

Through 2016, a pilot demonstration[42] continued into its second full year, involving four second-generation electric buses in for-fare service with the City of Winnipeg transit system, and including both on-route rapid charging and garage-based overnight charging. This is currently the most advanced electric bus activity within Canada, and thousands of consumers have now ridden these vehicles. Consortium partners have included: Manitoba Government, City of Winnipeg, Sustainable Development Technology Canada, New Flyer, Manitoba Hydro, Red River College, and Mitsubishi Heavy Industries.

Figure 4: Electric transit bus operating in downtown Winnipeg, Manitoba, in active service during winter (Source: Manitoba Growth, Enterprise and Trade, Energy Division)

19.4.3 Electric Pick-up Trucks Demonstration

A demonstration project carried out by Ecotuned Automobile, a pick-up truck retrofit company established in Québec, aims to convert the drivetrain of conventional internal combustion engine pick-up trucks having 2-3 years of wear to reusable electric drivetrains. The Québec government[43] is investing in this project that will, as a first step, convert two prototype vehicles, that will be added to the fleet of the Québec Ministry of Transportation, Sustainable Mobility and Transportation Electrification. Following the prototype and refinement phase, Ecotuned Automobiles will produce a first series of eight vehicles in partnership

[42] Winnipeg, “Electric Bus Demonstration,” http://winnipegtransit.com/en/major-projects/electric-bus-demonstration, accessed May 2, 2017.
[43] MERN, “Le ministre Pierre Arcand annonce 3,5 M$ en aide financière pour trois entreprises de la metropole,” https://mern.gouv.qc.ca/2016-04-25-pierre-arcand-aide-financiere-trois-entreprises-metropole, April 25, 2016, accessed May 2, 2017.

with various testers. By taking advantage of the longevity of the electric motor and its components, the powertrain system will be designed to be easily transposed and reused later in another vehicle of the same category. The Ecotuned solution extends the life of light trucks and reduces greenhouse gas emissions from fuel combustion, scrapping, and the production of new pick-up trucks.

20 Denmark

20.1 Major Developments in 2016

With approx. 1,400 new EV registrations in 2016, the Danish EV sales and stock growth slowed down. In comparison EV sales in 2015 was 4,500. The slowdown was caused by the termination of the tax exemption on EVs. A progressive reduction of the tax exemption was decided in 2015, starting from 2016 and with full taxation phased in by 2020. This led to the reduction in sales of BEVs in 2016, where taxation was phased in with a 20 % share.

Denmark has a strong EV charging infrastructure thanks to the major private e-mobility providers: CLEVER, E.ON, CleanCharge Solutions, and Tesla. Many EV projects have been launched to familiarize companies, public authorities, and private consumers with EVs and strengthen Denmark's position as an important green transport corridor in Northern Europe. According to Danish EV Alliance, 1,312 passenger vehicles, 3 buses and minibuses, 57 light commercial vehicles and one medium and heavy weight truck was sold during 2016. In sum, 8,643 passenger vehicles, 6 buses and minibuses, 623 light commercial vehicles, and 5 medium and heavy weight trucks were distributed and sold in Denmark.

Table 1: Available vehicles and prices of EVs in Denmark (1 DKK = 0,13 EUR)

Market-Price Comparison of Selected EVs and PHEVs in Denmark	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in DKK and EUR)**
Nissan Leaf	248,190 ; 32,265
VW e-up!	186,300 ; 24,219
E-golf	286,500 ; 37,245
BMW i3	282,000 ; 36,660
Nissan Evalia	284,000 ; 36,920
Tesla, model S 90	840,700 ; 109,291

n.a. = not available

20.2 Framework for the Electrification of Transport

With policy strategies and grant schemes since 2008, Denmark has been one of the first mover countries in introducing battery electric cars and hydrogen and fuel cell based transport; from 2008, in a testing and demonstration context; from 2012, also in deployment mode.

Incentive programmes have focused broadly on electric application in passenger cars, busses, vans, garbage trucks etc, including charging infrastructure. Private and public fleets together with city car sharing systems have been a main priority. In the private segment, commuters and families with more than one car have been another important focus area. Denmark is actively represented and participating in a broad palette of regional, international and EU programmes, ranging from charging and roaming standards, cross bordering charging corridors and smart grid projects to e-mobility as service and as an energy efficient and environmental friendly form of transport. Hydrogen programmes have especially focused on R&D in fuel cells and deployment of a Danish network of hydrogen filling stations.

Denmark has a very ambitious target of being independent of fossil fuels by 2050, with stepping stones on the way. According to EU targets, greenhouse gas emissions from buildings, agriculture and transport must be reduced by 20 % by 2020. Moreover, 10 % of energy in transport must be renewable in 2020. Total EU emissions must be reduced by 40 % between 1990 and 2030, with a 30 % reduction in transport.

Denmark holds the world record of fluctuating wind power in the electricity mix. In 2015, the wind power generation in Denmark corresponded to 42 % of the electricity consumption. During the next 10 years, this share is expected to increase to approx. 60 % (Energinet.dk).

In 2016, the World Energy Council ranked 125 countries' energy systems on three core dimensions: energy security, energy equity, and environmental sustainability and found that Denmark won the first place in this Global Energy Trilemma Index[44].

The combination of a pricewinning, very strong and flexible energy system and record-breaking high shares of fluctuating renewable energy positions Denmark as an interesting test bed for exploring the interplay between the energy system, renewable energy and e-mobility in terms of smart grid, smart energy and storage, both in relation to technology and business models. With very well developed public transport systems in Denmark, e-mobility as a service, electric busses and self-driving vehicles will also be at the forefront in the coming years. Globally, a

[44] https://trilemma.worldenergy.org

new interesting area of electrification will be electric maritime propulsion, where Denmark as a traditional shipping nation and with several ongoing e-ferries projects will play an active part. Biking is very important in Denmark and e-biking continues to grow, in 2016 likely moving beyond 10 % of sales.

Different broad political agreements have governed the development. The energy agreement from 2008 continued the decarbonising of the energy system and initiated the first test schemes and fleet programmes for electric mobility and charging infrastructure. The energy agreement from 2012 set out the ambitious targets for the energy system in 2020 and 2050 and new electric mobility programmes and charging infrastructure with focus on deployment and alternative fuels.

The current government has appointed an Energy Commission to review and propose measures from 2020 onwards.

In the transport sector two political agreements in 2009 and 2014 focused on a Green Transport Policy and financial support for green solutions in the public transport sector (2009), for research in alternative fuel technologies, and for small-scale tests of electricity and CNG vehicles (2013).

The support for green transport provided by the government has helped regional and municipal authorities to develop initiatives promoting e-mobility like Copenhagen Electric.

20.3 New Policies and Incentives in Denmark

Until 1 January 2016, battery electric vehicles (BEV) were exempted from the relatively high registration tax on passenger cars (VAT was applied). The exemption was a very strong incentive, which together with the national and regional activities brought Denmark in the e-mobility forefront. The taxation system lead to some disproportionate incentive towards expensive BEV which resulted in rather high shares of sales.

A progressive reduction of the tax exemption was decided in 2015, starting from 2016 and full taxation phased in by 2020. The detailed phase-in steps are 20 % in 2016, 40 % in 2017, 65 % in 2018, 90 % in 2019 and 100 % 2020.

No other state support for the acquisition of BEVs are in place, as in many other countries. This has led to a drop in sales of BEVs in 2016, where taxation was phased in with a 20 % first step.

The drop has happened despite registration tax generally is subject to a tax discount per km/l a passenger car can drive above 16 km/l, resulting in a substantial discount on the registration tax for a BEV.

There are ongoing political discussions on how to ensure a continued electrification and influx of new BEV and PHEV to the passenger car fleet.

Electricity prices have been in the political focus in Denmark for some time, and a broad political agreement will shift the so-called Public Service Obligation (PSO) tariff, used for financing renewable energy production away from the electricity bill and to the national budget from 1 January 2017.

When fully phased in, this will reduce electricity prices in 2022 e.g. for households approx. 20 % thus making e-mobility more economic. Energy taxation of electricity is almost 3 times higher than gasoline and diesel per energy content.

Charging operators are also not paying energy tax for electricity used for commercial charging in 2017. This gives the Danish charging industry the possibility to lower the costumer prices for their different products. It is not decided if this tax exemption will continue in 2018.

Denmark is actively participating in Mission Innovation which is an international platform to accelerate the pace of clean energy innovation and achieve performance breakthroughs and cost reductions. The target is to provide widely affordable and reliable clean energy solutions that will revolutionize energy systems throughout the world over the next two decades and beyond.

Thus, Denmark has chosen to strengthen dedicated public investment in clean energy research, development and demonstration. Focus will be on reduction of technology costs and CO_2 emissions and with an emphasis on innovative projects that can be replicated and scaled up with the involvement of private investors. The target is a doubling departing from a baseline of the average funding to the Danish Energy Technology Development and Demonstration Programme (EUDP) of the years 2015-2016 and until 2020:

- Country-Determined Baseline Year(s): FY 2015-16
- Baseline Funding Amount: 292 million DKK (45 million USD)
- Doubling Target-Year: FY 2020
- Doubling Target Amount: 580 million DKK (90 million USD)

The Danish Clean Energy R&D Focus Areas in relation to e-mobility will be:

- Vehicles & other transportation
- Solar, wind & other renewables
- Hydrogen & fuel cells
- Electricity grid
- Energy storage

20.4 HEVs, PHEVs and EVs on the Road

The Danish EV and PHEV stock increased in 2016 to approx. 9.300 EV units and 1.300 PHEV units. The number of new EV registrations in 2016 was reduced to approx. 1.400 EV units and 650 PHEV units due to the new taxation system for EV and PHEV.

20.5 Charging Infrastructure

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

The Danish Road Directorate has conducted tenders to establish public charging infrastructures at rest stops on national Danish highway system. E.ON and CLEVER have deployed combined fast chargers on these sites, while Tesla has deployed chargers close to the highway system.

E.ON, CLEVER and Clean Charge provide data to a map that gives an overview of publicly available charging infrastructure in Denmark. The project is supported by the Danish Transport and Construction Agency. The map is hosted by the Danish Electric Vehicles Alliance[45]. In terms of interoperability, all quick chargers in Denmark are today multi-standard types (CHAdeMO, CCS and Mennekes type 2) and are connected to backend systems which allow billing of customers based on actual consumption of kWh.

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.

CleanCharge Solutions is a Danish e-mobility provider and a part of the RWE co-operation network. The company installing equipment and providing value-added services (billing services, charging data processing, etc.) to charging point operators and parking operators that provides open access with direct payment for the use of the recharging stations.

Tesla has installed a network of Supercharger stations in Denmark where drivers can fully charge their Tesla vehicles for free.

[45] www.ladekort.danskelbilalliance.dk

Table 2: Information on charging infrastructure in 2016 (Data source: Danish EV Alliance)

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	n.a.
AC Level 2 Chargers	1,675
Fast Chargers	120
Superchargers	56
Inductive Charging	n.a.
Totals	**1,851**

20.6 National EV Demonstration Projects

Since 2008 the Danish Energy Agency (DEA) has administrated several programmes to support the deployment EVs in the Danish transport sector. The funds have been 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 programmes all end in 2015, but will be running until their projects periods end, typically within 3-5 years.

This funding went into three categories: Alternative fuel infrastructure, grants for electric buses, and pilot and deployment schemes for EVs.

Three examples of projects will be presented, in the following:

"The Partnership for Purchase of EVs" was allocated funds contributing towards participants' purchase of 870 EVs in 2016. Moreover, the partnership joined public and private stakeholders in order to achieve a strategy on alternative infrastructure and a national joint procurement strategy.

"The Partnership for Increased use of E-Mobility in Northern Jutland" was allocated funds to support deployment of 40 public charging stations, helping to ensure that EV users have a nearby charging station all over the Region.

The project ***"Electric buses at Copenhagen Airport"*** was allocated funds for 2 EV buses to Copenhagen Airport's bus fleet, allowing Copenhagen Airport to gain practical experience with electric buses for their specific needs.

20.7 International Projects

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.

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.

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 Denmark and Sweden. The charging sites will be located in transport “hotspots” such as bus and train stations to underpin multimodal e- mobility. The project is in line with the Oresund Regional development strategy, which calls for development of “green corridors”. CLEVER is a key project partner.

Platform for E-mobility in ÖKS Region

The project aims to increase environmentally friendly transport in the Öresund-Kattegat-Skagerrak region by helping the municipalities adapt to e-mobility. A common platform delivers expertise to help increase deployment of EV in public fleets and among private citizens. The platform is established by The Danish EV Alliance (DK), Power Circle (SWE), and Elbilforening (NOR). It is funded with 50 % by the EU Interreg programme.

The Nikola Research Project

Nikola is a Danish research and demonstration project analysing how to integrate EVs in the distribution grid. The focus is on the economic viability of participation in the market and the development of new technologies. The project runs from 2013 to 2016 and has a total budget of approx. 2 million EUR (15.1 million DKK).

20.8 Outlook

The progressive reduction of the historically tax exemption which started with 20 % taxation in 2016, followed by 40 % in 2017, 65 % in 2018, 90 % in 2019 and 100 % 2020 has reduced 2016 sales significantly.

There are ongoing political discussions on how to ensure a continued electrification and influx of new BEV and PHEV into the car fleet.

Despite the setback in EV and PHEV sales, Denmark still holds a very strong positions in terms of environmental targets, record-breaking wind power shares, robust and flexible energy system, charging infrastructure and industry, actively engagement in a multitude of national and international projects on e-mobility, smart grid, smart energy. In relation to Mission Innovation Denmark will double dedicated public investment in clean energy research, development and demonstration, including in relation to e-mobility.

21 Finland

21.1 Major Developments in 2016

21.1.1 EVs in Finland is Slowly Gaining Prominent Market Share

2016 proved that electric vehicles are finally making their way into Finland. According to the Finnish Transport Safety Agency the amount of electric vehicles doubled during the year to a total of 3,285 EVs. The growth was especially significant with plug-in hybrid electric vehicles.

The market share of electric vehicles was 1.2 % of all new cars registered in 2016, also doubling from 0.6 % in 2015. A significant amount of EVs are also brought from outside the country, which can't be seen in the statistics.

With governmental subsidies for public EV charging infrastructure and more advanced cars in the market the amount of EVs is expected to grow even faster in 2017.

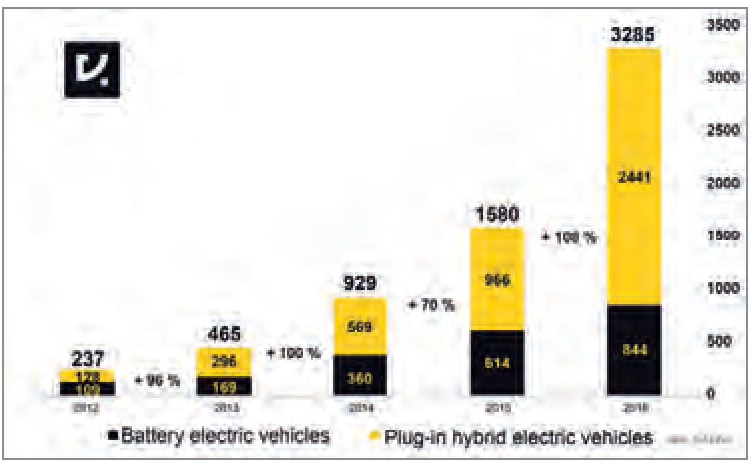


Figure 1: Statistics on EV and PHEV in Finland in the period between 2012 and 2016 (Source: Virta Global)

The number of electric cars will grow considerably in Finland in the near future and, according to forecasts, there will be an estimated 250,000 electric and hybrid cars on our roads by 2030. According to the automobile trade, the single biggest factor slowing down the sale of electric cars in Finland is the lack of charging stations.

21.1.2 Finnish Government Boosts EV Charging Infrastructure

The Finnish government has decided to speed up the development of EV infrastructure in Finland with a 5 million EUR subsidy. The subsidy is an important step towards sustainable transport and makes Finland a forerunner in smart charging solutions.

The Ministry of Economic Affairs and Employment decided to allocate 4.8 million EUR to further expand public EV charging infrastructure in Finland between 2017 and 2019. The objective is to catalyze 15 million EUR in investments to EV charging systems and triple the current amount of public charging stations.

The subsidy is targeted only to public smart charging stations and especially tries to boost the implementation of fast chargers. The subsidy rate for normal chargers is 30 %. Half of the 5 million is allocated to fast chargers, which get a higher 35 % subsidy rate.

21.1.3 Supporting Smart Charging Makes Finland a Forerunner

A key element in the subsidy is that it is allocated only to smart charging devices. The term smart charging is being used to describe a system where there is a data connection between an electric vehicle and a charging device, and also a data connection between the charging device and a charging operator.

In practice smart charging is a charging device connected to a back-end service that enables monitoring, controlling and restricting the usage of the device. Smart charging enables operators to utilize EVs as a part of the energy system.

Initially public charging becomes more common in commercial real estate locations and along highways. However charging business is not restricted to any industry, and any company can offer subsidized EV charging as a service on their premises.

The finish company Varma is preparing for the coming of electric mobility. Starting from summer 2017, it will be possible to charge electric and hybrid cars at some 250 parking spots at the parking facility of Varma’s head office in Salmisaari, Helsinki.

Table 1: Information on charging infrastructure in 2016 (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 2016	
Chargers	**Quantity**
AC Level 1 Chargers	150 (est.)
AC Level 2 Chargers	235
Fast Chargers	75
Superchargers	4
Inductive Charging	0
Totals	**464**

est. = estimated

21.1.4 New Finnish Energy and Climate Strategy

In late 2016, the Finnish government created a new Energy and Climate Strategy. The strategy aims to decrease transport-related emissions and one of the main goals is to increase the number of electric vehicles up to 250,000 by 2030. The growth from thousands to hundreds of thousands awakes questions about the capacity of the national electrical grid. Can the existing grid handle the growth?

The shift from combustion engine vehicles to the greener alternatives takes time, which gives the electrical grid time to adjust to the changes, like coping with a large number of fast chargers. In addition to this, energy efficiency keeps improving in other areas and the consumption of electricity for example in the construction and housing sectors will decrease in the next few years. Energy utilities are also constantly developing new solutions for electricity demand response.

However, even a significant increase in the number of EVs will not shake the operation of the electric grid, if the vehicles are being charged using smart charging solutions. The hypothetical 250,000 cars don’t have to be plugged in all at the same time, or during the rush hours of electricity consumption. But most importantly with smart charging we can control the timing of charging events. Virta already offers a solution to optimize charging events automatically based on price and thus demand at the local electricity market. In addition, with smart charging, the charging power can be decreased automatically when needed if the local grid momentarily gets strained.

In the next decade new technologies will evolve. For example vehicle-to-grid (V2G) charging that allows electricity to be returned to the grid is already being tested. Nevertheless, the target set for 2030 in Finland is not an utopian scheme even with today's technologies. Massive rebuilding of the electrical grid is not needed if smart charging services are being used. Utilizing smart solutions in the development of transportation is also a goal included in the Energy and Climate Strategy of the Finnish government.

21.1.5 First Electric Buses in Turku

Turku Region Public Transport Föli has adopted their first all-electric buses in autumn 2016. The six electric buses were supplied by the Finnish Linkker Oy. With the charging system, the total value of the procurement is approximately 3.8 million EUR. The Ministry of Employment and the Economy has granted approximately 1 million EUR in investment aid for the implementation of the system.The strategic goal of the City of Turku is to become carbon neutral by 2040, which requires ambitious climate and environmental measures. In fact, the city aims to purposefully increase the share of electric equipment in public transport and outsourced services (taxis, transport services, the city's own equipment).

The electric buses will be adopted on line 1 of Turku City Transport, which operates on the route Harbour–Market Square–Airport. During rush hours, two diesel-powered buses are operated alongside the electric buses. Turku Energia will build quick-charge stations for the electric buses at the harbour and the airport. Turku Energia will also implement the charging equipment at the operator's bus depot for night-time charging. The agreement includes a service agreement for the buses and charging equipment for a period of seven years. The procurement decision is a significant first step in the electrification of bus transport on a national level. Until now, electric buses have primarily been used in Finland on an experimental basis, and the only other place where an entire line is being operated with electric buses is one line in Espoo.

21.1.6 Helsinki's First Electric Buses Hit the Road

The Helsinki Regional Transport Authority's (HSL) vision is to power a third of its fleet in the Helsinki metropolitan area with electricity by 2025. HSL has yet to announce how this would influence ticket prices. HSL is deploying several 400 kW opportunity chargers during 2017-2018. In 2017 HSL will have 12 buses in use.

Figure 2: Electric bus in Helsinki (Source: HSL).

21.1.7 Tekes Programme Activities in EV Sector

Tekes' EVE programme (2011-2015) came to its end. A final seminar was held in January 2016. The total expenditure of the five year programme was roughly 80 million EUR. Tekes funded about half of the total costs. However, support for electric traffic innovations by Tekes still continues. EV related projects are now within the framework of a Smart City programme under the theme "smart mobility" together with MaaS, autonomous vehicle projects, that are hot topics in Finland today.

22 France

22.1 Major Developments in 2016

22.1.1 Low-Emission Vehicles in Public Fleets and Bonus Malus System

The 22nd Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP22) ended with the announcement that 2018 would see the finalization of the Paris Treaty implementation arrangements adopted in 2015. Given that the transport sector still accounts for about a quarter of the greenhouse gas emissions, the electric vehicle has its place in this type of negotiations.

Eight states voluntarily signed a declaration aiming at integrating low-emission vehicles during the renewal of their public fleet: France, China, Japan, Norway, Sweden, the United Kingdom, and the United States.

France is counting on 75,000 additional electric vehicles in the national car fleet for 2020. As a reminder, according to the Energy Transition for Green Growth Act, the French State and its administrations must incorporate at least 50 % of low-emissions vehicles during the renewal of their fleet. This obligation is of 20 % for the local authorities as well as for the national companies.

22.1.2 The Ecological Bonus

For individuals and professionals, the government has introduced an environmental bonus, which encourages buyers to move towards new low CO_2 emissions models.

In order to be eligible, the purchaser must buy or lease (for more than two years) a new passenger car or light commercial vehicle that meets the requirements for greenhouse gas emissions. Of course, this measure concerns EVs, which benefits from the bonus of 6,300 EUR. However, it is important to note that diesel vehicles have been excluded from the system in 2016.

Most rechargeable hybrids benefit from a bonus of 1,000 EUR provided that their CO_2 emissions remain below 60 g/km. Full hybrid gasoline vehicles see their premium reduced to 750 EUR. Diesel hybrids are excluded from the scheme.

22.1.3 The Conversion Premium

In 2016, the conversion premium for passenger cars is maintained with a significant change. Vehicles registered before January 2006 are eligible (compared with 2001 in the previous version). The amount of the premium is unchanged: 3,700 EUR for an electric car and 2,500 EUR for a rechargeable hybrid vehicle.

Table 1: Ecological bonus and conversion premium for CO_2 emissions of vehicles in France

CO_2 emissions	Ecological bonus (except diesel vehicles)	Conversion premium
0 to 20 g CO_2/km	6,300 EUR	3,700 EUR
21 to 60 g CO_2/km	1,000 EUR	2,500 EUR
61 to 110 g CO_2/km	750 EUR	

22.1.4 Low Emissions Zone

In 2016, the city of Paris set up the first Low Emissions Zone. Motorists must provide their vehicle with an air quality certificate called Crit'Air in order to travel in Paris.

In France, the scheme was introduced by the Energy Transition Act. Paris became the first city to seize it into force with the entry of its Low Emissions Zone backed by Crit'Air air quality certificates. In order to travel, motorists must display the Crit'Air sticker visibly on their windshield. The stickers provide an indication of pollutants emitted by the vehicle. Six categories exist, with a corresponding color and a specific vignette for electric vehicles.

Initially, gasoline and diesel passenger cars of more than 10 years of age, motorized 2- and 3-wheelers more than 16 years of age and buses, coaches and heavy vehicles of more than 15 years of age are prohibited Monday to Friday from 8 am to 8 pm.

These restrictions will progressively affect more and more categories of vehicles.

Drivers who exceed the driving ban are liable to a fine of 65 EUR for individual cars and 135 EUR for medium and heavy freight trucks.

First, police officers will visually control the stickers, but a process is already underway to implement automated controls.

The CRIT’AIR identification stickers will also be used to allow traffic to only less pollutant vehicles in case of peak pollution. In the same way, EVs can now be easily identified with a green sticker and they can benefit from free parking in Paris.

22.1.5 Financing of Charging Infrastructures

In 2016, the ADVENIR program was launched to allow the financing of private charging infrastructures in company car parks and in apartment buildings.

The principle is to oblige the energy companies to finance energy savings by obtaining a certificate. These companies can carry out the energy saving measures themselves, purchase certificates from the non-obligated ones, or pay a surtax to the State.

For the ADVENIR program, the price of the energy saving certificate was set at 3.25 EUR per MWhc for a total amount targeted by the various partners of 15.6 million EUR. EDF is already committed to the amount of 9.75 million EUR by choosing to finance the ADVENIR program.

ADVENIR's objective is to fund 12,000 private charging points installed:

- On the parking lot of a company accessible to employees
- On private spaces (car parks of commercial buildings...) with public access
- In collective housing (a tax credit is already in place for individuals)

The ADVENIR premium covers the costs of supplying and installing charging infrastructure with an aid of 40 % for businesses and 50 % for collective residential.

With this program, the partners intend to remove the obstacles to the development of electric mobility by giving users access to a main recharge point, whether at home or at the workplace.

The initiative completes the 30 % tax credit on the acquisition of charging systems for individuals. It also completes the ADEME financing scheme targeting the installation of charging stations open to the public.

The ADEME system provides financial support for cities that are involved in the deployment of charging points on public roads, in residential or business areas.

22.2 HEVs, PHEVs and EVs on the Road

22.2.1 Electric Passenger Cars

In 2016, the E-passenger cars market exceeded the symbolic threshold of 20,000 registrations, with a total of 21,751 units compared to 17,268 in 2015, representing an increase of 26 %. The year was marked by the launch of three new models (Citroën e-Mehari, Tesla Model X, Hyundai Ioniq) and two monthly sales peaks in March and December. Those sales peaks reflect the effect of the conversion premium and of the deliveries of the first Renault ZOE with 300 km of autonomy in real conditions.

In 2016, EV sales for passenger cars represents 1.08 % of total vehicle sales in France compared to 0.9 % in 2015. The distribution of EV sales by model for passenger cars is provided in Figure 1.

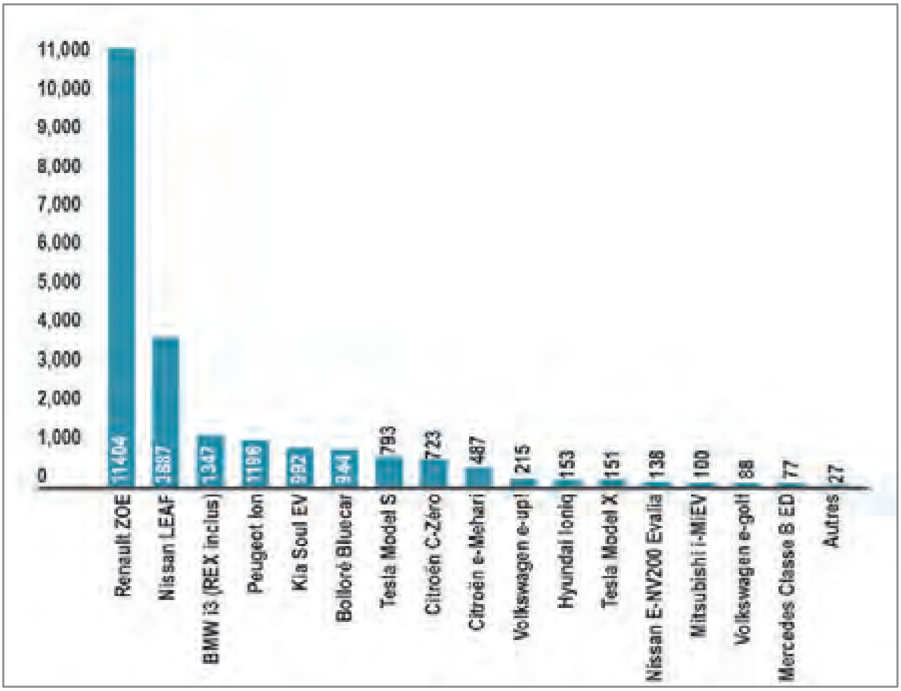


Figure 1: Distribution of electric vehicle sales by model in 2016 for passenger cars (Source: AVERE, France)

22.2.2 Electric Light Commercial Vehicles

In 2016, the electric light commercial vehicles market represents 5,556 registrations compared to 4,919 in 2015, an increase of +12.9 %. In 2016, EV sales for light commercial vehicles represents 1.35 % of the total light commercial vehicles sales in France compared to 1.3 % in 2015. The distribution of EV sales by model for light commercial vehicles is provided in Figure 2.

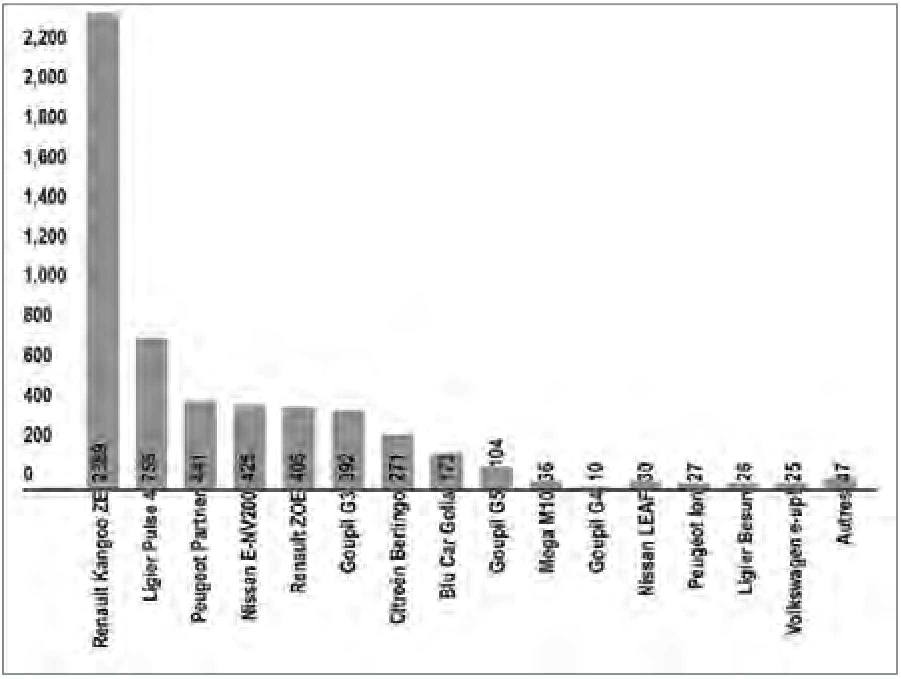


Figure 2: Distribution of electric vehicle sales by model in 2016 for light commercial vehicles (Source: AVERE, France)

22.2.3 PHEVs

In 2016, 6,467 PHEVs were registered, compared to 5,039 in 2015, representing a progression of +28 %. This general growth is mainly due to the diversification of the models available. Specifically, 7 models arrived on the market in 2016. However, the growth was limited by the reduction of the ecological bonus from 4,000 EUR to 1,000 EUR.

In 2016, PHEVs sales represented 0.32 % of total passenger cars sales compared to 0.26 % in 2015. The distribution of PHEV sales by model for passenger cars is provided in Figure 3.

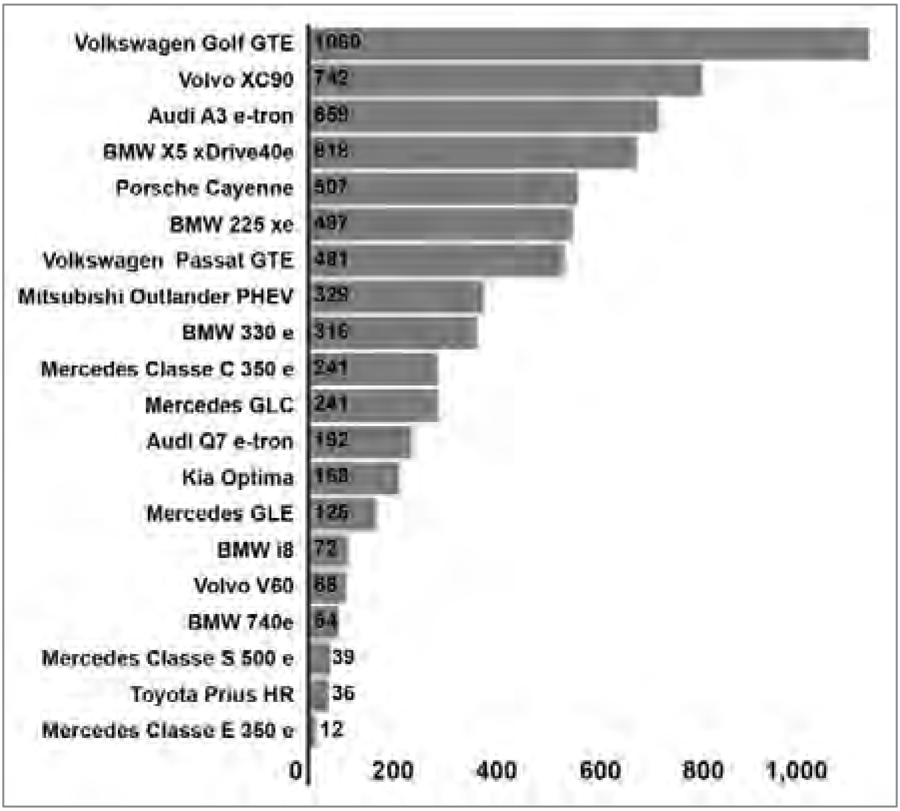


Figure 3: Distribution of PHEV sales by model in 2016 for passenger cars (Source: AVERE, France)

22.3 Charging Infrastructure or EVSE

According to GIREVE, France accounts 15,883 charging points accessible to the public at the end of 2016. The number of charging stations has significantly increased in 2016 (+ 57 %), when compared to the 10,200 listed in 2015. It is still in the Paris region where it is the easiest to charge an EV since the region accounts 7,416 charging spots. The Auvergne – Rhône Alps and the New – Aquitaine are then the regions with more charging points with 1,462 and 1,351 charging spots, respectively. However, reported to the population, the distribution is more balanced as shown in Figure 4.

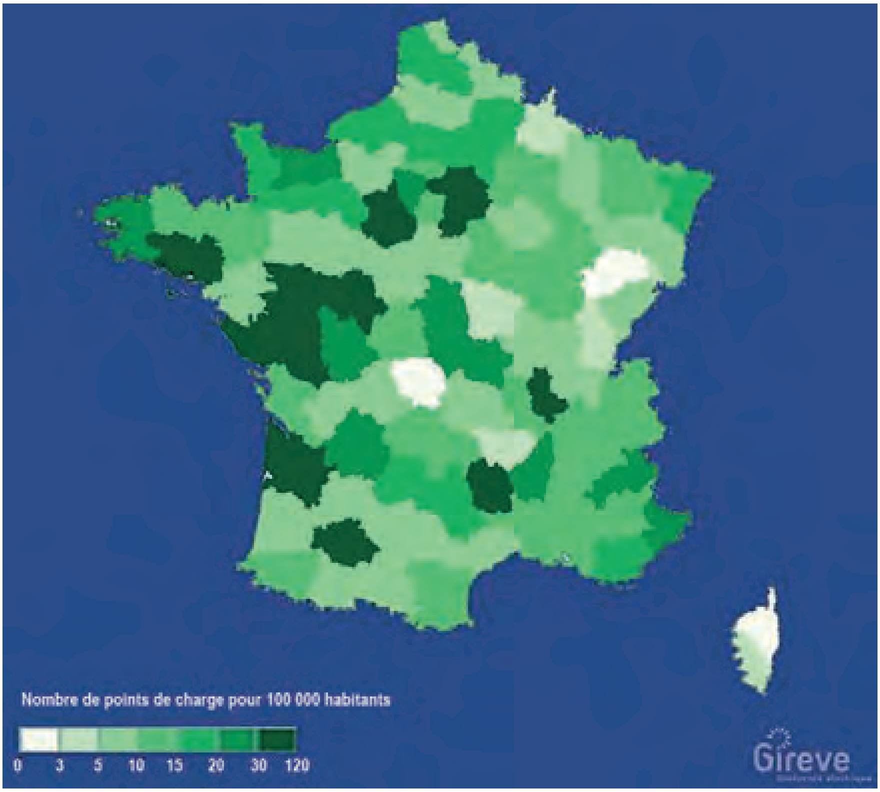


Figure 4: Distribution of charging points for 100,000 inhabitants by region in 2016 (Source: GIREVE)

Table 2: Information on publicly accessible charging infrastructure in 2016 in France (Data source: EAFO and ADEME)

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	14,250
AC Level 2 Chargers	362
Fast Chargers	936
Superchargers	295
Inductive Charging	0
Totals	**15,883**

Table 3: Distribution and sales of EVs, PHEVs and HEVs in 2016 (Data source: Global EV Outlook, EAFO, ACEA)

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
Passenger Vehicles[a]	27,310	6,470	283,670	n.a.	30,192,00
Buses and Minibuses[b]	350	n.a.	750	n.a.	94,000
Light commercial vehicles[c]	22,140	30	610	n.a.	4,511,000
Medium and Heavy Weight Trucks[d]	100	n.a.	n.a.	n.a.	1,272,000
Totals	**49,900**	**6,500**	**285,030**	**n.a.**	**36,069,000**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
Passenger Vehicles[a]	21,751	7,749	50,830	n.a.	2,269,010
Buses and Minibuses[b]	74	n.a.	n.a.	n.a.	n.a.
Light commercial vehicles[c]	5,546	15	340	n.a.	n.a.
Medium and Heavy Weight Trucks[d]	n.a.	n.a.	n.a.	n.a.	n.a.
Totals	**27,380**	**7,770**	**51,170**	**n.a.**	**2,269,010**

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

Table 4: Available vehicles and prices in France in 2016

Market-Price Comparison of Selected EVs and PHEVs in France	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
BMW Serie I	38,865
Bollore Bluecar	18,217
BYD E6	25,000
Citroën C Zero	26,900
Ford Focus	32,900
KIA Soul	36,117
Lumeneo Neoma	44,012
Mia	23,658
Mini	29,872
Mitsubishi i-MiEV	33,980
Nissan Leaf	26,900
Nissan NV 2000	26,600
Peugeot iOn	23,257
Renault Fluence	25,156
Renault ZOE	87,987
Tesla Model S	37,590
Tesla Roadster	23,260
Think City	38,865
Volkswagen Golf	18,217
Volkswagen IP	25,000
Volvo C30E	26,900

23 Germany

23.1 Major Developments in 2016

In 2016, the German government has taken a landmark decision to ratify the Paris Climate Agreement. The agreement's goal is to limit global warming to well below two degrees Celsius and, if possible, to 1.5 degrees. To achieve this, countries worldwide intend to achieve greenhouse gas neutrality by 2050. Principles and goals of the German government's climate policy are defined in a national climate action plan 2050. The plan sets sectoral targets regarding greenhouse gas emissions. The aim for the transport sector is to reduce greenhouse gas emissions by approx. 40 % in 2030 compared to 1990. This target can be regarded as ambitious, as greenhouse gas emissions of German transport in 2014 equalled those in 1990 with approx. 160 million tonnes CO_2[46]. Measures to achieve this target will be specified by the end of 2018. The electrification of the German vehicle fleet is a major building block in that strategy.

23.1.1 New Policies

The German Government considers it as essential to build up charging infrastructure to speed up the market success of PEV. Therefore, in May 2016 the cabinet decided to support the installation of charging stations with 300 million EUR, including 200 million EUR for fast charging stations[47].

In November 2016, the German cabinet adopted a new strategic framework for expanding infrastructure of alternative fuels with a focus on (quick) public charging infrastructure[48]. Another aim is to overcome legal obstacles regarding the installation of private charging stations.

In order to lead by example, the share of PEV bought by public authorities shall rise to at least 20 % of all new vehicle purchases. A budget of 100 million EUR was dedicated to this purpose.

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[46] https://unfccc.int/files/focus/long-term_strategies/application/pdf/161114_climate_action_plan_2050_en_bf.pdf
[47] www.bmwi.de/Redaktion/DE/Dossier/elektromobilitaet.html
[48] www.bmvi.de/SharedDocs/DE/Anlage/MKS/mks-nationaler-strategierahmen-afid.pdf

Due to continuing exceedances of air pollutant limits, the German Bundesrat discussed the introduction of an environmental badge, the so-called “Blaue Plakette”. Criteria for receiving the “Blaue Plakette” have not been finally decided, but it is likely that they include compliance with Euro 6 emission standards for Diesel vehicles and minimum Euro 3 for petrol vehicles.

23.1.2 Legislation

In May 2016, the “Umweltbonus”[49], a federal monetary purchase incentive programme for electric vehicles was introduced. The purchase of PEVs is supported with 4,000 EUR for BEV and 3,000 EUR for PHEV (half of the amount is to be paid by the OEM). A budget of 600 million EUR has been provided to promote the purchase of at least 300,000 vehicles. The incentive will end when the budget has been spent, or latest at the end of 2019.

The subsidy is restricted to BEV, FCV or PHEV (CO_2 emission ≤ 50 g CO_2/km) listed by the Federal Office for Economic Affairs and Export Control[50]. Requirements include:

- Initial vehicle registration
- Category M1, N1 or N2[51] vehicles (L-category vehicles are excluded)
- Models with a net list price of ≤ 60,000 EUR (basic version)

In March 2016, a federal regulation defining technical requirements for the installation and operation of public charging stations, the so-called “Ladesäulenverordnung (LSV)”[52] entered into force. It transposes EU regulation into national law and supports an accelerated implementation of charging infrastructure. The central element of the regulation is the specification of standardised plugs and socket-outlets according to IEC 62196. Depending on charging power, type 2 (> 3.6 kW) or Combo 2 (>22 kW) connections are mandatory for new charging stations.

23.1.3 Tax Incentives

In November 2016, a law for the tax promotion for electric mobility entered into force. It extends the tax exemption for fully electric vehicles to ten years with retroactive application for vehicles registered after January 1st, 2016. Vehicles

49 www.bafa.de/SharedDocs/Downloads/DE/Energie/emob_merkblatt_antrag.pdf
50 www.bafa.de/SharedDocs/Downloads/DE/Energie/emob_liste_foerderfaehige_fahrzeuge.pdf
51 If covered by a category B driver’s license
52 www.bmwi.de/Redaktion/DE/Downloads/V/verordnung-ladeeinrichtungen-elektromobile-kabinettbeschluss.pdf

converted to purely electric vehicles by technically appropriate, authorized means are included in the tax exemption[53].

Income tax law additionally promotes electric mobility. The benefit in kind in form of gratuitous charging at work, granted to employees by their employer, is exempted from income tax. Exemption is valid both for purely and hybrid electric vehicles. Charging infrastructure given to the employee for free may be taxed with a flat-rate tax of 25 %. The same tax rate may be applied for subsidies for charging infrastructure granted by employers.

23.1.4 Automotive Industry

At the end of 2016, 24 PEV models were available at the dealerships of German manufacturers. The portfolio covers all segments from small cars to large sports utility vehicles and luxury cars. The majority of electric vehicles made in Germany are PHEV. Only six BEV models were available in 2016. It can be noticed that PHEV have become a usual option of choice such like existing variants of Diesel and Gasoline powertrains. However, all German manufacturers consider battery electric vehicles in the future. In addition to the BEV concepts from Audi and Porsche already presented in 2015, Daimler and Volkswagen have shown their concepts at the 2016 Paris Motor Show. With EQ, Daimler created its own brand for intelligent electric vehicles[54], following the example of BMW i. The series vehicle following the Volkswagen I.D. concept (in 2020) is planned to be the first car based on the newly developed MEB (modular electric line-up) platform, which is supposed to find use in a wide number of EVs.

Besides the continuously growing portfolio of electric passenger cars, German manufacturers of light and heavy duty vehicles have visibly increased their activities concerning electric mobility. At the 2016 IAA Commercial Vehicles show, all major manufacturers presented electrified concepts like the Daimler Urban E-Truck and Vision Van, MAN e-TGS tractor and Volkswagen e-Crafter. Except Daimler’s Vision Van concept all of the aforementioned models are expected to undergo customer testing. Apart from presenting new concepts, the largest producer of battery electric light duty vehicles, Streetscooter, reached the milestone of 1,000 produced units[55].

In November 2016, BMW, Daimler, Ford and Volkswagen with Audi and Porsche agreed to establish a high-powered charging network in Europe[56]. The build-up is

[53] www.bundesfinanzministerium.de/Content/DE/Gesetzestexte/Gesetze_Verordnungen/2016-11-16-G-stl-Foerderung-Elektromobilitaet.html
[54] www.daimler.com/innovation/specials/elektromobilitaet/eq.html
[55] www.bmub.bund.de/pressemitteilung/deutsche-post-und-bundesumweltministerium-praesentieren-den-1000sten-streetscooter
[56] http://media.daimler.com/marsMediaSite/en/instance/ko.xhtml?oid=14866747

planned to start in 2017 and will eventually lead to a network of 400 350 kW DC ultra-fast chargers across Europe. The network will be equipped with the Combined Charging System (CCS) standard and is supposed to facilitate the BEV adoption across Europe.

Daimler and Porsche announced investments in BEV production sites in Germany. Porsche expands its main factory in Stuttgart, while Daimler will produce its first EQ model in Bremen. Furthermore, Daimler plans to spread its BEV manufacturing onto its international production network.

Volkswagen confirmed that its first battery production site will be built in Germany. The location and completion date have not yet been finally decided[57].

The automotive supplier ZF founded a new E-Mobility division to merge all its powertrain electrification activities. Bosch expanded its e-mobility activities by creating a sharing service for electric two wheelers. The station-based project is named “Coup” and started in Berlin with a fleet of 200 scooters. With an initial fleet of 50 Hyundai ix35 Fuel Cell vehicles, German chemical gas supplier Linde entered the car sharing business with its service BeeZero.

Figure 1: Mercedes Benz Concept EQ (Source: Daimler AG)

23.2 HEVs, PHEVs and EVs on the Road

New car sales in 2016 have cumulated to 3.35 million. This corresponds to a 4.3 % year-on-year growth. PEV sales increased by 7.2 % year-on-year to 25,154. HEV sales experienced a strong growth of 113 % to 47,996 sales in 2016. The widespread discussion of air pollution by diesel cars might have led to a drop of

[57] www.sueddeutsche.de/wirtschaft/volkswagen-vw-will-batteriefabrik-in-deutschland-bauen-1.3241880

their sales share to 45.9 %. So did that of gasoline cars (52.1 %), but it still remains at a high level. The average CO_2 emission of the new car fleet decreased by almost 2 g/km to 127.4 g/km.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2016 (Data source: Kraftfahrtbundesamt)

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[d]**
Passenger Vehicles[a]	34,022	20,975	144,430	n.a.	45,803,560
Buses and Minibuses[b]	168	0	318	n.a.	78,949
Medium and Heavy Weight Trucks[c]	6,595	4	122	6	2,911,907
Totals	**40,785**	**20,979**	**144,870**	**6**	**48,794,416**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[d]**
Passenger Vehicles[a]	11,410	13,744	47,996	n.a.	3,351,607

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

As of January 1st 2017, 55.6 million motorised vehicles were on the road in Germany, including 45.8 million passenger cars, 4.3 million motor bikes, 2.9 million trucks and 78,949 busses. The electric vehicle fleet increased to 216,680 (+28.1 %). Considering only passenger cars, the stock of BEV amounted to 34,022, that of HEV to 144,430. This corresponds to a year-on-year growth of 33.4 % and 10.8 %, respectively. With 2,804 sold units the Renault Zoe was the most popular BEV in 2016. It is followed by the BMW i3 (1,521) and the Tesla Model S (1,474). The most popular PHEV were the Audi A3 Sportsback e-tron (1,615), the Mitsubishi Outlander PHEV (1,436), and the Volkswagen Golf GTE (1,314). Sales of the BMW i3 Range Extender amounted to 1,342 units.

Table 2: Available vehicles and prices in Germany (vehicles that are more expensive than 60,000 EUR are not eligible for subsidy)

Market-Price Comparison of Selected EVs and PHEVs in Germany	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Renault Twizy 45 (plus battery leasing)	6,950
Citroen C-Zero	16,639
Renault ZOE	18,242
Nissan Leaf	19,634
Renault Kangoo Z.E. (plus battery leasing)	20,300
Citroen Berlingo electric	20,990
Peugeot Partner electric	21,290
Volkswagen e-up!	22,605
Nissan e-NV200	26,644
Hyundai Ioniq Elektro	27,983
Ford Focus Electric	29,328
BMW i3 (60 Ah)	29,370
Volkswagen e-Golf	30,168
BMW i3 (94 Ah)	30,378
Volkswagen Golf GTE	31,008
Toyota Prius Plug-in	31,555
Audi A3 Sportsback e-tron	32,605
BMW 225xe	32,900
Mercedes B 250 e	33,151
BMW i3 (60 Ah) Range Extender	33,605
Mitsubishi Outlander PHEV	31,849
BMW i3 (94 Ah) Range Extender	34,160
BMW 330e	36,639
Volkswagen Passat GTE	37,185
Mercedes C 350 e	42,900
Mercedes GLC 350 e 4MATIC	44,300
Mercedes E 350 e	49,950
BMW X5 xDrive40e iPerformance	58,655
Tesla Model S 60	59,999
Mercedes GLE 500 e 4MATIC	62,650
Audi Q7 e-tron quattro	68,824
Porsche Cayenne S E-Hybrid	72,381
BMW 740e iPerformance	77,731

Tesla Model X 75 D	89,748
Porsche Panamera 4 E-Hybrid	90,381
Mercedes S 500 e	92,650
BMW i8	109,244
Tesla Model S P 100 D	135,782
Tesla Model X P 100 D	137,143

Data source = OEM websites (all accessed February 2017)

23.3 Charging Infrastructure or EVSE

As of June 2016, a total of 6,517 charging points were publicly available (see Table 3). Publicly available charging stations amount to 2,859[58]. Most of the charging points enable 22 kW charging. About 230 charging points facilitate fast charging.

Table 3: Information on charging points in Germany in 2016

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC 1-phase type 2 (7.4 kW)	615
AC 3-phase type 2 (22 kW)	3,253
AC 1-phase type 2 (7.4 kW) & AC 3-phase type 2 (22 kW)	1,672
DC CHAdeMO (50 kW)	17
AC 3-phase type 2 & DC CHAdeMO	27
DC Combo 2 (50 kW)	75
AC 3-phase type 2 & DC Combo 2 & DC CHAdeMO	16
DC Combo 2 & DC CHAdeMO	47
AC 3-phase type 2 & DC Combo 2 & DC CHAdeMO	48
SchuKo (3.6 kW)	747
Totals	**6,517**

23.4 EV Demonstration Projects

The German national electric mobility development plan aims to enhance R&D of EV and their further market introduction. The programme is embedded in four federal ministries: the Federal Ministry for Economic Affairs and Energy (BMWi), the Federal Ministry of Transport and Digital Infrastructure (BMVI), the Federal Ministry of Education and Research (BMBF) and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

[58] www.bdew.de/internet.nsf/id/bdew-erhebung-elektromobilitaet-de?open&ccm=300110010020

The inter-departmental, promotional programme “Electric Mobility Showcase” ended in 2016 after four years. In four regions in Germany, 90 joint projects were funded with 180 million EUR, with a total investment of almost 300 million EUR[59]. One major impact of the programme is seen in having electric mobility made visible and tangible on German roads. Open topics for a further market penetration of EVs are seen in the installation of a nationwide public charging infrastructure, the interoperability of E-roaming platforms, the integration of EVs in intelligent grids, and the realisation of urban mobility concepts. Policy recommendations drawn from the experiences within the programme wereto guaranty a uniform and barrier-free access to public charging stations, to increase the use of electric buses in cities, and to enhance second-life usage of traction batteries, amongst others[60].

Accompanying research was commissioned in 2014 to organise a knowledge transfer between the “Electric Mobility Showcase” projects and the professional public. A variety of results documents have been published, i.e. on the topic of successful use cases for EV (social services and commuters), good E-roaming practice, second-life concepts for traction batteries, EV integration in micro smart grids and hybrid grids, urban mobility concepts, legislative framework and total costs of ownership[61].

Science and industry, funded by the BMWi with 18 million EUR, are working together in the project “SLAM” to build up and enhance a Germany-wide network of DC fast charging stations[62]. The aim is to have 600 charging stations installed until the end of 2017, covering metropolitan areas and connecting routes.

BMVI funding for R&D work is targeted at supporting the EV market launch including infrastructure. Within its programme “Electromobility Model Regions”, the cooperation of industry, science and the public sector is strengthened to enhance the integration of electric mobility into everyday life[63].

The BMUB funded projects “InitiativE-BB”[64] and “InitiativE-BW”[65] ended in 2016 after three years. Through them, around 900 EVs were brought into the market, mostly in commercial fleets. The accompanying research was focused on real world driving patterns, energy consumption, emissions, costs as well as user expectations and acceptance of electric mobility.

59 http://schaufenster-elektromobilitaet.org/en/content/index.html
60 http://schaufenster-elektromobilitaet.org/de/content/dokumente/dokumente_1/dokument_details_19264.html
61 http://schaufenster-elektromobilitaet.org/de/content/dokumente/dokumente_1/dokumente_2.html
62 www.slam-projekt.de
63 www.now-gmbh.de/en/electromobility-model-regions
64 www.emo-berlin.de/initiative
65 www.initiative-bw.de

24 Ireland

24.1 Major Developments in 2016

EV sales grew by only 14 % from 2015 to 2016. Within these figures, BEV sales actually decreased for the first time but this was offset by a dramatic increase in the sales of PHEVs as BMW and Volvo models became available in the Irish market for the first time. The decrease in BEV sales was attributed to a number of factors such as technical delays at the start of the year with the new Nissan Leaf, a lack in BEV alternatives and low cost private second hand imports arriving from the UK market.

Ireland is at risk of failing to meet its 2020 CO_2 emission targets within the EU and much attention is being given to transport emissions. Towards the end of the year, the Government established a Low Emissions Vehicle (LEV) Task Force to assess ways to increase the uptake rate of lower emission vehicles.

In 2016, the Commission for Energy Regulation (CER) issued a consultation to determine how to manage and develop the charging infrastructure for EVs. It is currently being managed by ESB Ecars until the CER have made their decision. This is causing a delay in the development of further infrastructure and may lead to doubts and uncertainties for potential new BEV customers until it is resolved.

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 purchasers of new EVs by ESB Ecars (a company which belongs to the same group as the Distribution System Operator). The charge point and installation is valued at approximately 900 EUR. ESB has committed to continue this incentive until the end of 2017 even if the 2,000 installation figure is exceeded.

24.2 HEVs, PHEVs and EVs on the Road

The cumulative number of Passenger EVs (BEV and PHEV) on Irish roads was 2,053 vehicles at the end of 2016 representing an increase in stock levels of 69 % which includes the private import of many EVs from the neighbouring UK market. BEV sales in fact decreased by 20 % in 2016 up on the previous year. PHEV sales however increased dramatically by 143 % with the introduction of the BMW and Volvo PHEV vehicles into the Irish market. There are now 24 EV model available in the Irish market and 150 EV Dealers participating in the EV Grant scheme and promoting the sale of EVs in Ireland.

24.3 Charging Infrastructure

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. The charging network was used over 140,000 times between November 2015 and November 2016, this converted to over six million zero tailpipe emission kilometers on Irish roads, displacing as much as 390,000 litres of fossil fuels in the process.

ESB also introduced an enhanced charge point management system, now powered by infrastructure software provider Driivz. The system allows ESB to monitor the availability of the charge point network and to remotely operate charge point units in the field, as well as the ability to carry out fault diagnoses and repair. Furthermore, the system feeds real time information into the charge point map and app enabling drivers to better plan their journey.

Table 1: Information on charging infrastructure in 2016 (Data source: ESB Ecars)

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers[a]	107
AC Level 2 Chargers	700
Fast Chargers[b]	79
Superchargers	0
Inductive Charging	1
Totals	**887**

[a] Level 1 includes publically accessible non-domestic chargers only
[b] AC Fast Charger may be used in parallel with CHAdeMO or CCS

Figure 1: Charging infrastructure future ownership and operation under discussion (Source: ESB Ecars)

24.4 Outlook

It is expected that more 300 km range BEVs will emerge in the Irish market which will hold significant attraction for the Irish motorist the size of the country and the good coverage of fast chargers around Ireland. The LEV Task Force is due to report on a range of subsidies which could be introduced in addition to those already available to encourage a greater uptake of EVs. The Task Force will also consider the requirements for infrastructure and its recommendations may have an impact on the pending decision which the CER will make in relation to ownership, operation and development of the current charging infrastructure. If this is resolved satisfactorily before the end of 2017 together with a range of further EV incentives, then it is possible that 2018 will see a strong increase in EV sales.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2016 (Data source: Department of Transport, Tourism & Sport, SEAI, SIMI)

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	28	n.a.	1	n.a.	38,023
Passenger Vehicles[b]	1,667	386	13,637	n.a.	2,049,529
Buses and Minibuses[c]	0	n.a.	0	n.a.	11,444
Light commercial vehicles[d]	78	1	47	n.a.	307,028
Medium and Heavy Weight Trucks[e]	n.a.	n.a.	n.a.	n.a.	35,231
Totals with bicycles	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**
Totals without bicycles	**1,773**	**387**	**13,685**	**n.a.**	**2,441,255**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	5	n.a.	1	n.a.	1,546
Passenger Vehicles[b]	385	297	2,565	n.a.	146,533
Buses and Minibuses[c]	0	0	0	n.a.	457
Light commercial vehicles[d]	10	0	0	n.a.	27,677
Medium and Heavy Weight Trucks[e]	n.a.	0	0	n.a.	374
Totals with bicycles	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**
Totals without bicycles	**400**	**297**	**2,566**	**n.a.**	**176,587**

n.a. = not available
[a] UNECE categories L1-L5
[b] UNECE categories M1, includes taxis, hackneys, limousines
[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

25 Italy

25.1 Major Developments in 2016

2016 was a positive year regarding to the new passenger car registrations, which globally increased moderately compared to 2015.

In 2016, the efforts to promote and financially support the introduction of cleaner vehicles were continued. Even if the direct incentives to purchase electric vehicles provided by Law n. 134 until 2015 were finished, other incentives for use and circulation were confirmed, as the exemption from the annual circulation tax (ownership tax) for a period of five years from the date of the first registration and after this five-year period electric vehicles benefit from a 75 % reduction of the tax rate applied to equivalent petrol vehicles. Further, for the insurance tariffs, electric vehicles receive a discount from various insurance companies. Finally, in some big Municipalities (for example Milan and Rome) electric vehicles have free parking in urban areas in any parking space and free circulation in limited circulation areas (ZTL zones). As an additional push to the diffusion of electric vehicles, against the still high vehicles price, the Ministry of Transport and Infrastructure has regulated the conversion (retrofit) of circulating conventional vehicles in electric vehicles, by a specific Legislative Decree issued in 2015 and become effective in 2016.

Regarding company fleets, by the "Legge di stabilità 2016" the super amortization as a fiscal detraction to purchase new instrumental vehicles was introduced.

Looking at the legislation on charging infrastructure, the updated version of the National Plan for Electric Charging Infrastructure (PNIRE) became effective, further the Legislative Decree for the reception of 2014/94/UE Directive, Directive Alternative Fuel Initiative (DAFI) was issues and finally the "Quadro Strategico Nazionale" was adopted: all together they define the national strategy for the widespread diffusion of electric vehicles charging infrastructure. In 2016 the Ministry of Economic Development also adopted the National Plan for Hydrogen Refueling Infrastructure (Piano Nazionale di Sviluppo – Mobilità Idrogeno Italia), so far missing in Italy.

Partnerships were established between car makers and electric energy distributors to promote services with electric vehicles, for example car sharing services in various Italian cities. Special proposals for electric vehicles fleets were reserved by car makers to Public Administration, in particular Municipalities (delegation vehicles or vehicles for Municipal Police) and Regions, trade Associations and private Companies. Also Security Force (Carabinieri, Polizia) started to use electric vehicles. A lot of agreements were registered between energy distributors and Municipalities for installing charging infrastructures. From this context, big plans of public charging infrastructures and various demonstration projects came to light.

In spite of this, the statistics of year 2016 show a reduction of new battery electric passenger car registrations. Very good, instead, were the new plug-in hybrid electric passenger car registrations, so that the balance of new electric chargeable passenger cars was positive, with a moderate growth compared to 2015. Also very good were the new hybrid electric passenger car registrations. On the other side, a significant reduction was registered in new other alternative fuels passenger cars registrations (natural gas, LPG, ethanol) and, consequently, also the new total alternative fuel passenger cars registrations in 2016 had a moderate reduction.

25.1.1 Legislation, Funding, Incentives and Taxation

In Italy, direct incentives (discount, VAT exemption, fiscal detractions) to purchase electric vehicles are not provided, but some incentives for use and circulation are present: exemption from the annual circulation tax (national policy), detractions on some tariffs, for example exemption from parking payment, tolls, free circulation in limited circulation areas (ZTL zones), exemption from total or partial circulation interruptions (regional policy, which regards less than 50 % of national citizens). Electric vehicles are exempt from the annual circulation tax (ownership tax) for a period of five years from the date of the first registration and after this five-year period they benefit from a 75 % reduction of the tax rate applied to equivalent petrol vehicles. In some Regions and Municipalities the total exemption is extended to the overall vehicle life. Further, for the insurance tariffs, electric vehicles receive a discount from various insurance companies. Finally, in some big Municipalities (for example Milan and Rome) electric vehicles are exempt from payment in reserved parking areas and can enter the limited circulation areas (ZTL zones). As a reference, if a medium size BEV or PHEV passenger car, at the price of 30,000 EUR (VAT excluded) and a lifetime of ten years, is considered, the economic equivalent of the available incentives is about 3,000 EUR for the BEV and 2,000 for the HEV (data updated at the end of 2016).

Company fleets receive a fiscal detraction in terms of super amortization to facilitate the diffusion of electric vehicles where the annual distance covered is higher and, consequently, to promote the “environmental sustainability”.

High purchase cost remains one of the main barrier to the diffusion of electric mobility, even if it is determined to be reduced in the future. Help to solve this problem could come from the “electric retrofit” of circulating conventional vehicles, which was regulated by the Ministry of Transport and Infrastructure with a Legislative Decree, issued in 2015 and became effective in January 2016.

Regarding incentives dedicated to charging infrastructure, they are present in terms of direct investments (national policy) that is Public Administration directly participate to the development of charging infrastructure, financing with public funds projects in this field. The instrument to incentivize charging infrastructure is the National Plan for Electric Charging Infrastructure (PNIRE), which provides the funding of public charging infrastructures by the Ministry of Transport and Infrastructure . The first version of PNIRE was in 2013, successively updated in 2014 and, more recently, in 2015; this last version became effective in 2016. For the financing, a dedicated fund of 33.5 million EUR was established. The Ministry participates in financing the projects presented by Regions and Local Authorities until a maximum equal to 50 % of the purchase and installation costs. Of the 33.5 million EUR allocated, around 4.5 million EUR are dedicated to all the regions in favor of projects to build charging infrastructures in the main urban areas characterized by high traffic congestion. With these projects the installation of 700 charging points in more than 100 Municipalities is expected. Actually, projects for more than 3.5 million EUR have already been signed and public funds are going to be distributed. The residual part of the funds, about 29 million EUR, is dedicated to the regions to incentivize private charging (domestic and company charging), the renewal of fuel stations, the development of public charging networks and the realization of public infrastructures.

In compliance with the Directive EU 2014/94, the Government worked for the preparation of the respective National Legislative Decree (Decree n. 257 issued on 16 December 2016 to become effective in January 2017) which establishes the guidelines for manufacturing electric vehicle charging infrastructures in the next years; it also included the ones relating to the so called “alternative fuels” (hydrogen, biofuel, natural gas and LPG).

By the same decree, the ”Quadro Strategico Nazionale” is adopted, which defines targets and development strategies of the above infrastructures, absorbing what was already established by the National Plan for Electric Charging Infrastructure (PNIRE) and promoting the adoption of guidelines for sustainable mobility urban plans.

The PNIRE, together with the National Legislative Decree to adopt the DAFI Directive and the “Quadro Strategico Nazionale”, define the National strategy for the widespread diffusion of electric vehicles charging infrastructure.

In this strategy, some interesting arguments can be highlighted:

- A target of 4,500 – 13,000 slow/accelerated charging points and more than 2,000 – 6,000 fast charging stations on the national territory at 2020 is defined, giving priority to urban areas which belong to metropolitan cities and, successively, suburban areas, extra-urban roads, state roads and highways.
- The “technology neutral” approach is used as a total strategic vision, and is able to appreciate the contribution of each fuel type to realize environmental targets.
- It is established that new fuel stations – or the ones under renewal – must provide methane or natural gas and install charging stations for electric vehicles.
- The constraint for Public Administrations to buy 25 % at least of methane, natural gas or electric vehicles, when substituting their fleets is established.
- Finally, by 31 December 2017 Municipalities must update their building regulations to meet the requirements of the provision on alternative fuels and, starting from the 1st June 2017, new buildings[66] or the ones under significant renovations must provide connections to install charging stations.

Correspondingly, electric vehicles charging was indicated by the Italian Authority for Electric Energy and Gas (AEEG) to be considered in the revision of domestic tariffs as one of the factors which change consumptions and power use. About this, the Authority is studying the introduction of incentives/penalties to favor the renewal of condominiums for the period of 2017 – 2019.

A first important step in the direction of structured incentive schemes and implementation roadmaps on behalf of the Italian Government towards the commercial deployment of FCEV for transport in Italy has been set in May 2016 by the Ministry of Economic Development through the adoption of a strategy document, “Piano Nazionale di Sviluppo – Mobilità Idrogeno Italia”, that has been developed by a core working group of experts in abidance to the DAFI (2014/94/EU). The “Piano Nazionale di Sviluppo – Mobilità Idrogeno Italia” thoroughly analyses the prospects for FCEV transport in all sectors (passenger, transit and material handling vehicles) and proposes a roadmap for the deployment of FCEV as well as associated Hydrogen Refueling Stations (HRS) from 2020 through to 2050, including a detailed projection of costs, fleet volumes, hydrogen sources, distribution of HRS, abated pollution, suggested European and national incentive schemes. The scenario predicts FC passenger cars to grow in number from 1,000 in 2020 to 27,000 in 2025, 290,000 in 2030, and FC buses to reach 3,660 in 2030 from an initial 100 in 2020 and 1,100 in 2025. This should be

[66] Buildings of new construction for not residential use with a surface bigger than 500 m^2 and residential buildings of new construction with 50 apartments at least.

matched by the deployment of 440 strategically placed HRS by 2030, starting from an initial 20 in 2020 and around 200 in 2025. The estimated amount of public support necessary in this decade would be less than 340 million EUR from national sources, which would be matched by 500 million EUR from the EU. In the following decades to 2050 these amounts would be reduced to 310 million EUR and 460 million EUR (2031–2040) and 210 million EUR and 310 million EUR (2041–2050) to reach over 8.5 million FC passenger cars and 23,000 FC buses on the Italian roads by 2050, nearly 6,000 HRS.

25.1.2 Research

For several years the National Research Council of Italy (CNR) has been studying the development of an electric mobility/energy production integrated system from renewable energetic sources/storage/management. The application of this study is the integration of alternative sustainable mobility systems, Intelligent Transport system (ITS) by the means of an ICT platform directed to systems, infrastructures and electric vehicles, FC and hybrid (FC and battery) vehicles. Another field is the experimental study of the management of energetic flows inside the hybrid propeller: it gives information to build simulation models of the energetic flows and pollutants generation. This study wants to define and experimentally evaluate the best control strategies for the optimal management of the propulsion system. Finally, CNR studies the different types of energy storage systems (batteries and supercapacitors) on board of the electric vehicles.

In 2016, the Italian National Agency on New Technologies, Energy and Sustainable Economic Development (ENEA) continued the activity relating to the “Sustainable Electric Mobility” project, included in the National Research Program for the Electrical System founded by the Ministry of Economic Development. This activity includes studies and researches to realize support instruments for planning and/or evaluating electric mobility and developing innovative technologies for charging infrastructures, especially the investigation of the impacts of electric mobility on the transport system in urban context and the development of useful instruments for Local Public Transport (LPT) Companies or Local Administrations. Here is a list of the activities made by ENEA in 2016:

- Studies on wireless charging, in terms of realization of static (Figure 1) and dynamic wireless charging systems and analysis of human exposure to electromagnetic fields near these systems.

Figure 1: EV static wireless charging system (Source: ENEA)

- Study of high power charging for LPT. A modular charging system that is safe and able to connect to the medium voltage grid. An experimental prototype on scale will be made to test the multi level structure.
- In the field of electric mobility scenarios, study of support instruments for LPT. The target of this study is the realization of a software to evaluate feasibility and convenience of electric traction in LPT, with technologies available on the market and new technologies.
- Optimal localization of charging infrastructures. Following the indications from PNIRE, a growth of the charging infrastructures network, able to manage the increasing request from users, is a priority for electric mobility diffusion. An operative instrument, able to join the request from users based on their real movements and the implementation of a “fuzzy” decisional logic to produce a spatial distribution of charging points.
- TPL with intermediate fast charging. The size reduction of the storage system on board is possible in LPT by fast charging strategies. In this context, a storage system (battery module with battery management system and thermal control) was tested in a life cycle under a fast charge and a balanced discharge to evaluate the reduction of the operative performances.

“Ricerca sul Sistema Energetico” (RSE), another main research institute, has been working together with CNR and ENEA for different years on electric mobility, not only on vehicles, but especially on their impacts on the grid and the optimization of mobility in the context of the wider energetic scenario. In 2016 RSE was scientific partner of “rEVolution - Electric Drive Days “, an event where the companies ENEL, A2A, Gruppo Hera and Class Onlus have elaborated and signed a strategic platform for electric mobility, the so called “Carta di Arese”. The document wants to summarize the guide lines for the development of electric mobility with concrete measures as incentives to purchase electric vehicles, the reduction of energy cost for charging vehicles, the modification of the rules on the road relating to dedicated areas for public charging and policies for the development of smart grids. On mandate coming from the Lombardia region, RSE contributed to elaborate the Guide Lines to realize a suitable infrastructure and the technical requirements to meet. Finally, in 2016, RSE presented the “e-Moticon” project, with a duration of 30 months and a budget (co-financed by the EU) of 2.2 million EUR, to promote electric mobility in the Alpine area. The project, which RSE is the promoter of, includes 15 partners, coming from the nations of the “Alpine Region”. After a first step of analysis, e-Moticon will produce a document named “Libro Bianco” for planning infrastructures: the scope is to create a transnational strategy for Public Administration which could be adopted in the instruments of urban planning.

25.2 HEVs, PHEVs and EVs on the Road

In 2016, overall new passenger car registrations increased by about 16 % compared to 2015, reaching a total of 1,824,568. As shown in Figure 2, new battery electric passenger car registrations slowed down by about 5.3 % compared to the previous year, while new plug-in hybrid electric passenger car registrations increased by about 63 %. Totally new electrically chargeable passenger cars increased significantly by about 20.7 %. Also new hybrid passenger car registrations increased significantly with respect to 2015, with a rate of 47.2 %. New other alternative fuel (natural gas, LPG, ethanol) passenger car registrations had a significant contraction of about 20.7 %. Totally, new alternative fuel passenger car registrations, hybrid and “electric chargeable” enclosed, had a reduction of about 12.1 % compared to 2015. Figure 3 shows the development of HEVs (on the left) and BEVs (on the right) over the last five years.

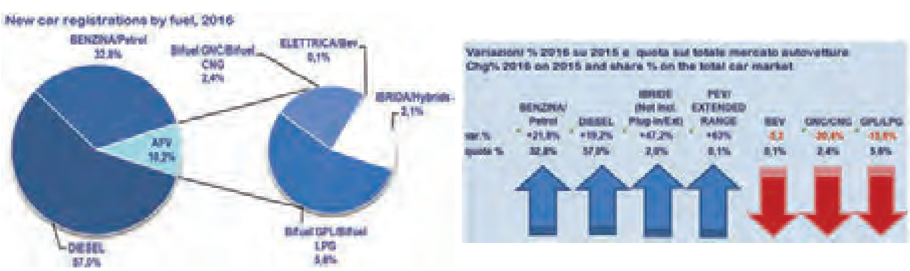

Figure 2: New car registration by fuel (left), change 2016/2015 and share on the total car market (right) (Source: ANFIA)

Figure 3: Historical sequence of new hybrid (left) and battery electric (right) passenger cars registrations (Source: UNRAE)

A large rise was registered for hybrid passenger cars, thanks to the continuous extension of range: these vehicles went beyond the share threshold of 2 %. After latest years with a significant increase, due to subsidy for the purchase of clean vehicles from 2013 to 2015, battery electric passenger car slowed down for about 5.3 %, with a share still under 0.1 % with respect to the total.

The reasons of this slow progress are versatile. The first is the high price of vehicles – which in other Countries is balanced by significant fiscal detractions – and the low number of charging infrastructure. These two elements must be added to the consumers doubts about electric vehicles and slow down the market development. In fact, in Italy the owners of “full electric” cars are mostly companies or rent companies: new electric passenger cars registered in 2016 are property of companies of about 85 % and natural persons of only 15 %. But something is moving on the charging infrastructures side, thanks to the DAFI Directive on alternative fuels, recently adopted by the Government.

Figure 4 shows the amount and share (following the European standard on polluting emissions, from Euro 0, the most polluting, to Euro 6, the cleanest) of circulating passenger cars, updated on 30 June 2016.

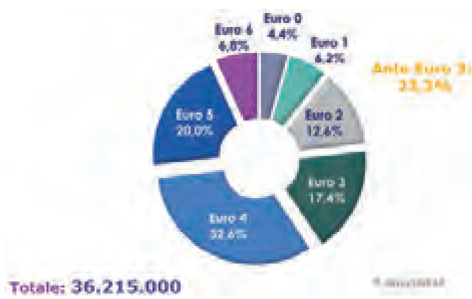

Figure 4: Amount and share of circulating passenger cars (Source: UNRAE)

A certain attention towards electric vehicles is beginning: free parking and circulation in limited circulation areas (ZTL) are reserved for electric vehicles in many cities, there are various projects included in the mobility urban plan for services diffusion, logistics of goods and car sharing based on electric vehicles. In fact, a supporter of automotive industry is represented by electric energy distributors, which have established partnerships with car makers to promote services based on electric vehicles, as it is for the announcements for car sharing services issued from various Italian cities.

From the “First National Report on Sharing Mobility”, published in December 2016 by the Sharing Mobility Observer, it appears the growth and use rate of this new form of mobility which counts 700,000 citizens that share cars and bikes. Between 2013 and 2015 the number of share vehicles in Italy has quadrupled, while the number of users and rents multiplied respectively by 12 and 30, thanks to the presence of important operators such as Car2Go and Enjoy. 5,764 vehicles in car sharing were counted in July 2016: 34 % of these in Milan, which has 370,000 users, followed by Rome (26 % vehicles and 220,000 users) Torino (16 % vehicles) and Florence (11 % vehicles). In 2015, overall 6,5 million rents were made and a total of 50 million km driven. Bike sharing (13,700 share bikes were counted on national surface in July 2016) works very good in Milan (260 bikes per 10 km^2), Turin (70 bikes per 10 km^2), Brescia, Bergamo, Siena and Pisa. Regarding to the number of rents in a month, Torino is in the 1st position with 90 rents, followed by Brescia (76), Bergamo (66), and Milan (56). It’s time to include the sharing mobility in the new Road Regulation, give fiscal incentives to operators and users, define new types of insurance for shared vehicles. Figure 5 shows a map of Italian car and bike sharing service in 2016.

In Italy, in July 2016, 5,764 shared vehicles were counted: the electric share of these vehicles is about 12 %, thanks to some operators which based their service exclusively on electric vehicles.

In 2015 only Milan was involved in the scooter sharing service, with a fleet of 150 vehicles. In 2016, due to the great interest of the market for this type of service, new services were activated in Rome (300 vehicles, updated in July 2016) and Catania (30 vehicles, updated in July 2016).

Figure 5: Map of bike sharing (left) and car sharing (right) service (Source: First National Report “La sharing mobility in Italia: numeri, fatti, potenzialità”, 2016)

Fully electric cars are starting to be present in Italian Municipalities with various examples. Car makers are interested to promote electric mobility, for this reason in the latest years they have established agreements with Public Administration, Municipalities (delegation vehicles or vehicles for Municipal Police), Regions, trade Associations and Private Companies (for example vehicle rent Company). Also Security Force (Carabinieri, Polizia) started to use electric vehicles.

Relating to the fleets of electric taxi, there are a few examples in Italy in 2016: Rome with 30 cars and Florence, where 70 authorizations for fully electric taxis will be released very soon.

Further, in 2016 there was a real customization of special vehicles in Italy, commercial vehicles and passenger vehicles. For example, in the sector of distribution of little packages in urban areas there was a proliferation of new vehicles of little size and low cost (e-bike, cargo-bike, e-scooter, mini car, single-seater for personal mobility), proposed also by academic start-ups and little national companies. For several years also “Poste Italiane”, the main Italian company for mail distribution, has chosen the free duck for urban deliveries, with a 1,000 vehicles fleet.

The sales of light commercial vehicles (< 3.5 t) and medium/heavy weight trucks (> 3.5 t) registered a very good trend during 2016, due to the fiscal benefit of the super amortizing, which has accelerated the renewal of a very old circulating fleet. Figures 6 and 7 show the registrations and the circulating fleet for light commercial vehicles and medium/heavy weight trucks respectively. In light of confirming this fiscal benefit, also the trend is expected in growth in 2017.

Figure 6: Light commercial vehicles registration (left) and circulating fleet (right) (Source: UNRAE)

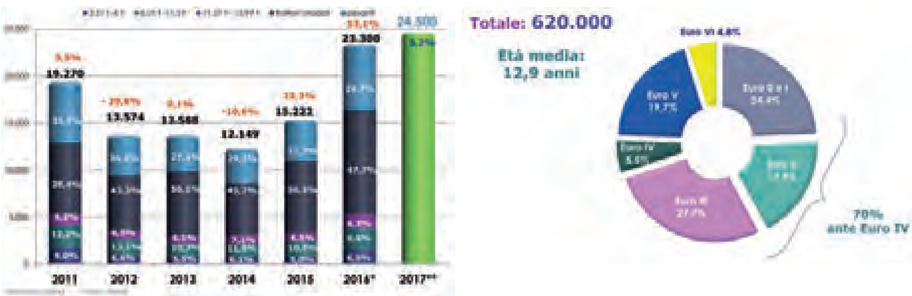

Figure 7: Medium/heavy weight trucks registrations (left) and circulating fleet (right) (Source: UNRAE)

In 2016, new buses and minibuses registrations reached 2,900 (UNRAE estimate). In 2017, a growth of more than 15 % is expected and the public tenders for new fleets will be essential. Figure 8 shows the registrations and circulating fleet for buses and minibuses.

In Milan the tender for the local transportation company (ATM) was adjudged and the winner is IVECO (the main Italian bus manufacturer). Herewith, 120 new hybrid buses will be provided in the framework of the plan to renew the fleet.

BYD, one of the most important Chinese companies which manufacture electric vehicles, won the tender to provide 16 fully electric buses, 12 m long, for the local transportation company (GTT) in Turin. Another 3 electric buses 12 m long from BYD will be delivered in Novara for the local transportation company (SUN), reaching a total of 19 buses.

Figure 8: Buses and minibuses registrations (left) and circulating fleet (right) (Source: UNRAE)

As regards FCEVs, from a national survey held in 2015, it emerges that at least 68 enterprises are currently active in the field of Fuel Cells and hydrogen technologies in Italy. 20 of these are devoted to FCEV deployment in transport and material handling. In spite of this, data on sales and circulating fleets of this type of vehicles are not available.

Statistics for the total vehicle fleets and sales in Italy are reported at the end of the chapter, in Table 2.

25.3 Charging Infrastructure or EVSE

In Italy about 9,000 charging points can be estimated, 7,000 – 7,500 (around 80 %) of them are private charging points. The situation is in continuous progress, because the National Plan for Electric charging Infrastructure (PNIRE), edited by the Ministry of Infrastructures and Transport (MIT) has to be applied. This makes the census of charging infrastructures particularly complicated. The results, to the best of actual possibilities, were obtained by consulting the source which is in direct contact with the infrastructure manufacturers/installers and energy distributors and directly reports to the Ministry of Infrastructures and Transport and the European Alternative Fuel Observatory (EAFO). They are reported in Table 1.

Table 1: Information on charging infrastructure in 2016 (Source: CEI-CIVES/EAFO).

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	1,796[a]
AC Level 2 Chargers	
Fast Chargers	211[b]
Superchargers	116[c]
Inductive Charging	n.a.
Totals	**2,123**

n.a. = not available
[a] Charging points ≤ 22 kW in public areas, updated at April 2016
[b] Charging points > 22 kW in public areas, updated at April 2016
[c] Very (> 50 kW) fast charging points Tesla, updated at September 2016

In 92 Italian provinces (see Figure 9) there is at least one public charging point, but charging points are concentrated in the main urban areas and cities with greater attitude towards the “smartness” concept. In Florence there are more than 300 charging points, around 200 in Rome, 150 in Milan and 40 in Perugia.

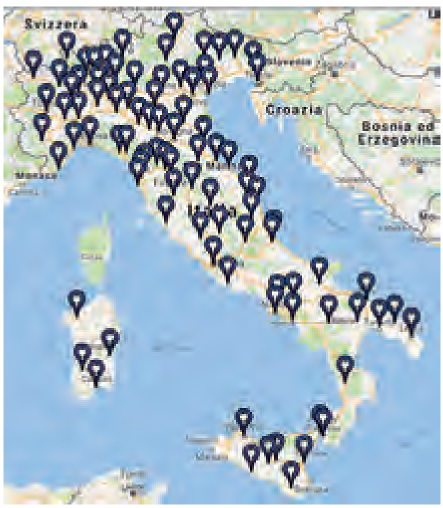

Figure 9: Map of charging infrastructures for electric vehicles (Source: www.colonnineelettriche.it)

PNIRE is the instrument which navigates the development of charging infrastructure. It established a target of 4,500 – 13,000 normal power charging points[67] (i.e. charging power equal or lower than 22 kW) and 2,000 – 6,000 high power charging stations (i.e. charging power bigger than 22 kW).

Under the push of PNIRE, various regions have already implemented Electric Mobility Plans and/or guidelines for the development of electric mobility. Dedicated plans for all other regions are in progress.

25.4 EV Demonstration Projects

Many programs/projects/initiatives continued to be promoted and financed/co-financed in 2016 by the EU, which Italian research institutes, companies or cities have taken part in, as described in details in the relating website:

- "Horizon 2020" (https://ec.europa.eu/programmes/horizon2020)
- "Civitas" (www.civitas.eu)
- "Life" (http://ec.europa.eu/environment/life)
- "Connecting Europe Facility" (https://ec.europa.eu/inea/en/connecting-europe-facility)
- "Urbact" (http://ec.europa.eu/regional_policy/en/atlas/programmes/2014-2020/europe/2014tc16rfir003)
- "Smart Cities and Communities European Innovation Partnership" (http://ec.europa.eu/eip/smartcities/index_en.htm)
- "Sustainable Urban Mobility Plan Award" (https://eu-smartcities.eu/content/first-eu-sustainable-urban-mobility-plan-award-local-authorities-now-open-submissions)

On 31st December 2015 the pilot projects (ENEL, A2A, Hera Group and Class Onlus) promoted by the AEEG for tests on charging of electric vehicles were completed. The experience was used to make some assessments in terms of models for electric vehicles charging services in places accessible to the public, taking into account the indications of Directive 2014/94/EU of the European Parliament and of the Council, on the creation of infrastructure for alternative fuels (AFID), which establishes the principle that the charging of electric vehicles should be carried out under competitive conditions.

According to the Project "Smart City L'Aquila", in collaboration between the City of L'Aquila and ENEL, the largest Italian electric utility, the installation of 39

[67] National targets for public charging of passenger cars were defined considering, in the first instance, a ratio of 1:10 between charging points and electric vehicles. In the hypothesis of an electric vehicles circulating fleet from 45,000 to 130,000 vehicles in 2020, the targets become: 4,500 – 13,000 slow/accelerated charging points. Slow/accelerated charging infrastructures must provide at least one socket with power 22 kW otherwise the only one socket must provide 22 kW. An infrastructure equipped with two sockets which allows the charge of only one vehicle at once must be counted as one charging point. Also an infrastructure which allows the charge of two (or more) vehicles simultaneously, but only one of the two (or more) sockets is able to provide a power of 22 kW, has to be counted as one charging point.

charging stations is planned, 2 of them with rapid charging technology, for a total of 80 charging points. In the initial part of the project, ENEA has created the on-demand transport service with a bimodal vehicle within a route called ”smart ring” in the historic town centre.

ENEL has signed an agreement with AISCAT (Associazione Italiana Società Concessionarie Autostrade e Trafori) in order to equip the highways with an electric charging network for fast charging in the service areas. The agreement includes the launch of a strategic, technological and logistic testing program of a network of electric fast charging infrastructure in the service areas. The experimentation phase will last for about three years and will include both a phase of studies and analysis, and a pilot implementation phase in the field. The first installations will begin in 2017. This agreement also wants to encourage the moving beyond the idea of using the electric vehicle exclusively in an urban context. In fact, there were mainly AC charging stations located in urban areas in Italy in 2016.

ENEL, as coordinator, and Austria’s main utility Verbund are collaborating on a fast-recharging network project in Italy and Austria, alongside some of the world’s largest EV carmakers including Renault, Nissan, BMW and Volkswagen Group Italia (represented by Volkswagen and Audi). Electric Vehicle Arteries (EVA+) aims to create a fast charging infrastructure for electric vehicles on key roads and motorways in Italy and Austria. A grant agreement worth a maximum of 4.2 million EUR (4.4 million USD) has already been signed with INEA, the Innovation and Networks Executive Agency delegated by the European Commission (EC). EVA+ will be officially launched in Brussels in January 2017. Over the course of the three-year project 200 multi-standard fast charging stations, each capable of offering all the fast charging standards (CSS Combo 2, CHAdeMO or AC charging), will be installed. Of the project’s 200 columns, 180 Fast Recharge Plus columns (a technology developed by ENEL that enables two vehicles to be simultaneously fast charged in 20 minutes) will be installed in Italy by ENEL, while the remaining 20 will be installed by Verbund’s subsidiary SMATRICS in Austria, also offering all fast charging standards.

”Puglia Active Network” (Pan) is the project of ENEL, supported by the European Community and the Ministry of Environment. It is co-financed with 85 million EUR in the framework of the EU NER 300 instrument, with the goal to promote the use and development of renewable sources, energy efficiency and electric mobility. In fact, the project includes, inter alia, to enable new services for citizens by developing a network of charging infrastructure for electric vehicles on a regional scale. It will be installing more than 70 intelligent and interoperable (which may be used by customers of different operators) charging infrastructures, distributed in about 40 sites of the Municipalities, ring roads and access roads to major urban centers of the region, as well as on the primary highway network.

Project “E-Vai 3.0”, launched by “FN Mobilità Sostenibile” (company of the group “Ferrovie Nord Milano”) in collaboration with ENEL, is a project of integrated mobility that combines railway and green car sharing using only electric vehicles. The project will be active until June 2018 in the Municipalities of Varese and Saronno, with 12 cars and 3 charging stations respectively installed in parking areas (6 parking spaces each) at the railway stations of Varese and Saronno.

Project Unit-E, started from the larger program Connecting Europe facility (CEF) of the European Commission, in which the ABB Group takes part, in a consortium with the EDF Group, BMW, Nissan, Renault, École des Ponts, Porto Antico di Genova, and the International Institute of Communications. ABB will supply 4 fast charging stations multi standard installed from Genoa to Mentone.

In the Environment Park of Turin the Smart Recharging Island was realized, where it is possible to “smart” charge electric cars connected to the grid in order to take full advantage of the energy produced from renewable sources through an integrated management system including a charging station, an energy storage unit and a photovoltaic system.

Concerning the electric car sharing, an agreement was signed between ENEL and University Roma 3 for 30 vehicles (10 ZOE and 20 Twizy) and dedicated charging stations, in order to allow students and teachers to use and test these services. The service was free until 31st December 2016, while from 2017 it will be offered with flexible and affordable rates.

In Italy there are numerous examples of pioneering demonstration in FC-powered transport. H2 Alto Adige is a large-scale project for the production, storage and refueling of renewable hydrogen for FCEV. Three electrolysers make up the HRS and convert power from renewables like wind and solar PV to 345 kg of H_2 per day, sufficient for 15 buses or 700 passenger cars. Besides Bolzano, other HRS development activities are ongoing in Milano, Sanremo, Rome, Venezia, Brunico, and Rovereto. These HRS in Italy are strictly connected to three pan-European FC bus demonstration projects financed by the EU, which Italy has been part of from the beginning: CHIC, High V.LoCity, 3Emotion. Italian involvement in FC bus demonstration goes back to the 1999 project “Autobus ad Idrogeno – Emissioni Zero” where a specifically developed FC bus operated regular passenger service for the city of Torino. In Venezia, the first public transport ferry powered by Fuel Cells is operational: the “Hepic”.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2016 (Data source: see legend)

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	n.a.	n.a.	n.a.	n.a.	9,000,000[g]
Passenger Vehicles[b]	5,955[h]	2,867[h]	117,898	n.a.	36,215,000[i]
Buses and Minibuses[c]	n.a.	n.a.	n.a.	n.a.	60,600[i]
Light commercial vehicles[d]	n.a.	n.a.	n.a.	n.a.	3,585,000[i]
Medium and Heavy Weight Trucks[e]	n.a.	n.a.	n.a.	n.a.	620,000[i]
Totals with bicycles	**505,955**	**2,867**	**n.a.**	**n.a.**	**84,480,600**
Totals without bicycles	**5,955**	**2,867**	**117,898**	**n.a.**	**49,480,600**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	875[j]	n.a.	n.a.	n.a.	217,063[j]
Passenger Vehicles[b]	1,375[k]	1,317[k]	37,128[k,l]	n.a.	1,824,968[k]
Buses and Minibuses[c]	n.a.	n.a.	n.a.	n.a.	2,900[m]
Light commercial vehicles[d]	n.a.	n.a.	n.a.	n.a.	199,500[m]
Medium and Heavy Weight Trucks[e]	n.a.	n.a.	n.a.	n.a.	23,300[m]
Totals with bicycles	**3,653**	**1,317**	**37,128**	**n.a.**	**4,118,877**
Totals without bicycles	**2,250**	**1,317**	**37,128**	**n.a.**	**2,267,731**

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 vehicle[g]
[g] Data source: ANCMA
[h] Data source: ENEA estimate
[i] Data source: UNRAE estimate, updated at 30 July 2016
[j] Data source: ENEA elaboration on data ANCMA
[k] Data source: ACEA
[l] HEVs + EREVs = 38,580; EVs + PHEVs + EREV = 2,827 (total electrically chargeable)
[m] Data source: UNRAE

Table 3: 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)**
BMW 330e Performance	45,350
BMW 225xe Active Tourer	38,400
BMW i8	139,650
BMW X5	73,600
BMW i3 (various versions)	36,600 – 42,600
Citroën C-Zero	30,690
Citroën E-Mehari	25,990
DS 5 Hybrid (various versions)	44,250 – 47,600
Fisker Karma (various versions)	105,600 – 121,200
Honda NSX	197,900
Hyundai Ioniq Electric (various versions)	36,750 – 38,750
Hyundai Ioniq Hybrid (various versions)	24,900 – 29,000
Infiniti Q70 Hybrid (various versions)	62,850 – 65,800
KIA Optima Plug-in Hybrid	44,000
Land Rover Range Rover Hybrid (various	138,900 – 197,200
Lexus CT Hybrid	38,650
Lexus IS Hybrid (various versions)	38,200 – 50,700
Lexus GS Hybrid (various versions)	53,000 – 76,100
Lexus LS Hybrid (various versions)	117,300 – 152,600
Lexus RC Hybrid (various versions)	46,000 – 49,950
Lexus NX Hybrid (various versions)	39,950 – 55,300
Lexus RX Hybrid (various versions)	69,000 – 76,000
Mercedes B 250e	41,600
Mercedes C 350e	49,920
Mercedes C 300	49,225
Mercedes S 300	108,280
Mercedes S 400 (various versions)	111,530 – 114,870
Mercedes S 500	119,270
Mercedes GLC 350e	62,960
Mercedes GLE 500e	83,760
Mitsubishi Outlander PHEV (various	46,850 – 52,850
Mitsubishi i-MiEV	29,900
Nissan Leaf (various versions)	23,910 – 39,085

Opel Ampera	33,400 (late 2017)
Peugeot iOn	28,151
Porsche Panamera E-Hybrid (various	114,043 – 121,729
Renault Fluence	28,750 (out of production)
Renault ZOE (various versions)	25,700 – 38,300
Renault Kangoo Maxi	22,000
Renault Twizy	6,900
Smart Fortwo Electric Drive (various	21,850 – 25,200 (early
Suzuki Ignis Hybrid	16,800 – 19,000
Tesla Model S (various versions)	84,140 – 161,240
Tesla Model X (various versions)	105,440 – 163,240
Toyota Auris Hybrid (various versions)	25,750 – 27,500
Toyota Prius Plug-in (various versions)	29,250 – 36,200
Toyota C-HR Hybrid (various versions)	29,050 – 30,700
Toyota RAV4 Hybrid	34,100 – 41,050
VW e-up!	27,850
VW e-Golf	38,000
VW Passat Variant Plug-in Hybrid	48,000

25.5 Outlook

The prospects for EVs, PHEVs and HEVs in Italy are judged positively and with a significantly 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. 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 is expected by the EU directive for the installation of a clean fuel infrastructure throughout Europe with approved national plans for implementation by 2020 and beyond. The National Plan for Electric Charging Infrastructure prepared by the Italian Government is operative, and the one for hydrogen refueling infrastructure is already prepared by the Ministry of Economic Development and ready to become operative. The presence of charging infrastructures will drive the growth of clean vehicles.

26 The Netherlands

26.1 Major Developments in 2016

Dutch businesses, social institutions, knowledge institutes and government agencies have joined forces at the national and international level to accelerate the adoption of electric transport, intending to capitalize on the economic opportunities associated with it.

This has once again born fruit in 2016. For one thing, the number of electric cars in the Netherlands has again increased significantly. In November 2016, the Netherlands welcomed its 100,000th electric passenger car.

It is evident from the growing interest in electric transport that this innovation offers economic opportunities for the Dutch business sector. Dutch companies are involved in various related activities, including the provision of a charging infrastructure, smart charging and charging services, the manufacture of components and the production of buses, trucks and light electric vehicles such as electric scooters.

More and more organizations are active in innovative projects relating electric vehicles to the energy transition.

Figure 1: Electric vehicle and solar roofs (Source: Rob Vos | Living Lab Smart Charging)

The Ministry of Economic Affairs published a Vision on the Charging Infrastructure for Electric Transport, with a policy agenda looking ahead to 2020.

An important item is that Dutch government and companies together call for the use of open standards and open protocols in charging infrastructure, so as to stimulate innovation and global access.

More information on major developments in the Netherlands can be found in the annual report on 2016 which focuses on the most important highlights in e-mobility in 2016 in the Netherlands[68].

26.1.1 Green Deals

Green Deal on Electric Transport 2016-2020

The Dutch Minister of Economic Affairs, Mr Kamp, signed the Electric Transport Green Deal for 2016-2020 along with 17 other parties in April 2016. The objective of this Green Deal is to bring together initiatives that relate to e-mobility, in order to accelerate the transition to electric transport. As part of the Green Deal, the Formula E-Team, a public-private co-operation between companies, research institutes, NGOs, the government, and local authorities, is extended for five years.

Figure 2: The signatories to the Electric Transport Green Deal 2016-2020

The Netherlands is one of the world leaders in the field of electric transport. The aim of the Green Deal is to maintain this leading position. The ambition for 2020 is that 10 % of newly-sold passenger vehicles should have an electric powertrain. In addition, 75,000 private individuals should be driving an electric car by 2020, with 50,000 of these being second-hand and 25,000 new vehicles. Finally, by 2025, 50 % of all newly-sold cars should have an electric powertrain. A minimum of 30 % of these, i.e. 15 % of all newly-sold cars, must be BEV.

[68] www.rvo.nl/sites/default/files/2017/04/Highlights-2016-Electric-transport-in-the-Netherlands-RVO.nl_.pdf

In addition, the Formula E-Team will focus on improving and expanding the charging infrastructure, the linkage with sustainably-generated energy, developing the consumer market and supporting innovation.

Green Deal on Zero Emission City Logistics

The end goal of the Zero Emission City Logistics Green Deal is to reduce harmful emissions – i.e. CO_2, NOx and particulate matter – and noise from city logistics to zero by 2025. Local experiments are being undertaken to explore how effective contributions can be made to this reduction. As part of this effort, the more than 100 participants in the Green Deal launched so-called Living Labs in 2016.

These testing grounds are used to explore which combinations of logistics, regulations, vehicles and behaviour can make an effective contribution to reducing harmful emissions. In the Living Labs, new expertise with logistics concepts and the corresponding business models is being developed.

Administrative Agreement on Emission-free Buses

In April 2016, State Secretary Ms Dijksma (Infrastructure and the Environment), together with 14 transport authorities, signed the administrative agreement “Zero Emission Regional Public Transport by Bus”. The agreement stipulates that, from 2025, all new buses must be free of harmful exhaust emissions.

26.1.2 Market Developments

Several cities and regions launched tender procedures for the installation of charging points. The provinces of North-Brabant and Limburg published the largest regional tender to date – for 2,500 smart charging points. In addition, it will result in new charging points being put in place without any investments from government authorities.

In 2016, Ebusco exported a large number of electric buses to various countries in Northwestern Europe. For example, the city of Paris asked the Dutch company to supply it with ten electric city buses. These buses can drive 300 kilometres without having to recharge. The development of the city bus that will be used in Paris was made possible by an ‘Innovation Credit’ loan from the Netherlands Enterprise Agency.

Figure 3: King Willem-Alexander and Queen Maxima next to an electric Ebusco bus in Paris (Source: Ventura Systems)

As of mid-December 2016, transport provider Hermes is responsible for public transport in Eindhoven and Helmond. The company is deploying 43 fully-electric articulated city buses for this, making southeast North Brabant's fleet the largest electric bus fleet in Europe. The vehicles are model VDL Citea Electrics, 18 metres in length and with a capacity of 125 passengers. The bus's battery pack is charged using a pantograph at the bus depot, which takes only 5 to 20 minutes using the Heliox Fast Charger.

Heineken Wholesale is now operating eight 13-ton electric trucks in Amsterdam. This transition supports the beer company's ambition of using exclusively zero-emission transport in all the major cities in the Randstad conurbation for its on-trade distribution. The trucks, provided by logistics service provider Simon Loos, use electricity generated by the solar panels on the roof of the Heineken distribution centre in Amsterdam.

Figure 4: Heineken aims to use emission-free transport in all major cities by 2020 (Source: www.iepieleaks.nl)

Since May 2016, near Haarrijn along the A2 motorway between Amsterdam and Utrecht, MisterGreen Electric Lease uses old batteries from electric cars in their fast charging station. The old batteries are used as part of a storage system for solar power that is used to fast charge electric cars.

Mobility as a Service (MAAS) is gaining popularity, with many SMEs popping up offering electric car sharing and other related services.

There are several active Partners for International Business projects (PIBs) in the field of e-mobility. These projects are a cooperation between companies and knowledge institutes in two countries, aiming on doing business together. There are PIBs with the United States (West Coast), Germany (North and South Germany), Austria, and India.

26.1.3 Innovation and Research

The National Knowledge Platform for Charging Infrastructure aims to bring down the cost for public charging infrastructure, through research and innovation projects (http://en.nklnederland.nl). Some interesting projects:

- To identify a trend line from 2013-2020, a benchmark study was carried out to show the cost and revenue of public charging infrastructure in 2016. Compared to 2013, the cost for public charging infrastructure has decreased by around 30 %. Moreover, the usage at the public charging point increased over the same period from 5 to 8.5 kWh per day.
- A study on alternative locations to install charging points at existing large power grid connections, eg ship locks or moving bridges.

The University of Applied Sciences of Amsterdam monitors and analyses the use of public charging poles in the cities of Amsterdam, Rotterdam, Utrecht and The Hague and the provinces of North-Holland, Utrecht, and Flevoland on a regular basis. This results in a lot of valuable information, a.o. for city planning purposes.

Student teams of Technical Universities and Universities of Applied Sciences keep innovating and developing new electric vehicles and technology. Team FAST, a student team from Eindhoven University of Technology presented the prototype for an electric car that runs on formic acid. The Formula Student Team from Delft University of Technology has developed a new electric racing car that only weighs 160 kilos.

Figure 5: STORM's electric motor cycle in the United States (Source: Bart van Overbeeke)

STORM Eindhoven, a team of 23 students from Eindhoven University of Technology, has completed a journey around the world in 80 days on an electric motorcycle they built themselves. The students travelled 23,000 kilometres on two electric touring motorcycles which had a maximum speed of 160 km/h and a range of 380 kilometres. The bikes' batteries were charged every day on the local electricity grid, at businesses, universities or in private homes.

26.1.4 Financial and Fiscal Incentives

One of the main drivers behind the increase of electric vehicles is fiscal stimulation. Starting on 1st January 2016 there is more focus on zero emission vehicles. Until 2020, fiscal incentives for plug-in hybrid cars will gradually be reduced to the same level as that of conventional cars. Table 1 provides an overview of the incentives that were in place in 2016.

Table 1: Fiscal incentives in the Netherlands 2016

Policy measure	Details
Registration tax	Zero emission cars are exempt from paying registration tax. For conventional cars the system is progressive, with a starting tariff and 5 levels of CO_2 emissions and amounts of registration tax. Plug-in hybrid cars get a discount compared to conventional cars, they do not have a starting tariff and have 3 levels of CO_2 emissions and amounts of registration tax.
Road tax	Zero emission cars are exempt from paying road tax. Plug-in hybrid cars < 51 gr CO_2/km pay half tariff (up to 2020). This is 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 or 22 % of the catalogue value on the taxable income. For zero emission cars this percentage is 4 %. For all other cars, including plug-in hybrid cars, it is 22 %.
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 cars < 31 gr CO_2/km (and not with a diesel engine) are on the list of deductible investments, as are the accompanying charging points.

In addition to these national instruments, there are some regions that subsidise electric cars (passenger cars, commercial cars, trucks and/or scooters) and/or the installation of charging points. The city of The Hague, for example, had a very successful subsidy scheme for electric cars in place in 2016, also applying to second hand cars.

As part of the Green deal on Public Charging Infrastructure, 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. The Ministry of Economic Affairs intents to raise the amount by 1.5 million EUR in 2017.

26.2 HEVs, PHEVs and EVs on the Road

The number of plugged-in electric vehicles grows steadily in the Netherlands. In November 2016, the 100,000th electric passenger car was registered, an important milestone.

At the end of 2016, 112,038 electric passenger cars were registered in the Netherlands. Of these almost 12 % were Battery Electric Vehicles (BEVs), the majority consisting of Plug-in Hybrid Vehicles (PHEVs or E-REVs), and a few FCEVs (30 in number). When compared to the end of 2015, BEVs increased by 40 % and PHEVs by 27 %.

There were 141,559 HEVs on the road at the end of December 2016. In the year 2016, the number of registered HEVs increased by 8 %.

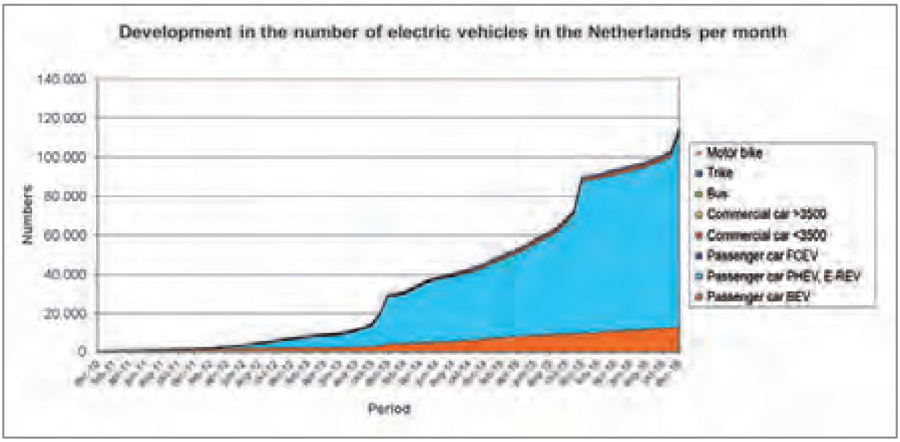

Figure 6: Development of plugged-in electric vehicles 2010-2016 in the Netherlands (Source: Dutch Road Authority, edited by RVO.nl)

At the end of 2013, 2015 and 2016, the effect of upcoming changes in fiscal incentives is clearly visible.

Over the year 2016 6.4 % of new registrations were BEVs or PHEVs. In 2015 this percentage was 9.7 and in 2014 it was 3.9. At the end of 2015 about 1 % of the total passenger car fleet was electric (BEV and PHEV).

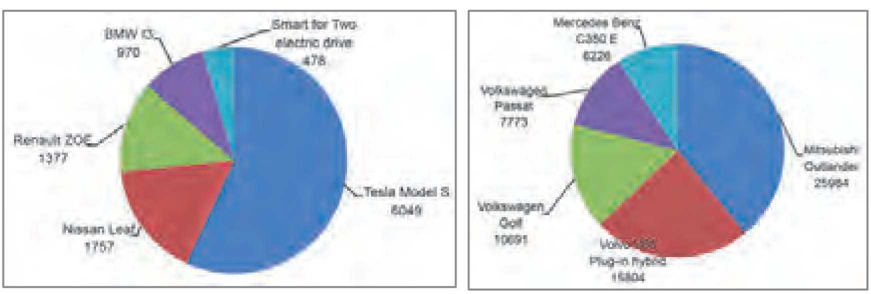

Figure 7: Top 5 registrations in fleet BEV (left) and PHEV (right), 31 December 2015 (Source: Dutch Road Authority, edited by RVO.nl)

The most popular models in the Dutch passenger car fleet for PHEV and BEV are shown here.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2016 (Data 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 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	37,594	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles[b]	13,105	98,903	141,559	30	8,439,318
Buses and Minibuses[c]	168	n.a.	n.a.	1	9,720
Light commercial vehicles[d]	1,628	n.a.	n.a.	2	927,186
Medium and Heavy Weight Trucks[e]	66	n.a.	n.a.	4	135,322
Totals without bicycles	**14,967**	**98,903**	**141,559**	**37**	**9,511,546**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	4,385	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles[b]	3,737	20,740	10,548	9	382,825
Buses and Minibuses[c]	74	n.a.	n.a.	0	n.a.
Light commercial vehicles[d]	168	n.a.	n.a.	0	66,904
Medium and Heavy Weight Trucks[e]	16	n.a.	n.a.	2	14,964
Totals without bicycles	**8,380**	**20,740**	**10,548**	**11**	**464,693**

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 (Source: www.anwb.nl, www.peugeot.nl, www.renault.nl, March 2017)

Market-Price Comparison of available (FC)EVs and PHEVs in the Netherlands	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price for Base Model (in EUR)**
Audi A3 Sportback e-Tron	37,900
Audi Q7 e-Tron	85,000
BMW 225xe	39,800
BMW 330e	44,746
BMW 740(L)e	93,500
BMW i3	35,500
BMW i3 range extender	39,990
BMW i8	138,000
BMW X5 xDrive40e	81,000
Citroën C-Zero	28,990
Ford C-Max Plug-in Hybrid	36,995
Hyundai IONIQ electric	33,995
Hyundai ix35 FCEV	66,550
KIA Soul EV	32,495
Mercedes B-Electric Drive	40,995
Mercedes C350 e Plug-in Hybrid	49,995
Mercedes GLE 500e	80,400
Mercedes S500 Plug-in Hybrid	116,700
Mitsubishi i-MIEV	26,600
Mitsubishi Outlander PHEV	41,990
Nissan E-NV200 Evalia	30,982 (excl. battery rent)
Nissan Leaf	24,835 (excl. battery rent)
Peugeot iOn	22,360
Porsche Cayenne S E-Hybrid	85,900
Porsche Panamera S E-Hybrid	110,100
Renault Kangoo ZE	20,195
Renault Twizy	7,590
Renault ZOE	20,990 (excl. battery rent)
Smart Fortwo Electric Drive Cabrio	22,450 (excl. battery rent)
Tesla Model S	79,200
Tesla Model X	100,600
Toyota Mirai	79,000

Toyota Prius Plug-in Hybrid	34,450
Volkswagen e-Golf	36,190
Volkswagen e-up!	25,925
Volkswagen Golf GTE	38,190
Volkswagen Passat GTE	44,650
Volvo V60 Twin Engine	54,995
Volvo XC90 T8 Twin Engine	77,995

26.3 Charging Infrastructure or EVSE

At the end of 2016, there were over 11,700 public charging points and more than 14,000 semi-public charging points in the Netherlands. The number of fast charging points increased from 465 at the end of 2015 to 612 at the end of 2016 – along highways but also in the cities, in total at 150 different locations. This includes 10 Tesla Supercharger locations with 85 chargers in total. Next to these publicly accessible charging points, an estimated minimum of at least 72,000 private charging points were in operation.

Table 4: Information on charging infrastructure in 2016 (Source: Oplaadpalen.nl, edited by RVO.nl)

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 and 2 Chargers	26,088
Fast Chargers	4,612 (150 locations)
Superchargers	25 (10 locations)
Inductive Charging	• For passenger cars 1 pilot project in Rotterdam • For buses two cities with a bus line on inductive charging (Utrecht and Den Bosch)
Totals	**30,725**

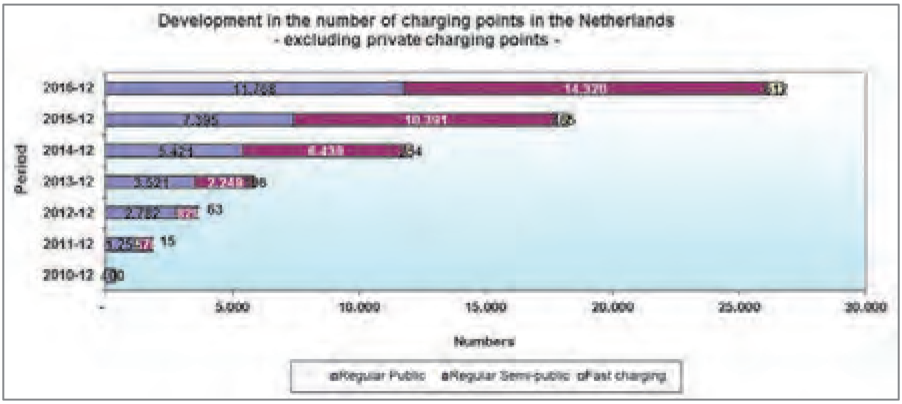

Figure 8: Charging infrastructure development in the Netherlands, 2010-2016 (Source: Oplaadpalen.nl, edited by RVO.nl)

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 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.

26.4 EV Demonstration Projects

Figure 9: Living Lab Smart Charging (Source: Living Lab Smart Charging)

By turning itself into one huge Living Lab for the Smart Charging of electric vehicles, the Netherlands is rapidly becoming the international frontrunner for smart charging electric vehicles (EVs), using them a.o. to store peak power production of solar and wind energy. Already 325 municipalities (including Amsterdam, Rotterdam, Utrecht and The Hague) have joined the Dutch Living Lab Smart Charging scheme, representing 80 percent of all public charging stations.

Figure 10: We Drive Solar in Utrecht (Source: Renault)

The V2G project in Utrecht's Lombok district in a Smart Solar Charging consortium led by LomboXnet, with a.o. Stedin, the municipality of Utrecht, GE, Vidyn, Last Mile Solutions, Economic Board Utrecht, Elaad, and Jedlix deploys electric cars as local energy storage for solar energy. The project was scaled up to a more regional scale by Renault joining the project, aiming to put in place a regional energy system with 1,000 charging points, 1,000 electric cars and 10,000 linked solar panels. Electric cars can charge using the solar energy or store it for later use. It is now also coupled with e-car sharing project We Drive Solar.

Figure 11: Launch of the inductive charging pilot (Source: Rogier Bos | Municipality of Rotterdam)

The first wireless charging system for electric passenger vehicles using an induction plate was put into operation in Rotterdam. Using this induction plate, suitable cars can be charged in public spaces. The induction plate is part of a pilot project with which the Municipality of Rotterdam intends to gather knowledge to be prepared for the rollout of wireless charging. The intention is that the experiences gained in this project will contribute to the future wide-scale application of the technology. The pilot project will explore issues of safety, user-friendliness and interoperability. One of the objectives is to figure out how to charge two different vehicles on the same charging system. The pilot will come to an end in the first quarter of 2017.

26.5 Outlook

Technology is moving fast, as smart mobility, connected and autonomous driving gain terrain. The Netherlands wants to be prepared for changing mobility demand by facilitating developments and removing hurdles. It also acts as a testing ground for connective, cooperative and automated driving.

As far as electric mobility is concerned, the market is anxiously looking forward to many new models with larger battery capacity that will arrive in 2017/2018. There are also some challenges towards the future of e-mobility for the Netherlands. As most electric cars are still business (leased) cars, consumers need to adopt electric vehicles for actual market scale-up. The installation of easily accessible public charging infrastructure remains a point of attention for the government. Besides that, the number of workplace chargers will need to increase. And last but not least, the importance of open standards worldwide is undeniable for the creation of a global e-mobility market.

27 Republic of Korea

27.1 Major Developments in 2016

A public telephone booth used as electric car charging station

The Ministry of Environment (Minister Yoon Sung-kyu) announced that it would install nine quick chargers in public telephone booths such as in Seoul City in cooperation with KT Linkes (KT subsidiary) and start operating on 15 July 2016. The nine units that were installed are: three in Seoul City, three in Daegu City, two in Suncheon City, and one in Seongnam City. Detailed installation locations can be found at the Korea Charity Information Center (www.ev.or.kr). The charge rate of the rapid charger installed in the public phone booth is 313.1 KRW (0.25 EUR) per kilowatt hour (kWh), which is the same as the charge for charging the public rapid charger from 11 April 2016. The Ministry of Environment consulted with local governments to avoid parking charges for using the rapid charger installed in the public telephone booth. The existing public phone booth charger[69] is a slow charger that takes 3-5 hours to charge, but this time, the fast charger installed by the Ministry of Environment can charge within 25-30 minutes.

The Ministry of Environment plans to expand the installation of rapid chargers to more than 20 public telephone booths every year. In addition to the public telephone booth, we plan to increase the installation of the rapid charger in a place where it is convenient to use a charger such as a large mart. On the other hand, the Ministry of Environment, in addition to installing the public rapid charger, supports the installation fee of 4,000,000 KRW (approx. 3,200 EUR) for the electric car buyer.5,405 fast chargers have been installed nationwide so far.

27.1.1 Legislation, Funding, Incentives and Taxation

From 8 July 2016, the Korean government raised the electric vehicle subsidy from KRW 12 million to KRW 14 million, i.e. from 9,600 EUR to 11,250 EUR, respectively. The Ministry of Environment said it will receive a subsidy of 14 million KRW, which will increase by 2 million won from those who buy an

[69] Installed 3 slow charging chargers in public phone booth in Seoul (February 2015)

electric car tomorrow (8 July 2016) and register the vehicle. As a result, buyers of electric cars can benefit from government subsidies of 14 million KRW and tax reduction of 4 million KRW (3,200 EUR). Herewith, the difference in price when purchasing gasoline (17 million KRW, 13,700 EUR) and electric cars (35 million KRW, 28,200 EUR) has been eliminated. The purchaser of the electric car can receive the subsidy of the state subsidy and tax reduction as well as 4 million won of the installation fee of the fast charger and up to 8 million won of the local subsidy. This measure does not apply retroactively if you register an electric car by 7 July 2016 (based on the first registration date of the vehicle registration certificate), but apply for the registration of electric cars from 8 July 2016 (including when the purchase procedure is in progress). The Ministry of Environment announced that it plans to submit a supplementary plan for 2016 in order to increase the electric vehicle purchasing quantity from 8,000 units to 10,000 units[70] in addition to a 2 million KRW increase in electric vehicle subsidy[71].

27.1.2 Electric Car Fast Charger Rate - Determined at 313.1 KRW per kWh

Transition from the government-centered to the market-centered through private participation the Ministry of Environment decided to collect electricity charges for fast chargers from the beginning of April when electric car users were collecting only electric charges. The charge of using this rapid charger is based on the deliberation and decision of the Green Growth Committee in 2014 to alleviate the burden on the national government and to foster private charging companies. In the meantime, it is the intention to shift the center of the market by utilizing private capital and capacity to install an electric car charger centered on the government. The Ministry of the Environment held a public hearing in October 2016 in consideration of the electricity bill, maintenance and repair expenses, and management fee for the use of the rapid charger[72].

At the public hearing, opinions of electric car users and private charging companies were compromised, and finally the fast charging fee was settled. Compared to the fuel cost of the internal combustion engine, the charge rate of the rapid charger is 44 % compared to the gasoline car and 62 % of the light car. Electricity charges are about 33 % of gasoline cars and 47 % of light trucks when the fast charger and rapid charger are used together.

[70] 8,000 units (currently KRW 12 million) → 10,000 units (KRW 14 million)
[71] However, 100 electric buses in the 10,000 units will be supported by 100 million won as usual
[72] First plan: 279.7 KRW / kWh, second plan 313.1 KRW / kWh, third plan 431.4 KRW / kWh

Table 1: Comparison with electric fee and an internal combustion engine fuel cost (all prices given in KRW ;1 EUR = 1,240 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

The Ministry of Environment plans to operate the payment system in the same way as the actual payment on 1 April 2016, but the actual costs will be collected from 11 April 2016, considering the adjustment of the payment system of the electric car users and preparation period. Meanwhile, the location of the 337 rapid chargers installed and operated by the Ministry of Environment can be confirmed at the electric car charging station convenience store (www.ev.or.kr), and a dedicated page for mobiles is provided so that it can be conveniently viewed on a smartphone. The convenience store can check the status of the rapid charger in real time, and the charger is regularly checked at least once a month so that the electric car users can use the charger without inconvenience. An official from the Ministry of Environment said, ”The electric car charger installed in the private sector is recognized as 109 fast chargers and 358 fast chargers”. If the rapid charger is charged, private companies will be more actively involved in charging infrastructure projects.

Table 2: Public Rapid Recharging Facility Installation Status and Plan

Year	Amount	High speed road	Leading city	Other areas					Reserve minute*
				Metrololitan area	Right	All rights reserved	Chungcheong region	Kang Won Kwon	
2011-2014	237	16	154	43	9	6	6	3	-
2015	100	30	5	11	18	25	7	4	-
2016	150	31	-	1	17	8	12	13	68
2017	150	23	-	0	28	13	14	21	51
	637	**100**	**159**	**55**	**72**	**52**	**39**	**41**	**119**

27.2 HEVs, PHEVs and EVs on the Road

At the end of 2016, more than 10,000 electric vehicles were delivered to costumers and a new exhibition hall dedicated to purchasing electric cars and a new call center, and electric car charging tickets worth 300,000 KRW (242 EUR) were provided at the end of the year. Domestic electric vehicles have been launched since 2011, and as per 13 December 2016, the number of electric vehicle has reached 10,528 units more than 10,000 units back then. The Ministry of Environment plans to set up an exhibition hall dedicated to electric cars and operate a dedicated integrated call center (1661-0970) in order to spread electric vehicles and exceed the number of 10,000 electric vehicles. The exhibition hall for electric vehicles will be installed at the COEX Alumni Plaza during the COEX Winter Festival, which will be held until 31 December 2016, and those who wish to purchase can visit the exhibition hall to purchase electric cars and receive contracts. In addition, we have improved the fact that consumer inquiries related to electric cars have been dispersed to the Ministry of Environment, local governments, automobile manufacturers, etc., thereby improving the integration of inquiry centers with integrated call centers and promoting the purchase of electric vehicles. Meanwhile, the Ministry of Environment decided to pay electric vehicle recharge rights equivalent to 300,000 KRW (242 EUR) when a buyer of an electric car concludes purchase contract through exclusive call center and exclusive exhibition hall by the end of this year. Purchasers can go to the exhibition hall to sign a contract, or through a call center to make a contract through a designated sales representative of an electric car, and receive the right to charge when the vehicle is delivered. The charging rights can be used not only by nationwide public rapid chargers, which are planned to be installed or installed by the Ministry of Environment, but also by chargers installed by private charging companies.

Supply of 14,000 electric cars next year

This year, about 5,000 electric cars will be supplied, next year subsidies will be 14 million won + α. The expansion of the charging infrastructure includes the installation of 530 rapid charging stations. The Ministry of Environment said that the number of electric cars supplied from January to 8 December 2016 was 4,622, plus 64 % from 2,821 last year. The number of applications for electric cars in the same period is 7,042, of which 2,420 units, excluding 4,622 units already shipped, are due for release. Subsidy for the installation of a fast charger is 3 million KRW (2,400 EUR) per month, down by 1 million KRW (805 EUR) compared to 4 million KRW (3,220 EUR) this year, and the number of subsidies will be 9,515, which is 485 times lower than the 10,000 won this year. This is the result of considering the installation of charger for apartment house[73] and the installation of replacement charger such as the mobile charger[74].

Accordingly, from next year, we will focus on various chargers that can solve the problem of the installation of the charger for apartment buildings by utilizing the latest information and communication technology such as the multi-channel charger that is easy to use jointly at home or business.

Table 3: Electricity distribution budget in 2017 (In millions of KRW; 1 EUR = 1,240 KRW)

Division		2016		2017 (B)	Increase (B-A)
		Main course (A)	Future		
Amount		**148,524**	**64,420**	**264,274**	**115,750**
Total		104,800	43,420	206,000	101,200
Passenger		94,800 (7,900 units)	43,420 (2,100 units)	196,000 (14,000 units)	101,200
Bus		10,000 (100 units)	-	10,000 (100 units)	-
Charger	Moderate	31,600 (7,900 units)	8,400 (2,100 units)	28,545 (9,515 units)	3,055
	Fast	10,500 (150 units)	10,500	26,205 (530 units)	15,750
Other operating costs		1,624		3,524	1,900

Table 4: Distribution and sales of EVs, PHEVs and HEVs in 2016

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[c]**
Passenger Vehicles[a]	5,095	0	58,596	58	63,749

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[c]**
Passenger Vehicles[a]	4,583	313	60,431	0	65,327
Light commercial vehicles[b]	14	n.a.	n.a.	n.a.	14
Totals	**4,597**	**313**	**60,431**	**0**	**65,341**

n.a. = not available
[a] UNECE categories M1
[b] UNECE categories N1
[c] Including non-electric vehicles

[73] 2,515 chargers will be installed in 856 apartment complexes
[74] Charger using 220 V outlet already installed in apartment

27.3 Charging Infrastructure or EVSE

In the end of 2016, more than 10,000 electric vehicles were delivered to costumers.

Significant improvement in charging conditions for electric vehicles next year

- Rapid Charger Current 750 units, February next year 1,283 - June 1,915 expansion
- Charger (public, individual) Expansion to 9,258 at present and 19,579 in June next year

The Ministry of Environment will expand and build up 9,258 fast chargers nationwide and 9,258 fast chargers (public and private) in June with 1,915 rapid chargers and 19,579 slow chargers, dramatically reducing the problem of electric vehicle charging infrastructure.

Table 5: Electric car charger distribution achievement and plan

Division	Amount	Rapid Charger			Slow Charger		
		Unit	Ministry of Environment	KEPCO, etc.	Unit	Ministry of Environment (individual)	KEPCO, etc. (Public)
Total	21,494	1,915	921	994	19,579	17,900	1,679
2016.Nov	10,008	750	491	259	9,258	8,385	873
20-6.Dec ~2017.Feb	533	533	180	353	-	-	-
2017.2Feb~'2017.Jun	10,953	632	250	382	10,321	9,515	806

The Ministry of Environment is installing and operating 491 rapid chargers, and plans to install the 180 units reflected in the 2016 supplementary budget until February next year, and the 250 units reflected in the 2017 budget by June next year. In addition, it supports up to KRW 4 million (3,220 EUR) for personal charger installation fee for electric car buyers, and up to now, 8,385 full charge chargers have been installed. Private electric power companies such as Korea Electric Power Corporation are installing and operating 259 fast chargers and 873 slow chargers, and will install 353 rapid chargers by next February. Korea Electric Power Corporation (KEPCO) is in the process of making public offerings for installing chargers for 4,000 apartment complexes nationwide. Locations of chargers nationwide can be found at ”EV of Electric Vehicle Charging Station” (www.ev.or.kr) operated by Korea Environment Corporation and ”EV where” and ”EV Infra” smartphone applications operated by private companies. An electric car charging station convenience store provides information such as charging station location and condition, and it has been improved so that it can be linked with smart phone apps such as next map, “NAVER map”, and “T-map” so that a charging station can be conveniently found on a smart phone. The Korea Environment Corporation has opened the location and status information of the electric car charging station to the private sector. It is more convenient to find the charging station by using the private app (“EV where” and “EV Infra” etc). With 1,915 rapid chargers planned until 2017, the number of electric cars per one rapid charger will be 15.6[75].

This is equivalent to the area of 63.09 km^2 per Japanese rapid charger in 2015, and the number of electric cars per unit of rapid charger is 21.1 units. In two years, Korea will also have a charging infrastructure coverage similar to Japan.

Table 6: Charging facility installation result and plan

Division		Total	Performance	Planning (additional installation)	
			(Until ‘16.11.7)	(Until ‘17.2)	(Until ‘17.6)
Total		**21,494**	**10,008**	**533**	**10,953**
Fast Charger	Sub Total	1,915	750	533	632
	Ministry of Environment	921	491	180	250
	Korea Electric Power	849	114	353	382
	Private business operators, etc.	145	145	Undefined	Undefined
Slow Chargers	Sub Total	19,579	9,258	-	10,321
	Ministry of Environment (individual)	17,900	8,385	-	9,515
	KEPCO (public)	819	13	-	806
	Private operator (public)	860	860	-	Undefined

[75] Assuming that 30,000 units of electricity are supplied as planned by the government

Table 7: Information on charging infrastructure in 2016

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	n.a.
AC Level 2 Chargers	19,579.
Fast Chargers	1,915
Superchargers	n.a.
Inductive Charging	n.a.
Totals	**21,494**

n.a. = not available

Table 8: Available vehicles and prices (1 EUR = 1,240 KRW)

Market-Price Comparison of Selected EVs and PHEVs in Korea	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in million KRW and EUR)**
BMW i3 (EV)	63.6 (47,885)
BMW i8 (PHEV)	196.8 (149,500)
Hyundai Ioniq (EV)	18.4 (14,000)
Kia Soul (EV)	22.33 (16,600)
Renault Samsung Motors SM3 (EV)	20.0 (15,000)
Chevrolet Bolt (EV)	47.79 (37,495)

28 Spain

28.1 Major Developments in 2016

28.1.1 VEA Strategy 2014-2020

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 2014-2020 (the so called VEA Strategy).

Three main guidelines considered in the VEA Strategy are targeting:

- 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 brought on 22 October 2014, which is concentrating on the promotion of infrastructure of alternative fuels and technologies. This 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 the industrial development in order to meet energy and environmental challenges.

28.1.2 Spanish National Policy Framework (MAN)

Directive 2014/94/EU states that each Member State shall adopt a national policy framework for the development of the market as regards as alternative fuels in the transport sector and the deployment of the relevant infrastructure and notify them to the European Commission before 18 November 2016.

Directive 2014/94/EU was transposed into Spanish normative through Royal Decree 639/2016 on 9 December 2016, and the Spanish National policy framework (Marco de Acción Nacional-MAN-), consistent with the VEA Strategy 2014-2020 and establishing an objective of 150,000 electric vehicles by 2020, was notified on time to the EC.

28.1.3 MOVEA Website

In the frame of the VEA Strategy, the MOVEA website was created, a Government official site for sharing relevant information of the different alternative fuels and technologies in the transport sector. On this website, a database on alternative vehicles is available where users can search the different models of vehicles available in the Spanish market and technical information of them.

Figure 1: MOVEA Website (Source: www.moveaplan.gob.es)

28.1.4 Environmental Car Labelling

Another measure that is highly contributing to the alternative vehicles penetration in the Spanish market, with an evident impact in electric and conventional hybrid technologies, is *the Environmental car labelling*, promoted by Spanish Traffic Authorities (DGT).

Vehicles have been classified into different labels, related to their environmental emissions (which are shown below, sorted from best to worst):

- **“0 emissions” label:** officially presented through Instruction 15/V-110 on 7 April 2015. With this label electric vehicles (BEV, EREV, and PHEV with more than 40 km range), hydrogen (HICEV), and fuel cell vehicles (FCEV) are included.

- **“ECO” label:** officially presented through Resolution of 13 April 2016. In this label PHEV with less than 40 km range, conventional Hybrid Electric vehicles (HEV), Compressed and Liquid natural Gas vehicles (CNG; LNG), and LPG vehicles are included.

- **“C” label:** officially presented through Resolution of 13 April 2016. In this label petrol cars and vans which comply with Euro 4, Euro 5 and Euro 6 regulations and diesel Euro 6 (Euro 6 regulation for industrial vehicles) are included.

- **“B” label:** officially presented through Resolution of 13 April 2016. In this label petrol cars and vans which comply with Euro 3 regulation, and diesel Euro 4 and Euro 5 regulations (Euro 4 and Euro 5 regulations for industrial vehicles) are included.

These four labels represent 50 % of the total Spanish fleet and classify vehicles with respect to their emissions levels. Environmental car labelling was created as a reference tool, to be used by Governments at National, Regional and Local levels for implementing measures aimed to improve the air quality in regions and cities.

A practical example of the implementation of the Environmental car labelling is that Spanish Traffic Authorities allow driving vehicles with “0 emissions” label in the High Occupancy Lane of the Highway A-6 in Madrid. Madrid city council also authorizes taxi vehicles which comply with the municipal requirements for Taxis and also have the “0 emissions” label or the “ECO” label.

28.1.5 Plan MOVEA: Incentives Plan for the Acquisition of Alternative Vehicles

On 28 November 2015, the Spanish Government approved “Plan MOVEA” (Royal Decree 1078/2015, of 27 November 2016), a National Plan of direct incentives for the acquisition of alternative vehicles (LPG, CNG /LNG and electric vehicles and also the deployment of recharging infrastructure for EVs). Plan MOVEA lasted from 1 January 2016 to 15 October 2016 and it was funded with a total budget of 16.6 million EUR.

A number of 3,938 alternative vehicles and 42 public recharging points for electric vehicles were subsidized in the frame of this plan, with a final budget applied of approximately 12.25 million EUR. Most of the subsidized vehicles were electric (83 %), in addition to LPG vehicles (12 %) and Natural Gas vehicles (5 %).

Table 1: Plan MOVEA - Detail of incentives per electric vehicle (BEV, EREV, PHEV)

Plan MOVEA: Incentives (in EUR) for acquisition of electric vehicle (range in kilometers for a pure electric mode)			
Category	**15 km ≤ range ≤ 40 km**	**40 km < range ≤ 90 km**	**90 km < range**
M1* (passenger cars)	2,700	3,700	5,500
N1* (vans < 3,5 t) N2 (trucks ≤ 12 t) M2 (busses ≤ 5 t)	8,000 (range > 60 km)		
M3 (busses > 12 t) N3 (trucks > 12 t)	20,000 (range > 60 km)		
L6e (Light Quadricycles)	1,950		
L7e (Heavy Quadricycles)	2,350		
L3e, L4e, L5e (Motorbikes)	1,500; 3 ≤ P (kW) < 4,5 2,000; 4,5 ≤ P (kW)		
Electric bikes	200		

Plan MOVEA: Incentives per recharging point of EVs (in EUR)	
Recharging Point 15 ≤ P (kW) < 40	15,000
Recharging Point 40 ≤ P (kW)	2,000

* Incentives increased by 750 EUR, in case the vehicle is retired (scrapped)

In addition to the above table of incentives for electric vehicles and recharging infrastructure, car dealers had to facilitate the installation of recharging points, assuming the cost of 1,000 EUR (150 EUR in case that the category of the vehicles is L6e or L7e).

Table 2: Plan MOVEA: electric vehicles figures (BEV, EREV, PHEV)

Plan MOVEA: Electric vehicles subsidized							
Category	M1	N1	M3	L6e	L7e	L3e	Electric bikes
Nº vehicles	1,132	295	1	13	53	239	1,513

MOVEA: Recharging points subsidized	
Recharging Point 15 ≤ P (kW) < 40	28
Recharging Point 40 ≤ P (kW)	14

28.2 EVs and HEVs on the Road

In the year 2016, there were 6,171 electric vehicles (considering BEVs, PHEVs and REEVs) registered in Spain. This number represents an increase of 83 % compared to year 2015, with a number of 3,367 EVs registrations. This increase was heavily supported by National incentives programs for EVs acquisition (Plan MOVEA) and also by other initiatives and incentive programs for vehicle acquisition at a regional or local scale.

Focusing on conventional HEVs, the huge increase in passenger car registrations in 2016 is remarkable, a total number of 30,602, coming from a total of 7,759 registrations during 2015 (almost triplicating figures of 2015). It is remarkable that at a national scale there was no incentives program running for the acquisition of these vehicles over the last years, but this is more than compensated by the impact of the new Environmental car labelling and the measures implemented for clean air in regions and cities.

Table 3: Distribution, sales and models of BEVs and HEVs in 2016 (Data source: Spanish Traffic Authorities)

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[g]**
Bicycles (assisted pedaling)	122,656	0	0	0	30,000,000 approx.
Mopeds (L1, L2)	2,411	0	1	0	1,929,602
Motorbikes (L3, L4, L5)	3,833	36	29	0	3,174,605
Quadricycles[b]	2,595	22	1	0	116,256
Passenger Vehicles[c]	5,717	2,795	94,771	0	22,939,959
Buses and Minibuses[d]	76	51	132	1	62,172
Light commercial vehicles[e]	2,414	3	5	0	4,020,363
Medium and Heavy Weight Trucks[f]	59	0	18	0	879,851
Totals without bicycles	**17,105**	**2,907**	**94,958**	**1**	**32,242,957**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[g]**
Bicycles (assisted pedaling)	35,000	0	0	0	1,140,000[h]
Mopeds (L1, L2)	763	0	0	0	17,656
Motorbikes (L3, L4, L5)	674	0	1	0	159,501
Quadricycles[b]	104	0	1	0	3,438
Passenger Vehicles[c]	2,148	1,668	30,602	0	1,230,080
Buses and Minibuses[d]	17	8	103	0	3,760
Light commercial vehicles[e]	785	0	2	0	135,729
Medium and Heavy Weight Trucks[f]	12	0	14	0	34,383
Totals without bicycles	**4,503**	**1,676**	**30,723**	**0**	**1,584,547**

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 both conventional and alternative technologies
[h] Estimated data at the end of 2016 (Source AMBE - Spanish Association of Bicycles and Brands-)

Regarding fleet numbers in Spain and considering vehicle registration figures showed in Table 3, the electric vehicle fleet in Spain (considering BEVs, PHEVS and REEVs) rose to a total number of 20,012 at the end of 2016, coming from a total amount of 13,883 electric vehicles registered during 2015 (an increase of 44 %).

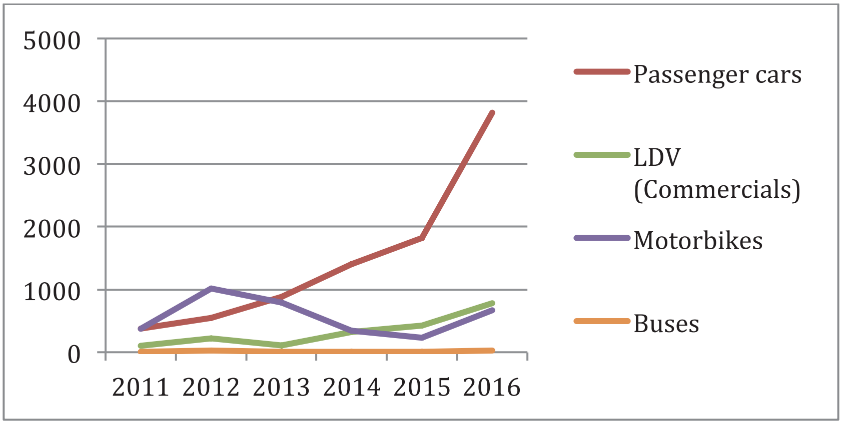

Figure 2: EVs market trend (annual sales per category) in Spain, 2016

In the case of conventional hybrid vehicles (HEV), the passenger car fleet amounted to 94,771 vehicles in 2016, coming from a fleet of 64,235 vehicles at the end of 2015 (a significant increase of 48 %, similar to that experienced by the electric vehicles fleet).

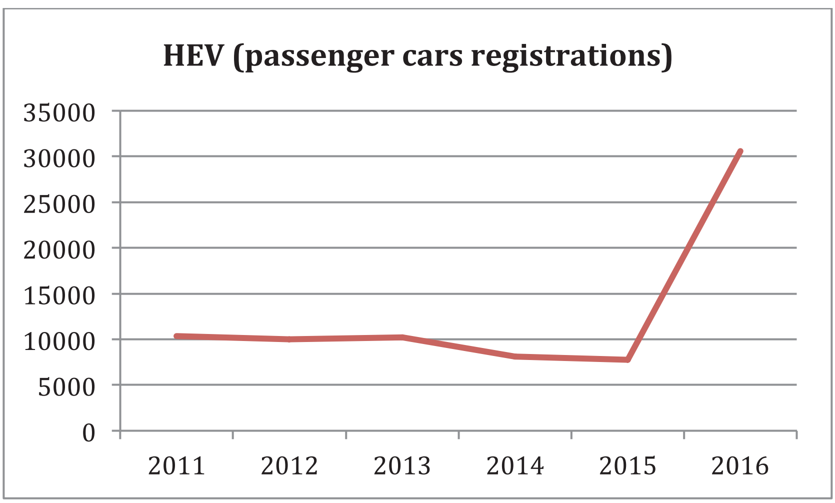

Figure 3: HEVs market trend (annual sales for passenger cars) in Spain, 2016

28.3 Charging Infrastructure or EVSE

After an initial stage characterized by recharging vehicles for free in the frame of pilot demonstration projects promoted by city councils and regional administrations, a public infrastructure service for recharging electric vehicles in Spain must be operated at present by authorized recharging operators "Gestores de Cargas", established and defined by the national normative (Royal Decree 647/2011).

At the end of 2016, there were 40 recharging operators officially registered and published by the National Commission of Markets and Competition (CNMC), which deployed a total of 116 public recharging stations for EVs in different cities all over the national territory, as shown on the following website: https://sede.cnmc.gob.es/tramites/energia/gestores-de-carga.

However, there is an estimated total number of 1,600 public charging stations and an amount of 4,547 charging points in Spain, most of them deployed in the frame of pilot demonstration projects, pending registration in the recharging operators list of the CNMC, which means a ratio of 8 recharging points per electric vehicle registered in Spain.

Table 4: Emplacements of recharging stations and recharging points for EVs in Spain (Source: Professional associations of different activity sectors)

Emplacements of recharging stations and recharging points for EVs in Spain		
Emplacements/Sites	**Number of Recharging stations**	**Number of Recharging points**
Car dealers	189	398
Hotels	131	234
Restaurants	85	172
Petro stations	64	144
Shops/Malls	31	143
Car repair garajes	35	88
Campings	14	30
Taxi stops	5	9
Airports	4	8
Total (incl. other sites)	**1,659**	**4,547**

Apart from different regional and local initiatives in order to promote recharging infrastructure for EVs all over the Spanish territory, there are other relevant initiatives at a national level:

- Plan MOVEA: Incentives for private and public companies to deploy quick and semi-quick recharging points for EVs for public use
- Operative Program of Sustainable Growth (POCS), financed by Structural and Investment European Budget (EIE Founds) includes financing for local administrations which promote the deployment of recharging infrastructure, in the framework of Sustainable Urban Mobility Plans, effective until 2020
- Railway operator RENFE is preparing a plan for deploying recharging infrastructure of EVs in parking lots of different railway stations
- Airport operator AENA is studying a business model for the current recharging infrastructure of EVs in parking lots of the Spanish airports
- PIRVEC 2016-2019, Strategic Plan for the deployment of recharging infrastructure of electric vehicles in Catalonia

The CIRVE Project: Spanish and Portuguese National Governments promoted the creation of a consortium formed by 8 partners to deploy quick charging points through the Mediterranean and Atlantic corridors as a business model to study the future implementation of RTE-T European recharging network and connecting Iberian Peninsula with the rest of the European continent.

The CIRVE Project has a quantitative objective of installing a number of 25 new quick charging points and to adapt another 15 existing quick charging points in the Iberian corridors. The investment associated with this project is co-financed by the 2015 call for proposals of the “Connecting Europe Mechanism (CEF).

Figure 4: Iberian corridors of quick charging points (Source: EU Project CIRVE)

28.4 EV Demonstration Projects

28.4.1 Massive Infrastructure Deployment in the City of Barcelona

In the city of Barcelona, there is a working number of 303 public recharging points currently, 121 of these are located in streets (including 15 quick charge points), and the other 182 are located in covered parking facilities (74 % for cars and 26 % for motorbikes).

Moreover, Barcelona city has also more than 100 recharging points in different private facilities (hotels, malls, etc.) for public use, but privately managed.

Regarding the Barcelona Metropolitan Area, a collaboration agreement was signed by the following entities: FGC, SIMON, DTES, RAILGRUP, VOLTOUR, ICAEN, IMESAPI, EMPARK to deploy charging stations for EVs in five train stations.

28.4.2 Quick Charge Club (E-Car)

The energy company “Endesa” deployed six quick charging points all over the island of Mallorca. The medium distance between the recharging points is 35 km. At these recharging points, EV users can charge 80 % of the car’s battery in less than 30 minutes.

The infrastructure is co-financed by the European budget “FEDER Program”. Recharging points are equipped with the three technologies currently available in the market and can be reserved and controlled through a mobile phone application.

28.4.3 Zero Emissions Mobility to All Project (ZEM2ALL)

The initiative “Zero Emissions Mobility to All”, was a project promoted by the Málaga City Council, the Spanish Centre for the Development of Industrial Technology (CDTI) and Endesa, with the collaboration of the Japanese Government, through NEDO.

The ZEM2ALL project was running for four years in the city of Málaga and its surroundings (Marbella and Fuengirola), and finalized in January 2016, and it was the major demonstrative pilot project of electric vehicles launched in Spain, with an impact of 200 electric vehicles, 220 conventional recharging points and 23 quick charging points in 9 different places.

29 Sweden

29.1 Major Developments in 2016

In 2016, both politics and the media have been focusing on plug-in electric vehicles and slightly less on biofuels than before. However, biofuels accounted for 18.6 % of the energy content of all delivered vehicle fuel in Sweden in 2016. These figures mean that Sweden is the best in Europe when it comes to switch from fossil fuels to biofuels.

Substantial state-funded R&D support continues to finance innovative research projects in the field of electric mobility and since 2011 there has been a purchase rebate to plug-in electric vehicles. This rebate system will likely be replaced by a cost neutral bonus-malus support scheme in 2018. Experiences gained from PEV demonstrations in the 1990's showed that public charging infrastructure was not an initial bottleneck, hence governmental support was not prioritised until 2015 where the sales of PEVs had taken off in Sweden. However, in 2015 the Swedish government introduced two investment support schemes, which both aimed to facilitate charging infrastructure and these shaped the development during 2016. The scheme Climate Leap (*Klimatklivet*) is a local investment support scheme thatallocates support foremost to charging infrastructure for passenger vehicles. By 2016, over 6,000 charging outlets, both normal and fast charging, had been granted support. The other scheme, Urban Environment Agreements (*Stadsmiljöavtal*), aim to co-invest together with municipalities and public transport providers for example. A step towards the electrification of the heavy duty sector took also place in May 2016 when the first electric road system on public roads was demonstrated.

29.1.1 EV Bus Rebate

In 2016, the Government implemented the subsidy, which specifically is targeting electric buses. Both battery electric and plug-in hybrid buses can be granted a variable rebate. the Swedish Energy Agency has been appointed by the Government to manage the rebate scheme. In 2016, 5.6 million EUR were allocated for this purpose, and proposed for 2017-2019 as an annual budget of 11.2 million EUR. The regulation specifies the size of the rebate and varies with the maximum transport capacity. Buses classified in emission category *electric* and *trolley buses* is granted the maximum rebate – between 33,000 and 78,000 EUR per vehicle depending on transport capacity. Buses classified in emission category *plug-in hybrid* get half the rebate, given that the bus can operate in electric mode at least 70 % of the mileage and for the rest, the bus operates on a renewable fuel.

29.1.2 Super Green Car Rebate "Supermiljöbilspremie"

The Super Green Car rebate is granted new-sales passenger vehicles with lower tail-pipe emissions than 50 g CO_2/km, i.e. plug-in electric vehicles. The subsidy was introduced in 2012 and became differentiated between BEVs and PHEVs in 2016. Both private cars and company cars are granted the super green car rebate. For BEVs, the rebate corresponds to 40,000 SEK (approx. 4,000 EUR), and from 2016 on PHEVs have been granted 20,000 SEK (approx. 2,000 EUR). For a company car, the rebate covers approximately 35 % of the price difference between a super green car and the nearest comparable car. The budget for 2016 was initially 32 million EUR, but the big interest motivated an additional 19 million EUR. For 2017, 74 million EUR are allocated to the scheme. The Super Green Car Rebate will likely be replaced by a cost neutral bonus-malus support scheme in 2018.

29.1.3 Reduced Value of Fringe Benefits

In addition to the Super Green Car rebate, company cars may reduce the value of fringe benefits for PEVs compared to the equivalent, conventional fossil-fueled car. After the adjustment, the value of fringe benefits is reduced by 40 %, a maximum of 1,700 EUR in 2012-2016 and to 950 EUR in 2017.

29.1.4 Five Year Exemption of Annual Tax

Light-duty vehicles in compliance with the Green vehicle definition are exempted from the annual vehicle tax for the first five years it operates. The Green vehicle definition has a broader scope than the above mentioned Super Green Vehicle rebate, and the subsidy aim to generally encourage the acquisition of energy efficient cars or vehicles powered by renewable fuels. A PEV specific criteria is that of a maximum energy consumption of 37 kWh/100 km. The annual vehicle tax varies between 53-315 SEK/year (5-33 EUR/year) tax and subsequently the exemption implies 260-1,600 EUR in tax relief in the first 5 years.

29.2 HEVs, PHEVs and EVs on the Road

The number of PEVs in Sweden has almost doubled every year since 2011 and by the end of 2016, 28,113 PEVs were registered. PHEVs dominate the Swedish market with a market share of approximately two thirds. Even though the majority of the PEVs operate in one of the three bigger metropolitan areas in Sweden, there are PEVs registered in 286 out of 290 municipalities in Sweden. This means that the plug-in electric vehicles are not only an urban phenomenon in Sweden but well spread throughout the country.

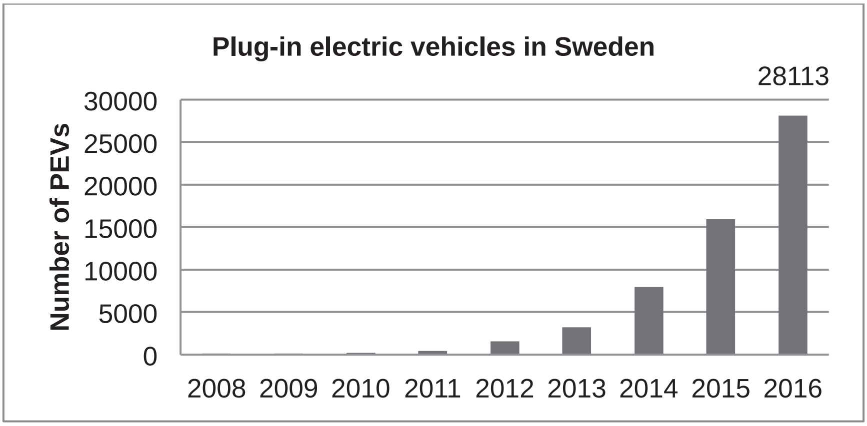

Figure 1: Development of plug-in electric vehicles in Sweden

29.3 Charging Infrastructure or EVSE

The public charging infrastructure is currently being developed in Sweden. With regards to 50 kW DC fast charging, southern Sweden has reached a point where it could be considered as well-developed and links together all parts of the region. Public normal charging is developed by many actors, both public and private. In total, the public charging infrastructure by end of 2016 was approximately 2,600 charging outlets, distributed over 730 charging stations.

The prerequisites for non-public charging infrastructure in Sweden is favorable, with a robust electricity grid and an already widespread development of block-heaters. Even though block-heaters are not recommended for charging a vehicle, it’s rather easy to update these installations.

Table 1: Information on charging infrastructure in 2016 (Data source: Global EV Outlook 2016, EAFO)

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	1,654
AC Level 2 Chargers	561
Fast Chargers	387
Superchargers	136
Inductive Charging	1
Totals	**2,739**

In 2015, the government introduced two investment support schemes (*Climate Leap* and *Urban Environment Agreements*) aiming to facilitate charging infrastructure, which were influential to the development in 2016.

Climate Leap scheme ”*Klimatklivet*”

In 2015, the Swedish government launched the investment support scheme Climate Leap, *Klimatklivet*, with the aim to grant investment support to measures that reduce the GHG emissions in a long-term, but it specifically encourages investments in charging infrastructure for passenger vehicles (Swedish Parliament, 2015). The programme period is between 2015 and 2020, with a total budget of approximately 315 million EUR and through 4 calls/year support is granted to the measures that contribute to the most significant reduction of GHG emissions. It is a general support, hence not entirely dedicated to charging infrastructure for passenger vehicles, and the allocation principle is to rank the proposed measures according to GHG reduction per total investment cost and grant to most climate-efficient measures. By December 2016, charging infrastructure measures have been granted almost 14 million EUR, which will fund the installation of approximately 6,000 charging points. Two thirds of these are normal charging outlets (even distribution between non-public and public) and one third are fast charging outlets (75 % public). The large number of fast chargers are mostly the outlets formerly known as semi-fast chargers and not 50 kW DC chargers. There are some requirements to be granted support for charging infrastructure for passenger vehicles from the Climate Leap scheme:

- The charging station should be equipped with at least one of the EU standard outlets, i.e. type 2 described in the standard EN 62196-2 or type Combo 2 described in standard EN 62196-3.
- The charging station hardware should allow for future functionality updates which for example enables electricity metering and billing of electricity cost.

- The charging station is located where it contributes to an effective distribution of charging stations in the area in question.

Urban Environment Agreements *”Stadsmiljöavtal”*
The aim of the national support scheme is to promote sustainable urban environments by creating the conditions for a larger share of passenger transport in cities using public transport. The granted 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 scheme aims to promote innovative capacity-strong and resource-efficient solutions for public transport. The budget is 210 million EUR for the period 2015-2018, and during 2016 projects that included charging infrastructure for electric buses were granted support.

29.4 EV Demonstration Projects

The Swedish Energy Agency hosts a specific research programme on EV demonstration, which has granted 40 million EUR to different demonstration projects since 2011. The portfolio includes all types of electric vehicles (super light, light and heavy duty vehicles and different kind of boats), all types of charging technology (normal, fast, inductive, ERS) and under a variety of conditions and applications (urban, rural, marine, agriculture, mining, forest industry, for example).

The following example is a demonstration project that is a joint initiative between several public agencies and is a part of an innovation procurement process for demonstrating electric road systems (ERS) on public roads. On 22 June 2016, a test section of an electric road system was inaugurated on the E16 outside the city of Sandviken. The test section is two kilometers long and the technology is similar to light rail, with contact lines 5.4 meters over the roadway. The truck has a pantograph on the roof that feeds 750 volts DC into the truck’s hybrid electric system. The pantograph connects automatically at speeds up to 90 km/h. The test section is equipped with poles, 60 meters apart, which holds up the contact lines over one of the lanes. Other traffic on the road will not be affected. With this, Sweden have become one of the first countries in the world to conduct tests with electric power for heavy transports on public roads.

Figure 2: Tests with electric power for heavy trucks (Author: Jan Nylander)

29.5 Outlook

It is likely that a cost neutral bonus-malus system will replace the Super Green Car rebate in 2018. The implementation of the bonus-malus system aims to ensure subsidies to the most environmentally friendly vehicles without burdening the national finances.

Sweden aims to reduce the CO_2-emissions from the transport sector by 70 % by 2030, compared to 2010, and to be completely fossil free by 2045. The Swedish government has therefore commissioned the Swedish Energy Agency together with five other public authorities to develop a strategic action plan for the transition of the transport sector, which will be presented to the Government in April 2017. The action plan aims to present proposals that facilitate conditions to create an energy-efficient and renewable transport system.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2016

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	n.a.	n.a.	n.a.	n.a.	375,188
Passenger Vehicles[b]	8,030	21,290	55,770	10	4,768,060
Buses and Minibuses[c]	50	20	70	0	13,890
Light commercial vehicles[d]	1,150	10	50	0	534,748
Medium and Heavy Weight Trucks[e]	0	0	20	0	81,430
Totals without bicycles	**9,230**	**21,320**	**55,910**	**10**	**5,773,316**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
2- and 3-Wheelers[a]	n.a.	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles[b]	2,950	10,460	13,760	3	n.a.
Buses and Minibuses[c]	40	20	0	0	n.a.
Light commercial vehicles[d]	50	0	0	0	n.a.
Medium and Heavy Weight Trucks[e]	0	0	0	0	0
Totals without bicycles	**3,040**	**10,480**	**13,760**	**3**	**n.a.**

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 in Sweden

Market-Price Comparison of Selected EVs and PHEVs in Sweden	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Mitsubishi i-MIEV	27,358
Mitsubishi Outlander PHEV	50,516
Nissan Leaf	33,420
Peugeot iOn	38,105
Porsche Panamera S E-Hybrid	108,632
Renault ZOE	23,147 (+ rental of battery)
Renault Kangoo Maxi	28,421 (+ rental of battery)
Renault Twizy	7,263 (+ rental of battery)
Tesla Model S 60 kWh	98,768
Toyota Prius Plug-in	38,421
VW e-up!	29,463
Volvo XC 90 PHEV	84,316
Volvo V90 PHEV	64,726

30 Switzerland

30.1 Major Developments in 2016

30.1.1 Recommendations for the Deployment of Fast Charging Stations Along Motorways

The Federal Roads Office of Switzerland (FEDRO) supports the development of a comprehensive network of fast charging stations for electric vehicles along motorways. Fast charging stations are designed to enable motorists to recharge their vehicles as quickly as possible.

In December 2016, FEDRO published its “Recommendations for the deployment of fast charging stations along motorways”. The paper advices cantons as landowners of the service areas, service area operators, as well as companies to set up non-discriminatory fast charging stations, which are accessible around the clock and at which the vehicles can be charged with all common connector types. With these recommendations FEDRO contributes to the standardization and harmonization of the fast charging infrastructure.

30.1.2 Platform Charging Network Switzerland

The program SwissEnergy of the Swiss Federal Office of Energy (SFOE) has launched a platform for the development of a nationwide non-discriminatory charging network. This platform supports the build-up of charging infrastructure for electric vehicles. It is a follow-up of the master plan for e-mobility presented by the Swiss Federal Council in 2015. It will be active over a period of two years.

The platform invites representatives of the e-mobility industry and the responsible authorities to adapt the charging infrastructure development for plug-in vehicles to customer-friendliness, high availability, maximum coverage and optimal synergies. Added value is to be created for all actors involved in the development and expansion of the nationwide charging network. Centred on questions concerning data, regulation and coordination, open points in the field of charging are identified and solutions are developed with the actors. This aims to avoid uncoordinated access and payment solutions and to make it easier to find high-quality locations. The build-up process is supported by defining clear framework conditions, removing existing obstacles and addressing regulatory gaps.

One project of the platform aims at compiling a factsheet on private and public charging infrastructure for new dwellings and fully refurbished buildings. This will help architects, engineers and builders to find suitable solutions for charging electric vehicles at home and at work.

30.1.3 A 34-ton Fuel Cell Truck and the First Public Hydrogen Filling Station

The Swiss SMEs ESORO, Ceekon and Emoss have developed the world's first 34-ton hydrogen truck for the retailer Coop. It has the necessary transport capacity to be fully integrated into the regular logistics disposition process and it will be used for deliveries to sales outlets. The truck is based on the MAN TGS Chassis. The fuel cell also provides energy free of emissions for all auxiliary units such us cooling aggregates mounted on top. When replacing a conventional diesel truck, it saves around 70 to 80 tonnes of CO_2 per year, as its fuel is generated free of CO_2 emissions by a nearby hydropower station.

In November 2016, the retailer Coop opened Switzerland's first public hydrogen filling station at the freeway A1 between Zurich and Bern. It is integrated into one of its conventional filling stations and is open to all owners of fuel cell vehicles.

The pump allows filling up a truck at 350 bar and a car at 700 bar at the same time. H_2 is stored in large 50 bar tanks and compressed to 950 bar for intermediate tanks providing the fuel for the fueling pump. A new truck delivers the fuel in 200 bar tanks to the filling station which has a maximum capacity of 388 kg hydrogen.

Figure 1: Fuel cell truck from Coop (Source: Coop)

30.1.4 The Last Swiss Post's Petrol Scooter Arrived at the Museum

In late 2016, the Swiss Post has taken its last petrol-powered scooter out of service and handed it over to the Museum of Communication. As from now on, all of its approx. 6,300 two- and three-wheelers used for mail delivery in Switzerland will be battery-powered, representing the largest fleet of electric scooters of its kind in Europe.

The electric vehicles require around six times less energy than a petrol scooter. As all scooters are running on certified wind energy, they save a total of about 4,600 tonnes of CO_2 emissions annually.

The three-wheeled Kyburz DXP model now accounts for the bulk of the mail carrier delivery fleet. These vehicles were first introduced in winter 2010/2011. Together with a trailer, the three-wheeler, which was developed by the Swiss company Kyburz to meet Swiss Post's needs, can transport up to three times more than a two-wheeler. It also makes considerably less noise, is more ergonomic, has a better manoeuvrability and allows for safer driving particularly in difficult situations. Higher costs due to tyre wear caused by better torque proved to be one of the very few setbacks.

After approximately seven years of use, their batteries have a storage capacity of around 80 percent. This is not sufficient for mail deliveries, but for stationary energy storage units. In a pilot project at the Umwelt Arena in Spreitenbach near Zurich they will be used to store excess solar energy.

Figure 2: In the future, Swiss Post will use electric Kyburz DXP for mail deliveries only (Source: Susanne Wegmann)

30.1.5 eCar4Car

In 2016, the Association Swiss eMobility launched its new project eCar4Car. Persons interested in testing an electric car can book a BEV at a BMW or Nissan dealer nearby for 24 to 48 hours from the Swiss eMobility website. When confirmed, they drive their conventional car to the dealer, park it there and in return receive an EV for the test drive. This project, supported by the SFOE by its program SwissEnergy allows potential customers to test charging routines and to check whether an EV proves to be suitable for their everyday use.

30.1.6 Comparison of Well-to-Wheel Efficiencies for Different Drivetrain Configurations of Transit Buses

Electrifying the vehicle's drivetrain can be an effective measure to significantly reduce energy consumption and emissions of the road-bound public transport, which uses mainly diesel buses. During the past decade, various alternative technologies have evolved. To determine well-to-wheel energy efficiency, both the drivetrain's efficiency and the efficiency of the energy supply must be considered.

Michael Schwertner and Ulrich Weidemann from the Institute for Transport Planning and Systems of the ETH Zurich[76] have compared seven drivetrains for urban transit buses: diesel, natural gas, diesel-electric, hybrid electric (series and parallel), fuel cell electric, battery electric (BEB), and trolley buses. They found that the trolley bus was the most efficient, even when the share of renewable energy in electricity generation was low. Close second were BEBs. The researchers also showed the potential to reduce specific energy consumption by increasing the occupation rate of the buses.

This study will be the main part of a more extensive model that will support decision making in bus procurement processes by using an analytic approach instead of a simulation tool. The model shows the total as well as the specific energy consumption of four generic bus types operating on a dedicated bus line.

30.2 HEVs, PHEVs and EVs on the Road

In 2016, a total of 415,000 new road vehicles were registered in Switzerland[77]. This is 3 % less than in 2015. The total stock has increased to almost 6 million vehicles (+1.6 %), 75 % of which were passenger cars.

3,572 new BEVs and EREVs were registered which is 8.7 % less than in the previous year and a market share of 1.1 % of passenger cars. This compares to 10,494 new gasoline-electric and diesel-electric HEVs and PHEVs (+24.2 %). However, with a market share of 3.3 % they are a long way from the mass market.

[76] https://trid.trb.org/view.aspx?id=1393507
[77] Swiss Federal Statistical Office (FSO)

The best sold PHEV models were Volvo XC 90 Twin Engine (397 cars), Mitsubishi Outlander (331) and Mercedes-Benz GLC 350e (250). As in the year before, Tesla Model S was ahead of all BEVs with a total of 1,299 sales before Renault ZOE (406) and Tesla Model X (402).

1,384 e-scooters and motorcycles including three and four wheeled vehicles were sold in 2016, which is less than in the year before. The best-selling e-model was once again the three wheeled Kyburz DXP (516 vehicles) with Swiss Post being its major customer. Second best selling was Vengo E200 with 196 vehicles, a newly introduced e-scooter and sold by a retailer in Switzerland.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2016 (Data source: Swiss Federal Statistical Office and Swiss Federal Office of Energy). In Switzerland, the fleet totals are available only as of 30 September, whereas total sales are reported for the full calendar year (1 January through to 31 December).

Fleet Totals on 31 December 2016						
Vehicle Type	**EVs**	**PHEVs**	**EREVs**	**HEVs**	**FCVs**	**Totals[g]**
2- and 3-Wheelers[a]	10,245	n.a.	n.a.	n.a.	n.a.	704,595
Quadricycles[b]	1,487	n.a.	n.a.	n.a.	n.a.	15,786
Passenger Vehicles[c]	9,350	4,753	1,512	53,159	14	4,524,029
Buses and Minibuses[d]	55	n.a.	n.a.	n.a.	5	69,676
Light commercial vehicles[e]	654	n.a.	n.a.	n.a.	n.a.	352,468
Medium and Heavy Weight Trucks[f]	18	n.a.	n.a.	n.a.	n.a.	53,098
Totals without bicycles	**21,809**	**4,753**	**1,512**	**53,159**	**19**	**5,719,652**

Total Sales during 2016						
Vehicle Type	**EVs**	**PHEVs**	**EREVs**	**HEVs**	**FCVs**	**Totals[g]**
2- and 3-Wheelers[a]	1,203	0	0	1	0	46,505
Quadricycles[b]	181	0	0	1	0	1,670
Passenger Vehicles[c]	3,303	2,832	269	7,662	10	319,331
Buses and Minibuses[d]	2	0	0	30	0	5,175
Light commercial vehicles[e]	175	0	0	0	0	30,435
Medium and Heavy Weight Trucks[f]	6	0	0	6	0	4,346
Totals without bicycles	**4,870**	**2,832**	**269**	**7,700**	**10**	**407,462**

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

Table 2: Available vehicles and prices 2016 (Data source: car dealers, official websites)

Market-Price Comparison of Selected EVs and PHEVs in Switzerland	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)[1]**
Audi Sportback A3 e-tron	39,400
BMW i3	31,100
BMW i3 REX	36,500
Hyundai ix35	60,900
Hyundai IONIQ electric	33,600
Kia Soul	33,500
Mercedes B 250 e	33,500
Mitsubishi i-MIEV	21,800
Mitsubishi Outlander PHEV	36,400
Nissan Leaf (24 kWh) [2]	20,600
Nissan e-NV200 Evalia [2]	30,800
Renault ZOE [2]	23,800
Renault Kangoo Z.E.[2]	22,800
Renault Twizy [2]	8,800
Tesla Model S 60	70,600
Tesla Model S 90D	90,800
VW Golf GTE	38,900
VW e-Golf	34,000
VW e-up!	27,200

[1] EUR 1 = CHF 1.10
[2] Sales price excludes monthly battery rental fee

30.3 Charging Infrastructure or EVSE

By the end of 2016, more than 1,600 public charging locations with approx. 4,000 charging points were registered in the Swiss national database. There were 1,400 Level 1 and 2 AC-locations with 1 to 3 EVSEs each and 145 fast charging locations (CHAdeMO, CSS, Tesla Superchargers and 43 kW AC) with 1 to 6 EVSEs each.

Table 3: Information on the Swiss charging infrastructure in 2016 (Data source: LEMnet.org)

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	849
AC Level 2 Chargers	636
Fast Chargers	135
Superchargers	10
Inductive Charging	0
Totals	**1,630**

The Swiss charging infrastructure is built and operated almost exclusively by the private sector. Three major developments have been observed in 2016:

MOVE: Alpiq E-Mobility and Groupe E merged their charging networks to become the biggest player in Switzerland. Their new MOVE network gives access to 300 stations throughout Switzerland and is compatible to 15,000 stations all over Europe. A smart phone app easily directs the user to the next free charging station. The customer gets access either by a prepaid system or by subscription and is benefitting from a support service around the clock.

evpass: The Swiss startup Green Motion is further expanding its ”evpass” charging stations network together with partners including McDonald’s, Aldi, Parking Zurich, Avia service stations, the energy utility SAK in St. Gall and others. Their installed charging stations counted 260 by the end of 2016 and Green Motion plans to increase this number to 1,000 stations in 2017.

GOFAST opened its first high performance charging station (150 kW / 1,000 V) in Stalvedro at the Ticino portal of the St Gotthard tunnel in summer 2016. It is using the “swisscharge” accounting system and allows for charging within 10 minutes to drive up to 100 km. GOFAST is a founding member of the European Open Fast Charging Alliance that owns and operates more than 500 fast chargers in six countries.

30.4 EV Demonstration Projects

30.4.1 Trial With Fuel Cell Buses Concluded

As planned, Swiss PostBus has concluded its project with five fuel cell Postbuses in the region of Brugg, which were used from December 2011 to January 2017 on scheduled routes. The project was part of the CHIC European project (Clean

Hydrogen in European Cities), a venture in which several European cities tested a total of 26 fuel cell buses.

Passengers and drivers alike were pleased with the vehicles, as they were offered a quiet and smooth ride. In addition, PostBus benefitted from the regular discussion with international experts, from the scientific support provided by project partners, and from the broad public and media interest. The fuel cell buses were also used at special events, such as the World Economic Forum in Davos or the Locarno Film Festival. Altogether, the five vehicles covered a total of 1.3 million kilometers, reducing CO2 emissions by 1,600 tons compared with diesel vehicles. This means that PostBus achieved 80 % of its original aim to save 2,000 tons of CO_2.

Maintenance costs for both the vehicles and the filling station were rather high. Five years after starting the project, the economic viability of the fuel cell buses had not reached the desired level. Fuel cell buses are considerably more expensive to buy than diesel or hybrid buses and operating costs are higher as well. Furthermore, as the vehicles were prototypes, procuring spare parts for the vehicles would have become more difficult in the coming years. Nevertheless, PostBus believes in the future of electric and hydrogen technologies. The company will keep a close eye on the development of the market and might start further tests.

Figure 3: Fuel cell bus of PostBus Switzerland Ltd near Brugg (Source: PostBus)

30.4.2 E-Dumper

Lithium Storage GmbH and Kuhn Schweiz Ltd announced in a press release, that they are building the world’s largest battery-powered tipper truck, based on the Komatsu 605-7. The completion of the “e-dumper” was scheduled for December 2016. The e-dumper is not only the world’s largest electric vehicle, it also has the largest battery (600 kWh) ever installed in a vehicle. A comparable diesel vehicle consumes between 50,000 and 100,000 liters of diesel per year and emits 131 to

262 tons of CO_2. Never before has it been possible to save as much CO_2 by replacing a single vehicle by an electric one. The e-dumper can even be operated as a plus energy vehicle. It can generate more energy by driving downhill fully loaded than it consumes driving uphill without a load.

Figure 4: Komatsu 605-7 (Source: Komatsu)

30.4.3 eBus

Zurich public transportation services VBZ has started to test an electric bus on its local bus lines in a two-year trial. The daily range of VBZ town district buses is up to 300 km. This requires interim charging at the garage for a full day service by BEBs. VBZ is considering replacing all small and mid-sized vehicles used on the district bus lines with battery-powered vehicles from 2019 onwards, if the test results are positive in respect of suitability for daily use, cost effectiveness and operational impact.

Figure 5: In Zurich, a battery electric bus is tested on district lines (Source: VBZ)

30.5 Outlook

SBB Green class eBus

Starting in January 2017, the Swiss federal railways (SBB) are testing their new mobility concept "SBB Green Class" in a one year pilot project, which combines individual and public transport by customized door-to-door transport at a flat rate of 12,200 CHF (11,100 EUR) per year. Following a public invitation to participate in fall 2016, an unexpected total of 2,500 persons applied for this trial and 150 have been selected.

The participants get a 1st class annual train pass for unlimited travel, annual subscriptions to the PubliBike cycle scheme for 900 bicycles and e-bikes at 100 locations, Mobility car sharing for 2,900 cars at 1,460 locations and the yearlong use of a BMW i3. The fully insured electric car comes with a charging port at home and an annual parking pass for car parks at Swiss rail stations. ETH Zurich is monitoring the participants' movements by a smart phone app, allowing researchers to analyze how and when Green Class participants use the various means of transport included in the pass.

Figure 6: The SBB "Green Class" pass includes the use of an electric car (Source: SBB)

31 Turkey

31.1 Major Developments in 2016

In 2016, the Turkish government continued its efforts to attain and accumulate experience associated with regards to hybrid and electric vehicles and their underlying technologies in the country. Several funding mechanisms, projects and clusters have been initiated in this area and significant work has been conducted to bring universities, R&D organizations and private companies together. An Automotive Excellence Center and Motor Excellence Center was built in The Scientific and Technological Research Council of Turkey (TÜBITAK) MRC in 2016 to provide the necessary support in this roadmap.

In mid-2016, the 11th Efficiency Challenge Electric Vehicle competition was held in Turkey. The competition aimed to increase environmental awareness of university students and facilitate the development of new corresponding technologies and was organized by TÜBİTAK. The MilAT S2 vehicle developed by the Istanbul University team won the electro-mobility competition by consuming 1,210 Wh energy in 30 laps.

Figure 1: Istanbul University Electromobile Team and MilAT vehicle (Source: Istanbul University)

In late 2016, the Avenue EV electric bus, jointly developed by ASELSAN and bus manufacturer TEMSA was showcased. The electric traction system of the bus was developed by ASELSAN. The companies claim that the bus can travel 50-70 kilometers on a single charge.

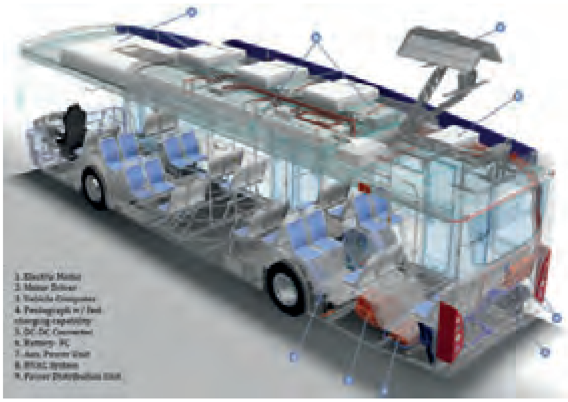

Figure 2: Temsa announced Avenue EV, electric bus jointly developed by ASELSAN (Source: Temsa Company)

Moreover, Toyota Motor launched the production of its C-HR (Coupe high-rider) small SUV in Turkey and the model is expected to be exported to all global markets including North America. The most efficient hybrid model incorporates a developed version of the Prius 1.8-liter petrol engine and electric motor combination, driving the front wheels, enabling 74.3 mpg and 86 g/km of CO_2.

31.1.1 Legislation, Funding, Incentives and Taxation

In 2016, a new legal regulation on the motor vehicle taxation system has been declared. On 24 November 2016, the new special consumption tax regulation for automotive industry issued on Official Gazette of the Republic of Turkey. The new taxation regulation classify the special consumption tax of conventional vehicles and hybrid vehicles based on engine cylinder volume; untaxed vehicle price and electric motor power where former SCT regulation only takes engine cylinder volume into account. Untaxed price limits are defined by Turkish Lira, which would increase the market sensitivity on exchange rates. Also the demand on the passenger vehicles produced in Turkey would increase. The new regulation states special consumption tax reduction (from 90 % to 45 %) on low engine volume and high electric power vehicles from hybrid vehicle point of view. The effects of the new SCT regulation on the sales of low engine volume conventional vehicles and hybrid vehicles (engine volume lower than 1,800 cc and electric motor power >50 kW) are expected to be more apparent in 2017.

Table 1 and Table 2 show the vehicle sales SCT (special consumption tax) categories for initial new passenger vehicles and motorbikes. Table 2 shows the new SCT rates of hybrid vehicles.

Table 1: Special consumption tax classification categories for new conventional and electric only vehicles in 2016 (Data source: Official Gazette of the Republic of Turkey, 24 November 2016)

Special Consumption Tax for Conventional and Electric Vehicles					
	Conventional			Electric Only	
Vehicle Type	**Engine Cylinder Volume (cc)**	**Untaxed Price (₺)***	**Special Consumption Tax (%)**	**Electric Motor Power (kW)**	**Special Consumption Tax (%)**
Passenger Vehicle	< 1,600	< 40,000	45	< 85	3
		40,000-70,000	50	85-120	7
		> 70,000	60	≥ 120	15
	1,600-2,000	< 100,000	100		
		> 100,000	110		
	> 2,000		160		
Motorbikes	< 250		8	< 20	3
	> 250		37	> 20	37
***Currency: Turkish Lira (TRL); 30 December 2016 exchange rate: 1 USD = 3.52 TRL; 1 EUR = 3.70 TRL**					

Table 2: Special consumption tax classification categories for new hybrid vehicles in 2016

Special Consumption Tax for Hybrid Vehicles				
Vehicle Type	**Engine Cylinder Volume (cc)**	**Electric Motor Power (kW)**	**Untaxed Price (₺)***	**Special Consumption Tax (%)**
Passenger Vehicle	≤ 1,600			60
	1,601 ≤ 1,800	≤ 50 kW		110
		> 50 kW	< 50,000	45
			50,000-80,000	50
			> 80,000	60
	1,801 ≤ 2,000			110
	2,001 ≤ 2,500	≤ 100 kW		160
		> 100 kW	< 100,000	100
			> 100,000	110
	> 2,500 cc			160
*** Currency: Turkish Lira (TRL); 30 December 2016 exchange rate: 1 USD = 3.52 TRL; 1 EUR = 3.70 TRL**				

Table 3: Total vehicle fleet according to the vehicle types between 2012 and 2016 (Data source: TURKSTAT Road Motor Vehicle Statistics, December 2016)

Fleet Totals on 31 December 2016					
Vehicle Type	**2012**	**2013**	**2014**	**2015**	**2016**
Passenger car	8,648,875	9,283,923	9,857,915	10,589,337	11,317,998
Minibus	396,119	421,848	427,264	449,213	463,933
Bus	235,949	219,885	211,200	217,056	220,361
Light commercial vehicle	2,794,606	2,933,050	3,062,479	3,255,299	3,442,483
Truck	751,650	755,950	773,728	804,319	825,334
Motorcycle	2,657,722	2,722,826	2,828,466	2,938,364	3,003,733
Special purpose Vehicle	33,071	3,6148	40,731	45,732	50,818
Tractor	1,515,421	1,565,817	1,626,938	1,695,152	1,765,764
Totals without bicycles	**17,033,413**	**17,939,447**	**18,828,721**	**19,994,472**	**21,090,424**

31.2 HEVs, PHEVs and EVs on the Road

31.2.1 Fleet

In Turkey, the number of vehicles on the road continued to increase in 2016. The number of vehicles registered on traffic exceed 21 million which shows a more than 1 million rise compared to the previous year. However, H&EVs still incorporated a negligible fraction of the total vehicles in 2016. In late 2016, the initial sale numbers of the Toyota C-HR Hybrid production in Turkey show that the model will be a leading player in the hybrid vehicle market. Passenger car sales once again dominated the fleet in 2016 with 53.6 % of the total fleet volume. Compact and entry level vehicles were still the first choice of customers in the passenger car market. By the end of year 2016, the average age of the total of 21,090,424 road motor vehicles registered in traffic was calculated to be 12.9 years old. Table 3 shows the total vehicle fleet by the vehicle types from 2012 to 2016. The HEV & EV new sales are collected by the Automotive Distributors Association (ODD) as shown in Table 4.

31.2.2 Sales

Passenger car sales in 2016 increased by 31,342 units when compared to the previous year. 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 96.35 % (729,324 units). In 2016, there were 44 EV passenger cars sold in Turkey compared to 120 units the year before. Also, 1,010 hybrid passenger cars were sold in 2016.

Table 4: Passenger car market according to the engine/electric motor size between 2015 and 2016 (Data source: ODD Press Summary, December 2016)

Total Sales during 2016					
Engine Size	**Engine Type**	**2015 (end of Dec)**	**2016 (end of Dec)**	**SCT Tax Rates***	**VAT Tax Rates (%)**
≤ 1,600 cc	Gas/diesel	695,113	729,324	45–60**	18
> 1,600 cc ≤ 2,000 cc	Gas/diesel	23,105	22,521	100-110	18
> 2,000 cc	Gas/diesel	6,284	4,039	160	18
≤ 85 kW	Electric	38	23	3	18
> 85 kW ≤ 120 kW	Electric	0	0	7	18
> 120 kW	Electric	82	21	15	18
≤ 1,600 cc	Hybrid	963	886	60	18
> 1,600 cc ≤ 1,800 cc (≤ 50 kW)	Hybrid	0	0	110	18
> 1,601 cc ≤ 1,800 cc (> 50 kW)	Hybrid	3	0	45-60	18
> 1,801 cc ≤ 2,000 cc	Hybrid	0	89	110	18
> 2,000 cc ≤ 2,500 cc (≤ 100 kW)	Hybrid	0	0	160	18
> 2,000 cc ≤ 2,500 cc (> 100 kW)	Hybrid	2	0	100-110	18
> 2,500 cc	Hybrid	6	35	160	18
Totals		**725,596**	**756,938**		

* SCT tax rates announced on 24 November 2016. Previous rates can be seen in the 2015 report.
** SCT tax rates differ between 45 % and 60 % based on the new regulation, Table 2 shows details. New SCT taxation takes account of engine volume, electric motor power and pre-tax price.

When the passenger car market is examined according to average emission values in 2016, a significant increase on the passenger car sales with emission values below 100 g/km is observed. Also, Table 5 shows the passenger cars under 140 g/km CO_2 emissions accounted for more than 83 % of the vehicle sales.

Table 5: Passenger car market according to average emission values in 2016 (Data source: ODD Press Summary, December 2016)

Passenger Car Sales during 2016 by Average Emission Values					
Average Emission Values of CO_2 (g/km)	2015 (end of Dec)		2016 (end of Dec)		2016/ 2015
	Units	%	Units	%	%
< 100 g/km	82,122	11.32	106,744	14.10	29.98
≥ 100 to < 120 g/km	304,901	42.02	337,375	44.57	10.65
≥ 120 to < 140 g/km	206,474	28.46	186,409	24.63	-9.72
≥ 140 to < 160 g/km	104,622	14.42	101,780	13.45	-2.72
≥ 160 g/km	27,477	3.79	24,630	3.25	-10.36
Totals	**725,596**	**100.00**	**756,938**	**100.00**	**4.32**

31.3 Charging Infrastructure or EVSE

EVSE installation efforts are still underway in Turkey by various private companies. These efforts are mostly concentrated in shopping centers, hotels, restaurants, public buildings and auto-dealers in Istanbul and Ankara. The charging infrastructure installation projects are mainly conducted individually by a few entities. Although official statistics are not currently available, over 300 charging stations are estimated to exist in Turkey by the end of 2016. Esarj, currently the largest charging infrastructure provider, has 144 public destination chargers. 107 of those belong to ChargeNow in collaboration with BMW. The rest belongs to other EVSE providers such as BD Oto, DMA, G-Charge, Voltrun, Yesilgüç. In terms of fast chargers (CHAdeMO), the numbers of stations built/planned are still very low. In previous years, Tesla Motors announced their plans to install fast chargers in 9 cities in Turkey in 2016. However, the company postponed their plans to 2017. Maps showing the charging stations by some of the private companies throughout the country can be found in Figure 3 and Figure 4. Some active charging stations operated by these private companies are highlighted in Figure 5.

Figure 3: Map of Esarj charging stations throughout Turkey (Source: Esarj Electric Vehicle System Incorporated Company)

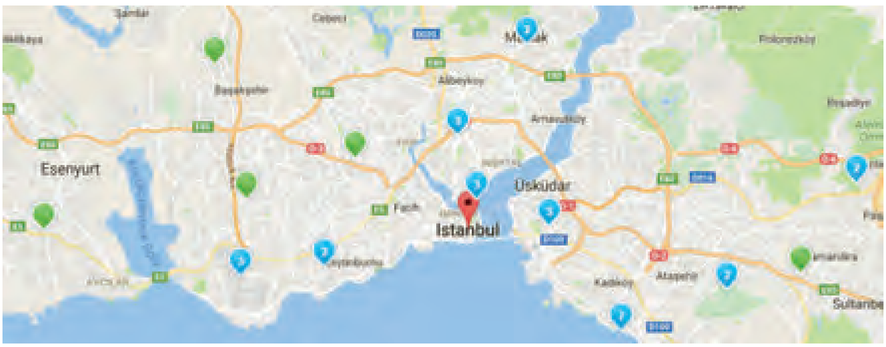

Figure 4: Map of BD OTO charging stations throughout Turkey (Source: BD OTO)

Figure 5: Various charging stations throughout Turkey (Source: Esarj Electric Vehicle System Incorporated Company and BD OTO)

32 United Kingdom

Figure 1: BMW i3 in front of the Palace of Westminster (Source: CleanTechnica)

32.1 Major Developments in 2016

32.1.1 Funding, Strategic Issues and Legislation

In the 2015 Spending Review[78] the UK Chancellor of the Exchequer announced that “The government will spend more than 713 million EUR between 2015-16 and 2020-21 to support uptake and manufacturing of ultra-low emission vehicles (ULEVs) in the UK” and in the 2016 Autumn Statement[79] he said that the UK Government “will invest a further 465 million EUR by 2020-21 to support ultra-low emission vehicles (ULEVs), renewable fuels, and connected and autonomous vehicles (CAVs). This includes 95 million EUR for ULEV charging infrastructure, 180 million EUR in support for low emission buses and taxis. This investment is aimed at keeping the UK on track to meet its target of nearly all cars and vans being zero emission by 2050.

[78] www.gov.uk/government/uploads/system/uploads/attachment_data/file/479749/52229_Blue_Book_PU1865_Web_Accessible.pdf
[79] www.gov.uk/government/uploads/system/uploads/attachment_data/file/571559/autumn_statement_2016_web.pdf

Following a consultation[80], which commenced on 26 October 2016, on legislative measures to improve the provision of infrastructure for electric and hydrogen vehicles the Vehicle Technology and Aviation Bill[81] was introduced to the UK parliament on the 22 February 2017. The elements of the bill on ultra low emission vehicles aims to make it easier for drivers to access infrastructure for electric vehicles. The measures could also ensure the right infrastructure is in place for the growing market for electric vehicles.

Motorway services and large fuel retailers could be made to provide electric charge points and hydrogen refuelling stations under planned new laws.

The measures could also make sure data about the location and availability of charging stations is openly available, and make it easier to use the different networks which are available.

Vehicle Support

The UK's Plug-in Car Grant offers 25 % off the price of a qualifying vehicle up to a maximum of 5,350 EUR and at the end of 2016 over 80,000 grants have been given to drivers of ULEVs. In March 2016[82] the rates of the grant were changed and a differentiation made between vehicles delivering different levels of electric range and CO_2[83] emissions and a price cap was set for category 2 and3 vehicles. Currently there are 36 car models[84] available for the grant with many more expected to become eligible over the coming months.

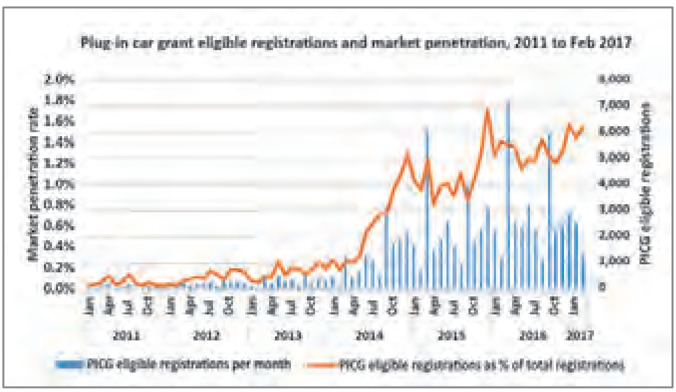

Figure 2: Plug-in car grant eligible penetrations and market penetration (Source: Gov.uk)

[80] www.gov.uk/government/consultations/proposed-ulev-measures-for-inclusion-in-the-modern-transport-bill
[81] http://services.parliament.uk/bills/2016-17/vehicletechnologyandaviation.html
[82] www.gov.uk/government/uploads/system/uploads/attachment_data/file/502056/plug-in-grant-rate-changes-2016.pdf
[83] Section 5.1 here: www.gov.uk/government/publications/plug-in-car-grant/plug-in-car-grant-eligibility-guidance
[84] www.gov.uk/plug-in-car-van-grants/eligibility

On 23 October 2016, the Office for Low Emission Vehicles announced an extension of the Plug-In Van grant[85] which means N2 vans (3.5 – 12 tonnes gross weight) and N3 vans (over 12 tonnes gross weight) are now eligible for the grant. This means that electric trucks are eligible for a grant of up to 23,750 EUR. There are currently nine vans on the eligible list and more are expected to be added during 2016.

OLEV widened its offer on vehicle grant with the introduction of the eligibility criteria[86] for the Plug-in Motorcycle Grant[87] on 14 October 2016. This grant offers 20 % off the cost of a qualifying powered two wheeler up to a maximum of 1,780 EUR.

The winners of the Low Emission Bus scheme[88] were announced on the 25 July 2016. This initiative will see 326 low emission buses enter service in the UK as well as the supporting refuelling infrastructure being installed, a total investment of over 35.5 million EUR by the UK government.

A fund of 23.75 million EUR has already been set aside for taxi dedicated infrastructure across a number of local authorities and a grant to support uptake for new ULEV purpose built taxis (black cabs). The 2016 Autumn Statement committed a further 60 million EUR.

This money will be used to support the new market for ULEV taxis, help tackle poor air quality in city centres and expose more people to the benefits of ULEV technology.

15 local authorities (LAs)[89] have put bids in for infrastructure funding based on feasibility studies they previously submitted. Dedicated Taxi Infrastructure will be vital to the uptake of ULEVs for both Hackney Carriages (including the new ULEV taxis) and Private Hire Vehicles.

Go Ultra Low Communications Campaign

Go Ultra Low[90] is a joint government/industry communications campaign designed to raise awareness, promote the benefits of and dispel misconceptions about Ultra Low Emission Vehicles (ULEVs) amongst private and fleet purchasers. There are eight leading vehicle manufacturers (Audi, BMW, Kia, Mitsubishi, Nissan, Renault, Toyota, and Volkswagen) in the Go Ultra Low campaign.

[85] www.gov.uk/government/news/4-million-boost-to-help-businesses-switch-vans-and-trucks-to-electric
[86] www.gov.uk/government/publications/plug-in-motorcycle-grant-eligibility/plug-in-motorcycle-grant-eligibility
[87] www.gov.uk/plug-in-car-van-grants/what-youll-get
[88] www.gov.uk/government/publications/low-emission-bus-scheme-2016-to-2017-successful-bidders
[89] www.airqualitynews.com/2015/07/24/eight-cities-shortlisted-in-20m-electric-taxi-scheme
[90] www.goultralow.com

Go Ultra Low is aimed at increasing awareness and consideration of low emission vehicles rather than advertising individual brands. Lack of awareness of the benefits of ULEVs is still a barrier to take up. As part of the Go Ultra Low campaign over 70 organisations have been awarded Go Ultra Low Company[91] status to celebrate their work with electric cars.

Research and Development

The Office for Low Emission Vehicles (OLEV) funds and manages a programme of industry-led research and development to support emerging technologies which the UK can exploit and lead globally, where full commercial funding is not otherwise available.

Innovate UK have a long-established "Low Carbon Vehicles Innovation Platform"[92] and are well placed to engage with industry and to run competitions which attract high quality project applications. Together, Innovate UK and OLEV have worked to ensure these competitions are relevant and suited to industry needs and that winning projects will contribute effectively to Government objectives for economic growth, UK capability and reduced carbon emissions.

OLEV are continuing to work with Innovate UK, with new Innovate UK competitions such as "Seeding tomorrow's vehicle technologies today"[93] and "Developing advanced lightweight vehicles"[94] and the recent battery R&D competition. The UK has also part funded the Advanced Propulsion Centre's[95] battery spoke at the Energy Innovation Centre[96] part of the Warwick Manufacturing Group.

In the 2017 Budget the UK's Chancellor of the Exchequer announced initial funding of 320.7 million EUR[97] for the Industrial Strategy Challenge Fund, part of which will help the UK lead the world in the development, design and manufacture of batteries that will power the next generation of electric vehicles, helping to tackle air pollution.

[91] www.goultralow.com/company-cars-and-fleet-vehicles/go-ultra-low-companies
[92] https://connect.innovateuk.org/web/idp
[93] https://interact.innovateuk.org/competition-display-page/-/asset_publisher/RqEt2AKmEBhi/content/integrated-delivery-programme-12-seeding-tomorrow-s-vehicle-technologies-today
[94] https://interact.innovateuk.org/competition-display-page/-/asset_publisher/RqEt2AKmEBhi/content/developing-advanced-lightweight-vehicles
[95] www.apcuk.co.uk
[96] www2.warwick.ac.uk/fac/sci/wmg/research/automotive/greener
[97] www.gov.uk/government/uploads/system/uploads/attachment_data/file/597467/spring_budget_2017_web.pdf

32.2 HEVs, PHEVs and EVs on the Road

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2016

Fleet Totals on 31 December 2016				
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**Totals[f]**
2- and 3-Wheelers[a]	4,037	27	0	1,268,871
Passenger Vehicles[b]	32,129	57,210	215,053	31,214,048
Buses and Minibuses[c]	202	0	3	168,220
Light commercial vehicles[d]	4,808	104	31	3,736,036
Medium and Heavy Weight Trucks[e]	164	0	0	506,211
Totals	**41,340**	**57,341**	**215,087**	**36,893,386**

Total Sales during 2016				
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**Totals[f]**
2- and 3-Wheelers[a]	439	11	0	n.a.
Passenger Vehicles[b]	10,509	27,403	51,229	n.a.
Buses and Minibuses[c]	59	0	2	n.a.
Light commercial vehicles[d]	1,055	78	14	n.a.
Medium and Heavy Weight Trucks[e]	9	0	0	n.a.
Totals	**12,071**	**27,492**	**51,245**	**n.a.**

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

32.3 Charging Infrastructure

> *"Charging points are vital. One of the great challenges for industry and Government is to ensure that there are adequate numbers of charging points across the whole country. That particularly applies in rural areas such as the one I represent."*

Minister of State for Roads, Rt Hon John Hayes MP. Hansard, 12 January 2017

The UK recognises that it is important to have the right amount of infrastructure in the right places to support the growing market for ULEVs. The expectation is that the majority of recharging will occur at home overnight or during the day at a workplace. There is a recognition that there is a need for some destination charging but this is something that would best be provided by partnerships.

In the 2016 Autumn Statement the UK Chancellor of the Exchequer, Philip Hammond, announced 95 million EUR of additional funding[98] to support recharging infrastructure. Details of how this money will be invested will be announced later in 2017. How this support will be used will also be outlined later in 2017.

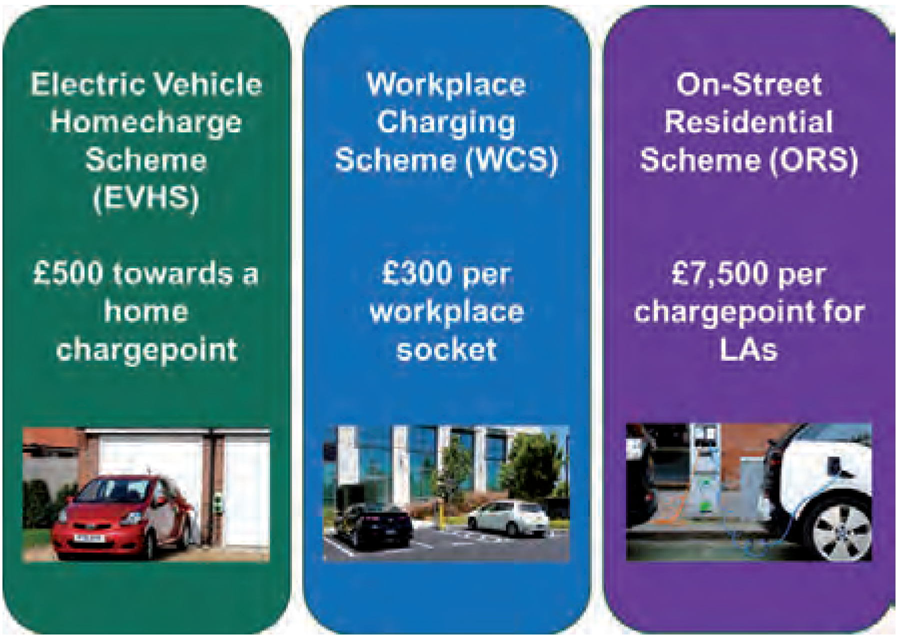

Figure 3: An overwiev of support for recharching infrastructure (Source: own research)

The UK has a number of schemes to support the installation of charge points in the UK. There is the electric vehicle home charge scheme[99] which offers 75 % of the cost, up to a maximum of 600 EUR, of installing a charge point for drivers who access to off street parking. To date over 70,000 charge points have been installed under this and predecessor schemes.

For those drivers who do not have access to off-street the revamped on-street residential scheme[100] was announced on 13 October 2016. This initiative offers

98 www.gov.uk/government/publications/autumn-statement-2016-transport-announcements/autumn-statement-2016-transport-projects
99 www.gov.uk/government/collections/government-grants-for-low-emission-vehicles#electric-vehicle-homecharge-scheme
100 www.gov.uk/government/news/35-million-boost-for-ultra-low-emission-vehicles

local authorities up to 8,900 EUR to install a dedicated on street chargepoint. Installations could involve new and innovative charging solutions.

Also announced on 13 October 2016 was the work place charging scheme[101] which offers a grant of 350 EUR per socket up to a maximum of 20 sockets for organisations in the public and private sectors who want to encourage their employees to use ultra low emission vehicles.

Table 2: Information on charging infrastructure in 2016

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	79,143
AC Level 2 Chargers	2,451
Fast Chargers	983
Superchargers	168
Inductive Charging	0
Totals	**82,745**

32.4 EV Demonstration Projects

32.4.1 Go Ultra Low Cities

The winners of the 47.5 million EUR Go Ultra Low City competition[102] were announced in January 2016. The winning Go Ultra Low Cities – Nottingham, Bristol, Milton Keynes and London – will receive funding that encourages thousands of people to consider switching to an electric car. In turn, this will support the UK's thriving green vehicle sector, improve air quality in urban hotspots and help the government meet its emission-cutting targets. Below are some examples of how the cities will be using their allocated funding:

- London has been awarded 15.44 million EUR to create "Neighbourhoods of the Future", prioritising ultra low emission vehicles (ULEVs) in several boroughs across the capital. Proposals include over a dozen streets in Hackney going electric, with charging infrastructures such as car-charging street lighting; while Harrow will develop a Low Emission Zone, offering parking and traffic priority to owners of plug-in vehicles.

[101] www.gov.uk/government/collections/government-grants-for-low-emission-vehicles#workplace-charging-scheme
[102] www.gov.uk/government/news/40-million-to-drive-green-car-revolution-across-uk-cities

- Milton Keynes will receive 10.7 million EUR to open a city centre Electric Vehicle Experience Centre – a ”one-stop-shop” providing consumer advice and short-term vehicles loans. The city also proposes to open up all of its 20,000 parking bays for free to electric vehicles, and will co-brand bus lanes as “Low Emission Lanes”, giving plug-in vehicles the same priority at traffic lights as local buses.
- Bristol will get 8.3 million EUR to offer free residential parking for ULEVs, over 80 rapid and fast chargers across the city, and a scheme encouraging people to lease a plug-in car for up to four weeks – helping them to better understand the range of benefits that electric vehicles bring.
- Nottinghamshire and Derby[103] will use 7.1 million EUR of funding to install 230 charge points and will offer ULEV owners discount parking, as well as access to over 13 miles of bus lanes along key routes across the cities. The investment will also pay for a new business support programme, letting local companies “try before they buy”.

Figure 4: Go Ultra Low City winners: Bristol, London, Milton Keynes and Nottingham (Source: Go Ultra Low)

In addition, the government has also set aside 5.94 million EUR of the total 47.5 million EUR fund for specific initiatives in Dundee, Oxford, York and the North East region, to help ensure that more people than ever before are going ultra low.

32.4.2 Hydrogen Technology Advancement Programme (HyTAP)

The UK Government’s HyTAP is providing 5.7 million EUR to help develop an initial network of 12 hydrogen refuelling stations to support the roll out of Fuel Cell Electric Vehicles (FCEVs). The balance of the 7.84 million EUR investment

[103] http://goultralownottingham.org.uk

in these stations is coming from EU or commercial funding. These stations will come on-line from February to November 2017. They are located in and around London, in Swindon, Sheffield, South Wales and there are two mobile refuellers. This is a first step towards a national network of 65 refuelling stations identified by UKH2Mobility[104] as enough to support national roll-out of FCEVs and will support manufacturers geographically targeted initial FCEV roll-out.

On the 23 October 2016, OLEV announced that 2.38 million EUR had been awarded to public and private sector organisations to deploy hydrogen fuel cell vehicles[105].

32.5 Outlook

The UK government believes that its investment of over 1 billion EUR to 2020 will facilitate the inevitable and desirable transition to zero emission road transport. This transition will help in dealing with the health impacts that poor air quality has on the populations of many of our towns and cities. It will also help the UK address the stretching targets for reducing carbon dioxide emissions from transport and it can help us balance a grid that will have an increasing proportion of energy generated from renewables. Perhaps, most importantly, it will provide the UK automotive industry with the opportunity to become one of the leading global players in the design, development and manufacture of ultra low emission vehicles.

[104] www.ukh2mobility.co.uk
[105] www.gov.uk/government/news/35-million-boost-for-ultra-low-emission-vehicles

33 United States

33.1 Major Developments in 2016

Consumers in the United States continued to rely on road vehicles for personal transportation. In 2016, the total national vehicle miles traveled (VMT) increased by 3.3 % (to 1.58 trillion miles) compared to its 2015 value (1.54 trillion miles)[106]. There were 30 plug-in electric vehicle (PEV) models and 37 hybrid electric vehicle (HEV) models available in the United States during 2016. Sales of HEVs were slowly declining but PEV sales hit an all-time record of 159,616 units during the year. Several additional automobile manufacturers announced plans to offer all-electric vehicles by the 2020 timeframe[107], including Audi, Hyundai, Jaguar, Mercedes, Porsche, Subaru, Volvo, and VW.

Some specific major developments in the U.S. EV industry during 2016 were as follows:

- Tesla unveiled its 215-mile range EV Model 3 (priced 35,000 USD) in March 2016, and received nearly 400,000 reservations (each requiring a 1,000 USD deposit) for it. The company has projected it would achieve an annual production volume of 200,000 by late 2017 (for Model 3), and a combined annual production volume of 500,000 by 2018 (for Model 3, Model X, and Model S all together)[108].
- In December 2016, GM started delivery of its Bolt EV (having a range of 238 miles) priced 36,000 USD. It plans a national rollout by mid-2017[109].
- Several manufacturers now offer options for extended battery ranges for existing EV models. The 2016 Chevrolet Volt offers a 40 % longer range (53 miles) as does the BMW i3 (114 miles). The Ford Focus Electric offers a 50 %

[106] U.S. Department of Transportation, “U.S. Driving Up 3.3 Percent In First Half of 2016, New Federal Data Show,” www.transportation.gov/briefing-room/us-driving-33-percent-first-half-2016-new-federal-data-show, August 22, 2016, accessed February 16, 2017.
[107] Cadie Thompson, “19 long-range electric cars you'll be able to drive by 2021,” www.businessinsider.com/electric-cars-launching-2021-2016-11, Business Insider, November 4, 2016, accessed February 16, 2017.
[108] Fred Lambert, “Tesla has 373,000 Model 3 reservations as of May 15, after 8k cancellations and 4k duplicates,” https://electrek.co/2016/05/18/tesla-model-3-reservations-cancellations-duplicates, electrek, May 18, 2016, accessed February 16, 2017.
[109] Jay Cole, “First Chevrolet Bolt EVs Delivered, Nationwide Release by Mid-2017,” http://insideevs.com/first-chevrolet-bolt-evs-delivered-nationwide-release-by-mid-2017, InsideEVs, December 2016, accessed February 16, 2017.

longer range (115 miles) and the 2016 Nissan LEAF offers a 25 % longer range (107 miles).

- Tesla's Gigafactory factory opened in July 2016 at 14 % operation[110]. By the end of 2016, it was nearly 30 % complete and had started production[111]. The Gigafactory plans an annual production of 35 GWh of battery capacity by 2018, which will be increasing to 150 GWh by 2020.
- Battery costs have dropped precipitously over the past few years. GM currently pays LG Chem 145 USD/kWh (at cell level) for the battery it uses in the Bolt. This cost is estimated to drop to 100 USD/kWh by 2022[112]. Tesla claims its pays 190 USD/kWh (at battery pack level)[113]. These figures represent a significant improvement over 2009-2010 costs, which had ranged from 600 - 1200 USD per kWh.
- Volkswagen's settlement with the U.S. Environmental Protection Agency and the California Air Resources Board included a 2 billion USD investment into the U.S. EV charging infrastructure over the next 10 years. Charging station installations will begin in 2017, and will include both Level 2 and direct-current fast chargers (DCFC)[114].

33.1.1 Major Policy and Legislation Developments in 2016

In July 2016, DOE released a guidance document entitled *Guide to Federal Funding, Financing, and Technical Assistance for Plug-in Electric Vehicles and Charging Stations*[115]. This document highlights examples of federal programs in support of PEVs and charging infrastructure. For further information, DOE's Alternative Fuels Data Center provides a comprehensive database of federal and state programs that support EVs and infrastructure.

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[110] Tesla, "Tesla Gigafactory Grand Opening," www.tesla.com/videos/tesla-gigafactory-grand-opening, July 30, 2016, accessed February 16, 2017.

[111] Tesla, "Battery Cell Production Begins at the Gigafactory," www.tesla.com/blog/battery-cell-production-begins-gigafactory, January 4, 2017, accessed February 23, 2017.

[112] Jay Cole, "GM: Chevrolet Bolt Arrives in 2016, $145/kWh Cell Cost, Volt Margin Improves $3,500," http://insideevs.com/gm-chevrolet-bolt-for-2016-145kwh-cell-cost-volt-margin-improves-3500, InsideEVs, February 2016, accessed February 16, 2017.

[113] Fred Lambert, "Tesla confirms base Model 3 will have less than 60 kWh battery pack option, cost is below $190/kWh and falling," https://electrek.co/2016/04/26/tesla-model-3-battery-pack-cost-kwh, electrek, April 26, 2016, accessed February 16, 2017.

[114] Volkswagen, "Volkswagen reaches settlement agreements with U.S. federal regulators, private plaintiffs and 44 U.S. states on TDI diesel engine vehicles," http://media.vw.com/release/1214, June 28, 2016, accessed February 16, 2017.

[115] U.S. DOE, "Guide to Federal Funding, Financing, and Technical Assistance for Plug-in Electric Vehicles and Charging Stations," https://energy.gov/sites/prod/files/2016/07/f33/Guide%20to%20Federal%20Funding%20and%20Financing%20for%20PEVs%20and%20PEV%20Charging.pdf, July 2016.

DOE also released *the Public Plug-in Electric Vehicle Charging Infrastructure Guiding Principles*[116] as a guidepost for its efforts and decisions by communities, companies, and other stakeholders working to deploy PEV infrastructure. The principles focus on three critical components of infrastructure deployment that are necessary for PEV market success:

- Catalytic investments that spur additional investment from stakeholders for visible and accessible PEV infrastructure
- Standardized, open charging systems that ensure easy access by all in a competitive and highly-innovative market
- Analysis-driven infrastructure investments that will most substantially increase PEV deployments

The State of California conducted a mid-term review of its 2012 Advanced Clean Cars program, including its Zero-Emission Vehicle (ZEV) regulation that requires manufacturers to produce increasing numbers of ZEVs and PHEVs over the 2018 to 2025 timeframe. In addition to California, the regulation also covers 9-15 other “Section 177” states[117], resulting in the overall coverage of 25-30 % of all new vehicles sold in the United States. The mid-term review indicates that manufacturers have consistently exceeded annual requirements for California, bringing in 215,000 ZEVs and PHEVs since the regulation was enacted in 2012, resulting in an estimated 1.2 million in cumulative sales by 2025. The state has announced plans to maintain those regulatory requirements through 2025, developing a “strong set of post-2025 requirements” to meet its 2030 GHG targets, and promoting an estimated additional three million ZEVs and PHEVs on roads between 2026 and 2030[118].

33.1.2 Continued Research, Development, and Deployment Funding

In FY 2016, VTO supported development of electric drive vehicles in collaboration with industry stakeholders. Its battery technologies R&D program (103 million USD in FY 2016) focused on the development of advanced batteries; its electric drive technologies (EDT) research (36 million USD in FY 2016) focused on developing revolutionary new power electronics, electric motor, and traction drive system technologies, leading to electric drive systems with lower

[116] U.S. DOE, “Public Plug-in Electric Vehicle Charging Infrastructure Guiding Principles” https://energy.gov/eere/articles/public-plug-electric-vehicle-charging-infrastructure-guiding-principles, January 13, 2017, accessed February 16, 2017.
[117] TransportPolicy.net, “US: Section 177 States,” http://transportpolicy.net/index.php?title=US:_Section_177_States, September 6, 2013, accessed February 16, 2017.
[118] Air Resources Board, “California’s Advanced Clean Cars Midterm Review: Summary Report for the Technical Analysis of the Light Duty Vehicle Standards,” www.arb.ca.gov/msprog/acc/mtr/acc_mtr_finalreport_full.pdf, accessed February 16, 2017.

cost and improved efficiency; and its vehicle systems (VS) research (34 million USD in FY 2016) constituted the remaining component, performing systems engineering to develop and evaluate advanced vehicle systems and infrastructure.

VTO works with key U.S. automakers through the United States Council for Automotive Research (USCAR) – an umbrella organization for collaborative research consisting of Fiat Chrysler LLC, the Ford Motor Company, and the General Motors Company. Collaboration with automakers through the US DRIVE (Driving Research and Innovation for Vehicle Efficiency and Energy Sustainability) Partnership enhances the relevance and the potential for success of the overall research platform.

Several different electric vehicle research and development funding opportunities were released in 2016, from both federal and state sources. The federal funding initiatives from 2016 are briefly summarized below:

- DOE VTO selected 23 electric vehicle projects to fund, representing nearly 35 million USD in federal cost share allocated to both industry and academia. The projects include PEV public showcases as well as PEV batteries and motors R&D[119].
- In December 2016, DOE VTO announced 18 million USD in funding in support of five projects for research, development, and demonstration of innovative PEV and engine technologies, as well as community-based projects to accelerate the adoption of alternative fuel vehicles. Four of those projects (which include two PEV projects and two community deployment projects) accounted for 16.6 million USD of this funding[120].

33.2 HEVs, PHEVs and EVs on the Road

This section provides information on the number of hybrid and electric vehicles on the road in the U.S. at the end of 2016 and an overview of prices for the most popular such vehicles.

For PEVs, the 2016 total sales reached 159,616 units. The highest-selling models included the Tesla Model S (30,200 units), Chevrolet Volt (24,739 units), Tesla Model X (19,600 units), Ford Fusion (15,938 units), and Nissan LEAF (14,006 units). A total of 25 PEV models sold over 1,000 units in 2016, which included 10

[119] U.S. DOE, "FY 2016 Vehicle Technologies Program-Wide Funding Opportunity Announcement Selections," https://energy.gov/sites/prod/files/2016/08/f33/FY%2016%20VT%20Program-Wide%20Selection%20Table.pdf, August 2016, accessed February 13, 2017.

[120] U.S. DOE, "Energy Department Announces $18 Million Investment to Accelerate the Development of Plug-In Electric Vehicles and Use of Other Alternative Fuels," https://energy.gov/eere/articles/energy-department-announces-18-million-investment-accelerate-development-plug-electric, December 22, 2016, accessed February 13, 2017.

BEVs and 15 PHEVs[121]. Figure 1 shows the annual sales, highlighting the eight most popular models.

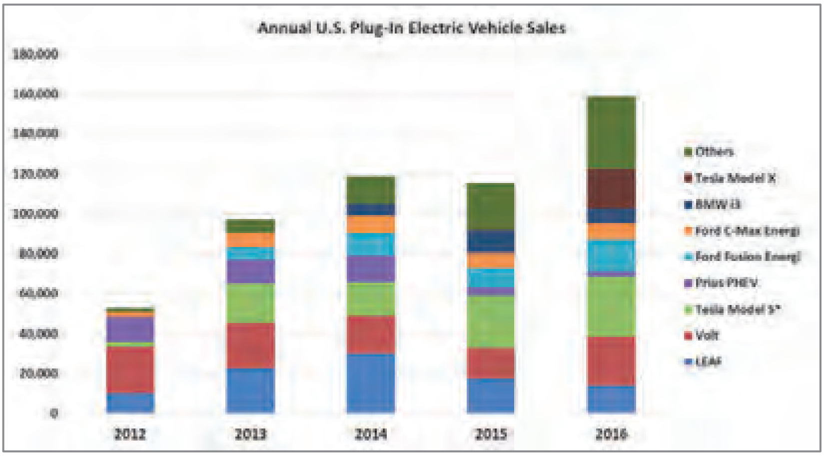

Figure 1: U.S. PEV sales by model between 2012 and 2016 (Source: DOE)

During 2016, there were 30 PEV models sold in the U.S., which included 13 all-electric EV models and 17 plug-in hybrid EV (PHEV) models. The manufacturers included Audi, BMW, Cadillac, Chevrolet, Fiat, Ford, Hyundai, Kia, Mercedes, Mitsubishi, Nissan, Porsche, Smart, Tesla, Toyota, Volkswagen, and Volvo. In addition to Chevrolet (which released the all-electric Bolt), several other manufacturers announced future availability of their PEVs: Honda (announcing Clarity EV by late 2017), Hyundai (announcing IONIQ by spring 2017), and Tesla (announcing Model 3 by mid-2017).

In 2016, HEVs continued to increase in both variety and performance. There were 37 HEV models available, and 20 of them had annual sales exceeding 1,000 units. The original equipment manufacturers (OEMs) offering HEVs included: BMW, Daimler AG, Ford, GM, Honda, Kia, Nissan, Porsche, Subaru, Toyota, and Volkswagen. The most popular models included the Toyota Prius Liftback (98,863 units), Toyota RAV4 (45,070 units), Ford Fusion (33,648 units), Toyota Camry (22,227 units), Toyota Prius C (20,452 units), and the Hyundai Sonata (18,961 units)[122]. The Prius line-up continued to dominate sales and controlled 38 % of the

[121] Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates," www.anl.gov/energy-systems/project/light-duty-electric-drive-vehicles-monthly-sales-updates, February 2017, accessed February 16, 2017.

[122] Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates," www.anl.gov/energy-systems/project/light-duty-electric-drive-vehicles-monthly-sales-updates, February 2017, accessed February 16, 2017.

U.S. HEV market in 2016. Figure 2 shows the annual U.S. HEV sales by manufacturer.

2016 sales of U.S. vehicles (including conventional vehicles) exceeded 17 million. Light trucks accounted for over 10 million of that total, among which, the top sellers included Ford F-Series trucks (820,799 units), Chevrolet Silverado (574,876 units), and Ram Pickup (489,418 units)[123].

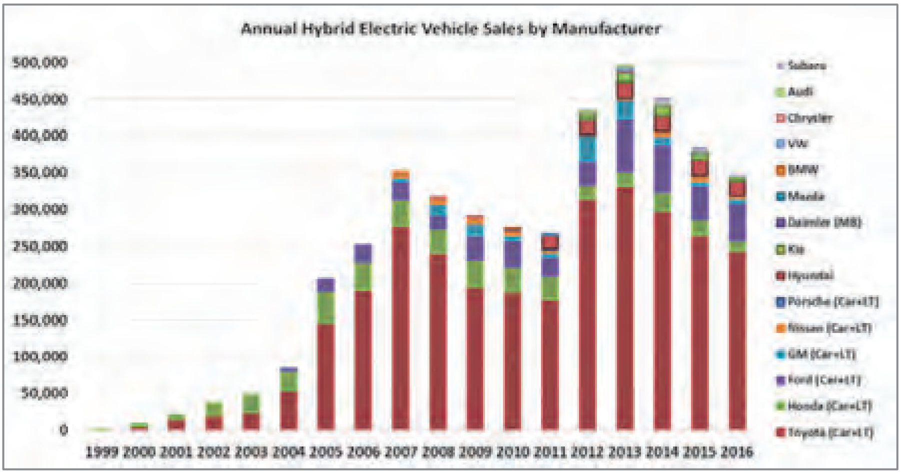

Figure 2: Overiew of annual U.S. HEV sales by manufacturer between 1999 and 2016 (Source: DOE)

Table 1 shows the U.S. distribution and sales of all-electric EVs, PHEVs and HEVs in 2016, and how these compare with the vehicle fleet totals. Table 2 lists the prices for select plug-in electric vehicles sold in the United States. The table captures the most popular selling models. The prices given are in U.S. dollars and reflect the manufactured suggested retail price (MSRP). This information was current as of February 2017.

[123] Timothy Cain, "2016 Year End U.S. Vehicle Sales Rankings - Top 299 Best-Selling Vehicles In America - Every Vehicle Ranked," www.goodcarbadcar.net/2017/01/usa-2016-vehicle-sales-by-model-manufacturer-brand.html, Good Car Bad Car, June 1, 2017, accessed February 16, 2017.

Table 1: Distribution and sales of all-electric EVs, PHEVs and HEVs in 2016

Fleet Totals on 31 December 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
Passenger Vehicles	294,110[a]	266,775[a]	4,267,157[a]	1,233[a]	~115,000,000[c]
Buses and Minibuses[b]	n.a.	n.a.	n.a.	n.a.	~127,000,000[c]
Medium and Heavy Weight Trucks	n.a.	n.a.	n.a.	n.a.	11,203,000[c]
Totals without e-bikes	**294,110**	**266,775**	**4,267,157**	**1,233**	**~253,203,000**

Total Sales during 2016					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[f]**
E-Bikes	220,000[d]	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles	86,731[a]	72,885[a]	346,949[a]	1,074[a]	6,873,000[e]
Buses and Minibuses[b]	n.a.	n.a.	n.a.	n.a.	10,296,000[e]
Medium and Heavy Weight Trucks	n.a.	n.a.	n.a.	n.a.	697,000[e]
Totals with bicycles	**306,731**	**72,885**	**346,949**	**1,074**	**17,866,000**
Totals without e-bikes	**86,731**	**72,885**	**346,949**	**1,074**	**17,866,000**

n.a. = not available

[a] Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates," www.anl.gov/energy-systems/project/light-duty-electric-drive-vehicles-monthly-sales-updates, February 2017, accessed February 16, 2017.

[b] Approximate 2015 data. Includes both personal and commercial pickups, SUVs, minivans, vans, and other light trucks.

[c] Oak Ridge National Laboratory, "Transportation Energy Data Book," http://cta.ornl.gov/data/tedb35/Edition35_Full_Doc.pdf, Edition 35, Quick Facts, October 2016, accessed February 16, 2017.

[d] Correspondence with Light Electric Vehicle Association, www.levassociation.com.

[e] Ward's Automotive, 2017, http://wardsauto.com.

[f] Including non-electric vehicles

Table 2: A list of some available U.S. vehicles and their prices, as of February 2017 (Data source: websites of chosen car makers)

Market-Price Comparison of Selected EVs and PHEVs in the United States	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in USD)**
BMW i3	42,400
BMW X5 xDrive40e	62,100
Chevy Bolt	37,495
Chevy Volt	33,220
Fiat 500e	31,800
Ford C-Max Energi	27,120
Ford Fusion Energi	31,120
Ford Focus Electric	29,120
Mercedes Benz B-Class	39,900
Nissan LEAF	30,680
Tesla Model S	68,000
Tesla Model X	74,000
Toyota Prius Prime	27,100
Volkswagen e-Golf	28,995

33.3 Charging Infrastructure or EVSE

In 2016, EV charging infrastructure in the United States grew considerably, particularly for Level 2 and DC Fast Charging Stations, both of which increased their number of installed stations by 30 %. Additionally, the number of plugs per installed station increased by an average of 6 %, largely driven by the 30 % increase in plugs per station at fast charger installations. Table 3 provides an overview of the number of public charging stations in the United States by charger type, and Figure 3 shows the geographical distribution of charging stations in the U.S. This information is collected and posted by the U.S. Department of Energy's Alternative Fuels Data Center[124]. DOE is funding national laboratory research on extreme fast charging (at 350 kW) which can enable 200 miles of range in 10 minutes, exploring its impact on vehicles, batteries, infrastructure, and operating costs[125].

[124] U.S. DOE, "Alternative Fuels Data Center," www.afdc.energy.gov, accessed February 15, 2017.
[125] U.S. DOE, "FACT SHEET: Federal and Private Sector Actions to Accelerate Electric Vehicle Adoption in the United States", https://energy.gov/articles/fact-sheet-obama-administration-announces-federal-and-private-sector-actions-accelerate, July 21, 2016, accessed February 15, 2017.

Table 3: Information on U.S. public EV charging infrastructure in 2016[126]

Charging Infrastructure on 31 December 2015		
Chargers	**Installed Locations**	**Available Plugs**
AC Level 1 Chargers	1,515	2,983
AC Level 2 Chargers	13,841	23,996
DC Fast Chargers:		
- Tesla Superchargers (120 kW)	357	2,452
- Other DC Fast Chargers	1,682	3,075
Totals	**17,395**	**32,506**

As of December 2016, 400 employers have participated in the Department's Workplace Charging Challenge (WCC). More than 700 workplaces have installed a total of over 7,000 charging stations accessible to nearly one million employees. Figure 4 summarizes the number of chargers that have been installed since 2013[127]. In addition to the Level 1 and Level 2 chargers, WCC partners have installed 136 direct-current fast charging stations.

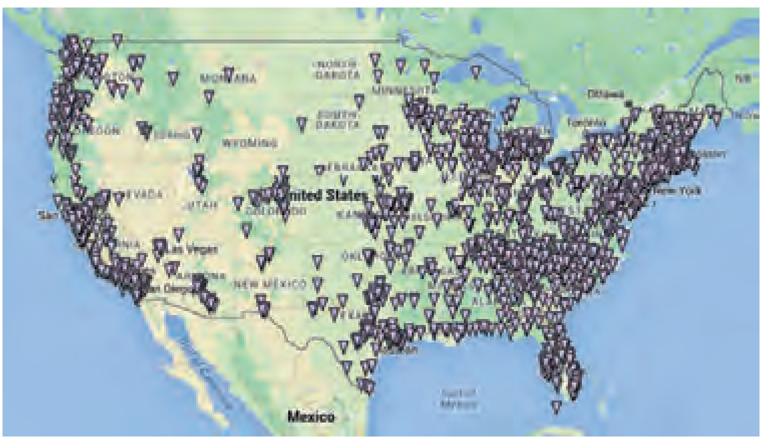

Figure 3: Electric vehicle charging stations in the United States (Source: http://maps.nrel.gov/transatlas)

[126] U.S. Department of Energy Alternative Fuels Data Center, "Electric Vehicle Charging Station Locations," www.afdc.energy.gov/fuels/electricity_locations.html, accessed February 15, 2017.
[127] U.S. DOE, "WCC Progress Update 2016: A New Sustainable Commute", https://energy.gov/sites/prod/files/2017/01/f34/WPCC_2016 Annual Progress Report.pdf, January 2017, accessed February 15, 2017.

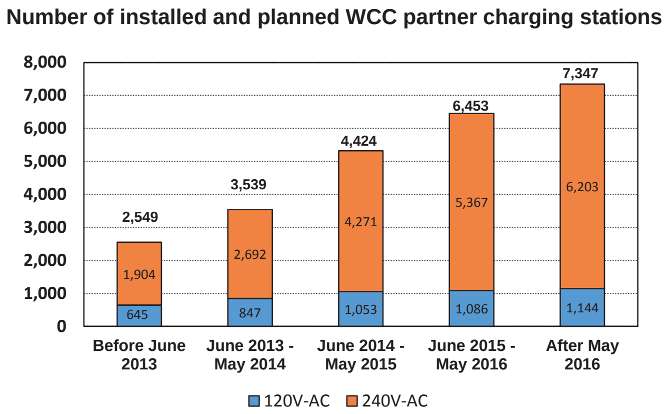

Figure 4: Number and type of installed and planned WCC partner charging stations[128]

33.4 Outlook

Global sales of light, medium, and heavy duty PEVs are estimated to continue growing, according to past Navigant Research reports (published in 2015)[129,130], as well as a 2016 study by Bloomberg New Energy Finance[131]. ICCT estimates that full-function hybrid systems are likely to drop 50 % of their cost before 2025, pushing mild electrification into the U.S. fleet at ever-increasing levels[132]. Lithium-ion battery costs have dropped considerably, and will continue dropping as described earlier in updates from GM and Tesla[133,134]. Many state and local policies to promote the market acceleration of PEVs, e.g., the Multi-State ZEV Action Plan and federal/state/local incentives are under development.

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[128] U.S. DOE, “WCC Progress Update 2016: A New Sustainable Commute”, https://energy.gov/sites/prod/files/2017/01/f34/WPCC_2016 Annual Progress Report.pdf, January 2017, accessed February 15, 2017.

[129] Green Car Congress, “Navigant forecasts 29.3% CAGR growth for electric-drive and electric-assisted commercial vehicles to nearly 160K units in 2023,” www.greencarcongress.com/2015/01/20150128-navigant.html, January 28, 2015, accessed February 10, 2017.

[130] Green Car Congress, “Navigant forecasts global annual sales of LDVs of 122.6M by 2035, up 38% from 2015,” www.greencarcongress.com/2015/07/20150706-navigant.html, July 6, 2015, accessed February 16, 2017.

[131] Randall, Tom, “Here’s How Electric Cars Will Cause the Next Oil Crisis,” www.bloomberg.com/features/2016-ev-oil-crisis, Bloomberg, February 25, 2016, accessed February 16, 2017

[132] German, John, “Hybrid Vehicles: Technology Development and Cost Reduction,” The International Council on Clean transportation (ICCT), http://theicct.org/sites/default/files/publications/ICCT_TechBriefNo1_Hybrids_July2015.pdf, July 2015, accessed February 16, 2017.

[133] Jay Cole, “GM: Chevrolet Bolt Arrives in 2016, $145/kWh Cell Cost, Volt Margin Improves $3,500,” http://insideevs.com/gm-chevrolet-bolt-for-2016-145kwh-cell-cost-volt-margin-improves-3500, InsideEVs, February 2016, accessed February 16, 2017.

[134] Fred Lambert, “Tesla confirms base Model 3 will have less than 60 kWh battery pack option, cost is below $190/kWh and falling,” https://electrek.co/2016/04/26/tesla-model-3-battery-pack-cost-kwh, electrek, April 26, 2016, accessed February 16, 2017.

34 Non-Member Countries

34.1 China

Development of electric vehicles is a national strategy for transformation and upgrade of the automotive industry in China, and the Chinese government attaches great importance to the development of the electric vehicle industry. With a joint effort made by the government and the market, the electric vehicle of China shifted from an introduction period to a growth period in 2016. Quality and performance of new energy vehicle products became more mature, categories and quantity of products became more abundant, production and sales volume hit a new record and the industrial scale took a lead in the world.

China has established an optimal new energy vehicle policy system, which covers contents such as technical research and development, financial subsidy, industrial administration, tax preference and government purchase, and involves various phases such as research and development, production, use and recovery of electric vehicle products, and key components. China has officially issued over 70 standards on electric vehicles and over 20 standards on charging facilities, and the demand of electric vehicles for standard is reflected on different levels and from different directions.

Production and sales of electric vehicles in China exceeded 500,000 units and nationwide ownership exceeded 1 million units in 2016, laying a foundation for the realization of the national development target in 2020 and making a contribution to dealing with climate change and abatement of atmospheric pollution.

As of the end of 2016, China has established 141,254 public charging pillars, the construction of charging infrastructure has been accelerated and propelled, and the environmental use of electric vehicles has been optimized day by day. The target of charging infrastructure development of China is to construct 12,000 concentrated battery charging/swapping stations and 4.8 million charging pillars as of 2020, so as to meet the charging demand of 5 million units of electric vehicles nationwide.

34.1.1 National Subsidies

China issued a “Notice on Financial Aiding Policies for Popularization and Application of New Energy Vehicles between 2016 and 2020 (Cai-Jian [2015] No. 134)” (Hereinafter referred to as the *No. 134 document*). In April 2015, so as to implement a generalized system of preferences for funds, subsidy for consumers who have purchased a new energy vehicle in the scope of the entire country, subsidy will be granted only to battery electric vehicles, plug-in hybrid electric vehicles, and fuel cell electric vehicles incorporated in a “Catalogue of Recommended Models for NEV Promotion and Application Project” of the Ministry of Industry and Information Technology, see the subsidy policy in 2016 in Table 1.

China issued a “Notice on Adjusting the Policy of Financial Subsidies for Promotion and Application of New Energy Vehicles (Cai-Jian [2016] No. 958)” (Hereinafter referred to as the *No. 958 document*) in December 2016, under the precondition to keep the No. 134 document stable generally. A new energy vehicle subsidy standard will be adjusted and a dynamic adjustment mechanism and a strict penalty mechanism will be established, so as to further encourage technical progress and support superior and strong products, and promote a sustainable development of the new energy vehicle industry. In terms of subsidy standards, the subsidy standard for new energy buses and special vehicles will be adjusted, and a standard for new energy passenger cars will continue to adopt the requirements of the No. 134 document. With the exception of fuel cell electric vehicles, 2019-2020, central and local government subsidy standards and upper limits for various vehicle types will phase out by 20 %. For provinces and cities granting local government subsidies, the sum of subsidy of local finance at all levels should not exceed 50 % of a single vehicle subsidy amount granted by national finances. In terms of subsidy doorsill, technical requirements such as energy consumption of the complete vehicle, range, battery performance and safety requirements will be substantially enhanced, and a market sampling inspection mechanism will be established, so as to ensure the efficient and effective implementation of a subsidy policy. The change of the national subsidy standard for new energy passenger cars in 2017 is shown in Table 2.

Table 1: Information on subsidy standards of Chinese Central Government in 2016 (1 EUR = 7.4 CNY)

2016 Subsidy Standard of Chinese Central Government		
Vehicle Type	**Range (Mileage)**	**Subsidy (10,000 CNY/ Vehicle)**
Pure electric passenger vehicle	100 ≤ R < 150	2.5
	150 ≤ R < 250	4.5
	R ≥ 250	5.5
Plug-in hybrid passenger vehicle (extended range included)	R ≥ 50	3.0
Pure electric special vehicle	1,800 CNY/KWh; not exceeding 135,000 CNY/vehicle	
Fuel cell passenger vehicle	2,000 CNY/vehicle	
Fuel cell commercial vehicle	Light-duty bus and goods vehicle	30
	Large/medium size bus and medium/heavy duty goods vehicle	50

Data source: The original text of policy

Table 2: Information on change of subsidy standards for new energy passenger car in 2017 (1 EUR = 7.4 CNY)

Change of National Subsidy Standard for New Energy Passenger Car in 2017 (unit: 10,000 CNY)				
Range	**National subsidy + local subsidy in 2016**	**A: National subsidy + local subsidy in 2017**	**B: National subsidy + local subsidy in 2017[a]**	**Change of standard**
Battery Electric Vehicle 100≤R<150	2.5+2.5=5	2+1=3	3*1.1=3.3	**A:** 5-3=2 **B:** 5-3.3=1.7
Battery Electric Vehicle 150≤R<250	4.5+4.5=9	3.6+1.8=5.4	5.4*1.1=5.94	**A:** 9-5.4=3.6 **B:** 9-5.94=3.06
Battery Electric Vehicle R≥250	5.5+5.5=11	4.4+2.2=6.6	6.6*1.1=7.63	**A:** 11-6.6=4.4 **B:** 11-7.63=3.83
Plug-in hybrid electric vehicle R≥50	3+3=6	2.4+1.2=3.6	-	**A:** 6-3.6=2.4

Data source: China Automotive Technology & Research Center

[a] Subsidy will be granted as per 1.1 times for traction battery system of which mass energy density is higher than 120Wh/kg

Beijing is one of the key cities for promotion and application of new energy vehicles in China. In September 2015, the Beijing Municipal Government issued “Measures of Beijing Municipality for Management of New Energy Cars in Demonstrative Application” (as amended in 2015) (Jing-Ke-Fa [2015] No. 458) (Hereinafter referred to as the “No. 458 document”) on the basis of the national subsidy policy, specifying that subsidies will be granted as per proportion of 1:1 of national subsidy to local subsidy for battery electric vehicles and fuel cell electric vehicles incorporated in the "Battery Electric Car Registration Catalogue of Beijing", so as to propel the development of new energy vehicles in the local regions. With the adjustment and implementation of the national subsidy policy, the new energy vehicle subsidy standard of Beijing will be adjusted in 2017 on the basis of the No. 458 document in combination with requirements of the national policy.

Table 3: Information on subsidy standards for Beijing in 2016 (1 EUR = 7.4 CNY)

2016 Beijing Subsidy Standard		
Vehicle Type	**Range (Mileage)**	**Subsidy (10,000 CNY/Vehicle)**
Pure electric passenger vehicle	$100 \leq R < 150$	2.5
	$150 \leq R < 250$	4.5
	$R \geq 250$	5.5
Fuel cell bus		20

Data source: The original text of policy

34.1.2 Main Policies in China in 2016

Table 4: An overview of main policies in China in 2016

Main Policies of 2016		
Name of Policy	**Issuing Organization**	**Issuing Time**
"Administrative Method for Carbon Quota of New Energy Vehicles" (Draft for Comments)	**NDRC**	**August 2016**
Main contents: Set up annual proportion requirements on production and sales of new energy vehicles and fuel vehicles for specified scale enterprises of fuel vehicles in accordance with plan target, and convert the requirements as carbon quota of new energy vehicles to be handed in by enterprises. Enterprise should submit carbon quota no less than the due amount annually to carbon trade authority, and should bear legal liability in case of failure to fulfill obligations for handing in quota on time.		
"Tentative Method for Parallel Administration of Corporate Average Fuel Consumption and New Energy Vehicle Credit"(Draft for Comments)	**MIIT**	**September 2016**
Main contents: The Method implements administration on average fuel consumption of enterprises that sell passenger cars and production of new energy passenger cars in territory of China, for passenger car enterprise of which annual production volume or import volume of traditional energy passenger car in territory of China is more than 50,000 units, set up the requirements on annual proportion of new energy vehicle credit, it is allowed to freely trade positive credit		

of new energy vehicle but it is not allowed to carry over credit.		
"Technical Roadmap of Energy Saving and New Energy Vehicles"	MIIT	October 2016
Main contents: Taking new energy vehicle and intelligent & connected vehicles as main breakthrough, optimization, upgrade and transformation of energy power system as key point, enhancement of intelligence level as main line, and common technologies such as advanced manufacture and lightweight as support, propel low carbon, information technology, intelligence and high quality of automotive industry in an overall manner.		
"Notice Regarding Further Optimization of Safety Supervision Work of Popularization and Application of New Energy Vehicles"	**MIIT**	**November 2016**
Main contents: New energy vehicle manufacturer is the principal of safety, and takes general responsibility of complete vehicle products. It is necessary to firmly establish sense of quality safety responsibility, and implement strict management and control of all procedures such as research, development, production, operation monitoring, maintenance and service, so as to ensure quality safety and COP of new energy vehicle products promoted and applied.		

Data source: The original text of policy

34.1.3 HEVs, PHEVs and EVs on the Road

In 2016, production and sales of BEVs in China were respectively 417,000 units and 409,000 units, posting a growth of 63.9 % and 65.1 % in comparison with the same period of the previous year; production and sales of PHEVs in China were respectively 99,000 units and 98,000 units, posting a growth of 15.7 % and 17.1 % in comparison with the same period of the previous year. The production of HEVs in China was 85,000 units, posting a growth of 466.7 % in comparison with the same period of the previous year.

Table 5: Production and Sales of New Energy Vehicles in China in 2015 and 2016 (Data source: Website release of Ministry of Industry and Information Technology)

2015 & 2016 Production of New Energy Vehicles		
Vehicle Type	**2015**	**2016**
Battery electric passenger vehicle	14,280	24,100
Plug-in hybrid passenger vehicle	6,360	8,100
Hybrid electric vehicle	1,500	8,500
Battery electric commercial vehicle	14,790	17,600
Plug-in hybrid commercial vehicle	2,460	1,800

Totals	**39,390**	**60,100**

2015 & 2016 Sales of New Energy Vehicles		
Vehicle Type	**2015**	**2016**
Battery electric passenger vehicle	14,670	25,700
Plug-in hybrid passenger vehicle	6,070	7,900
Battery electric commercial vehicle	10,080	15,200
Plug-in hybrid commercial vehicle	2,300	1,900
Totals	**33,120**	**50,700**

34.1.4 Charging Infrastructure or EVSE

According to statistics of the China Electric Vehicle Charging Infrastructure Promotion Alliance, as of the end of December 2016, China has 141,254 public charging pillars, including 52,778 AC charging pillars, 38,096 DC charging pillars and 50,380 AC/DC integrated charging pillars.

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)

Top 10 of China's Provincial Administrative Regions on Charging Pillars Built by End of Dec. 2016		
No.	**City**	**Quantity**
1	Beijing	21,940
2	Guangdong	21,108
3	Shanghai	16,444
4	Jiangsu	15,869
5	Shandong	12,340
6	Hebei	7,307
7	Tianjin	6,782
8	Anhui	6,756
9	Zhejiang	5,246
10	Hubei	4,266

Table 7: Information on charging infrastructure in 2016 (Data source: China Electric Vehicle Charging Infrastructure Promotion Alliance)

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC charging pillars	52,778
DC charging pillars	38,096
AC/DC charging pillars	50,380
Totals	**141,254**
Public charging pillars	128,246
Special charging pillars	13,008
Totals	**141,254**

n.a. = not available

34.1.5 Market structure of HEVs, PHEVs and EVs

The passenger car was the majority of the electric vehicle market of China in 2016. The production volume of passenger cars accounted for over 60 % of the total production volume. Furthermore, with the enhancement of requirements of private consumers for vehicle range, comfort and appearance, electric passenger car models developed towards premium vehicle models, the production of vehicles above class B reached over 25 %, posting an increase of approximately 15 % in comparison with the same period of the previous year.

In 2016, subject to the influence of tightened regulations on vehicle fuel consumption, hybrid technology as an effective fuel-saving technology attracted wide attention, the market share of HEV passenger cars was further expanded in China, posting an increase of approximately 20 % in comparison with the same period of the previous year, and the class B vehicle was the majority of vehicle type.

Table 8: Production of EVs, PHEVs and HEVs in 2016 (Data source: China Automotive Technology & Research Center)

Fleet Totals on 31 December 2016 (10,000 Vehicles)				
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**Total**
Mini car	3.6	0	0	3.6
A00	1.6	0	0	1.6
A0	7.5	0	0	7.5
A	9.1	2.4	0	11.5
B	2.2	5.6	8.36	16.16
C	0.1	0.1	0.14	0.34
Totals	**24.1**	**8.1**	**8.5**	**40.7**

Table 9: Available vehicles and prices (Data source: autohome.com.cn; 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)**
Denza Lifestyle	369,000 ; 50,000
BYD- Tang	251,300 ; 33,900
BYD- Qin	209,800 ; 28,300
BYD- e5	229,800 ; 28,800
BYD- e6	309,800 ; 41,800
Tesla Model S	708,900 ; 88,900
Tesla Model X	904,000 ; 113,400
BAIC EV series	177,800 ; 22,300
Roewe e950	288,800 ; 36,220
Roewe e550	239,800 ; 30,000
Trumpchi GA5	199,300 ; 25,000

34.1.6 Outlook

In the future, China will still take battery electric driving as the main strategic direction of electric vehicle development, continuously support the development of electric vehicles and fuel cell electric vehicles, further enlarge investments in research and development of electric vehicles, grasp low carbon, information technology and intelligent core technologies of motor vehicles, and enhance engineering and industrialization capability of core technologies such as traction battery, driving motor, efficient internal combustion engine, advanced transmission, lightweight material and intelligent control, etc. China will also accelerate the construction of charging infrastructure, and further expand the proportion of application of electric vehicles in fields such as urban bus, taxi, environmental sanitation and logistics, etc., establish an optimal market mechanism for stimulation of endogenetic power of industrial development and promote further development of the electric vehicle market. China will make every effort to realize the target that the production capacity of battery electric vehicles and plug-in hybrid electric vehicles reaches 2 million units and accumulative production and sales exceed 5 million units as of 2020, fuel cell electric vehicles and the vehicle hydrogen energy industry keep pace with the international development.

34.2 Japan

34.2.1 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)

	2016 Results	2030 Targets
Conventional Vehicles	**65.15 %**	**30 ~ 50 %**
Next-Generation Vehicles	**34.85 %**	**50 ~ 70 %**
Hybrid Vehicles	30.76 %	30 ~ 40 %
Electric Vehicles	0.37 %	20 ~ 30 %
Plug-in Hybrid Vehicles	0.22 %	20 ~ 30 %
Fuel-Cell Vehicles	0.02 %	~ 3 %
Clean Diesel Vehicles	3.46 %	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 PHEVs toward the Dissemination of Electric Vehicles and Plug-in Hybrid Vehicles").

34.2.2 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 600,000 JPY (5,405 USD)
- **CDVs**: up to 150,000 JPY (1,351 USD)
- **FCVs**: up to 2,080,000 JPY (18,738 USD)

34.2.3 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 the first and second 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”.

34.2.4 Research

METI has provided approximately 4.33 billion JPY to support for R&D in 2016, 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

34.2.5 HEVs, PHEVs and EVs on the Road

As of the end of 2016, cumulative EVs/PHEVs/FCVs sales were over 160,000 in Japan. In 2016, there were about 4.15 million newly registered passenger vehicles in Japan. Of this newly registered total, 1,275,560 were HEVs, 15,461 were EVs, 9,390 were PHEVs, and 1,055 were FCVs.

34.2.6 Charging Infrastructure or EVSE

METI has 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 2016, more than 24,000 public charging stations, including 7,061 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 2: Information on charging infrastructure in 2016 in Japan

Charging Infrastructure on 31 December 2016	
Chargers	**Quantity**
AC Level 1 Chargers	17,260[a]
AC Level 2 Chargers	n.a.
Fast Chargers	7,061[a]
Superchargers	51
Inductive Charging	n.a.
Totals	**24,372**

n.a. = not available
[a] Data source: Zenrin

Table 3: Available vehicles and prices (Data source: Next generation vehicle promotion center, 111 JPY = 1 USD)

Market-Price Comparison of Selected EVs and PHEVs in Japan	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in JPY and USD)**
Mitsubishi i-MiEV	2,105,000 ; 18,963
Mitsubishi Minicab MiEV	1,638,000 : 14,756
Mitsubishi Outlander PHEV	3,388,400 ; 30,526
Nissan Leaf(24kwh)	2,526,000 ; 22,756
Nissan Leaf(30kwh)	2,891,000 ; 26,045
Nissan eNV200	3,050,000 ; 27,477
Toyota Prius Plug-in	3,020,000 ; 27,207
Toyota MIRAI (FCV)	6,700,000 ; 60,360
Honda CLARITY FUELL CELL	7,092,593 ; 63,897
Audi A3 Sportback e-tron	5,222,223 ; 42,047
BMW i3	4,620,370 ; 41,624
BMW i8	18,435,185 ; 166,082
BMW X5 xDrive40e	8,787,037 ; 79,162
BMW 225xe	4,518,519 ; 40,707
BMW 330e	5,129,630 ; 46,212
BMW 740e	10,824,074 ; 97,514
VW Golf GTE	4,342,593 ; 39,122
VW Passat GTE	4,813,889 ; 43,368
Porsche Cayenne S e-hybrid	10,805,556 ; 97,347
Porsche Panamera S e-hybrid	13,870,371 ; 124,958

Volvo XC90	9,342,593 ; 84,167
Mercedes Benz S 550 e long	15,166,667 ; 136,636
Mercedes Benz C 350e	6,675,926 ; 60,143
Mercedes Benz GLC e 4MATIC	7,990,741 ; 71,988
Tesla Model S 60 kWh	7,388,888 ; 66,566
Tesla Model S 90 kWh	10,240,740 ; 92,258
Tesla Model X 60 kWh	8,287,037 ; 74,657
Tesla Model X 100 kWh	14,918,518 ; 134,401

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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
TCP	Technology Collaboration Programme
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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