IEA INTERNATIONAL ENERGY AGENCY

HYBRID & ELECTRIC VEHICLE TECHNOLOGY COLLABORATION PROGRAMME

HEV TCP

Hybrid and Electric Vehicles

The Electric Drive Automates

2018

www.ieahev.org

International Energy Agency

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

Hybrid and Electric Vehicles

The Electric Drive Automates

September 2018

www.ieahev.org

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.

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

Cover Photo: Driverless electric mini-buses of Navya and EasyMile operated in a demonstration project on the premises of the Charité hospital in Berlin (Germany)

(Image Courtesy: Berliner Verkehrsbetriebe - BVG)

The Electric Drive Automates

Cover Designer: Anita Theel

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 2017

Hybrid and Electric Vehicles

The Electric Drive Automates

Editor: Gereon Meyer (Operating Agent Task 1,
VDI/VDE Innovation + Technik GmbH)
Co-editors: Jadranka Dokic, Heike Jürgens, Luca Bühler
(VDI/VDE Innovation + Technik GmbH)

Contributing Authors:

Ibtihal Ait Abdelmoula	IRESEN	Morocco
René-Pierre Allard	Natural Resources Canada	Canada
Zuiou Ashihara	METI	Japan
James Barnes	Barnes Tech Advising	United States
Graham Brennan	SEAI	Ireland
Steven Boyd	U.S. Department of Energy	United States
Carol Burelle	Natural Resources Canada	Canada
Pierpaolo Cazzola	IEA	France
Cristina Corchero	IREC	Spain
Charles Crispim	Natural Resources Canada	Canada
Meally Declan	SEAI	Ireland
Andreas Dorda	BMVIT	Austria
Julie Francis	Allegheny Science & Technology	United States
Halil S. Hamut	TÜBITAK MRC	Turkey
David Howell	U.S. Department of Energy	United States
Gerfried Jungmeier	Joanneum Research	Austria
Peter Kasche	Swedish Energy Agency	Sweden
Ryosuke Kikuchi	METI	Japan
Matthias Kloetzke	DLR	Germany
Martti Korkiakoski	Tekes	Finland
Mikko Koskue	Finpro	Finland
Juan Fco. Larrazábal Roche	IDEA	Spain
Matthias Laske	FZ Jülich	Germany
Jun Li	CATARC	China
Ock Taeck Lim	University of Ulsan	Rep. of Korea
Walter Mauritsch	AustriaTech	Austria
Gereon Meyer	VDI/VDE-IT	Germany
James F. Miller	Argonne National Laboratory	United States
Carlo Mol	VITO	Belgium
Sonja Munnix	Netherlands Enterprise Agency	The Netherlands
Urs Muntwyler	HEV TCP Chairman	Switzerland
Hannes Neupert	EnergyBus	Germany
Burak Ozpineci	Oak Ridge National Laboratory	United States
Maxime Pasquier	ADEME	France
Claudio Pfister	Electrosuisse	Switzerland
Michael Rask	Raskgreentech	Denmark
Aymeric Rousseau	Argonne National Laboratory	United States
Manel Sanmarti	IREC	Spain
Stephan Schmid	DLR	Germany
Francesco Vellucci	ENEA	Italy
Philipp Walser	Association e'mobile	Switzerland
Tim Ward	OLEV	United Kingdom
Martina Wikström	Swedish Energy Agency	Sweden
Bert Witkamp	AVERE	Belgium

Contents

1 Chairperson's Message

As the Chair of the Hybrid and Electric Vehicles Technology Collaboration Programme (HEV TCP) of the International Energy Agency (IEA) I have the pleasure to introduce you to the Annual Report 2018. This is my last introduction to the Annual Report of the IEA HEV TCP. I have had the pleasure to chair the IEA HEV TCP for 20 years and now it is time to hand over to a new Chair to be elected in fall 2018. The new chair will take over an active community with 13 working groups - EVs and HEVs are hot topics now. This disruptive technology will change automotive business further in the next decades.

In the past 20 years, the framework for this disruptive technology has changed dramatically. 20 years ago, the electric drive train was surviving in some hybrid cars from Japan, mainly the "Prius". Pure electric vehicles disappeared after the "hype" in California with the "zero emission act", calling for "zero emission vehicles" (ZEVs). Some car proponents believed that the hydrogen car without a battery would be the future and many member countries dropped out of our Technology Collaboration Programme (TCP).

The Change to the Electric Drive Train is Ongoing

Now, 20 years later, the cars with combustion engines are under pressure from different sides. The CO2 policy targets in Europe require lower emissions and a higher efficiency. As politicians were not able to fulfill the emissions targets, the courts now decided that the traffic can be stopped, if needed. Decisions such as in Germany in spring 2018, which allow to ban "dirty cars" for certain roads, act as a wake-up call.

This puts cars with combustion motors under pressure even more. The diesel motor suffers from the "fraud" with the emissions in the USA and Europe. Diesel cars seem to phase-out these days. Hybrid- and electric vehicles sales are going up, but still represent a very low number. The pure electric vehicle increasingly offers the range that is needed for mass market customers. The production and sales price will go down as the production numbers go up. But to establish all the suppliers will still need time.

Countries such as China are much more pro-active. They set targets for car technology. The lead for the electric car is now in China. Before, the lead was in the USA, pushed by a private company. It's a time for disruption of the car industry.

Cars Sales Went up as Predicted

Like 20 years ago and today even more, people still like driving a car. In 1998, the IEA HEV TCP secretary, Frans Koch and myself presented an overview on the worldwide use of cars. We counted a total of 700 million cars that were predominantly driven in the IEA countries (Europe, Australia, New Zealand, Japan, Republic of Korea, Canada, and the USA). In 1998, we counted over 600 cars/1,000 inhabitants in these countries, as compared to 10 cars/1,000 inhabitants in the then "low income countries" such as India, China, etc. The numbers can be seen in Table 1.

Table 1: An overview of the worldwide use of cars (published in 1998)

1998	Population [mio]	Cars [mio]	Cars / 1,000 persons
IEA countries	852	516,4	606
"Tiger-States"	1,767	159	90
Low income countries	3,235	31,6	10

In the last 20 years, the number of cars went up at a rate of 1 car/second (see, for example www.live-counter.com). This website also evidences 1,254 million cars worldwide in March 2018. The expected number for 2035 is 1,800 million cars. This development demonstrates the extraordinary success and the wish of the people to get a car, if they can afford it. If the global population envisages sustainable development and aims at reducing both the energy consumption and the CO_2 emissions, a new technology is needed. The "electric drive train" can fill this gap. As concerns electric cars, the last years let products emerge in the market, which offer enough power, comfort and range. Not to talk about driving comfort and acceleration, which is much better in an electric car compared to a conventional cars.

Shows and Announcements Confuse and Block Consumers

I am writing these lines during the opening ceremony of the International Motor Show 2018 in Geneva, Switzerland, the biggest car show in a "no car producing country". During this show, car producers announce funny novelties to occupy some territory and check the customer reaction. I have seen hundreds if not thousands of concept cars and studies in the last thirty years. Most of them will never show up again and hence, it is a waste of time to even look at them. In these times, some car producers even don't appear at such shows, because of the "mainly show" element. Two of the most popular and attractive EVs are not even presented at the International Motor Show 2018 in Geneva. There seem to be easier ways to attract and find customers.

What counts are cars in the dealer show room, motivated dealers and a short delivery time. This is a serious problem these days. As opposed to gasoline cars, sales prices stay high and there is no visible "rebate battle" for EVs. For example, the costs for an Opel "Ampera-e" car is higher by 50 % in Switzerland than in the USA. This is not a competitive price. The target customers are still "innovators" and "opinion leaders". These groups only contribute 5 % to the car market share. It will be interesting for the IEA HEV TCP to look at Norway and in this context, the fact that Norway is likely to join our TCP is extremely good news!

Goals for EVs?

"If you have no plan - you plan to fail!" This quote from the Canadian swim star Alex Baumann – his two gold medals in Olympia 1984 nicely indicate that we need plans and goals if we want to reach a goal. Therefore, it is a good sign that we increasingly hear and see goals communicated for the market introduction of pure EVs. This can be a car producer such as Volvo or a country aiming to ban all new internal combustion engine (ICE) cars from its territory. An interesting option is the ban of "dirty cars" under specific air quality conditions. This prevents a buyer of an ICE car, especially with a diesel motor, from the possibility to use the car during certain times. Such prohibitions are a failure of the political system and a sign that the alternative was not introduced at the right time. Finally, it is the customers who will lose money.

To track the topic, I started a list of countries and states that announced plans to ban ICEs (see below). Should some state or country be missing on this list, please contact me via e-mail.

Table 2: The list of countries that announced to ban ICE

Country	Year	Source	Comment
The Netherlands	2025/ 2030	Guardian 18.10.2017	Sales of new vehicles
Germany	2030		Resolution Bundestag 2016
Norway	2025	Guardian 18.10.2017	Stiff reduction…- only sales of EVs after 2030
China	2018	Different	Quote on EVs
China	2018	Different	All new taxis must be BEV
France	2040	Guardian 18.10.2017	Gvt. Announcement – Nicolas

			Hulot, Minister for Ecology
India	2030	Wikipedia	… or only 30 %...?
Ireland	2030	Irishtimes.com	Sales of new vehicles
Taiwan	2035	XhinuaNET	No 2-wheelers
	2040	XhinuaNET	No 4-wheelers
California	2040	Electrive.net	No ICE CARB law
Scotland	2032	Electrive.net	
Cities	**Year**	**Source**	**Comment**
Paris	2030	Diverse	
London	2040	Diverse	
Copenhagen	2019	Businessinside 10/17	Starting in 2019
Vancouver/ Milan/ Quito/ Cape Town/ Auckland		Businessinside 10/17	… large parts by 2030
Balearic Islands (Spain)	2020/ 2030	electrive.net	Annually +10 % EVs for rent = 1000 % in 2030
Producers	**Year**	**Source**	**Comment**
Volvo	2019 onwards		Only electric drives

EVs and PV - Wind Electricity as a Disrupting Technology

As outlined in the Annual Report 2017, the combination of EVs with wind and especially decentralized PV electricity production is very strong. I was very delighted to learn that the Technology Collaboration Programme (TCP) “Photovoltaics (PVPS)” is about to start a new task on “PV and transport”. The initiative comes from the Japanese Government (NEDO), and Professor Hirota from Waseda University (Japan) is the Operating Agent. The four subtasks are:

Subtask 1: Benefits and requirements for PV-powered vehicles

Subtask 2: PV-powered applications for electric systems and infrastructure

Subtask 3: Potential contribution of PV in transport

Subtask 4: Dissemination

I very much appreciated this initiative and look forward to new collaboration potentials!

International Collaboration Leads to Coordinated Action

A smooth introduction of a new technology is in the interest of all countries. But this is difficult. The "old technology" has good networks and the "novelty" must overcome a lot of resistance. Eventually, the customers need to be convinced to buy HEVs, PHVs, EVs or even FCVs. The marketing theory tells us that the move into the "early majority" is like entering a "new world". This transition is called the "chasm", and a new approach is needed to enter the mass market.

Considering the price and the range of electric vehicles, we need a new kind of vehicles. With the new models, e.g., Tesla model 3, Ampera-e (Chevrolet Bolt), Renault Zoe, etc. and ranges of about 400 km and more, we are close to the point. But some prices are still too high, as prices lower than for ICEs should be aimed at. For the car producers, a lot of problems need to be solved, including sales and service concepts. As more of these cars are on the road, new questions will arise, extending towards regulations and tax systems, which are not yet compatible with electric cars.

The Working Groups of the HEV TCP

The above mentioned challenges must be solved on an international level, many of them are currently addressed by the HEV TCP. The practical work in the HEV TCP is carried out in so called "Tasks" that can be initiated by at least two Member countries. By implementing a new funding scheme, we could speed up the time needed to initiate a new Task. Countries can suggest new questions and Tasks and attract collaborators for the topic during Executive Committee (ExCo) Meetings. This procedure allows the IEA HEV TCP to quickly act on the interests of Member countries and their EV experts. It has hence turned out to be highly successful and the IEA HEV TCP now works (in parallel) on many topics (see below). The contact for collaboration with researchers is the Member country expert, which is also a Member of the ExCo in the HEV TCP (address to be found in the address list of the Annual Report).

Current Tasks of the IEA HEV TCP are:

- Task 1: Information Exchange
- Task 23: Light Electric Vehicle Parking and Charging Infrastructure
- Task 26: Wireless Power Transfer for EVs
- 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: EV Consumer Adoption and Use
- Task 37: Extreme Fast Charging
- Task 38: Marine applications (e-Ships)
- Task 39: Interoperability of E-Mobility Services
- Task 40: Critical Raw Material for Electric Vehicles

In 2017, the IEA HEV TCP could also successfully close the following two Tasks:

- Task 25: Plug-in Electric Vehicles
- Task 27: Electrification of Transport Logistic Vehicles (eLogV)

Here, I would like to seize the opportunity and express my thanks to the Operating Agents (OAs) of all Tasks. My thanks also extend to the Members of the Working Groups for their contributions, and to the Member countries which support these Working Groups!

Advantages of Cooperating in the HEV TCP

In a new market, the “market development” approach helps everyone as capacities can be bundled. That is the same for basic research. We can also learn from leaders. To replace ICEs with EVs is a major task and many joint forces are needed. Similar to other fields of technology, the exchange of know-how, components, technologies and cars speeds up the process. These are only some of the reasons for participating in the Hybrid and Electric Vehicles Technology Collaboration Programme (HEV TCP).

Others are:

- Collaborate with researchers from all over the world.
- Use of the best public-sector laboratories in the world.
- Obtaining information on best practice 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 experience among Government officials responsible for automotive research during HEV TCP meetings twice a year.
- Exchange between experts from member countries.

- A well-informed overview of future automotive technology.
- Sharing best practice for implementing alternative-drive vehicle fleets.
- Make a profit from "world-wide best practice".
- Team-up with other countries, lower costs and speed up the process.
- Gain benefits for your industry and country.
- Lower the expenses for research and information gathering by collaboration.

What Else? – Do we see the end of the Work?

Sometimes people may ask: "When do we see the end?" Let me say: It is in the "genes" of us engineers that things can always be better. Only if we can produce a "competitive advantage", we get the money to do the next step. Therefore, EVs will be better in future. Some challenges to be focused on in the future are:

- Raw materials in mass market dimensions.
- Establish profitable recycling processes.
- Build lighter cars and make them more efficient.
- Make cheaper cars.
- Build up the infrastructure.
- Integrate the infrastructure in buildings, parking slots, etc.
- Integrate the electric infrastructure in business models with renewable energies.
- Build up the renewable electricity production for EVs.
- Use the EVs as storage systems in the grid.
- Combination with public transport, if existing.
- Using new possibilities, such as self-driving cars and car sharing.
- Build attractive and safe cars for the consumers all around the world.
- As work progresses, you will always find more things to do!

When do we see the EVs Become Dominant in the Vehicle Market?

Pushing a new technology in an established application sometimes needs more time than expected by the eager pioneer. The German physicist Max Planck said: "A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it"[1].

[1] Source: https://www.brainyquote.com/quotes/max_planck_211830

EVs hence still need a lot of time to take over the whole vehicle market. These thoughts should be integrated into the considerations when planning the next working programme of the next HEV TCP phase.

Management and Collaboration in the HEV TCP 2017

2017 was the second year in office for our secretary Dr. James Miller from the Argonne National Laboratories - ANL, USA. His professional assistance is of great help for everyone in the HEV TCP! He is supported by the Deputy Chairs Carol Burelle (Canada), David Howell (USA), and Ock Taeck Lim (South Korea). The Executive Committee is seconded by two Committees for “strategic planning” and “external relations”. Here, we can especially count on Julie Perez Francis (USA) who coordinates the work in the strategic planning group in the quality rating of the task works.

The two ExCo meetings in 2017 were held in Beijing (China) and in Vienna (Austria). The meeting in Beijing in April 2017 was perfectly organized by Mrs. Jun Li and the China Automotive Technology and Research Center CATARC. We got a first impression about the efforts of the Chinese Automotive Industry in the field of electric mobility. We hope that this first meeting will be the start of a fruitful collaboration. Many thanks to our host and to all CATARC specialists!

The fall meeting in Vienna was also perfectly organized by Astrid Wolfbeisser and the ExCo Member Andreas Dorda from the Bundesministerium für Verkehr, Innovation und Technologie - bmvit. The Austrian specialists are a long-term stable backbone of our HEV TCP work. We could use the location for collaboration with the AMV TCP and other IEA initiatives. Again, many thanks to our host and to all Austrian specialists!

My compliment goes to the Operating Agents running their Tasks and all the collaborators in the tasks. Bringing up a new topic and start a Task is a sophisticated piece of work and a lot of patience and much effort is needed to bring the Task to a successful end. It is always a pleasure to encourage and support these professionals from all over the world!

My sincerest thanks also go to the Department of Energy (DOE), which continued to support the IEA HEV TCP in 2017 and financing the service of the secretary James F. Miller and Julie Perez Francis. I also highly appreciate the efforts of VDI/VDE-IT and of all the people in the team of Gereon Meyer, specifically the management of Task 1, the production of the annual report and the website management (www.ieahev.org).

My final thanks go to the Swiss Federal Office for Energy SFOE, which sent me to the first meeting for a TCP on “electric vehicles” in Stockholm in 1992, and which has since then and over the long period of over 32 years supported me, starting with a first brochure on "Elektrofahrzeuge" in 1986!

Who Should do all This Work? – No Worries – The Young Folks Will Take Over!

People are often stressed by all the challenges we see in technology and society. In Switzerland, the Government decided to treat renewable sources of energy in 2050 as a priority. This "Energy Strategy 2050" aims at phasing out all nuclear power plants (>20 % of the electricity production in Switzerland today) and at producing more than 20 TWh electricity from new renewable energies, mainly "photovoltaics". The Swiss people agreed on this Strategy in a referendum in summer 2017.

While most Swiss politicians will not be active in professional life anymore in 2050, the next generation (e.g., all my students, which I teach), will still be working at that time. They are the ones who will do all this work! They are well trained, motivated and will tackle the challenges with effort. So, my message to all the concerned citizens and doubting voices is always: "Relax! You must not do all this work! My students and their colleagues around the world will take over!"

A new technology needs a lot of trained specialists, from research to development, sales and after sales activities, etc. The future specialists are the next generation engineers and professionals from both sexes that we train today! We, therefore, need to ensure that we educate enough young folks and hand over the responsibility to them at the right time. How can the IEA HEV TCP steer activities towards these avenues? Our "student exchange" programme needs a new start!

That is what I will do from now on. My time as the Chair of the IEA HEV TCP will end in fall 2018. It has been my great pleasure to push electric mobility forward on the global roads and worldwide agenda, jointly with all the other ExCo Members, Operating Agents and desk officers from the IEA headquarter. – Not to forget all the taxpayers, from which we obtain the budgets and always need to fight for a surplus.

Professor Urs Muntwyler, HEV TCP Chairman, Burgdorf, Switzerland

Figure 1: Chairman IEA HEV TCP - Professor Urs Muntwyler

Mr. Urs Muntwyler
Professor for Photovoltaic/ Berne University of Applied Sciences BUAS
Burgdorf
Switzerland
urs.muntwyler@bfh.ch

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 – 2017			
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).

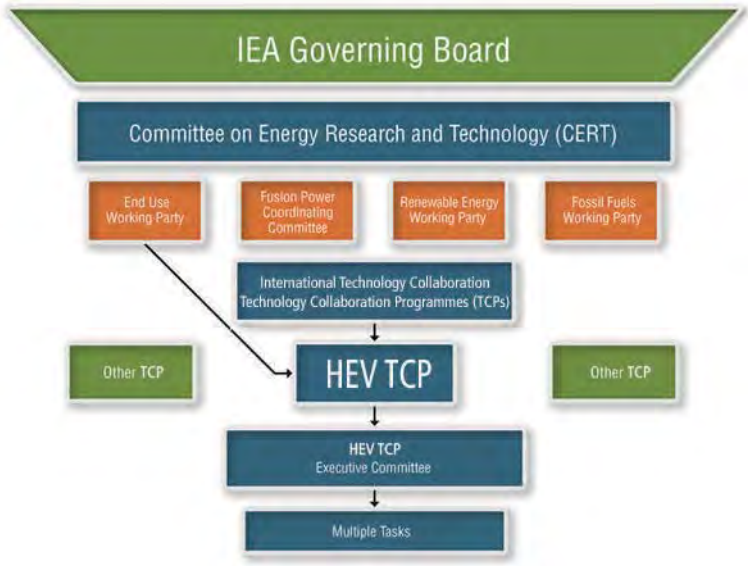


Figure 1: The IEA energy technology network[2]

2.1.3 IEA Technology Collaboration Programmes

The IEA also provides a legal framework for international collaborative energy technology RD&D (research, development, and deployment) groups, through multilateral technology initiatives known as Technology Collaboration Programmes (TCPs). A TCP may be created at any time, provided that at least two IEA members agree to work on it together. There are currently 40 TCPs covering fossil fuels, renewable energy, efficient energy use (in buildings, energy, and transport), fusion power, electric power technologies, and technology assessment methodologies. One of these TCPs is the Technology Collaboration Programme for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV TCP). HEV TCP reports to the Working Party on Energy End-Use Technologies (EUWP). An overview of the the activities and recent accomplishments of TCPs is available on the IEA web site[3].

IEA TCPs are at the core of the IEA's international energy technology network. This network embraces numerous other activities that enable policy makers and experts from IEA-member and non-member countries to share views and experience on energy technology issues. Through published studies and

[2] From 2015, the IEA is rebranding the IAs as Technology Collaboration Programmes - TCPs. Accordingly, IA-HEV was recently renamed to HEV TCP.

[3] http://www.iea.org/publications/freepublications/publication/technology-collaboration-programmes.html

workshops, these activities are designed to enhance policy approaches, improve the effectiveness of research programmes and reduce costs.

Over three decades of experience have shown that the TCPs contribute significantly to achieving faster technological progress and innovation at lower cost. Such international co-operation helps to eliminate technological risks and duplication of effort while facilitating processes, like harmonization of standards. Special provisions are applied to protect intellectual property rights.

The “IEA Framework for International Energy Technology Co-operation” defines the minimum set of rights and obligations of participants in IEA TCPs. Participants are welcomed from OECD member and OECD non-member countries, from the private sector, and from international organisations.

Participants in TCPs fall into two categories: Contracting Parties and Sponsors. This issue is defined in Article 3 of the framework:

- **Contracting Parties** may be governments of OECD member countries and OECD non-member countries (or entities nominated by them). They can also be international organisations in which governments of OECD member and/or OECD non-member countries participate, such as the European communities. Contracting Parties from OECD non-member countries or international organizations are not entitled to more rights or benefits than Contracting Parties from OECD member countries.
- **Sponsors**, notably from the private sector, may be entities of either OECD member or OECD non-member countries that have not been designated by their governments. The rights or benefits of a sponsor cannot exceed those of Contracting Parties designated by governments of OECD non-member countries, and a sponsor may not become a chair or vice-chair of a TCP.

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

The TCP mechanism is flexible and accommodates various forms of energy technology co-operation among participants. It can be applied at every stage in the energy technology cycle, from research, development, and demonstration through validation of technical, environmental, and economic performance and on to final market deployment. Some TCPs focus solely on information exchange and dissemination. The benefits of international co-operation on energy technologies in TCPs are shown in Table 2.

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

Benefits of International Energy Technology Co-operation through IEA Technology Collaboration Programmes
• Shared costs and pooled technical resources
• Avoided duplication of effort and repetition of errors
• Harmonized technical standards
• An effective network of researchers
• Stronger national R&D capabilities
• Accelerated technology development and deployment
• Better dissemination of information
• Easier technical consensus
• Boosted trade and exports

Financing arrangements for international co-operation through TCPs are the responsibility of each TCP. The types of TCP financing fall into three broad categories:

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

Effective dissemination of results and findings is an essential part of the mandate of each TCP. Wide-ranging products and results are communicated by various means to those who can use them in their daily work. The IEA Secretariat circulates the online OPEN Energy Technology Bulletin, which reports on activities of the TCPs. HEV TCP activities are regularly highlighted in the OPEN Bulletin. The IEA also issues the "Energy Technology Perspectives," or ETP, which is an annual publication that presents updates on roadmaps for the technologies addressed by TCPs. The ETP has been published since 2006 and, most recently, in May 2014. These reports can be downloaded for a fee at www.iea.org/etp.

In March 2008, the vice chairman for transport of the EUWP started a new initiative by organising a Transport Contact Group (TCG) workshop for the transport-related TCPs, with the objective of strengthening their collaboration. HEV TCP actively participates in the Transport Contact Group.

2.2 Technology Collaboration Programme on Hybrid and Electric Vehicles

Very few IEA countries do not have issues with urban air quality, and a few others are self-sufficient in oil, but all IEA countries have problems with greenhouse gas emissions from automobiles and other vehicles. Today there exists a range of technologies available to address these problems - most notably hybrid and electric vehicles. A sound basis therefore exists for an IEA TCP dedicated to developing and deploying these vehicles.

The IEA Technology Collaboration Programme for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV TCP) was created in 1993 to collaborate on pre competitive research and to produce and disseminate information. HEV TCP is now in its fifth five-year term of operation that runs from March 2015 until March 2020. The 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 2017, the ExCo approved the start of three new Tasks:

- Task 38 “Marine applications (E-Ships)” (in October 2017)
- Task 39 “Interoperability of E-mobility Services” (from 2018)
- Task 40 “Critical Raw Material for Electric Vehicles (CRM4EV)” (from 2018)

During 2017 the Task 27 “Electrification of transport logistic vehicles (eLogV)”and Task 25 ”Plug-in Electric Vehicles” completed.

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 (Task 29) • 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. 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. Governments currently active in the EVI include Canada, Chile, the People’s Republic of China (“China”), Finland, France, Germany, India, Japan, Mexico, Netherlands, New Zealand, Norway, Sweden, United Kingdom, and United States. This group includes the largest and most rapidly growing EV markets worldwide and accounted for the vast majority of global EV sales in 2017. Canada and China are the co-leads of the initiative. The International Energy Agency serves as the EVI co-ordinator.

For the development of EVI activities, the IEA secretariat co-operates with the IEA Technology Collaboration Programmes on Advanced Fuel Cells (AFC) and Hybrid and Electric Vehicle Technologies and Programmes (HEV). Other partners include: Argonne National Laboratory (ANL); C40; ClimateWorks Australia; ClimateWorks Foundation; Electrification Coalition; European Association for Electromobility (AVERE); Forum for Reforms, Entrepreneurship and Sustainability (FORES) in Sweden; Global Environment Facility; GreenTech Malaysia; International Council for Clean Transportation (which hosts the secretariat of the International Zero-Emission Vehicle Alliance); International Electrotechnical Commission (IEC); International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE); International Renewable Energy Agency (IRENA); Hewlett Foundation; King Mongkut's University of Technology Thonburi (Thailand); Lawrence Berkeley National Laboratory; Mission 2020; Natural Resources Defence Council (NRDC); National Renewable Energy Laboratory (NREL) of the United States; Nordic Energy Research; Partnership on Sustainable, Low Carbon Transport (SloCaT); REN21; Rocky Mountain Institute (RMI); Swedish Energy Agency; The Climate Group; the United Nations Environment (UN Environment); the United Nations Human Settlements Programme (UN Habitat); the United Nations Industrial Development Organization (UNIDO); World Resources Institute (WRI) and Urban Foresight.

To date, the EVI has developed analytical outputs that include several editions of the Global EV Outlook (2013, 2015, 2016, 2017 and 2018), the Nordic EV Outlook 2018 and two editions of the EV City Casebook, with a focus on initiatives taking place at a local level.

The EVI has also successfully engaged private sector stakeholders in roundtables in Paris in 2010, in Stuttgart in 2012, and at COP21 in Paris in 2015 and COP22 in Marrakesh in 2016 to discuss the roles of industry and government in EV development as well as the opportunities and challenges ahead for EVs.

The EV30@30 campaign, launched at the Eighth Clean Energy Ministerial in 2017, redefined the EVI ambition by setting the collective aspirational goal for all EVI members of a 30% market share for electric vehicles in the total of all vehicles (except two-wheelers) by 2030. The campaign includes several implementing actions to help achieve the goal in accordance with the priorities and programmes of each EVI country. These actions include:

- Supporting the deployment of EV chargers and tracking progress.
- Galvanising public and private sector commitments for EV uptake in company and supplier fleets.
- Scaling up policy research, including policy efficacy analysis, information and experience sharing and capacity building.
- Supporting governments in need of policy and technical assistance through training and capacity building.
- Establishing the Global EV Pilot City Programme, a global co-operative programme that aims to facilitate the exchange of experiences and the replication of best practices for the promotion of EVs in cities.

In 2017, the HEV TCP and the EVI worked together on the collection of data. This allows 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 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 2017 included the following:

- Task 1 Information Exchange meetings were held in Beijing, China, in April 2017, and in Vienna, Austria, in November 2017.
- The HEV TCP annual report on 2016 entitled Hybrid and Electric Vehicles – The Electric Drive Chauffeurs was published in 2017. Postcards with the cover page and the download link for the report were provided to all participants of the EVS-30 Conference in Stuttgart (Germany)
- A panel discussion involving HEV TCP Task leaders was held at the EVS-30 Conference in Stuttgart (Germany)

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:

Mr. Gereon Meyer
VDI/VDE Innovation + Technik GmbH
Steinplatz 1
10623 Berlin
Germany
Tel: +49 30 310078-134
E-Mail: Gereon.Meyer@vdivde-it.de

4 Light-Electric-Vehicle Parking & Charging Infrastructure (Task 23)

Members: Spain, Germany, Belgium, Turkey

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.

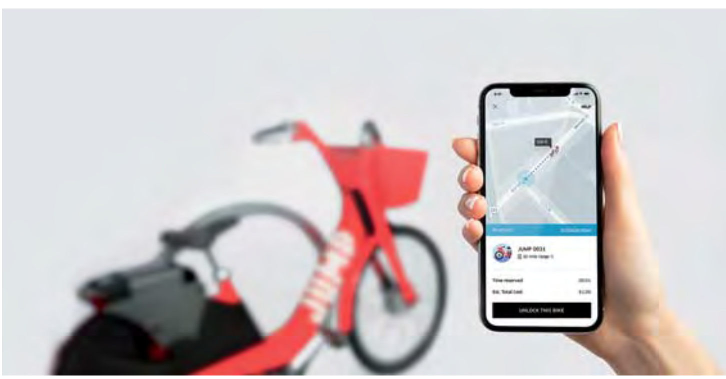


Figure 1: The Bicycle Sharing Fleet which has reached probably close to 20 Million units globally in 2018 is turning electric. The market leaders from China like Mobike and OFO as well as US and European companies rush into this area. The ride hailing company Uber has recently acquired Jump Bikes and added the option to take a Jump bike ride to their popular Uber app. By 2019 the global fleet of LEVs in sharing services will probably reach 5+ Million units worldwide and is growing fast (Source: Uber)

Figure 2: Dockless stand up scooter systems have flooded many US cities with electric scooters which can be on one hand considered as a success since it proves that Light Electric Mobility can replace car journeys in many cases. But on the other hand the regulatory frameworks of the cities have been proven to not at all be prepared for such a flood of "free floating" sharing vehicles (Source: 6abc channel screenshot)

Figure 3: Police report on scooter parking issues in Venice CA. Well summarized wild west situation by San Francisco City Supervisor Aaron Peskin, who was quoted in Wired magazine recently: "I really want to send a message not only to these scooters [...] It would be very nice if the tech bros could come in and ask in a collaborative fashion for permission rather than after the fact forgiveness."

4.2 Objectives

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), the IEC SC23h is defining the connectors used for the future parking and charging infrastructure. Since May 2016 Task 23 is active in the ISO 4210-10 which for the first time is defining the Pedelec internationally within a harmonized standardization body. The key activity here 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 equal 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 setting the lead globally followed by the ISO 18243, referencing as well 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, but it will become mandatory by law, enabling easy infrastructure interconnection down the road.

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.

Figure 4: Many fatalities caused by LEV battery fires have led to a rigorous policy in China banning charging of Lithium Batteries inside buildings. New Regulations created a huge demand in public charging solutions for all kinds of LEVs in China (Source: China Police)

4.2.1 Target a Blueprint for Public Tenders for LEV Infrastructure

After the complete publication of the IEC TS 61851-3-1/7 (unfortunately due to activities led by Japanese Experts delayed again to potentially 2019) 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 problem effectively. 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 to deploy strict regulations early.

Figure 5: The IEC standardized Socket which will be used around the world by all kinds of privately owned as well as by shared LEVs and bicycles to park them in accordance to public interests regulated by non-moving traffic management regulations (Source: EnergyBus)

4.2.2 Creating Events for Information Exchange on LEV Infrastructure

Task 23 has been 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.

4.2.3 Best Practice Sharing Study Trips

Gathering experts at locations where local governments have established successful LEV infrastructure systems and sharing findings and summarizing the positive and negative experiences – distilling the findings into easy-to-follow recommendations was in Task 23 scope of work. 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, Netherlands, Germany, and Austria for best practice sharing visits. In 2018, an internationalization of the participation in the ISO 4210-10 work was promoted by bringing members of other countries on board which participated in meetings in Japan and US and scheduled later in 2018 for another meeting in France.

4.2.4 Publications With Recommendations on LEV Infrastructure

Creating publications summarizing key findings and listing recommendations on how to establish the most suitable LEV infrastructure. Several lectures have been hold during 2017 and 2018 about Task 23 activities.

4.2.5 Promoting the Needs to Potential Suppliers

Task 23 was making joint presentations at relevant trade shows and conferences, explaining the use of suitable methods, the requirements for local governments, potential manufacturers and providers of LEV infrastructure and rental vehicles.

Within 2017 and 2018 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 in 2015 (Source: IAA)

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 Members and Potential Members

It started with Antwerp (Belgium) and Barcelona (Spain), followed by Istanbul (Turkey), and talks about active involvement in Task 23 have subsequently been conducted with various local governments and stakeholders from around the world. To name just a few: Malta, the DIFU Institute representing most German cities, Karlskrona and Växjö (Sweden), Hangzhou, Chengdu, Deyang (China), Taichung City (Taiwan), Kyoto and Osaka City (Japan), Copenhagen (Denmark), Warsaw (Poland), Graz & Bregenz (Austria), Indonesia, Delhi (India), Munich, Frankfurt, Cologne, Münster, Rostock, Hannover, Berlin, Merseburg, Tegernsee (Germany), Grenoble (France) – and these are just the most significant talks. To date, the active phase including the preparation of the blueprints for tenders to acquire LEV infrastructure has not yet started. It is expected to happen during Summer 2018.

4.3 Results

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

The publication of the EN 50604-1 in 2016 was a major milestone and the finalization of the Connector Standard by the IEC SC23h group in 2017 too. By 2018 the long-postponed 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 was finalized. Standards secure safe and interoperable technical ecosystems.

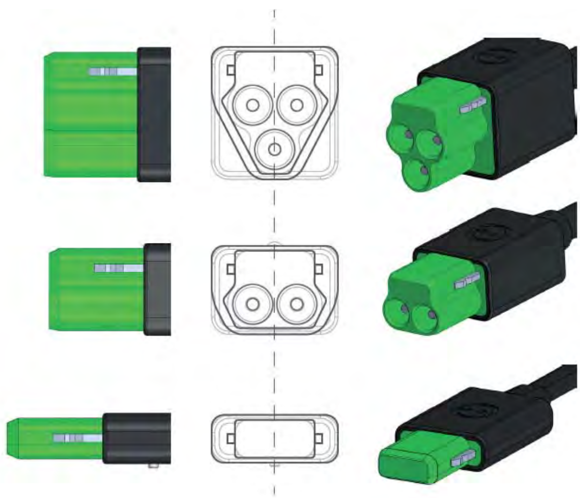


Figure 7: The 3 versions of the IEC connectors for public charging of LEVs all fitting into the same sockets to be installed in public and semi-public locations. The 3 Pin connector version is meant for larger motor scooters or LEVs – this connector can handle up to 7.2 kw charge current at voltages up to 120 V DC. The 2 pin connector will be probably the most popular with power limited to 3,6 kw charge current and a maximum voltage of 60 V DC. The 0 Pin connector could be used for non electric cycles which do use bicycle parking facilities (Source: Atelier Papenfuss)

4.4 The Charge & Lock Solution for Many Urban Issues

The Copenhagen Gobike 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 the years 2011 and 2013, the first functional version of the EnergyLock was trialed in the Tegernsee region, Germany. The idea was proven to work. But a clear finding was that the locking system, based around a heavy duty locking mechanism and steel-reinforced cable, was considered as too heavy by users. This necessitated a complete reconsideration of the anti-theft concept. As a result, the mechanical safety layer was downgraded to a mild level, whereby the locking action is just good enough not to be unlocked easily by manual force, but it will pop open before it is damaged when pulled strongly. The anti-theft function is moved to the digital realm, in that all electronic components on the pedelec will deactivate themselves in the event of unauthorized disconnection. This would make removing a vehicle that has fully implemented this safety strategy very unattractive for thiefs. On 18 March 2015, the next generation of the charge & lock cable was presented for the first time to the public 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.

4.5 Next Steps

Task 23 would likte to do 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. Beside the focus on standardization in 2019, Task 23will be mainly focused on pilot applications in China at the City of Deyang in the Sichuan province.

A political activity, started in July 2018, is the Petition trying to initiate a change of the UN vehicle definition which was defined 50 years ago in Vienna. The target is

to redefine the cycle to safely include the electric assisted cycle as well as new kinds of micro mobility. The proposed definition is based on the IEA HEV Task 11 Results presented in 2012.
Link to the petition: https://www.openpetition.de/petition/online/pedelecs-e-bikes-sollen-dem-fahrrad-gleichgestellt-werden.

4.6 Contact Details of the Operating Agent

For further information, please contact the Task 23 OA and co-OA:

Hannes Neupert (Operating Agent)
EnergyBus e.V. / EnergyBus Operations GmbH
Koskauer Str. 100
07922 Tanna
Germany
E-mail: hannes.neupert@EnergyBus.org

Carlo Mol (co-Operating Agent)
VITO – Vlaamse Instelling voor Technologisch Onderzoek
Boeretang 200
2400 Mol
Belgium
E-Mail: carlo.mol@vito.be

5 Plug-in Electric Vehicles (Task 25)

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

5.1 Introduction

The cost competitiveness of different drivetrains depends on relative costs of vehicles, fuel, and other cost components. The tasks considers costs from the perspective of a consumer with sufficient foresight to consider relevant costs over the ownership period of the vehicle, or relevant cost of ownership (RCO), as suggested by Mock [1] and used by Redelbach et al. [2] and Rousseau et al. [3]. We examine how the RCO of PEVs compares to competing powertrains under various combinations of fuel consumption, annual driving distance, battery costs, and other factors that can vary significantly between different drivers in different countries. We examine ranges of these factors relevant to drivers in the United States and Germany using estimated future costs of vehicles and fuels.

To the extent that consumers choose vehicles on the basis of ownership costs, how fuel consumption is measured and reported are important. European and U. S. regulators have made or proposed updated fuel economy certification procedures to provide fuel economy estimates that are more representative of real world driving [4, 5]. Fuel economy values reported by U. S. drivers vary over a wide range [6]. Of potentially greater significance to the consumer considering a PEV purchase are vehicle prices and energy costs over the vehicle ownership period. PEV prices are driven by component costs, in particular the cost of the battery pack, but energy costs depend on fuel price and annual driving distance. For plug-in hybrid electric vehicles (PHEVs) and extended range electric vehicles (EREVs), fuel costs also depend on the utility factor (UF) - the fraction of distance driven in charge-depleting (CD) mode - which can differ widely between drivers owing to different charging frequencies and driving distances.

5.2 Objectives

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

Objectives associated with vehicle energy consumption are:

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

Objectives associated with Component Cost, Vehicle Cost 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 the same set of inputs.
- Using consistent methodologies, evaluate potential causes of increase in market(s) size, such as rising oil prices, lower battery pack costs, economical infrastructure adaption, changes of consumer perception.
- Evaluate policy alternatives to increase market(s) size.
- Taxes at initial purchase, annual fees, fuel/electricity tax.
- Subsidy structures and quantities.

5.3 Working Method

Vehicle Attributes

To evaluate the fuel efficiency benefits of advanced vehicles, each vehicle was simulated using Autonomie [7]. Each vehicle component powertrain is sized to meet similar vehicle technical specifications such as performance and grade-ability [8]. The energy efficiency was then estimated for the different vehicles over the Worldwide harmonized Light vehicles Test Cycle (WLTC) and the U. S. combined cycle. Conventional and plug-in midsize vehicles were simulated through six different timeframes (2020–2050) for gasoline and diesel fuels. The attributes of future vehicles were taken from Moawad et al. [8]. We focused on four different powertrains (conventional; split PHEV [PHEV20]; EREV [PHEV40]; and Battery Electric Vehicles [BEV100, BEV200 and BEV300]). The split PHEV was modelled with one electric motor and a power-split design, and the EREV was modelled with two electric motors and a powertrain similar to the Voltec design [21].

We assumed technology advancement based on the U. S. Department of Energy (DOE) Vehicle Technology Office research and development goals. Further details on the simulations can be found in Moawad et al. [8].

The above vehicles were simulated in Autonomie under the Worldwide harmonized Light vehicles Test Procedure (WLTP), U. S. Urban Dynamometer Driving Schedule (UDDS), and U. S. Highway Fuel Economy test (HWFET) drive cycles, using the same road load coefficients for all cycles. Adjustments were applied to the UDDS and HWEFT drive cycle fuel consumption values in accordance with the U. S. current fuel economy label procedures [4].

To estimate the UF (the fraction of distance driven in CD mode), the daily driving distance was assumed to follow a gamma distribution, which was found to fit detailed driving records from Seattle by Lin et al. [17]. A mean of 61.8 km/day and a mode of 20.6 km/day was assumed for U. S. drivers, based on an analysis of the U. S. 2009 National Household Travel Survey by Krumm [9]. This distribution gave a dependence of UF on the PHEV CD range that approximated the CD range dependence used in the standard practice recommended by SAE International for PHEVs that are charged once per day [10]. This distribution may not be accurate for other populations [11], but it captures the qualitative shape of realistic driving distributions and provides a convenient way to approximate how PHEV UF depends on daily average driving distance [12]. The mean distance was varied to account for different annual driving distances, and the mode was assumed to vary in proportion to the mean. A constant value of 300 driving days per year was assumed. PHEV drivers were assumed to charge once per day.

We estimated the ownership costs under different assumptions to represent U. S. and German consumers. Combinations of the following parameters were evaluated that make PEVs cost-competitive with competing (conventionally powered) vehicles:

- The fuel and electricity consumption as estimated by WLTP and U. S. adjusted drive cycles;
- The future vehicle prices, estimated for year 2025;
- A range of potential future battery cost estimates;

- The fuel prices (reflecting ranges of possible prices in the U. S. and Germany);
- The annual driving distance (ranges representative of U. S. and German drivers).

Cost Calculations

The vehicle costs are calculated from the characteristics of the components (power, energy, weight, etc.) [8]. Both the vehicle and fuel cost, based on the energy efficiency values, are then used to calculate ownership cost. Maintenance costs for year 2025 were assumed to be 0.05 USD_{2015}/km for all powertrain types. This value was in the middle of the range suggested by Rousseau et al. [3].

The assumptions shown in Table 1 are used to represent the near-term (year 2025) average prices of energy in Europe (Germany) and the United States and were assumed to be constant in future years. Constant electricity prices were assumed, neglecting alternative rate structures such as time-of-use, tiered rates, or special rates for PEVs.

Energy prices and average annual distance driven in the United States were based on the U.S. Energy Information Agency's Annual Energy Outlook (AEO) for 2017 reference case. Energy prices for Germany were estimated for the year 2025 based on the projected price of crude oil (Brent Spot price of 85.03 USD_{2015}/barrel). High and low energy prices were based on AEO 2017 High Oil Price and Low Oil Price cases. Annual distance driven in new light duty vehicles (LDVs) by U. S. drivers were taken from AEO 2016 reference case. The mileage for German drivers is taken from the latest national transport survey [20].

Table 1: Energy cost assumptions for 2025

Zone	Distance travelled (km/year)	Annual discount rate (%)	Vehicle life (years)	Gasoline price (USD_{2015}/liter)	Diesel price (USD_{2015}/liter)	Electricity price (USD_{2015}/kWh)
Germany	14,000	5	12	1.522	1.482	0.397
United States	22,530	5	12	0.677	0.727	0.116

Cost models were used to estimate manufacturing costs for major vehicle components and subassemblies, which were then summed to give the total manufacturing cost of each vehicle in year 2025 [8]. These manufacturing cost estimates were assumed to be the same for both American and European automakers (Table 2). Cost model parameters were assigned values based on input from U. S. DOE vehicle technology managers and industry experts who provided a range of values from highly optimistic (high case) to pessimistic (low case).

Table 2: Estimated future manufacturing cost

Year	Optimism of cost estimate	Glider cost (USD2015)	Battery pack cost (USD2015/kWh)			
			PHEV 20	PHEV 30	BEV100	BEV200 and BEV300
2025	Low	10,509	500	450	325	325
	Medium	11,319	400	375	250	250
	High	11,631	315	290	170	170

The RCO was calculated from vehicle prices and other costs [3]:

$$C_{RCO} = C_{Invest} + \sum_t^N \left(\frac{(C_{Energy,t}+C_{Main,t}+C_{Fees,t}}{(1+r)^t}\right) - \frac{V_{Res}}{(1+r)^N}$$
$$V_{res} = C_{Invest}(1 - 15 \times 10^{-7} \times N \times VKT - 0.476)$$

Where N = ownership period (years)

r = discount rate (%)

VKT = annual vehicle kilometers travelled.

Investment costs include the vehicle manufacturing direct costs, manufacturer mark-up (accounted for by a retail price equivalent [RPE] factor), sales tax or value-added tax, both applied to the retail price, incentive (or bonus/malus premium/charge), and initial registration/licensing fees or taxes. For the BEV in the United States, the cost of home electric vehicle service equipment (EVSE) is also included in the investment cost. Given the capacity of BEVs, charging times using only a Level 1 charger do not meet the requirements of most consumers: a recent survey of California drivers found that only 12 % of Nissan Leaf owners did not have Level 2 EVSE at home [13]. Because of the higher voltage level (240 V) in Europe, EVSE costs are not considered for Germany.

Residual values after a service time of 10 years were calculated using regression equations developed by Pröpfe et al. [18] for each powertrain type. These equations were developed from European vehicle sales data and may not accurately model resale values in the United States. Resale values are uncertain, particularly for PEVs, since the used PEV market is very immature. Residual values were estimated as a fraction of the total investment cost rather than purchase price, since the investment cost was assumed to approximate more closely the transaction cost as it includes incentives and fees, and since evidence suggests that incentives decrease residual values [19]. A residual value of zero was assumed after a service time of twelve years or a total distance travelled higher than 338,000 kilometers.

$$C_{Invest} = (C_{Manuf})(F_{RPE})(1 + Tax_{Sales}) - (C_{Incentives} + C_{Fee,init} + C_{Batt\,repl} + C_{Home\,EVSE})$$

where C_{Invest} = Total investment (upfront) cost

C_{Manuf} = Manufacturing cost

F_{RPE} = Retail price equivalent or mark-up factor = 1.5 [14]

$C_{Incentives}$ = Feebate (bonus/penalties) or incentive, see Table 3. Incentives are shown as positive if they decrease the cost and negative if they increase the cost.

$C_{Fee,\,init}$ = Fees payable upon vehicle purchase see Table 3

Tax_{Sales} = State sales tax

$C_{Batt\,repl}$ = Battery replacement (PHEV and BEV); we assumed no battery replacement in this paper.

$C_{Home\,EVSE}$ = Average cost of installing Level 2 EVSE [15]

The incentives have a high impact on the RCO and are geographically dependent. In the United States, we considered only the federal subsidies (tax credits) for plug-ins, which depend on the battery total rated capacity in kWh as follows: 2,500 U. S. dollars (USD) for each PEV with at least 5 kWh total battery capacity, plus 417 USD for each kWh in excess of 5 kWh, up to a maximum of 7,500 USD. We treat these values as 2015 USD. In reality, the subsidy decreases for each automaker after the automaker sells more than 200,000 PEVs, which was neglected in this study. In Germany, the subsidies are 3,000 EUR for each PHEV and 4,000 EUR for each BEV [16]. Using a conversion factor of one EUR to 1.0598 USD results in 3,179 USD for each PHEV and 4,239 USD for each BEV. These values are also treated as 2015 USD.

We evaluated sensitivities to assumptions by examining ranges of fuel prices, battery costs, and annual distance travelled. From these results, we examined which factors are most important in the United States and Germany for cost of ownership of PHEVs and BEVs, and under what combination of conditions PHEVs and BEVs are cost-competitive with other drivetrains.

Table 3: Values for initial fees, incentives, and EVSE for year 2025 in USD_{2015}

Area	Incentives, Costs, and Fees	Conventional Spark Ignition	Conventional Compression Ignition	PHEV	BEV
Germany	Incentives	0	0	3,179	4,239
	Initial fee	22	22	22	22
	Motor tax (USD_{2015}, period average)	29	121	0	0
	EVSE cost	0	0	0	0
	Maintenance (USD_{2015}/km)	0.06	0.06	0.06	0.05
U.S. federal	Incentives	0	0	> 2,500	> 2,500
	Initial fee	186	186	186	186
	EVSE cost	0	0	0	1,204
	Maintenance (USD_{2015}/km)	0.05	0.05	0.05	0.05

5.4 Results

To be concise, this report primarily focuses on ownership costs of a 2025 midsize car for average advanced technology and medium optimism cost estimates (cf. Table 2). In addition, we assumed a period of 10 years of ownership and that the customer is not going to change the battery pack during this period. The energy prices applied are displayed in Table 1. The incentives applied, EVSE installation cost, and other ownership fees are displayed in Table 1 according to the geographic area. Glider costs were assumed to be the same for the United States and Europe but vary by year (cf. Table 2). We also assumed that after the battery guaranty period (eight years or 160,000 km travelled), the total energy capacity of the battery pack decreases by 4 % each year.

Energy Consumption

Fuel and electricity (energy) consumption by different powertrains (conventional, PHEV, and BEV) are compared in Figure 1. One can notice that the U. S. cycle, even though it is less aggressive than the WLTC, leads to higher vehicle energy consumption, especially for electrified vehicles, because of its real-world adjustment factor. The right-hand axis of Figure 1 shows the relative difference in energy consumption in the U. S. combined cycle vs. the WLTC by each vehicle type.

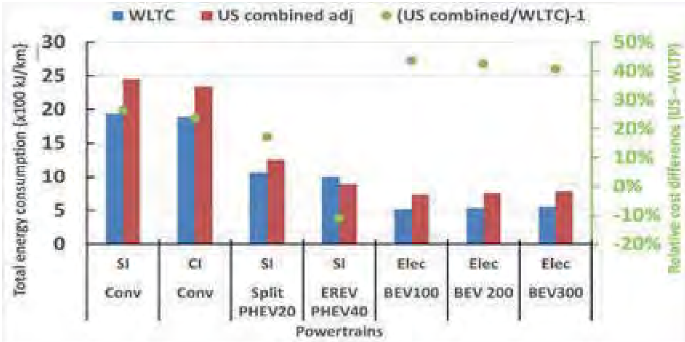


Figure 1: Energy consumption comparison by powertrain and driving cycle

Energy Costs

Figure 2 shows the cost metric in Europe (using the WLTC as reference) and in the United States (with the U. S. combined adjusted cycle as reference). Mainly because of higher European energy prices (cf. Table 1), the cost of the energy per kilometer travelled is higher in Europe than in the United States.

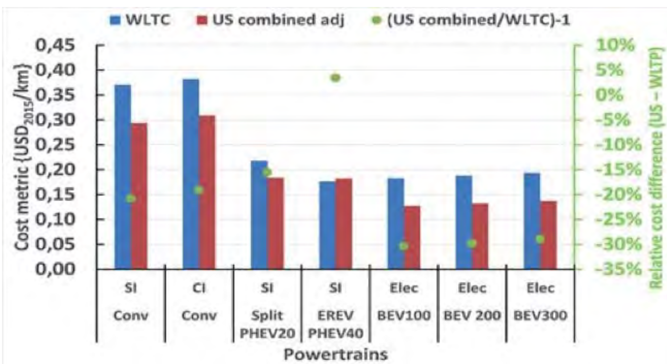


Figure 2: Cost metric comparison by powertrain and driving cycle

To properly compare the overall cost of ownership between the United States and Germany, we need to include the manufacturing cost, the maintenance cost over the years, taxes, and fees. These are shown in Figure 3 for Germany and Figure 4 for the United States. Negative costs (incentives) are shown below the axis and the total resulting RCO is shown as a filled, red circle.

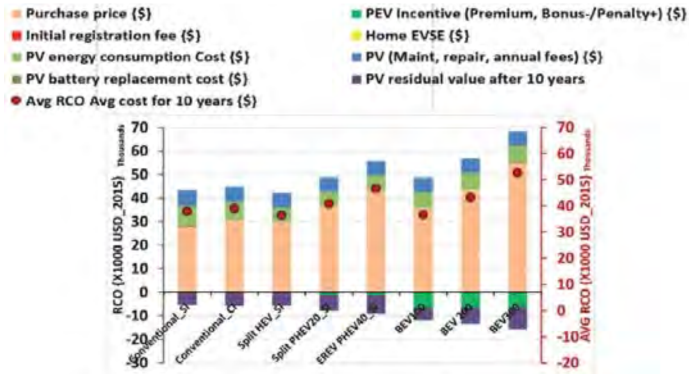


Figure 3: RCO comparison between powertrains for 10 years of ownership in Germany using the WLTC as reference

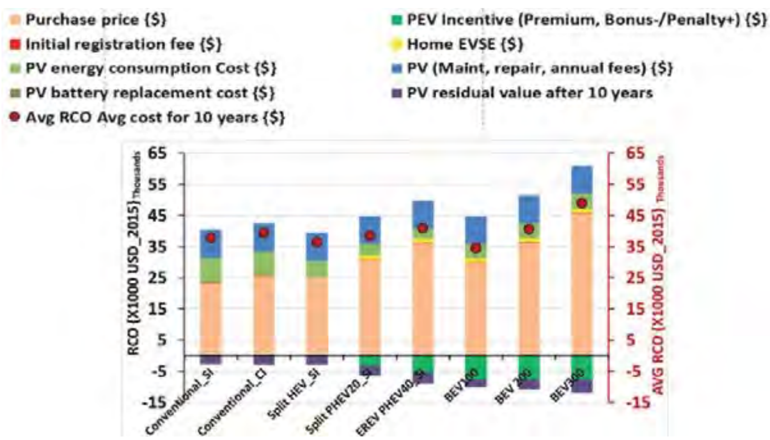


Figure 4: RCO comparison between powertrains for 10 years of ownership in the United States using the U.S. combined adjusted driving cycle as reference

For an ownership period of 10 years, only the BEV100 in both Germany and the United States seems to be cost competitive with conventionally powered cars when using the current market price as reference (cf. Figures. 3 and 4). However, as shown in Figure 5, even though the U. S. driving cycle leads to higher energy consumption for electrified vehicles compared to the WLTC, fuel savings by PEVs are higher in Germany than in the United States, because of the high price of fuel.

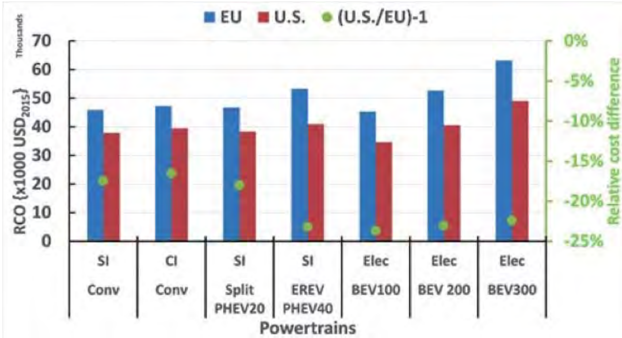


Figure 5: RCO comparison between the United States and Germany for 10 years of ownership

5.4.1 Impacts of Other Factors

We evaluated the effect of different factors on the competitiveness of PEVs on the U. S. and German markets.

Manufacturing Cost

The battery manufacturing cost has a direct impact on the selling price of the vehicle and hence on the customer purchase decision. The heat maps below (Tables 4 and 5) display the RCO by powertrain for a range of manufacturing battery costs. The color of each cell in the table indicates whether the RCO is higher (red) or lower (green) in comparison to the others. Values in Tables 4 and 5 are based on the annual distance, discount rate, and fuel prices shown in Table 1. Tables 4 and 5 show that the PEVs become more competitive as the battery cost decreases. For instance, the BEV300 becomes even more economical in the United States than conventional vehicles at 100 USD_{2015}/kWh or less, for an ownership period of 10 years.

Table 4: RCO by battery cost and powertrain for 10 years of ownership in the United States using the U.S. combined adjusted driving cycle as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec
Battery costs (USD_2015/kWh)	400	37,841	39,467	38,279	41,523	39,643	49,002	62,414
	300	37,841	39,467	36,876	38,949	36,270	43,355	53,472
	200	37,841	39,467	35,474	36,376	32,896	37,708	44,530
	100	37,841	39,467	34,873	34,378	29,523	32,061	35,588
	50	37,841	39,467	34,873	34,378	27,836	29,238	31,117

Table 5: RCO by battery cost and powertrain for 10 years of ownership in Germany using the WLTC as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec
Battery costs (USD_2015/kWh)	400	35,734	37,582	37,064	43,543	41,207	51,541	66,357
	300	35,734	37,582	35,531	40,728	37,518	45,366	56,578
	200	35,734	37,582	33,997	37,914	33,829	39,191	46,799
	100	35,734	37,582	33,340	35,729	30,140	33,015	37,021
	50	35,734	37,582	33,340	35,729	28,295	29,928	32,131

Annual Distance Travelled

As expected, the annual distance travelled by the customer will have a direct impact on the cost competiveness between different powertrains (cf. Figure 6); higher annual distance travel plays in favor of the PEVs. For instance, in the United States, at around 24,000 km/year for 10 years of ownership, the PHEV20 and BEV100 become more economical than the conventional spark ignition (SI) vehicle (Table 6). In Germany, largely owing to the higher fuel and electricity prices, the PHEV20 becomes competitive at higher distances travelled than in the United States (cf. Tables 6 and 7).

Table 6: RCO by annual distance travelled and powertrain for 10 years of ownership in the United States using the U.S. combined adjusted driving cycle as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec
Annual VKT (Km)	40,233	53,695	55,285	52,059	54,129	47,547	54,522	64,172
	32,186	47,112	48,779	46,503	48,956	42,379	48,968	58,331
	24,140	39,385	41,019	39,648	42,226	35,882	41,937	50,556
	16,093	31,660	33,260	32,842	35,502	29,386	34,908	42,781
	8,047	23,936	25,502	26,243	28,822	22,891	27,879	35,007

Table 7: RCO by annual distance travelled and powertrain for 10 years of ownership in Germany using the WLTC as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec
Annual VKT (Km)	40,233	65,514	65,916	62,098	69,968	58,991	69,494	81,625
	32,186	57,323	58,260	55,559	63,002	54,235	62,480	74,159
	24,140	47,769	49,109	47,375	54,082	46,021	53,541	64,216
	16,093	38,217	39,960	39,192	45,161	37,808	44,602	54,274
	8,047	28,667	30,813	31,009	36,223	29,597	35,665	44,333

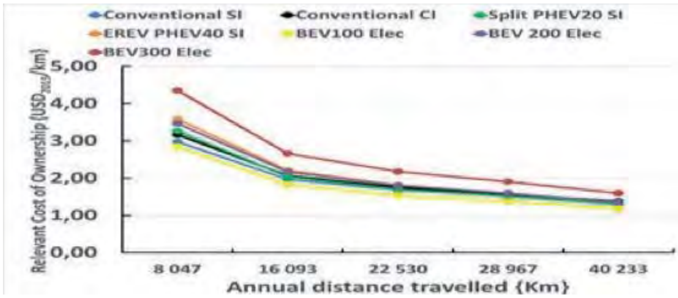


Figure 6: RCO by annual distance travelled and powertrain for 10 years of ownership in the United States using the U.S. combined adjusted driving cycle as reference

Energy Price

The impact of fuel price is far more important in Europe. Table 8 shows the impact of a potential fuel price evolution in Germany. At a gasoline price of 2.38 USD_{2015}/liter (9.01 USD_{2015}/gallon), the PHEV20 and the BEV100 will become more economical than conventional cars. The electricity price also plays a role in the overall cost for the owner of a PEV, as shown in Table 9. At electricity prices as low as 0.08 USD_{2015}/kWh, the PHEV20 and the BEV200 become cost competitive over an ownership period of 10 years. However, the RCO of the PHEV40 or the BEV300 are higher than for conventional cars even at an electricity rate as low as 0.08 USD_{2015}/kWh. If carbon emissions are priced, and the cost is reflected in higher fuel prices, this will tend to favor lower-carbon emitting PEVs, especially BEVs.

Table 8: RCO by fuel price and powertrain for 10 years of ownership in Germany using the WLTC as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300		
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec		Variable 2
Gasoline price (USD_2015/Liter)	2.38	40,793	42,383	38,938	44,243	35,673	42,278	51,689	2.38	Diesel price (USD_2015/Liter)
	1.98	38,450	40,258	38,070	43,592	35,673	42,278	51,689	1.98	
	1.32	34,544	36,716	36,624	42,509	35,673	42,278	51,689	1.32	
	0.92	32,201	34,591	35,756	41,859	35,673	42,278	51,689	0.92	
	0.26	28,296	31,049	34,309	40,775	35,673	42,278	51,689	0.26	

Table 9: RCO by fuel price and powertrain for 10 years of ownership in Germany using the WLTC as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec
Electricity price ($/kWh)	0.4	35,734	37,582	37,083	42,868	35,725	42,332	51,745
	0.32	35,734	37,582	36,572	42,086	34,341	40,899	50,253
	0.24	35,734	37,582	36,060	41,303	32,957	39,465	48,761
	0.16	35,734	37,582	35,548	40,520	31,573	38,031	47,269
	0.08	35,734	37,582	35,037	39,737	30,190	36,598	45,777

For the combination of factors considered here (Table 1), the U. S. gasoline price must reach 1.32 USD_{2015}/liter (5.0 USD_{2015}/ gallon) for most PEVs to become cost competitive (cf. Table 10).

Table 10: RCO by fuel price and powertrain for 10 years of ownership in the United States using the U.S. combined adjusted driving cycle as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec
Gasoline price (USD_2015/Liter)	2.38	58,279	39,467	44,623	44,764	34,583	40,532	49,001
	1.98	53,517	39,467	43,145	43,859	34,583	40,532	49,001
	1.32	45,581	39,467	40,681	42,351	34,583	40,532	49,001
	0.92	40,819	39,467	39,203	41,445	34,583	40,532	49,001
	0.26	32,882	39,467	36,739	39,937	34,583	40,532	49,001

Incentives Influence

Incentives have a significant impact on the relevant cost of ownership. Therefore, we applied hypothetical variations on the initial value to enhance their impact on the RCO. Four different cases were applied in this study:

- Suppression of the incentive (0 % of the current incentive’s values applied);
- Reduction of 50 % of the current value of the incentives;
- No change in the incentive (100 % of the current values applied);
- A hypothetical case of an increase of 50 % of the incentive (150 % of the current incentive’s values applied).

Tables 11 and 12 below display the new RCO according the incentive variation and the geographical area. They show how much the incentive influences the RCO of electrified vehicles. Indeed, if the incentive is suppressed in the U. S., the RCO for the BEV100 will decrease by almost 10 % and by 7 % for the Split PHEV20. If PEV incentives are decreased or eliminated, this can be expected to reduce PEV market share.

Table 11: RCO by incentives variation and powertrain for 10 years of ownership in the United States using the U.S. combined adjusted driving cycle as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec
Incentive (% of current value)	0%	37,841	39,467	40,986	45,539	41,226	47,175	55,644
	50%	37,841	39,467	39,632	43,209	37,905	43,853	52,323
	100%	37,841	39,467	38,279	40,879	34,583	40,532	49,001
	150%	37,841	39,467	36,925	38,549	31,261	37,210	45,679

Table 12: RCO by incentives variation and powertrain for 10 years of ownership in Germany using the WLTC as reference

		Conventional	Conventional	Split PHEV20	EREV PHEV40	BEV100	BEV 200	BEV300
Variable 1		SI	CI	SI	SI	Elec	Elec	Elec
Incentive (% of current value)	0%	35,734	37,582	39,630	45,405	39,095	45,700	55,111
	50%	35,734	37,582	38,347	44,122	37,384	43,989	53,400
	100%	35,734	37,582	37,064	42,839	35,673	42,278	51,689
	150%	35,734	37,582	35,781	41,556	33,962	40,567	49,978

Combination of Factors

We examined ranges of factors to determine what combinations enable BEVs to be cost-competitive with conventional SI vehicles. The ratio of the RCO of a BEV200 to that of a conventional SI vehicle under different assumptions is shown in Figures 7 and 8. Those figures display the contours of a constant RCOBEV200/RCOConvSI ratio for ranges of battery costs and annual distance travelled for three different electricity prices. All other parameters remain constant (as given in Tables 1, 2, and 3).

In Germany, mainly due to the high fuel cost for conventional vehicles, at high annual distance travelled, the BEV200 can be competitive with conventional vehicles (Figure 7). Furthermore, the electricity price will also have an impact on both the cost ratio between BEV200 and conventional SI, and on the way the annual VKT and battery cost will affect this ratio. Indeed, (cf. contours outlined in red in Figures 7 and 8) the slope of the RCOBEV200/RCOConvSI lines increases as electricity price decreases and the difference in the energy cost per kilometer increases. As shown in Figure 8, at high electricity prices (0.35 USD_{2015}/kWh in the United States) while others parameters remain constant, the slope of contours become negative, since the energy cost per kilometer for the BEV is higher than that of the conventional vehicle, and the RCO ratio increases with annual distance travelled.

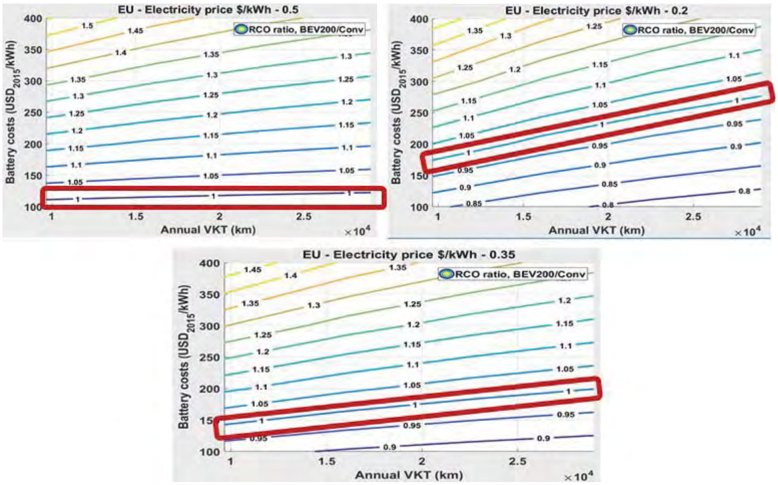


Figure 7: RCO ratio between BEV200 and conventional SI by annual distance travelled, battery cost, and electricity price, for 10 years of ownership in Germany using WLTC as reference

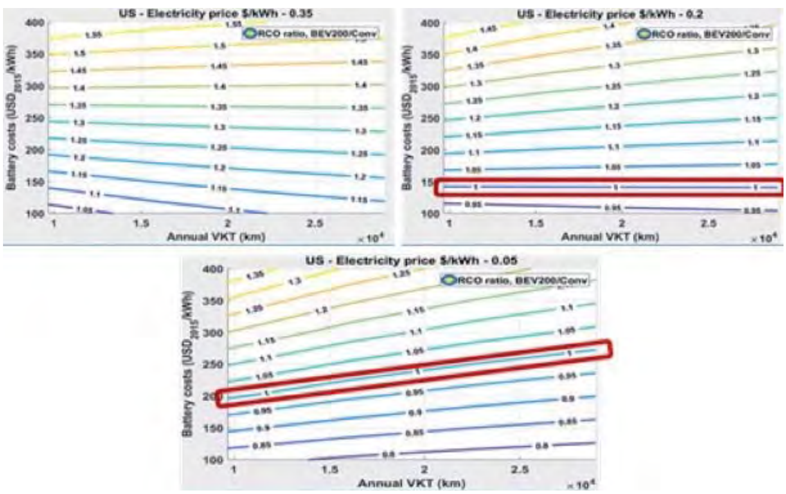


Figure 8: RCO ratio between BEV200 and conventional SI by annual distance travelled, battery cost, and electricity price, for 10 years of ownership in the United States using the U. S. combined adjusted driving cycle as reference

5.5 Conclusions

PEVs can be cost-competitive with other powertrains under favorable conditions. These include various combinations of high fuel prices, low battery costs, and high annual driving distances. Energy savings from PEVs, especially BEVs, are somewhat sensitive to the fuel and electricity consumption estimates. The differences in fuel costs between the WLTP and adjusted U. S. cycles indicate the importance of energy consumption values. These differences become more important under high fuel prices. When energy costs per kilometer for PEVs and conventional vehicles differ widely (high gasoline price and low electricity price), annual distance travelled becomes an important factor and PEVs can be cost competitive at high annual VKT. When energy cost per kilometer is similar, purchase price differences are more important, and PEV cost competitiveness is more sensitive to assumptions about battery costs. Since future fuel prices are uncertain, and driving distances differ between drivers, it is difficult to predict how competitive PEVs will be, but it is important to consider the interactions of multiple factors. However, there are factors that we did not consider that influence BEV adoption, such as the difference between the acceleration performance of PEVs and conventional vehicles, the limited range of the BEV100 and BEV200, and also availability of public charging stations.

5.6 Contact Details of the Operating Agent

For further information, please contact the Task 25 OA:

Mr. Aymeric Rousseau
Argonne National Laboratory
Building 362, Room C265
9700 South Cass Avenue
Argonne, IL, 60647
United States
Tel: (+1) 630-816-5471
E-Mail: arousseau@anl.gov

References

1. *P. Mock. "Entwicklung eines Szenariomodells zur Simulation der zukünftigen Marktanteile und CO2 Emissionen von Kraftfahrzeugen (VECTOR21)." Universität Stuttgart, Stuttgart (2010).*

2. *M. Redelbach, E. D. Özdemir, and H. E. Friedrich. "Optimizing battery sizes of plug-in hybrid and extended range electric vehicles for different user types." Energy Policy 73 (2014): 158–68. doi:10.1016/j.enpol.2014.05.052.*

3. *A. Rousseau, T. Stephens, J. Brokate, E. D. Oezdemir, M. Kloetzke, S. A. Schmid, P. Ploetz, F. Badin, J. Ward, and O. T. Lim. "Comparison of energy consumption and costs of different plug-in vehicles in European and American context." EVS28, Korea (2015).*

4. *Protection of Environment, 40 C.F.R. Vol. 32, Part 600, Fuel Economy and Greenhouse Gas Exhaust Emissions of Motor Vehicles, https://www.epa.gov/laws-regulations/regulations, accessed on July 5, 2017.*

5. *European Union Regulation (EU) No 333/2014 of the European Parliament and of the Council of 11 March 2014 amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO2 emissions from new passenger cars (2014).*

6. *Z. Lin and D. Greene. "Predicting individual fuel economy." SAE Int. J. Fuels Lubr. 4 no. 1 (2011): 84–95. doi:10.4271/2011-01-0618.*

7. *Argonne National Laboratory. Autonomie Toolkit, http://www.autonomie.net/index.html, accessed on July 5, 2017.*

8. *A. Moawad, N. Kim, N. Shidore, and A. Rousseau. "Assessment of vehicle sizing, energy consumption and cost through large scale simulation of advanced vehicle technologies." Argonne National Laboratory report ANL/ESD-15/28 (2016). http://www.autonomie.net/publications/fuel_economy_report.html.*

9. J. Krumm. "How people use their vehicles: Statistics from the 2009 National Household Travel Survey." SAE Technical Paper 2012-10-0489 (2012), doi: 10.4271/2012-01-0489.

10. *SAE International. "Utility factor definitions for plug-in hybrid electric vehicles using travel survey data," http://standards.sae.org/j2841_201009/, 2010.*

11. *P. Plötz, N. Jakobsson, and F. Sprei. "On the distribution of individual daily driving distances. " Transport Research Part B: Methodological. 101 (2017): 213–227.*

12. *Z. Lin, and D. L. Greene. "Significance of daily VMT variation over time and among drivers on assessment of PHEV energy impact." Proceedings of 90th Annual Meeting of the Transportation Research Board Compendium of Papers. No. 11-2242 (2011).*

13. *G. Tal, M. S. Nicholas, J. Davies, and J. Woodjack. "Charging behavior impacts on electric VMT: evidence from a 2013 California drivers survey." Presented at the Transportation Research Board Annual Meeting, Washington, DC, Jan. 2014.*

14. *A. Vyas, D. Santini, and R. Cuenca, R. "Comparison of indirect cost multipliers for vehicle manufacturing: Technical memorandum in support of electric and hybrid vehicle cost estimation studies." Technical memorandum, Argonne National Laboratory, Argonne, IL (Apr. 2000).*

15. *Electric Power Research Institute (EPRI). "Total cost of ownership model for current plug-in electric vehicles." EPRI Technical Report no. 3002001728, Palo Alto, CA: EPRI (2013). https://www.epri.com/#/pages/product/000000003002001728/, accessed July 7, 2017.*

16. *Federal Ministry for Economic Affairs and Energy (2017). "Electric mobility in Germany." http://www.bmwi.de/Redaktion/EN/Dossier/electric-mobility.html, accessed July 7, 2017.*

17. *Z. Lin, J. Dong, C. Liu, and D Greene, "PHEV energy use estimation: Validating the Gamma Distribution for representing the random daily driving distance." Transportation Research Record 2287-05 (2012).*

18. *B. Pröpfe, M. Redelbach, D. Santini, and H. E. Friedrich. "Cost analysis of plug-in hybrid electric vehicles including maintenance and repair costs and resale values." Presented at Electric Vehicle Symposium 26, Los Angeles, USA, May 2012.*

19. *P. Holweg, and P. A. Kattuman. "The incentive whiplash: Sales discounts and the dynamics of residual value in the automobile industry." (unpublished), http://www.eea-esem.com/files/papers/EEA-ESEM/2006/2414/IncentiveWhiplash.pdf, accessed February 14, 2015.*

20. *R. Follmer, D. Gruschwitz, B. Jesske, S. Quandt, B. Lenz, C. Nobis, K. Köhler and M. Mehlin. "Mobilität in Deutschland 2008: Ergebnisbericht Struktur–Aufkommen–Emissionen–Trends." Federal Ministry for Transport, Building and Urban Development, Germany (2010).*

21. *N. Kim et al., "Vehicle Level Control Analysis for Voltec Powertrain." EVS30 Symposium Stuttgart, Germany, October 9 –*

6 Wireless Power Transfer for Electric Vehicles (Task 26)

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

6.1 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.

6.2 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 the 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 regard to misalignment, leakage fields, and debris tolerance and response

6.3 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.

6.4 Results

Task 26 sponsored one workshop in 2017 focused on installations and alignment. The workshop was jointly sponsored by VEDECOM and held in Versailles, France on April 25-26, 2017. The workshop combined technical presentations, site demonstrations and working group discussions.

6.4.1 Summary of Installations and Alignment Workshop

The "Installations and Alignment" workshop consisted of presentations from the European Commission, Germany, Italy, Latvia, South Korea, Spain, the United Kingdom, and the United States. The workshop was attended by over 30 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 Installations and Alignment workshop

Title	Presenter	Country
VEDECOM involvement in FABRIC	Stephane Laporte, VEDECOM	France
EMF compliance assessment of a 20 kW dynamic wireless charging track for electric vehicles	Leandro Percebon, Qualcomm	Germany
European Commission projects for Green Vehicles charging	Maurizio Maggiore, European Commission	EU
Construction and on-road integration of the electrical infrastructure for a dynamic IPT system: challenges and lessons learned from a real implementation	Paolo Guglielmi, Politecnico di Torino	Italy
Electric road construction: Road infrastructure impacts and solutions	Damien Bateman, TRL	United Kingdom
VICTORIA project	Hans Bludszuweit, CIRCE	Spain
Wireless Charging Systems at VEDECOM	Mustapha Debbou, VEDECOM	France
Essential Enabling Alignment and Communication Subsystems for Advanced Automatic Wireless Charging	Bruce Long, Momentum Dynamics	United States
Optimization of the system Electric Vehicle – Grid with Wireless Power Transfer	Giampiero Brusaglino, Centro Ricerche Fiat	Italy
Low cost electric highway solution	Leslie Adrian, Lesla, Ltd	Latvia
On-Line Electric Vehicle (OLEV) Project and Vehicular Wireless Power Transfer Technology	Seungyoung Ahn, KAIST	South Korea
Lessons Learned in Commercial Deployments of Wireless Charging for Electric Buses in Public Transportation	Michael Masquelier, WAVE & Co-Chair SAE J2954 HDV	United States

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

In addition to the presentations, members visited one demonstration site. The site was a dynamic wireless track within the VEDECOM facilities to explore the power transfer efficiencies while the vehicle is in motion. A picture of the wireless track is shown in the following figure.

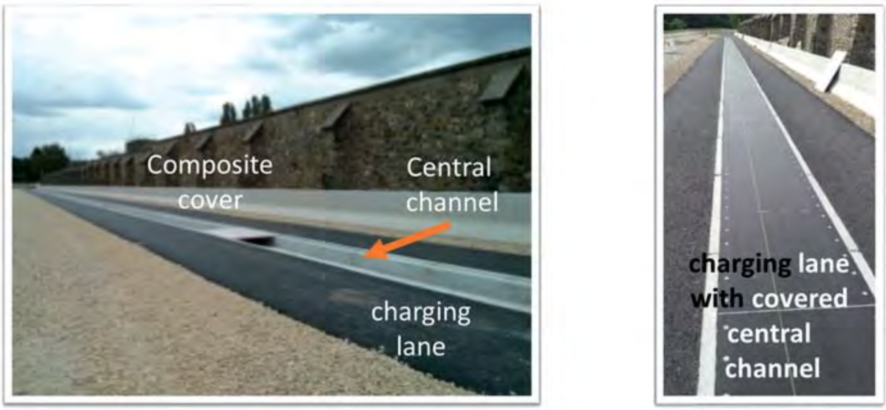


Figure 1: Dynamic wireless track installation site visited during Installations and Alignment Workshop

6.5 Next Steps

In 2018, this Task plans to hold additional three workshops. The following table provides topics and locations for remaining workshops.

Table 2: Schedule for remaining workshops

Workshop Topics	Anticipated Dates	Host / Location
Grid impacts and bi-directional wireless	March 19-20, 2018	Newcastle University Newcastle Upon Tyne, UK
Dynamic Systems	June 5-6, 2018	Politecnico di Torino, Turin, Italy
Communications & Autonomous	Fall 2018	TBD Detroit, MI
Summary Report Generation	Spring 2019	TBD

6.6 Contact Details of the Operating Agent

For further information, please contact the Task 26 OA:

Burak Ozpineci, PhD, Task 26 Operating Agent
Center for Transportation Analysis (CTA)
Oak Ridge National Laboratory
2360 Cherahala Blvd.
Knoxville, TN 37932, USA
Phone: +01-865-946-1329
E-Mail: burak@ornl.gov

7 Electrification of Transport Logistic Vehicles (Task 27)

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

7.1 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.[4] Furthermore, higher gradients are observed for freight emissions compared to passenger travel emissions for most of the IEA countries.[5] 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.

7.2 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

---

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

[5] 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

- Light commercial vehicles, medium and heavy freight trucks
- 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

7.3 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.

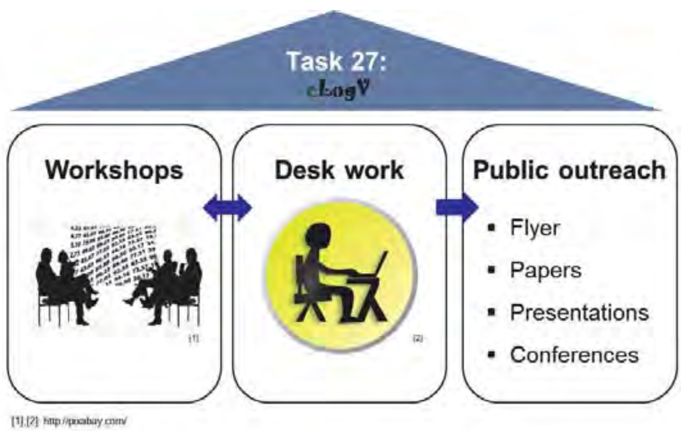


Figure 1: Task 27 working method

Workshops
External experts from industry, research organizations, and technology policy institutions around the world are invited 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 is free of charge. However, the Task is based on a work sharing principle and contributions of some kind are expected.

7.4 Results

The **first Task 27 workshop** "Electric transport logistic vehicle technology and its application" was held in Stuttgart (Germany) on March 19, 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

The **fourth Task 27 workshop** "The Road to Electrification of Logistics" took place in Coventry (United Kingdom) on April 26, 2017. Dedicated topics at the workshop were:

- Regional stakeholder approach to electrification of transport logistics
- Planned and ongoing pilots supporting electrification of transport logistics
- Overcoming the technical challenges to electrification of transport logistics

All presentations are available for download over the HEV TCP website, under http://www.ieahev.org/tasks/e-logistics-task-27/.

7.4.1 Results From Workshops

- High investment costs for electric trucks (about three times higher compared to conventional diesel trucks) is 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. Reward 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.
- 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 results of Task 27 are presented in the final report. The outcome of all activities including the four workshops, the vehicle database (includes about 120 electrified transport logistic vehicles), and the project profiles for demonstration projects are described. Key recommendations are to further develop the policy framework by a close coupling between all relevant stakeholders; to define an integral European vision with a more integrated city management approach; to reward frontrunners through subsidies, parking and loading spaces, and time windows for loading-unloading zones; to strengthen and support cross-company, cross-sectoral and multi-institutional cooperation; and to intensify research on the applicability of heavy EFVs in regional delivery and long-distance haulage.

The Task 27 final report is publicly accessible on the HEV TCP website for download.

7.5 Next Steps

Task 27 ended as scheduled at the end of 2017. A second phase is currently under negotiation.

7.6 Contact Details of the Operating Agent

For further information, please contact the Task 27 OA or Task 27 co-OA.

Mr. Florian Kleiner
German Aerospace Center
Institute of Vehicle Concepts
Pfaffenwaldring 38-40
70569 Stuttgart
Germany
Office: +49 711 6862 8120
E-Mail: Florian.Kleiner@dlr.de

DI. Martin Beermann
JOANEUM RESEARCH
Forschungsgesellschaft GmbH
Elisabethstraße 18/II
8010 Graz
Austria
Office: +43 316 876 1434
E-Mail: Martin.Beermann@joanneum.at

8 Home Grids and V2X Technologies (Task 28)

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

8.1 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 was 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.

8.2 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.

8.3 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 of 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.

8.4 Results

During 2017, Task 28 organized the following expert Workshops and two special sessions:

- **Workshop VI: V2X Business models, recent developments and international pilot projects overview**
  This Workshop was held in Jeju Island (South Korea) on March 21-22, 2017. The workshop had a specific focus on V2X business models, recent developments and international projects review. The Korean electric vehicle (EV) market and V2X development in Korea were also addressed with input from local partners. A V2X international pilot projects session reviewed experiences in the US, Denmark, UK, and Switzerland including a review of the EV market in Thailand. Other relevant topics addressed were Distribution System Operator (DSO) perspectives for V2X development, standards and potential of plug-in hybrids for V2X. A technical visit to the e-Bus battery swapping facility was organized in addition to a visit to the Korean Renewable Energy Center in Jeju Island.
- **EEVC Round Table: Challenges and opportunities for V2G applications as part of the EV massive roll out**
  Round table at the European Battery, Hybrid & Fuel Cell Electric Vehicle Congress held in Geneva (Switzerland) on March 14-16, 2017. The participants where representing car OEMs, distribution system operator (DSO), protocol developers and demo projects.
- **EVS30 special session: V2X insights and applications**
  This session took place within the 30th International Electric Vehicle Symposium & Exhibition (EVS 30) in Stuttgart (Germany) on 11 October

2017. The topics presented where "V2X protocols" by CHAdeMO, "Fiscal barriers" by ElaadNL and "V2G as and economic gamer" by INSERO.

Beside this main events, Task 28 also participates in the following events:

- Invited talk "**Vehicles to buildings: electric cars as storage systems**" at WSED'17 (World Sustainable Energy Days) in Wels (Austria) on March 2-3, 2017.
- Invited talk "**V2X insights and applications**" at 2nd V2G Conference in Amsterdam (Netherlands) on May 11-12, 2017.

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

8.4.1 Insights to the Korean EV Market and Demonstration Projects

The 6th workshop was dedicated to Korean and Asian markets, with special focus on demonstration projects review, business models and recent technology developments. The 2017 EV market in Korea is as follows: an estimated 12,000 EVs are on the road, a total of 9,300 charging points are available and 1,300 fast chargers are installed (considering both publicly available and private ones belonging to KEPCO). The 2020 targets are: 250,000 EVs, 50,000 PHEV and 3,000 fast chargers.

The Korean policy does not only address incentives but also technology development (such as increased range, reliability and efficiency) and infrastructure policy and deployment as key elements for EV massive penetration. As an example, incentives are slowly decreasing in time but special promotion campaigns for residential apartment buildings charging infrastructure have been launched with a target of installing 30,000 charging points.

From the point of view of the Korean DSO, KEPCO, the key elements for EV integration in the Korean energy system are the integrated EVSE platform development. In the Jeju Island pilot project (2016-2030), they are developing an AC/AC V2G charger including V2G service demonstration (2015-2017), building security infrastructure for smart grid vulnerability test and analysis (2015-2017) and developing a 6.6 kW wireless power transfer EV charger (with special focus on luxury class EVs and autonomous EVs). The services planned to be introduced are demand response (peak reduction and load levelling) at distribution level. At present, V2H is limited due to regulation, but can be performed as a demand response (DR) service through a EVSE or V2G provider.

The Korea Automotive Technology Institute presented the evolution of the automotive industry in Korea which after 60 years of evolution enters into the globalized advanced country in the world unprecedently: a total of 900 Tier-1, 3,000 Tier-2 and 5,000 Tier-3 parts companies are collaborating with 14 assembly sites of 7 OEMs in Korea. Internationally, Hyundai-Kia motors are producing 2.5 million vehicles in 10 plants abroad. The Eco-car in Korea (supported by government's law) focuses on eCar (PEV, HEV/PHEV, and FCEV), and clean and efficient ICE. In parallel, the government is promoting EV charging and fast charging infrastructure in Korea. Hyundai has launched its first full electric vehicle Ioniq EV and Kia is planning its first own electric version of Kia Niro. Both companies have been commercializing HEV and PHEV since 2016.

8.4.2 EV Status in Thailand

HEV and PHEV demand is increasing (80,000 cumulative sales through 2016) while BEV demands are decreasing. The National Reform Council (NRC) proposed an action e-Mobility plan to the governement (in 2015) based on promoting Thailand as an Association of Southeast Asian Nations (ASEAN) Electric Vehicle Hub, promoting Electric Vehicle usage on Thai roads, promoting Electric Vehicle production in Thailand, supporting local EV companies, supporting R&D of EVs parts and charging infrastructure and supporting investments on EVs.

The main demonstration project, EVAT, is a 100 EV charging station project supported by EPPO (Thailand Ministry of Energy). It includes fast and normal charging points for hotels, offices, condominium, etc., together with the launch of a communication platform and scheme with shareholders, namely EV users, charger owners, and service providers. Special attention is placed on standardization of protocols and connectors for charging systems and services. A registration database is proposed for 4 categories of EVs (with the 4 categories being electric motorcycle, electric 3-wheelers, electric 4-wheelers, and tractors). The other relevant demonstration project is the eTuk Tuk with the scope of replacing 22,000 Tuk Tuk motors with electrical motors by 2021.

8.4.3 Fiscal Barriers for Smart Charging

During the EVS 30 ElaadNL[6] presented an interesting analysis on the fiscal barriers that the smart charge and V2G have to face. The main important regulatory questions that arise during the talk have previously been analyzed also in other expert workshops:

[6] Fiscal Barrier for Smart Charging. Baerte de Brey. EVS30, Stuttgart, Germany.

- Does the smart charging qualify as energy supply?
- Between what parties is this supply effected?
- How does smart charging relate to netting?
- How does smart charging relate to self-generated power exemption?

Different case studies were presented in which these questions were tried to be answered in different countries and demonstration projects. Lomboxnet project (Utrecht, Netherlands) has installed a number of solar PV systems that are directly linked to charging points in the area, bi-directional charging points allow generated solar energy to be stored temporarily in EVs and to be re-delivered at a later time, increasing own use and allowing storage to be used to balance the local grid.

Another interesting project presented is a set of fast charging points installed on a highway, each installation consists on a solar PV system, a charging station for four EVs and a battery system. The power consumption from the grid is lower due to storing of solar energy in the battery allowing the grid operator to avoid grid reinforcement.

One of the highlighted fiscal barriers is the absence of financial stimulation to EV owners who also have solar panels, that will allow optimization of own consumption and an enhanced usage of the self-generated electricity. Moreover, when adding V2G technology there is the possibility of suffering double taxing, one when the vehicle is charged and one when it is discharged.

8.5 Next Steps

The work within Task 28 will continue until the end of 2018. As it was until 2017, the aim is to organize biannual expert workshops together with different side events. There is a workshop planned to be held in March 2018 in Newcastle (UK), taking advantage of the UK Energy Storage Conference 2018 venue. Later, a scientific workshop will be organized in Barcelona (Spain) and the last workshop is planned to be organized in autumn in Brussels (Belgium).

The partners contributing to Task 28 activities will also be present in other electric mobility events such as the 31st International Electric Vehicle Symposium & Exhibition (EVS 31) in Kobe (Japan) or the IEEE Smart Grids for Smart Cities Forum in Genk (Belgium).

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 with 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.

8.6 Contact Details of the Operating Agent

For further information, please contact the Task 28 co-OA:

Ms. Cristina Corchero
Catalonia Institute for Energy Research
Jardins de les Dones de Negre 1, 2nd floor
08930 Sant Adrià del Besòs, Spain
Phone: +34 933 562 615
E-Mail: ccorchero@irec.cat

Mr. Manel Sanmartí
Catalonia Institute for Energy Research
Jardins de les Dones de Negre 1, 2nd floor
08930 Sant Adrià del Besòs, Spain
Phone: +34 933 562 615
E-Mail: msanmarti@irec.cat

9 Electrified, Connected and Automated Vehicles (Task 29)

Members: Austria, Germany, United States

9.1 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 of 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. 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 programmes, Task 29 was launched by the HEV TCP.

9.2 Objectives

Task 29 focuses on the 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.
- Asses the impact of user/driver behavior on the combination of electrification, connectivity and automation and conclude on needs for measures in awareness and legislation.

The participants of Task 29 particularly aim to understand the impact that the topic has on innovation policy, i.e. roadmaps, funding programmes and regulations.

9.3 Working Method

Task 29 is organizing a series of expert workshops scheduled in conjunction with dedicated conferences. The workshops 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. Moreover, the exchange of information about the impact on research funding policies and on regulatory actions shall be fostered. The actual activities are aligned to 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.

9.4 Recent Advancements

On 4 April 2017, Task 29 co-organized (together with the EU-funded SCOUT project) a breakout session entitled “Shared Economy – Automation & Electro-mobility” as part of the European Commission’s 1st EU Conference on Connected and Automated Driving in Brussels. Speakers included Daniel Watzenig, Virtual Vehicle Centre (Austria), Wolfgang Dettmann, Infineon (Germany), Wolfgang Gruel, Stuttgart Media University (Germany), Marius Macku, Uber (Belgium), and Luc Texier, Bestmile (France). The moderator was Gereon Meyer, VDI/VDE-IT (Germany), the operating agent of Task 29 (see Figure 1).

Figure 1: Session “Shared Economy – Automation & Electro-mobility” co-organized by the HEV TCP Task 29 and the EU-funded SCOUT project on 4 April 2017 (Source: European Commission)

The panelists’ contributions and the discussions covered the theme of the session in a comprehensive way in both technical and non-technical terms. It made clear that automation of vehicles is a first step towards smart mobility, but also needs to go along with electrification, shrinking of vehicle size and shared economy. Automation by itself could possibly lead to unintended consequences as for example the initial increase in traffic use due to the high attractiveness of automated driving to additional user groups. Hence, it might not necessarily help to reduce congestion and emissions. Therefore, a more efficient use of vehicles has to be aimed at. One possibility to go along with automation is electrification which potentially reduces overall emissions and provides synergies at the electronic architecture and control level. An additional option is ride sharing as a smart alternative to car sharing, which would directly cut down on road use. Those sharing concepts need to be brought together with public transportation to provide attractive transport possibilities and make collective transport convenient for its users. Alternatively, radical changes have to be made regarding the size of the vehicles for individual use. Automation and connectivity of vehicles are aimed to make road traffic accident free, which implies that passive safety systems will be obsolete one day, and cars can be made super light and efficient.

Regarding the impact on innovation policy, Task 29 found that the synergetic potential of combining the topics of automation and electrification is covered in a number of roadmaps and strategy plans, partly due to the involvement of Task 29 participants in the related consultation processes:

- Strategic Research Agenda of the European Technology Platform on Smart Systems Integration (EPoSS, 2017)
- European Roadmap Electrification of Road Transport of the European Technology Platforms ERTRAC, EPoSS, EITP SNET (2017)
- A3PS Roadmap Eco Mobility 2025+ (2015)
- Strategic Transport Research and Innovation Agenda (STRIA) of the European Commission (2017)
- Strategic Research Agenda of the Joint Undertaking ECSEL (2017)

Also, first impacts on reseach funding programmes could be observed, e.g.

- German Federal Ministry of Education and Research (BMBF), Electronics for autonomous, electrical driving (ELEKTRONOM)
- German Federal Ministry of Education and Research (BMBF), Disruptive vehicle concepts for autonomous electric mobility (Auto-Dis)
- Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT), Mobility of the Future

Further impacts can be expected by the planning of the European Commission and the industry for the European Green Vehicles Initiative PPP in the next framework programme Horizon Europe (from 2021). In the next step, Task 29 will foster the exchange of information about the outcomes of these activities, i.e. funded projects and their results.

9.5 Financing and Sponsorship

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

9.6 Contact Details of the Operating Agent

For further information, please contact the Task 29 OA:

Mr. Gereon Meyer
VDI/VDE Innovation + Technik GmbH
Dept. Future Mobility and Europe
Steinplatz 1
10623 Berlin
Germany
Phone: +49 30 310078 134
E- Mail: gereon.meyer@vdivde-it.de

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

Members: Austria, Canada, Germany, Spain, Republic of Korea, United States

10.1 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.

10.2 Objectives

The aim of Task 30 (2016 – 2020) 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, www.ieahev.org/tasks/task-19-life-cycle-assessment-of-evs/, 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. 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 PM and NOx emissions. Therefore Task 30 will focus on the following topics covering methodologies, data and case studies:

- Effects of EVs on water (emissions to water, waste water, “Water Footprint” of EVs)
- Effects 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 NOx, PM and CxHy, 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).

10.3 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 1). The Task will proceed by holding a series of expert 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

10.4 Results

10.4.1 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

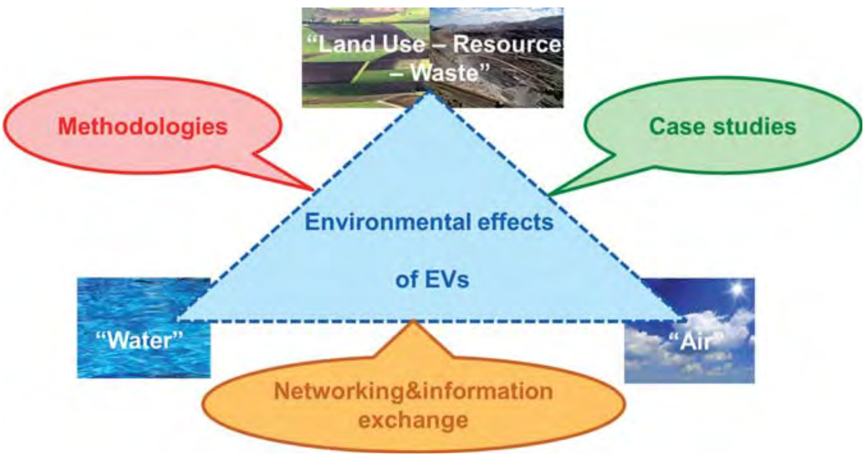


Figure 1: Working method in Task 30

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.

10.4.2 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 was on Battery Electric Vehicles (BEV) and Plug in Hybrid Electric Vehicles (PHEV). The two topics for the workshop were:

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

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

The possible next activities of IEA HEV Task 30 might be 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
  - 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 then might be included in the FACT SHEETS for the IEA HEV 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
  - impact assessment (e.g. water quality, thermal pollution, etc.)

10.4.3 Estimated Environmental Effects of Worldwide EV Fleet

Since 2014, Task 19 has been estimating the LCA based environmental effects of the worldwide electric vehicle fleet 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 2.

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 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 conventional new ICE vehicle is assumed in the range of 50 - 75 kWh/100 km.

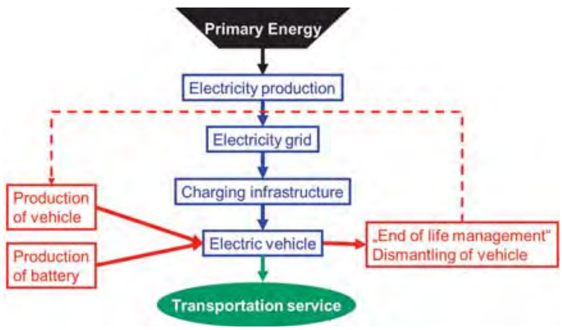
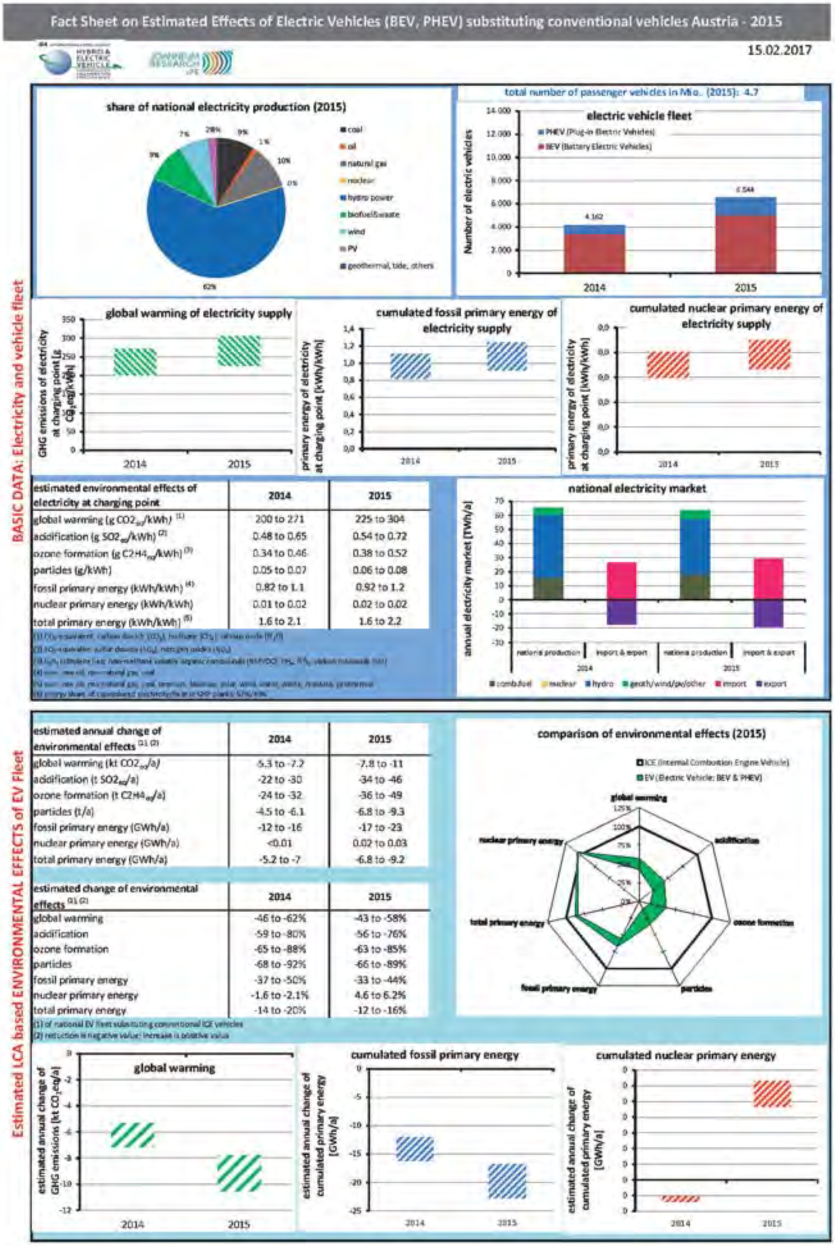


Figure 2: System boundaries

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 (Figure 4)

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



estimated environmental effects of electricity at charging point	2014	2015
global warming (g $CO2_{eq}$/kWh) (1)	200 to 271	225 to 304
acidification (g $SO2_{eq}$/kWh) (2)	0.48 to 0.65	0.54 to 0.72
ozone formation (g $C2H4_{eq}$/kWh) (3)	0.34 to 0.46	0.38 to 0.52
particles (g/kWh)	0.05 to 0.07	0.06 to 0.08
fossil primary energy (kWh/kWh) (4)	0.82 to 1.1	0.92 to 1.2
nuclear primary energy (kWh/kWh)	0.01 to 0.02	0.02 to 0.02
total primary energy (kWh/kWh) (5)	1.6 to 2.1	1.6 to 2.2

estimated annual change of environmental effects (1) (2)	2014	2015
global warming (kt $CO2_{eq}$/a)	-5.3 to -7.2	-7.8 to -11
acidification (t $SO2_{eq}$/a)	-22 to -30	-34 to -46
ozone formation (t $C2H4_{eq}$/a)	-24 to -32	-36 to -49
particles (t/a)	-4.5 to -6.1	-6.8 to -9.3
fossil primary energy (GWh/a)	-12 to -16	-17 to -23
nuclear primary energy (GWh/a)	<0.01	0.02 to 0.03
total primary energy (GWh/a)	-5.2 to -7	-6.8 to -9.2

estimated change of environmental effects (1) (2)	2014	2015
global warming	-46 to -62%	-43 to -58%
acidification	-59 to -80%	-56 to -76%
ozone formation	-65 to -88%	-63 to -85%
particles	-68 to -92%	-66 to -89%
fossil primary energy	-37 to -50%	-33 to -44%
nuclear primary energy	-1.6 to -2.1%	4.6 to 6.2%
total primary energy	-14 to -20%	-12 to -16%

(1) of national EV fleet substituting conventional ICE vehicles
(2) reduction is negative value; increase is positive value

Figure 3: Country Fact Sheet – Example Austria

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 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:

- 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.
- 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
- Additional renewable electricity with adequate charging maximizes environmental benefits
- Adequate loading strategies to optimize the use of renewable electricity are essential for further significant reductions

So there is scientific evidence that under appropriate framework conditions, electric vehicles can substantially contribute to a sustainable transportation sector in the future.

10.5 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.

Further dissemination activities were:

- 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

Acknowledgement
The work of the Austrian participation (2018 – 2020) is financed by the Austrian Climate and Energy Fund and the FFG.

10.6 Contact Details of the Operating Agent

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

Mr. Gerfried Jungmeier
JOANNEUM RESEARCH Forschungsgesellschaft mbH
LIFE – Centre for Climate, Energy and Society
Waagner Biro Strasse 100
A-8020 Graz, Austria
Phone: +43 316 876 7630
E-Mail: gerfried.jungmeier@joanneum.at

11 Fuels and Energy Carriers for Transport (Task 31)

Members: Denmark, France, Sweden

11.1 Introduction

Under the IEA TCP on Hybrid and Electric Vehicles, Task 31 “Fuels and energy carriers for transport” has been executed in 2016 and 2017. Supporting countries were The Netherlands (lead), Sweden, and Denmark. The objective of Task 31 has been to execute a review, based on state-of-the-art, independent studies to determine the impact of different drivetrain options, fuels and vehicle use on CO_2 emissions of passenger cars. The output of Task 31 is aimed to inform policy makers in an easy way on the key environmental aspects of electric vehicles (EVs) in comparison to conventionally fueled vehicles (Internal Combustion Engine Vehicles or ICEVs). Within this first phase the focus has been on greenhouse gas (GHG) emissions. In addition, an easy to use proprietary tool has been developed to compare CO_2 emissions and energy efficiency of cars and their drivetrain and fuel options. Enabling policy makers and other stakeholders to compare and analyse GHG impacts of passenger cars is increasingly important as life time GHG impacts are receiving increased attention, and the information in media and scientific papers is to a large extent dependent on underlying assumptions. Using the model (results) gives understanding about the influential parameters in a passenger car LCA and hence which information is critical to make a complete comparison between vehicles. This helps to interpret passenger car LCA results published elsewhere. As the in-use GHG emissions of electric vehicles are zero, many stakeholders now report on life cycle based GHG emissions to compare electric vehicles with combustion engine vehicles. The sources of information and assumptions made in these published figures is not always clear and may lead to unclear or misleading conclusions. The scientific work and modelling has been done in cooperation with TNO (Netherlands), Chalmers University (Sweden), and the VUB (Belgium).

11.2 Objectives

The objective is to compare current (2016) and future electric and plug-in hybrid vehicles with vehicles running on the conventional motor fuels gasoline and diesel. The model covers the full life cycle of the vehicles, consisting of the phases production, use and decommissioning (including recycling). The production chain of the fuel or electricity is included as well. The model uses independent, state-of-the-art environmental evaluations (LCA) of vehicles and their use. In the full report, the approach followed is described in detail.

The Task 31 work only looks at GHG (Green House Gas) emissions, expressed as CO_2-equivalents (CO_2-eq). The model is prepared to report on energy use and efficiency as well however the values (references) have not yet been defined.

The multitude of model settings enables scenario analysis on a vehicle level and can show the consequences of e.g. a changing electricity mix, or of an increasing average battery size and range of electric vehicles. In the full report, the model is described in detail.The model is prepared for extension into future years, which would enable an investigation of the effect of future developments in manufacturing, use and recycling. Thus far, this has been implemented only for electricity mix compositions.

The present work provides answers to questions such as:

- How do BEVs, PHEVs and ICEVs (gasoline and diesel) compare on environmental impacts if not only direct emissions are considered but also the indirect emissions from energy production chains and vehicle production and decommissioning?
- Is the environmental impact comparison between BEV, ICEV and PHEV different for different market segments with corresponding drive patterns?
- How may future developments influence the comparison between electric vehicles and combustion engine vehicles, in terms of greenhouse gas?
  - Efficiency improvement of combustion engine vehicles
  - Trend towards more sustainable electricity mix
  - Developments in battery capacities and life span
  - Changes in driving behavior: autonomous driving, intelligent traffic systems, platooning
- What is the influence of the electricity mix on the performance of electric vehicles?
- What is the impact of PHEVs?
- What is the variation among passenger car market segments, from compact to luxurious vehicles?
- What are the impacts of the vehicle production and recycling?
- What are the impacts of the battery?
  - Battery capacity in kWh (or weight)
  - Battery production (using renewable energy or not)
  - Battery chemistry

- Battery lifetime (in km's)
- Battery recycling

11.3 Working Method

Environmental Impact Chain

An important aspect in changing to electric mobility (electric drive) is the trade-off in emissions between the use of the vehicle, the production of the energy carrier and the production and recycling of the vehicle. To evaluate the potential contribution to climate change and air pollution, each of these three parts is included in the analysis, see Figure 1.

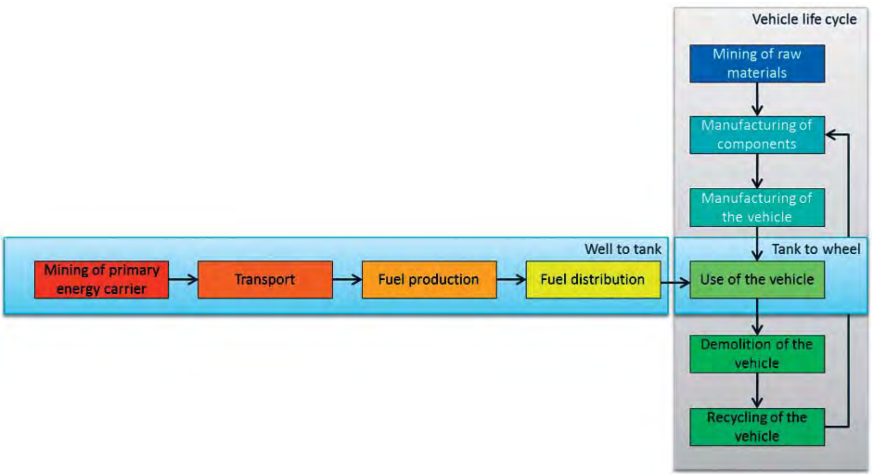


Figure 1: Scope for environmental impact assessment

Impacts

The impacts considered are:

- Contribution to climate change, because of the emission of greenhouse gases including CO_2, methane and N_2O, expressed as CO_2-equivalents using GWP-factors.

Impacts NOT in the current scope but possible as follow up:

- Emission of air pollutants (nitrogen oxides and particulate matter) and noise, and an indication of their combined impacts, expressed in external costs. Vehicle emissions include tailpipe emissions as well as brake and tire wear.

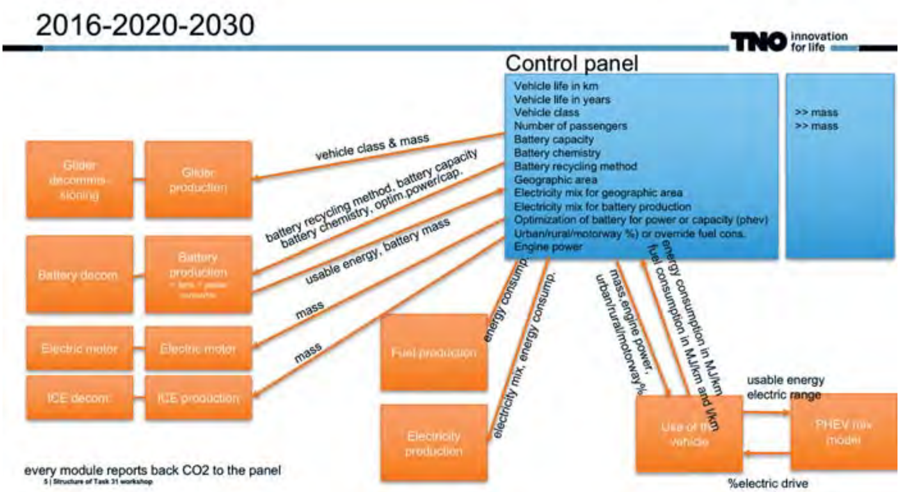


Figure 2: The LCA (GHG) model description - Schematic representation of the Task 31 model illustrating the different calculation modules and the control panel choices which can be modified by the user

What Does the Model do?

The model allows the user to define the vehicle configuration to be analysed by setting parameter values in the control panel. The model then calculates for that given configuration the life cycle CO_2 impacts. Using the control panel, existing vehicles can be simulated and compared to published data. “Virtual” vehicles can be defined as well. This allows the user to study the impact of changing one or more parameters.

In the model, the inputs are translated into a material composition of the vehicle and (if present) the battery, and into an energy demand in terms of fuel or electricity during the use of the vehicle. Simply put, these are subsequently multiplied with CO_2 emission factors per material and per energy carrier. The direct CO_2 emission is calculated as well.

The output is provided in kg CO_2 per vehicle-lifetime, and as g CO_2/km driven. The total CO_2 emission (per vehicle-lifetime and per km) is decomposed in the life phases production, use and recycling and energy carrier production. The battery production and recycling/disposal is shown separately.

How can the Model Support Policy Makers?

- It allows policymakers to compare CO_2 emissions and energy efficiency for different car types, drivetrains in an easy manner but based on credible and peer reviewed scientific data, enabling them to define parameters fitting the geographical and fuel (footprint) situation in their specific country. The user interface and free configuration of parameters enable the user to study impacts of changing fuel/power over time.
- Providing easy to understand outcomes (comparisons), which are based on credible peer-reviewed published scientific research results. The examples in this report demonstrate the use of the model in creating required comparisons.

Approach and Data Sources

For the model, data have been used from published sources. Several widely quoted and used meta-studies on many Life cycle assessment (LCA) studies have been used as the primary source in addition to data from Eco-invent LCA database.

The vehicle's energy requirement calculation is largely based on algorithms published previously in the Service Request 6 report (TNO).

Based on experience as well as on literature, the key factors are identified that determine how the life cycle of an electric vehicle compares to the life cycle of an internal combustion engine vehicle, in terms of environmental impact.

Among these key factors are:

- Size, weight, range of a vehicle
- Engine power / performance
- Engine type of ICEVs and applied emission control measures
- Fuel / energy carrier type and its production pathway
- Material composition of a vehicle, and its source (virgin/recycled)
- Use (km/year) and use pattern (urban/rural/highway)
- Driving style / driving dynamics
- Weight, chemistry, capacity and production method of the battery

This wide range of variables demonstrates the difficulty to compare vehicles using different drivetrains and fuels. The range of an electric vehicle is, depending on the assumed battery capacity, usually smaller than that of an ICE vehicle. Also, an electric vehicle may be heavier because of the weight of the battery, and therefore require more energy for acceleration – although this is in part offset by brake energy recovery. Using free to define values for key parameters, the model allows to consider the most relevant of these.

Life Cycle Assessment (LCA)

The work resulted in a life-cycle assessment of greenhouse gases from ICEVs and EVs. The life-cycle assessment is composed of well-to-tank emissions, tank-to-wheel emissions and vehicle life cycle emissions (see next paragraphs).

The contribution to the climate change was calculated using the Global Warming Potentials (GWPs) in the Fifth Activity Report of the IPCC [IPCC, 2013]. Functional unit: Providing personal transportation over a distance of 1 km.

Tank to Wheel Assessment

Energy consumption and vehicle direct emissions are dependent on the size of the vehicle, engine technology, region of use, driving style, condition of the vehicle, temperature and other factors. The model allows the user to define the key parameters. Vehicles will be categorized per the following table.

Table 1: Vehicle segments and energy carriers

Vehicle type (segment)	Drivetrain
Small (A/B)	petrol ICEV / diesel ICEV / BEV / PHEV
Standard (C/D)	petrol ICEV / diesel ICEV / BEV / PHEV
Luxury (E/F)	petrol ICEV / diesel ICEV / BEV / PHEV
SUV	petrol ICEV / diesel ICEV / BEV / PHEV

For each category, the user is free to define a lifetime mileage as well as a representative use pattern, expressed as the shares of urban/rural/highway driving. Some standard driving patterns are included, as well as the NEDC and WLTP test cycles, whereby the flexibilities are partially accounted for.

The vehicle lifetime and the distribution among urban rural and highway driving both have a significant impact on the environmental impact per kilometer of each vehicle type.

The tank to wheel assessments for ICEVs were based on the SR6 report [Ligterink, 2016] and a general understanding at TNO of the factors that influence the energy consumption of a vehicle. For the present project, the tank to wheel assessment is extended for electric and plug-in electric vehicles, using component efficiency factors provided by Chalmers University and VUB. For plug-in hybrid vehicles, an estimation is made of the percentage of kilometers driven electrically. This was done based on actual data for different models with different battery capacities. More information about the tank to wheel modelling is provided in the full report.

Vehicle Life Cycle

The production and demolition and recycling of vehicles is covered from mining of raw materials to delivery of the vehicle, and from scrapyard to recycling facilities. Data for the various materials and processes were collected for European averages from the Ecoinvent 3.3 database, and validated against existing LCA literature. This should allow a high degree of comparability as Ecoinvent is the most common primary source used in the literature. If possible the sources underpinning the LCAs are used directly to enable consistent modelling of environmental impact over different vehicle sizes, weight and battery capacities.

A practical approach is followed and where available, worldwide average data will be used. Insofar single materials or processes influence the total greenhouse gas emission or air pollutant emission; a sensitivity analysis will be made to show the robustness. If needed, the analysis is fine-tuned. If possible, information is collected about which part of the emissions takes place in urban areas. The calculation of external costs makes it possible to distinguish the effect.

Consolidation as Input for the Configuration of the LCA (GHG) Model and Analysis

The collected literature data is used as input for the LCA (GHG) model which has been developed to determine the GHG emissions for the vehicle life cycle GHG emissions.

Each study has its own scope and depth. Even LCA studies reported in accordance with the ISO 14040/14044 standards and other guidelines such as the ILCD Handbook can differ significantly amongst each other. Moreover, vehicles discussed in one source may not have the same specified functionality, such as load capacity for trucks, as vehicles in another source.

The aims of the consolidation are:

- To create consistent vehicle data sets for well-to-tank, tank-to-wheel and vehicle life cycle data.
- To create vehicle cases with comparable functionality/performance among BEVs, PHEVs and ICEVs.
- To develop a parametrized model for structuring the comparison of environmental impacts for vehicles in different segments.
- To translate data obtained from literature into input data for the model.
- To calculate impacts for several scenarios with respect to the input data and specifications of the compared vehicles.

The consolidation has been done by matching literature data. The rules to scale or otherwise interpret the data to perform the matching, are derived from the variety of literature. A model will be built that contains the derived rules, for example the relation between environmental impact and the weight of a vehicle (excluding battery), or the relation between a fuel's direct emissions and the impact of its production. The relation between vehicle use and fuel consumption will be included as well, based on TNO experience with measurements in this field.

Next, vehicle cases were constructed for both passenger cars that fulfil matching minimum requirements in terms of power to weight ratio and minimum range, as described above.

11.4 Results

The objective of Task 31 of the IEA Hybrid and Electric Vehicle Technology Collaboration Program is to provide stakeholders with credible LCA based information related to cars. This information enables users to determine the impacts on greenhouse gas emissions of different vehicle configurations and use profiles and fuels. The initial set up was to provide a set of data on cars illustrating these impacts. Although this would provide the required comparisons, these would be one time analyses and almost by definition differ from published results. To realize the flexibility needed to analyse and compare for example GHG life cycle data published from different sources, a model has been made allowing the user to define and configure cars as needed. The objective of the model developed is not to predict the future, but to investigate the impacts of possible future pathways and thus enable policymakers to make fact based decisions.

Using an easy to use input panel as shown in the figure below, the user defines the car to be analysed using pre-set choices (for example for the choice of drivetrain or car class) or free value fields (for example for vehicle weight or the battery capacity). The model uses peer reviewed and open LCA data as well as data published in EU Framework publications.

Credible data

In the final report it is explained in detail how the LCA approach has been applied and which sources for the data have been used. The LCA related data are sourced from multiple scientific publications including several scientific meta studies where a very large number of publications (dozens or more) were being evaluated. The modular approach in the model facilitates to update LCA data when available. Especially in the battery related areas the impacts can change significantly with changing chemistries, manufacturing processes, scale and locations. Our model can accommodate specific knowledge for all the relevant parameters and supplies bestguess defaults where parameters are unknown. The accuracy of the calculation can be demonstrated by replicating literature results. For other data like the use of the vehicle, test conditions and results, data which was already published in EU related framework projects or commissioned work has been used. Credibility and transparency of the data used is a requirement for having a credible tool.

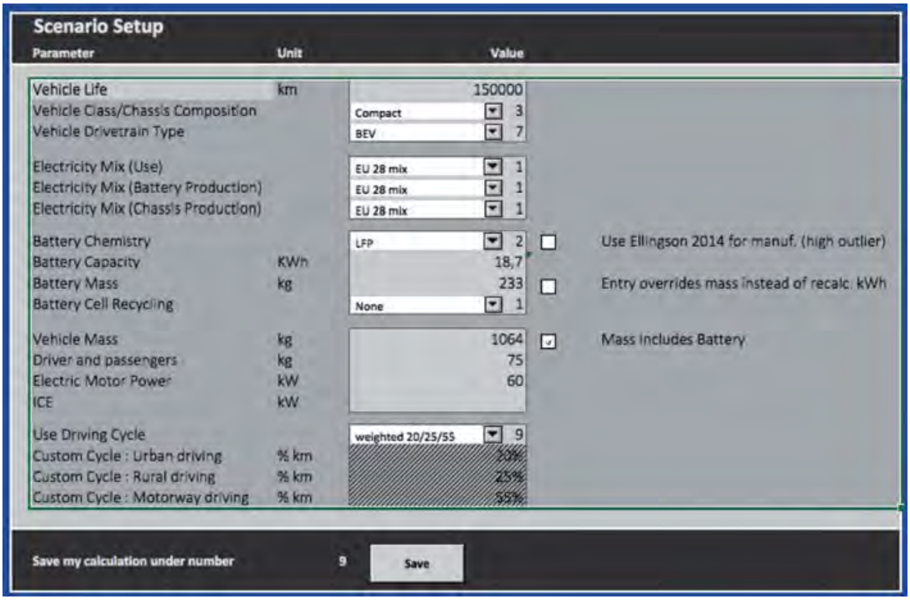


Figure 3: Task 31 model user interface to design cars for GHG LCA analyses

Analysing Data Published by OEMs and Comparing "Apples to Apples"

An important function of the Task 31 model is to make analyses looking at the impacts of certain vehicle, use, and fuel parameters to study the impacts. Examples of these are given in the full report and some observations from these analyses are listed below. This enables the user for example to look at the impact of greening of the electricity produced in the EU, the impacts of higher battery capacities used in vehicles, higher battery densities, different use cases and so on.

Observations Made From Task 31 Model Analyses

- For a standard car, the life time GHG emissions of a BEV are approximately 50 % lower than those of an average ICEV using the EU electricity mix.
- A BEV using renewable energy for recharging has close to 90 % lower life cycle GHG emissions than its ICEV equivalent.

- The choice of the lithium-ion battery chemistry used has only a marginal impact on the life cycle GHG emissions of a BEV.
- In Urban driving, the life cycle GHG emissions of BEV (standard car) are about 30 % of those of an average ICEV when using the EU-mix electricity. When using renewable energy to charge the vehicle the GHG emissions are 12 times lower than those of the equivalent ICEV.
- A light-weight REEV driving 80 % electric has only 10 % higher life cycle GHG emissions than a BEV (standard car). A PHEV driving 30 % electric has GHG emissions which are slightly higher than those of the equivalent ICEV.
- For luxury segment cars, a PHEV driving 30 % electric (EU-mix) has about 20 % lower GHG life cycle emissions than the average ICEV in that segment. A luxury BEV has 50 % lower GHG emissions than the ICEV equivalent when using EU mix electricity, 90 % lower when using renewable energy. For a luxury car, the GHG savings of a BEV using renewable energy are 270 grams per kilometer compared to an ICEV.

Using the Task 31 Model (T31) to Analyse and Compare Published GHG LCA Life Cycle Emission Data

The T31 model is to analyse and compare published LCA data in an “apple to apple” comparison. This makes it possible for the user to evaluate the credibility of the published data or to see what changing parameters will do with the LCA impacts of that car model. If the model is further developed it has the potential to become a reference model for LCA analyses.

Published data from VW Golf, VW Up!, Nissan LEAF and Nissan Pulsar have been compared with the T31 model analysis. From these comparisons, several observations have been made:

- Published data are very difficult to compare which each other as different assumptions are made for example for vehicle mileage, electricity GHG footprint, test method or real driving fuel consumption.
- Large differences are observed for the GHG emissions related to vehicle manufacturing, unclear whether this is related to inclusions or not of recycling (impacts), differences in assumptions for the manufacturing impacts on the components or the energy footprint. For the VW data, the OEM vehicle emissions are much higher than the T31 model as well as third party Spritmonitor data.
- Model T31 can be useful in making data from different sources comparable.
- A systematic analyses and comparison of OEM and other third party published data will probably be of high interest to policy makers and other

stakeholders as it will provide more transparency on these published data and make them comparable.

11.5 Next Steps

Task 31 has demonstrated that the modelling of the GHG LCA impacts is possible and can be very useful. To make it a “tool of reference”, the model needs to be reviewed by third parties and additional effort is needed to make it more robust and credible. This is of the highest priority. The increasing importance of having reliable and comparable GHG emission data for cars provide a good opportunity for this as it is a clear need which currently cannot be fulfilled. To enhance the credibility additional LCA expert stakeholders can be involved in the work and a continuous effort to maintain the (LCA) data used up to date needs to be defined. A separate proposal will be defined on how this work can be defined, organized and executed. To make the model more accurate and applicable for a wider variation in vehicle characteristics, it is recommended to make the following improvements:

- Verification and calibration of real world fuel consumption calculation with measurement data
- Adding specific LCA data for the parts production and assembly of vehicles
- Review and further detail the battery module as this will be one of the most important items for future developments and it is also an item about which a lot is published
- Adding vans (Light Commercial Vehicles) as this is an important vehicle category for policymakers in cities and logistics companies
- Adding other additional “alternative fuels” like natural gas, synthetic fuels and biofuels as options for comparison of the impact of GHG life cycle emissions
- An “energy” module and other modules like air quality (NOx, PMs) can be developed and added.

11.6 Contact Details of the Operating Agent

For further information, please contact the Task 31 OA:

Mr. Bert Witkamp
Valuad
Rue de Maestricht 12
4600 Visé, Belgium
E-Mail: b.witkamp@valuad-expert.com

12 Small Electric Vehicles (Task 32)

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

12.1 Introduction

Pressure on reconsidering transport options is increasing. Growing global population, a global motorization rate that rose by 21 % between 2005 and 2013[7], 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 the fulfilment of targets. The 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[8]. 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 empty weight up to 1,200 kg. Examples for this type of vehicle are the smart ED or Mitsubishi i-MiEV.

12.2 Objectives

The objective of this Task is to promote a wider commercialization, acceptance and a further development of small electric vehicles (SEVs) by collecting and sharing pre-competitive information, exchange about framing conditions, best

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

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

practices and ideas, how to develop the market conditions and mobility concepts further. In this sense, the objectives in short are twofold:

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 focuses 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.

12.3 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 confidential if asked for by participants.

In addition to 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

For this purpose, a flyer is prepared which describes 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 contributions of some kind are expected.

12.4 Results

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

- RAK-E: A concept LEV from Opel
- EU regulations relevant for small four-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

The **second Task 32 workshop** “Market Conditions and Mobility Concepts” took place in Brussels, Belgium, on September 18, 2017 at the German Aerospace

Center (DLR) Brussels Office. The main topic of the workshop was the exchange on common interests and future activities of LEV lobby organisations and key stakeholders.
The **third Task 32 workshop** “Accelerating SEV uptake, is present diversification in regulatory requirements in different markets a positive attribute or is harmonisation required?” was held in Rotterdam, The Netherlands, on November 20, 2017. The workshop focussed on vehicle manufacturers from six European countries and one from the United States.

Amongst others, the main conclusion especially on ultra-lightweight vehicles were:

- The regulation was the primary focus for the in-use phase, primarily.
- Consensus that there is limited consolidation in this area and this is detrimental.
- Attendees look for support to understand how the regulatory landscape will develop.
- Requirements for comprehensive assessment of regulatory landscape

12.5 Next Steps

- Development of a database with L-category regulation.
- Next workshop about “Policies for mobility concepts with SEVs: viewpoints of cities and municipalities, mobility planner and regulators” planned to take place at the end of May 2018 in Valladolid, Spain.

12.6 Contact Details of the Operating Agent

For further information, please contact the Task 32 OA:

Mr. Stephan Schmid
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Pfaffenwaldring 38-40
D-70569 Stuttgart, Germany
Phone: +49 711 6862 533
E-Mail: Stephan.Schmid@dlr.de

13 Battery Electric Buses (Task 33)

Members: Austria, Canada, Germany, Republic of Korea, Spain

13.1 Introduction

Battery Electric Bus Systems have been drawing increasing 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 an all-day operation 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, e.g. 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 a battery electric buses an evaluation and analysis of key aspects from 60 electric bus projects is ongoing worldwide (e.g. charging strategies, electric energy storage systems). 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.

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)

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

"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)

13.2 Objectives

The objective of the Task 33 (2016 – 2019) is to analyze and assess the current state of technology & demonstration experiences of battery electric buses. This covers the bus technology on one hand, 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 analyses 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 close cooperation with the relevant stakeholder of the three focus groups:

1. Provider of public transportation services
2. System and technology provider
3. Research institutions

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

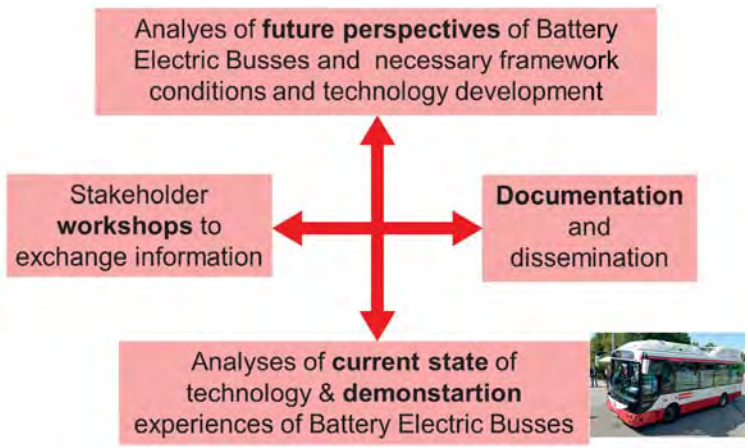


Figure 2: An overview of objectives in Task 33

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 visit
- 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 glossy brochure of results
- Presentations and contribution at conferences

13.3 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. provider of public transportation services, system and technology provider, research institutions. The organization of workshops with participation from 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 application.

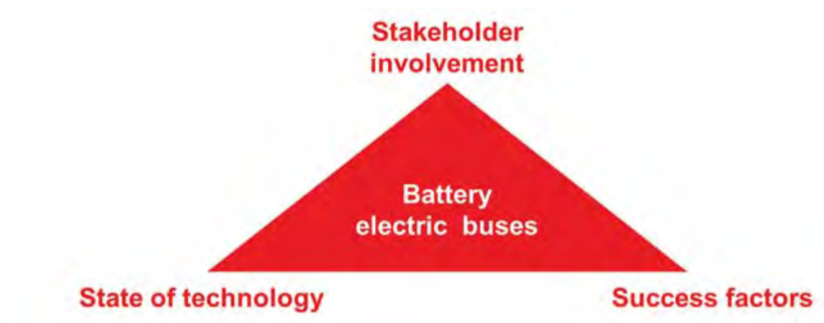


Figure 3: Working method

13.4 Results

Numerous innovative projects have been initiated in recent years, especially in central Europe, e.g. 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[9].

[9] 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 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)

In this analysis the electric bus systems are characterized by the

- types of electric buses (Fig. 5),
- charging technologies (Fig. 6) and
- charging strategies (Fig. 7).

The main focus of the assessment is on battery electric buses, Plug-in hybrid buses with ICE and (Hybrid) Trolley buses.

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 8).

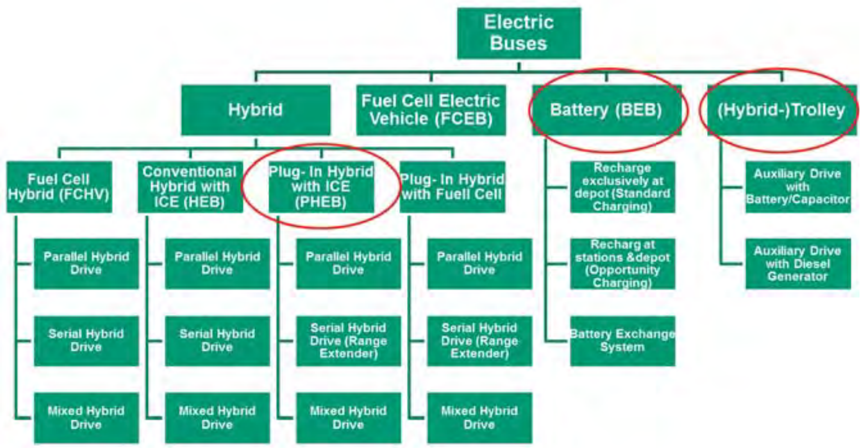


Figure 5: Types of electric buses

Figure 6: Charging technologies

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. In Figure 9 the bus types & lengths and their charging strategies in these demonstration projects are shown. Most of them are a combination of battery electric buses and opportunity fast charging. By focusing on 12 m battery electric bus the energy consumption is about 1.5 kWh/km. The Lithium ion battery costs are in the range of 300 – 400 €/kWh.

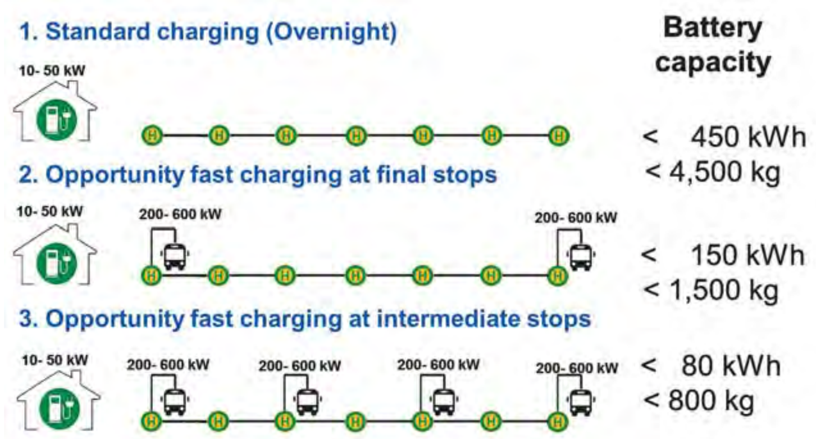


Figure 7: Charging strategies

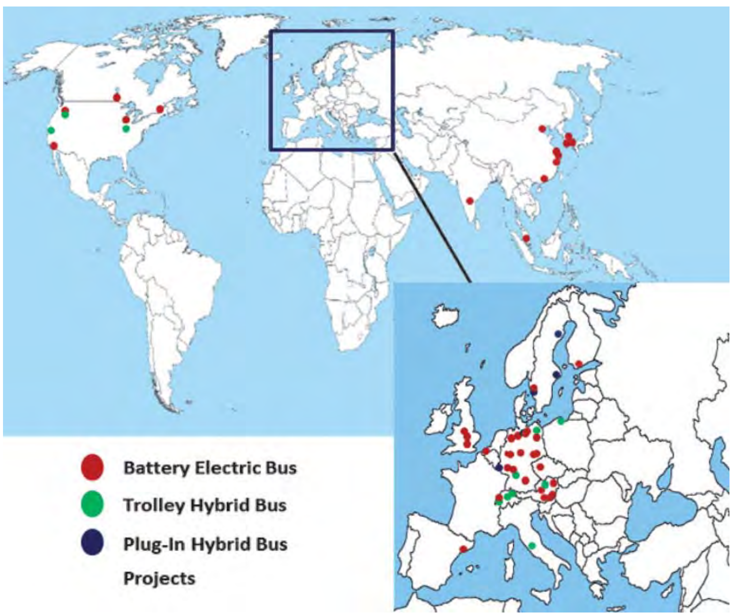


Figure 8: Initial analysis of 58 electric bus demonstration projects worldwide

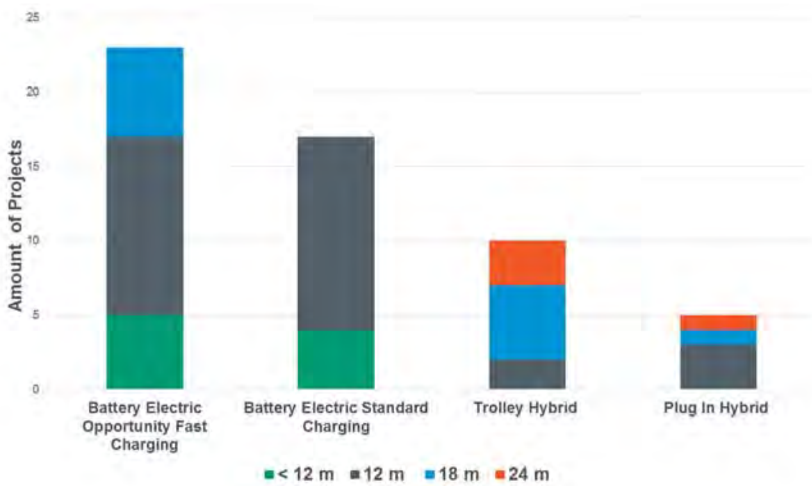


Figure 9: Bus types & lengths and their charging strategies

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

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.

13.5 Next Steps

The expert workshop „State of Technology of Battery Electric Buses“ will take place in Austria 2018, 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: *Battery Electric Buses in Urban Public Transport – Current Demonstrations and Future Opportunities*, International Conference on Electric Mobility in Systems of Public Transport, Santiago, Chile, May 10 – 11, 2017.
- Paper & poster: 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.
- Visual presentation and paper: *Successful Demonstration of Battery Electric Buses Worldwide – A Game Changer in Urban Public Transport*, Transport Research Arena TRA 2018 in Vienna, April 16 – 19, 2018.

13.6 Contact Details of the Operating Agent

For further information, please contact the Task 33 Operating Agent:

Mr. Gerfried Jungmeier
JOANNEUM RESEARCH Forschungsgesellschaft mbH
LIFE – Centre for Climate, Energy and Society
Waagner Biro Strasse 100
A-8020 Graz, Austria
Phone: +43 316 876 7630
E-Mail: gerfried.jungmeier@joanneum.at

Acknowledgement
The work of the Austrian participation (2018 – 2019) is financed by the Austrian Climate and Energy Fund and the FFG.

14 Batteries (Task 34)

Members: Canada, Germany, Sweden

14.1 Introduction

Task 34 was formally approved by the Executive Committee (ExCo) at its meeting in Amsterdam in April 2016. At that meeting, about six countries informed the committee that they planned to join, and a similar number expressed strong interest in the Task. The scope of Task 34 is to focus on issues related to battery safety. Within the area of safety, the Task expects to address topics ranging from basic cell phenomenon to battery safety issues in vehicular systems. In 2017, this task was inactive due to unforeseen personal circumstances of Operating Agent (OA).

The ExCo recently agreed to broaden this Task beyond battery safety and include 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). A new Operating Agent will be established.

14.2 Objectives

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

14.3 Working Method

The working method has been revised to reflect the change in scope and OA. The primary focus of this Task will now be on collecting and reporting information on EV battery performance and cost state-of-the-art, and on R&D being conducted worldwide through country to country information exchange and public meetings.In this context, this report will focus on reporting R&D being conducted by the Vehicle Technologies Office (VTO) of the Department of Energy (DOE) on advanced transportation technologies which is of particular interest. Technologies supported by the VTO include electric drive components such as advanced energy storage devices (batteries and ultracapacitors), power electronics and electric drive motors, advanced structural materials, energy efficient mobility systems, advanced combustion engines, and fuels.

VTO is focused on early stage funding, high-reward/high-risk research to improve critical components needed for more fuel efficient (and consequently, also cleaner-operating) vehicles. A major VTO objective is to enable U.S. innovators to rapidly develop the next generation of technologies that achieve the cost, range, and charging infrastructure necessary for the widespread adoption of PEVs. An important prerequisite for the electrification of the nation's light duty transportation sector is the development of more cost-effective, longer lasting, and more abuse-tolerant plug-in electric vehicle (PEV) batteries. One of the ultimate goals of this research, and currently a strong trend in vehicle electrification, is an EV which can provide the full driving performance, convenience, and price of an internal combustion engine (ICE) vehicle. To achieve this, VTO has established the following overarching goal:

"*VTO supports early-stage R&D to identify new battery chemistry and cell technology with the potential to reduce the cost of electric vehicle batteries by more than half to less than 100 USD/kWh and increase the range to 300 miles while decreasing the charge time to less than 15 minutes by 2028*."

The cost target supports a levelized cost of driving (LCD) of a 300-mile BEV at 0.28 USD/mile, which is comparable to that for future ICEs at 0.27 USD/mile. The ultimate cost goal for a 300-mile BEV battery is 80 USD/kWh, which achieves an LCD of 0.26 USD/mile.

During the past year, VTO continued R&D support of PEVs such as plug-in hybrid vehicles, extended range electric vehicles, and all-electric vehicles (EVs), as well as some conventional hybrid vehicle technologies, particularly the 12 volt start/stop hybrid. VTO competitively awards funding through funding opportunity announcement (FOA) selections. The projects are fully funded through the duration of the project in the year that the funding is awarded. Directly-funded work at the national laboratories (also awarded competitively through a lab-call process) is subject to change based on annual appropriations.

Stakeholders for the VTO R&D activities include universities, national laboratories, other government agencies and members of the industry including automakers, battery manufacturers, material suppliers, component developers, private research firms, and small businesses. VTO works with key U.S. automakers through the United States Council for Automotive Research (USCAR) – an umbrella organization for collaborative research consisting of the Fiat Chrysler LLC, the Ford Motor Company, and the General Motors Company. Collaboration with automakers through the partnership known as U.S. Driving Research and

Innovation for Vehicle Efficiency and Energy Sustainability (US DRIVE) attempts to enhance the relevance and the potential for success of the research portfolio.

To quantify the improvements needed to accelerate the large-scale adoption of PEVs and HEVs, performance and cost targets have been established. Some sample targets for EV batteries are shown in Table 1, both at cell level and at system (pack) level.

Table 1: Subset of EV requirements for batteries and cells

Energy Storage Goals (by characteristic)	Pack Level	Cell Level
Cost @ 100k units/year (kWh = useable energy)	100 USD/kWh*	75 USD/kWh*
Peak specific discharge power (30s)	470 W/kg	700 W/kg
Peak specific regen power (10s)	200 W/kg	300 W/kg
Useable specific energy (C/3)	235 Wh/kg*	350 Wh/kg*
Calendar life	15 years	15 years
Deep discharge cycle life	1000 cycles	1000 cycles
Low temperature performance	>70 % useable energy @C/3 discharge at -20°C	>70 % useable energy @C/3 discharge at -20°C

*Current commercial cells and packs not meeting the goal

14.4 Results

During the past year, due to circumstances beyond control, no battery safety meetings or workshops could be conducted by this Task. However, an assessment of current battery R&D in the US has continued and its findings are summarized here. This R&D is primarily supported by the VTO and conducted in collaboration with industry and national laboratories. Detailed information on individual projects is available at the website for the VTO annual progress report for batteries.[10]

Current Battery R&D

Batteries R&D efforts include activities ranging from focused fundamental materials research to prototype battery cell development and testing. It also includes R&D on beyond lithium-ion (BLI) and next-gen materials and cell

[10] U.S. Department of Energy, Office of EERE, Vehicle Technologies Office, FY 2017 Annual Progress Report for Batteries, https://www.energy.gov/eere/vehicles/annual-progress-reports, retrieved April 27, 2018.

components, on synthesis and design, and on ways to address high cost – as listed below.

Advanced Cell and Battery Research and Development

The VTO advanced cell and battery R&D activity focuses on the development of robust battery cells and modules to significantly reduce battery cost, increase life, and improve performance. It includes the following project areas:

- United States Advanced Battery Consortium (USABC)-supported battery development & materials R&D (15 projects)
- Advanced processing (nine projects)
- Computer-aided engineering for batteries (CAEBAT) (eight projects)
- High-energy, long-life lithium-ion battery (one project)
- Extreme fast-charging (one project)
- Small business innovative research (SBIR) (multiple Phase I and Phase II projects)

A large part of this effort occurs in partnership with the automotive industry, formalized via a cooperative agreement with the USABC. In FY 2017, VTO supported 15 cost-shared contracts with developers to further the development of PEV and HEV batteries and battery components.

Figure 1 shows an Envia 11 Ah capacity pouch cell undergoing teardown and failure analysis, developed in one of those projects.

Figure 1: Images of an 11 Ah capacity pouch cell undergoing teardown and failure analysis (Source: private)

Advanced Materials Research

The advanced materials R&D activity addresses fundamental issues of materials and electrochemical interactions associated with rechargeable automotive batteries, conducted by researchers from various national labs, universities, and industry. It develops new/promising materials and it makes use of advanced material models to discover such materials (and their failure modes), utilizing scientific diagnostic tools and techniques to gain insight into the failure process. It spans mainly two general areas – “next gen” chemistries (which employ an alloy anode and/or a high voltage cathode) and beyond lithium-ion (BLI) chemistries (which employ a lithium metal anode). The next generation lithium-ion battery R&D area’s goal is to advance material performances, designs, and processes to significantly improve performance and reduce the cost of Li-ion batteries using an alloy or intermetallic anode and/or high voltage cathode. Specific areas of investigation include high-energy anodes (e.g., those containing silicon or tin), high voltage cathodes, high voltage and non-flammable electrolytes, novel processing technologies, high-energy and low-cost electrode designs, and certain other areas. The beyond Li-ion battery technologies R&D includes solid-state technology, lithium metal systems, lithium sulfur, lithium air, and sodium-ion.

The main areas of focus include new methods to understand/stabilize lithium metal anodes; Li polysulfides to enable the use of sulfur cathodes; and developing electrolytes for lithium air and lithium sulfur cells. These systems offer further increases in energy and potentially reduced cost compared to the next-gen lithium-ion batteries. VTO is investigating the issues and potential solutions associated with cycling metal anodes. The activity also includes 13 Lithium sulfur R&D projects, three Lithium-air batteries R&D projects and two sodium-ion batteries R&D. In one of its projects (based at the University of Maryland), first principles calculations were applied to investigate the interface stability between garnet and formed Li-Al alloys (Figure 2).

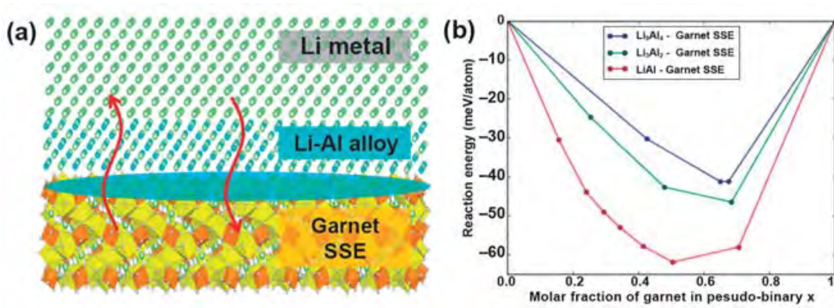


Figure 2: Calculated mutual reaction energy, ΔED, of garnet and Li-Al alloy interfaces

Battery Testing, Analysis, and Design

The Battery Testing, Analysis, and Design activity supports all other battery R&D activities. It includes conducting testing (for performance, life and abuse) for contract deliverables, laboratory- and university-developed cells, and benchmark systems from the industry; thermal analysis, thermal testing and modeling; cost modeling; other battery use and life studies; and the recycling of core materials. Battery technologies are evaluated according to USABC-stipulated battery test procedures. Benchmark testing of an emerging technology is performed to remain abreast of the latest industry developments.

As part of this, the *cost assessments and requirements analysis* activity includes an ANL project on developing the performance and cost model BatPaC. This ANL model, developed over time and rigorously peer-reviewed, is used to design automotive Li-ion batteries to meet the specifications for a given vehicle, and estimate the cost of manufacturing it. An analysis using BatPaC compared the estimated costs of cells and packs for different electrode chemistries (Figure 3 shows the pack costs).

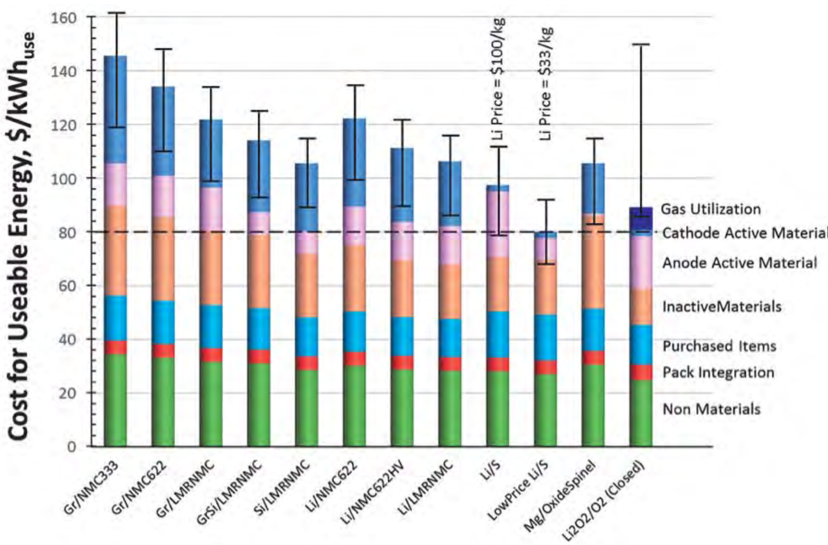


Figure 3: Estimated costs of cells in automotive battery packs with different combination of electrodes. The packs are rated for 100 kWhTotal (85 kWh useable), 300 kW, 315 V, 168 cells, and produced at a plant volume of 100K packs/year

Long-term Battery R&D: Battery500 Innovation Center

Lithium (Li)-ion batteries play a critical role in modern day technologies, but their specific energy (Wh kg^{-1}) and energy density (Wh L^{-1}) are approaching the maximum practically achievable values based on existing manufacturing processes with the conventional cathode and anode materials. The *Battery500 Innovation Center* is a combined effort by a team of four National Labs (PNNL, INL, BNL and SLAC) and five universities (University of Texas-Austin, Stanford University, Binghamton University, University of Washington, and University of California, San Diego) whose goal is to develop commercially viable Li battery technologies with a cell level specific energy of 500 Wh/kg while simultaneously achieving 1,000 deep-discharge cycles. The consortium keystone projects focus on innovative electrode and cell designs that enable the maximization of the capacity of advanced electrode materials. Two battery chemistries, high nickel content lithium nickel-manganese-cobalt oxide (high-Ni NMC, Ni>60 %), coupled with a Li metal anode, and Li-S chemistry, indicate a potential to achieve an energy density of at least 500 Wh/kg. The Li anode combined with a compatible electrolyte system and two cathodes – one high NMC and another sulfur – is to be studied and developed to reach a high energy density. The consortium will work closely with the R&D community, battery/materials manufacturers and end-users/OEMs to ensure that these technologies align well with industry needs and can be transitioned to production.

Battery Recycling and Sustainability

Battery recycling and sustainability projects investigate the material and energy flows pertaining to battery material production, battery manufacturing and assembly, and battery recycling, to characterize the life-cycle energy and environmental burdens of LIB. By interacting with battery manufacturers and recyclers, researchers obtain primary data on the energy and water use for commercialized LIB production and recycling, and identify environmental impact drivers, production bottlenecks, and other barriers, for LIB production and recycling. The *recycling and sustainability* activity involves studies of the full life-cycle impacts and costs of Li-ion battery production/use; cost assessments and impacts of various recycling technologies; and the available material and cost impacts of recycling and secondary use. It includes three projects, all based at the ANL:

- Life cycle assessment of Li ion batteries
- Battery production and recycling materials issues
- Process and cost modeling of recycling activities

Challenges to be faced for Li-ion battery recycling are shown in Table 2, along with suggested R&D areas for how they can be addressed. Detailed understanding of recycling processes will be necessary to maximize material recovery.

Table 2: Challenges for Li-Ion Battery Recycling

Challenge	R&D Needed to Address
Long-term performance of some recycled materials is not proven	Long-term testing
There is no standard chemistry or design	Convergence of chemistries and designs, Flexible processes, Design for recycling Automation
There are no regulations, so restrictive ones could be imposed	Fashioning regulations that will protect health and safety without hindering recycling
Many of the constituents have low market value	Process development to recover multiple high-value materials
Low value of mixed streams, prevention of fires and explosions	Effective labeling and sorting

14.5 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 schedule for this meeting is not yet decided.

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.

14.6 Contact Details of the Operating Agent

For further information, please contact the Task 34 OA:

Mr. David Howell
Vehicle Technologies Office
United States Department of Energy
1000 Independence Avenue SW
Washington, DC 20585, USA
E-Mail: david.howell@ee.doe.gov

15

Fuel Cell Electric Vehicles (Task 35)

Members: Austria, Republic of Korea

15.1 Introduction

The motivation of Task 35 is related to the transport system that has significant impacts on the environment, spending between 20 % and 25 % of the world's energy consumption and producing carbon dioxide emissions. The majority of the emissions are created by the direct burning of fossil fuels. Greenhouse gas emissions due to transport are increasing faster than any other energy using sector. Road transport is also a major contributor to local air pollution and climate change. Fuel cell vehicles (FCVs) have the potential to significantly reduce our dependence on fossil oil and lower harmful emissions that contribute to the climate change. FCVs run on hydrogen gas rather than gasoline and emit no harmful tailpipe emissions. Several challenges must be overcome for them to be competitive with conventional vehicles, but their potential benefits are substantial. FCVs run on hydrogen can be representing as one of the sustainable mobility modes. The interest in hydrogen as an alternative fuel descended from their ability to power fuel cells in zero-emission electric vehicles, their potential for domestic production and the fuel cell's potential for high efficiency and the easier to overcome distance anxiety unlike with electric vehicles. In fact, a fuel cell coupled with an electric motor is two to three times more efficient than an internal combustion engine running on gasoline.

However, nowadays, FCVs still have limitations because only very few hydrogen stations are available. Then, the major manufacturers such as Hyundai and Toyota, for example, are currently offering their production fuel cell electric vehicles for sale or lease to customers living in markets where hydrogen fuel is available. Therefore, it will be very useful to look in detail at FCVs as a sustainable mobility representative and its energy infrastructure such as its technology concepts, prospects, research needs, market condition, and hydrogen stations (international differences and best practices).

15.2 Objectives

The objectives of Task 35 are to analyze the technology for FCVs and hydrogen stations and to disseminate the policy of FCVs and hydrogen stations. Furthermore, to share the information about related technology among the stakeholders through workshops and conferences and to document and disseminate these to related topics, such as mentioned below.

15.3 Working Method

The main approach of Task 35 is to collect and exchange information, opinions and concerns in workshops and to disseminate the results amongst stakeholders and policymakers. Three major topics are distinguished:

- FCVs concepts: technologies, prospects and research needs.
- Hydrogen station for FCVs concepts: Technologies, prospects and research needs.
- Market condition for FCVs and hydrogen station: international differences and best practices.

The workshops aim to attract professionals from research, enterprises and policy makers, depending on the individual topics. An international survey distributed to a wider audience complements the workshops. Major insights and results together with other findings from desktop research will be published at conferences and in scientific journals.

Utilizing the existing HEV TCP framework, Task 35 will answer the main key questions related to FCVs research and development, e.g.:

- What are technologies to improve FCVs, their efficiency, range, comfort and how to lower their costs?
- Which barriers exist for bringing more FCVs to the market?
- What safety concepts for FCVs exist, how efficient are they and where are options for improvement?
- Safety for hydrogen stations.

The results of the Task are shared with the public as agreed with the workshop participants. Literally citations of companies' representatives might be excluded by gentleman's agreement. The presentations and discussions within the workshops are shared by the participants. 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.

15.4 Results

At the current time, there are no results that can be reported.

15.5 Next Steps

Next workshop will be about “Fuel cell vehicles (FCVs) and technologies”.

15.6 Contact Details of the Operating Agent

For further information, please contact the Task 35 OA:

Mr. Ocktaeck Lim, Ph.D. Professor,
School of Mechanical and Automotive Engineering
University of Ulsan
93 Daehak-ro, Nam-gu,
44610 Ulsan
Republic of Korea
Phone: +82-52-259-2852
E-Mail: otlim@ulsan.ac.kr

16 Extreme Fast Charging (Task 37)

Members: United States

16.1 Introduction

Battery electric vehicles (BEVs) have continued to increase their market share worldwide, with advantages in efficiency, low operating costs, and emissions. However despite decreases in cost within the BEV powertrain and significant improvements in drivability and performance, the BEV market still accounts for a small share of new vehicle sales annually. An identified gap to wider adoption of BEVs is the ability to refuel quickly or to fast charge. The majority of BEV recharging is done at home, but data shows that having access to public direct current (DC) fast chargers can have a big impact on BEV utility from a consumer perspective. Studies have shown that in areas where drivers have access to 50-kW or 120-kW fast charge stations, annual electric vehicle (EV) miles traveled increased by over 25 %, even in cases where fast charging was used for 1 % to 5 % of total charging events[11,12]. Having access to these fast charge stations can help alleviate the "range anxiety" commonly cited as a reason for consumer hesitation to buy a BEV.

Based on these trends, even higher power charging stations could drive further BEV adoption. To address the fast charge barrier, charging at power levels up to and even exceeding 400 kW, often referred to as extreme fast charging (XFC), have been proposed. This task focuses on XFC technology, gaps, installations, and operations.

16.2 Objectives

Task 37 is focusing on the following objectives: investigating station siting – what factors are considered (i.e. space requirements, city center, community/corridor,

---

[11] Lutsey, N., S. Searle, S. Chambliss, and A. Bandivadekar, 2015, "Assessment of Leading Electric Vehicle Promotion Activities in United States Cities", International Council for Clean Transportation, July 2015.

[12] McCarthy, Michael, 2017, "California ZEV Policy Update", SAE 2017 Government/Industry Meeting, Society of Automotive Engineers, January 25, 2017, Walter E. Washington Convention Center, Washington, DC, conference presentation.

etc.); quantifying the costs of installation – including physical site location and infrastructure costs as well as costs associated with the charging equipment; documenting grid connection details for current and planned installations, including any co-located renewable generation or energy storage; understanding the implications of XFC on battery design, performance, and cost; documenting pay structures and/or consumer interfaces for payment; and studying consumer education methods and topics.

It is generally accepted that for XFC to be successful, charging stations should be able to recharge a BEV in less than 10 minutes and provide approximately 200 additional miles of driving. However, this introduces a host of new challenges that need to be addressed. As a result, it is expected that packs designed to meet XFC will initially be significantly more expensive than BEVs optimized for current charging technology. From the battery cell to the power grid these 400-kW chargers are connected to, this research outlined in the report discusses issues that need to be addressed at each level in order to implement a 400-kW charging network.

16.3 Working Method

Task 37 is working to finalize member countries at this point, and is currently reporting out XFC related activities and reports from the United States. The task plans to organize a series of workshops scheduled in conjunction with dedicated conferences and HEV TCP Executive Committee (ExCo) meetings. The workshops will gather a variety of stakeholders coming from academia, industry and public authorities. Workshops may also include site visits to XFC installations, providers, or manufacturers. The purpose is to identify trends and scenarios, to analyze challenges and opportunities, and to deliver conclusions for future actions. The XFC research findings so far are summarized below.

For XFC to be successful, stations should be able to recharge BEVs in less than 10 minutes and provide approximately 200 additional miles of driving for each vehicle. However, this introduces a host of new challenges that need to be addressed. As a result, it is expected that packs designed to meet XFC will initially be significantly more expensive than those for BEVs optimized for current charging technology.

16.4 Results

16.4.1 U.S. DOE Study on XFC Technology Gap Assessment

Synopsis

A recent study[13], funded by the U.S. DOE, investigated the technical gaps and challenges posed by XFC and divided them into three primary focus areas: batteries, vehicles, and infrastructure with economic considerations. A multi-national laboratory team consisting of Argonne National Laboratory (ANL), Idaho National Laboratory (INL), and National Renewable Energy Laboratory (NREL) engaged with industry stakeholders to identify barriers and opportunities for technology R&D solutions needed to achieve 400 kW charging power levels and combine the findings into a single document for governments and private industries to reference. Outcomes from this study could be used to inform the development of technical targets and research and development plans for stakeholders. Although the study is U.S.-focused, the findings should be applicable to other countries with mature automotive infrastructures. Many technical gaps and challenges for XFC have been identified which impact several key technology sectors such as automotive OEMs, battery manufacturers, codes and standards bodies, EVSE manufacturers and network operators, and utility suppliers. For XFC to be successfully implemented, these technology sectors need to foster new levels of collaboration and communication regarding technology intersections and overlaps. Results from each of the three focus areas (battery, vehicle, and infrastructure) are summarized below.

Summary Findings

Battery cost is often cited as a barrier to EV adoption. XFC could increase the cost of a cell by more than 90 %, with anode thickness being the primary cost driver. Within the battery cells, a bulk of the research identified centers around the anode and mitigating the onset of lithium plating and minimizing heat generation, which can lead to dramatic cell degradation and pose safety concerns. Heat generation in general is a known mechanism for electrochemical and mechanical battery material degradation. As such, thermal management of batteries when subjected to XFC protocols require R&D. Thermal management research coupled with robust battery management controls and charging protocols R&D will help achieve XFC while prolonging life.

[13] Howell, David, et al. "Enabling Extreme Fast Charging: A Technology Gap Assessment", Department of Energy, Office of Energy Efficiency Renewable Energy, 23 Oct. 2017, energy.gov/eere/vehicles/downloads/enabling-extreme-fast-charging-technology-gap-assessment.

For vehicles, higher voltage battery packs, up to 1000 V from conventional EV's 400 V systems, can drive much research in the electrical architecture of the vehicle and power electronics which support the electric drive system. Cybersecurity and interoperability of vehicle and EVSE communications is needed to ensure XFC capable vehicles, and legacy vehicles alike, can provide reliable transportation and not be disrupted by cybersecurity events or differences in charging equipment.

In infrastructure, conductive EV charging using a cord and plug require research in thermal management of the charger power electronics and charge cable. For wireless charging technologies, electromagnetic field shaping and shielding have the bulk of the R&D investment. XFC's intermittent demand for electricity could pose challenges to the electric grid's stability which raises concerns from utilities as a potential for cybersecurity vulnerabilities. Infrastructure sees the introduction of the largest and most broad base of stakeholders ranging from EVSE manufacturers and network operators to utility suppliers and regulators. Coordination and cooperation within this group of stakeholders is recommended in order for XFC to make it to market.

16.4.2 U.S. DOE Grid Interaction Tech Team (GITT) Meeting

Summary

On December 6, 2017, a U.S. DOE GITT meeting was held in Southfield Michigan, USA. The purpose of the meeting was to understand perspectives from EVSE makers and utilities on technologies, infrastructure, business models, and integration issues of implementing extreme fast chargers. It was attended by 26 participants from the various member countries.

Participants

The meeting was attended by 26 participants from the several international suppliers of electric vehicle supply equipment, as listed in Table 2. The agenda included presentations by AeroVironment, an American technology company involved in energy systems, electric vehicle systems, and unmanned aerial vehicles; ABB, a global company specializing in electrification products; and Efacec Electric Mobility, USA, offering a full range of Electric Vehicles Chargers for private, public, fast, ultra-fast and wireless segments. These were followed by a discussion of 2017 accomplishments; a presentation by BTC Power, a transformer technology company for the telecom and internet infrastructure market; and one by DTE Energy, Detroit, Michigan-based utility. A tour of the NextEnergy facility was followed by a group discussion on market timing, technology, site storage, business model, and finally, a wrap-up session. A list of key findings from this meeting appears next.

Key Findings and Action Items

The following key findings emerged during the GITT meeting:

- Connecting lower power charging cabinets (e.g 50 kW) is becoming the path forward to get to 350+ kW chargers
- The need for cooled cables for high power charging creates challenges: cost, weight, flexibility, durability, cooling power
- Demand charges/costs for fast charging is high, but peakiness of the load could be addressed by working with utilities
- On-site storage reduces peaks – need to study its economics
- Public utility commissions (PUCs) don't allow a utility to recoup cost of chargers by raising base rates – no business case yet
- A uniform site specifications is beneficial, even for a city
- Need to consider legacy vehicles and backward compatibility
- Consumer education is important

16.4.3 Current Specifications for Fast-charging EVSE

Table 3 contains a comparison of four different commercially available fast-charging EVSE systems, as summarized in the DOE Technology Gap Assessment report[14].

Table 1: Specifications for four EVSE systems for fast-charging

FC EVSE Specifications	Hyper-charger 150 (150 kW)	BTCP Fast Charger (200 kW)	ABB Terra HP cabinet (350 kW)	Hyper-charger 300 (300 kW)
DC Connection Standard	CCS Combo 2	CCS Combo 2	CCS Combo 2	CCS Combo 2
	CHAdeMO optional	CHAdeMO	CHAdeMO	CHAdeMO optional
Efficiency	94 % at full power	>95 %	95 % at nominal output power	94 % at full power
AC Input Voltage	3 x 400 V 50 HZ	480, 3 Phase	480 VAC ±10 %	3 x 400 V 50 HZ
	3 x 480 V 60 Hz	50/60 Hz	50/60 Hz	3 x 480 V 60 Hz
AC Input Current and Power from Grid	233 A	300 A	Unknown	466 A
	160 kW	210 kW	Unknown	320 kW

[14] Howell, David, et al. "Enabling Extreme Fast Charging: A Technology Gap Assessment", Department of Energy, Office of Energy Efficiency Renewable Energy, 23 Oct. 2017, energy.gov/eere/vehicles/downloads/enabling-extreme-fast-charging-technology-gap-assessment.

Table 2: Participants at the U.S. DRIVE Grid Interaction Tech Team (GITT) Meeting, December 6, 2017

Sector	Participant	Company
Government	Steven Boyd (Task 37 OA)	U.S. Department of Energy (DOE)
	Lee Slezak	U.S. Department of Energy (DOE)
National Labs	Keith Hardy	Argonne National Laboratory (ANL)
	Ted Bohn	Argonne National Laboratory (ANL)
	Barney Carlson	Idaho National Laboratory (INL)
	Chris Michelbacher	INL/DOE
	Tony Markel	National Renewable Energy Laboratory (NREL)
	Andrew Meintz	National Renewable Energy Laboratory (NREL)
Vehicle OEMs	Aleksandra Bukleska	FCA
	Elaine Herbon	FCA
	Larry Logli	FCA
	Richard Scholer	FCA
	John Snyder	Ford
	Allen Gale	Ford
	Jim Tarchinski	GM
EVSE Makers	Erin Galiger	ABB
	Charlie Botsford	AeroVironment
	Carlos Cortes	BTC Power
	Larry Hayashigawa	BTC Power
	Mike Anderson	EFACEC
Non-profit Organization	Jim Saber	NextEnergy
Utilities	Nelu Andrei	DTE Energy
	Richard Mueller	DTE Energy
	Andrew Renz	DTE Energy
Utility Research	Mark Kosowski	Electric Power Research Institute (EPRI)
Other	Julie Francis	AST/DOE

16.5 Next Steps

The gaps identified within the research carried out so far could serve as a useful guide for research programs spanning varying degrees of technology maturity across a broad industry landscape. Identification and dissemination of XFC technical issues will help the stakeholder community focus and advance each technology area at a quicker pace than may otherwise be possible if each organization were to undertake a similar effort on its own. Task 37 will report out future ExCo meetings and hopes to gain participation from other countries that have so far expressed an interest. Future meetings and workshops will be scheduled with input from members.

16.6 Contact Details of the Operating Agent

For further information, please contact the Task 37 OA:

Mr. Steven Boyd
Vehicle Technologies Office, United States Department of Energy
1000 Independence Avenue SW
Washington, DC 20585, USA
E-Mail: steven.boyd@ee.doe.gov

17 e-Ships (Task 38)

Members: Denmark, United States

17.1 Introduction

The IEA HEV TCP Executive Committee (ExCo) unanimously approved Task 38 in 2017. Task 38 will run until February 2020. Until now Parties from Canada, Netherlands, Norway, Japan, Sweden, South Korea, Germany, European Commission, Chile and Switzerland have shown interest to become members. New members are encouraged to participate. Task 38 focuses on overviewing and encouraging the development and deployment of e-Ships. The working method to achieve this will be by building and sharing key knowledge on projects, technology performance, segments and demand. Including in three regional workshops at the moment tentatively planned for being held in Europe/Scandinavia, the Americas and Asia.

Fully electric ships are a new and emerging technology tail winded by the substantial reductions in battery and renewable electricity production costs. Electric maritime propulsion also supports direct use of renewable energy, significant improvements in energy efficiency and zero emission transport.

With the Paris Agreement, nations have agreed to keep the global mean temperature rise to be well below 2°C by 2100. Shipping industry is one of the large carbon emitters. As the demand for shipping is continuously growing, there is a great need for low and zero emission shipping. The focus of the Task is on battery electric ships and related issues such as battery and charging technology. But it will also include related and relevant topics including hybrid battery electric systems, electric retrofit readiness for new ships and the synergy between electric and autonomous ships.

As a new Task, acquisition of additional member countries and parties are important and ongoing. The Task scope, deliverables, and products will be refined and consolidated with all the members. The first phase of Task 38 will be to give an overview of e-Ships projects, technology, policies and potential deployment with the focus on Scandinavia and Europe, where many new electric projects are being built. The second phase is planned to include the Americas and the third phase to overview Asia and the rest of the world. There will be a cross cutting focus on e-ships on islands. A country and stakeholder workshop will be held in each of the regions.

Participating parties and countries are expected to provide information and relevant contact persons on e-ships related to their own country or region. Attendees at the meetings are kindly asked to cover their own costs linked to participation (i.e., salaries, travel expenditures, accommodation, etc.).

17.2 Objectives

Task 38 currently emphasizes on present state of technology and demonstrates e-Ships projects with the following objectives:

- Provide a leading network and platform on e-Ships for policymakers, researchers and industry bridging 'blue' maritime, 'green' energy, e-mobility including energy system, charging and automation perspectives
- Document international e-Ships success cases in a common format
- Overview, characterize and showcase technology, economics, policies, energy and environmental aspects, applications and market potentials
- Look for segmentation, convergence and scaling of supply and demand
- Analyze and document the current drivers and future perspectives for e-Ships
- Develop methods for data collection and key figures for modelling, for EU Directive on Infrastructure, for IEA, EVI etc.
- Concentrate knowledge and data into policy relevant information to advance adoption and market acceptance of e-Ships

17.3 Working Method

Within the Task, a number of workshops and meetings are to be planned in different member countries/regions and draw interest of other countries and stakeholders to join the Task. The workshops will involve stakeholders from various research institutes, maritime organizations, battery technology companies, shipbuilders and owners etc.

All the members will collect data about technology, projects, policies, economics, environmental aspects, etc. from their countries and all around the world. The information and data on the state of present e-Ships technology and future prospects will be discussed and documented. Every member country/party will also write a detailed country report, on relevant projects and the current market organization, including market players and supporting policy measures and framework.

Task 38 will offer a global network and platform for building and sharing knowledge and data about e-Ships, including on technology, policies and measures, standardization, environmental and industrial perspectives. Members will get the opportunity to learn about key stakeholders, best practices, latest developments and implementation measures aimed at successful commercialization of e-Ships technology. New projects, accelerated deployment and pooling of demand for more segmented serial production could be facilitated by network between interested industry and demanders from countries, islands, cities, industry etc.

17.4 Results

The Task will deliver a yearly updated overview and status on e-Ships in terms of technology, performance, projects, economy, environment, deployment, industry, markets and perspectives, including data. A number of pioneering projects on e-Ships have been started in the recent years. Assessments of ferries, cargo ships, etc. around the world have indicated promising potentials for e-Ships to be more profitable and efficient in comparison to the traditional ships. As a Danish example, a report from 2016 by Siemens analyzed the 42 domestic routes along the Danish coast serviced by 52 ferries. The conclusion was that 30-35 of these ferries would be more profitable as electric ferries[15].

In 2016 it was estimated that there were 50 routes in Norway alone where battery-powered ferries could operate profitably[16]. Furthermore, battery technology, including in the automobile industry has been advancing very rapidly, leading to a greener future with electric vehicles. Also maritime battery systems are expected to become considerably more efficient and less expensive in the future. Some of the innovative examples of projects on e-Ships are described briefly below.

The Danish Ærø e-Ferry project

"Ellen" is a highly energy efficient medium sized and a long 22 nautic mile range e-ferry for passengers, cars, trucks and cargo in island communities, coastal zones and inland waterways. It is supported by the European H2020 initiative, demonstrating design, building and operation of a fully electric powered 'green' ferry. Electricity from wind power of the Danish island Ærø will allow "Ellen" to run without any emissions. The e-ferry is expected be in operation in 2018/2019.

[15] https://www.siemens.com/press/pool/de/feature/2015/corporate/2015-05-e-ferry/study-electrification-e.pdf

[16] https://www.siemens.com/innovation/en/home/pictures-of-the-future/mobility-and-motors/electromobility-electric-ferries.html

Figure 1: Left hand side, the image by the e-Ferry project. On the right, photo made by the OA

"Ellen" is a highly energy efficient medium sized and a long 22 nautic mile range e-ferry for passengers, cars, trucks and cargo in island communities, coastal zones and inland waterways. It is supported by the European H2020 initiative, demonstrating design, building and operation of a fully electric powered ‘green’ ferry. Electricity from wind power of the Danish island Ærø will allow "Ellen" to run without any emissions. The e-ferry is expected be in operation in 2018/2019.

The World´s Largest Battery-driven Ferries HH-ferries/Scandlines

Tycho Brahe and Aurora cross 4 km between Helsingborg in Sweden and Helsingör in Denmark carrying 7.3 million passengers and 1.8 million vehicles annually. The combined 8,320 kWh battery is equivalent to 10,700 car batteries. With a 15 minutes schedule, charging must be fast and automated with shore-side charging in both ports using robots, 3D laser scanning and wireless communication between ship and shore to optimize connection time and maximize charging period. Tycho Brahe is expected to be in full electric operation in summer 2018. The project is co-financed by the European Union Connecting Europe Facility.

Figure 2: The largest battery driven ferries (Source: HH-ferries/Scandlines)

Fast Electric Commuter E-Ferry

BB Green by Green City Ferries is the world's first fully electric and air lifted commuter ferry. The concept reduces friction by 40 per cent, reduces waves and increases speed up to 30 knots. It is targeted sheltered waterways and relatively short routes (5 – 14 NM).

Figure 3: The BB Green e-ferry (Source: http://www.volvopenta.com/marinecommercial/en-en/news/2017/june/bb-green-electric-commuter-ferry-awarded-electric-and-hybrid-pro.html)

BB Green is used as a zero emissions commuter ferry for up to 99 passengers on the inland waterways around Stockholm, the capital of Sweden. The project is supported by the European Union Seventh Framework Programme.

Electric ferries in Norway and Finland

"Ampere", operated by the Norwegian ship owner Norled is the world's first fully electrical car- and passenger ferry. It started operation in May 2015, and has traveled a distance of more than 1.5 times around the equator. It travels six kilometers in 20 minutes across the fjord 34 times a day. Shifting from diesel propulsion to battery has reduced fuel costs by up to 60 percent. "Ampere" was the result of a competition in 2010 by the Ministry of Transport and Communications and the Public Roads Administration, where successful development of an electrical ferry would receive a 10 year concession. After "Ampere" Siemens has delivered several electric ferries.

In June 2017, "Elektra" began regular operation between Nauvo and Parainen in the Turku archipelago in Finland. With nearly 98 meters long and 16 meters wide, Elektra can transport up to 90 cars per trip when traveling the route every 15 minutes. The batteries are charged in five minutes. The two lithium-ion batteries each have a capacity of 530 kWh.

Figure 4: The “Ampere” e-ferry in Norway (Source: Siemens via www.siemens.com/press)

Figure 5: The “Elektra” e-ship in Finland (Source: Siemens via www.siemens.com/press)

Electric Container Barge to Connect Rotterdam and Vossenberg-West

Two battery-electric container ships to be owned by Port-Liner and hired by logistics company GVT from Tilburg are expected to connect Rotterdam (Netherlands) and Vossenberg-West business park (Belgium) from late 2018. Sized 110 m times 11.4 m it can carry up to 270 containers in inland waterways. The battery packs are expected to operate up to 34 hours and stored in a container it can either be swapped or charged at a terminal. Port-Liner is reported to build a total of 15 electric-powered cargo ships of different sizes, to join ship fleets in the

Netherlands and Belgium. The first six electric container ships are estimated to remove 23,000 trucks from the roads annually in the Netherlands. The project is supported by the European Union.

Figure 6: Electric container ship (Source: https://electrek.co/2018/01/12/large-tesla-ships-all-electric-barges/)

World's First Fully Electric and Autonomous Container Ship in Norway

Yara Birkeland is the world's first fully electric and autonomous container ship with zero emissions. The ship is propelled by electric motors driving two azimuth pods and two tunnel thrusters with a battery capacity of 7.0 – 9.0 MWh. The ship will have a cargo capacity of 120 TEU (Twenty-foot Equivalent Units), operating between Herøya and Brevik (~7 nautical miles) and between Herøya and Larvik (~30 nm) at a service speed of 6 knots.

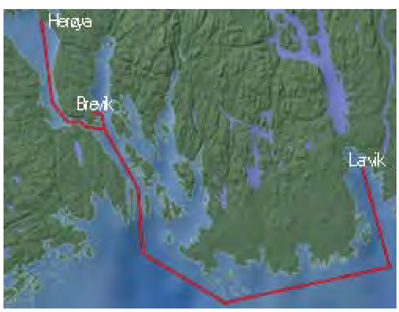


Figure 7: The operating route of Yara Birkeland (Source: https://www.km.kongsberg.com/ks/web/nokbg0240.nsf/AllWeb/4B8113B707A50A4FC125811D00407045?OpenDocument

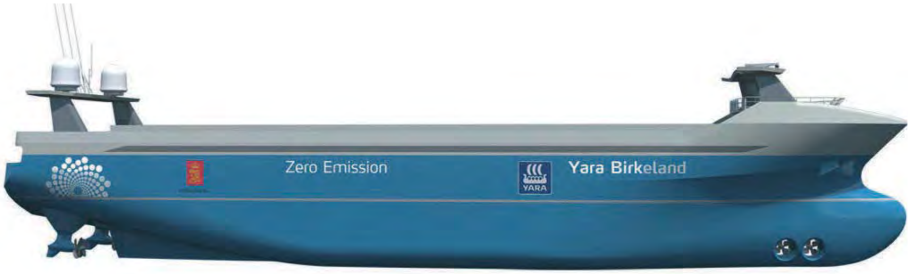


Figure 8: The first fully electric and autonomous container ship in the World (Source: https://www.km.kongsberg.com/ks/web/nokbg0240.nsf/AllWeb/4B8113B707A50A4FC125811D00407045?OpenDocument)

In the first phase a detachable maneuvering and navigation bridge will be implemented. When the ship is ready for autonomous operation this module will be lifted off. Delivery into full operation is expected in 2019 and fully autonomous operation in 2020.

18.5 Next Steps

The Task is looking for more members to join efforts, and to make workshops and exchange of knowledge and data possible, so stakeholders and experts can showcase projects and knowledge about recent developments in technology, policy and concepts related to e-Ships. Hereby, the development, the deployment and the environmental impact of maritime electric propulsion is supported.

The next major step will be to organize and have the first of three Task workshops. This will be in the fall of 2018 and it will have a European and Scandinavian focus on e-Ships.

18.6 Contact Details of the Operating Agent

For further information, please contact the Task 38 Operating Agent:

Mr. Michael Rask
Raskgreentech
Gammel Lundtoftevej 34D
2800 Lyngby, Denmark
Phone: +45 24470011
E-Mail: raskgreentech@gmail.com

18 Interoperability of E-Mobility Services (Task 39)

Members: Belgium, The Netherlands

18.1 Introduction

The IEA HEV TCP Executive Committee (ExCo) unanimously approved Task 39 at the 48th ExCo meeting held in April 2018 in Dublin (Ireland). Task 39 will run for two years during the period 2018-2019. The Netherlands has been official member from the start and many other countries expressed their interest to join Task 39.

The market of electric vehicles is growing worldwide at an increasing speed. More and more electric vehicle models are being introduced on the market. End users and governments get more and more interested in the potential benefits of electric mobility since it offers a great potential to solve many of our environmental, societal and economic challenges. Therefore, policy makers are implementing supportive measures to facilitate the further uptake of electric mobility in their region. Main barriers to be addressed are the higher purchase cost, limited driving range and limited charging infrastructure.

Task 39 will focus on the charging infrastructure and more specifically on the interoperability aspects of e-mobility services like charging of passenger cars in the public and semi-public domain. Also smart charging is within the scope of Task 39. Governments and industry are making huge investments in charging infrastructure in the public and semi-public domain to facilitate the further uptake of electric mobility and to try to convince the end users to make this step. These investments are certainly needed since charging will be needed, in more or less quantities, at all locations: residential, workplace and also the semi-public and public domain.

However, it is not only about the quantity of available charging points in a region. Much more important is the quality of the charging service offered to the end user. This charging service needs to be easy to use, reliable and cost transparent. Information about the location and availability of charging points, about the way to get access to these charging points, about the tariffs, etc. are crucial for the end user to be confident enough to make the step towards electric mobility.

Interoperability between the different e-mobility services offered today is therefore crucial for the comfort and ease-of-use of the end users. Look at the roaming in the telecom sector. But interoperability is equally important for the governments and companies making investments in charging infrastructure and services. Information exchange between the back offices of the different stakeholders like charge point operators and mobility service providers is an important aspect and having open and interoperable solutions can have a positive impact on the business case and on the flexibility to offer higher quality and/or combined e-mobility services to the end user.

18.2 Objectives

Today, EV drivers are still not having easy access to all necessary information about the charging possibilities in their region. Many initiatives are being taken to improve this situation, but today EV drivers still have to put a lot of time and effort in collecting this crucial information about the charging infrastructure (location, availability, accessibility, pricing, …) for their specific charging needs. Only the EV addicts will go through this effort and most other people interested in electric mobility will wait until this situation improves.

Task 39 will bring together experts from member countries to share information and best practices to improve the interoperability and accessibility of charging services.

Aspects to be studied related to charging in the (semi-) public domain are:

- How to find the charging station: static database, real-time navigation or apps, etc.?
- How to know the real-time status of the charging station: free, in use, defect, etc.?
- How to reserve the charging station (= optional)?
- Which authentication is needed at the charging station: none, via RFID card, via app, ad-hoc use possible, etc.?
- Pricing and payment information: which tariff scheme is used is mostly unclear today.

An overview of the ongoing initiatives to stimulate interoperability of e-mobility services will be set-up. Every member country will also write a detailed country report, explaining the current local market organization (market players & supporting policy measures), which will be very valuable information for the EV drivers in that specific country.

Ultimately, Task 39 intends to set-up recommendations for governments and industry how to improve the interoperability of charging services.

The main focus in Task 39 will be on “standard” charging services, but also the aspect of “smart” charging and its interoperability aspects will be taken into account.

18.3 Working Method

Task 39 will be executed in a pragmatic way and will make use of mainly telco’s and two workshops to collect, discuss and write down the existing knowledge available from the experts of the member countries. This information will be complemented by additional desktop research and contacts with different initiatives to collect the most recent information. All detailed collected information will be stored in the IEA HEV TCP SharePoint site and will be accessible to the member countries.

Putting the available information on paper in a clear and concise way and share it with the EV community (end users, governments and industry) is the ultimate ambition of Task 39. The country reports and recommendations will be shared via the Annual Report and the website of IEA HEV TCP.

The working method and number of workshops can be adapted when new member countries join and/or opportunities arise.

18.4 Next Steps

Since Task 39 just started recently, the first next step is the acquisition of additional member countries. A higher number of member countries leads to more and higher quality information exchange and ultimately to better recommendations to stimulate interoperability of e-mobility services, not only within one country but also cross-border. This information is valuable for the EV drivers, governments and stakeholders from the industry.

18.5 Contact Details of the Operating Agent

For further information, please contact the Task 39 OA:

Mr. Carlo Mol
VITO / EnergyVille
THOR Park
3600 Genk, Belgium
Phone: +32 492 58 61 24
E-Mail: carlo.mol@vito.be

19 Critical Raw Material for Electric Vehicles CRM4EV (Task 40)

Members: Germany, Republic of Korea, Sweden, United Kingdom, United States

19.1 Introduction

Electric Vehicles manufacturers are reducing the costs of EVs and at the same time improving the performance and longevity. Policymakers and other stakeholders forecast and plan an important role for EVs in reducing GHG and other emissions from transport. Several countries have announced a full or partial transition to ZEVs for personal cars with an important role for BEVs.

With this projected mass deployment of EVs, attention is drawn to potential supply chain issues for several Critical Raw Materials (CRMs) needed for EV manufacturing. For materials, like Lithium, Cobalt, Graphite and Rare Earth Elements news headlines referring to these (potential) supply chain issues are now frequently seen in the main stream press. Reference is for example made to a potential lack of supply of these critical material availability or undesired environmental impacts or social impacts.

Additional uncertainties like how rapid will the mass EV deployment happen and to what extent and how much of the critical materials are required per vehicle. Other uncertainties are how rapid the EV technologies are evolving and thus impacting the type and quantities of critical materials needed and whether alternative technologies or solutions will become available in the future. All this makes any projection of the supply chain needs difficult and uncertain.

For Electric Vehicles, several materials are considered as (potentially) critical for a (quick) ramp up of production volumes. However, fact based and accurate up to date information on this is not easily available to all the relevant stakeholders.

Headlines pointing to issues of supply raise questions to which reliable answers often are not readily available but which are relevant to know for stakeholders looking at a mass deployment of EVs. Examples of the issues which need to be covered are:

- Which materials are critical raw materials for EVs?
- Are there currently already supply chain issues?

- What are other uses of the CRMs and how will these develop?
- Towards a future of mass deployment, are there any supply chain issues? If so, are these temporarily or structural and under what circumstances would these issues occur?
- Are there alternative materials or solutions available?
- What are the impacts of evolving battery technologies?
- What is the nature of the supply chain issues: material availability, environmental impacts, social impacts, geographical dependencies (concentration)?

Materials like Lithium, Cobalt, Graphite, Rare Earth Elements and others are frequently in the news related to their (presumed) scarcity, environmental or social issues. Lithium has been a "hot topic" for years but is perhaps less an issue in the long run, Nickel is not but will probably be on the list as well. Conflicting information are making it difficult for policymakers and administrations to get fact based and reliable information.

Combustion engine technologies also require critical materials, often with overlooked or already accepted impacts. Fuel Cells use currently PGMs (Platinum Group Metals). The Task will review impacts of mass BEV deployment on the currently critical raw materials as well from a material availability point of view.

19.2 Working Method

The overall objective of CRM4EV is to generate and continuously update the relevant information needed related to critical raw materials for EVs by Task member countries and other Task stakeholders.

To achieve this, the Task will build a global representative network on the topic "Critical Materials for EVs" with stakeholders from administrations, industry, policymakers, researchers and other relevant stakeholders representing the different value chains of the identified "in-scope" critical materials. The network will meet twice per year through workshops and a structure with several sub-groups for different critical materials / topics may be defined. Use the actual need for information and analyses from governments (and the EU) and those of other stakeholders as the basis to define the detailed tasks to be conducted. IEA HEV TCP participating countries will be in the lead for this!

- Define and maintain a list of critical raw materials and the relevant impact categories for EVs. For these raw materials information needs to be collected and kept up to date. The starting list will contain Cobalt, Lithium, Nickel, Graphite, Neodymium, Dysprosium and Copper will be reviewed for inclusion.

- Provide reliable, up to date and relevant information to the Task participants and publish (a selection of this) information.
- Prepare and maintain "Fact Sheets" per CRM and topic containing the key information needed by stakeholders. The Fact Sheets will be made available for publication (in full or summarized version).
- Data collected, outcome of analyses done by the Task participants or scenario studies made for possible future needs of CRMs for EVs.

Next to country representative involvement, international, national or regional stakeholders from industry, research (projects), NGO's and other stakeholders will be included in the network. Workshops are key to get large numbers of stakeholders on board. Participating IEA HEV TCP countries will be encouraged and expected to bring relevant stakeholders on board.

- Develop global views as well as regional or country perspectives, based on the stakeholder needs and outputs from the Task (information, analysis, scenarios).
- Data collection and analyses will be a continuous process to be validated and build on during the workshops.
- Experts and stakeholder involvement to review "Fact Sheets" and other outcomes.
- Define and maintain a list of Critical Raw Materials to include in the scope of the Task CRM4EV u Define "criticality" of the Critical Raw Materials in scope:
- Depending on geography
- Depending on penetration rate in the EV application (scenarios)
- Depending on the use of the CM in EVs, cars and in other applications
- Short term versus long term supply issues
- Evaluate (future) availability of alternative solutions or materials (e.g. Rare Earth Element free electro-motors, solid state batteries).
- Define the different sources (mines: where, what) and exploitable reserves of the different Critical Raw Materials (are they exploited as primary or secondary product?). Evaluate the impact of permitting processes in expanding existing or opening new mines.
- Evaluate quality (and purity) requirements and issues (materials from different mines / processes can have different characteristics).
- Evaluate environmental (life cycle) and social impacts.

- Evaluate importance of recycling today, gap analyses in recovery and recycling technologies. Cost position of recycling, legislation?
- Evaluate LCA impacts, variations by region, source, refining processes and other parameters.
- Review existing (and in development) recycling processes and collection of materials for recycling, obligations (legislation), costs.
- Define and analyse scenarios for future requirements and needs for CRMs for EVs.

19.3 Results

The Task will start in 2018. At the current time, there are no results that can be reported.

19.4 Next Steps

Define reporting deliverables (e.g. reports, analyses, publications, casebook) and maintain the information up to date considering the latest developments.

- List of EV Critical Raw Materials and "needs to know" for these CRMs
- List of Transport (vehicles) CRMs impacted by EVs (replacement)
- Short summary "Fact Sheets" on CRMs and CRM4EV topics (like recycling, LCA)
- Insights in the current mining, refining, main applications of the CMs
- Insight in planned and potential mining and refining capacities
- Insight in current and projected (scenarios) needs of the CMs
- Insight in need of the CRMs per unit, current and future
- Insight in alternatives of the CRMs (and impacts if alternative is used)
- Insight in recycling processes and legislation (Including collection potential)
- Workshops and dissemination at relevant conferences
- Yearly reports
- CRM4EV Casebook

Besides, there will be two workshops per year as a combination of closed and open (on invitation) workshops:

- Workshop 1 (on invitation only) Workshop: November (15+16) 2018 in Brussels (during the EU Raw Material Week with its Summit November 14).

- Workshop 2 (partly public): May 2019 in Korea (in combination with the annual JeJu Island EV conference and exhibition)

19.5 Contact Details of the Operating Agent

For further information, please contact the Task 40 OA:

Mr. Bert Witkamp
Valuad
Rue de Maestricht 12
4600 Visé, Belgium
E-Mail: b.witkamp@valuad-expert.com

20 Overview of Hybrid and Electric Vehicles in 2017

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

Table 1 shows the fleet totals for passenger vehicles[17] of HEVs, EVs, and PHEVs over the last three years. The numbers for 2015 and 2016 have been taken from the previous HEV TCP Annual Reports. The country chapters provide more detailed numbers for 2017 sales and fleet totals for EVs, PHEVs, and HEVs.

[17] 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

	HEVs			EVs and PHEVs		
Country	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
Austria	14,350	17,746	23,546	6,544	11,360	18,566
Belgium	n.a.	n.a.	52,559	8,586	17,268	30,498
Canada	163,269	186,057	211,019	18,451	29,270	47,788
Denmark	3,799	n.a.	16,500	8,059	8,373	10,161
Finland	14,054	18,732	n.a.	1,580	3,285	n.a.
France[a]	229,550	283,670	n.a.	53,911	82,229	121,470
Germany	119,556	167,552	192,291	36,311	61,465	98,280
Ireland	104,74	13,637	20,295	1,215	2,053	3,580
Italy	25,661	*117,898*	181,296	4,616	8,822	13,233
Netherlands	131,011	141,559	158,245	87,531	112,008	119,332
Rep. of Korea	n.a.	58,596	n.a.	10,267	11,210	26,208
Spain	64,169	94,771	164,696	4,746	8,562	16,283
Sweden	42,737	55,770	70,237	14,541	29,320	43,216
Switzerland	46,261	53,159	n.a.	9,021	14,103	14,539
Turkey	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
UK	n.a.	215,053	320,180	46,978	89,339	135,406
United States	3,804,630	4,267,157	4,430,000	406,536	560,885	750,000
Totals HEV TCP	**4,669,521**	**5,691,357**	**5,840,864**	**719,622**	**1,051,473**	**1,448,560**

n.a. = not available

21 Austria

21.1 Major Developments in 2017

In 2017 13,726 EVs have been registered, 5,189 (+61 % compared to 2016). This is a significant increase as already 2016 showed a registration growth rate of 65 %. In 2016, the increase was linked to tax incentives, which made the purchase of EVs more attractive for companies and self-employed persons, e.g. company cars have become eligible for deduction of input tax and are exempted of non-cash compensation regulations. In 2017, the increase correlates with the introduction of the “Förderpaket für Elektromobilität” program. This program is a federal support package for EVs which consists of purchase subsidies and subsidies for the construction of charging infrastructure. In addition, the program offers incentives for the EV-use on federal level such as the particular green license plate.

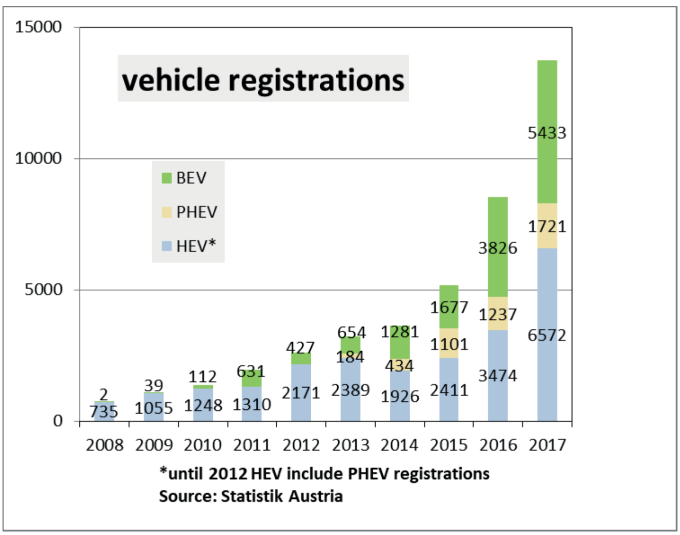


Figure 1: Development of BEV/ PHE/ HEV vehicle registration in Austria

Austria is facilitating the nationalwide deployment of EVs through the creation of a nationwide network of charging stations. In a first step, 11 electricity suppliers combine 1,300 of their charging stations. From April 11th, 2017 onwards EV drivers have access to the combined network, which will grow to 2,000 charging stations until the end of the year.

Other major developments (1) on a political level is the strong commitment to e-mobility in the 2017 Austrian government program, (2) the Austrian co-operation activities within European Battery Initiative or (3) the continuous research and innovation funding in the area of e-mobility such as the funding program "Mobilität der Zukunft" (Mobility of the Future).

21.1.1 New policies, legislation, incentives, funding, research, taxation, etc.

In November 2016, the Austrian minister for Transport, Innovation and Technology (bmvit) and minister of Agriculture, Forestry, Environment and Water Management (BMLFUW) together with the spokesman of the Austrian automobile importers presented the "Förderpaket für Elektromobilität"[18], a package of measures to support e-mobility. The program runs for two years and will make 72 million EUR available for the purchase of EVs and the installation of charging stations. The package contains also EV-use incentives like a particular green license plate. The main objective of the green license plate is to allow flexibility in the introduction of tailored incentives on regional and local levels.

7,100 funding application for EVs have been submitted in 2017. 5,300 of these are related to passenger EVs. With 87 % BEVs represent the lion's share here. There is also a considerable demand for the green license plate as 1,869 plates have been issued only in the first two weeks after its introduction on April 1st, 2017.

On December 6th, 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*"[19] (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.

[18] https://www.bmvit.gv.at/presse/aktuell/downloads/leichtfried/emobilpaket.pdf

[19] https://www.bmvit.gv.at/verkehr/elektromobilitaet/downloads/strategierahmen.pdf

21.2 HEVs, PHEVs and EVs on the Road

In 2017, the number of motor vehicles on Austrian roads has risen to 6,771,395 (+1.8 % compared to 2016) out of which 4,898,578 (+1.6 %) represent passenger vehicles. The numbers are in line with the long-term trend towards a growing passenger vehicle fleet, which showed an average growth rate of 1.4 % per year in the last ten years.

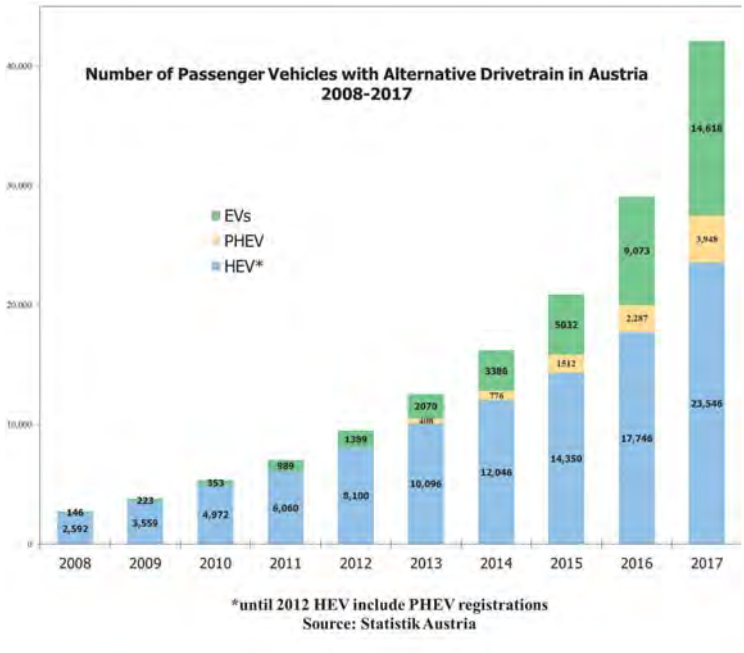


Figure 2: Passenger BEV/ HEV/ PHEV development 2008-2017

42,112 (0.9 %) of the passenger cars on Austrian roads are EVs. Figure 2 illustrates the split between BEV/ HEV/ PHEV. In absolute numbers HEVs dominate with a total of 23,546 cars with an increase by 5,800 (+33 % compared to 2016), followed by 14,618 BEVs (+5545 vehicles or +61 % vehicles) and 3,948 PHEVs (+1661 vehicles or +73 %). The number of FCEVs (not included in Figure 2) increased since 2016 from 13 to 18. Although the passenger EV share of the total vehicle fleet is not significant yet, the number of newly registered EVs and its yearly growth rate show a promising trend towards an accelerating EV uptake.

In 2017, a total number of 457,174 motor vehicles (+6.1 % compared to 2016) and 353,320 passenger cars (+7.2 % compared to 2016) were newly registered. 13,726 or 3.9 % (+5189 compared to 2016) of the newly registered passenger vehicles are EVs. Remarkable is the high EV registration growth rate of +61 % in 2017 which considerably outperforms the overall market growth. The trend is a continuation similar to previous years with EV registration growth rates of +43 % in 2015 and +65 % in 2016. Within the passenger EV sector differences in the registration growth between BEV/ HEV/ PHEV can be identified. HEVs show the highest growth with +6572 vehicles (+89 %), followed by BEVs with +5433 vehicles (+42 %) and by PHEVs with +1721 vehicles (+39 %).

21.3 Charging Infrastructure or EVSE

In Austria most public charging stations (EVSE) are operated and/or owned by regional energy service providers and many operators require a specific registration for the customer in order to charge at their stations. To overcome this EV-use barrier the Climate and Energy Fund funded the project “ÖHUB”. In the project 11 regional energy service providers connected their existing charging infrastructure to a shared network. This step gives EV-drivers access to 80 % of the current public Austrian charging infrastructure with only one single contract. In 2017, approximately 2,000 charging points became part of the ÖHUB network. Until 2020 the network plans to expand to 5,000 charging points.

Another relevant service provider yet not part of the ÖHUB network is SMARTRICS, a company which provides a public charging network. Shareholders of SMARTRICS are the “Verbund”, Austria’s biggest energy service provider, and Siemens. The SMARTRICS charging network includes around 435 charging points located along motorways and in urban centers out of which 210 are high-speed charging points with 43 or 50 kW output.

Table 1: Charging infrastructure in 2017 (Data source: e-tankstellen-finder.com)

Charging Infrastructure on 31 January 2017	
Chargers	**Quantity**
AC Level 1 Chargers	n.a.
AC Level 2 Chargers	3,329
CHAdeMO	196
CCS	181
Tesla	30
Inductive Charging	n.a.
Totals	**3,736**

Austrian EVSEs are not obliged to register in a central data base. Therefore the number of public available EVSEs and their charging capacity vary depending on the data set source. The number of charging points accessible at a single EVSE depends on the used charger type. EVSEs using AC level 2 Charger with a

charging capacity of maximum 22 kW consist of in average three charging points. EVSEs using other charger types provide in general one charging point.
3,736 EVSEs are publically accessible. 3,178 of these allow a charging capacity of up to 22 kW. The remaining 588 stations offer accelerated charging or fast charging.

The figures in table 1 are based on a comprehensive data base provided from the website "*e-tankstellen-finder.com*" of the regional energy service provider KELAG (*Kärntner Elektrizitäts-Aktiengesellschaft*), which is a member in the ÖHUB consortium. Although EVSE operators are free to add their stations to the data base, the information can be considered as reliable and up-to-date as EV drivers use the website and the related app for charging station decisions.

21.4 EV Demonstration Projects

klimaaktiv mobil[20], the national action program for mobility management, provides a national framework for developing and implementing measures to reduce CO_2 emissions. It promotes environmentally friendly and energy efficient mobility and stimulates new innovative business opportunities and green jobs. Between 2006 and 2016, more than 8,400 green mobility projects have been initiated. This enabled annual savings of 640,000 tons of CO_2. In 2016, 19 million EUR funding has been made available. For the whole program period an overall funding of 87.5 million EUR is planned.

The Program "***Leuchttürme der Elektromobilität***"[21] (Electric Mobility Flagship Projects) is a funding program within the *Climate and Energy Fund.* Its objective is to demonstrate the suitability of Austrian electric mobility technologies for everyday use and to translate innovations into close-to-the-market applications. The program addresses technological areas such as automotive engineering, software development, usability optimization or transport planning to tackle the challenges of electric mobility. From 2014 to 2017, four calls have been published. This program has an annual budget of approximately 5 million EUR.

The research program "***Mobilität der Zukunft***"[22] (*Mobility of the Future)* is an Austrian national transportation R&D-funding program for the period 2012–2020. The program was developed by the Austrian *Federal Ministry for Transport Innovation and Technology* (bmvit). It includes four complimentary thematic fields: *Personal Mobility*, *Mobility of Goods*, *Vehicle Technology*, and *Transport*

[20] http://www.klimaaktiv.at/mobilitaet.html

[21] https://www.klimafonds.gv.at/assets/epaper/en_catalog_7042335/html5.html#/1

[22] https://www.bmvit.gv.at/innovation/mobilitaet/mobilitaetderzukunft.html

Infrastructure. The annual budget of *Mobilität der Zukunft* is between 13 and 19 million EUR.

In 2006, the Austrian *Federal Ministry for Transport Innovation and Technology* (bmvit) founded the "***Austrian Association for Advanced Propulsion Systems (A3PS***)"[23] 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 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.

It is worth to mention that according to VCÖ[24] (Verkehrsclub Österreich) 86.500 e-bikes were sold in 2016, which makes Austria number 3 in terms of sold e-bikes per inhabitant in Europe. However, these impressive numbers are not included in the above statistics as electric bikes, e-bikes or pedelecs (pedal-electric-vehicles) are defined as bicycles with assisted pedaling.

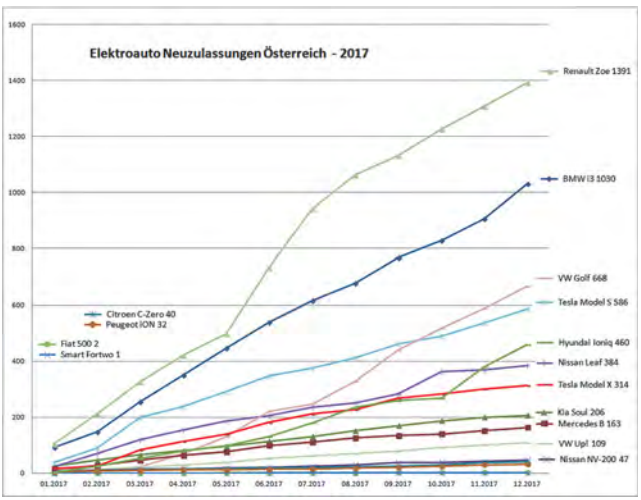


Figure 3: Newly registered electric passenger vehicles in Austria in 2017. Data source: https://myampera.wordpress.com/statistik/, based on Statistik Austria Data

[23] http://www.a3ps.at/

[24] https://www.vcoe.at/news/details/vcoe-in-oesterreich-fast-400-000-e-fahrraeder-klarer-spitzenreiter-bei-e-fahrzeugen

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: Statistik Austria)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[5]**
2- Wheelers[1]	5,975	8		0	796,478
3-Wheelers and Quatricycles[1]	1,082	5		0	35,741
Passenger Vehicles[2]	14,618	3,948	23,546	19	4,898,578
Buses and Minibuses[3]	143	4		0	9,956
Trucks[4]	1,713	9		0	474,778
Totals without bicycles	**23,531**	**27,520**		**19**	**6,215,531**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[5]**
2- Wheelers[1]	1,838	0	0	0	43,361
3-Wheelers and Quatricycles[1]	145	0	0	0	2,812
Passenger Vehicles[2]	5,433	1,721	6,572	0	353,320
Buses and Minibuses[3]	6	0	0	0	1,244
Trucks[4]	237	0	0	0	44,127
Totals without bicycles	**7,659**	**1,721**	**6,572**	**0**	**444,864**

n.a. = not available
[1] UNECE categories L1-L5 ; [2] UNECE categories M1 ;
[3] UNECE categories M2-M3 ; [4] UNECE categories N1-N3 ; [5] Including non-electric vehicles

Table 3: Available vehicles and prices (Data source: ÖAMTC, February 2018)

Market-Price Comparison of Selected EVs and PHEVs in Austria	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Audi A3 e-tron	41,270
BMW i3	38,400
BMW i3 Rex	43,100
Citroen Berlingo	33,300
Citroen C-Zero	21,990
Ford Focus Electric	34,900
Hyundai Ioniq Elektro	34,990
KIA Soul EV AC	33,290

Mercedes Benz B-Klasse Electric Drive	39,800
Mercedes Benz S 500 Plug-In Hybrid	86,750
Mitsubishi i-MIEV	29,990
Mitsubishi Outlander PHEV	44,640
Nissan e-NV200 2.Zero Edition	42,444
Nissan Leaf Visia 40kWh	32,950
Peugeot iOn	21,990
Peugeot Partner	33,300
Porsche Panamera 4 E-Hybrid	111,754
Renault Kangoo Z.E.1	25,440
Renault Twizy 45 Life2	7,180
Renault Zoe R903	22,190
Smart Fortwo Electric Drive4	19,420
Tesla Model S 75D	85,200
Tesla Model X 75D	92,050
Toyota Prius Plug-In Lounge	38,890
VW e-Golf	38,690
VW e-up!	27,190
VW Golf GTE	41,360
Audi A3 e-tron	41,270

Figure 3 illustrates the number of newly registered passenger BEVs for specific OEM models. Like in the previous years, Renault Zoe was the most popular electric vehicle in Austria.

21.5 Outlook

The “Förderpaket für Elektromobilität”, package of measures to support e-mobility will be continued in 2018.

Several funding programs provide a stable and lasting framework for e-mobility reseach innovation and demonstration projects.

Austria is also planning to further develop H2 infrastructure and is setting up a hydrogen flagship region which will demonstrate a feasible transition of the Austrian economy and energy production towards a hydrogen based energy system.

18 Belgium

22.1 Major Developments in 2017

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 has been 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 online on http://www.ieahev.org/tasks/economic-impact-assessment-of-e-mobility-task-24/. The Netherlands has updated their country chapter again in 2017 and this information (available in Dutch) can be found on https://www.rijksoverheid.nl/documenten/rapporten/2017/12/22/rapport-verzilvering-verdienpotentieel-ev-2017.

Since the beginning of 2017, 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 2017 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 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. Audi Brussels has been producing the Audi A1 family in the European capital of Brussels since 2010. In 2017, around 95,284 automobiles rolled off the production line. In 2018, Audi Brussels will exclusively produce and present the first fully electric series model: the Audi e-tron. With its range of 500 kilometers and the fast charging options at up to 150 kilowatts the new SUV allows customers to drive purely electrically without making compromises. Until the start of series production, almost 250 development vehicles will complete testing under extreme conditions worldwide.

Audi attaches great importance to resource-conserving production. As the first of its kind, the e-tron will be produced completely CO_2-neutral at the converted Brussels plant, where also the model’s batteries will be assembled. Audi has been investing considerably in rebuilding the factory. The site is now covering all production processes and all other emissions generated at the plant by either renewable energies (approximately 95 percent) or environmental projects (approximately 5 percent). Audi Brussels thus operates the world's first certified CO_2-neutral high-volume production plant in the premium segment.

For example, with a total area of 37,000 square meters Audi Brussels has built the largest photovoltaic system in the region on top of their plant’s roofs. This way, the company saves around 17,000 tons of CO_2 per year, equivalent to the consumption of around 1,500 people.

Figure 1: Audi e-tron quattro concept (Source: Audi AG)

Volvo Cars Gent has been 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 to above 5,000 employees.

Figure 2: 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 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, Green Propulsion, 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 buses. Van Hool presented its inductively charged electric buses driving in the city of Bruges during Busworld 2015.

Figure 3: EquiCity Articulated Trolleybus with battery APU for TPG Geneva (Source: Van Hool)

With EquiCity, the so-called trambus, Van Hool developed an innovative concept for sustainable public transport in which hybrid, battery electric or fuel cell powertrain can be integrated. In March 2018, Van Hool announced that it is to build 58 trambuses for Trondheim in Norway, where they are set to enter service as from August 2019. This is the largest order that Van Hool has ever secured for its trambus, which has been available on the market since 2011 and of which more than 250 vehicles have been ordered in 11 countries to date.

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. In the beginning of 2018, Van Hool announced that it has signed a significant contract with RVK Köln and WSW Wuppertal (Germany), to supply 40 hydrogen buses of the latest generation. This order consists of 30 fuel cell buses for Cologne and 10 for Wuppertal, making it the largest order for hydrogen-powered vehicles ever been placed in Europe. These high-tech vehicles will be built in the Van Hool factory in Koningshooikt. The first buses will be delivered in the spring of 2019. Van Hool has been building hydrogen buses for the American market since 2005 and for the European market since 2007. By now, Van Hool has produced 53 hydrogen buses for North America (21) and Europe (32). The eight hydrogen-powered tram-buses Van Hool is manufacturing for Pau (France) should be added to this total. These are to be delivered in the second half of 2019.

VDL Bus Roeselare, part of VDL Bus & Coach bv, produces public transport buses and coaches in the city of Roeselare. VDL Bus Roeselare plays a significant role in the development and production of the full electric public transport bus portfolio within the VDL Groep and has supplied its products to numerous European projects amongst which 43 articulated buses in Eindhoven (NL) and 100 articulated buses in Amsterdam (NL).

Figure 4: VDL Citea SLFA Electric bus fleet in Amsterdam (Source: VDL Bus & Coach bv)

The VDL Citea is available in 9, 12 and 18 meter length-variants of which the latter two are produced in Roeselare. VDL Bus Roeselare is also delivering 121 hybrid buses to the Flemish public transport operator De Lijn and electric buses to cities in Sweden, Finland, Germany, the Netherlands, Switzerland and France.

Freight Logistics

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

Addax Motors (http://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 5: 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 has developed a novel modular and scalable propulsion platform for electric vehicles. It is made available in two vehicle categories, the small City-KURTs and the larger KURT-Shuttles. Both are targeted at urban environments only. 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, since a few years, the electric bicycle is the most successful vehicle in Belgium. The trend was confirmed in 2016, with sales of 186,000 electric bikes, a 25 % increase compared to 2015. In 2017, the sales of electric bicycles even went up until 218.000 which corresponds to a market share of 45 %. 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 (http://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. In 2018, a further investment of 300 million EUR was announced. These investments will enable the company to sixfold existing capacity by the end of 2020 compared to 2015 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.

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 and 2017 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 6: 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 (http://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. 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,...) 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 2017 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 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 in electric and hybrid vehicles with an impressive track record. It develops electric and hybrid vehicles technologies, and evaluates new concepts in mobility and logistics on their sustainability. Its multidisciplinary team of 100 specialists enables a holistic approach. The group possesses considerable expertise in the scientific and operational management of multi-partner research projects, and is currently involved in 15 European projects. It has a unique position to address the EU roadmapping activities. Some example project references are: FIVEVB - Five Volt Battery, ELIPTIC - Electrification of public transport in cities and ASSURED - Fast and Smart Charging Solutions for Full Size Urban Heavy Duty Applications.

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, … Some example project references are: ZEB – Zero Emission Bus Platform, VKSL – Flemish Knowledge Platform Smart Charging and EVERLASTING - Electric Vehicle Enhanced Range, Lifetime And Safety Through INGenious battery management.

National Policy Framework - "Alternative Fuels Infrastructure Directive (AFID)"

In response to the **Directive 2014/94/EU** of the European Parliament and of the Council of 22 October 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 & 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 a higher purchase price of alternative fuel vehicles, the lack of recharging infrastructure, a 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 & Transport (federal government of Belgium) coordinated the national concertation and development of the Belgian policy framework. However, the Regions of Belgium (i.e. Flemish Region, Walloon Region & Brussels-Capital Region) are competent in most aspects of Directive 2014/94.

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 & 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 & other	- Standardisation/ normalisation - Price indication of energy products & inspection of price indications	- Integration of refueling and charging points in petrol stations; - Development of public network of refueling and charging infrastructure; - Spatial planning.	/

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. In December 2017, the ministers of the Benelux-countries signed a political declaration on borderless e-mobility services, also referred to as **eRoaming**.

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 2: Number of targeted alternative fuel vehicles in Belgium (2020) (Source: National Policy Framework Belgium)

Targeted AFVs (2020)	Total	Flemish Region	Walloon Region	Brussels Capital Region
Electric vehicles	**86,641**	74,100	9,903	2,638
CNG vehicles	**42,584**	41,000	1,344	240

Table 3: Number of targeted recharging points in Belgium (2020) (Source: National Policy Framework Belgium)

Targeted recharging points (2020)	Total	Flemish Region	Walloon Region	Brussels Capital Region
Normal & high power recharging points (Public)	**8,324**	7,436	688	200
Shore-side electricity supply in maritime and inland ports	**527**	524	-	3

Flemish Policy Framework

The Flemish policy framework regarding alternative fuels infrastructure for transport in response to Directive 2014/94/EU is based on the **Flemish 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 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 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 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 are being implemented:

- Fiscal incentives for Clean Power vehicles (exemption from registration and annual circulation taxes).
- Financial incentives for zero-emission vehicles. A zero-emission premium of 5,000 EUR maximum for individuals when purchasing or leasing battery-electric or hydrogen vehicles. The zero-emission premium is currently being revised, among others with the aim of stimulating electric car-sharing.
- The 2 year prolongation of the financial support provided under the ecology subsidy to companies for the installation of electric charging infrastructure.

- The setup of a website dedicated to Clean Power (www.milieuvriendelijkevoertuigen.be) 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 design of an electric mobility guide for local governments and a guide for charging and home charging.
- The obligation of the Distribution Grid Operators (DGOs) to install 5,000 extra publicly accessible charging points through public procurement in 2020 distributed over the more than 300 municipalities in Flanders. Currently, more than 1,000 of these are already in operation. Local governments are responsible for the installation of the parking spot and parking policies (e.g. enforcement). The charging points should enable EV drivers to conveniently charge in Flanders.
- The introduction of a notification requirement for publicly accessible charging points. Gather data on locations of publicly accessible charging points/fueling stations in Flanders and inform citizens through our clean vehicles website. Currently, more than 1,700 normal charging points and 34 locations for fast charging are registered in Flanders.
- The deployment of the first publicly accessible hydrogen refueling stations.
- The setup of actions to encourage the use of shore power for vessels on inland waterways.
- The use of European financial instruments to stimulate infrastructure development in Flanders. Initiated by Flanders and in cooperation with the Netherlands and Brussels Capital Region, the BENEFIC Action (www.benefic.eu), which was selected for financial support under the CEF transport call 2016, has the ambition to implement more than 700 additional infrastructure points for clean vehicles on the TEN-T core network and in the urban nodes, combining normal/fast/ultra-fast charging points, natural gas and hydrogen fueling stations and shore power installations.
- In addition, a number of European projects, initiated by stakeholders, will stimulate the up-take of infrastructure for alternative fuels on the TEN-T core network in Flanders (e.g. FAST-E, ULTRA-E, UNIT-E, H2Benelux, LNG Blue Corridors, …).
- The mobilization of funds (1 million EUR each year) to support studies (e.g. light electric vehicles) and Clean Power projects. At the moment, 17 CPT projects are being implemented (e.g. zero-emission buses and taxis, projects on car-sharing and light electric vehicles, projects on grid

integration). More information on some of these CPT projects/studies can be found under chapter EV Demonstration Projects.

Meanwhile, Flanders is preparing a following-up policy programme for a further transition towards zero-emission transport horizon 2030. In preparation of the policy vision, all relevant stakeholders were actively involved in stakeholders sessions on different topics (e.g. charging infrastructure, role of natural gas and hydrogen and role of local governments).

Walloon Policy Framework

The Walloon Region has recently boosted its intent to foster alternative fuels on its territory. While electric mobility has improved its ability to replace fossil fuels vehicles in recent years, we have reached a point where an increased support to alternative fuels becomes necessary. Recently, the Walloon Government has approved some decisions that will impact the development of alternative fuels in coming years (i.e. 2030 and 2050). The Government has set up a ban on diesel vehicles in 2030 and a 50 % replacement rate on battery electric vehicles (100 % in 2050).

In order to reach those ambitious objectives, several formal decisions have been approved:

- 2 million EUR budget to support deployment of publically accessible charging infrastructures;
- 50 million EUR investment plan for power to hydrogen innovative projects where transport will be specifically addressed (with an aim on logistics and public transportation);
- 40 million EUR for 2018 and 2019 for specific climate actions where transport is a major objective to be encountered;
- Implementation of the first hydrogen refueling station within the H2BENELUX project;
- 400 hybrid buses to be deployed within 2 to 3 years (already 20);
- Study of the potential of electric mobility as a support to the electricity grid;
- Specific scope on transport and mobility within the National Plan on Energy and Climate;
- Plan FAST that will boost intermodality in the transport and aiming the creation of 100 platforms with shared electric or CNG vehicles, refuelling infrastructures, etc. A provisional budget has been approved in order to launch the first platform at last in 2019.

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 of the BCR (STIB/MIVB) is currently testing electric buses as to prepare the transition for an electric bus fleet as from 2030.

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. A concession is being prepared for the installation of public charging infrastructure in the Region. The first normal charging points will be installed as from the summer of 2018, to create a regional basic infrastructure, after which the next round of points will be installed based on users demand. 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.

The Brussels Capital Region (BCR) is also partner in the BENEFIC action (www.benefic.eu), together with the Flemish Region and the Netherlands with the purpose to provide financial support for the installation of two additional CNG stations, ten fast chargers, one ultra-fast charger and three shore-side electricity points for the Brussels' port.

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.

However, the federal government of Belgium 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 & 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 was 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 & Electric Vehicles, etc.

Main federal policy measures/competences are related to federal fiscal measures, economy & employment, mobility & transport (networked and integrated transport), energy & environment (synergy electric mobility and renewable energy), federal government fleet, standardization (CEN – NBN) and security. Some examples:

- Federal fiscal measures for (alternative) company vehicles: tax reduction for certain electric vehicles, advantageous deductibility rates for clean company cars in function of CO2 emissions, lowering deductibility rates for polluting vehicles, incentives via system "benefit in kind" for company cars, advantageous excise duties for example for natural gas as a motor fuel, etc. Fiscal measures with regard to private vehicles is a regional competence in Belgium.
- Economy & employment: incentives were created by the federal government (tax shift - reduced employer contributions, tax benefit systems for shift work, tax credit for research and development, etc) which facilitated the choice of Audi to produce its first EV, the e-tron Quattro SUV, in the plant in Vorst (Brussels) for production in 2018, and its second, the e-tron Sportback, which will also be built in Brussels starting in 2019. The plant in Brussels will also produce the batteries for the electric vehicles. Further efforts will be made in order to attract additional investments with regard to the production of electric vehicles/batteries in Belgium. In February 2018, the federal government organized a stakeholders meeting on Batteries.
- Mobility & Transport: new federal regulation and incentive measures were adopted in 2017 with regard to speed pedelecs and normal (electric) bikes. Moreover, in February 2018, a smart mobility call was launched by the federal government (budget: 4 million EUR). The call will focus on - among others - projects regarding car sharing, intermodality, services / apps which provide real time information on transport services, open data with regard to mobility, etc.
- Energy & climate: integration of transport objectives in the energy & climate plans of Belgium. Moreover, a transport chapter is included in the interfederal "Energy Pact" for 2030/2050, of which the political negotiations are currently being finalized. This will have a considerable impact on the Belgian CPT policy framework with a time horizon of 2025/2030.
- Federal government fleet: new rules were adopted in 2017 with regard to the purchase of vehicles for the federal government. In general, the following objective was set: the federal government fleet consists of at least

25 % of battery-electric , hybrid or CNG vehicles and at least 25 % of the fleet has an “ecoscore” of 75 (or higher).

- Standardization issues: various standards have been developed and published by the Belgian national organization for Standardization (NBN), also regarding Directive 2014/94.

Other Policy/Incentives

Low-Emission Zones (LEZ)

Recently, low-emission zones have been entered into force in Belgium. This measure aims to improve the local air-quality by keeping polluting vehicles outside certain areas in the city or region.

The federal level created a sign so that there is uniformity throughout Belgium for indicating low emission zones. Cities in Flanders can introduce low-emission zones starting in March 2016. The first city to introduce a low-emission zone was Antwerp starting in February 2017. Other cities in Flanders will follow. The Brussels Region turned its whole territory with only a few exceptions left into a low-emission zone on January 1, 2018.

Figure 7: New road signs for low-emission zones (Source: Federal Public Service of Mobility & Transport)

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. More information: http://gedeeldemobiliteit.be/english/.

In Flanders, the number of electric car-sharing vehicles has quintupled in one year up to 71 vehicles at the end of 2017. The reason is that more and more car-sharing initiatives are active in Flanders and some of them even focus completely on electric car-sharing. In 2018, initiatives like Poppy (Antwerp) will introduce hundreds of extra electric car-sharing vehicles in Flanders. The ambition of the Green Deal is to reach 1,000 electric car-sharing vehicles in 2020. The seven partners in the Green Deal are:

- www.autodelen.net
- www.cambio.be
- www.battmobiel.be
- www.partago.be
- www.poppy.be
- www.stappin.be
- www.zencar.eu

In Brussels, car-sharing initiatives like DriveNow, Cambio, Ubeeqo, ZipCar and Zen Car are active. Zen Car already have more than 100 electric car-sharing vehicles on the road today.

Standardisation Support to Electric Mobility in Belgium

In Belgium, the Belgian Bureau for Standardisation (NBN) has started to develop a Belgian standard on “Electrical propelled road vehicles – controlling risks during interventions” in 2017.

The reason for this initiative is the fact that more and more vehicle manufacturers in the EU are placing e-mobility vehicles on the market. The take-off of e-mobility has started slowly, but is now in full expansion transforming the automobile sector fundamentally, from assembly to recycling. This new technology has a serious influence and impact on all safety procedures, requirements and precautions which need to be considered in case of interventions on these vehicles.

Standardization of procedures and practices across the European Union and providing adequate, correct and updated information to first and secondary emergency responders and persons working on electric traction vehicles becomes a priority matter. This Belgian standard is being developed by the standardisation committee NBN/B Electric Vehicles. Within this committee there are representatives of the private and public transport sector, the academic institutions, and the technical service departments of car manufacturers or their importers involved in Belgium.

The purpose of this standard is to define the requirements for the control of risks during interventions on electric traction hybrid, plug-in hybrid, full electric passenger cars, small commercial vehicles and motorcycles (categories M-N-L). Special requirements will be identified to remove any electrical risk and to properly handle damaged and defective components of such vehicles.

Several other EU Member States have developed similar standards in the past few years: the Netherlands (NEN 9140-2013), France (NF C18-550), and Germany (DGUV 205-022). In addition to these European initiatives, the International Standard Organisation (ISO) has been working on the standard ISO 17840 "Road Vehicles - Information for first and second responders" since 2015 which is to be published in 2018.

This standard consists of four parts:

- ISO 17840-1, Rescue sheet for passenger cars and light commercial vehicles
- ISO 17840-2, Rescue sheet for buses, coaches and heavy commercial vehicles
- ISO 17840-3, Emergency Response Guide template
- ISO 17840-4, Propulsion Energy Identification

Educating technical personnel and intervention teams has become an integral part in the deployment of electric traction vehicles on the European marketplace. Technical information and advice is essential to control all the risks potentially associated with this new technological mobility development.

22.2 HEVs, PHEVs and EVs on the Road

The number of electric passenger cars in Belgium has been growing quickly. Most sold electric passenger cars in 2017 are PHEV's with Mercedes GLC350e, BMW X5 40e, Volvo XC90 PHEV, BMW 530e and BMW 330e. as top sellers Within the BEV's segment, the top sellers in 2017 are Tesla Model S, Tesla Model X, Nissan Leaf, Renault Zoe and BMW i3.

Figure 8: Top 10 PEV (M1) market share Countries in European Union (Source: EAFO)

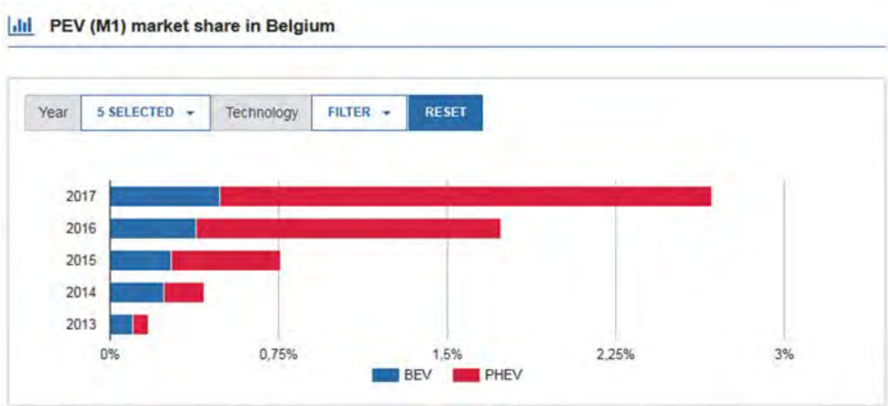


Figure 9: PEV (M1) market share in Belgium (Source: EAFO)

Figure 10: New registrations for PEV (M1) in Belgium (Source: EAFO)

All statistics on electric passenger cars but also on the other types of electric vehicles like 2-wheelers, light commercial vehicles, medium and heavy freight trucks and electric buses can be found below.

Table 4: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: Federal Public Service of Mobility & Transport)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	10,878	0	178	0	606,589
Passenger Vehicles[2]	7,524	22,974	52,559	15	5,798,628
Buses and Minibuses[3]	10	0	269	5	15,987
Light commercial vehicles[4]	776	0	0	0	741,015
Medium and Heavy Weight Trucks[5]	14	0	13	0	145,088
Totals without bicycles	**12,350**	**22,974**	**53,018**	**20**	**7,300,239**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	6,024	0	0	0	39,968
Passenger Vehicles[2]	2,705	11,832	12,235	4	552,102
Buses and Minibuses[3]	0	0	63	0	855
Light commercial	127	0	0	0	76,116

vehicles[4]					
Medium and Heavy Weight Trucks[5]	0	0	4	0	10,130
Totals without bicycles	**4,172**	**11,832**	**12,302**	**4**	**674,448**

[1] UNECE categories L1-L5
[2] UNECE categories M1
[3] UNECE categories M2-M3
[4] UNECE categories N1
[5] UNECE categories N2-N3
[6] Including non-electric

22.3 Charging Infrastructure or EVSE

Within the National Policy Framework "Alternative Fuels Infrastructure" extra policy measures have been taken to stimulate the market for charging infrastructure in Flanders, Walloon Region and Brussels Capital Region. See chapter "National Policy Framework" for all details.

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. Worldwide, 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 at the moment all information is scattered over different databases/websites/apps and not always up-to-date and certainly not available in a standardized way. So big improvements are needed for user-friendly access to charging infrastructure information.

Therefore a new **Task 39 on "Interoperability of e-mobility services"** has been started within the framework of the IEA HEV TCP (see chapter 19). Task 39 will be coordinated by VITO (Belgium). In the annual report of 2018, a more comprehensive country chapter focused on the charging infrastructure market in Belgium will be included. For this annual report we will focus in detail more on the statistics on charging infrastructure in Flanders.

Statistics on Charging Infrastructure in Flanders

Triggered by the 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 Flanders, 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. As described in the chapter “National Policy Framework”, a lot of new policy measures have been taken to stimulate the alternative fuels infrastructure. To avoid duplication of information, we recommend to read that chapter. All measures aim for having more publicly accessible charging points and for giving the potential EV drivers more accurate information. All information is centralized on the following website: www.milieuvriendelijkevoertuigen.be

Currently, 1,726 normal charging points and 34 locations for fast charging are registered in Flanders (Source: Annual Report Flemish Action Plan CPT).

More charging infrastructure is expected in the next years, coming from initiatives like BENIFIC (www.benefic.eu) and via the obligation of the Distribution Grid Operators (DGOs) to install 5,000 publicly accessible charging points through public procurement in 2020. In order to differentiate between private and (semi) public charging infrastructure, a definition of publicly accessible charging points (24/7 accessibility) was integrated in the Energy Decree of the Flemish Government. The charging points are distributed over the more than 300 municipalities in Flanders. Currently more than 1,000 of these are already in operation. Local governments are responsible for the installation of the parking spot and parking policies (e.g. enforcement). The charging points should enable EV drivers to conveniently charge in Flanders. An overview of all publicly accessible charging points is available on the clean vehicles website (www.milieuvriendelijkevoertuigen.be/laden).

22.4 EV Demonstration Projects

Electric company cars (PEB)

The “Platform elektrische bedrijfswagens” (Platform electric company cars or “PEB”) aims at accelerating the adoption of electric vehicles in company fleets in Belgium/Flanders. Its primary objective is to adopt a thorough selection of EV in the car policy of multiple companies and create incentives for employees to implement the adoption in practice. PEB offers a platform for fleet owners and market players to share knowledge on the subject and challenge each other, with a clear focus on bringing more EV on the road. PEB is an initiative from Fleet &

Mobility (the Belgian organization of fleet owners), Traxio (the Belgian umbrella organization of mobility retailers) and The New Drive (management consultants in e-mobility). The Platform is supported and co-financed by the Flemish government through the Clean Power for Transport program. The project started on January 1, 2017 and will run over the course of two years.

In 2017, the Platform organization brought together a group of five companies which aim at an average 25 % EV share (total fleet, not new sales). These frontrunner companies, have a diverse fleet in terms of size, utility/person cars and legal entity (profit and non-profit). The 25 % goal was reached after several in depth knowledge sessions in which best practices and experience from other companies was shared. The Platform initiated a Request for Information (RFI) toward the market (car, leasing and charging service companies) to review the market offer and roadmap and to challenge the TCO, compared to gasoline company cars. 24 companies participated in the RFI (Allego, Alphabet, Athlon, Arval, Audi, Belfius, BMW, EDF Luminus, ENGIE, Eneco, EV-Box, Fastned, Jaguar, Mini, Mobility+, Land Rover, New Motion, Powerdale, Renault, Tesla, Total, Volvo, VW, and VW D'Ieteren Lease). The deliverable was a report which showed us that the TCO of electric cars dropped below gasoline cars in certain cases, especially at a yearly distance of 25,000 km or more. The report was shared with more than 20 fleet owners with over 20,000 company cars.

At the end of 2017, the Platform developed a model e-car policy, together with the front runner companies, which was made publicly available in March 2018. The Platform also initiated two conferences with fleet owners and market players, to share best practices. In spring 2018, there will be an EV experience test for the employers of the frontrunner companies. They will test electric cars during a period from 1 to 3 weeks. The aim of this experience is to convince the employees and make the choice for an electric company car. At the end of spring 2018, the Platform will also publish an electric fleet manual/guideline, to support even more fleet owners to electrify their fleet.

E-Taxis

The "Clean Power for Taxis" project is led by BBL and taxi federation GTL with support from the Flemish government. The scope of the project is to have at least one out of ten taxis driving electrically in 2020. The "Clean Power for Taxis" builds further on the pilot projects in Antwerp and Louvain and will also roll-out in Bruges, Ghent and Mechelen. The project wants to support cities and taxi companies in the process to introduce electric taxis.

Figure 11: Clean Power for Taxis (Source: Jasper Léonard)

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

E-Buses

ZEB Platform & 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. At the latest Busworld Europe in Kortrijk (Belgium), 41 electric buses were presented. In 2017, the ZeEUS project produced an update of the **ZeEUS eBus Report**, a very comprehensive overview of the electric buses being used in Europe today and gives information about 90 European cities and a growing number of bus manufacturers. The 2017 update also included electric system suppliers for the first time. From Belgium, input was foreseen from the city of Bruges and Namur and from bus manufacturers Van Hool and VDL Bus & Coach. VITO gave support in creating the ZeEUS eBus Report.

The **Flemish Zero Emission Bus Platform (ZEB Platform)** was approved at the end of 2016 and is running from 2017 until mid 2018 (http://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. Many workshops have been conducted. The ZEB platform worked 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.

Figure 12: FBAA Symposium on electric public transport (Source: FBAA)

The ZEB platform had its first symposium at FBAA (https://vimeo.com/210910748/8cb8dc93bf). The public transport authorities and operators were informed about the barriers and opportunities of introducing electric buses in operational use. At Busworld 2017, the first intermediate results have been presented and the final ZEB report is in preparation and will be delivered by mid 2018.

TEC Group

TEC Group, the Public Transport company of the Walloon Region, has very ambitious plans in the electrification of its bus fleet. TEC ordered 90 electric hybrid buses and 12 charging stations for Charleroi and Namur.

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 four 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.

The 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 13: Volvo 7900 Electric Hybrid charging in Namur (Source: TEC Group)

Figure 14: 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 150kW 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 twelve 150kW 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.

STIB/MIVB

STIB/MIVB, the Public Transport company of the Brussels Capital Region, is currently testing electric buses to prepare the transition for an electric bus fleet as from 2030.

De Lijn

De Lijn, the Public Transport company of the Flemish Region, has the ambition to drive completely electric in 2025 in the “urban environments”. The first project with inductive charging for electric buses in daily operation started already a few years ago in the city of Bruges.

Today, De Lijn is starting up projects with six full electric buses in three cities (Ghent, Antwerp and Louvain). The buses will be charged via pantograph opportunity charging.

Brussels Airport and De Lijn are starting up a pilot project with a self-driving bus on the Brussels Airport. The vehicle that is being developed for this, will be one of the first to drive in Belgium in mixed traffic. After the summer of 2019, tests without passengers will begin at constructor 2GetThere in Utrecht (The Netherlands). The shuttle bus will arrive at Brussels Airport in the beginning of 2020 for further tests.

ECAR

ECAR (http://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. Final prototypes were shown at the Brussels Motorshow in January 2017, creating a lot of interest of regional and national government. Industrial partners have been identified who will industrialize the whole concept.

ECAR is an L5 category full 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 batteries stretching the overall life of the battery to over 20 years, time at which recycling will generate a surplus versus its cost.

Figure 15: Design of self-driving electric bus (Source: De Lijn)

Figure 16: ECAR (Source: Xavier Van der Stappen)

Saroléa

Saroléa (www.sarolea.com) was the first Belgian producer of motorcycles, and one of the first producers of motorcycles in the world. This Belgian factory was established in 1850 by Joseph Saroléa. As of 2008, Saroléa is focused on the development and production of high-performance electric two-wheelers and electric drivetrains. The Saroléa SP7 electric race bikes and the Saroléa MANX7 road bikes are built around an innovative carbon fibre monocoque chassis and an ultra-efficient 180 kW axial flux motor, powered by a 22 kWh interchangeable battery pack. This combination of materials and techniques results in ultra-efficient motorcycles with an autonomy already surpassing 330 km.

Saroléa is also supplying high-performance / high-capacity battery packs as well as electric drive-trains for automotive, nautical and aerospace applications.

Figure 17: Saroléa SP7 electric race bike with DC quick-charge capabilities (Source: Saroléa)

22.5 Outlook

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

23 Canada

23.1 Major Developments in 2017

23.1.1 National Developments

Pan-Canadian Framework

In December 2017, the Government of Canada along with provincial and territorial governments released the first annual synthesis report on the status of the Pan-Canadian Framework (PCF) on Clean Growth and Climate Change. As part of this work, federal, provincial and territorial governments committed to modernize transportation systems through new emission standards for vehicles, a plan for establishing retrofit requirements for heavy-duty vehicles, and a strategy to put more zero-emission vehicles (ZEVs) on the road. In addition, governments are enhancing investments in lower-emitting public transportation and electric and alternative fuel vehicle charging and refueling infrastructure.[25]

The PCF aims to achieve Canada's international commitments in the Paris Agreement and confirms the commitment of Canada's First Ministers to implement policies in support of meeting or exceeding Canada's 2030 target to reduce greenhouse gas (GHG) emissions by 30 % below 2005 levels while transitioning Canada to a stronger, climate resilient, low carbon economy.

Under the PCF, federal, provincial and territorial governments also committed to work with industry and stakeholders to develop a Canada-wide ZEV strategy, to be released in 2018. The ZEV strategy will build on existing programs and policies to meet 2030 emission reduction targets. A sectoral Advisory Group comprised of government, industry, academia, and other stakeholders was established to develop options for addressing the key barriers that are preventing the broader deployment of ZEV technologies.[26]

---

[25] Government of Canada. "Pan-Canadian Framework on Clean Growth and Climate Change: First Annual Synthesis report on the Status of Implementation". December 2017.

[26] Transport Canada. "National Zero Emission Vehicle Strategy". https://www.canada.ca/en/transport-canada/news/2017/05/government_of_canadatodevelopanationalzero-emissionsvehiclestrat.html Accessed: January 26, 2018.

Also in 2017 after consultations, the Government of Canada published a regulatory framework on a new clean fuel standard. The clean fuel standard aims to reduce GHG emissions through the increased use of lower carbon fuels, energy sources, and technologies. Consultations will continue in 2018 with the intent of publishing regulations in mid-2019[27].

Finally, work is underway to ensure carbon pricing applies across Canada. Some jurisdictions have carbon pricing systems in place while others are working to develop and implement pricing systems. In the event that jurisdictions do not have a pricing scheme in place by 2018, a federal backstop system will apply that will ensure that carbon pollution pricing applies in every province to a broad set of emission sources with increasing stringency over time[28].

Investing in Electric Vehicle and Alternative Transportation Fuel Infrastructure

The 2016 federal budget allocated 48.3 million USD over 2 years to Phase I of the Electric Vehicle and Alternative Transportation Fuels measures in order to support the demonstration of next-generation electric vehicle (EV) charging infrastructure and the deployment of charging infrastructure for EVs, as well as refueling infrastructure for alternative transportation fuels, such as natural gas (NG) and hydrogen (H_2).

The Demonstration Program supports the use of innovative and next generation EV charging infrastructure technologies in real-world applications such as multi-unit residential buildings (MURBs), workplaces, and public transit, where market failures are preventing the development and commercialization of new charging technologies. Upon the successful completion of projects (some of which have been extended to 2020), the Demonstration Program is expected to result in over 200 next-generation EV charging stations which include Level 2 (240V AC) and DCFC (direct current fast-charge).

The aim of the Deployment Initiative is to increase the number of EV fast charging stations along Canada's highways, NG refueling stations along key freight corridors, and H2 refueling stations in strategic urban centers. In 2018, upon successful completion, this initial investment will result in the deployment of over 100 new publically accessible EV fast chargers, 7 NG and 3 H_2 refueling stations

[27] Government of Canada. "Clean Fuel Standard". https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html, Accessed: February 7, 2018.

[28] Government of Canada. "Technical paper: federal carbon pricing backstop". https://www.canada.ca/en/services/environment/weather/climatechange/technical-paper-federal-carbon-pricing-backstop.html, Accessed: February 07, 2018.

in 7 provinces. Budget 2017 announced an additional 61 million USD over 4 years (starting in 2018) in support of Phase II of the EV and Alternative Fuel Infrastructure Deployment Initiative, to further deploy NG refueling stations along key freight corridors, establish H_2 stations in key metropolitan areas, and to bolster Canada's coast-to-coast EV fast charging network. An additional 23 million USD was also allocated over 4 years for Phase II of the EV Infrastructure Demonstration Program to support new and innovative EV infrastructure projects. Finally, 7 million USD was allocated to the development of supporting codes and standards for electric and alternative fuel vehicles, as well as charging and refueling infrastructure.

Leading by Example, Greening our Government Fleets

In December 2017, the Government of Canada released an aggressive strategy to reduce emissions from all Government operations, including facilities and fleets. This strategy includes commitments to adopt low-carbon mobility solutions, deploy supporting infrastructure in its facilities, and modernize its fleet. Starting in the 2019-2020 fiscal year, 75 % of new light-duty administrative fleet vehicle purchases will be ZEVs or hybrid, with the objective that the Government's administrative fleet comprises at least 80 % ZEVs by 2030. Priority is to be given to purchasing ZEVs. Also starting in the 2018-2019 fiscal year, all new executive vehicle purchases will be ZEVs or hybrids. To assist all federal departments in succeeding in this commitment, the Government is coordinating across all departments to help collect and analyze the energy usage of vehicles in their fleets, and determine the lowest emitting option that continues to meet their operational needs. This includes identifying options for electrification, fuel switching, fleet right sizing, and fuel-efficient driver training.

Encouraging Innovation with the Smart Cities Challenge

In 2017, the Government of Canada launched the first phase of the Smart Cities Challenge. The challenge will award 60 million USD in 2018 to 4 communities. Eligible recipients include municipalities, regional governments, and indigenous communities. The Challenge encourages communities to improve the quality of life for urban residents through better urban planning, the implementation of clean, digitally connected technology including greener buildings, smart roads and energy systems, and advanced digital connections for homes and businesses.

23.1.2 Provincial Policies and Incentives

British Columbia[29]

British Columbia (B.C.) has a multitude of policies and programs to accelerate the deployment of low-emission vehicles within the province.

In 2017, the provincial government launched its 30 million USD Specialty-Use Vehicle Incentive program. The funding aims to accelerate the deployment of electric and H_2 vehicles and expand refueling infrastructure. Over 20 million USD will be available for vehicle purchase incentives. In addition to incentives for light-duty and low speed vehicles, rebates are available for medium and heavy-duty vehicles, airport and port specialty vehicles, and forklifts. The goal of the program is to stimulate the sale of clean energy vehicles where by 2020, five percent of new light duty vehicle sales in B.C. will be clean energy vehicles. The remaining funding will enhance charging and H_2 infrastructure across the province by expanding fast charging, workplace charging, and charging at MURBs. The province's first of six public H_2 refueling stations is also expected to open in 2018.

The BC Scrap-It program also provides an incentive of 2,500 USD to vehicle owners that scrap an aging fossil fuel powered vehicle in favor of a more fuel-efficient vehicle. The program was enhanced in 2017 to increase the incentive to 4,500 USD when scrapping an older vehicle and purchasing a new EV, and 2,250 USD when purchasing a used EV. Other financial incentives are available to encourage public transit, active transportation, and ride sharing. The BC Scrap-It Program incentives can be combined with incentives for the purchase of clean energy vehicles up to 8,250 USD.

Manitoba

The Government of Manitoba and the City of Winnipeg formed a joint task force to investigate the viability of deploying electric transit buses in the provincial capital. A number of electric buses and overhead chargers are being tested on routes that were typically serviced with diesel buses. Preliminary results of the demonstration reveal that the electric buses reduce operating costs (fuel and maintenance), reduce environmental impacts, and enhance energy security and price predictability. While a number of obstacles exist (high capital cost of electric versus diesel buses), there is a case for larger scale deployments in a transit setting.

---

[29] B.C. Government. "CEV for BC". 2017. https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program/cev-for-bc, Accessed online: February 20, 2018.

Newfoundland

In 2017-18, the province established an EV working group consisting of representatives from the provincial government, municipalities, Newfoundland Power, Newfoundland and Labrador Hydro, and industry. This group is assisting in the development of the province's policy approach for increasing the market penetration of EVs in Newfoundland and Labrador moving forward.

The provincial government also launched the Vehicle Efficiency and Cost Calculator (VECC) to inform consumers about the costs and benefits associated with purchasing a fuel-efficient and alternatively powered vehicle. The VECC provides calculations for both EVs and those that run on gasoline or diesel. The VECC allows users to compare different vehicles to estimate their costs of ownership and impact on the environment by inputting information such as the vehicle type, purchase price, repayment structure, fuel consumption rating, and annual kilometers driven.

Ontario[30]

On July 11, 2018, the newly elected government of Ontario announced that it was terminating its electric vehicle incentive program that provided up to 10,500 USD on eligible electric and hydrogen vehicles, as well as its electric vehicle infrastructure programs targeted at expanding electric vehicle infrastructure in Ontario.

The government has committed to provide an update on its plan to address climate change in the fall of 2018.

Québec[31]

The Government of Québec aims to have 100,000 PHEVs and EVs on Québec roads by 2020. To support this goal, the province announced a multitude of initiatives in 2017, as described below.

Regulations were published that will provide consumers with more EV and PHEV vehicle choices. Starting with model year 2018, regulations will establish EV/PHEV sales targets for each reporting vehicle manufacturer. The legislation requires manufacturers to sell an increasing percentage of EVs and PHEVs over time. In the event that manufacturers do not comply, they will be able to purchase "credits" from other manufacturers to meet their mandated sales thresholds. With

[30] Government of Ontario, "Climate Change Action Plan", 2016. https://www.ontario.ca/page/climate-change-action-plan, Accessed online, February 19, 2018.

[31] Government of Québec. "Propelling Québec Forward With Electricity: Transportation Electrification Action Plan 2015>2020". 2015. ISBN 978-2-550-73274-7.

this new measure, manufacturers will be motivated to offer more models and to use low-carbon technologies.

In addition, new regulations enable eligible EV, PHEV, and hydrogen fuel cell vehicle (HFCV) owners to obtain a green license plate. These vehicle owners will be exempt from paying the additional annual registration fees for luxury vehicles that applies to the portion of a vehicle's value between 30,000 USD and 56,000 USD.

A new outreach program (Electrifying Encounters) was also launched that will allow employers and employees to try a variety of EVs and to learn more about EV technologies from industry experts. Four hundred thousand motorists from across the province are expected to participate in the program.

In addition to these measures, the Government of Québec offers incentives to encourage the uptake of electric and H_2 cars and trucks and electric school buses. Programs and incentives also exist to expand charging infrastructure along major routes, to increase the availability of charging infrastructure at workplaces and for residents of MURBs.

23.2 HEVs, PHEVs and EVs on the Road

Increased consumer awareness, greater availability of charging infrastructure, improvements in vehicle technology, more PHEV and EV choices offered by the vehicle manufacturers, purchase incentives offered by provinces, and infrastructure supports from all levels of government, have all contributed to an increase in plug-in vehicle sales in Canada in 2017.

As Table 1 illustrates, at the end of 2017, Canada had almost 25,000 EVs on the road, 23,000 PHEVs, and over 200,000 HEVs. There are almost 23 million light-duty vehicles on Canadian roads[32] where EVs, PHEVs and HEVs now represent just over 1 % of Canada's total light-duty fleet.

Year over year sales of EVs increased by almost 100 % in 2017 (9,838 versus 5,130), whereas sales of PHEVs increased by almost 50 % (8,730 versus 5,893). The sale of both EVs and PHEVs totaled 18,568 vehicles, representing a 68 % increase over 2016 sales of 11,000 vehicles. Canadian light-duty vehicle sales in

[32] Statistic Canada, "Annual Vehicle Registrations", http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=4050004&&pattern=&stByVal=1&p1=1&p2=37&tabMode=dataTable&csid, Accessed: February 16, 2018

2017 totaled 2,038,600[33] units where EVs, PHEVs, and HEVs represented over 2 % of new vehicle sales.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2017[34]

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total**
Passenger Vehicles	24,748	23,040	211,019	n.a.	26,308,468[1]
Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total**
Passenger Vehicles	9,838	8,730	24,962	n.a.	2,038,600

[1] Fleet total estimated from 2016 registration data and 2017 vehicle sales
n.a. = not available

Table 2 illustrates the top selling EVs and PHEVs in Canada in 2017. In both the EV and PHEV categories, Chevrolet led the way with the Bolt and Volt product offerings.

Table 2: 2017 Top Three Selling Plug-in Vehicles in Canada

EV Models	# of EVs sold	PHEV Models	# of PHEVs sold
Chevrolet Bolt	2,107	Chevrolet Volt	4,340
Tesla Model X	1,803	Chrysler Pacifica	838
Tesla Model S	1,675	Toyota Prius Prime	734

In terms of geographic distribution of plug-in vehicle sales in Canada, provinces that offer consumers purchase incentives for low emission vehicles have the highest sales. Over 7,000 EVs and PHEVs were sold in both Ontario and Québec, whereas British Columbia witnessed sales of 3,200 vehicles. Table 3 provides a list of some of the EVs and PHEVs for sale in Canada and their estimated pricing.

[33] DesRosiers Automotive Consultants Inc. "Automotive Reports: Market Snapshot December 2017".

[34] Schmidt, Eric. Fleetcarma: "Electric Vehicle Sales in Canada, 2017". https://www.fleetcarma.com/electric-vehicle-sales-canada-2017/, Accessed: February 14, 2018.

Table 3: Available vehicles and prices in Canada (Data source: based on Manufacturers Suggested Retail Price as advertised on manufacturer websites; Note 1 USD=1.25 CAD)

Market-Price Comparison of Selected EVs and PHEVs in Canada	
Available Passenger Vehicles	Untaxed, Unsubsidized Sales Prices (in USD)
Audi A3 e-tron	36,720
BMW i3	40,800
BMW i3 Rex	44,400
BMW i8	122,400
BMW 330e	40,960
BMW X5 xDrive/40e	60,000
Chevrolet Bolt	34,400
Chevrolet Volt	31,200
Chrysler Pacifica Hybrid	31,200
Ford Focus Electric	22,400
Ford C-Max energy	22,000
Ford Fusion energi	28,000
Hyundai Sonata Plug-in	35,200
Karma-Revero	124,800
KIA Soul EV	28,800
KIA Optima Plug-in	28,000
Mercedes GLE-550e 4Matic	67,200
Nissan Leaf	27,200
Smart Fortwo Electric Drive	23,200
Tesla Model S 100 D	97,500
Tesla Model X 100D	105,700
Toyota Prius Prime	26,400
VW e-Golf	29,200

23.3 Charging Infrastructure or EVSE

Due to initiatives by the federal, provincial, and municipal governments, as well as, utilities and private firms, public charging infrastructure is continuing to grow in Canada.

As shown in Table 4, there were approximately 5,843 EVSEs in Canada in 2017, of which 5,168 were Level 2 (240V AC), 483 were DCFC, and 190 were Tesla Superchargers. This represents a 38 % increase in public charging infrastructure installations across Canada compared to 2016. Most of the newly installed charging infrastructure was in British Columbia, Ontario, and Québec, however, there was also a notable increase in other provinces such as in Alberta and New Brunswick.

It is important to note that there are no requirements by respective jurisdictions to register EVSEs as they are installed. As a result, tracking of operational Level 2, Level 3 and Tesla Supercharger stations is performed through the issuance of service contracts to collect the charger information, or through voluntary reporting by charging network owners and managers, as well as end users. Level 1 (120V AC) EVSEs are not reported on since this infrastructure typically relates to charging via a residential wall outlet.

Table 4: Information on charging infrastructure in 2017[35]

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers	n.a.
AC Level 2 Chargers	5,168
Fast Chargers	483
Superchargers	190
Inductive Charging	n.a.
Totals	**5,843**

n.a. = not available

23.4 EV Demonstration Projects

23.4.1 Enhanced Charging Infrastructure via Vehicle Side Data

Natural Resources Canada is providing 2.6 million USD to CrossChasm Technologies Inc. to demonstrate that the collection and analysis of real-world vehicle charging data, such as battery state and all charge events, will improve the operation and the deployment of EV charging infrastructure. This will be accomplished by monitoring data on the vehicle side through a logging module installed for the project duration.

The results and analytics will be widely disseminated and enable Canadian utilities and policy makers to identify where grid overloading may occur, as well as where grid and charging infrastructure upgrades are required. Research will also provide

[35] Natural Resources Canada, "Electric Charging and Alternative Fuelling Locations"

decision-makers with tools to successfully deploy EV charging infrastructure at workplaces and MURBs.

23.4.2 Demonstration of Next Generation Integrated Smart Infrastructures for Charging Electric Vehicles

Approximately 5.4 million USD will be provided to AddÉnergie Technologies Inc. to develop and demonstrate new and innovative EV charging technologies. Activities include: the development of next generation EV fast charging stations; exploring a monthly subscription based charging business model; and installing street-side charging in five major Canadian cities.

23.4.3 EV Charging Stations across Trans-Canada Highway (TCH) – Ontario and Manitoba

Funding of 6 million USD will be provided to Fast Charge TCH. The objective of this project is to demonstrate an EV fast charging network using battery storage across the Trans-Canada Highway that can serve as an example for rural areas that have low-power grid connections. The network will include 34 locations, connecting northern Ontario to the Manitoba-Saskatchewan border along the inter-provincial national highway.

23.4.4 TransLink Electric Bus Demonstration and Integration Trial

South Coast British Columbia Transportation Authority (TransLink) will receive approximately 1 million USD to install, operate and maintain two high-powered, overhead bus charging systems with one on-route and an in-depot charging solution to support four electric buses.

The project, which is part of a pan-Canadian initiative led by the Canadian Urban Transit Research and Innovation Consortium (CUTRIC), will integrate more than one bus manufacturer and more than one charging system provider, allowing to assess bus and charging station cross-compatibility, as well as to evaluate the performance of electric buses and overhead chargers in a Canadian transit setting. A third party will gather, validate, and share data and intellectual property emanating from the trial regarding charging episodes, powertrain performance, vehicle and charging system ruggedness, and durability. Data will be disseminated to the wider Canadian community of transit and utility systems and will result in improving the performance, charging speed and safety of DCFC systems associated with overhead electric bus hardware.

23.4.5 High Voltage Utility Connected Level 2 Electric Vehicle Charging Demonstration

British Columbia Hydro and Power Authority will receive approximately 0.9 million USD for a novel Level 2 EV charger aimed at MURBs, and large commercial and municipal buildings. In this project, the transformer would be integrated into the charger, which will eliminate the need for the designated transformer reducing space requirements in the meter room, reduce the number of conduits and wiring, and improve the EV charger system's performance and reliability, while also reducing costs. The space savings would be especially beneficial for charger installations in older buildings. A smart utility meter will be integrated into the charger to allow for individual metering and billing, as well as remote monitoring.

23.4.6 Next Generation EV Charging Infrastructure

British Columbia Institute of Technology (BCIT) will receive approximately 0.8 million USD to demonstrate EV charging solutions destined for the urban environment. The project will demonstrate curbside charging using existing streetlight infrastructure, and provide charging infrastructure in commercial outdoor parking lots by leveraging the existing lighting systems. The project will also demonstrate a load-management system and user interface to emulate a MURB, and an open, non-proprietary communication protocol to improve interoperability between charging technologies from different vendors.

Figure 1: Streetlight integrated, curbside charging in front of a MURB in the City of New Westminster, British Columbia (Source: BCIT)

Figure 2: Simulation of MURB EV charging using a load-management system at the OASIS (Open Access to Sustainable Intermittent Sources) installation at the BCIT campus (Source: BCIT)

24 Denmark

24.1 Major Developments in 2017

- In 2017 EV taxation was reduced to revitalize the EV market by extending the 20 % registration tax break until the end of 2018 or until 5,000 additional sales.
- However, EV sales in 2017 is still at the low level since the introduction of the EV vehicle registration tax in 2016 and the ending of the EV support programmes. Sales in early 2018 show an upward trend.
- 2017 was a new record year with 43.4 % of Denmark's electricity consumption supplied by wind power. Renewable energy production from wind power has more than doubled since 2008. At least 50 % will be covered by renewable energy by 2030 as new offshore wind farms are developed. Thus electric transport also becomes more sustainable.
- Research and demonstration, new green and autonomous mobility solutions, novel business models and integration between smarter and greener transport and energy sector has developed more focus, including in V2G and V2X projects (Vehicle to Grid/Everything).
- New modes of electric transport are gaining momentum in Denmark. Large electric ferries are introduced, more electric buses in public transport, several electric car-sharing services including DriveNow, GreenMobility and LetsGo.
- Denmark has a strong EV charging infrastructure thanks to the major private e-mobility providers: CLEVER, E.ON, CleanCharge Solutions, Tesla and Nerve Smart Systems.
- 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.

24.1.1 Framework for the Electrification of Transport in Denmark

Denmark is supporting the Paris Agreement including a very ambitious national target of being fully independent of fossil fuels by 2050, and a 2030 milestone of 50 % of energy consumption supplied by renewable energy.

According to EU targets, EU greenhouse gas emissions must be reduced 20 % in 2020 (10 % of energy in transport must be renewable in 2020), 40 % in 2030 and 80-95 % in 2050 (all these EU targets are compared to 1990). Within the EU, Denmark is expected to have a 39 % reduction target in non ETS sectors (which include transport) in 2030 (compared to 2005).

Globally, as well as in Denmark, transport is recognized as a challenging sector for greenhouse gas emission reductions. Transport demand, energy consumption and greenhouse gas emissions are all increasing. And transition to low carbon and renewable solutions is depending on a range of new technologies to be matured, industrially scaled and price-competitive before becoming a mass market mover.

For more than a decade, the transformation of Danish transport sector has been seen in relation to the very ambitious transformation of the Danish energy sector. Denmark holds several years of world records of fluctuating wind power in the electricity mix. In 2017, the wind power generation in Denmark corresponded to 43.4 % of the electricity consumption.

In 2017, 2016, and 2015, World Energy Council ranked Denmark as number one among 125 countries energy systems on three core dimensions: energy security, energy equity, and environmental sustainability.

The combination of a prize-winning, strong and flexible energy system with record-breaking shares of fluctuating renewable energy positions Denmark as an interesting test laboratory for exploring the interplay between the energy system, renewable energy and e-mobility in terms of smart grid, smart energy and storage. Well-developed public transport, focus on new and electric mobility, new business models and e-mobility as a service, e-car-sharing, e-buses and autonomy will also be at the front in the coming years. Electric maritime propulsion is upcoming, with several ongoing e-ferries projects in Denmark. Biking is very important in Denmark and e-biking continues to grow.

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

Incentive programmes focused broadly on electric application in passenger cars, buses, vans, garbage trucks, 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 has 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 and highway 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.

Broad political agreements governed the development. The 2008 energy agreement continued the decarbonising of the energy system and initiated the first programmes for electric mobility and charging infrastructure. The broad political energy agreements from 2012 set out the ambitious targets for the energy system in 2020 and 2050 and also initiated new e-mobility and charging infrastructure programmes with focus on deployment vehicles and infrastructure for alternative fuels, mainly electrically, but also hydrogen and biogas.

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). These funds and programmes largely ended in 2015, with projects running until their projects periods end, typically within 3-5 years. A small scheme of 1,6 million USD (1.35 million EUR) funds new fuel cell vehicles and infrastructure in 2018.

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

In 2016, Copenhagen City published a new climate plan aiming at making the city the first CO_2-neutral capital by 2025, including in the public transport sector. The plan contains objectives, main activities and initiatives adopted by the City Council to be implemented to achieve this goal.

24.1.2 Taxation

Until January 1, 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 systems lead to some disproportionate incentive towards expensive BEVs which resulted in rather high shares of sales.

A progressive reduction of the tax exemption was decided in 2015, starting from 2016 and with full taxation phased in by 2020. The detailed phase-in steps were initially 20 % in 2016, 40 % in 2017, 65 % in 2018, 90 % in 2019, and 100 % in 2020. This led to a drop in sales of BEVs in 2016, where taxation was phased in with a 20 % first step. Due to low EV sales, the taxation was changed again with two political agreements in 2017.

New Political Agreement as per April 18, 2017:

- EV taxes stay 20 % for the next 5,000 EVs or latest to the end of 2018.
- EV purchase tax is 40 % in 2019, 65 % in 2021, 90 % in 2021, 100 % from 2022 on.
- New (2017-2021) BEV and PHEV purchase tax rebate of 225 USD/kWh (190 EUR/kWh) battery, max 45 kWh (10,000 USD; 8,458 EUR).
- Energy tax exemption (0.124 USD/kWh) (0.105 EUR/kWh) for commercial charging to 2019, from 2020 full tax.
- Energy tax exemption for charging e-buses extended to 2023 or longer according to the EU.
- Grant scheme for Hydrogen filling stations: 5 million DKK (0.7 million USD) (0.59 million EUR) in 2017-2018
- New Car Taxation Political Agreement as per October 3, 2017:
- Vehicle low purchase tax is reduced from 105 to 85 % high tax is maintained 150 %.
- Cut between low and high tax is moved from (16,900 USD; 14,294 EUR) to (29,300 USD; 24,783 EUR).
- Bonus/Malus from 16 to 20 km/l gasoline and 18 to 22 km/l diesel.
- Malus rose from 1,000 DKK/l (134.27 EUR/l) to 6,000 DKK/l (805.63 EUR/l); Bonus is still 4.000 DKK/l (537.08 EUR/l).

Effects generally:

- Cheap ICE cars getting a bit more expensive, expensive cars getting cheaper, also HEV
- Lower cost EVs not much more expensive first years, high cost EVs more expensive
- Consumer reaction on tax exemption removed at the end of 2015 has been dramatic
- Taxation changes in 2017 did not change this, but slightly upward trend

24.2 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.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in Denmark in 2017 (Data source: Dansk Elbil Alliance/De Danske Bilimportører DBI (Danish car importers association); Bus numbers are from Movia; E-bikes numbers are from Danish Bicycle Retailers, but usually not available before April 2018)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[f]**
2- and 3-Wheelers[a]	217	0	0	0	217
Passenger Vehicles[b]	8,513	1,648	16,500	81	26,742
Buses and Minibuses[c]	5	0	20	0	25
Light commercial vehicles[d]	512	173	1,200	1	1,886
Medium and Heavy Weight Trucks[e]	5	0	2	4	11
Totals without bicycles	**9,252**	**1,821**	**17,722**	**86**	**28,881**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[f]**
2- and 3-Wheelers[a]	n.a.	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles[b]	698	614	7,101	15	8,428
Buses and Minibuses[c]	0	0	0	0	0
Light commercial vehicles[d]	61	23	493	0	577
Medium and Heavy Weight Trucks[e]	2	0	0	0	2
Totals without bicycles	**761**	**637**	**7,594**	**15**	**9,007**

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

24.3 Charging Infrastructure or EVSE

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 CleanCharge 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 here: https://www.ladekortet.dk.

In terms of interoperability, all quick chargers in Denmark today are 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. 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.

Table 2: Information on charging infrastructure in 2017 (Data source: Dansk Elbil Alliance)

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers	0
AC Level 2 Chargers	948
Fast Chargers	146
Superchargers	85
Inductive Charging	0
Totals	**1,179**

24.4 EV Demonstration Projects

Since 2008, the Danish Energy Agency (DEA), the Danish Road Safety Agency and the Danish Road Directorate administrated several programmes to support deployment of electric, plug in hybrid and hydrogen transport and infrastructure in the Danish transport sector. Funds have been used to support projects that allow companies, public bodies, and private consumers to familiarize themselves with EVs and other vehicles, develop synergies between relevant stakeholders and support the deployment of alternative fuel infrastructure. These funds and programmes largely ended in 2015, but will be running until their projects periods end, typically within 3-5 years.

Electric Car-Sharing Schemes in Denmark

Denmark hosts several electric car-sharing services, including DriveNow, GreenMobility and Let's Go.

- DriveNow operates in several European countries, but in Copenhagen its fleet is 100 % electric. It includes some 400 BMW i3s to be booked via an app. The pricing models include rates per minute, daily rates or monthly subscriptions.
- GreenMobility operates in Copenhagen and surrounding regions. It includes more than 400 Renault ZOEs to be booked and accessed via an app. The pricing models include rates per minute, daily rates or monthly subscriptions.
- Let's Go is a non-profit organisation operating in several Danish cities, currently with 30 electric cars, representing 15 % of the total fleet. Let's Go is a membership-based organisation, with dedicated parking. Members pay based on time and distance travelled.

Partnerships with the public sector, and funding from the Danish Energy Agency and the Capital Region of Denmark for the deployment of public charging infrastructure, has helped to expand the operational zone of these schemes, for example to serve hospitals.

Electric Buses in Danish Public Transport

Movia is the Public Transport Authority (PTA) in East Denmark including the capital area of Copenhagen. Movia started using electric buses in 2009-2014, with 11 all-electric 8 m buses in Copenhagen. In 2014-2015, Movia tested two 12 m depot-charged electric BYD buses. In 2016-2019, Movia and Copenhagen are testing opportunity-charged electric Finnish Linkker buses. Out of Movia's 1,241 in-service buses today three are electric buses. Movia has decided that by 2030, all bus operation must be fossil-free. Furthermore, local NOx must be reduced by 97 %, particles by 92 % and external bus noise by 15 %. This is on top of former targets, of a 29 % reduction of the CO_2-emission and a 75 % reduction of the NOx and particles in 2020 compared with the baseline year 2008. To meet the goal of fossil-free bus fleet by 2030, all new bus operation starting from 2018 and forward must be fossil-free – or prepared for fossil-free operation.

In 2016, Copenhagen published a new climate plan aiming at making the city the first CO_2-neutral capital by 2025, including the public transport sector. It contains objectives, activities and initiatives adopted by the City Council. For public buses, the goal is to shift the bus fleet to all-electric buses. The City Council has decided that from 2019 and forward, all new city buses must be electric - or perform alike on CO_2-emission, local emissions and noise. Furthermore, the Lord Mayor has expressed a strong interest in electric harbour buses in Copenhagen from 2020.

The City Council of Roskilde decided in February 2018, that all bus-lines run by the municipality to be electric from April 2019 on. The world's largest bus manufacturer Chinese Yutong will deliver e-buses, chargers and maintenance.

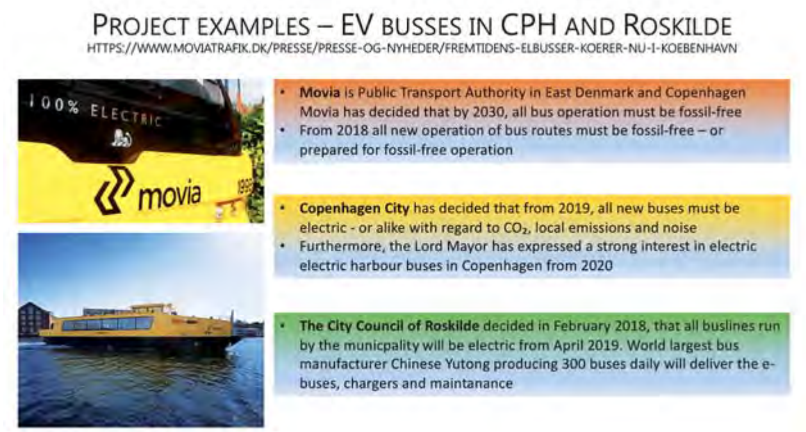


Figure 1: Project examples, e-buses in CPH and Roskilde

Parker Project - V2G Cars Providing Energy System Services

The Parker project builds on two previous Danish projects, the EDISON and Nikola projects, which have founded the understanding the electric vehicle's potential for balancing the Danish power system. Parker represents the next technology readiness level by allowing balancing services to be applied to a fleet of electric vehicles.

Figure 2: Project examples, “Parker” project

Research and development in the project is carried out as a multidisciplinary collaboration between commercial OEMs, technology providers, fleet owner and customers as well as academic institutions.

Parker works together with the world’s first commercial pilot of series produced V2G cars providing system services, the Frederiksberg Pilot, to ensure market adoption, applicability and re-usability to power systems in Denmark and elsewhere. One of three goals is to produce a Grid Integrated Vehicle (GIV) certificate which demonstrates whether vehicles and chargers are able to support the power grid.

350 kW High Power Battery Assisted Charging

Nerve Smart Systems is a new Danish company developing a charging solution based on a battery system making charging significantly faster without overloading the power grid. The solution allows an electric car to be charged in less than 10 minutes via a 350 kW high power charging station connected to the energy grid with a regular connection.

The GREAT Project

The Green Region for Electrification and Alternatives fuels for Transport project (GREAT) aims to development a green transport corridor connecting Norway, Sweden, Denmark, and Germany.

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 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 the 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 EVs 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 by 50 % by the EU Interreg programme.

The Danish Ærø e-Ferry Project

”Ellen” is a highly energy efficient medium sized and a long 22 nautical mile range e-ferry for passengers, cars, trucks and cargo in island communities, coastal zones and inland waterways. It is supported by the European H2020 initiative, demonstrating design, building and operation of a fully electric powered ‘green’ ferry. Electricity from wind power of the Danish island Ærø will allow ”Ellen” to run without any emissions. The e-ferry is expected be in operation in 2018/2019.

Figure 3: Project examples, image by the “e-Ferry” project

World's Largest Battery Ferries HH-ferries/Scandlines

Tycho Brahe and Aurora cross 4 km Helsingborg in Sweden and Helsingör in Denmark carrying + 7.3 million passengers and 1.8 million vehicles annually. The combined 8,320 kWh battery is equivalent to 10,700 car batteries.

With 15 minutes schedule, charging is fast and automated in both ports using robots, 3D laser and wireless communication to maximize charging time. Co-financed by the European Union Connecting Europe Facility, Tycho Brahe is expected to be in full electric operation in summer 2018.

Figure 4: World's largest battery ferries (Source: Scandlines)

24.5 Outlook

- DK world leader in greening energy systems, gCO_2/kWh 550 g in 2006 to below 200 g in 2017.
- Record breaking strong energy system, RE shares and ambitious targets.
- DK first mover with EV policy strategies and grant schemes since 2008.
- Very strong charging infrastructure with several operators.
- New EV taxation is very challenging, but with increasing sales in the beginning of 2018.
- Applications in fleets, buses, ships, bicycle etc. increases.
- A lot of exciting projects show that DK is an ideal technical and commercial test bed for interplay between e-mobility, smart energy system, renewable energy and energy storage.
- Cities and regions as Capital Region of Copenhagen/CPH Electric City and commercial players are very active in many projects.
- For electric buses in DK the charging tax exemption could mean a positive commercial business case due to lower energy cost (EV bus basically twice as expensive, but three times more energy efficient).
- E-Trucks are not taxed.

25 Finland

25.1 Major Developments in 2017

25.1.1 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.

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.

25.1.2 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.

25.1.3 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 2017 (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
n.a. = not available

25.1.4 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.

25.1.5 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.

25.1.6 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 1: Electric bus in Helsinki (Source: HSL)

25.1.7 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."

26 France

26.1 Major Developments in 2017

26.1.1 The Ecological Bonus

The bonus system aims to reward purchasers of new cars or vans emitting from 0 to 20 grams of CO_2 per kilometer through long-term purchase or lease financing (2 years and more). Set up in 2008, the bonus is reviewed annually in order to adapt to the evolution of the offer of low-emission vehicles.

The bonus applies to new vehicles belonging to the category of passenger cars, vans and specialized motorized vehicles, as well as to two- or three-wheeled vehicles and quadricycles. Vehicles eligible for the bonus may be registered by individuals or by companies. Used vehicles are not eligible.

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

CO_2 emission rate (in grams per kilometer)	Type of vehicle	Amount of the bonus on 1 January 2018 (in EUR)	Remarks
0 to 20 g	Private car, van or specialized motor vehicle	6,000 (up to 27 % of the acquisition cost)	This corresponds to pure battery electric vehicles and range extender electric vehicules
Without threshold	Motor vehicles with 2 or 3 wheels and quadricycles with electric motors, which have an engine maximum net power of not less than 3 kWh and do not use a lead-acid battery	250 per kWh of battery energy (up to 27 % of the acquisition cost, up to a limit of 1,000 EUR)	This only concerns electric vehicles
Without threshold	Motor vehicles with 2 or 3 wheels and quadricycles with electric motors, which have an engine maximum net power less than 3 kWh and do not use a lead-acid battery	100	This only concerns electric vehicles

Used vehicles are not eligible. Also plug-in hybrid vehicles will no longer be eligible for the bonus in 2018.

26.1.2 The Ecological Malus

The ecological malus is a first registration tax on the most emitting vehicles of carbon dioxide.

Via a registration tax the ecological malus aims to encourage consumers to acquire new passenger cars emitting the least CO_2. This tax aims to cut global warming by reducing greenhouse gas emissions from transport. The scale of the penalty is progressive: the higher the CO_2 emissions of the vehicle, the higher the penalty (from 50 to 10,500 EUR).

The bonus-malus automobile scheme is designed to balance the amount of aid paid under the bonus and the conversion bonus by amount of revenue from the malus levied on passenger cars with the highest CO_2 emissions. Thus, revenues from the malus, due by buyers of passenger cars emitting more than 119 g CO_2/km, are entirely dedicated to financing aid for the acquisition of the most virtuous vehicles, including cars and electric vans.

26.1.2 The Conversion Premium

As part of the Climate Plan, the French Government wants to accelerate the renewal of the old and polluting car fleet by helping buying a cleaner new or used car in exchange for the scrapping of an old vehicle.

The conversion premium is for private and professional users. The old scrapped vehicle must be a car or van, with a gross weight which does not exceed 3.5 tonnes. It should also meet the following criteria:

- taxable household / professional: diesel vehicle registered before 2001 and gasoline vehicle registered before 1997;
- non-taxable household: diesel vehicle registered before 2006 and gasoline vehicle registered before 1997.

The amount of the premium depends on the vehicle and the tax situation of the household:

- purchase of a used electric vehicle or a new or used Crit'air 1 or 2 ICE vehicle (petrol or diesel), emitting less than 130 g CO_2/km: 1,000 EUR for a taxable household, 2,000 EUR for a non-taxable household;
- purchase of a new electric vehicle: 2,500 EUR, without condition of income;

- purchase of new motorized two-wheelers or three-wheelers or quadricycle: 100 EUR for a taxable household, 1,100 EUR for a non-taxable household.

New electric vehicles receive an ecological bonus, which may be added to the conversion premium.

26.1.3 Air Quality Certificates: Crit'Air

The air quality certificate is a self-adhesive sticker to stick on the vehicle, which indicates its environmental class according to its emissions of atmospheric pollutants.

There are six classes of certificates. The air quality certificate promotes the least polluting vehicles:

- Favorable parking arrangements;
- Privileged traffic conditions;
- Possibility of driving in Low Emissions Zones.

The air quality certificate is mandatory to circulate in low emissions zones established by certain communities (Paris). The vehicles are divided into six environmental classes, with the exception of the most polluting vehicles, which are not classified and are not entitled to the air quality certificate.

The classification depends on the type of vehicle (passenger cars, two-wheelers, tricycles and quadricycles, light commercial vehicles and heavy vehicles including buses and coaches), its engine, and the European emission standard it respects (Euro standard). A specific class is set for electric vehicles.

The air quality certificate can therefore be used by local authorities to ensure that the least polluting vehicles benefit from privileged parking conditions or can enter into low Emissions Zones.

26.1.4 Low Emissions Zone

The law on the energy transition for green growth offers the possibility to the communities that wish to set up low emissions zones with restricted circulation for the most polluting vehicles, on all or part of their territory, in order to protect the population health in areas regularly subject to air pollution.

Vehicles in the Low Emissions Zones must have an air quality certificate.

26.1.5 Financing of Charging Infrastructures

The Government has put in place a series of measures to promote the deployment of the charging infrastructure network for electric vehicles.

Depending on the type of infrastructure and the entity leading the deployment project, there are various financial aids to the installation of a charging point:

- Communities: Several editions of the Program “Investment for the Future” helped to provide 61 million EUR for the installation projects of more than 20,000 charging points, largely supported by local authorities.
- SMEs and artisans: The ADVENIR program has encouraged the installation of 12,000 private charging stations in car parks (shops or businesses) and in collective housing through financial assistance.
- The installation of private charging stations is also helped: individuals can benefit from a 30 % energy transition tax credit for the installation of a charging plug.
- The Government also promotes the development of the infrastructure network through its legislation. A decree on the pre-equipment of parking spaces during the construction of buildings was published. A decree from January 2017 on recharging infrastructures for electric vehicles implements various measures to transpose Directive 2014/94 / EU on Alternative Fuels Infrastructure. This decree will allow a homogeneous development of the charging points by regulating in particular the power according to the type of recharge, the interoperability, and the access to the recharge.

Table 2: Aid for infrastructure deployment in France

Accessibility	End-User	Aids	Amount
Private	Citizen	Tax Credit Energy Transition	Credit of 30 % of the cost of the infrastructure
Reserved for a resident	Collective residential	ADVENIR	50 % of the cost (material + installation), ceiling at 960 EUR
Shared between the inhabitants	Collective residential	ADVENIR	50 % of the cost (material + installation), ceiling at 1,660 EUR
Employees and fleets	Business	ADVENIR	40 % of the cost (material + installation), ceiling at 1,360 EUR
Semi-Public (Public access on private sites such as supermarket parking)	Business	ADVENIR	40 % of the cost (material + installation), ceiling at 1,860 EUR
Public	Business	National operators project	Exemption from the occupancy charge

Public	Communities	Program "Investment for the Future"	Grants according to the project

26.2 HEVs, PHEVs and EVs on the Road

26.2.1 Electric Passenger Cars

With 30,921 vehicles registered in 2017, the electric vehicle market continues to grow. Electric cars account for 1.2 % of new vehicle registrations in 2017. However, growth is stagnating: in 2017, registrations increased by only 13 %, compared to 23 % in 2016 and 47.5 % in 2015. This slowdown is a reminder of the fragility of the market and the importance of state support for its development.

The Renault Zoe Still Dominates the Market

The passenger car market remains the most important with 25,983 new registrations (up 14 % year-on-year), or 1.47 % of new passenger car registrations, compared with 1.35 % in 2016. Like last year, the Renault Zoe gets the biggest share of sales with 15,245 units (58.6 % of sales). Better, with a 34 % increase over one year, the Renault Zoe gains market share thanks to its new offer with a range of 400 kilometers. The Zoe is followed by the Nissan Leaf with 2,381 cars sold, down 38 %, and the BMW i3, with 1,954 registrations (including 1,073 with a range extender) up 45 %.

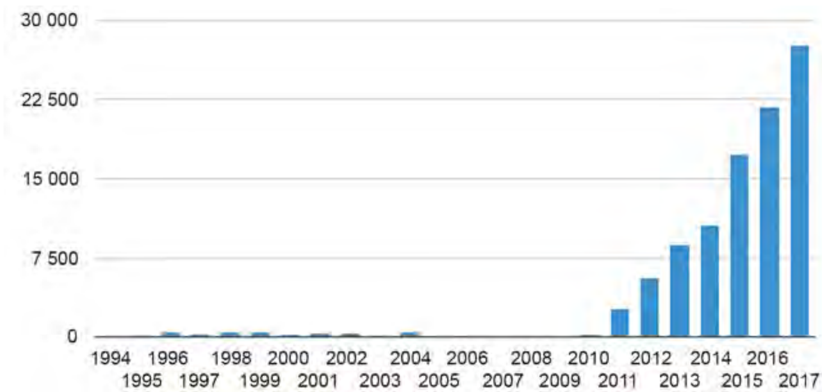


Figure 1: Evolution of BEV sales for passenger cars (Source: ADEME, France)

26.2.2 Electric Light Commercial Vehicles

The market for electric commercial vehicles reaches 6,011 new units, an increase of 8 %. The Renault Kangoo remains the leader in the sector with 2,546 units (up

7 %), followed by the Zoé (675 registered models, up 67 %) and the Peugeot Partner (660 vehicles, up 50 %).

26.2.3 PHEVs

In 2017, 13,458 PHEVs were registered, compared to 6,467 in 2016, representing a progression of +108 %. This strong increase can be explained by fiscal incentives (bonus, conversion premium) refocused on these vehicles in 2017 and the technological maturity of the market on this type of model which allows the supply of greatly expand.

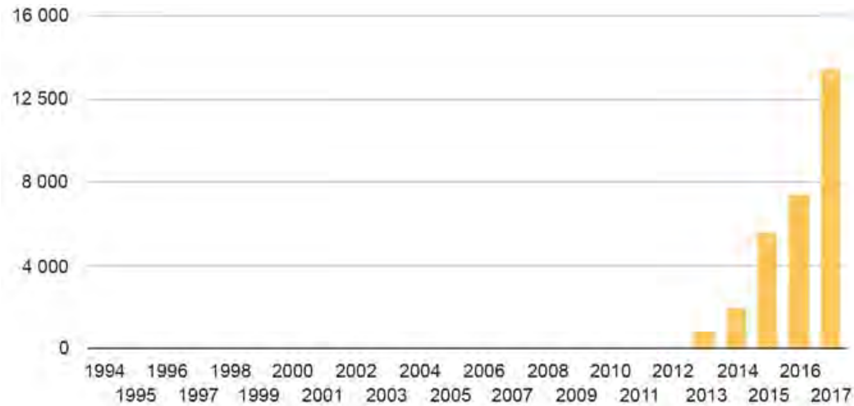


Figure 2: Evolution of PHEV sales for passenger cars (Source: ADEME, France)

26.3 Charging Infrastructure or EVSE

The number of public charging points increased by +35.5 % in one year on the national territory. Ile-de-France, Auvergne-Rhône-Alpes, and New Aquitaine are the most equipped regions.

Today, 20,048 parking spaces, divided into 7,242 stations open to the public, allow to charge an electric vehicle. The charging point network is up 35.5 % from last year (14,799 charging points out of 4,507 stations). A network to which charging points at home and at workplaces can be added (estimated at 106,000 charging points).

This acceleration was achieved thanks to the deployment of local Government networks, partly financed by the State, and the proliferation of private initiatives.

Table 3: Information on publicly accessible charging infrastructure in 2017 in France (Data source: EAFO and ADEME)

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
Normal Power (<=22kW)	14,407
High Power (>22kW)	1,858
Totals	**16,265**

Table 4: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: Global EV Outlook, EAFO, ACEA)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
Passenger Vehicles[a]	115,000	6,470	283,670	n.a.	33,263,00
Buses and Minibuses[b]	350	n.a.	750	n.a.	94,000
Light commercial vehicles[c]	28,151	30	950	n.a.	4,511,000
Medium and Heavy Weight Trucks[d]	100	n.a.	n.a.	n.a.	1,272,000
Totals	**143,601**	**6,500**	**285,030**	**n.a.**	**39,140,000**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Totals[e]**
Passenger Vehicles[a]	25,983	13,458	76,544	n.a.	2,304,119
Buses and Minibuses[b]	n.a.	n.a.	n.a.	n.a.	n.a.
Light commercial vehicles[c]	6,011	n.a.	340	n.a.	n.a.
Medium and Heavy Weight Trucks[d]	n.a.	n.a.	n.a.	n.a.	n.a.
Totals	**31,994**	**13,458**	**76,544**	**n.a.**	**2,304,119**

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 5: Available vehicles and prices in France in 2017

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
Smart ForTwo	n.a.
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

n.a. = not available

27 Germany

27.1 Major Developments in 2017

The UN Climate Change Conference - November 2017 took place 6-17 November in Bonn, Germany. Chancellor Angela Merkel confirmed in her speech Germanys commitment to the national climate action plan 2050[36] and the goal to reach largely greenhouse gas neutrality in the mid of the century. For 2020, Germany faces the ambitious target of 40 % reduction related to 1990. This also played a central role in the forming of the new German government[37]. In the contract of the renewed 'grand coalition' the role of Germany as a pioneer in climate protection and its commitment to the national, European and international climate goals for 2020, 2030 and 2050 is confirmed. The gap to the 2020-targets needs to be reduced and a law for the 2030-targets is envisaged[38]. For transport and mobility, air pollution prevention is also an important topic here: incentives for low-emitting mobility, the support of car-sharing and alternative power trains, investments in electric mobility, amongst others hydrogen and fuels cells, as well as the support of battery cell production in Germany and the build-up of 100,000 charge points until 2020 is mentioned here.

27.1.1 New Policies

Meeting the EU air quality standards set in the Sixth Environment Action Programme of the European Community entitled "Environment 2010: Our Future, Our Choice" and in Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe[39] is a matter of ongoing discussion in Germany. Concentrations of ambient air with nitrogen dioxide (NO_2) have improved however still about 70 municipalities faced

---

[36] https://unfccc.int/files/focus/long-term_strategies/application/pdf/161114_climate_action_plan_2050_en_bf.pdf

[37] https://www.bundesregierung.de/Content/DE/Rede/2017/11/2017-11-15-bk-cop23.html?nn=391850#Start

[38] https://www.mdr.de/nachrichten/politik/inland/download-koalitionsvertrag-quelle-spd-100-downloadFile.pdf

[39] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2008.152.01.0001.01.ENG&toc=OJ:L:2008:152:TOC

threshold exceedances in 2017[40]. Also particle concentrations were lower in 2017 in average compared to 2005-2016. However still about 87 % of all measurement stations in Germany are above the WHO target of exceeding 50 µg/m^3 at the utmost of three days per year (ibid.).

Therefore, in November 2017, the German Government and related Federal States and cities and municipalities agreed on a programme for better air quality in cities. The German Government issued an instant programme "Clean Air 2017-2020" which supports the following in the context of e-mobility amongst other items[41]:

- Electrification of urban commercial transport
- Electrification of taxis, rental cars, and car sharing vehicles
- Electrification of bus fleets in public transport
- Support of charging infrastructure related to the incentivised vehicles
- Improvement of electricity grid stability due to new charging infrastructure
- Built-up of low-cost infrastructure and mobile-metering charge points.

27.1.2 Legislation

In 2016, the federal regulation defining technical requirements for the installation and operation of public charging stations, the so-called "Ladesäulenverordnung (LSV)" 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. In 2017, minimum payment standards have been set with the amendment of the charge point rules in 2017[42] (Ladesäulenverordnung, LSV) securing the non-discriminating access to charging infrastructures [43].

In 2016, the "Umweltbonus[44]", a federal monetary purchase incentive programme for electric vehicles has started. Purchase of PEV 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

[40] https://www.umweltbundesamt.de/presse/pressemitteilungen/luftqualitaet-2017-rueckgang-der

[41] https://www.bundesregierung.de/Webs/Breg/DE/Themen/Saubere-Luft/_node.html

[42] https://www.umwelt-online.de/PDFBR/2017/0256_2D17.pdf

[43] http://www.bmwi.de/Redaktion/DE/Dossier/elektromobilitaet.html

[44] http://www.bafa.de/SharedDocs/Downloads/DE/Energie/emob_merkblatt_antrag.pdf?__blob=publicationFile&v=5"

300,000 vehicles. The incentive will end when the budget has been spent, or latest of at the end of 2019.

Until February 2018, a total of 54,274 applications have been handed in which distributes among the vehicle categories as follows [45]:

- 31,312 for BEV
- 22,946 for PHEV
- 16 for FCEV

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 [46]. Requirements include:

- initial vehicle registration
- category M1, N1 or N2[47] vehicles (L-category vehicles are excluded)
- models with a net list price ≤ 60,000 EUR (basic version)

27.1.3 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 1, 2016. Vehicles converted to purely electric vehicles by technically appropriate, authorized means are included in the tax exemption[48].

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.

[45] http://www.bafa.de/DE/Energie/Energieeffizienz/Elektromobilitaet/elektromobilitaet_node.html

[46] http://www.bafa.de/SharedDocs/Downloads/DE/Energie/emob_liste_foerderfaehige_fahrzeuge.pdf?__blob=publicationFile&v=8

[47] if covered by a category B driver's license

[48] http://www.bundesfinanzministerium.de/Content/DE/Gesetzestexte/Gesetze_Verordnungen/2016-11-16-G-stl-Foerderung-Elektromobilitaet.html

27.1.4 Automotive Industry

At the end of 2017, 29 PEV models were available from German manufacturers[49]. 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. Five BEV models were available in 2017. However, all German manufacturers announce battery electric vehicles for the future.

Furthermore, in 2017 Mercedes Benz presented its SUV with fuel cell plug-in hybrid technology as part of the IAA as a pre-production model. The GLC F-Cell is expected in the market in 2018. After BMW announced an electric offensive with twelve pure electric and 13 plug-in hybrid models by the year 2025, the German company also showed the SUV-Concept X7 iPerformance at the IAA, which will be presented in the coming year as a production model. Audi presented two concept vehicles with electric drives at the IAA 2017. The two showcars are an SUV coupe based on the e-tron Sportback concept with three electric motors and a luxury class concept with four electric motors and a range between 700 and 800 kilometers. VW announced an electrification offensive with the “Roadmap E”.

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. With his Brand Fuso, the Daimler Group improved the competitiveness of electric light trucks. The Fuso eCanter has been produced since July in a small series in the Portuguese plant Tramagal. MAN Truck and Bus has also started to produce its electric distribution-truck with a Range of a total of 200km in a small series. Apart from presenting new concepts, the largest producer of battery electric light duty vehicles in Germany, Streetscooter, reached the milestone of 1,000 produced units[50].

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[51].

---

[49] vda.de

[50] http://www.dpdhl.com/de/presse/pressemitteilungen/2016/deutsche_post_bundesumweltministerium_praesentieren_1000sten_streetscooter.html

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

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.

27.2 HEVs, PHEVs and EVs on the Road

New car sales in 2017 have cumulated to 3.44 million. This corresponds to a 2.7 % year-on-year growth. BEV sales experienced a strong growth of 120 % year-on-year to 25,056; HEV sales increased by 76 % to 84,675; PHEV sales increased by 114 % year-on-year to 29,436. The widespread discussion of air pollution by diesel cars might have led to a 13 % decrease in sales compared to 2016, reaching a share of 38.8 %. Gasoline cars (57.8 %) still remain at a high level. The average CO_2 emission of the new car fleet increased by 0.5 g/km to 127.9 g/km compared to 2016.

As of January 1, 2018, 56.5 million motorised vehicles were on the road in Germany, including 46.5 million passenger cars, 117,000 L category vehicles, 4.2 million motor bikes, 5.2 million trucks and 79,000 buses. The stock of BEV amounted to 53,861, that of HEV to 236,710. This corresponds to a year-on-year growth of 58 % and 43 %, respectively. With 4,322 sold units the Renault Zoe was the most popular BEV in 2017. It is followed by the VW Golf (3,026) and the Smart Fortwo (2,987). The most popular PHEV were the Audi A3 e-Tron (4,454 sold units), the BMW 225xe Active Tourer (3,680 sold units), and the Mitsubishi Outlander PHEV (2,234 sold units[52]).

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: KBA, Kraftfahrtbundesamt)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[5]**
2- and 3-Wheelers, Quadricycles[1]	9,305	2	260	0	4,372,978
Passenger Vehicles[2]	53,861	44,419	192,291	325	46,474,594
Buses and Minibuses[3]	183	1	361	15	79,438
Medium and Heavy Weight Trucks[4]	11,813	9	122	2	3,031,139
Totals without bicycles	**75,162**	**44,431**	**193,034**	**342**	**53,958,149**

[52] http://eafo.eu/vehicle-statistics/m1

Total Sales during 2017					
Vehicle Type	EVs	PHEVs	HEVs	FCVs	Total[6]
Passenger Vehicles[2]	25,056	29,436	84,675	18	3,441,262

n.a. = not available

[1] UNECE categories L1-L7

[2] UNECE categories M1

[3] UNECE categories M2-M3

[4] UNECE categories N1-N3

[5] Including non-electric vehicles

Table 2: Available vehicles and prices (Data source = OEM websites; all accessed in January 2018)

Market-Price Comparison of Selected PEVs in Germany	
Available Passenger Vehicles	Untaxed, Unsubsidized Sales Price (in EUR)
Renault Twizy 45	6,950 (plus 50 per month for battery rent)
Renault Twizy	7,650 (plus 50 per month for battery rent)
Citroen C-Zero	21,800
Peugeot iOn	21,800
Smart fortwo electric drive	21,940
Smart forfour electric drive	22,600
Citroen Berlingo Electric (L1)	24,978
Smart cabrio electric drive	25,200
Peugeot Partner Electric (L1)	25,335
Citroen Berlingo Electric (L2)	26,228
Peugeot Partner Electric (L2)	26,585
VW e-up!	26,900
VW e-load up!	27,495
Citroen E-Mehari (Courreges)	29,050
Kia Soul EV	29,490
Renault ZOE	30,100
Nissan Leaf (ZE1)	31,950
Hyundai IONIQ Elektro	33,300
Renault ZOE Z.E. 40 Battery	34,100
Nissan e-NV200 (L1/L2)	34,105
Ford Focus Electric	34,900
Renault Kangoo Z.E. 33	35,605
VW e-Golf	35,900
Renault Kangoo Maxi Z.E. 33	37,033

Market-Price Comparison of Selected PEVs in Germany	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
BMW i3 (94 Ah)	37,550
Nissan e-NV200 EVALIA	38,404
Opel Ampera-e	39,330
BMW i3s (94 Ah)	41,150
Nissan e-NV200 Combi	41,690
Tesla Model S 75D	69,019
Tesla Model X 75D	91,250
Tesla Model S 100D	105,320
Tesla Model X 100D	110,800
Tesla Model S P100D	144,670
Tesla Model X P100D	156,100

27.3 Charging Infrastructure or EVSE

As of June 2017, a total of 10,878 charging points were publicly available. Publicly available charging stations amount to 4,730[53]. Most of the charging points enable 22 kW charging. About 566 charging points facilitate fast charging.

In November 2016, BMW, Daimler, Ford and Volkswagen with Audi and Porsche agreed to establish a high-powered charging network in Europe[54]. The build-up started 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.

The build-up of hydrogen infrastructure is slightly slower, but also advancing. The German alliance H2 Mobility by Air Liquide, Daimler, Linde, OMV, Shell and TOTAL has drawn a roadmap to build up 100 hydrogen fuel stations until 2018. Their target is to have up to 10 stations in the six biggest cities Hamburg, Berlin, Rhein-Ruhr area, Frankfurt, Stuttgart and Munich[55].

---

[53] https://www.bdew.de/presse/presseinformationen/schon-10700-ladepunkte-deutschland/ and https://www.bdew.de/media/documents/PI_20171024_Anlage_Grafiken-Erhebung-Ladeinfrastruktur.pdf

[54] http://media.daimler.com/marsMediaSite/en/instance/ko.xhtml?oid=14866747

[55] http://h2-mobility.de/

28 Ireland

28.1 Major Developments in 2017

EV sales grew by 46 % from 2016 to 2017. Several new models entered the market in 2017. Traditionally BEVs have represented the larger share of EVs sold in Ireland. However, this has become increasingly challenged as the number and range of PHEVs available is steadily increasing. In the BEV market, there is still not enough depth and variety to the vehicles on offer. For instance the Tesla Model S represents an ideal family sized car, but it is too expensive to gain wide scale adoption in Ireland. The Leaf and the Ioniq represent the most prominent BEV options in the Irish market.

The Government established the Low Emissions Vehicle (LEV) Task Force to assess ways to increase the uptake rate of lower emission vehicles, which examined market subsidies and infrastructure for EVs. As sales of EVs continued to grow in 2017, progress is still slow with respect to ownership issues surrounding the existing public charging infrastructure.

28.1.1 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 were 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 stopped providing this incentive at the end of 2017, but the scheme has continued in 2018 as a grant of 600 EUR per installation by the Sustainable Energy Authority of Ireland (SEAI).

28.2 HEVs, PHEVs and EVs on the Road

The cumulative number of Passenger EVs (BEV and PHEV) on Irish roads was 3,580 vehicles as of the end of 2017. Imports of vehicles from the UK were significant again in 2017 with good exchange rate and availability of low cost EVs being a key factor.

28.3 Charging Infrastructure

Table 1 indicates the current number of chargers available at publically accessible locations in the Republic of Ireland. Development activity was relatively low for the national infrastructure in 2017 apart from replacement of early unreliable infrastructure with more reliable units. Some Chademo only Fast Chargers have also been changed out with triple headed units which supply CCS and Fast AC along with Chademo. Tesla have introduced a number of superfast charger stops around the country with little fanfare.

Charging infrastructure is also available in Northern Ireland and drivers may roam between and readily access the infrastructure in both parts of Ireland.

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.

Figure 1: Charging infrastructure future ownership and operation under discussion in 2017 (Source: ESB Ecars)

Table 1: Information on charging infrastructure in 2017 (Data source: ESB Ecars 2016 data - no significant development in 2017, Level 1 includes publically accessible non-domestic chargers only, AC Fast Charger may be used in parallel with CHAdeMO or CCS)

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers (non-domestic)	107
AC Level 2 Chargers	700
Fast Chargers (<=50kW)	79
Superchargers (Tesla only <=120kW)	32*
Inductive Charging	1
Totals	**464**

* charger data is taken from Tesla website

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: Department of Transport, Tourism & Sport and SIMI)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[f]**
2- and 3-Wheelers[a]	31	2	17	n.a.	39,873
Passenger Vehicles[b]	2,718	862	20,295	n.a.	2,066,112
Buses and Minibuses[c]	0	0	1	n.a.	11,953
Light commercial vehicles[d]	100	4	56	n.a.	312,628
Medium and Heavy Weight Trucks[e]	n.a.	n.a.	n.a.	n.a.	36,415
Totals without bicycles	**2,849**	**868**	**20,369**	**0**	**2,466,981**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[f]**
2- and 3-Wheelers[a]	4	0	11	n.a.	1,431
Passenger Vehicles[b]	620	326	4,435	n.a.	131,253
Buses and Minibuses[c]	0	0	0	n.a.	396
Light commercial vehicles[d]	36	2	0	n.a.	24,094
Medium and Heavy Weight Trucks[e]	0	0	0	n.a.	2,245
Totals without bicycles	**660**	**328**	**4,446**	**0**	**159,419**

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 Ireland (Data source: SEAI - basic entry level price show for each model)

Market-Price Comparison of Selected EVs and PHEVs in Ireland	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price in EUR)**
Mitsubishi i-MIEV	28,095
Mitsubishi Outlander PHEV	35,137
Nissan Leaf 30kWh	30,073
Nissan ENV200	23,411
Renault Fluence	20,139
Renault Kangoo Van ZE	20,000
Renault Zoe	15,514
Citroen C-Zero	25,183
BMW i3 BEV	30,668
BMW i8 PHEV	101,342
BMW 225xe PHEV	35,131
BMW 330e PHEV	33,880
VW eGolf	30,216
VW Golf GTE PHEV	33,431
VW Passat GTE PHEV	34,349
Audi A3 E-Tron PHEV	33,431
Volvo V60 PHEV	47,807
Volvo XC90 PHEV	58,045

28.5 Outlook

The LEV Task Force will report with its main recommendations to the Government in 2018. It is expected that the Government will introduce several more subsidies in order to encourage greater growth of the EV market. More developments are expected in terms of vehicle driving range and consumer choice. The driving cycle (NEDC) is due to change to the WLTP which will have a significant impact on reported driving range and CO_2 emissions figures for PHEVs.

A period of transition will be required for the consumer and also there is an opportunity to revise the vehicle tax mechanisms to further enhance the uptake of EVs. European manufacturers must plan for post 2020 CO_2 regulations which are likely to require a percentage reduction on their 2021 figures. However, significant risk exists for a disconnect between progress on CO_2 targets before and after the change over to the WLTP drive cycle.

29 Italy

29.1 Major Developments in 2017

2017 was a positive year regarding to new passenger car registrations, which globally had a moderate increase (+7.9%) compared to 2016, reaching a global amount of about 2 million cars which makes Italy the fourth biggest market in the European Union. Also sales of alternative fuel vehicles increased (+24 %) due to the benefit from demand for LPG-fueled cars, the sales of which registered the biggest absolute value, while sales of battery and hybrid electric vehicles (especially plug-in hybrid electric vehicles) registered the highest percentage increases compared to the previous year.

The efforts to promote and financially support the introduction of cleaner vehicles were continued. Even if the national policy does not give direct incentives for purchasing electric vehicles, other incentives for use and circulation were confirmed in 2017: 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, electric vehicles receive a discount from various insurance companies and finally, in some big municipalities (for example Milan and Rome) they benefit of free parking in urban areas and free circulation in limited traffic areas. On the other side, some dealerships of different brands reserved a bonus to people scrapping or trading in their outdated diesel cars for hybrid ones. The fiscal advantage of super amortization was confirmed but limited to only instrumental vehicles.

Looking at charging infrastructure, the implementation of the National Plan for Electric Charging Infrastructure and the European Directive on Alternative Fuel Infrastructure is in progress. Further Enel, the largest Italian electric utility, launched its plan to provide Italy with an appropriate charging infrastructure.

These are good premises in a Country where global statistics still show a very low diffusion of hybrid (about 0.5 % and 3 % respectively in car fleet and sales) and electric (about 0.02 % and 0.1 % respectively in car fleet and sales) vehicles and charging infrastructure while, on the other side, hybrid and electric vehicles have positive perspectives: Italy has the highest motorization rate combined with the oldest vehicle fleet in Europe and these could be driving forces (in addition to the mandatory constraints in CO_2 emissions by 2020 and the air quality control) to usefully capitalize on a nationwide project of e-Mobility industrial development the numerous, major competencies boasted in Italy.

29.1.1 Legislation, Funding, Incentives and Taxation

In Italy, direct incentives (discount, VAT exemption) 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 and tolls payment, free transit in limited traffic areas, exemption from total or partial disruption to traffic (regional or municipal 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. Further, electric vehicles receive a discount from various insurance companies.

The national legislation does not consider hybrid electric vehicles (petrol/electric or diesel/electric). Some regional administrations have acted autonomously: in the Lazio Region, for example, owners of new hybrid electric vehicles are exempt from the ownership tax for a period of three years from the date of the first registration.

In some big municipalities (for example Milan and Rome) electric vehicles are exempt from payment in reserved parking areas and can enter the limited traffic areas.

According to the “Balance Law”, the fiscal detraction in terms of super amortization was confirmed for year 2017, but limited to vehicles directly used for carrying on company’s business. Multipurpose vehicles, or vehicles used by employees, are excluded from the benefit.

Incentives dedicated to charging infrastructure are in terms of direct investments (national policy), that is, Public Administration directly participating to the development of charging infrastructure, co-financing projects presented by Regions and Local Authorities. The instrument to incentivize charging infrastructure is the National Plan for Electric Charging Infrastructure (PNIRE) by the Ministry for Transport and Infrastructure. The first version of PNIRE was issued in 2013, successively updated in 2014 and, more recently, in 2015: this last version became effective in 2016[56].

The Government has implemented the European Directive on the deployment of alternative fuel infrastructure (DAFI 2014/94/ EU) issuing the National Legislative Decree n. 257, issued on December 16, 2016 and become effective on January 14, 2017.

The PNIRE and the National Legislative Decree n. 257 define the national strategy for the widespread diffusion of electric vehicle 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 by 2020, 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 to realize environmental targets by means of each type of alternative fuel;
- New fuel stations – or the ones under renewal – must provide methane or natural gas and install charging stations for electric vehicles;
- Public Administrations are required to buy 25 % at least of methane, natural gas or electric vehicles, when substitute their fleets;57
- Within December 31, 2017, municipalities must update their building regulations to meet the requirements for supplying alternative fuels and, starting from June 1, 2017, new buildings58 or the ones under significant renovations must provide connections to install charging stations for electric vehicles.

To implement the PNIRE, that is to receive governmental funds, the Decree 4/8/2017 by the Ministry for Infrastructures and Transport requires metropolitan cities, municipalities and municipalities associations with more than 100,000 inhabitants to provide and adopt new Urban Plans for Sustainable Mobility.

---

[56] In 2016 the Ministry for Economic Development adopted the strategy document "Piano Nazionale di Sviluppo – Mobilità Idrogeno Italia", that has been developed by a core working group of experts in abidance to the European Directive on the deployment of alternative fuel infrastructure. It proposes a roadmap for the deployment of fuel cell electric vehicles as well as associated hydrogen refueling stations from 2020 through to 2050, the details of which are in the report of the previous year [1], together with the description of FCEV demonstration projects.

[57] Chamber of Deputies draft law n. 4083 (actually under examination) requires Public Administrations to buy only full electric road vehicles as from 1 January 2020.

[58] New buildings for not residential use, with a surface bigger than 500 m^2 and new residential buildings with 50 apartments at least

Following the Balance Law 2017, the “Strategic national plan on sustainable mobility” is in preparation. It contains provisions for replacing bus fleets in the public transport: stop “Euro 0” and “Euro” 1 buses (7,200 units, ACI source), 5,000 new buses will be put into service in 2018 and 1,500÷2,000 from 2019 to 2033.

In November 2017 the Ministry for Economic Development and the Ministry for Environment issued the final version (after public consultation) of the National Energy Strategy (SEN), which has a section dedicated to transport and sustainable mobility, where several measures are mentioned: local regulation (to limit the circulation of pollutant vehicles in urban areas, free entrance of HEVs and EVs in limited traffic areas, preferential lanes and parking for zero emissions vehicles), revision of fiscal systems on transport (registration and owner taxes, duties on petrol and diesel, etc.), sharing and smart mobility, strengthening of charging infrastructure for alternative fuel vehicles, enhance public transport.

A lot of initiatives from stakeholders, environmental and user Associations, representatives of Local/Central Public Administrations and Research Organizations have been held, suggesting recommendations to policy makers for a better mobility planning: the “Tiscar Round Table”, a joint resolution by the Public Works and Environment Committees of the Senate of the Italian Republic, the “Metropolitan Chart on Electromobility”. They recommend direct incentives for purchasing EVs and fiscal advantages, incentives to replace old vehicles with AFVs, use of EVs in Public Administration’s fleets, banning motorcars fueled by fossil petrol and diesel within 2040 and introducing BEVs and PHEVs (target 3 % of the market within 5 years), circulation tax linked to vehicle’s pollution, clear identification of zero emission vehicles in the “Rules of the road”, to use PNIRE co-founds also to purchase vehicles for electric car sharing, local regulation, incentives for charging infrastructure, charging points in new residential buildings and also in already existing ones.

As an effect of legislation and initiatives from Ministries, regions and municipalities, various funding were activated in 2017.

The Ministry for Environment issued 15 million EUR for projects on efficiency, mobility and climate in minor islands and 75 million EUR to municipalities for a National Experimental Program about “home-school and school-home mobility” aimed to reduce traffic, pollution and stops of cars near schools and working sites, by means of bike & car sharing & pooling.

An Industrial Plan for the city of Rome was issued with more than 500 million EUR (about 100 by municipality, 90 by Lazio region, and 330 by the Ministry for

Economic Development) for sustainable mobility & energy, renewal of public transport vehicle fleets, car sharing and 700 new electric vehicle charging stations.

The Apulia region issued 50,000 EUR for EV domestic charging points fueled by renewable energy sources (max 1,500 EUR per allowed installation).

Emilia Romagna provides incentives to buy new light commercial vehicles: 2,500 EUR for scrapping and replacing of an old vehicle with a new alternative fuel vehicle (with a maximum of 200,000 EUR per company).

The Lombardia region issued 15 million EUR for the diffusion of electric vehicles and their charging infrastructure in municipalities. Further, this region provides incentives on private charging points: 1,500 EUR per charging point in case of charging system with a single socket, 1,000 EUR per socket in case of charging systems with several sockets, until a maximum of 10,000 EUR per applicant.

In the Mobility Plan of the Sardinia region, 15 million EUR were issued to increase the electric vehicles fleet and charging infrastructure, with 650 new charging stations planned.

The Bolzano Province provides incentives to buy electric (4,000 EUR) and hybrid plug-in electric (2,000 EUR) cars. Further, the exemption from annual circulation tax for five years and then 77.5 % (instead of 75 % as for the national policy) reduction of the tax rate. Finally, incentives are provided for EV charging infrastructure: 1,000 EUR per charging station.

In the Mobility Plan for the Trento Province, investments were planned for 21 million EUR.

The Italian electric mobility wins the confidence of important international bodies too: the European Investment Bank issued 230 million EUR in favor of Florence municipality for a three years investments plan in”smart city projects“. Sustainable mobility is a part of it.

29.1.2 Research

The National Research Council of Italy (CNR) has been studying for different years the development of an integrated system between electric mobility and energy production from renewable energetic sources and storage. 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, fuel cell and hybrid (fuel cell and battery) vehicles. Another area of study is 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) for electric vehicles.

The Italian National Agency on New Technologies, Energy and Sustainable Economic Development (ENEA) in 2017 continued its activities relating to the "Sustainable Electric Mobility" project, included in the National Research Program for the Electrical System founded by the Ministry for Economic Development. These activities include 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 an 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 2017:

- Studies on dynamic wireless charging, in terms of system design and implementation on a little size experimental vehicle.
- To design the transformation of a conventional vehicle into a mobile fast charging station to be used as a rescue track. This study is aimed to establish a road rescue service useful to remove the uncertainties on residual range when travelling long distances and create new working opportunities for service companies along roads or call-services.
- Risk analysis and management of the residual risk for batteries in electric vehicles. Even if batteries and their management systems are subject to hard safety tests, the risk analysis (and experience) shows that there is the possibility of undesired events. This study analyses different arguments: failure of safety systems during vehicle use and recharge, crash situations, fire.
- Studies on support instruments for LPT: to evaluate technical feasibility and economic convenience of electric traction in public road transport lines for a major city; to run energy consumption measures of urban buses in real operative contexts.
- Optimal location 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 the diffusion of electric mobility. An operative instrument, able to join the request from users (according to their real movements) and the implementation of a "fuzzy" decisional logic to produce a spatial distribution of charging points.
- Development of an instrument, aimed at electricity distributors, able to predict the needs of electric mobility in an urban area.

- User safety and protection from residual electromagnetic fields during electric vehicle charging.

"Ricerca sul Sistema Energetico" (RSE), another main research institute together with CNR and ENEA, has been working for different years on electric mobility, not only vehicles but especially their impacts on the grid and the optimization of mobility in the context of the wider energetic scenario. A study realized by RSE evaluates the impact of 10 million electric cars (a third of which battery electric vehicles and two thirds plug-in hybrid electric vehicles) in Italy in 2030: on the basis of this scenario, consistent with the ones made by other research organizations, considering the development of electricity consumptions expected in the future, the impact of charging electric cars would be an energy increase of 5 % (18.7 TWh out of 362 TWh) which can be managed at a national level without having to build new power stations or electricity grids.

29.2 HEVs, PHEVs and EVs on the Road

In 2017, overall new passenger car registrations increased by about 7.9 % compared to 2016, reaching a global amount of 1,970,497. The positive trend of previous years has continued and Italy is the fourth biggest market in the European Union. New battery electric passenger car registrations increased by 42.8 %, while registrations of new plug-in hybrid electric passenger car (+102.4%) accounted for the strongest growth. In total new electrically chargeable passenger cars increased significantly by 71.2 %. The demand for new hybrid electric passenger cars continued to grow (+70.2 %). New other alternative fuel (natural gas, LPG, ethanol) passenger car registrations had a moderate growth (11.2 %). Totally, new alternative fuel passenger car registrations increased by 24 %.

An analysis of sales based on categories of customers [2] shows that private customers bought fewer (-1.9%) than in the previous year. The drop was considerably higher in the case of purchase by companies (-11.3%): this would be pretty obvious after the boom (+24.7 %) caused in 2016 by the super amortization, no longer available in 2017 for all companies, but limited to only instrumental vehicles. In fact, rent companies belong to one of the few categories which have taken this fiscal advantage and their purchases increased (+18.8 %). Cars registered by manufacturers and dealers had a strong growth (52.3 %) so to balance the market share there is a reduction of private customers.

A large increase was registered for sales of hybrid electric passenger cars, thanks to the continuous extension of range: these vehicles went beyond the share threshold of 3 %. Nevertheless the strong growth in sales of battery and plug-in hybrid electric passenger cars, the share in sales for these type of vehicles still remains about 0.1 % with respect to the total. This is due to various reasons. The first one is the high purchase price – which in other countries is balanced by significant fiscal detractions – and the low number of charging infrastructure. In addition to this, there are consumers' doubts about electric vehicles (range anxiety). In fact, in Italy the owners of "fully electric" cars are mostly companies or rent companies or public administrations: new electric passenger cars registered in 2016 belong to companies for about 85 % and natural persons for only 15 %. But something is moving, thanks to the National Plan for Charging Infrastructure and the European Directive on alternative fuels, recently adopted by the Government.

Figure 1 shows the share (following the European standard on pollutant emissions, from Euro 0, the most polluting, to Euro 6, the cleanest) of circulating passenger cars, updated on January 1, 2017.

Figure 1: Share of circulating passenger cars (Source: ENEA elaboration on ACI data)

A certain attention towards electric vehicles is beginning: free parking and circulation in limited traffic areas are reserved to electric vehicles in many cities, there are various projects included in the mobility urban plan based on electric vehicles (services, logistics of goods and car sharing). Electric energy distributors have established partnerships with car makers to promote services based on electric vehicles, as it is in the announcements for car sharing services issued from various Italian cities. In 2017, 6,644 shared vehicles were counted in Italy: the electric share of these vehicles is growing, thanks to some operators which based their service on electric vehicles (Share'ngo, Drivenow, BlueTorino). A reduction of "Station Based" demand and, on the other side, strengthening of "Free Floating" was registered. The diffusion of bike sharing is growing too, especially because of "Free Floating": in a total of 29,404 shared bikes, 12,800 belong to this type of service. About scooter sharing service, in 2017 EniJoy terminated the service, but other new operators are entering the market: MiMoto (Milan), eCooltra, ZigZag (Rome). The total amount of shared scooters is 500. Figure 2 shows the statistics on sharing mobility in the last three years.

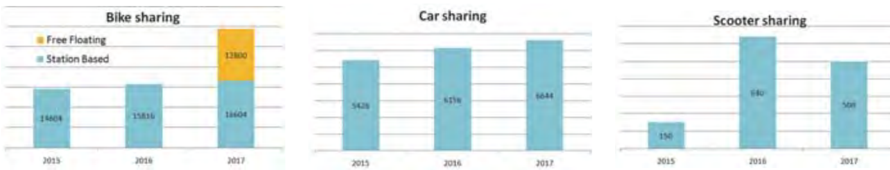


Figure 2: Statistics on sharing mobility in the last three years (Source: “Sharing Mobility Laboratory – Second National Report” preview, 15 November 2017)

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 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 the security force started to use electric vehicles.

In 2017, the Italian demand for light commercial vehicles (< 3.5 t) declined (-3.4 %) while sales of medium and heavy weight trucks (> 3.5 t) registered a growth (+4.5 % and +8.4 % respectively). The fiscal benefit of the super amortizing was continued but limited to only instrumental vehicles.

In 2017, new buses and minibuses registrations reached 3,357, with an increase (+20.3 %) compared to 2016 (2,791 vehicles sold). This confirms the expected big growth, also in relation with public tenders for new fleets. IVECO (the main Italian bus manufacturer) is providing 120 new hybrid buses in the framework of the plan to renew ATM’s (the local public transportation company in Milan) fleet. As regards FCEVs, a national survey in 2015 showed that at least 68 enterprises are currently active in the field of Fuel Cells and hydrogen technologies in Italy. In spite of this, only 13 FCEVs are registered and circulating in Italy at the time of writing (one Toyota Mirai, twelve Hyundai ix35 of which two are police cars).

Statistics for the total vehicle fleets and sales in Italy are reported at the end of the chapter, in Table 3.

29.3 Charging Infrastructure or EVSE

In Italy about 10,000 charging points can be estimated, 7,000 ÷ 7,500 (around 75 %) of them are charging points in private areas. The situation is in continuous progress, because the National Plan for Electric Charging Infrastructure (PNIRE), issued by the Ministry for Infrastructures and Transport (MIT) has to be applied. As a consequence of this, a general upward trend, shown in Figure 3, is registered but, on the other side, the inventory of charging infrastructures is particularly complicated: the results, to the best of actual abilities have been obtained by the

European Alternative Fuel Observatory's (EAFO) web site and are resumed in Table 1.

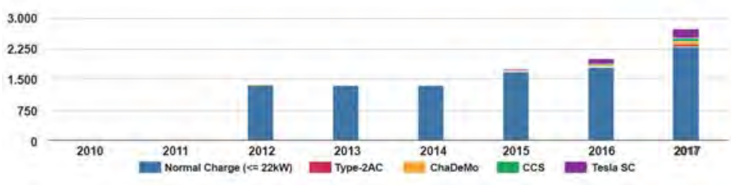


Figure 3: Total number of electric vehicle charging positions in public areas (Source: http://www.eafo.eu/electric-vehicle-charging-infrastructure)

Table 1: Information on charging infrastructure in 2017 (Data source: EAFO)

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers	2,298[a]
AC Level 2 Chargers	
Fast Chargers	223[b]
Superchargers	220[c]
Inductive Charging	n.a.
Totals	**2,741**

[a] charging points ≤ 22 kW in public areas, updated on 6 February 2018
[b] charging points > 22 kW in public areas, updated on 6 February 2018
[c] very (> 50 kW) fast Tesla charging points, updated on 6 February 2018

In 95 Italian provinces (see Figure 4) there is at least one public charging point. Charging points are concentrated in the main urban areas and cities, but thanks to the first installations of EVA+ project, the location of charging stations is now arriving very close to main highways in Italy. Several Apps keep track of the charging stations and help drivers to plan the charge: among others, Chargemap, evway, Open charge map, e-go Ricarica (by Enel), D-Mobility (by Duferco Energia).

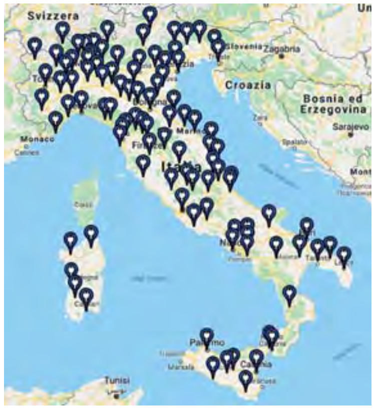


Figure 4: Map of charging infrastructures for electric vehicles (Source: website www.colonnineelettriche.it)

Some tests on electric vehicle charging, performed by the specialist magazine "Quattroruote" [3] with different charging power and type of vehicle, are shown in Table 2.

Table 2: Examples of electric vehicle charging (Data source: [3])

Examples of EV charging								
Type	Service operator	Location	Max power allowed by vehicle	Charging time (in minutes)	Energy charged kWh	Cost (1) EUR	Cost per min (2) EUR	Cost per kWh (2) EUR
50 kW CC	ENEL	Ronco Scrivia	50 kW CC or 7 kW AC	32	20.2	6.73	0.210	0.333
22 kW AC	DUFERCO ENERGIA	Pont Saint Martin	50 kW CC or 7 kW AC	60	7.0	2.50	0.042	0.357
43 kW AC	ENEL	Rodengo Saiano	22 kW AC	54	22.5	11.72	0.217	0.521
07 kW AC	GARDA UNO	Salò	22 kW AC	120	13.7	5.00	0.042	0.365

(1) Paid
(2) Calculated

Using the app "e-go Ricarica", Enel offers the charging service by app for the cost of 0.217 EUR per minute until January 15, 2018 from then on it will be 0.366

EUR. Using Enel drive card, the sign of a service agreement is required and the tariff is 0.40 EUR per kWh.
PNIRE is the instrument which rules the development of charging infrastructure: it establishes a target of 4,500 ÷ 13,000 normal power charging points (i.e. power equal or lower than 22 kW) and 2,000 ÷ 6,000 high power charging stations (i.e. power bigger than 22 kW) by 2020. Under the push of PNIRE, various regions have already implemented Electric Mobility Plans and/or guide lines for the development of electric mobility. Dedicated plans for all other regions are in progress.

On November 9, 2017 Enel launched its plan to provide Italy with an appropriate charging infrastructure. According to the study made by Enel & Polytechnic of Milan to prepare the plan, under the assumption of a fleet of 360,000 e-cars (against the 6,000÷7,000 e-cars now on the road) 12,000 charging stations would be required. Enel will use 100 to 300 million EUR, resulting from company investment, European founds and drivers' contribute, this is not going to be a part of electricity tariff and a burden on the electricity bill. Targets for Enel's Plan are:

- 2,700 charging points by 2018,
- 7,000 charging stations by 2020,
- 14,000 charging stations by 2022.

By the first half of 2018, Enel will install 250 charging stations in parking areas of Conad's sale points[59] throughout Italy: 40 Fast Charge Stations (50 kW) very close to main highways, enclosed in EVA+ project, and 210 Pole Stations (22 kW).

29.4 EV Demonstration Projects

Many programs/projects/initiatives, which Italian research institutes, companies or cities have taken part in, continued to be promoted and financed/co-financed in 2017 by the EU.

"Steve" is a project funded by the European Commission in the framework of the Program Horizon 2020. It involves 21 partners between universities, administrations and little/medium companies for the development of an innovative city electric car as a valid instrument to solve typical critical issues in urban centers. Torino and Venaria (Italy) Calvià (Spain) and Villach (Austria) will be pilot cities for this project.

"Smart-MR", Sustainable Measures for Achieving Resilient Transportation in Metropolitan Regions, is a European project aimed to help local (municipal and

[59] The brand Conad is one of the main supermarket chains in Italy.

regional) authorities to achieve resilient and low-carbon transportation and mobility in metropolitan regions. ATAC, the largest public transportation company in Rome, is the main stakeholder in the project.

Over the next three years E.ON (an international energy and e-mobility Company) and CLEVER (a Denmark based e-mobility service provider) will establish a network of 180 ultra-fast charging stations (150 kW with potential for upgrade to 350 kW) for electric vehicles in seven countries connecting Norway to Italy. The network is appointed as a European flagship project and has received 10 million EUR in funding support from the European Commission in the framework of Connecting Europe Facility Program.

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+) is aimed to create a fast charging infrastructure for electric vehicles on key roads and motorways in Italy and Austria. Over the course of the three-year project 200 multi-standard fast charge 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. The project's budget is 8.5 million EUR, 50 % co-funded by the European Commission under the "Connecting Europe Facility" Program. A grant agreement worth a maximum of 4.2 million EUR was signed with INEA, the Innovation and Networks Executive Agency delegated by the European Commission and EVA+ was officially launched in Brussels in January 2017. The first 30 "Fast Recharge Plus" charging points (one infrastructure every 60 km) were installed by Enel on the route between Rome and Milan.

"Puglia Active Network" (Pan) is a project of Enel, supported by the European Community and the Ministry for Environment: co-financed with 85 million EUR under the EU NER 300 Program, it wants 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 of a network of charging infrastructure for electric vehicles on a regional scale. More than 70 intelligent and interoperable (which may be used by customers of different operators) charging infrastructures will be installed, 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. The project was officially launched in 2016 and the first phase of installation was completed in 2017.

The 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 three charging stations respectively installed in parking areas (6 parking spaces each one) at Varese and Saronno’s railway stations.

The “E-Via” project, co-funded by PNIRE, will bring 35 charging stations into the region Val d’Aosta: 11 of them will be installed in the city of Aosta and 24 along the main roads and valleys of the region. The project started in February 2017 with the installation of the first charging station in Saint Vincent.

In December 2017, the “E-VIA - FLEX-E” project for the installation of 14 multi-standard Ultra-Fast Charging Stations in Europe was launched. The charging stations are ranging from 150 kW to 350 kW: 8 in Italy, 4 in Spain and 2 in France. The project is co-financed by the European Commission in the framework of the program “Connecting Europe Facility”.

In the works of the project “Mi Muovo elettrico-Free Carbon City”, funded by Emilia Romagna Region, 130 charging stations will be installed in urban and interchange areas.

Enel and the City of La Spezia made an agreement for a pilot project which involves 8 electric cars and 5 electric bikes, which will be given to the force of the Municipal Police, and 16 charging points.

The “Green Way Primiero” is a project on sustainable mobility realized by the City of San Martino di Castrozza, aimed to demonstrate the substitution of conventional fuels in transportation with electric energy from local renewable energy sources. It involves the installation of 13 charging stations in public areas and 18 EVs for local public transport.

Enel, Nissan Italia and the Istituto Italiano di Tecnologia (IIT) made an agreement for a pilot project on company electric car sharing and V2G charging system. IIT will be the company where the car sharing will be realized, by the means of two electric cars Nissan Leaf and two bidirectional (V2G) charging station installed by Enel.

Many demonstration projects put together the interest on e-mobility and the Italian environmental beauty to realize examples of sustainable mobility in touristic zones.

"Ischia Isola verde" is an eco-tourism pilot project made by a collaboration between Enel and Emotion (a "green cars" service company), which combines 20 rental e-cars and 30 charging stations in hotels. "Sicily Eco tour" is collaboration between Enel, Renault and the rental car company "Sicily by Car", which offers 200 Renault Zoe and 400 charging stations along tourist itineraries in Sicily. "Asinara Zero Emissions" is a project for substituting the diesel vehicles of Asinara Island's Park Authority with electric vehicles. It is founded by "Fondazione di Sardegna" and also provides for purchasing and installing charging stations initially connected to the grid, but in the final part of the projectto be integrated by a PV plant and an energy storage system to reduce the dependence from the grid as much as possible in favor of the use of "clean" energy.

29.5 Outlook

The prospects for EVs, PHEVs and HEVs in Italy are judged positively and with a significant growing trend in the medium to long term with higher attention from media general public and authorities. The major driving force for most countries and car makers in Europe will be the mandatory constraints in 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 for Economic Development and ready to become operative. The presence of charging infrastructures will drive the growth of clean vehicles.

As indicated in [4], Italy boasts numerous, major competencies that can be usefully capitalized on in a nationwide project of industrial development of e-Mobility, particularly in the areas connected with:

- bodywork and interiors: within R&D, there is a solid and prestigious tradition with engineering and design companies, as well as in bodywork manufacture and the design of interiors;
- electronic components: Italy is the second country in the world in terms of trade balance of electrical conductors for voltages above 80V;
- charging equipment: Italy excels in the engineering, industrial design and manufacture of electrical charging equipment – with companies such as

Enel, Bitron, Ducati Energia, Scame and ABB – that permit the launching in the short-term of a plan to develop a grid infrastructure on a national level;

- electrical grid: Italy is in the vanguard in this area and is developing projects and international collaboration in the development of Smart Grids, Smart Charging and Vehicle to-Grid technologies, including on a world level;
- mobility services: Italy has a long-standing tradition in the production of light electrical vehicles, electric bicycles and motorcycles, and a framework is emerging of innovative companies specialized in the development of software, applications and technological solutions for managing mobility, including intermodal.

Conversely, the battery and electric motor sectors are less-covered than their foreign competitors, however, in both sectors, there are interesting development opportunities for Italy, in particular in the battery energy storage market, where Italian knowhow in inverter production for industrial automation and energy generation from renewable sources could serve as a driver, and could be transferred and adapted to the e-Mobility sector.

Considering Italy and the overall perimeter of e-Mobility (motor vehicles, motorcycles, buses and commercial vehicles), the value chain involved represents a very significant range of activity, with 160,000 companies, a workforce of over 820,000 employees and annual revenues of nearly 390 billion EUR. Taking into account the electric motor vehicle market alone (not included: motorcycles, buses, commercial vehicles) and the turnover that can be generated in each stage of the value chain, a study [4] by Enel and “The European House - Ambrosetti” Consulting Group estimates that in the different development scenarios (lower, middle, upper, accelerated) hypothesized, an overall turnover of between 24 and 100 billion EUR by 2025 and between 68 and 303 billion EUR by 2030could be activated, see Figure 5. This is a significant impact, of which Italy could capture a relevant share in the component, bodywork and interiors sectors, as well as in the area of electric charging equipment, in addition to those that develops predominantly nationwide, that is the electricity grid, recycling and second life. It would be possible, therefore, to generate a value of between 14 and 59 billion EUR in Italy by 2025 and between 41 and 180 billion EUR by 2030.

	Motor vehicle		Electric charging infrastructures		ICT services		Recycling and second life		Total activable turnover*	
	2025	2030	2025	2030	2025	2030	2025	2030	2025	2030
Lower scenario	21	61	2	4	0.4	3	0.05	1	24	68
Middle scenario	31	92	2	5	0.5	4	0.05	1	33	102
Upper scenario	46	153	3	7	0.8	7	0.1	2	50	169
Accelerated scenario	92	276	5	13	1.8	11	0.1	3	100	303

Figure 5: Estimate of the cumulative revenues activatable along the electric car value chain as of 2025 and 2030 (absolute value in billions of euros), 2017 (Source: The European House - Ambrosetti data elaboration, 2017)

Figure 6 shows hypothetical scenarios of the spread of electric motor vehicles (BEVs and PHEVs) in the Italian car fleet and Figure 7 illustrates hypothetical scenarios of the spread of electric charging points and the ratio of electric motor vehicles (EVs) and charging points in Italy as of 2025 and 2030.

The histograms refer to hypothetical growth in the number of electric motor vehicles (BEVs and PHEVs) on a national level in the various development scenarios for the years 2025 and 2030, respectively 3 and 9 million electric motor vehicles in the accelerated scenario, with 30,000 public charging stations – 1.5 million private wall-boxes and 45,000 public charging stations – 4.5 million private wall-boxes.

Great expectations are on the Italian car manufacturer FCA, who is planning the production of some electric models of its range (Doblò). Maserati, a famous brand of the FCA Group for luxury and high performances cars, will be the pioneer company in the Group to develop hybrid and electric technologies. In 2019 it will start the production of plug-in hybrid electric cars and will further launch the first model of a fully electric car. The target would be electrifying 50 % of FCA’s models within 2022 [5].

Figure 6: Hypothetical scenarios of the spread of electric motor vehicles (BEVs and PHEVs) in the Italian car fleet as of 2025 and 2030 (absolute number and as a percentage of stock). Source: The European House - Ambrosetti data elaboration, 2017

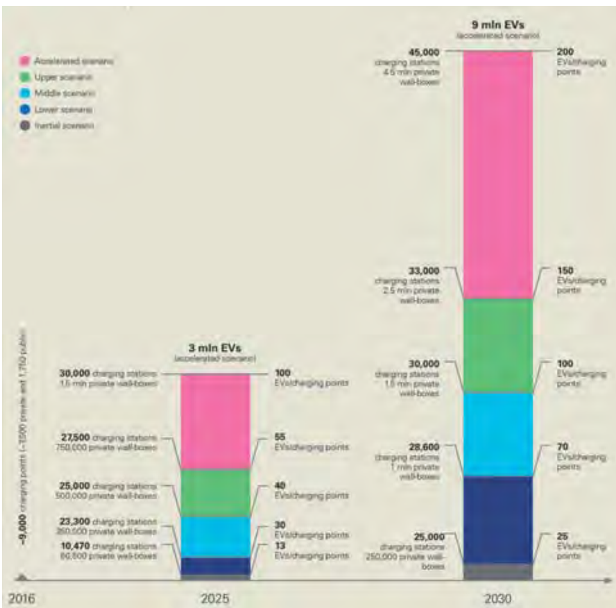


Figure 7: Hypothetical scenarios of the spread of electric charging points (public charging stations and private wall-boxes) and the ratio of electric motor vehicles (EVs) and charging points in Italy as of 2025 and 2030. Source: The European House - Ambrosetti elaboration based on Enel estimates, 2017

Table 3: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: see legend)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[f]**
2- and 3-Wheelers[a]	500,000[a]	n.a.	n.a.	n.a.	43,600,000[b]
Passenger Vehicles[b]	7,710[c]	5,513[c]	181,296[c]	13[d]	37,876,138[c]
Buses and Minibuses[c]	n.a.	n.a.	n.a.	n.a.	97,817[c]
Light commercial vehicles[d]	3,738[c]	n.a.	303[c]	n.a.	3,752,540[c]
Medium and Heavy Weight Trucks[e]	24[c]	n.a.	n.a.	n.a.	1,400,080[c]
Totals without bicycles	**11,472**	**5,513**	**181,599**	**13**	**51,726,575**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[f]**
2- and 3-Wheelers[a]	161,642[b]	n.a.	n.a.	n.a.	1,943,280[b]
Passenger Vehicles[b]	1,967[e]	2,646[e]	63,398[e]	n.a.	1,970,497[e]
Buses and Minibuses[c]	n.a.	n.a.	n.a.	n.a.	3,357[e]
Light commercial vehicles[d]	n.a.	n.a.	n.a.	n.a.	193,533[e]
Medium and Heavy Weight Trucks[e]	n.a.	n.a.	n.a.	n.a.	44,007[f]
Totals without bicycles	**3,609**	**2,646**	**63,398**	**n.a.**	**2,444,674**

n.a. = not available

[1] UNECE categories L1-L5

[2] UNECE categories M1

[3] UNECE categories M2-M3

[4] UNECE categories N1

[5] UNECE categories N2-N3

[6] Including non-electric vehicles

[a] Data on bikes available only, source: ANCMA

[b] Data source: ENEA elaboration on ANCMA data

[c] Data source: ENEA elaboration on ACI data (1 January 2017)

[d] Data source: ENEA

[e] Data source: ACEA

[f] Data source: ENEA elaboration on ACEA data

Table 4: Available vehicles and their prices in Italy (Data source: national automotive magazine “Quattroruote”, N. 748, December 2017)

Market-Price Comparison of Selected EVs and PHEVs in Italy	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
AUDI A3 SPB e-tron (petrol-electric plug-in hybrid)	39,550÷41,150
BMW 330e iPerformance (petrol-electric plug-in hybrid)	47,150
BMW 530e Business (petrol-electric plug-in hybrid)	58,750
BMW 740e (petrol-electric plug-in hybrid)	99,550
BMW 225xe Active Tourer (petrol-electric plug-in hybrid)	38,100
BMW i8 (petrol-electric plug-in hybrid)	141,750
BMW X5 (petrol-electric plug-in hybrid)	74,700
BMW i3 (electric)	39,150÷42,800
BMW/i3 (electric range extender)	43,850÷47,500
CITROEN C-Zero (electric)	30,740
CITROEN E-Mehari (electric)	26,040÷ 31,700
CITROEN E-Berlingo (electric)	33,000
DS 5 (diesel-electric hybrid)	50,600÷55,100
FERRARI LaFerrari Aperta (petrol-electric hybrid)	1,860,001
FORD Mondeo (petrol-electric hybrid)	41,600
HONDA NSX (petrol-electric hybrid)	201,000
HYUNDAI Ioniq (petrol-electric plug-in hybrid)	33,750÷36,250
HYUNDAI Ioniq (petrol-electric hybrid)	25,150÷29,250
INFINITI Q50 (petrol-electric hybrid)	51,990÷63,400
INFINITI Q70 (petrol-electric hybrid)	63,450÷66,400
KIA Optima (petrol-electric plug-in hybrid)	44,000
KIA Niro (petrol-electric hybrid)	25,000÷30,000
LAND ROVER Range Rover Sport (petrol-electric plug-in hybrid)	90,200÷111,500
LAND ROVER Range Rover (petrol-electric plug-in hybrid)	124,500÷140,500
LEXUS CT (petrol-electric hybrid)	31,750÷37,200
LEXUS IS (petrol-electric hybrid)	41,000÷51,000
LEXUS GS (petrol-electric hybrid)	53,000÷76,100
LEXUS LS (petrol-electric hybrid)	117,300÷152,600
LEXUS RC (petrol-electric hybrid)	46,000÷53,000
LEXUS LC (petrol-electric hybrid)	105,000÷115,500

LEXUS NX (petrol-electric hybrid)	47,500÷58,950
LEXUS RX Hybrid (petrol-electric hybrid)	69,000÷76,000
MERCEDES C 350e (petrol-electric plug-in hybrid)	50,101
MERCEDES C 300 (diesel-electric hybrid)	49,408
MERCEDES GLC 350e (petrol-electric plug-in hybrid)	57,063÷63,560
MERCEDES GLE 500e (petrol-electric plug-in hybrid)	85,050
MINI Countryman (petrol-electric plug-in hybrid)	38,050÷41,300
MITSUBISHI Outlander (petrol-electric plug-in hybrid)	46,850÷52,850
MITSUBISHI i-MiEV (electric)	29,900
NISSAN Leaf (electric)	33,070÷ 37,935
NISSAN e-NV200 Evalia (electric)	37,361÷ 39,811
PEUGEOT iOn (electric)	28,151
PEUGEOT Partner Tepee (Electric)	33,000
Porsche Panamera E-Hybrid (petrol-electric plug-in hybrid)	114,043÷121,729
RENAULT Scenic (diesel-electric hybrid)	29,100÷35,100
RENAULT Grand Scenic (diesel-electric hybrid)	30,600÷36,600
RENAULT ZOE (electric)	23,300÷ 39,200
SMART fortwo Electric Drive (electric)	23,920÷ 28,840
SUZUKI Swift (petrol-electric hybrid)	17,690÷19,190
SUZUKI Baleno (petrol-electric hybrid)	17,600
SUZUKI Ignis (petrol-electric hybrid)	16,800÷19,000
Tesla Model S 75 kWh (electric)	72,640÷87,680
Tesla Model S 100 kWh (electric)	111,130÷ 151,530
Tesla Model X 75 kWh (electric)	94,480
Tesla Model X 100 kWh (electric)	114,530÷160,930
TOYOTA Yaris (petrol-electric hybrid)	19,500÷22,250
TOYOTA Auris (petrol-electric hybrid)	24,500÷29,300
TOYOTA Prius (petrol-electric plug-in hybrid)	41,600
TOYOTA Prius (petrol-electric hybrid)	29,450÷36,300
TOYOTA C-HR (petrol-electric hybrid)	32,800
TOYOTA RAV4 (petrol-electric hybrid)	34,100÷41,050
VW e-up! (electric)	28,100
VW Golf (petrol-electric plug-in hybrid)	39,650
VW e-Golf (electric)	39,600
VW Passat (petrol-electric plug-in hybrid)	47,900÷48,900
VOLVO V60 (diesel-electric plug-in hybrid)	59,870

VOLVO S90 (diesel-electric plug-in hybrid)	72,950
VOLVO V90 (diesel-electric plug-in hybrid)	75,910
VOLVO XC60 (diesel-electric plug-in hybrid)	70,350÷75,550
VOLVO XC90 (diesel-electric plug-in hybrid)	81,100÷125,750

A fuel cell SUV from Hyundai is expected to be available for sale in summer 2018.

Vehicles Incentives from Car-Dealers

Until December 31, 2017, an offer by some Toyota dealerships gave a bonus of between 5,000 and 8,000 EUR to people scrapping or trading in their outdated (6 months, at least) diesel vehicle for an hybrid one. Other examples are given in Table 5.

Table 5: Examples of discounts from different car dealers (Data source: [6])

Examples of Discounts Offered from Different Car-Dealers	
Car Model	**Discount (in EUR)**
Lexus NX Hybrid	9,000
Hyundai Ioniq	3,250
Kia Niro	3,100
Suzuki Ignis	1,900
Toyota C-HR Hybrid Active	4,450 (any old vehicle traded-in)

References

[1] IEA_HEV_TCP_Report2017 "Hybrid and Electric Vehicles - The Electric Drive Chauffeurs"
[2] "Quattroruote" Magazine, N. 750, February 2018, pages 206÷207
[3] "Quattroruote" Magazine, N. 750, February 2018, pages 149÷155
[4] Enel, The European House – Ambrosetti, "E-Mobility Revolution – Impacts on Italy and its industrial value chain: Italy's agenda", 2017
[5] "Quattroruote" Magazine, N. 749, January 2018, Annex page 44
[6] "Quattroruote" Magazine, N. 748, December 2017, pages 210÷211

30 The Netherlands

30.1 Major Developments in 2017

By 2030, only zero-emission cars will be sold in the Netherlands. That is the Dutch government's ambition. With this goal in mind, businesses, social institutions, knowledge institutions and the government all work together in the Formula E-Team, the Dutch PPS platform to promote e-mobility, to accelerate the transition to electric vehicles. The aim is to help meet the climate targets and, in addition, to take advantage of the associated economic opportunities.

And their efforts bore fruit in 2017: the number of electric cars in the Netherlands grew once again. For the first time, the growth came entirely from fully electric cars: more than 8,600 new, fully electric passenger vehicles were registered, while the total fleet number of plug-in hybrids fell slightly.

The economic impact of e-mobility was monitored and research showed that in 2016, 3,730 fte were working in the sector. The number of jobs and the production volume has increased 40 % year-to-year. It is clear, therefore, that e-mobility is an innovation that offers economic opportunities for Dutch businesses. Amongst others, Dutch companies are active in the field of charging infrastructure, charging services, consultancy, the manufacture of electric trucks and buses, the manufacture of components and the manufacture of light electric vehicles, including electric scooters.

30.1.1 Policy Developments

In October 2017, the Rutte III new Dutch cabinet presented its coalition agreement. In the mobility chapter, the aim is for all new cars to be zero emission by 2030 at the latest. Tax incentives for zero emission cars will be phased out as this ambition is achieved. The cabinet states that it will ensure that charging infrastructure is in place to meet the needs of the new stock of electric vehicles, but that market parties will continue to bear primary responsibility for supplying and operating charging equipment. And by introducing low emission zones, and reducing parking charges for zero emission vehicles, the municipal authorities have instruments at their disposal to improve air quality in inner cities. Some cities already have environmental zones at place, but not yet for zero emission vehicles only.

The cabinet aims for a 49 % reduction in greenhouse gas emissions by 2030. In order to give economic sectors certainty about the long-term targets, a national climate and energy agreement will be made and should be ready in 2018.

Figure 1: Charging in the Netherlands (Source: Living Lab Smart Charging, photo: Bas Stoffelsen

Figure 2: Representatives from the Benelux countries signing e-roaming partnership agreement (Source: Benelux.int)

Together with her colleagues from Luxembourg and Belgium, the Netherlands' State Secretary for Infrastructure and Water Management, Ms Stientje van Veldhoven, is to put measures in place to make it easier for e-drivers to find charging stations and to make payment at these charging stations more user friendly. The countries have signed a partnership agreement that aims to promote "cross-border access to e-mobility services in the Benelux countries". This is designed to enable drivers of electric vehicles to travel seamlessly through the

Benelux countries. Under the agreement, drivers will be able to charge an electric vehicle in all three countries using a single charging card or app, and prices will be transparent. For this reason, Open Chargepoint Belgium, eViolin and Chargy – the sector organisations for providers of charging services from Belgium, the Netherlands and Luxembourg – are also party to the agreement.

30.1.2 Market Developments

Several regions have completed their tendering processes for (additional) public charging infrastructure. In the South, in the provinces of Brabant and Limburg, 1,250 additional charging points will be installed under a tender where a government grant per charging point is no longer required. The Metropolitan Region of Amsterdam has organized a successful tender for the operation of 360 existing charging points. The tender is unique in that it is the first time that a commercial player will pay for operation of the charging stations. Previously, the government provided co-finance.

Five European fast charging companies, including the Dutch company Fastned, have joined forces to form the Open Fast Charging Alliance. The parties will connect their networks through roaming to provide a high-quality network of fast charging stations throughout Europe. This network will be open to all fully electric vehicles, thereby facilitating long-distance travel.

More and more electric buses are being taken in operation in the Netherlands. Examples include the cities of Utrecht, Dordrecht, Haarlem and Amersfoort. Operator Hermes has reached a milestone for its 43 electric buses around Eindhoven, because it has covered 1 million electric kilometers with the buses – in operation since December 2016.

VDL Bus & Coach has launched an electric minibus called the MidCity Electric. The new electric vehicle is suitable for small-scale passenger transport. The fully electric minibus is 8 m long and has a low floor, which facilitates boarding for passengers and wheelchair users. In addition, the longer wheelbase provides a high level of flexibility in terms of the type and number of seats. The MidCity Electric has a maximum range of 220 km. VDL also produces the fully electric 12 to 18 meter long Citea, flexible in options of several electric drives, battery packs and charging systems, so that the ideal, optimal combination can be put together for any area of operation.

Figure 3: VDL's electric minibus for small-scale passenger transport (Source: VDL)

E-Trucks Europe has manufactured a fully electric garbage truck for the municipality of Breda. The electric garbage truck produces no emissions and is equipped to run on hydrogen in the future. The vehicle is currently capable of fast charging, i.e. its battery can be re-charged from empty within 2 hours.

Figure 4: E-Trucks's electric garbage truck (Source: E-Trucks Europe)

In Rotterdam, the first fully electric water taxi has been brought into service. The water taxi has a converted Tesla battery under its bonnet. It has enough power to run for a day at an average speed of 12 km an hour.

Figure 5: Rotterdam water taxi (Source: Watertaxi Rotterdam)

In 2017, a number of Dutch companies launched new models on the light electric vehicle market. Urban mobility firm Stint and the municipality of Zaanstad, for example, have developed a vehicle that the municipality will use for landscaping and street cleaning. Previously, municipality employees had to walk 6 km a day with a wheelie bin to empty the bins; now they use an electric vehicle developed by Stint, which can transport a load of up to 400 kg over a range of 90 km.

Figure 6: Stint especially developed for Zaanstad municipality (Source: https://stintum.com/projecten/zaanstad/)

Electric car sharing is gaining ground in the Netherlands, with several new initiatives in 2017. Hyundai, eg., has launched a project in Amsterdam and Ameland with more than 100 fully electric vehicles. And car2go welcomed its 50,000th member in Amsterdam. Their Smarts are now used almost 2,000 times a day. 4 % of all shared passenger cars in the Netherlands are electric. Also bike sharing is taking up in Dutch cities.

In 2017, a number of Dutch companies caught the eye of major multinationals. Some companies were taken over completely (eg. NewMotion by Shell and EVBox by Engie), while others sold a percentage of their shares (eg. 25 % stake in Jedlix by Renault).

30.1.3 Innovation and Research

The city of Arnhem has introduced a charging point for electric vehicles that derives its energy from batteries that are housed in the pylon of a trolley bus wire. This is the first time in Europe that power from braking trolleybuses has been harnessed to power electric vehicles. The city plans to introduce more of these charging points over the next few years.

ElaadNL, Liander, GreenFlux, NewMotion and EVnetNL have demonstrated in a pilot that charging electric vehicles more slowly during the evening peak does not adversely affect drivers of electric vehicles. During the project, the electric vehicles of 71 participants were charged at half the normal speed during the evening peak for 1 year in order to reduce the burden on the grid. This was offset by charging the fully electric vehicles 25 % more quickly outside peak hours.

Lightyear has unveiled the pre-design for its commercial solar car, the Lightyear One. The vehicle is fully electric, is powered exclusively by solar energy and will be launched in 2019. With a full battery, the vehicle can travel up to 800 km. The integrated solar panels on the roof of the new car generate enough energy to charge the battery during the day and plugging in to charge is rarely necessary. For very long journeys, the car can be charged using a normal socket, so a separate charging infrastructure is not required. In the meantime, more than 10 of the vehicles have already been sold at the pre-sale stage, even before the first prototype is ready.

Figure 7: Lightyear One (Source: Lightyear)

The province of Noord-Brabant, the Ministry of Infrastructure and Water Management, Rijkswaterstaat (the Dutch agency responsible for water and road management), and the municipalities of Eindhoven, Helmond and Tilburg, have set up the MobilitymoveZ.NL Urban Mobility Testing Area. The initiative comprises of a stretch of national, provincial and local roads that runs from Helmond to Tilburg via Eindhoven. MobilitymoveZ.NL provides national and international players with a controlled, manageable section of a public highway to develop and test new technologies and services in the field of smart mobility and innovative mobility services in practical situations.

Just as in previous years, the Dutch student teams had an excellent year in 2017, with the unveiling and development of new vehicles and technology and participation in international competitions:

- TU/ecomotive, a team of students from Eindhoven University of technology, has presented the design of Lina the car in the world to be made of a biocomposite. The electric city car, which can accommodate 4 people, weighs just 225 kg.
- Team FAST, a team of students from Eindhoven University of Technology, has unveiled an electric bus that runs on Hydrozine, a sustainably produced formic acid. The self-built system is housed in a small trailer that is connected to an electric bus, which converts the formic acid into electricity by splitting it into hydrogen and CO_2. The hydrogen is then used to generate electricity, which is used to power the bus.
- The Nuon Solar Team and the Solar Team Eindhoven have won the World Solar Challenge. Delft University of Technology's Nuna9 took first prize in the Challenger Class of the World Solar Challenge in Australia. Solar Team Eindhoven's Stella Vie won the Cruiser Class for 'practical' solar cars. Stella Vie can accommodate 5 people but can still cover some 1,000 km a day on solar power.

The Dutch Automobile Association, ANWB, published the E-mobility Monitor, which outlines developments in e-mobility in the Netherlands, consumer response to electric vehicles and any obstacles that have been encountered. The first edition of the Monitor indicates, amongst others, that 38 % of consumers are interested in e-mobility.

In 2017, the Netherlands Knowledge Platform for Charging Infrastructure (NKL) published their yearly benchmark of the costs associated with public charging infrastructure. This report indicates that the costs of public charging infrastructure continued to fall in 2017 to 35 % of the costs in the reference year (2013). Another of the report's findings is that, from 2017 onwards, the focus moves from cost reduction to professionalization of the market.

Figure 8: Nuon Solar Team win at the World Solar Challenge (Source: Delft University of Technology)

Figure 9: NKL maturity model (Source: http://en.nklnederland.nl)

This report "Charging infrastructure on private property built environment", which was produced by Ecorys and EVConsult, highlights obstacles to the installation of charging points for electric vehicles on private property built environment, such as shared car parks in apartment complexes and offices. According to the writers of the report, there are a number of different policy measures that could be implemented by the government to speed up an increase in the number of charging points.

PwC's research on the institutional barriers and potential solutions for the smart charging of electric vehicles reviews current obstacles to optimum use of electric vehicles in the Netherlands and suggests potential solutions. The report's recommendations include the following: optimization of the incentive to store energy in an electric vehicle for own use, avoidance of a double tax on energy use and reduction of the transmission charge.

30.1.4 Financial and Fiscal Incentives

One of the main drivers behind the increase of electric vehicles in the Netherlands is fiscal stimulation. As from 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 for conventional cars. Table 1 provides an overview of the incentives that were in place in 2017.

Table 1: Fiscal incentives in the Netherlands 2017

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 ones; 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 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 g CO_2/km (and not with a diesel engine) are on the list of deductible investments, as are the accompanying charging points.
Various local incentive schemes	Various Dutch municipalities, such as Amsterdam, The Hague and Rotterdam, offered different grants and schemes for electric vehicles.

As part of the Green Deal on Publicly Accessible Charging Infrastructure, the national government has committed a total of 7.2 million EUR to contribute to the installing of public charging points by municipalities. In the period 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. Up to the end of 2017, 216 municipalities have installed 7,800 charging poles through this arrangement.

30.2 HEVs, PHEVs and EVs on the Road

The number of plugged-in electric vehicles grows steadily in the Netherlands. At the end of 2017, almost 120,000 electric passenger cars were registered. Of these, almost 18 % were Battery Electric Vehicles (BEVs), the majority consisting of Plug-in Hybrid Electric Vehicles (PHEVs). When compared to the end of 2016, the number of BEVs increased by 61 % and the total number of PHEVs decreased for the first time by 1 %.

There were 158,245 HEVs on the road at the end of December 2017.

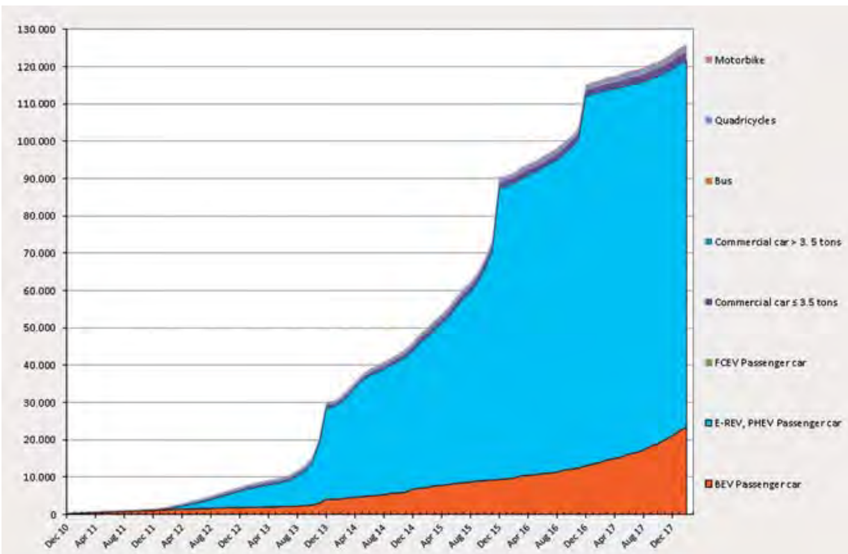


Figure 10: Development of plugged-in electric vehicles 2010-2017 in the Netherlands (Source: Dutch Road Authority, edited by RVO.nl)

Over the year 2017, 2.6 % of new registrations were BEVs or PHEVs. In 2016 this percentage was 6.7. About 1 % of the total passenger car fleet was electric.

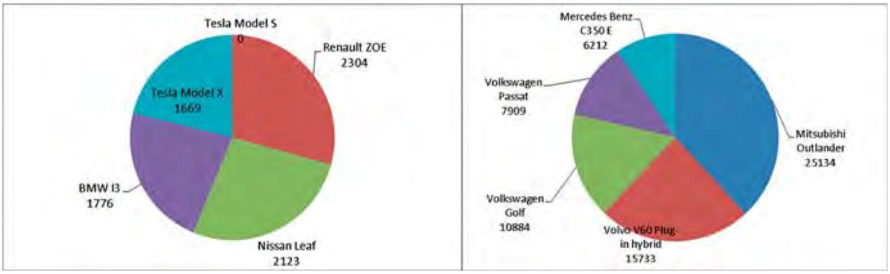


Figure 11: Top 5 registrations in fleet BEV (left) and PHEV (right), 31 December 2017 (Source: Dutch Road Authority, edited by RVO.nl)

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: Dutch Road Authority, edited by RVO.nl; fleet totals: CBS except buses: CROW; 2017 registration totals: BOVAG/RAI)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	1,542,474	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles[2]	21,115	98,217	158,245	43	8,373,244
Buses and Minibuses[3]	296*	n.a.	n.a.	6	5,000
Light commercial vehicles[4]	2,210	n.a.	n.a.	n.a.	883,350
Medium and Heavy Weight Trucks[5]	81	n.a.	n.a.	n.a.	139,656
Totals without bicycles	**66,176**	**98,217**	**158,245**	**49**	**9,401,250**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	299,887	n.a.	n.a.	n.a.	393,733
Passenger Vehicles[2]	8,116	1,093	23,459	13	418,461
Buses and Minibuses[3]	128*	n.a.	n.a.	5	n.a.
Light commercial vehicles[4]	582	n.a.	n.a.	n.a.	73,478
Medium and Heavy Weight Trucks[5]	15	n.a.	n.a.	n.a.	15,529
Totals without bicycles	**14,728**	**1,093**	**23,459**	**18**	**901,201**

* including trolley buses

n.a. = not available
[1] UNECE categories L1-L5
[2] UNECE categories M1
[3] UNECE categories M2-M3
[4] UNECE categories N1
[5] UNECE categories N2-N3
[6] Including non-electric vehicles

Table 3: Available vehicles and prices (Data source: https://ev-database.nl/, March 2018)

Market-Price Comparison of Selected EVs and PHEVs in the Netherlands	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR; prices include 21% VAT)**
Audi Q7 E-Tron	92,325
Audi A3 Sportpack E-Tron	42,975
BMW i3	40,412
BMW i3s	44,081
BMW330e	50,678
BMW 530e iPerformance	63,601
BMW X5 xDrive40e	94,552
BMW 740e	100,848
BMW i3s Range Extender	49,120
BMW i3 Range Extender	45,433
Citroën C-Zero	22,360
Citroën E-Berlingo Multispace	31,670
Hyundai IONIQ Electric	34,295
Jaguar I-Pace	80,330
Kia Optima Plug-In Hybrid	41,475
Kia Soul EV	36,335
Kia Niro PHEV	34,595
Kia Optima Sportswagon PHEV	42,975
Mercedes E 350e Plug-In	66,997
Mercedes GLE 500e Plug-In	93,879
Mercedes C 350e Estate	52,740
Mercedes C 350e Limousine	50,969
Mini Countryman Cooper S E ALL4	40,700
Mitsubishi i-MIEV	27,615
Mitsubishi Outlander PHEV	35,990
Nissan Leaf	33,990

Nissan e-NV200 Evalia Connect Edition	38,950
Opel Ampera-e	46,699
Peugeot Partner Tepee Electric	30,470
Peugeot iOn	22,360
Porsche Panamera S E-Hybrid	117,600
Renault ZOË R90	32,890
Renault ZOË Q90	33,590
Renault ZOË R90 Entry	30,390
Renault Kangoo Maxi	37,503
Smart ForFour Electric Drive	24,050
Smart ForTwo Electric Drive	23,669
Smart ForTwo Cabrio Electric Drive	27,043
Tesla Model S 100D	109,635
Tesla Model X 100D	112,985
Tesla Model S P100D	149,685
Tesla Model S 75D	86,585
Tesla Model X P100D	158,935
Tesla Model X 75D	93,335
Toyota Prius Plug-in	37,995
Volkswagen e-Golf	39,540
Volkswagen Passat GTE	45,570
Volkswagen e-up!	27,760
Volkswagen Golf GTE	41,050
Volkswagen Passat GTE Variant	47,170
Volvo V60 D6 AWD	57,975
Volvo XC-90 T8 Twin-Engine	81,875
Volvo V60 D5 AWD	54,975

30.3 Charging Infrastructure or EVSE

The Netherlands has a well-developed charging network.

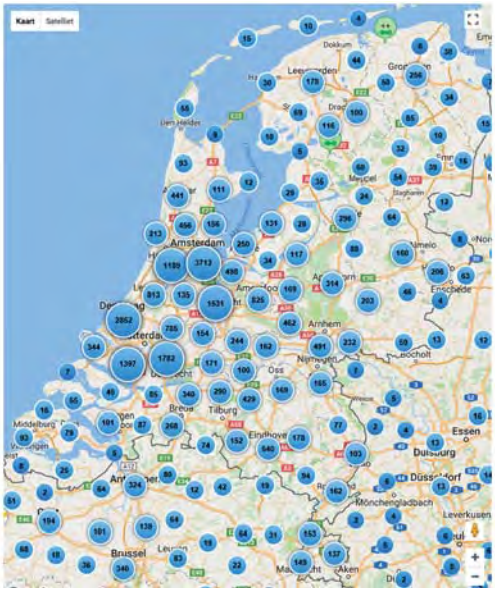


Figure 12: Map of (semi)public charging infrastructure for electric cars (Source: Oplaadpalen.nl)

Table 4: Information on charging infrastructure in 2017 (Source: oplaadpalen.nl, edited by RVO.nl)

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers	1,730
AC Level 2 Chargers	31,138
Fast Chargers	755 (178 locations)
Superchargers	118 (12 locations)
Inductive Charging	1 project passenger cars (Rotterdam) 1 bus line (Utrecht)
Totals	**33,743**

At the end of 2017, there were 32,875 regular charging points in the country, an increase of 26 % compared with the year before. 15,288 of these were public charging points and 17,587 were semi-public, the majority of those being destination chargers. The number of fast charging points increased by 23 %

compared to 2016, to a total of 755 – in total 178 locations along highways but also in cities.
Next to these public charging points, an estimated minimum of at least 80,000 private charging points was in operation.

About half the number of (semi)public charging points are already smart charging ready, reports the Living Lab Smart Charging. Moreover, all charging is interoperable, and has been so 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, and real-time billing, as well as mobile access of chargers.

The Dutch government, knowledge institutes and companies together call for the use of open standards and open protocols in charging infrastructure, so as to stimulate innovation and global access – thus stimulating EV uptake.

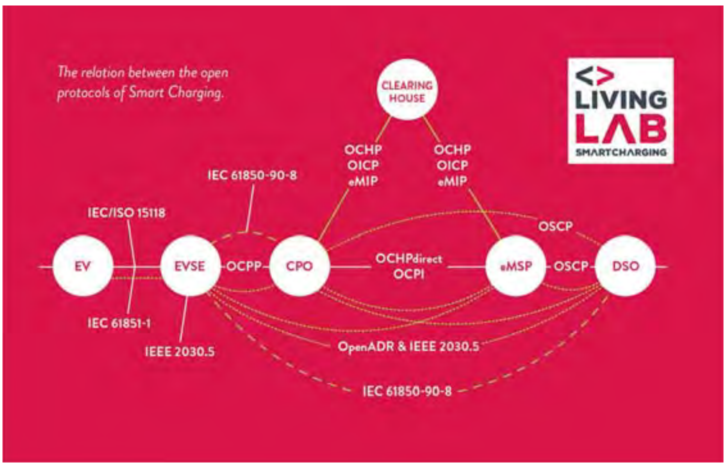


Figure 13: The relation between the open protocols of smart charging (Source: Living Lab Smart Charging)

30.4 EV Demonstration Projects

There are a great number of projects going on. This is only a small selection.

In partnership with Nuon, Liander and ElaadNL, the municipality of Amsterdam has introduced flexible charging of electric vehicles. In this pilot, electric vehicles are charged up using more power when there is less demand for electricity from other energy users and the demand for power is therefore low. And they are charged up using less power when less energy is available. 200 charging points in Amsterdam Centre, West, New West and South are taking part in this pilot.

In conjunction with car manufacturer Mitsubishi and network operator TenneT, NewMotion has launched a pilot that involves bidirectional charging of a number of electric vehicles in an effort to balance peak demand on the grid more effectively. A first charging station has now been brought into service.

After a successful pilot in Lombok, the sustainable energy system Smart Solar Charging is to be expanded to 5 districts in the Utrecht region and will include 70 electric We Drive Solar cars. During the day, a smart charging station stores local solar power in electric car-share cars, while at other times the excess energy is used locally thanks to vehicle2grid (V2G) technology.

The project ‘Amsterdam Arena’ is one of the pilots in the ‘SEEV4-City’ Interreg project. It researches and tests energy storage and V2G applications through 280 used Nissan Leaf batteries.

30.5 Outlook

In the summer of 2018 the new Energy and Climate Agreement will be ready, taken into account the large task on CO2 emissions reductions that the Netherlands will need to accomplish to meet the goals of the Paris Climate Agreement. This will serve as the new policy focus for all relevant sectors, including transport and mobility.

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 a larger battery capacity that will arrive in 2018/2019. 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.

31 Republic of Korea

31.1 Major Developments in 2017

Discussing electric car waste battery regulations

Korea's electric car waste battery regulations are announced in the Air Quality Preservation Act. It requires that the removed battery be returned to the local government when the electric vehicle is scrapped. However, there is no detailed procedure for recycling, disassembling and disposing of returned batteries, so it is necessary to prepare related regulations. Therefore, The Ministry of Environment is planning to hold a discussion meeting on the regulation for the improvement of system and policy direction for improving the circulation of waste batteries in electric cars. They will collect opinions from diverse stakeholders such as civic groups, recycling industry, automobile companies, as well as various methods from the discussions, and reflect them in related regulations.

Hyundai Motors Launched NEXO in March 2018

Hyundai Motors participated in 'CES 2018 (Consumer Electronics Show)' held in Las Vegas to unveil 'NEXO' car name, specifications and major technologies for the first time in the world.

Specification of NEXO: NEXO is 4,670 mm in length, 1860 mm in width and 1630 mm in height. The battery pack is equipped with a 40 kW battery pack and a 100 kW fuel cell. The maximum travelable distance is 609 km, the maximum output is 154 hp, and the zero back is 9.5 seconds. The price of the car is about 70 million KRW (approx. 55,400 EUR).

Supply Policy

The Ministry of Environment organized a budget for the supply of 130 hydrogen cars this year. Currently, there are four regions in Ulsan, Gwangju, Gyeongsangnam-do, Changwon, and Chungcheongnam-do that support the hydrogen car supplement subsidy. The additional subsidy is the highest at Ulsan with 27.5 million KRW (21,766 EUR), and the other subsidy is about 10 million KRW (7,913 EUR). In 2018, Seoul, Daejeon and Gangwon-do will provide subsidies in addition to the four regions.

Based on the Ulsan city government subsidy of 27.5 million KRW (21,766 EUR) and additional subsidies of 12.5 million won (9,889 EUR), the actual purchase price is expected to be 30 million KRW (23,734 EUR). Currently, there are 12 hydrogen filling stations, and the Ministry of Environment is also building 19 other facilities and announced plans to install 10 charging stations in 2018.

31.1.1 New policies, legislation, incentives, funding, research, taxation, etc.

The Ministry of Trade, Industry and Energy Supports Future Automobile Industry

The government plans to invest 35 trillion KRW (27.7 billion EUR) over the next five years in order to make a leap into future powers. The Ministry of Industry announced the 'Future Automobile Industry Development Strategy', which was established jointly by related ministries to provide a new growth breakthrough in the future automobile market such as electric and autonomous vehicles.

Electric Car Subsidy Differential Support System

Electric vehicles were subsidized by government subsidies (14 million KRW) (11,073 EUR) regardless of the type of vehicle until this year. From 2018, The Ministry of Environment announced that it will cut subsidy prices for passenger cars, but will expand the support for cargo and buses. Government subsidies (based on passenger cars) will be paid to 20,000 electric vehicles. Depending on the performance of the vehicle, the subsidy will vary from a maximum of 12 million KRW to a minimum of 10.17 million KRW (8,042 EUR).

$$= \text{Base amount} + \left\{\text{Battery capacity} \times \left(\textit{Unit subsidy} \times \frac{\textit{Weighted ratio}}{\textit{Lowest weighted ratio}}\right)\right\}$$

※ Base amount : 3,500,000 KRW (minimum subsidy)
※ Unit subsidy : 170,000 KRW (Unit payment according to battery capacity)
※ Weighted ratio : Ratio of 25% performance at low temperature (A ratio reflecting the driving distance and efficiency per charge / Purpose for minimizing the inconvenience of reducing driving distance in winter)
※ Lowest weighted ratio : The lowest weighted ratio of the target vehicle

Figure 1: Method of calculation of electric passenger vehicle subsidy

The provincial local subsidy system maintains a fixed subsidy system. In the case of micro electric cars, 4.5 million KRW (3,559 EUR) is paid semiannually regardless of the model. In the case of purchasers living in some local governments that do not conduct electric vehicle supply projects, only up to 500 cars can apply for subsidies through the Korea Environment Corporation without local subsidies. In addition to purchasing subsidies, individual tax exemption benefits of up to 3 million KRW (2,372 EUR), education tax of up to 900,000 KRW (711 EUR) and acquisition tax of up to 2 million KRW (1,581 EUR) will remain the same. The tax exemption for individual consumption tax will increase from 2 million KRW (1,581 EUR) to 3 million KRW (2,372 EUR), which will reduce the burden on buyers. Up to 2 million won (1,580 EUR) will be paid to the taxi, so the maximum amount of 12 million KRW (9,489 EUR) will be paid regardless of the type of vehicle. The Ministry of Environment plans to subsidize the 1 ton cargo truck, which is widely used in delivery vehicles, by 20 million KRW (15,815 EUR), so that it will actively support the aged passenger car used by the common people to be replaced by the electric car that will be released in the second half of 2018.

Table 1: Automotive and small EV (1.265 KRW = 1 EUR)

Type	Manufacturer	Vehicle type	Government subsidy support amount (10k KRW)
Passenger car	Hyundai	Kona(basic)	1,200 (9,486 EUR)
		IONIQ EV(`17) N, Q Trim	1,127 (8,908 EUR)
		IONIQ EV(`17) I Trim	1,119 (8,845 EUR)
	Kia	SOUL EV(`18)	1,044 (8,253 EUR)
		Ray EV	706 (5,579 EUR)
	Renault Samsung	SM3 Z.E(`18)	1,017 (8,037 EUR)
		SM3 Z.E(`17)	839 (6,630 EUR)
	BMW	I3 94ah(`18)	1,091 (8,622 EUR)
		I3(`17)	807 (6,378 EUR)
	Nissan	LEAF	849 (6,708 EUR)
	GM	Volt EV	1,200 (9,481 EUR)
	Tesla	Model S 75D	1,200 (9,481 EUR)
		Model S 90D	1,200 (9,481 EUR)
		Model S 100D	1,200 (9,481 EUR)
Small EV	Renault Samsung	TWIZY	450 (3,556 EUR)
	Dae-Chang motors	DANIGO	450 (3,556 EUR)
	Ssemisisco	D2	450 (3,556 EUR)

Electric buses will be subsidized to medium-sized buses. Subsidies are set at 60 million KRW (47,432 EUR) for medium-sized buses and 100 million KRW (79,062 EUR) for large buses The Ministry of Environment plans to induce town buses and school buses to be converted into electric vehicles. Government subsidies for hybrid vehicles (HEV) have been cut from 1 million won (790 EUR) to 500,000 won (395 EUR) this year, and the amount of subsidies has increased from 50,000 this year to 60,000 in 2018. The government subsidy system for hybrid vehicles will be abolished in 2019, but for the plug-in hybrid vehicle (PHEV) will be maintained (5 million KRW (3,953 EUR) per vehicle).

Table 2: EV trucks and EV vans (1.265 KRW = 1 EUR)

<table>
<tr><th>Type</th><th>Class</th><th>Manufacturer</th><th>Vehicle type</th><th>Government subsidy support amount (10k KRW)</th></tr>
<tr><td>Truck</td><td>Light</td><td>Powerplaza</td><td>Labo Peace (0.5 ton)</td><td>1,100 (8,693 EUR)</td></tr>
<tr><td rowspan="12">Bus</td><td rowspan="2">Medium</td><td>Joylong Korea</td><td>E6</td><td>6,000 (47,402 EUR)</td></tr>
<tr><td>BYD Auto Industry</td><td>BYD eBUS-7</td><td>6,000 (47,402 EUR)</td></tr>
<tr><td rowspan="10">Heavy</td><td>Hyundai</td><td>Elec-city</td><td>10,000 (79,004 EUR)</td></tr>
<tr><td rowspan="2">Edisonmotorsev Co.</td><td>e-FIBIRD (PIEV)</td><td>10,000 (79,004 EUR)</td></tr>
<tr><td>e-FIBIRD (BSEV)</td><td>10,000 (79,004 EUR)</td></tr>
<tr><td rowspan="2">Woojin Industrial Systems Co.</td><td>Woojin Industrial Systems Low-floor Electricity bus</td><td>10,000 (79,004 EUR)</td></tr>
<tr><td>Apollo Electricity bus</td><td>10,000 (79,004 EUR)</td></tr>
<tr><td>Epic Automotive Korea Co.</td><td>Envion</td><td>10,000 (79,004 EUR)</td></tr>
<tr><td>Daeyang Tech.</td><td>Greenearth</td><td>10,000 (79,004 EUR)</td></tr>
<tr><td>P-line</td><td>HYPERS</td><td>10,000 (79,004 EUR)</td></tr>
<tr><td>Zyle Daewoo</td><td>BS 110CN (BSEV)</td><td>10,000 (79,004 EUR)</td></tr>
</table>

Table 3: 2018 Electric vehicle subsidies by local government

City	Support Unit Price in 2017 (10k KRW)	Support Unit Price in 2018 (10k KRW)
Seoul	550 (4,347 EUR)	500 (3,952 EUR)
Busan	500 (3,952 EUR)	500 (3,952 EUR)
Daegu	600 (4,743 EUR)	600 (4,743 EUR)
Incheon	500 (3,952 EUR)	600 (4,743 EUR)
Gwangju	700 (5,533 EUR)	700 (5,533 EUR)
Daejeon	500 (3,952 EUR)	700 (5,533 EUR)
Ulsan	500 (3,952 EUR)	500 (3,952 EUR)
Sejong	700 (5,533 EUR)	700 (5,533 EUR)
Gyeonggi-do	500 (3,952 EUR)	500 (3,952 EUR)
Gangwon-do	640 (5,059 EUR)	640 (5,059 EUR)
Chungcheongbuk-do	800~1,000 (6,324~7,905 EUR)	800~1,000 (6,324~7,905 EUR)
Chungcheongnam-do	800~1,000 (6,324~7,905 EUR)	800~1,000 (6,324~7,905 EUR)
Jeollabuk-do	600 (4,743 EUR)	600 (4,743 EUR)
Jeollanam-do	440~880 (3,478~6,955 EUR)	440~1,100 (3,478~8,695 EUR)
Gyeongsangbuk-do	600~850 (4,743~6,719 EUR)	600~1,000 (4,743~7,905 EUR)
Gyeongsangnam-do	300~600 (2,371~4,743 EUR)	600~900 (4,743~7,114 EUR)
Jeju	600 (4,743 EUR)	600 (4,743 EUR)

Table 4: Diffusion goals and support benefits

EV	2017	2018	Remarks
Supply target	14,000 unit	20,000	42.9% Increase
Government subsidy budget	196 billion unit	240 billion unit	22.4% Increase
• Subsidies by car type declined as subsidy support changed. • Adjusted from 10.17 million to 12 million won depending on battery capacity and mileage (fuel economy).			

31.2 Charging Infrastructure or EVSE

Until now, charging infrastructure has been installed in highway rest areas, public institution parking lots, etc. in Korea. In the future, it is planned to improve charging conditions by installing the AC level 2 charger in welfare facilities such as accommodation facilities, large marts and parks. Therefore, the public charging conditions of plug-in hybrid vehicles (PHEV), which is evaluated as a quasi-electric car, is expected to improve significantly. In case of plug-in hybrid vehicles, it was difficult to use the nationwide installed fast chargers, because of battery capacity and cost problems. Therefore, the Ministry of Environment wants to install the charger through amendment of the guidelines, and is going to apply for the land owner or the customer who can use it publicly. In the existing charger installation instructions, it was limited to apartment houses and workplaces with more than 100 parking spaces. However, with this revision, there is space for charger installation, and anyone with a management staff can apply for installation. The charger installation application will be received from August 18, and the installation budget of 546 rapid chargers will be additionally reflected in the Congress in July, and a total of 1,076 rapid chargers will be installed only this year. As for the fast charger, 750 units were installed and operated nationwide by the end of last year. In addition, 1,076 units will be installed by the year 2018, and charging conditions are expected to improve by more than 40 % from last year.

Table 5: Information on charging infrastructure in 2017 (Data source: The Ministry of Environment)

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 2 Chargers	1,730
Fast Chargers	5,373
Totals	**10,198**

31.3 HEVs, PHEVs and EVs on the Road

Electric Car Distribution Status in This Year

At the end of this year, a total of 25,593 electric vehicles were supplied. The number of electric cars distributed this year was 13,826, 2.3 times more than last year's 5,914. The number of electric cars will increase from 1,075 units in 2014 to 2,907 units in 2015 and 5,914 units in 2016. The number of infrastructure units to be installed is doubling every year, including 750 units in 2016 and 1,801 units in currently year.

Table 6: Domestic supply amount (data from January 2018)

Car	26,208
Vans	141
Truck	57
For special	6
Total	26,412

Table 7: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: Ministry of Land, Infrastructure and transport, January 2018)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total**
Passenger Vehicles[1]	26,208	n.a.	320,652	177	347,037
Buses and Minibuses[2]	141	n.a.	280	n.a.	421
Medium and Heavy Weight Trucks[3]	57	n.a.	n.a.	n.a.	57
Totals without bicycles	**26,406**	**n.a.**	**320,932**	**177**	**347,515**

n.a. = not available

[1] UNECE categories M1

[2] UNECE categories M2-M3

[3] UNECE categories N1-N3

Table 8: Available vehicles and prices in South Korea

Market-Price Comparison of Selected EVs and PHEVs in Korea	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in KRW and EUR)**
Hyundai Ionic Electric	40~43 million KRW (31,626~33,976 EUR)
KIA Soul EV	43 million KRW (33,976 EUR)
KIA RAY EV	45 million KRW (35,569 EUR)
Renault Samsung Motors SM3 Z.E.	39~41 million KRW (30,826~32,407 EUR)

Renault Samsung Motors Twizy	15~15.5 million KRW (11,856~12,251 EUR)
GM Chevrolet BOLT EV	48 million KRW (37,940 EUR)
BMW i3	59~65 million KRW (46,635~51,370 EUR)
Tesla Model S 90D	115 million KRW (90,885 EUR)
Nissan LEAF	46~52 million KRW (36,356~41,098 EUR)

32 Spain

32.1 Major Developments in 2017

32.1.1 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.

32.1.2 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.

32.1.3 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.

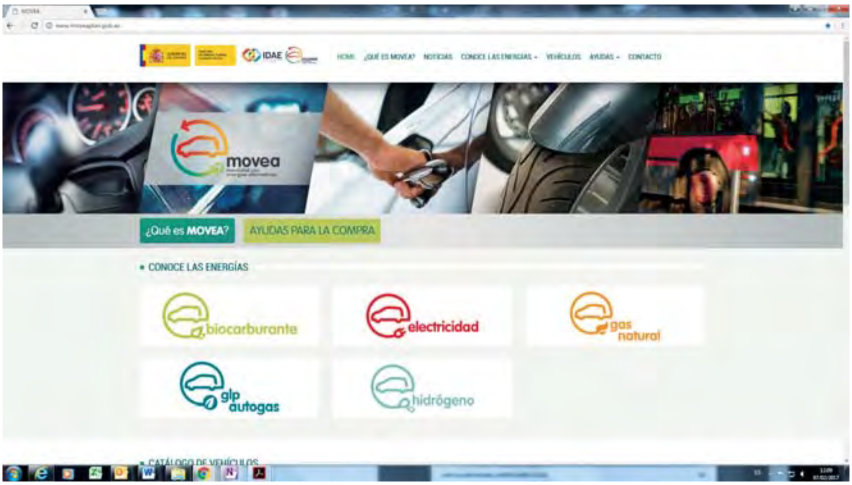


Figure 1: MOVEA Website (Source: www.moveaplan.gob.es)

Plan MOVEA 2017: An Incentive Plan for the Acquisition of Alternative Vehicles

In order to give continuity to MOVEA 2016 incentives plan, the Spanish Government published the “Plan MOVEA 2017” on June 23, 2017 (Royal Decree 617/2017), a National Plan of direct incentives for the acquisition of alternative vehicles (LPG, CNG /LNG and Electric vehicles and also the deployment of charging infrastructure for EVs). Plan MOVEA 2017 lasted from June 24, 2017 to October 15, 2017 and it was funded with a total budget of 14.26 million EUR.

A number of 2,444 alternative vehicles and 26 public charging points for electric vehicles were subsidized in the frame of this plan, with a final budget of 9,258,646 EUR applied. Most of the subsidized vehicles were electric (67 %), in addition to LPG vehicles (21 %) and Natural Gas vehicles (12 %).

Table 1: Plan MOVEA - Detail of incentives per electric vehicle (BEV, EREV, PHEV)

Plan MOVEA 2017: Incentives for Acquisition of Electric Vehicle	
Category	**Incentives (particulars / SME / big companies; in EUR)**
M1* (passenger cars)	1,300 / 1,300 / 1,100 (BEV), 15km ≤ range** ≤ 40 km 2,600 / 2,600 / 2,500 (BEV), 40km < range** ≤ 90km 5,500 / 4,300 / 3,200 (BEV), 90km < range**
N1* (vans <3,5t)	8,000 / 6,300 / 5,000 (BEV), range** > 60 km**
N2 (trucks ≤12t)	8,000 / 7,000 / 6,000 (BEV)
M2 (busses ≤5t)	8,000 / 7,000 / 6,000 (BEV)
M3 (busses>12t) N3 (trucks>12t)	20,000 (range **> 60 km), for all beneficiaries
L6e (light quadricycles)l	1,950 (BEV), for all beneficiaries
L7e (heavy quadricycles)	2,350 (BEV), for all beneficiaries.
L3e, L4e, L5e (motorbikes)	1,500 / 1,200 / 1,000 (BEV), 3 ≤ P (kW) < 4,5 2,000 / € 1,800 / € 1,500 (BEV) 4,5 ≤ P (kW) In all cases, range** >70km

Plan MOVEA 2017: Incentives per Charging Point of EVs	
Charging Point 7 ≤ P (kW) < 15	1,000 for all beneficiaries
Charging Point 15 ≤ P (kW) < 40	2,000 for all beneficiaries
Charging Point 40 ≥ P (kW)	15,000 for all beneficiaries

Plan MOVEA 2017: Electric Vehicles Subsidized						
Category	**M1**	**N1**	**M3**	**L6e**	**L7e**	**Total**
Nº vehicles	1,230	151	1	6	15	1,403

Plan MOVEA 2017: Charging Points Subsidized	
Nº Charging Points 15 ≤ P (kW)<40	28
Nº Charging Points 40 ≤ P (kW)	14
Total Charging Points	42

* Incentives increased by 750 EUR, in case the vehicle is retired (scrapped)
** Range in electric mode

In addition to the above table of incentives for electric vehicles and charging infrastructure, car dealers had to facilitate the installation of charging points, assuming a cost of 1,000 EUR (150 EUR in case of the category of the vehicles being L6e or L7e).

New Plan MOVALT: Two Incentive Plans for the acquisition of alternative Vehicles and to promote EV charging Infrastructure

Plan MOVEA 2017 incentives finished on October 15, 2017. After that, new incentives programs were approved:

"Plan MOVALT Vehicles": The Institute for Energy Diversification and Savings (IDAE), through the Resolution of its Council of November 7, 2017 and the Resolution of its General Manager of November 21, 2017, approved the regulatory bases and public call respectively, of a new incentives program for alternative vehicles acquisition, quite similar in format to MOVEA 2017.

MOVALT Vehicles is funded with a total budget of 20 million EUR and is running effectively from December 13, 2017 to June 30, 2018. In this context, the Spanish Government dedicated 36.6 million EUR during 2017, to incentive the acquisition of alternative vehicles.

"Plan MOVALT Infrastructure": The Institute for Energy Diversification and Savings (IDAE), through the Resolution of its Council of November 7, 2017 and the Resolution of its General Manager of January 10, 2018, approved the regulatory bases and public call respectively, of a new incentives program for EV charging infrastructure.

MOVALT Infrastructure was initially approved with a total budget of 15 million EUR that was increased by 5 million EUR in March 2018, and is running effectively from January 23, 2018 to December 31, 2018.

32.2 HEVs, PHEVs and EVs on the Road

In the year 2017, in Spain a number of 11,160 *electric vehicles* were registered, considering BEVs, PHEVs and REEVs (Table 2), which almost double the figures of the previous year of 2016, with a number of 6,179 EVs registrations. This increase was heavily supported by National incentives programs for EVs acquisition (Plan MOVEA 2017 and MOVALT Vehicles) and also by other initiatives and incentive programs for vehicle acquisition at regional or local scale.

Focusing on *conventional hybrid vehicles*, the huge increase of the passenger car registrations along the years 2016 and 2017 is remarkable, with a total number of

55,482 registrations during the year of 2017, coming from a total of 7,759 registrations during the year of 2015 (more than seven times the figures of 2015). It is remarkable that, at a National scale, there have not been any incentives programs 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 2: Fleet totals and sales of BEVs and HEVs, per category in 2017 (Data source: IDAE, based on registrations of Spanish Traffic Authorities)

Fleet Totals on 31 December 2017					
Vehicle Type	**BEVs**	**HEVs**	**PHEVs**	**FCVs**	**Total Fleet[h]**
Bicycles	187,000	0	0	0	30,000,000[i]
Mopeds[a]	4,360	0	0	0	1,892,995
Motorbikes[b]	5,147	56	0	0	3,279,398
Quadricycles[c]	2,074	0	0	0	116,181
Passenger vehicles[d]	9,724	164,696	6,559	0	23,500,403
Commercial vehicles[f]	3,335	9	4	1	4,031,563
Buses[e]	101	307	51	0	63,589
Trucks[g]	76	64	0	0	892,914
Totals (without bicycles)	**24,817**	**165,132**	**6,614**	**1**	**33,777,043**

Fleet Sales on 31 December 2017					
Vehicle Type	**BEVs**	**HEVs**	**PHEVs**	**FCVs**	**Total sales[h]**
Bicycles	60,000	0	0	0	1,140,000[i]
Mopeds[a]	1,958	0	0	0	21,815
Motorbikes[b]	233	0	0	0	143,960
Quadricycles[c]	112	0	0	0	3,056
Passenger vehicles[d]	4,206	55,482	3,689	0	1,342,011
Commercial vehicles[f]	923	1	1	0	150,678
Buses[e]	24	160	0	0	4,038
Trucks[g]	4	35	10	0	36,159
Totals (without bicycles)	**7,460**	**55,678**	**3,700**	**0**	**1,701,717**

n.a. = not available
[a] UNECE categories L1-L2
[b] UNECE categories L1-L5
[c] UNECE categories L6-L7
[d] UNECE categories M1
[e] UNECE categories M2-M3
[f] UNECE categories N1
[g] UNECE categories N2-N3
[h] Including both conventional and alternative technologies
[i] Estimated data at the end of 2017 (Source AMBE - Spanish Association of Bicycles and Brands)

In the specific case of electric passenger cars (BEVs, PHEV/EREVs), this category had a market penetration of 0.6 % during 2017. Considering both electric vehicles, jointly with hybrid electric vehicles (HEVs), resulted in a market penetration of 4.7 %. Regarding fleet numbers in Spain and considering vehicle registration figures showed in the Table 2, Electric vehicle fleet totals in Spain (considering BEVs, PHEVS and REEVs) during 2017, rose to a total number of 24,817, coming from a total amount of 20,012 electric vehicles registered during 2016 (an increase of 19.4 %)

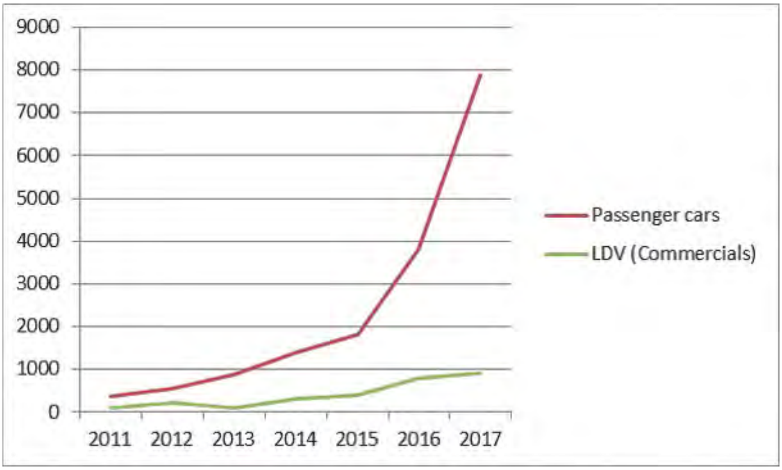


Figure 2: EVs market evolution (annual sales of cars –M1- and vans –N1-) in Spain

In the specific case of *conventional hybrid vehicles (HEV)*, the passenger car fleet amounted to a number of 164,696 vehicles in 2017, coming from a fleet of 94,771 vehicles at the end of 2016 (a remarkable increase of 74 %).

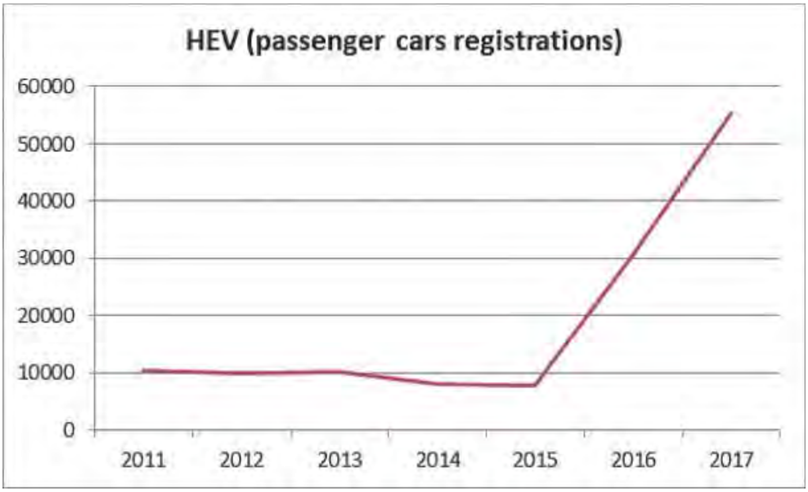


Figure 3: HEVs market evolution (annual sales of passenger cars –M1-) in Spain

32.3 Charging Infrastructure or EVSE

After an initial stage characterized by charging vehicles for free in the frame of pilots demonstration projects promoted by city councils and regional administrations, a public infrastructure service for charging electric vehicles in Spain must be operated at present by authorized charging operators “Gestor de Cargas”, established and defined by the National normative (Royal Decree 647/2011).

At the end of 2017, there were a number of 58 charging operators officially registered and published by the National Commission of Markets and Competition (CNMC), which deployed a total of 278 public charging stations for EVs in different cities all over the national territory, as it figures at the website.[60]

However, a total number of 1,600 public charging stations and an amount of 4,600 charging points is estimated in Spain, most of them deployed in the frame of pilot demonstration projects, pending of registration in the charging operators list of the CNMC, which means a ratio of 6,5 charging points per electric vehicle registered in Spain.

In this way, Spain is currently working on an accurate data collection of the placements and technical characteristics of the stations and charging points, according with the European Plan for Infrastructure deployment for alternative vehicles, as it is collected in Article 10, chapter 6 of the Directive 2014/94/UE.

[60] https://sede.cnmc.gob.es/sites/default/files/2018-04/201803_Listado%20Gestores%20de%20Cargas_CNMC.pdf

Table 3: Emplacements of charging stations and charging points for EVs in Spain (Data source: Professional associations of different activity sectors)

Emplacements/Sites	Number of Charging Stations	Number of Charging 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
Totals	**1,659**	**4,547**

Apart from different regional and local initiatives in order to promote charging infrastructure for EVs all over the Spanish territory, there are other relevant initiatives at a national level:

- Plan MOVEA and Plan MOVALT Infrastructure: Incentives for private and public companies to deploy quick and semi-quick charging 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 charging infrastructure, in the framework of Sustainable Urban Mobility Plans, effectives until 2020.
- Railway operator RENFE is preparing a plan for deploying charging infrastructure of EVs in parking lots of different railway stations.
- Airport operator AENA is studying a business model for the current charging infrastructure of EVs in parking lots of the Spanish Airports.
- PIRVEC 2016-2019, Strategic Plan for the deployment of charging infrastructure of electric vehicles in Catalonia

CIRVE Project - The Spanish and Portuguese National Governments promoted the creation of a consortium formed by eight partners to deploy quick charging points through the Mediterranean and Atlantic corridors, as a business model to study for the future implementation of RTE-T European charging network and connecting Iberian Peninsula with the rest of the European continent.

This 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 to this project is co-financed by the 2015 call for proposals of the “Connecting Europe Mechanism (CEF).

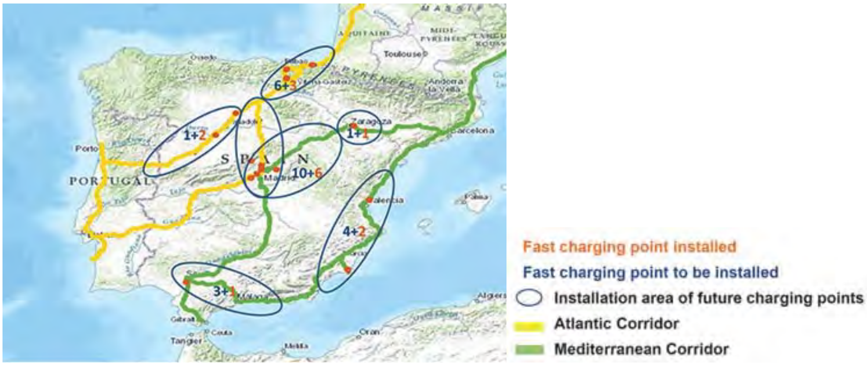


Figure 4: CIRVE (Iberian corridors of quick charging points)

E-VIA FLEX-E project - European project focused on the deployment of ultra-fast charging stations (150-350 kW), coordinated by Enel and co-financed by the European Commission and with the participation of the charging operator IBIL. This project started on December28, 2017 and will run in Italy, France and Spain, with the objective to deploy 14 ultra-fast chargers, to test that this network enables new electric vehicles, with a range of more than 300 km, to travel long distances and to contribute to the development and spread of e-cars in Europe[61].

32.4 EV Demonstration Projects

Massive Infrastructure Deployment in the City of Barcelona

In the city of Barcelona, there are currently a number of 303 public use charging points working, from which 121 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 charging 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,

[61] https://www.enel.com/media/press/d/2017/12/e-via-flex-e-eng

ICAEN, IMESAPI, EMPARK to deploy charging stations for EVs in five train stations.

A new relevant initiative in Barcelona is the launching of the project “Car-Esmatic Project”, promoted by the European Commission, with the participation of the Barcelona Port, jointly with the Luka-Koper Port (Slovenia) and the Neptune Lines shipping company, focusing on the role of electric vehicles in the intermodal transport and on the logistic requirements for EVs imports and exports through the Barcelona Port.

Quick Charge Club (E-Car)

The energy company “Endesa” deployed six quick charge points all over the island of Mallorca. The medium distance between the charging points is 35 km. In these charging points, EV users can charge 80 % of the car battery in less than 30 minutes.

The infrastructure is co-financed by the European budget “FEDER Program”. Charging points are equipped with the three technologies currently available in the market and can be reserved and controlled through a mobile phone application.

33 Sweden

33.1 Major Developments in 2017

In 2017, Sweden adopted a progressive climate law and the domestic road transport system has two overreaching environmental goals – to reduce its GHG emissions with 70 % by 2030 and become completely fossil-free by 2045[62]. Electrification, biofuels and a more transport-efficient society has been pointed out as key enablers to reach these goals by a report dispatched by six governmental agencies[63].

Sweden has the largest plug-in electric vehicle (PEV) market share in the EU (EAFO, 2018), third globally (IEA, 2017) and in 2017, PEVs constituted 5.1 % of the new-car sales (Bil Sweden, 2017). The number of PEVs reached over 45,000 vehicles in Sweden during 2017.

The public charging infrastructure in Sweden has developed significantly during 2017, from approximately 2,200 charging points to over 4,600. Many of these have been granted support through the investment scheme Klimatklivet, the Climate leap, which by the end of 2017 in total had granted investment support to over 12,000 charging points, both public and non-public. In 2017, several efforts to further promote the development of the charging infrastructure ecosystem in Sweden were made: first, a home-charging support scheme and secondly, a project to enable charging infrastructure along larger roads in Sweden, i.e. where Klimatklivet is enough to ensure market expansion.

In 2017, the Swedish government also decided that the PEV purchase rebate system will be replaced by a cost-neutral bonus-malus system. In addition to incentives towards passenger cars and van, a purchase rebate to e-bikes and light electric vehicles (LEVs) was introduced in 2017.

---

[62] http://www.government.se/articles/2017/06/the-climate-policy-framework/

[63] http://www.energimyndigheten.se/nyhetsarkiv/2017/strategisk-plan-for-hur-transportsektorn-ska-bli-fossilfri/

The Swedish Climate Law

In June 2017, Sweden adopted a new progressive climate law and the new law requires all policy areas, not only environment, climate, transport and energy, to contribute to achieve the targets. The two overreaching goals for the Swedish road transport system are to reduce its GHG emissions with 70 % by 2030 and to become completely fossil-free by 2045. By formalising the goals in a law means that to make changes, it must be passed through the parliament first.

Demand-Side Measures

The EU emission standard regulations highly influence Swedish policy and ultimately the PEV uptake. The EU regulations today don't push for PEVs specifically, hence the need for national incentives to promote the PEV uptake.

The Green and the Super Green Car Definition

In 2006, the first Green car definition was introduced in Sweden. The aim is to specify certain criteria, which vehicles in compliance with these get benefits, like tax reliefs and priority in public procurements. Over the years, the criteria have been altered, but the basic principal has focused on renewable fuels and/or energy-efficiency. Between 2006 and 2009, green cars were granted a purchase rebate. The Super Green Car definition was introduced in 2012 comprise vehicles tail-pipe emissions lower than 50 g CO_2/km, i.e. plug-in electric vehicles, and was the first demand-side measure to specifically promote PEVs.

Super Green Car Rebate "Supermiljöbilspremie"

The Super Green Car rebate is granted for new-sales passenger vehicles that comply with the super-green car definition, i.e. tail-pipe emissions lower than 50 g CO_2/km. 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 (4,000 EUR), and from 2016 PHEVs have been granted 20,000 SEK (2,000 EUR). For a company car, the rebate covers approximately 35 percent 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 additional 19 million EUR. For 2017, 74 million EUR is allocated the scheme. The Super Green Car Rebate will be replaced by a cost neutral bonus-malus support scheme in 2018 and the rebate to PEVs (< 60 g. CO_2/km) will be 6,500 EUR.

In July 2018, the Super Green Car rebate system will be replaced by a cost neutral bonus-malus system. The implementation of the bonus-malus system aims to ensure subsidies to the most environmentally friendly vehicles without burdening the national finances.

Reduced Value of Fringe Benefits

As mentioned, 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 adjustment, the value of fringe benefits is reduced by 40 %, maximum 1,700 EUR in 2012-2016 and 950 EUR in 2017.

Given the PEV deployment among company cars, it constitutes for over 70 % of the PEV ownerships; this has probably been the most important incentive to promote the use of PEVs in Sweden.

Vehicle Tax

Today, light-duty vehicles in compliance with the Green car definition are exempted from the annual vehicle tax for the first five years it operates. The subsidy aims to generally encourage the acquisition of energy efficient or powered by renewable fuels. The annual vehicle tax comprises a static basic sum of 360 SEK/year (35 EUR/year) and a variable part that is 22 SEK/g (2.15 EUR/g); CO_2 for each gram of CO_2 over 111 g CO_2/km. Subsequently the exemption implies at least 180 EUR in tax relief the first 5 years, but for the average Swedish car in 2016 (123.1 g CO_2/km) it would mean over 210 EUR. The coming bonus-malus system will limit the vehicle tax exemption to 3 years, but differentiate the vehicle tax further.

Support to E-Bikes and LEVs

In 2017, the Swedish government launched a purchase rebate to e-bikes and light electric vehicles (LEVs). In September, after the new support became official, the market of e-bikes increased with 230 % compared to August. The budget for 2018 is 35 million EUR and each rebate comprises 25 % of the cost up to 1,000 EUR.

33.1.1 Charging Infrastructure Policies

Klimatklivet – The Climate Leap

In September 2015, the Swedish government launched the investment support scheme Klimatklivet, the *Climate Leap*, which is a general investment support scheme[64]. The allocation principal of Klimatklivet is competitiveness. Each call

[64] https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2015517-om-stod-till-lokala_sfs-2015-517

generates applications that are ranked according to the climate-effectiveness of the proposed investments. Even though the scheme is general and welcome applications from all sectors, charging infrastructure is specifically mentions in the directive and the directive also commissions the Swedish Energy Agency as the national coordinator for the EVSE deployment. Applicants are primarily companies, private households can't apply, however tenant-owned cooperatives can apply. The programme period is 2015-2023 and since 2015, 320 million EUR have been allocated to this purpose. For 2018-2020, the yearly budget will increase from 150 million EUR in 2018, 200 million EUR in 2019 and 300 million EUR in 2020.

So far, Klimatklivet has granted over 14.000 charging points investment support. Most are normal charging points, both non-public and public, and the scheme has also successfully received and granted support to DC fast chargers along motorways (see Figure 2).

Home-Charging Support Scheme

In 2017, the Swedish government decided on a home-charging support scheme. From February 1, 2018, private households are subsidized up to 1,000 EUR, or by 50 %, when installing an EVSE at their home[65].

Additional Charging Infrastructure along Bigger Roads

Klimatklivet has contributed to the expansion of the fast charging corridors along several roads, but Sweden is a widespread country and there are roads where the market drivers currently are not enough. Therefore, the Swedish Government has commissioned the Swedish Transport Agency to investigate possible public measures to improve the market conditions in these areas[66].

33.1.2 Public Transport Incentives

EV Bus Rebate

In 2016, the Government introduced a purchase subsidy specifically targeting electric buses. In the beginning, battery electric and plug-in hybrid buses could be granted rebate. Since 2017, fuel cell buses using renewable hydrogen are also included in the scheme. Several other changes in the directive were also made last year, mainly to include more public transport providers and smaller buses. Now the

[65] https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20171318-om-bidrag-till_sfs-2017-1318

[66] http://www.regeringen.se/regeringsuppdrag/2018/01/uppdrag-om-laddinfrastruktur-langs-storre-vagar/

minimum capacity is 15 passengers. For 2017-2023, the annual budget is 100 million SEK (approx. 9.8 million EUR).

33.1.3 National Activities

Fossil-Free Sweden

Another public initiative is Fossilfritt Sverige, Fossil-free Sweden, launched by the Swedish government in 2015[67]. The initiative aims to gather all different types of public and private actors, associations and other, which all support the vision of a fossil-free society. Today, the initiative complies over 250 companies, municipalities, regions, universities, and other organizations, which all have adopted ambitious targets for their own businesses. To create a market push, the initiative launches different challenges, or campaigns. One example is Transportutmaningen, The Transport Challenge, a campaign were the participating actors have more ambitious targets for their own fleet then stated in the Climate Law and then used as showcasing forerunners. Another example for the transport sector is the campaign Tjänstebilsutmaningen, the Company Car challenge. Actors that sign up for this challenge, thereby oblige to only acquire plug-in vehicles and biogas vehicles as company cars. These kind of voluntary and market-driven commitments are an interesting complement to national policies and a showcase for positive sustainable business models.

Research and Demonstration

Electric mobility R&D and the Swedish industrial policy interact to put fossil-free vehicles and vessels to the market. Regarding the market for heavy-duty vehicles, Swedish companies represent 20 % of the global market. Between 2013 and Q1 2017, over 1,450 million SEK (approx. 141.5 million EUR) of public means where invested in electric mobility projects as R&D support. On top of that, the automotive industry has matched that investment. Sweden is an automotive country, with a broad portfolio of passenger cars, heavy-duty vehicles, construction machinery, vessels and marine engines, and the scope of the electric mobility in Sweden includes all segments. The Swedish government has granted 1 billion SEK (approx. 96.2 million EUR) to facilitate a new electromobility lab in Gothenburg, a test bed for electrified power train, but also charging systems[68].

A so called gigafactory for producing lithium ion batteries is to be built in the city of Skellefteå, accompanied by an R&D production line in Västerås with the

[67] http://fossilfritt-sverige.se/in-english/

[68] http://www.regeringen.se/pressmeddelanden/2017/05/nationell-satsning-pa-elektriska-fordon/

support from the Swedish government[69]. The production capacity of the plant will be 32 GWh/year and the plant is planned to operate in 2023.The size of the factory and the Swedish electricity mix constitute good conditions to produce lithium ion batteries to a low cost with a low environmental impact.

33.2 HEVs, PHEVs and EVs on the Road

Sweden has the largest global market share in the EU (EAFO, 2018), third globally (IEA, 2017) and in 2017, PEVs constituted 5.1 % of the new-car sales (Bil Sweden, 2017). The total stock of PEVs in Sweden is almost 40,000, see Figure 1. There are no separate regional or local policies, only variable levels of engagement. Common for the cities and regions in Sweden where the PEV uptake is high and the deployment of charging infrastructure is advanced, is that it's the results of consistent work for many years, and in most cases were initiated by an early PEV activity such as a demonstration project and/or the PEV technology procurement. Today, ten Swedish cities have introduced a total of 51 electric buses, many as a part of a broader EV strategy.

Even though the conditions for PEVs in Sweden are more favorable outside the dense cities, the three largest metropolitan areas – Stockholm, Gothenburg and Malmö – comprise 75 % of the PEVs in Sweden. The highest uptake of PEVs in Sweden is found in Stockholm. Approximately half of the PEV stock is registered here. There are two main explanations for this: The inspirational explanation, where the city of Stockholm has been actively promoting the use of PEVs for almost 10 years and have been involved in several demonstration projects and managed the PEV technology procurement. During 2017, Stockholm adopted an ambitious political programme to promote PEVs. There is also the practical explanation, where the new-car sales in Stockholm is high and it has the highest number of company cars throughout Sweden. The PEV market share in Stockholm is approximately 6.5 %. In Gothenburg, the automotive capital of Sweden, electric vehicles operate among all vehicle segments: passenger vehicles, electric garbage trucks and distribution vehicles. Electric buses operate central bus lines and elaborate on different concepts to enhance usage of public transport. Indoor bus stops, even one in a library, and decorative Christmas lighting are only two examples demonstrated. To promote PEVs, several public entities are involved and one of the most extensive EVSE deployment project is currently carried out by the parking company, with investment support from Klimatklivet.

[69] http://www.energimyndigheten.se/forskning-och innovation/projektdatabas/sokresultat/?projectid=24015

Two Swedish municipalities, Sölvesborg and Varberg, have more than 20 % PEVs in their fleets[70]. Both Sölvesborg and Varberg have consistently worked to deploy PEVs for several years and started off with different demonstration projects. Sölvesborg has been involved in the demonstration project Green Charge Sydost, which started in 2013. Varberg was a part of the PEV Technology Procurement Scheme initiated in 2010. The Swedish public fleet comprises approximately 32,000 vehicles (passenger cars and vans) and public fleets represent a significant purchaser group, thus a great potential contribute to the climate goals.

33.3 Charging Infrastructure or EVSE

The cold climate in Sweden implies an extensive deployment of block heaters and other power outlets (foremost standard household outlets, Schuko) to precondition the vehicles during the winter. This infrastructure amounts of more than 600,000 outlets and even though it is rudimentary, hence not adapted to power loads over several hours, it constitutes an excellent foundation for cost-effective EVSE upgrades, both at private houses but also in public parking lots.

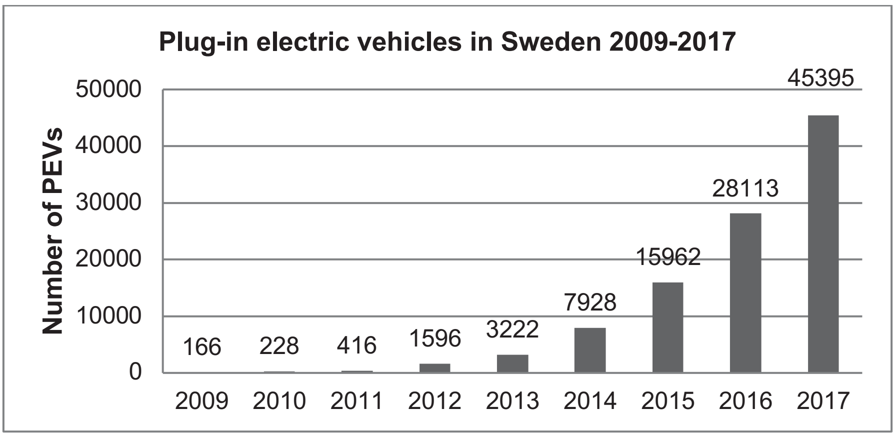


Figure 1: The number of plug-in electric vehicles in Sweden between 2009 and 2017

The public charging infrastructure in Sweden today is the result of public and private actions, sometimes in joint forces, and constitute of over 4,600 charging outlets at almost 1,300 charging stations[71], see Figure 2. The Swedish market for charging infrastructure is completely deregulated, which enables almost anyone to become a charge point operator (CPO). For example, a housing cooperative could make a charging point publicly available at their ground and charge users for this

[70] http://www.miljofordonsdiagnos.se/PDF/Miljöfordonsdiagnos%202017_rapport.pdf

[71] www.nobil.no

service. This makes it possible for a variety of different electricity suppliers and numerous charge point operators (CPOs) to create costumer value in their service to PEV users.

Table 1: Information on charging infrastructure in 2017 in Sweden

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers	469
AC Level 2 Chargers	2,987
Fast Chargers	427
Superchargers	188
Inductive Charging	0
Totals	**4,071 outlets (EU standard)**

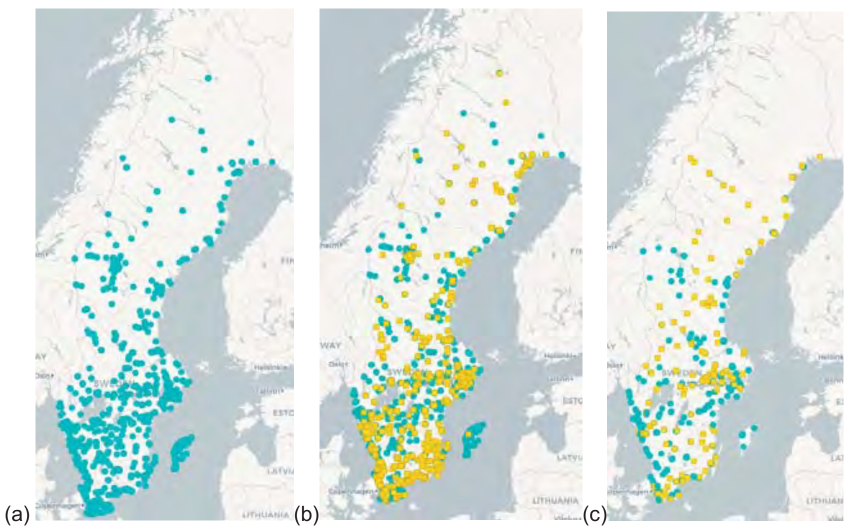


Figure 2: Public charging EVSE infrastructure in compliance with the EU standard, blue=existing yellow=granted support through Klimatklivet (a) existing EVSE (b) EVSE < 23kW (c) 50 kW DC

33.4 EV Demonstration Projects

A couple of years ago, the demonstration projects mainly focused on the vehicles itself and often on different types of road vehicles. Now the focus has shifted to study modal shifts in a transport-efficient society, a broader portfolio of vehicles (such as sea vessels and construction and mining trucks) and charging infrastructure concepts.

In June 2016, the world's first electric road system (ERS) on a public road was inaugurated at E16 and the technology has now been tested with good results on a two kilometer stretch through airborne electrical wiring. An extension of the route is now discussed. Another ERS project from the intergovernmental innovation procurement scheme, eRoadArlanda, connects Rosersberg logistics area with Arlanda airport. Instead of using a pantograph, eRoadArlanda feed electricity from a rail that is immersed in the roadway. It will be inaugurated in spring of 2018 and has been granted about 12 million EUR support. The innovation procurement scheme is collaboration between the Swedish Energy Agency, the Swedish Transport Administration and Vinnova.

The company Boliden, with financial support from the Swedish Energy Agency, has initiated a demonstration project for the electrification of in-pit truck transports in Aitik – Sweden's largest open pit copper mine – together with key partners in industry and academia. The project will develop, install and operate an electric transport route with electric trolley lines and four electric mine trucks. Up to 80 % reductions of greenhouse gas emissions are expected. There is also potential identified in transport electrification related to increased productivity.

Figure 3: Illustrated, an electrified mine truck in the Aitik mine

Life cycle analysis, LCA, has been used to study biofuels for several years. However, to compare different vehicle technologies overall impact, tail-pipe emissions or fuel-LCA data is not enough. During 2017, the topic of vehicle LCA, i.e. the carbon foot print of production, operation and scrapping of the vehicle, has been raised on the agenda. In 2017, the Swedish Energy Agency and the Swedish Transport Administration initiated a study on PEV battery production. The report "The Life Cycle Energy Consumption and Greenhouse Gas Emissions from

Lithium-Ion Batteries” highlighted the difficulties to obtain this data (there are not many primary sources of data and a lot of data is relatively old), but found a clear relationship between battery size and emissions. The study got a lot of attention in the media, which constitute the topic in the public awareness.

33.5 Outlook

In 2018, several new policies to promote PEVs will be in place but the most influential is the new bonus-malus system. This will come into action in July and it will be interesting to observe the market reactions to that.

During 2018, Sweden will be chair of the Nordic Council of Ministers. During the presidency, Sweden will initiate several PEV projects with the aim to address common Nordic challenges, exchange best practice and to enable a shared Nordic platform for charging point location data based on the Norwegian database Nobil.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2017

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	219	0	0	0	n.a.
Passenger Vehicles[2]	11,005	32,211	70,237	21	5,092,238
Buses and Minibuses[3]	51	4	94	0	14,999
Light commercial vehicles[4]	196	0	62	0	600,047
Medium and Heavy Weight Trucks[5]	0	0	56	0	77,718
Totals without bicycles	**13,237**	**32,215**	**70,449**	**21**	**5,460,824**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	4,359	15,986	14,467	14	324,178
Passenger Vehicles[2]	12	0	50	0	1,310
Buses and Minibuses[3]	80	0	12	0	55,390
Light commercial vehicles[4]	0	0	35	0	6,198
Medium and Heavy Weight Trucks[5]	4,359	15,986	14,467	14	324,178
Totals without bicycles	**4,451**	**15,986**	**14,564**	**14**	**387,076**

n.a. = not available

[1] UNECE categories L1-L5

[2] UNECE categories M1

[3] UNECE categories M2-M3

[4] UNECE categories N1

[5] UNECE categories N2-N3

[6] Including non-electric vehicles

Table 3: Available vehicles and prices (Data source: public site www.miljofordon.se, Renault)

Market-Price Comparison of Selected EVs and PHEVs in Sweden	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Audi A3 E-tron	40,100
BMW 330E	49,000
BMW I3 REX	37,000
Hyundai Ioniq Electric	38,000
Kia Optima PHEV	40,000
Kia Soul EV	38,000
Kia Niro PHEV	32,000
Mitsubishi Outlander PHEV	40,000
Nissan E-NV200	35,700
Nissan Leaf	37,500
Renault ZOE	34,000
Renault Twizy 45	9,900
Tesla Model S 75	87,500
Tesla Model X 75D	103,000
Toyota Prius Plug-in hybrid	38,000
Volvo V60 PHEV	50,000
Volvo XC60 T8 Twin engine	63,700
VW e-up!	28,600
VW Passat GTE	42,600

34 Switzerland

34.1 Major Developments in 2017

34.1.1 Swiss Energy Strategy 2050

Swiss population is sensitive and open-minded to the climate issue. On May 21, 2017 the population approved by vote the ”Energy Strategy 2050” to reduce energy consumption, increase energy efficiency and promote renewable energies under the motto ”Energy Strategy 2050”.

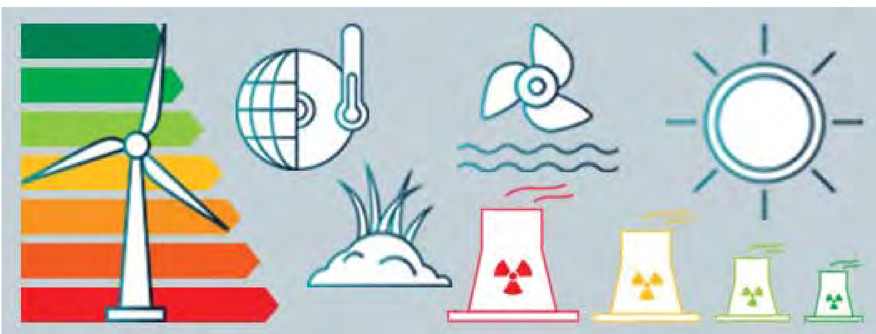


Figure 1: The first set of measures in the Swiss Energy Strategy 2050 (Source: SFOE)

Today Switzerland has a secure and cost-efficient supply of energy. Economic and technological developments as well as political decisions at home and abroad are currently leading to fundamental changes in the energy markets. In order to prepare Switzerland for these, the Federal Council has developed the Energy Strategy 2050. This should enable Switzerland to make advantageous use of the new starting position and maintain its high supply standard. At the same time the Strategy contributes to reducing Switzerland’s energy-related environmental impact[72].

[72] www.bfe.admin.ch/energiestrategie2050/index.html?lang=en&dossier_i

34.1.2 Swiss Population's Travel Behavior

The Microcensus on Mobility and Transport provides information on the mobility behavior of the Swiss population: possession of vehicles, driving licenses and public transport subscriptions, daily traffic volume, traffic purposes and use of transport modes. The data collected provide a detailed picture of passenger transport in Switzerland. They serve as a statistical basis for the preparation and validation of policy measures, but also as input for in-depth analyses of traffic development.

On average, each Swiss resident covered a daily distance of just under 37 kilometers within Switzerland in 2015. The majority of this (65 %) was covered by passenger cars. The most common reason for using transport (accounting for 44 % of the daily distances travelled) was leisure activities, followed by work (24 %).

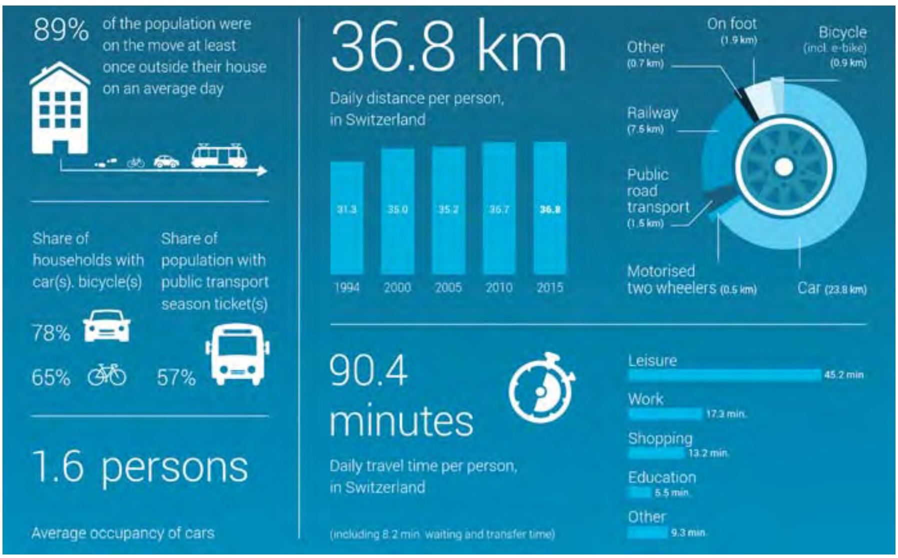


Figure 2: Swiss Population Mobility 2015 (Source: FSO, ARE)

34.1.3 Update on Swiss Regulations

CO_2 Emission Regulations

Since 2012, CO_2 emission regulations for new passenger cars have been in force in Switzerland in the same way as in the EU: by 2015, the average emissions of passenger cars registered for the first time on the roads should have been reduced to 130 grams of CO_2 per kilometer. At 134 grams of CO_2 per kilometer, this target was also slightly exceeded in 2016.

In the next stage, Switzerland, like the EU, will gradually reduce the CO_2 target for new passenger cars to 95 grams per kilometer from 2020 and introduce new targets for delivery vans and light articulated lorries (147 grams CO_2 per kilometer). In Switzerland, these values are to be reached in full by the end of 2023. Until the end of 2022, vehicles with a maximum of 50 grams of CO_2 per kilometer are subject to so-called supercredits, i.e. they are credited several times, and a small part of the fleet is still exempt from meeting the target (phasing-in). The relevant laws and regulations came into force on January 1, 2018.

News on the Energy Label for Passenger Cars

The new energy label classifications for passenger cars have been in force since January 1, 2018. In addition, the following points are new:

The average CO_2 emissions of all passenger cars registered for the first time in 2018 will now be 133 grams per kilometer instead of 134 grams as in 2017 – New is the energy label for cars driving on hydrogen, such as fuel cell vehicles. For the calculation of the gasoline equivalent, the CO_2 emissions from the pre-processes and the primary energy gasoline equivalents, the production path of the mix, which can be obtained at the two hydrogen filling stations open to the public in 2017, is used.

Revised National Road Regulation

The approximately one hundred rest areas (with WC and partly a snack bar) along the national roads are under the sovereignty of the federal government. Under previous law it was not possible to set up quick charging stations here. With the entry into force of the revised National Roads Ordinance on January 1, 2018, the Federal Roads Office is now obliged to create the technical conditions to enable the construction and operation of plants for the supply of alternative means of propulsion.

In order for the charging station network along the national roads to be completed quickly, it is important to provide a power supply with the necessary connections. The federal government supports this because - unlike the rest areas - there are no shops or restaurants with which the business model could be combined. The revised Federal Ordinance does not result in any changes for service areas under the sovereignty of the cantons. Quick charging stations are still possible.

New Energy Law Allows Private Energy Consumption Groups

On January 1, 2018, the “regulations for associations for own consumption” of electricity produced in-house came into force with the totally revised Energy Act.

The regulations create legal certainty and should encourage the formation of self-consumption communities. This is of interest to electric car owners, among others, who want to operate their vehicles with solar power they produce themselves.

34.1.4 SCCER Study

The SCCER Study[73] "Towards an Energy Efficient and Climate Compatible Future Swiss Transportation System" analyzes the status and structure of the Swiss transport system and sketches possible paths for its evolution towards an energy efficient, climate compatible and environmentally friendly mobility future. The report was motivated by the need to provide strategic directions, primarily to the research carried out within the Swiss Competence Center for Energy Research - Efficient Technologies and Systems for Mobility (SCCER Mobility). Moreover, it aims to communicate insights from engineering/natural as well as social/economic sciences to policy makers, opinion leaders and the interested public in general. It serves as a platform for reflection and synthesis of views from a variety of disciplines.

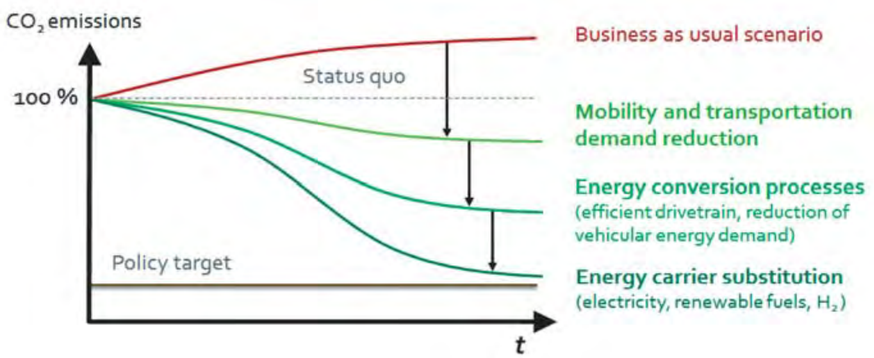


Figure 3: A systemic approach towards minimization of CO_2 emissions from transport must use synergetic efforts on both the demand and supply side (Source: SCCER)

In accordance with the Swiss Energy Strategy 2050 and recognizing the importance of the overarching goal of climate change mitigation, we focus on energy demand and in particular on CO_2 emissions as a proxy for the overall sustainability of future mobility. The core of our analysis concentrates on road transport, as it is the dominant contributor to both energy demand and CO_2 emissions of the Swiss transport sector. We focus on motorized individual transport, which accounts for about two-thirds of CO_2 emissions stemming from transportation, and in selected cases, we comment on the development of the even

[73] http://sccer-mobility.ch/export/sites/sccer-mobility/capacity-areas/dwn_capacity_areas/TowardsAnEnergyEfficientSwissTransportationSystem_Ver1.2.pdf

faster growing freight transportation sector as well. However, the report does not closely consider international aviation – despite its growing worldwide importance – since corresponding policy is a matter of international cooperation. Closer consideration of this mode will be important in the future.

34.1.5 Market Trends 2017 on Energy Efficient Vehicles by Swiss Energy

The edition 2017 of Market Trends on energy efficient vehicles by swiss energy, an initiative of the Swiss Federal Office of Energy SFOE, has been elaborated again by e'mobile, a division of Electrosuisse specialized on efficient mobility[74]. This yearly publication focusses on category "A" energy efficient cars that emit a maximum of 95 grams of CO_2 per kilometer. CO_2 emission regulations for new cars and light commercial vehicles: like the EU, Switzerland introduced CO_2 emission regulations for new cars in July 2012. The average level of emissions from cars registered in Switzerland for the first time may not exceed 130 grams of CO_2 per kilometer. This level is applicable until the end of 2019. With effect from 2020, a target level of 95 grams of CO_2 per kilometer will apply for cars.

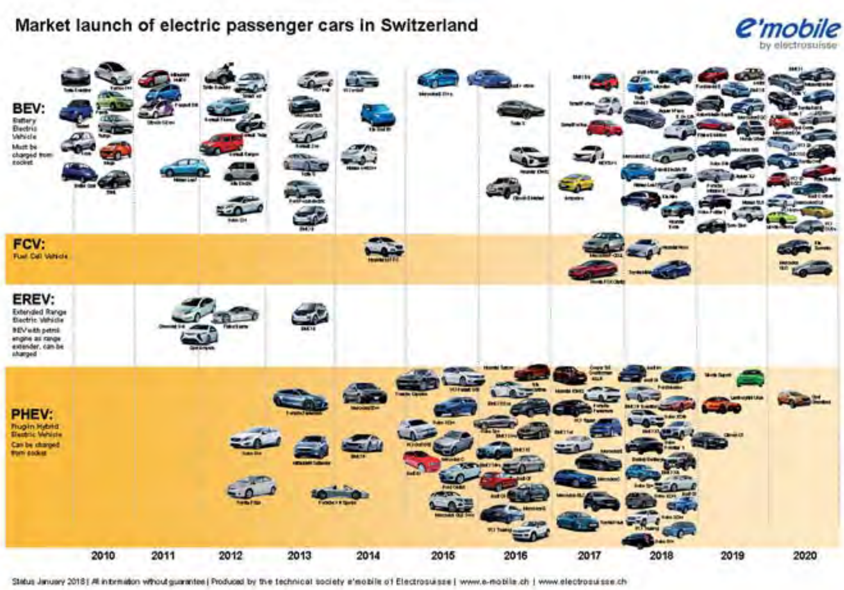


Figure 4: Market launch of electric passenger cars in Switzerland as of January 2018. (Source: e-mobile.ch)

74 https://e-mobile.ch/media/76/download

In the editorial of this yearly publication, Benoît Revaz, Director of the Swiss Federal Office of Energy (SFOE) emphasizes on the most important trends in the field of the efficient mobility: Electrification of the drive train - new forms of shared mobility - autonomous driving cars - potential of data and information in the always connected vehicles.

34.1.6 Electric Mobility Guideline for Communes by Swiss Energy

Road traffic in Switzerland is today almost completely dependent from fossil energy sources and responsible for over a quarter of the Swiss energy consumption. The Swiss "Energy Strategy 2050" aims, among other things, to increase energy efficiency and through that reduce the total energy consumption while at the same time reducing emissions of CO_2 and generally speaking air pollution.

Electric mobility is one way of achieving these goals, as electric motors are highly efficient compared to internal combustion engines. When using renewable energies, it can help to reduce dependence on fossil fuels and local emissions of air pollutants, greenhouse gases and noise. Electric mobility does indeed lead to an increased demand for electricity. However, thanks to its electricity mix with a high proportion of renewable energy sources, the conditions for meeting this demand on a sustainable basis are favorable in Switzerland.

In addition to the federal government and cantons, cities and municipalities can also make the transition from fossil fuel based road traffic towards energy-efficient and climate-friendly road traffic. They thus make a contribution to achieving Switzerland's ambitious energy and climate policy goals.

This guide shows cities and municipalities what they can do in the field of electric mobility. This includes proposals for measures, practical examples and information on further information and contact points. The guide is aimed at decision-makers in cities and municipalities and internal administrative experts in the fields of energy, transport, environment, construction and spatial planning[75].

34.1.7 New Head at e'mobile by Electrosuisse

One of the leading organizations in Switzerland pushing the electric mobility is e'mobile by Electrosuisse, a neutral specialist unit for efficient mobility. e'mobile has been strongly committed to the market launch of low-consumption and low-emission vehicles (road shows in the communities with car-explainers and cross-

[75] https://www.energieschweiz.ch/page/de-ch/Elektromobilitaet---Ein-neuer-Leitfaden-fuer-Staedte-und-Gemeinden

brand test drives, joint stand with partners from the industry at the Geneva International Motor Show) for decades with a wide range of measures in cooperation with the industry. Claudio Pfister, new head at e'mobile by electrosuisse, has taken over his responsibilities as of April 1, 2017.

34.2 HEVs, PHEVs and EVs on the Road

In 2017, a total of 412,827 new road vehicles were registered in Switzerland. This is 0.5 % less than in 2015. The total stock has increased to over 6 million vehicles (+1.2 %), 76 % of which were passenger cars. 4,985 new BEVs and EREVs were registered which is almost 40 % more than in the previous year and a market share of 1.6 % of passenger cars. This compares to 11,812 new gasoline-electric and diesel-electric HEVs and PHEVs (+24.2 %). However, with a market share of 3.8 % they are still a long way from the mass market.

The best sold BEV, as in the years before, is Tesla Model S (1,128), followed by Tesla Model X (824), Renault ZOE (741), BMW i3 (699) and Opel Ampera-e (397).

Only 1,001 e-scooters and motorcycles including three and four wheeled vehicles were sold in 2017, which is again less (-28 %) than in the year before. The best-selling e-model was once again the three wheeled Kyburz DXP (253 vehicles, -51 %) with Swiss Post being its major customer. Second best selling was Vengo V100 with 83 vehicles (-58 %).

34.3 Charging Infrastructure or EVSE

By the end of 2017, about 2,000 public charging locations with a total of over 5,000 charging points were registered in the Swiss national database. There were over 1,500 Type 1 and Type 2 AC-locations with 1 to 3 EVSEs each and 436 fast charging points (CHAdeMO, CSS, Tesla Superchargers).

The Swiss charging infrastructure is still built and operated almost exclusively by the private sector.

Three major developments have been observed in 2017:

- **MOVE**: The MOVE charging networks is one of the biggest players in Switzerland. Their new MOVE network gives access to 620 stations throughout Switzerland and is compatible to 1,600 further stations in Switzerland and 20,000 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**: Green Motion is further expanding the ”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 counts 791 and Green Motion plans to increase this number to over 3,000 stations by the end of 2020.
- **GOFAST** opened its first high performance charging station (150 kW / 1,000 V) in alliance with Energy 360° that allows charging all electric vehicles capable for fast charging, through the special DC-Type-2-Plug even for Teslas. GOFAST is a founding member of the European Open Fast Charging Alliance that owns and operates more than 500 fast chargers in six countries.
- **Plug’n’Roll**, the charging network of RePower and its partners focusses not only on the public charging infrastructure, but also on companies and private locations to combine them all into a performing charging network counting over 1,000 locations throughout Europe today.

Table 1: Information on charging infrastructure in 2017 in Switzerland

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers	334
AC Level 2 Chargers	1,180
Fast Chargers	162
Superchargers	13
Inductive Charging	n.a.
Totals	**1,689**

34.4 EV Demonstration Projects

34.4.1 Race for Water Catamaran

The Swiss catamaran, which will circumnavigate the earth for the second time between 2017 and 2021 using only renewable energies (solar energy, wind, hydrogen) in order to draw attention to the pollution of the oceans and to demonstrate as a floating laboratory that innovative technological developments can protect the oceans.

34.4.2 E-Dumper

At the beginning of 2018 the E-Dumper has left the factory to head for its defined operation. The Swiss industry develops locomotives, aerial cableways, trolley buses, construction machines, agricultural and military vehicles, as well as electric vehicles and aircraft. The research, development and marketing of heavy electrical transport and construction machines should be added to this tradition. A fully laden Komatsu e-Dumper from Kuhn Schweiz AG (total weight 111 tons) transports 60 tons of lime and marl from the high-elevation extraction area to the permanently installed transport system. Energy recovered on the downhill (laden) run is stored in batteries, provided by Lithium Storage GmbH, and is used to power the uphill run, and the surplus is fed into the electricity grid. With a history of constructing electric goods vehicles, Kuhn Schweiz AG is defining a new goal: the development, construction and marketing of electrified 100-tonne+ construction machines[76].

Figure 5: Race for Water Catamaran (Source: raceforwater.org)

Figure 6: E-Dumper in action (Source: edumper.ch)

[76] http://odyssey.raceforwater.org

Lithium Storage GmbH and Kuhn Schweiz Ltd built the world's largest battery-powered tipper truck, based on the Komatsu 605-7. 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.

30.4.3 SBB Green Class

After the successful testing of 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, SBB has decided to extend the pilot to an offering for the public with different options. The participants od the pilot got 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 monitored 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[77].

Figure 7: SBB Green Class advertisement picture (Source: sbb.ch)

[77] https://www.sbb.ch/en/travelcards-and-tickets/railpasses/greenclass.html

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2017 (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 30 September 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	n.a.	n.a.	n.a.	n.a.	712,734
Passenger Vehicles[2]	14,539	n.a.	n.a.	n.a.	4,570,823
Buses and Minibuses[3]	n.a.	n.a.	n.a.	n.a.	73,814
Light commercial vehicles[4]	n.a.	n.a.	n.a.	n.a.	363,131
Medium and Heavy Weight Trucks[5]	n.a.	n.a.	n.a.	n.a.	53,370
Totals without bicycles	**14,539**	**n.a.**	**n.a.**	**n.a.**	**5,790,287**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	n.a.	n.a.	n.a.	n.a.	45,894
Passenger Vehicles[2]	4,773	3,402	8,410	2	315,032
Buses and Minibuses[3]	n.a.	n.a.	n.a.	n.a.	5,607
Light commercial vehicles[4]	n.a.	n.a.	n.a.	n.a.	32,794
Medium and Heavy Weight Trucks[5]	n.a.	n.a.	n.a.	n.a.	4,705
Totals without bicycles	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**405,514**

n.a. = not available

[1] UNECE categories L1-L5

[2] UNECE categories M1

[3] UNECE categories M2-M3

[4] UNECE categories N1

[5] UNECE categories N2-N3

[6] Including non-electric vehicles

Table 3: Available vehicles and prices

Market-Price Comparison of Selected EVs and PHEVs in Switzerland	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in EUR)**
Audi A3 e-tron PHEV	39,400
BMW i3 (18.8kWh) BEV	33,500
BMW i3 REX	39,400
Citroën C0 (14.5kWh) BEV	20,500
Hyundai Nexo FCV	60,800
Hyundai Ioniq (28kWh) BEV	33,600
Hyundai Kona (64kWh) BEV	32,600
Jaguar I-Pace (90kWh) BEV	75,300
Kia Soul (27kWh) BEV	33,500
Mercedes B 250 e (28kWh) BEV	33,500
Micro Microlino (8kWh) BEV	12,000
Mitsubishi i-MiEV (16kWh) BEV	20,000
Mitsubishi Outlander PHEV	36,300
Nissan Leaf (40kWh) BEV	32,500
Nissan e-NV200 Evalia (40kWh) BEV	40,000
Opel Ampera-e (60kWh) BEV	47,900
Peugeot iOn (14.5kWh) BEV	20,500
Renault Twizy (6.1kWh) BEV	10,500
Renault Zoe (41kWh) BEV	32,000
Renault Kangoo Z.E. (33kWh) BEV	25,200
Renault Master Z.E, (33kWh) BEV	53,600
Smart Fortwo EQ (17.6kWh) BEV	21,700
Smart Fortfour EQ (17.6kWh) BEV	22,600
Tesla Model S (75kWh) BEV	72,900
Tesla Model X (75kWh) BEV	77,800
Toyota Mirai FCV	81,700
Volvo V60 PHEV	65,500
Volvo XC90 PHEV	84,800
VW e-up! (18.7kWh) BEV	27,200
VW e-Golf (35.8kWh) BEV	36,100
VW Golf GTE PHEV	42,800

35 Turkey

35.1 Major Developments in 2017

Turkey made national electric vehicles a priority in the past years and a consortium composed of five major corporations (Anadolu Group, BMC, Kıraça Holding, Turkcell and Zorlu Holding) supported by the government was established in November 2017 in order to develop Turkey's first locally produced national electric vehicle brand. The consortium has made a 15 year investment plan and targeted to have a running prototype by 2019 and start serial production in 2022. The vehicle is anticipated to have five electric models on a single modular platform and is planned to be exported as well as being sold in Turkey.

Furthermore, on the electric bus side; development, production and sales have been increasing in the past years. Turkish bus manufacturers introduced their fully electric vehicles during exhibitions in 2017. Karsan introduced its electrically drive midi-bus Jest Electric in Busworld Kortrijk. In addition, Bozankaya, Temsa, Otokar and Anadolu Isuzu have all showcased their electric buses, with ranges varying from 70 to 250+ kms. Bozankaya, a leader in the development of electric buses, has been sold more than 250 electric buses in the country with the main focus being İzmir metropolitan municipality. The company also agreed to deliver its Sileo brand all electric buses, with patented BMS system, to the several municipalities across Turkey in early 2018.

Moreover, The Electric Taxi Project was officially initiated in Istanbul, primarily using Renault "Zoe" EV vehicles, led by ITEO (Istanbul Chamber of Taxi Drivers) and funded by a private financial institution. Within this scope, charging stations were located at central car parks, taxi stands and shopping malls. Turkcell (country's largest mobile service operator) provided data service for the vehicles whereas the information technology services were provided by Ceiia.

Figure 1: The Electric Bus fleet developed by Bozankaya delivered to Izmir Metropolitan Municipality (Source: Izmir Metropolitan Municipality)

Figure 2: The Electric Taxi Project demonstrated by ITEO, Greenway and Renault in Istanbul (Source: ITEO)

On the R&D side, The Scientific and Technological Research Council of Turkey – Marmara Research Center (TÜBITAK MRC), within the Automotive Excellence Center, have also accelerated its research on vehicle and component level for electric and hybrid vehicle development, prototype building and testing in 2017. Various working prototypes have been developed regarding EV sub-components (electric motor, battery module/pack, battery management system, inverter and electronic control units) in the scope of different projects to be used in a wide range of vehicle applications. In addition, AVL Turkey, established its 2nd R&D

center in the country in order to conduct further research on autonomous and hybrid vehicle technologies.

On the university side, the 12th Efficiency Challenge Electric Vehicle competition on electro-mobile and hydro-mobile categories was held in Turkey in mid-2017. The competition was aimed to increase environmental awareness of university students and facilitate the development of new corresponding technologies and organized by TUBITAK. Çukurova University electro-mobility team won the electro-mobility competition by consuming 934 kW energy in 30 laps.

Figure 3: 12th Efficiency Challenge Electric Vehicle competition and Çukurova University Electromobility Team (Source: TUBITAK)

35.1.1 New policies, legislation, incentives, funding, research, taxation, etc.

Turkey has been using various legal and policy instruments to support electrification of transportation to encourage the use of hybrids and EVs. The taxation regulation, declared in late 2016, classify the special consumption tax (SCT) of conventional vehicles and hybrid vehicles based on engine cylinder volume; untaxed vehicle price and electric motor power. Also apparent tax advantage is valid for full EV vehicles.

The effects of SCT regulation on the sales of low engine volume conventional vehicle and hybrid vehicle (engine volume lower than 1,800 cc and electric motor power >50 kW) were apparent in 2017 sales and shown in Table 2. Thus, Table 1 and Table 2 show the vehicle sales SCT (special consumption tax) categories for initial new passenger vehicles, motorbikes and electric/hybrid vehicles.

35.2 HEVs, PHEVs and EVs on the Road

35.2.1 Fleet

In Turkey, the total number of road motor vehicles in traffic increased by 1,128,521 in 2017 compared to the previous year and number of vehicles registered on traffic exceeded 22 million. The number of electric and hybrid vehicles on the road has also increased with the introduction of new models in the country. The total number of hybrid & electric vehicle sales in Turkey passed over 4,500 units at the end of 2017. Despite the increase of sales, H&EVs still incorporate a negligible fraction of the total vehicle sales. Most common engine size was 1,501-1,600 cc among cars (40.8 %) registered in 2017. Among all vehicles sold, passenger cars dominated the fleet with a 54.1 % of total fleet, followed by small trucks 16.4 %. By the end of year 2017, the average age of the total registered road motor vehicles became 13.1. Table 3 shows the total vehicle fleet with respect to vehicle types from 2013 to 2017. The HEV & EV new sales collected by the Automotive Distributors Association (ODD) are shown in Table 4.

Table 1: Special consumption tax classification categories for new conventional and electric only vehicles in 2017 (Data source: Official Gazette of the Republic of Turkey)

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 (7,540 EUR)	45	<85	3
		40,000-70,000 (7,540-13,195 EUR)	50	85-120	7
		>70,000 (13,195 EUR)	60	≥120	15
	1,600-2,000	<100,000 (18,853 EUR)	100		
		>100,000 (18,853 EUR)	110		
	>2,000		160		
Motorbikes	<250		8	<20	3
	>250		37	>20	37
*Currency: Turkish Lira (₺); 7 June 2018 TCMB exchange rate: 1 €=5,3 ₺ ;					

Table 2: Special consumption tax classification categories for new hybrid vehicles in 2017

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 (9,434 EUR)	45
			50,000-80,000 (9,434-15,095 EUR)	50
			>80,000 (15,095 EUR)	60
	1,801≤2,000			110
	2,001 ≤2,500	≤ 100 kW		160
		> 100 kW	<100,000 (18,853 EUR)	100
			>100,000 (18,853 EUR)	110
	>2,500 cc			160
*Currency: Turkish Lira (₺); 7 June 2018 TCMB exchange rate: 1 €=5,3 ₺				

Table 3: Total vehicle fleet according to the vehicle types between 2013 and 2017 (Data source: TURKSTAT Road Motor Vehicle Statistics, December 2017)

Fleet Totals on 31 December 2017					
Vehicle Type	**2013**	**2014**	**2015**	**2016**	**2017**
Passenger car	9,283,923	9,857,915	10,589,337	11,317,998	12,035,978
Minibus	421,848	427,264	449,213	463,933	478,618
Bus	219,885	211,200	217,056	220,361	221,885
Light commercial vehicle	2,933,050	3,062,479	3,255,299	3,442,483	3,642,625
Truck	755,950	773,728	804,319	825,334	838,718
Motorcycle	2,722,826	2,828,466	2,938,364	3,003,733	3,102,800
Special purpose vehicle	3,6148	40,731	45,732	50,818	60,099
Tractor	1,565,817	1,626,938	1,695,152	1,765,764	1,838,222
Totals	**17,939,447**	**18,828,721**	**19,994,472**	**21,090,424**	**22,218,945**

35.2.2 Sales

Passenger car sales in 2017 decreased by 34,860 units compared to the previous year. When the passenger car market was evaluated according to the engine volumes, the passenger cars below 1,600 cc received the highest share of sales with 96.10 % (694,464 units). In 2017, there were 76 EV passenger cars sold in Turkey compared to 44 units the year before. On the hybrid passenger cars, 4,507 units were sold in 2017 where Toyota C-HR, a locally produced vehicle, led this segment.

Table 4: Passenger car market according to the engine/electric motor size between 2016 and 2017 (Data source: ODD Press Summary, December 2017)

Total Sales during 2017					
Engine Size	**Engine Type**	**2016 (end of Dec)**	**2017 (end of Dec)**	**SCT Tax Rates**	**VAT Tax Rates (%)**
≤1,600 cc	Gas/ diesel	729,324	694,464	45 – 60*	18
>1,600 cc ≤2,000 cc	Gas/ diesel	22,493	21,568	100 -110	18
>2,000 cc	Gas/ diesel	4,039	2144	160	18
≤85 kW	Electric	23	55	3	18
>85 kW ≤120 kW	Electric	0	0	7	18
>120 kW	Electric	21	21	15	18
≤1,600 cc	Hybrid	886	464	60	18
>1,600 cc ≤1,800 cc (≤ 50 kW)	Hybrid	0		110	18
>1,601 cc ≤1,800 cc (> 50 kW)	Hybrid	28	3704	45 - 60	18
>1,801 cc ≤2,000 cc	Hybrid	89	63	110	18
>2,000 cc ≤2,500 cc (≤ 100 kW)	Hybrid	0	0	160	18
>2,000 cc ≤2,500 cc (> 100 kW)	Hybrid	0	266	100 -110	18
>2,500 cc	Hybrid	35	10	160	18
Totals		**756,938**	**722,759**	**Tax Rates**	

* SCT tax rates differs between 45% and 60% based on regulation as previously shown in Table 2. New SCT taxation takes account of engine volume, electric motor power and pre-taxed price.

Furthermore, the breakdown of the vehicle sales with respect to various powertrains is shown in Figure 4.

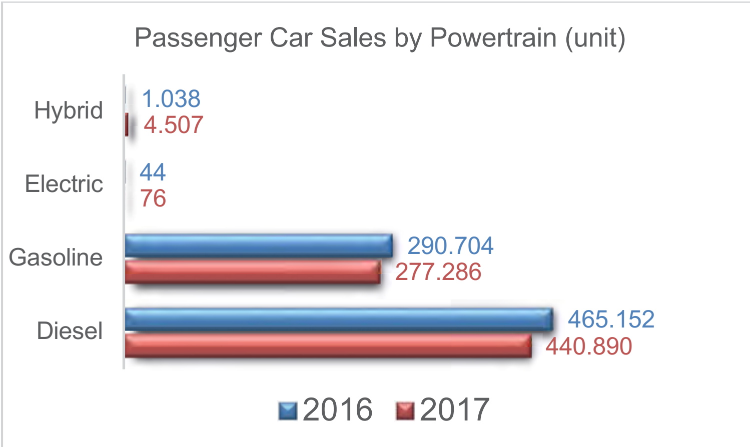


Figure 4: Passenger car sales by powertrain type (Data source: ODD Press)

When the passenger car market is examined according to average emission values in 2017, a significant increase on the passenger car sales with emission values between 140 g/km and 160 g/km is observed. Passenger cars with the emission values between 120 g/km and 140 g/km led the sales with 42.6 %. Moreover, Table 5 shows the passenger cars under 140 g/km CO_2 emissions accounted for more than 81 % of vehicle sales.

Table 5: Passenger car market according to average emission values in 2017 (Data source: ODD Press Summary, December 2017)

Passenger Car Sales during 2017 by Average Emission Values					
Average Emission Values of CO_2 (g/km)	2016 (end of Dec)		2017 (end of Dec)		2017 / 2016
	Units	%	Units	%	%
<100 g/km	106,718	14.10	111,495	15.4	4.5
≥100 to <120 g/km	337,226	44.55	307,659	42.6	-8.8
≥120 to <140 g/km	186,582	24.65	167,311	23.1	-10.3
≥140 to <160 g/km	101,782	13.45	111,376	16.0	13.4
≥160 g/km	24,630	3.25	20,918	2.9	-15.1
Total	**756,938**	**100.00**	**722,759**	**100.00**	**-4.5**

35.3 Charging Infrastructure or EVSE

According to Republic of Turkey Energy Market Regulatory (EPDK) announcement, 400+ charging stations for electric vehicles are active in the country. The number of private companies on EVSE installation and charging infrastructure has slightly increased in 2017. In addition, gas station companies such as Alpet, Aytemiz have also joined the competition in collaboration with the main charging infrastructure providers by establishing fast charging stations nearby their gas stations.

Installation efforts are mostly concentrated in shopping centers, hotels, restaurants, public buildings and auto-dealers in metropolitan municipalities. Esarj, currently the largest charging infrastructure provider, increased the charging capacity to 173 stations. The rest of the charging stations are owned by EVSE providers such as BD Oto, DMA, G-Charge, Voltrun, Yesilgüç, Fullcharger, Greenway, Phoenix Contact. In terms of fast chargers, the numbers of stations built/planned are still a low fraction of the total existing stations.

Furthermore, in 2017, Gersan announced an agreement with Tesla Motors for installations of superchargers within previously announced locations in Turkey by Tesla Motors. A Map showing the charging stations by private companies throughout the country is shown in Figure 5. Some of active fast charging stations established by gas station companies are highlighted on Figure 6.

Figure 5: Map of Esarj charging stations throughout Turkey (Source: Esarj Electric Vehicle System Incorporated Company)

Figure 6: New fast charging stations implemented by gas stations in Turkey (Source: Aytemiz and Petrol Ofisi)

36 United Kingdom

36.1 Major Developments in 2017

In 2017, the UK set out a commitment[78] that: 'Our ambition is for Britain to lead the world in electric vehicle technology and use. We want almost every car and van to be zero emission by 2050'. The UK's Air Quality[79] plan restated this. We will end the sale of new conventional petrol and diesel cars and vans by 2040. Meeting the 2040 commitment should be industry-led, with Government monitoring developments closely. Against a rapidly evolving international context, we will seek to maintain ambitious targets and our leadership position, intervening firmly if not enough progress is being made.

By 2040 almost all new cars and vans will need to deliver a significant proportion of journeys with zero tailpipe emissions. This ambition is technology neutral, and the UK Government welcomes any innovative thinking that helps us to achieve this ambition. An updated strategy detailing the Government's role in the decarbonisation of road transport will be published by the end of March 2018.

To achieve this, the UK Government is investing nearly £1.5 billion (1.7 billion EUR) between April 2015 and March 2021. This investment supports one of the most comprehensive global programmes of support for ULEVs (ultra low emission vehicles), with grants available for plug in cars, vans, lorries, buses, taxis and motorcycles, and schemes to support charge point infrastructure at homes and workplaces and on residential streets.

The UK's Clean Growth Strategy[80], National Air Quality Plan and Industrial Strategy,[81] all highlight the importance of electric vehicles, which is why the Prime Minister announced in December 2017 that the UK would host a Zero Emission Vehicle Summit in Autumn 2018. The UK's high level Government summit in autumn, will bring together countries from around the world to further the development of the global low emission and electric car market. It is hoped the

---

78 https://www.conservatives.com/manifesto

79 https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

80 https://www.gov.uk/government/publications/clean-growth-strategy

81 https://www.gov.uk/government/topical-events/the-uks-industrial-strategy

Summit will inspire attendees to make new commitments to investing in zero emission vehicle technology and infrastructure, helping to meet the ambitions of the Paris Agreement.

Figure 1: Overview of UK's support package for ULEVs (Source: Gov.uk)

36.1.1 Demand Side Support for Ultra-low Emission for ULEVS

Plug-in Car Grant

There have now been over 130,000 claims made for the Plug-in Car Grant82. The scheme offers up to £4,500 (5,099 EUR) off the cost of an electric or fuel cell car and up to £2,500 (2,832 EUR) off qualifying plug-in hybrids. The categories for the grant are explained in figure 2 and the guidance on the grant criteria needed for cars to be included on the approved list can be found on the Office for Low Emission Vehicles website[83]. The grant will continue with its current levels until April 2018[84] and there will be a grant of some sort until March 2020.

[82] https://www.gov.uk/plug-in-car-van-grants

[83] https://www.gov.uk/government/publications/plug-in-car-grant/plug-in-car-grant-eligibility-guidance

[84] https://www.gov.uk/government/news/funding-for-thousands-of-electric-car-charge-points-unused-by-councils

Plug in Van Grant

The Plug-in Van Grant[85] offers 20 % off the price of qualifying vehicles up to a maximum of £8,000 (9,064 EUR). In 2016 the UK Government announced that the grant would be expanded to include N2 & N3 vehicles (i.e. vans over 3.5 t and HGVs), with up to £20,000 (22,663 EUR) available for the first 200 vehicles. The Office for Low Emission Vehicles have published guidance[86] for manufacturers wishing to have their vehicles approved and placed on the list of eligible vehicles.

GRANT CATEGORIES	1	2	3
CO2 EMSSIONS (NEDC)	<50g CO_2/km	<50g CO_2/km	50-75g CO_2/km
ZERO EMISSION RANGE	70 miles+ (>112 km)	10-69 miles (16-111 km)	20 miles+ (>32 km)
GRANT OFFERED	£4,500	£2,500	£2,500
PRICE CAP	-	£60,000	£60,000

Figure 2: UK Plug-in Car Grant categories as of February 1, 2018

Plug-in Taxi Grant

Taxis are one of the main contributors to poor air quality in urban areas which is why in the UK cities like London are bringing in policies[87] to improve their environmental performance. To support these efforts the UK Government announced the Plug-In Taxi Grant[88] (PITG). £50 million (56.6 million EUR) has been set aside to support the Plug-in Taxi Grant programme. This grant will give licensed taxi drivers up to £7,500 (8,498 EUR) off the price of a new vehicle. In addition the UK is investing £14 million (15.8 million EUR) to deliver new dedicated charging points for electric taxis in 10 council areas.

[85] https://www.gov.uk/plug-in-car-van-grants

[86] https://www.gov.uk/government/publications/plug-in-van-grant/plug-in-van-grant-vehicles-list-and-eligibility-guidance

[87] https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/cleaner-greener-taxis

[88] https://www.gov.uk/government/news/1000-jobs-created-at-new-300-million-factory-for-electric-taxis

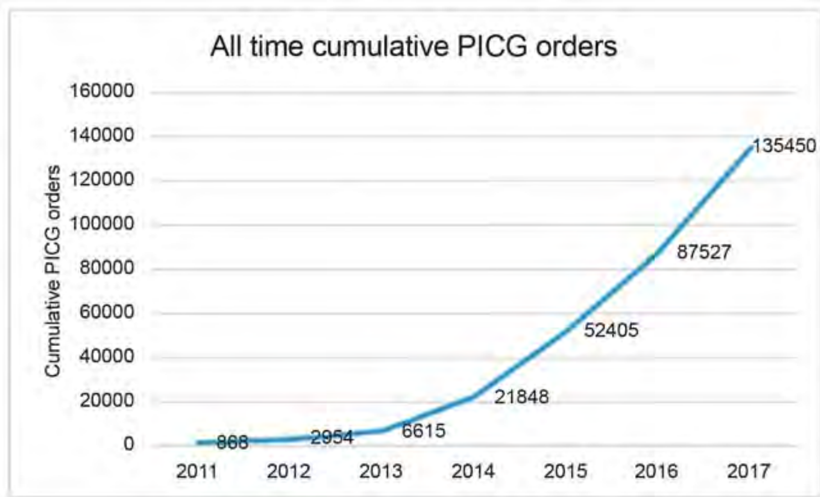


Figure 3: Uptake of the Plug in Car grant since its inception in 2011

Figure 4: London Electric Taxi (Source: emobilserver)

Low Emission Bus Scheme

In 2016, the 13 winners of the £30 million (33.9 million EUR) low emission bus scheme were announced. In total, 326 buses will be procured – including electric, hybrid, hydrogen and bio-methane buses – to their fleets, and will install more than £7 million (7.93 million EUR) worth of infrastructure. On August 28, 2017 it was announced that a further six local authorities will receive £11 million (12.46 million EUR) for low emission buses.

Plug-in Motorcycle Grant

The scheme was announced in 2016 with qualifying powered two wheelers being eligible for a grant of 20 % up to £1,500 (1,699 EUR). Currently there are over seven scooters and motorcycles eligible.

36.2 HEVs, PHEVs and EVs on the Road

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2017 (Data source: Driver and Vehicle Licensing Agency database for the UK)

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	1,105	0	0	1	1,272,028
Passenger Vehicles[2]	49,842	85,564	320,180	68	32,201,089
Buses and Minibuses[3]	305	0	6	0	164,026
Light commercial vehicles[4]	6,290	224	66	4	4,011,322
Medium and Heavy Weight Trucks5	385	0	0	1	523,336
Totals without bicycles	**57,927**	**85,788**	**320,252**	**74**	**38,171,801**

Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total[6]**
2- and 3-Wheelers[1]	402	0	0	0	116,412
Passenger Vehicles[2]	16,368	3,909	66,431	35	2,566,798
Buses and Minibuses[3]	45	0	2	0	9,049
Light commercial vehicles[4]	1,272	95	5	1	371,658
Medium and Heavy Weight Trucks[5]	12	0	0	0	51,959
Totals without bicycles	**17,697**	**38,004**	**66,438**	**36**	**2,999,464**

n.a. = not available
[1] UNECE categories L1-L5
[2] UNECE categories M1
[3] UNECE categories M2-M3
[4] UNECE categories N1
[5] UNECE categories N2-N3
[6] Including non-electric vehicles

36.3 Charging Infrastructure or EVSE

Thanks to Government leadership, a growing private sector & Local Authority engagement, the UK now has over 11,500 publically accessible charging points. This includes over 900 rapid charging points, one of the largest networks in Europe. Our grant schemes and the recently announced public-private Charging Infrastructure Investment Fund will see thousands more electric vehicle charging points installed across the UK. In addition, Highways England has commitment[89] to £15million (16.99 million EUR) to ensure there are charging points (rapid where possible) every 20 miles on 95 % of the Strategic Road Network.

Domestic Charging

The UK Government believes that the majority of electric vehicle charging will be carried out at home and overnight which is why they are supporting the Electric Vehicle Homecharge Scheme[90]. To date there have been over 90,000 installations under this and predecessor schemes and it was announced recently that the EVHS would continue at its current rate of £500 (566 EUR).

Table 2: Charging stations for EVs in the United Kingdom

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers	2,743
AC Level 2 Chargers	8,754
Fast Chargers	754 (AC) / 1,909 (DC) (Tesla 262 / Type 2 754 / Combi 691 / CHAdeMO 956)
Totals	**14,160**

36.4 EV Demonstration Projects

In 2016, the UK announced the winners of the Go Ultra Low Cities programme[91] . The four main winning cities were Bristol[92], London[93], Milton Keynes[94] and

[89] https://www.gov.uk/government/collections/road-investment-strategy#policy-documents

[90] https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles#electric-vehicle-homecharge-scheme

[91] https://www.goultralow.com/news/consumer/go-ultra-low-cities-winners-announced/

[92] https://travelwest.info/drive/electric-vehicles/go-ultra-low-west

[93] https://www.londoncouncils.gov.uk/our-key-themes/transport/roads/gulcs

[94] https://evexperiencecentre.co.uk/go-ultra-low/

Nottingham[95] in addition the governments also set aside £5 million (5.66 million EUR) of the total £40 million (45.31 million EUR) fund for specific initiatives in Dundee, Oxford, York and the North East region to finance some elements of their bids. The key deliverables for each city in the scheme are outlined in Figure 4.

Figure 5: Key deliverables from the Go Ultra Low City Scheme (Source: Go Ultra Low)

Hydrogen for transport

Following the analytical work of UKH2Mobility[96] the UK Government introduced an £11million (12.46 million EUR) Hydrogen for Transport Advancement Programme which has seen 12 hydrogen refueling stations installed and the introduction of 50 FCEVs on the UK's roads. In March we announced[97] a new £23.5 million (26.62 million EUR) fund to accelerate FCEVs and refueling stations.

Go Ultra Low Communications

The Go Ultra Low communications campaign is now into its fourth year. This jointly funded government and industry initiative aims to inform vehicle purchasers about the benefits of ULEVs and to dispel widespread myths. The Go Ultra Low industry partners are: Audi, BMW, Hyundai, Kia, Nissan, Renault, Toyota, and VW. Centered around the Go Ultra Low website[98] the campaign also includes multi-channel content including video on demand delivered via the Go

[95] http://goultralownottingham.org.uk/

[96] http://www.ukh2mobility.co.uk/

[97] https://ee.ricardo.com/htpgrants

[98] www.goultralow.com

Ultra Low YouTube channel[99] as well as paid for content in print media and on radio.

Research and Development

Alongside a £500 million (566.43 million EUR) Government investment in the joint-industry Advanced Propulsion Centre[100], the OLEV R&D programme includes support dedicated to research and development into ULEV-specific technologies, building UK capability, skills and leadership. Most OLEV R&D funding is delivered through a partnership with Innovate UK[101], a Business Energy and Industrial Strategy Department-sponsored organisation. Innovate UK's Low Carbon Vehicles Innovation Platform has three main aims: significantly reduce carbon emissions from vehicles; accelerate the introduction of low-carbon vehicle technologies; and to ensure that the UK automotive sector benefits from growing demand for ULEVs. In the last five years Innovate has supported over 300 projects through investment of over £500 million (566.43 million EUR) in collaborative research and development.

The Faraday Battery Challenge[102] (FBC) is part of the International Strategy Challenge Fund. In phase one the FBC will invest £246 million (278.71 million EUR) over the next four years to focus on collaborative research, development and scale up. This will accelerate the UK as a world leader in battery technology and provide the catalyst required for future investment of large scale production of batteries needed to sustain the UK's position in car production. The FBC will deliver a coordinated programme of competitions that will be split into three streams:

- £78 million (88.37 million EUR) for a new 'application-inspired' research programme coordinated at a national scale;
- An £88 million (99.71 million EUR) innovation programme to stimulate collaborative research and development with co-investment from the industry;
- An £80 million (90.6 million EUR) scale-up programme to allow companies of all sizes to rapidly move new battery.

[99] https://www.youtube.com/user/GoUltraLow

[100] http://www.apcuk.co.uk/

[101] https://innovateuk.blog.gov.uk/tag/electric-vehicles/

[102] https://www.gov.uk/government/collections/faraday-battery-challenge-industrial-strategy-challenge-fund

As part of the challenge, the Faraday Institution[103] was established to bring together key founding industry partners and universities with the shared aim of ensuring the UK is a global leader in battery research and technology. This includes taking advantage of the predicted £50 billion (56.66 billion EUR) market across Europe by 2025 and anchor the automotive sector to the UK.

Figure 6: Example Go Ultra Low creative content

Regulation

The Automated and Electric Vehicles Bill[104] has been laid in the UK Parliament and is proceeding through the necessary legislative steps. The Bill will give the government new powers to improve the provision of electric vehicle infrastructure. These proposals include powers to regulate technical standards of infrastructure to ensure easy compatibility with vehicles, to ensure availability of data on charging point locations and availability, and to require provision at motorway service areas and large fuel retailers.

36.5 Outlook

The way people, goods and services move is changing. The Government has a long term aim to ensure that almost all cars and vans on the road are zero emission by 2050. This shift presents significant air quality, carbon reduction and energy security benefits, and new global opportunities for UK businesses. This is why the Government will be publishing a strategy in 2018.

[103] http://www.faraday.ac.uk/

[104] https://services.parliament.uk/bills/2017-19/automatedandelectricvehicles.html

The Road to Zero strategy will set out how the Government will lay the groundwork now to ensure the UK has the right infrastructure and incentives in place and is well placed to capitalise on the opportunities.

The strategy will also set out steps we will take to clean up the existing vehicle fleet.

Priorities for the Government are to:

- have the cleanest vehicle fleet possible;
- drive up the uptake of zero emission vehicles;
- ensure we have the right infrastructure in place;
- prepare for the impact on the energy system;
- position the UK as the best place in the world to develop and manufacture these vehicles and find solutions for heavier vehicles.

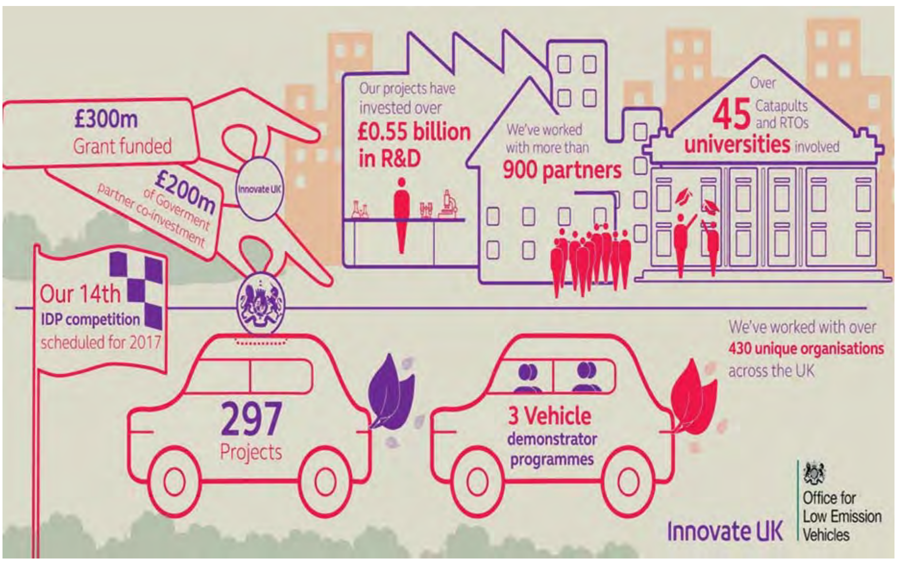


Figure 7: UK R&D Infographic (Source: Gov.uk)

37 United States

37.1 Major Developments in 2017

United States continues to rely on light-duty vehicles for personal transportation. November 2016 through November 2017 national vehicle miles traveled (latest data available) exceeded that for November 2015 through November 2016 by 1.2 %, reaching 3.20 trillion miles.[105] This presents a strong opportunity for reduced emissions and fuel use through vehicle electrification. HEV, PHEV, and full-electric or battery EV (BEV) sales all increased in 2017. There were 47 plug-in electric vehicle (PEV, including both PHEVs and BEVs) and 57 hybrid electric vehicle (HEV) models sold in the United States during 2017, reaching a total of 566,053 unit sales.[106]

Some major market developments in the U.S. EV industry in 2017 include:

- Three new electric vehicles were released: Tesla started limited deliveries of its Model 3 BEV sedan[107], Hyundai released its IONIQ lineup, which has HEV, PHEV, and BEV iterations[108], and Honda released its Clarity lineup, also with HEV, PHEV, and BEV iterations (limited markets initially).[109]
- Several manufacturers announced future electric vehicle plans[110]:
    - GM: 20 all-electric vehicles by 2023
    - Ford: 13 new electrified models by 2023
    - Toyota and Mazda are in partnership to develop basic EV technology for broad application across platforms and building a U.S. plant by 2021[111].

---

105 U.S. Department of Transportation Office of Highway Policy Information, “Travel Monitoring,” January 22,2018. Accessed February 20, 2018

106 Argonne National Laboratory, “Light Duty Electric Drive Vehicles Monthly Sales Updates. Data sourced from Hybrid Cars monthly sales dashboards.

107 Engadget, “Tesla just delivered the first round of Model 3s,” July 29, 2017. Accessed February 13, 2018.

108 Motor Trend, “2018 Hyundai Ioniq Plug-In Starts At $25,835,” December 29, 2017. Accessed February 13, 2018.

109 Forbes, “2018 Honda Clarity Plug-In Hybrid Charges In With $33,400,” November 16, 2017. Accessed February 13, 2018.

110 Mashable. “Here’s how every major automaker plans to go electric.” October 3, 2017. Accessed February 13, 2018.

- Daimler will be investing 1 billion USD in an Alabama plant to build all-electric SUVs, and investing 10 billion USD in overall EV development[112]. Mercedes Benz plans to offer 50 electrified models by 2022[113].
- Renault/Nissan/Mitsubishi plan 12 all-electric models by 2022[114].
- Jaguar/Land Rover plan to electrify the entire line-up by 2020[115].
- Volvo will be electrifying its entire line-up by 2019[116].
- Volkswagen/Audi/Porsche: 84 billion USD in EV development; electrified versions of 300 vehicles by 2030[117].

• Tesla announced the Tesla Semi, a fully electric Class 8 truck that aims to start at 150,000 USD for 300 miles of range. The company plans to produce 100,000 units of the truck per year within four years.[118] Several large companies have already placed orders: Anheuser-Busch, DHL, J.B. Hunt, Pepsi, Ryder, Sysco, Walmart, UPS, and others.[119]

• Light trucks (SUVs, minivans, and pickup trucks) continue to pull market share from the passenger cars. This trend has carried into the electrified vehicle market. Light trucks now hold 27 % of the summed HEV, PHEV, and BEV market; whereas in 2015 and before they held less than 5 %. Most of electrified light trucks sales have been HEVs.

---

[111] Fortune, Toyota and Mazda to Build $1.6Billion U.S. Plant, October 3, 2017, accessed February 22, 2018.

[112] The Wall Street Journal, Daimler to invest $1Billion in Alabama Plant, September 21, 2017, accessed February 22, 2018.

[113] Reuters, Mercedes Benz to offer electric option for every car by 2022, September 11, 2017, accessed February 22, 2018.

[114] Green Car Reports, Nissan, Mitsubishi, Renault to launch 12 new electric cars by 2022, September 15, 2017, accessed February 22, 2018.

[115] Consumer Reports, Jaguar Land Rover to Electrify Its Entire Lineup by 2020, September 8, 2017, accessed February 22, 2018.

[116] J.D.Power, Volvo Announces Its Entire Lineup to go Electric Starting in 2019, July 5, 2017, accessed February 22, 2018.

[117] Bloomberg Pursuits, VW to Build Electric Versions of All 300 Models by 2030, September 11, 2017, accessed February 22, 2018.

[118] FleetOwner, "Tesla can produce 100,000 electric Class 8 trucks a year, Musk says," February 12, 2018. Accessed February 13, 2018.

[119] Business Insider, "Tesla is now taking Semi orders in some European countries — here are all the companies buying the electric truck," January 10, 2018. Accessed February 13, 2018.

37.1.1 Continued Research and Development

Several different electric vehicle research and development (R&D) funding opportunities were released in 2017, from both federal and state sources. Selected prominent funding initiatives from 2017 are briefly summarized below:

- The U.S. Department of Energy Vehicle Technologies Office (VTO) funded a technology gap assessment of extreme fast charging (i.e., charging at a rate of 400 kW, which could provide for 200 miles of range addition in as little as 10 minutes). The technology gap assessment report explores impacts on vehicles, batteries, infrastructure, and operating costs and identifies technical barriers that must be overcome through R&D in order for extreme fast-charging to be widely adopted.[120]
- VTO announced up to 15 million USD for research projects on batteries and vehicle electrification technologies to enable extreme fast charging. Advanced battery projects will focus on early-stage research on battery cells that can enable extreme fast charging, while electrification projects will support the development and verification of electric drive systems and infrastructure for extreme fast charging (400 kW).[121]
- VTO announced 19.4 million USD for 22 new cost-shared projects to accelerate the research of advanced battery, lightweight materials, engine technologies, and energy efficient mobility systems, including 15 "Battery Seedling" Phase 1 projects for Battery500 Consortium research to more than double the specific energy (to 500 watt-hours per kilogram) of lithium battery technologies. After 18 months, promising Phase 1 awardees will be competitively awarded a Phase 2 research opportunity.
- California Energy Commission (CEC) awarded over 24 million USD in grants for clean energy freight transportation projects. The three grantees (Long Beach Harbor Department, South Coast Air Quality Management District, and Los Angeles Harbor Department) are building, deploying, and/or demonstrating battery electric trucks and charging infrastructure.[122]
- California's *Clean Vehicle Rebate Project*, which has issued rebates over 480 million USD for more than 218,000 EVs (over 2010-2017), recently

[120] U.S. DOE, "Enabling Fast Charging: A Technology Gap Assessment," October 2017. Accessed February 13, 2018.

[121] U.S. DOE, "Energy Department Announces $15 Million for Batteries and Electrification to Enable Extreme Fast Charging," October 23, 2017. Accessed February 13, 2018.

[122] CEC, "Energy Commission Awards More Than 36 Million USD for Clean Transportation," May 10, 2017. Accessed February 13, 2018.

announced that its *Rebate Now* program would allow car shoppers to apply online for pre-approval to expedite the rebate process.[123]

37.2 HEVs, PHEVs and EVs on the Road

This section provides information on the number of hybrid and electric vehicles on the road in the United States at the end of 2017, by powertrain technology. It also includes an overview of the prices of the most popular-selling hybrid and electric vehicles. Figure 1 shows the overall sales of electrified vehicles by manufacturer in 2017. Figure 2 shows the overall cumulative 2017 sales by type. It is seen that the top two market shareholders (Toyota and Ford) are primarily HEV-focused, while the 3rd and 4th largest (Tesla and Chevrolet) are PEV-focused.

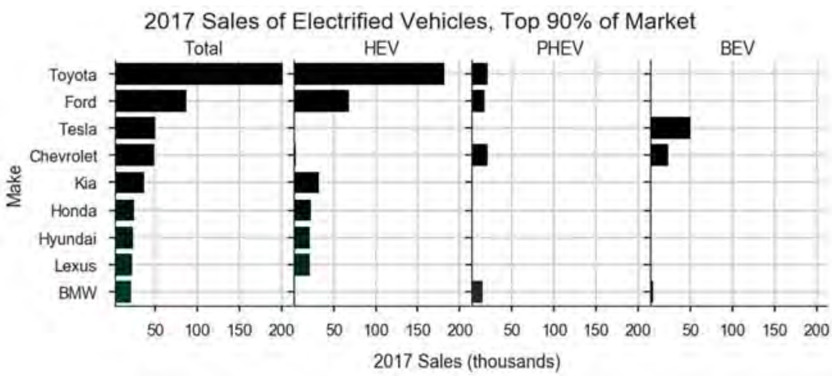


Figure 1: 2017 sales of electrified vehicles for market leaders (90 % of U.S. electrified vehicle sales; data source: Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates, which utilizes Hybrid Cars monthly sales dashboards)

[123] Center for Sustainable Energy, "Clean Vehicle Rebate Project Initiates Rebate Now In San Diego County," February 6, 2018. Accessed February 13, 2018.

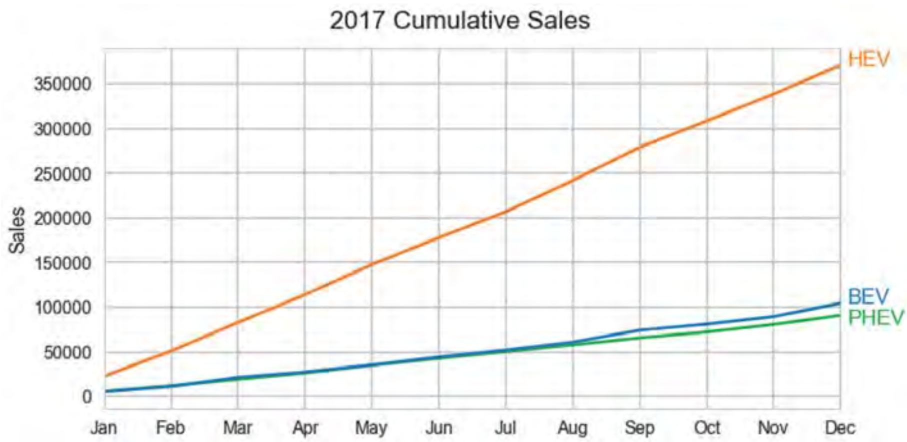


Figure 2: Cumulative sales of PEVs in 2017, not including FCEVs (Data source: Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates, which utilizes Hybrid Cars monthly sales dashboards)

The 2017 HEV sales reached 370,685 units, in a reversal of the prior sales decline (which occurred between 2013 and 2016). There were 40 different models sold across 18 manufacturers, with 23 models that accumulated annual sales over 1,000 units. The highest selling models were the Toyota Prius Liftback, Ford Fusion, and Toyota RAV4, which accounted for 47 % of the U.S. hybrid vehicle market. The Toyota Prius line-up controlled a considerably smaller share of the market (24 %) compared to its share in 2016 (38 %), possibly due to the increasing adoption of hybrid technologies across manufacturers. This shift in the market is evident in Figure, which shows annual HEV sales for the top 6 manufacturers (from those with over 2 % of the HEV market). Toyota's overall share shrank further in 2017 as newer players (e.g., Kia) and Ford offered competitive HEVs. [124] Out of the remaining 12 OEMs, four held 1-2 % of the market and eight held less than 1 % each.

[124] Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates. Data sourced from Hybrid Cars monthly sales dashboards.

Figure 3: Evolution of the U.S. HEV market over time starting in 2005. Only OEMs with over 2 % of the HEV market are shown in detail (Data source: Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates, which utilizes Hybrid Cars monthly sales dashboards)

In 2017, there were 30 PEV models sold in the United States, including 18 all-electric EV models across 13 manufacturers and 27 plug-in hybrid EV (PHEV) models across 14 manufacturers. As mentioned previously, three new PEV models were released in 2017: Honda's Clarity PHEV and BEV (announced late 2017), Hyundai's IONIQ PHEV and BEV (announced spring 2017), and Tesla's Model 3 (announced mid-2017).

Total 2017 PEV sales reached 195,368 units (non-Tesla: 145,398). A total of 25 PEV models sold over 1,000 units in 2017, including 12 BEVs and 13 PHEVs. The highest-selling 2017 models included Tesla Model S, Tesla Model X, Toyota Prius Prime, Chevrolet Volt, Chevrolet Bolt, and Nissan LEAF. Chevrolet, Tesla, Nissan, Ford, Toyota, and BMW cover 80 % of the complete 2017 U.S. PEV market. (It should be noted that monthly Tesla sales are *estimates*, since Tesla only publishes quarterly sales.) Figure shows the evolution of the U.S. PEV market over time. 2017 continued the upward trend in total annual sales and saw increased OEM diversity in the market – 21 different OEMs now offer a PEV model, compared to 17 in 2016 and 2015. The top six OEMs (among those with over 2 % of the PEV market), cover 90 % of the total historical PEV market, but held an 85 % share in 2017. Of the remaining 15 OEMs, nine held between 1-2 % of the PEV market and six held less than 1 %. Chrysler, Mini, and Volvo sold their first U.S. PEVs in 2017. Table 1 provides estimated total stock and sales numbers for the electrified fleet.

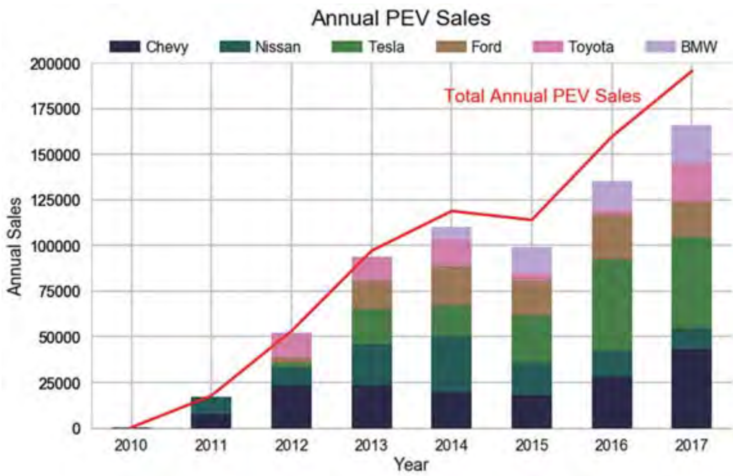


Figure 4: Evolution of the U.S. PEV market over time. Only OEMs with over 2 % of the PEV market are shown in detail (Data source: Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates, which uses HybridCars monthly sales dashboards)

A list of available vehicles and their respective prices appears in Table 2 and Table 3. It is seen that in 2017, seven of the 16 PEV models listed in table 2 (i.e., nearly half the models) sell for a price below the average of prices for all light-duty passenger vehicles (which was 36,113 USD as published by Kelly Blue Book[125]).

[125] Kelly Blue Book news release, January 3, 2018, accessed March 12, 2018.

Table 1: Distribution and sales of all-electric EVs, PHEVs and HEVs in 2017

Fleet Totals on 31 December 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total**
Passenger Vehicles[a]	350,000[126]	400,000[126]	4,430,000[126]	3,500[127]	116,740,000[126]
Light trucks[b]					125,380,000[126]
Medium and Heavy Weight Trucks[c]	n.a.	n.a.	n.a.	n.a.	11,203,000[128]
Total Sales during 2017					
Vehicle Type	**EVs**	**PHEVs**	**HEVs**	**FCVs**	**Total**
Electric Bicycles	260,000[129]	n.a.	n.a.	n.a.	n.a.
Passenger Vehicles[a]	80,505[130]	77,949[130]	253,871[130]	2,298[130]	6,873,000[128]
Light trucks[b]	23,857[130]	12,782[130]	116,794[130]	n.a.	10,296,000[128]
Medium and Heavy Weight Trucks[c]	n.a.	n.a.	n.a.	n.a.	697,000[131]
Totals without bicycles	**104,362**	**90,731**	**370,665**	**2,298**	**17,866,000**

n.a. = not available

[a] U.S. Cars

[b] U.S. Class 1-2 Trucks (<10,000 lbs. GVWR)

[c] U.S. Class 3-8 Trucks

[126] Estimates from U.S. Energy Information Administration Annual Energy Outlook 2018.

[127] Information not available; based on 2-year cumulative sales (2016-2017)

[128] Data from Oak Ridge National Laboratory Transportation Energy Data Book: Edition 36, "Quick Facts", December 2017. Note: This is 2016 data (latest available).

[129] Estimate from the Light Electric Vehicle Association.

[130] Argonne National Laboratory Light Duty Electric Drive Vehicles Monthly Sales Updates, as sourced from HybridCars.com monthly sales dashboards

[131] ORNL Transportation Energy Data Book: Edition 36, Table 5.3, December 2017. Note: This is 2016 data (latest available).

Table 2: Select available PHEVs and prices in the U.S. (Data source: manufacturer websites)

Available Passenger Vehicles	Untaxed, Unsubsidized Sale Price (in USD)
Audi A3 Sportback e-tron	39,500
BMW i3 (BMW i3 w/ Range Extender)	48,850
BMW X5 xDrive40e	63,750
BMW 330e	45,600
BMW 530e	52,650
BMW 740e xDrive	90,700
Chevy Volt	34,095
Chrysler Pacifica	39,995
Ford C-Max Energi	27,120
Ford Fusion Energi	31,120
Honda Clarity PHEV	33,400
Hyundai Sonata	32,600
Kia Optima	35,210
Mercedes C350We Plug-in Hybrid	47,900
Porsche Cayenne S E-Hybrid	79,900
Toyota Prius Prime	27,100
Average light-duty passenger vehicle price in 2017[132]	**36,113**
BMW i3 (BMW i3 w/ Range Extender)	44,450
Chevy Bolt	37,495
Fiat 500e	32,995
Ford Focus	29,120
Hyundai Ioniq Electric	29,500
Kia Soul	33,950
Nissan Leaf	30,875
Smart Fortwo Electric Drive	24,250
Tesla Model S 75D AWD (standard)	74,500
Tesla Model X 75D AWD (standard)	79,500
Tesla Model 3	35,000

[132] Kelly Blue Book news release, January 3, 2018, accessed March 12, 2018.

37.3 Electric Vehicle Charging Infrastructure

In 2017, EV charging infrastructure availability in the United States grew considerably. The number of available (public) stations grew by 25 %, including those for Level 2 and DC Fast Charging station count increases of 13 % and 9 % respectively, while Level 1 charging availability decreased about 13 % (a possible explanation for the drop could be the increased availability of Level 2 and Fast-chargers, which reduce the charging time substantially). The average number of plugs at each station increased considerably for Level 2 chargers (42 %) and was nearly constant for Level 1 and DC Fast Charge installations compared to 2016.

Table 3 provides an overview of the number of public charging stations in the United States by type including Levels 1 and 2, Fast Chargers, and Tesla Superchargers, while Figure 5 and Figure 6 show the state-level distribution of charging stations in the U.S. California leads the other states by an order of magnitude with over 23 % of the total stations and 30 % of the total available plugs. This information is all continuously collected by the U.S. DOE's Alternative Fuels Data Center (AFDC), and placed on their website.[133]

Table 3: Information on charging infrastructure in 2017; excluding non-public charging stations. Numbers represent the total installed stations, while those in parentheses indicate the total number of available plugs (Data source: U.S. DOE AFDC, accessed February 13, 2018)

Number of Charging Stations			
Chargers	**2016**	**2017**	**Change**
AC Level 1 Chargers	1,515 (2,983)	1,300 (2,604)	-14% (-13%)
AC Level 2 Chargers	13,841 (23,996)	15,639 (38,264)	+13% (+59%)
Fast Chargers	2,039 (5,527)	2,232 (6,267)	+10% (+13%)
Superchargers (incl. in Fast Chargers)	357 (2,452)	394 (2,831)	+10% (+16%)
Totals	**13,730 (30,245)**	**17,219 (47,135)**	**25% (56%)**

[133] U.S. DOE Alternative Fuels Data Center. Accessed February 13, 2018.

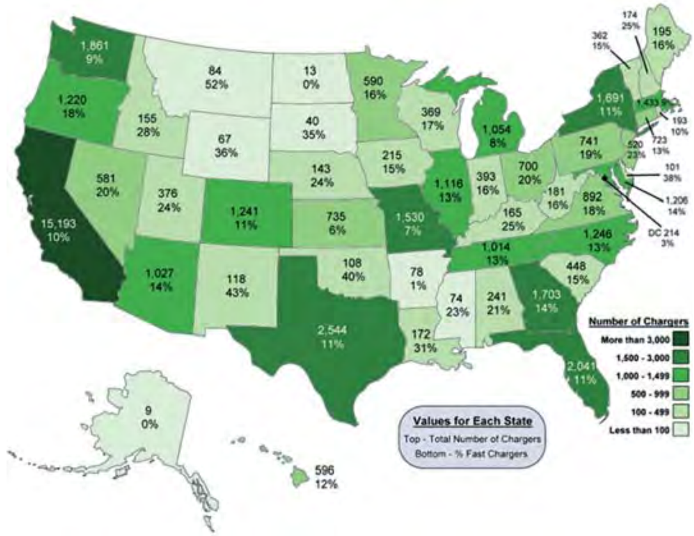


Figure 5: Level 2 and DC fast charge electric vehicle charging stations in the United States (Source: U.S. DOE)

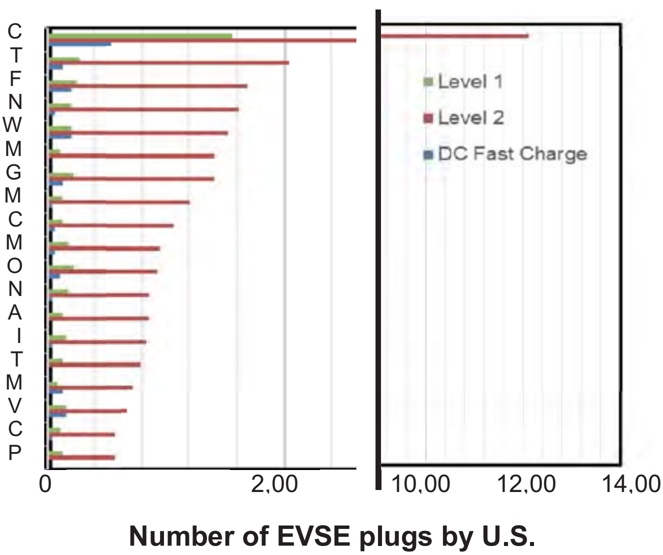


Figure 6: Number of EVSE plugs per U.S. State for 20 States with the most chargers, grouped by charging level (Data source: U.S. DOE AFDC, accessed February 13, 2018)

Due to the terms of their settlement with U.S. and California governments, Volkswagen will be spending a total of 2 billion USD over the next 10 years to install additional EV infrastructure across the U.S. The company created a subsidiary called *Electrify America* to facilitate station siting and installation and started the station rollout with 50 dual-standard DC fast chargers (50 kW) in 10 major metro markets. In December 2017, they announced plans to install 2,800 charging stations in 17 of the largest U.S. cities by 2019.[134]

In 2017, the U.S. DOE published its *Public PEV Charging Infrastructure Guiding Principles*[135] document. This was the collaboration among the PEV community to guide DOE VTO's research efforts and to support stakeholder decisions regarding PEV infrastructure deployment.

37.4 Outlook

Global sales of light, medium, and heavy duty PEVs are estimated to continue growing, according to revised forecasts from Bloomberg New Energy Finance (BNEF).[136] BNEF suggests that electric vehicles will reach cost parity with gasoline vehicles by 2025 due to the quickening pace of lithium ion battery cost reduction. OPEC and several oil producers, including Exxon, BP, and Statoil, also drastically increased their EV market penetration forecasts mid-year.[137] As noted earlier in this section, there is a broad industry consensus to increase electrification in the passenger vehicle market over the next 10 years.

Electrification also appears to be an integral feature of self-driving cars according to Ford (testing on the Fusion Hybrid), GM (testing on the Bolt EV), Uber (testing on Volvo's XC90 PHEV), Waymo (testing on Chrysler's Pacifica PHEV), and others. If this technology achieves the performance and cost claimed by its advocates and continues to use EVs, the share of electrified vehicle miles traveled could increase dramatically.

[134] Reuters, "Volkswagen to install 2,800 U.S. electric vehicle charging stations," December 18, 2017. Accessed February 13, 2018.

[135] U.S. DOE, "Public Plug-In Electric Vehicle Infrastructure Guiding Principles," January 2017. Accessed February 13, 2018.

[136] Bloomberg, "The Electric Car Revolution is Accelerating," July 6, 2017. Accessed February 14, 2018.

[137] https://www.bloomberg.com/news/articles/2017-07-14/big-oil-just-woke-up-to-the-threat-of-rising-electric-car-demand, July 14, 2017. Accessed February 22, 2018.

38 Non-Member Countries

38.1 China

38.1.1 Major Developments in 2017

In recent years, the scale of China's new energy vehicle (NEV) industry has been extending. The NEV production and sales volume reached 794,000 units and 777,000 units respectively in 2017. The NEV production volume accounted for 2.7 % of the total automotive production volume, ranking 1st in three consecutively years globally.

For new energy passenger cars, the production and sales volume of battery electric passenger cars was 478,000 units and 468,000 units, rising by 81.7 % and 82.1 % year by year; the production and sales volume of plug-in hybrid electric passenger cars was 114,000 units and 111,000 units, rising by 40.3 % and 39.4 % year by year.

For new energy commercial vehicles, the production and sales volume of battery electric commercial vehicles was 202,000 units and 198,000 units, rising by 17.4 % and 16.3 % year by year; the production and sales volume of plug-in hybrid electric commercial vehicles was the same of 14,000 units, decreasing by 24.9 % and 26.6 %.

38.1.1 New policies, legislation, incentives, funding, research, taxation, etc.

In April 2017, the National Development and Reform Commission, the Ministry of Industry and Information Technology, and the Ministry of Science and Technology issued a "Medium and Long Term Development Plan of Automotive Industry". It put forward the goals of NEV production and sales volume: by 2020, NEV annual production and sales volume reaching 2 million units, and by 2025, NEV production and sales volume accounting for more than 20 % of total automotive production and sales volume."

Purchase Subsidy

Currently, purchase subsidy is the main incentive for private customers. There are central subsidy and local subsidy. In 2017, subsidy for new energy passenger cars was provided as the following. Central subsidy for fuel cell electric passenger car in 2017 was RMB 200,000 each car.

Table 1: Subsidy for battery electric passenger car and plug-in hybrid electric (range-extender included) passenger car (CNY 1,000/car)

Vehicle type	Battery electric driving range R (working condition, km)				Upper limit of local subsidy
	$100 \le R < 150$	$150 \le R < 250$	$R \ge 250$	$R \ge 50$	
Battery electric passenger car	20	36	44	/	No more than 50 % of central subsidy
Plug-in hybrid electric passenger car (range extender included)	/	/	/	24	

Central subsidy for fuel cell electric passenger car in 2017 was CNY 200,000 (approx. 25,000 EUR) each car.

Purchase Tax Exemption

In August 2014, the Ministry of Finance, the State Administration of Taxation, and the Ministry of Industry and Information Technology jointly issued the bulletin of NEV purchase tax exemption starting from September 1, 2014 to December 31, 2017. In December 2017, a bulletin was issued stating that NEV purchase tax exemption should be implemented from January 1, 2018 to December 31, 2020.

Double Credit Policy

In September 2017, five ministries and commissions signed and issued the "Method for Parallel Administration on Corporate Average Fuel Consumption of Passenger Car and New Energy Vehicle Credit" (hereunder abbreviated as the "Method for Administration"). The "Method for Administration" will be implemented starting on April 1, 2018. According to the "Method for Administration", there is no requirement on NEV credit proportion for traditional passenger car manufacturers and importers whose annual production volume or imported volume is less than 30,000 units; for those manufacturers and importers with annual production or imported volume more than 30,000 units, there is NEV credit proportion requirement from 2019. The NEV credit proportion requirement for 2019 and 2020 is 10 % and 12 % respectively. The NEV credit proportion requirement for 2021 and the years afterward will be issued till further notice.

38.1.2 New Energy Passenger Car Sales in Cities

In 2017, top 10 new energy passenger car sales cities include Beijing, Shanghai, Shenzhen, Tianjin, Guangzhou, Hangzhou, Hefei, Changsha, Ningbo, and Chongqing.

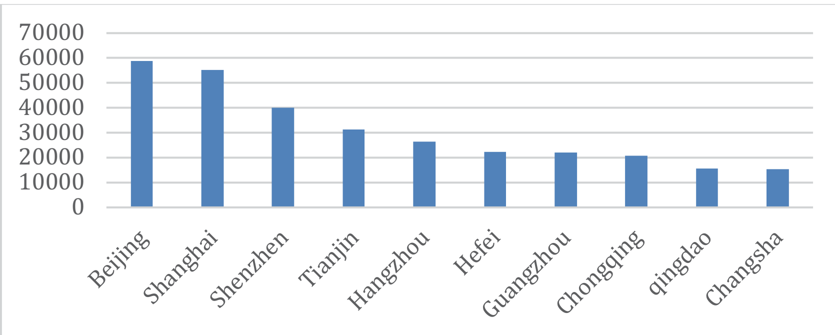


Figure 1: Top ten cites of new energy passenger car sales in 2017 (Data source: China Insurance Regulatory Commission)

38.1.3 Production of new energy passenger car brands in 2017

For new energy passenger car production, the top 10 brands were all self-owned brands, including Beijing, BYD, Roewe, Zotye, Geely, Jiangling, ChangAn, JAC, and Chery. The production volume of the top ten took 78.9 % of the total new energy passenger car production. BYD produced most plug-in hybrid electric passenger cars, followed by Roewe. The market concentration is high.

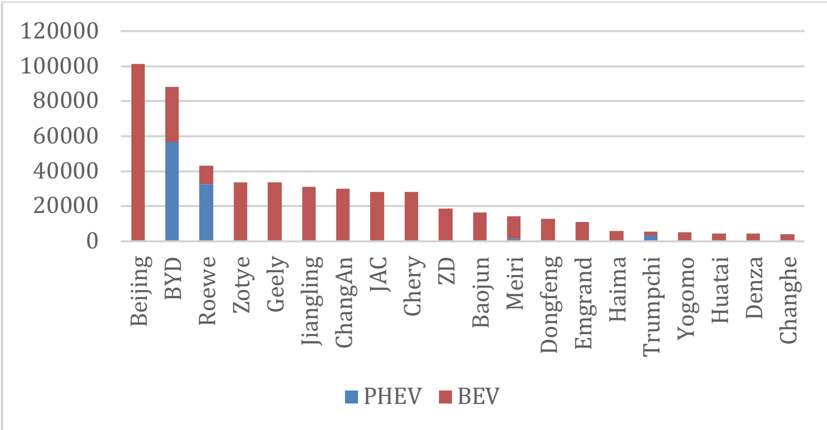


Figure 2: Production distribution of new energy passenger car brands in 2017 (Data source: China Automotive Technology and Research Center Co., Ltd)

The following table shows the prices of some new energy passenger cars on the market.

Table 2: New energy car prices (Data source = www.autohome.com.cn)

Market-Price Comparison of Selected EVs and PHEVs in China	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in CNY; 1 EUR = 7.98 CNY))**
BAIC BJEV EU series	205,900~252,650
BAIC BJEV EC series	151,800~164,800
BYD TANG	265,900~299,900
BYD YUAN	79,900~249,800
JAC iEV	128,500~158,500
Geely Emgrand GSe	119,800~145,800
ChangAn EADO	160,900~207,300
Roewe RX5 NEV	195,900~296,800
Zoyte E200	181,800~185,800
Chery eQ1	119,900~167,900
Denza	298,800~328,800
Venucia E30	242,800~261,800
BMW i3	349,800~415,800
Tesla Model S	710,600~1,232,600

38.1.4 Charging Infrastructure or EVSE

According to the data of the China Electric Vehicle Charging Infrastructure Promotion Alliance, by the end of 2017, there were 446,000 charging pillars built in China, including 214,000 public charging pillars and 232,000 private charging pillars. Public charging pillars consisted of 86,600 AC charging pillars, 61,400 DC charging pillars, and 66,000 AC and DC integrated charging pillars.

38.1.5 Outlook

The NEV production will keep growing in 2018. Although the purchase subsidy is reduced, the double credit policy will encourage the automotive manufacturers to invest more in NEV production. It is expected that the NEV production volume will exceed 1 million in 2018.

Table 3: Top ten cities/provinces regarding public charging pillar numbers in by April 2018
(Data source: China Electric Vehicle Charging Infrastructure Promotion Alliance)

No.	City/Province	Quantity
1	Beijing	40,184
2	Shanghai	33,666
3	Guangdong Province	32,693
4	Jiangsu Province	27,152
5	Shandong Province	20,282
6	Zhejiang Province	12,734
7	Tianjin	11,422
8	Hebei Province	11,087
9	Anhui Province	10,782
10	Hubei Province	7,340

38.2 Japan

38.2.1 Targets

Japan's Revitalization Strategy revised in 2015 (Cabinet approval on June 30, 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" (Followed by "2014 Automobile Industry Strategy" of METI). The total sales of EVs and PHEVs as of the end of 2017 were over than 200,000.)

Table 1: Diffusion targets by types of vehicles (targets set by the METI)

	2017 Results	2030 Targets
Conventional Vehicles	65.15 %	30 ~ 50 %
Next-Generation Vehicles	36.03 %	50 ~ 70 %
Hybrid Vehicles	31.25 %	30 ~ 40 %
Electric Vehicles	0.41 %	20 ~ 30 %
Plug-in Hybrid Vehicles	0.82 %	20 ~ 30 %
Fuel-Cell Vehicles	0.02 %	~ 3 %
Clean Diesel Vehicles	3.53 %	5 ~ 10 %

38.2.2 Clean Energy Vehicle Promotion Subsidy

A subsidy of passenger cars is available for electric vehicles (EVs), plug-in hybrid, vehicles (PHEVs), clean diesel vehicles (CDVs) and fuel-cell vehicles (FCVs).

- **EVs and PHVs**: up to 400,000 JPY (3,604 USD)
- **CDVs**: up to 150,000 JPY (1,351 USD)
- **FCVs**: up to 2,080,000 JPY (18,738 USD)

38.2.3 Taxation

EVs, PHEVs, CDVs and FCVs are exempt from paying "automobile acquisition tax" (local tax: registered vehicles: 3 %; light motor vehicles 2 %) and "motor vehicle tonnage tax" (national tax at 1st & 2nd inspection) and "automobile tax" (local tax: partially exemption).

HEVs are partially exempt from paying "automobile acquisition tax" and "motor vehicle tonnage tax" and "automobile tax".

38.2.4 Research

METI has provided approximately 3.27 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

38.2.5 HEVs, PHEVs and EVs on the Road

As of the end of 2017, cumulative EVs/PHEVs/FCVs sales were over 220,000 in Japan. In 2017, there were about 4.38 million newly registered passenger vehicles in Japan. Of this newly registered total, 1,370,568 were HEVs, 18,092 were EVs, 36,004 were PHEVs, and 849 were FCVs.

38.2.6 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 2017, more than 28,000 public charging stations including over 7,200 quick chargers were installed in Japan. Many private companies such as four Japanese car manufacturers' joint company[138] take an active role in installing quick chargers and normal chargers in response to the government.

Table 2: Information on charging infrastructure in 2017

Charging Infrastructure on 31 December 2017	
Chargers	**Quantity**
AC Level 1 Chargers	21,507
AC Level 2 Chargers	n.a.
Fast Chargers	7,255
Superchargers	72
Totals	**14,160**

n.a. = not available

[138] four car makers' joint company; - Toyota Motor Corporation, Nissan Motor Co., Ltd., Honda Motor Co., Ltd., and Mitsubishi Motors Corporation jointly established a new company in 2014 to promote the installation of chargers for electric-powered vehicles (PHVs, PHEVs, EVs) and to help build a charging network that offers more convenience to drivers who can use associated majority of public chargers by one membership cards in Japan.

Table 3: Available vehicles and prices

Market-Price Comparison of Selected EVs and PHEVs in Japan	
Available Passenger Vehicles	**Untaxed, Unsubsidized Sales Price (in JPY and USD)**
Mitsubishi i-MIEV	2,094,000 ;18,865
Mitsubishi Outlander PHEV	3,330,000 ; 30,000
Nissan Leaf	2,806,000 ; 25,279
Porsche Panamera S E-Hybrid	13,296,297 ; 119,786
Tesla Model S 60 kWh	8,000,925 ; 72,080
Toyota Prius Plug-in	3,020,000 ; 27,207
VW Golf GTE	4,342,593 ; 39,122
VW Passat GTE	4,813,889 ; 43,368
Toyota MIRAI (FCV)	6,700,000 ; 60,360
Honda CLARITY FUELL CELL	7,092,593 ; 63,897
BMW i3	4,620,370 ; 41,624
BMW i8	18,787,037 ; 169,253
Volvo XC90	9,712,963 ; 87,504
Mercedes Benz GLC350 e 4MATIC	7,990,741 ; 71,988
Audi A3 Sportback e-tron	5,222,223 ; 42,047

38.3 Morocco

38.3.1 Major Developments in 2017

Morocco, which is considered as an African leader in the field of clean energy has made his vision and commitment toward the environment clear by adopting a new national energy strategy, the signature of conventions and creation of international coalitions and by putting trams and electric buses into service in some Moroccan cities.

In 2017 the electric vehicles (EV) sector has known different developments in Morocco such as the implementation of demonstration projects and R&D facilities, the introduction of tax incentives for eco-friendly electric vehicles to promote the use of EVs and help the EV market find a starting point, the main development being the agreement on the establishment of a major EV factory to build battery-powered passenger cars, buses and trucks by the world's largest maker of electric vehicles.

38.3.2 Moroccan Roadmap for Sustainable Mobility

Morocco considers the electric mobility as an essential component of the Moroccan national energy strategy[139] and sustainable transformation of the transport sector. This sector emits 18.2 million of tons of CO_2 annually[140], which represents 15 % of the total emissions and 28 % of the emissions of the energy sector in the country. In addition, it consumes 5.6 Mt (37 %) of Morocco's petroleum products3. The motivation for electric mobility in the kingdom is therefore based on ecological, economical and even political interests to limit the energy dependency, reduce CO_2 emissions and to promote the EV Market.

The project of the roadmap for sustainable mobility was inspired by the global macro roadmap for transport transformation presented by the Paris Process on Mobility and Climate during the COP22 in Marrakech. Morocco decided to adopt this model and consequently developed its national roadmap for sustainable mobility. It aims to develop a shared vision to make transportation a real contributor to sustainable development and also to serve public and private stakeholders as a guiding framework for sector transformation, while balancing economic, energy, environmental and social objectives[141].

[139] The national energy strategy was implemented in 2009 and targets42 % of total electric installed capacity from renewable energy by 2020 and 52 % by 2030.

[140] Data 2015, https://frmd.ma/

[141] Projet Feuille de Route pour une Mobilité Durable au Maroc v1.1 Février 2018

38.3.3 Legislation

In the frame of the Moroccan roadmap for sustainable mobility, the direction of taxes of the Moroccan Kingdom under the umbrella of the ministry of environment has made a reflection of possible incentive measures and adapted taxation schemes to promote the use of eco-friendly vehicles.

In 2017, Morocco made the decision to remove circulating taxes for hybrid and electric vehicles in the framework of a tax package aimed at encouraging the development of electric-mobility in the country and to fulfill the engagement of the Moroccan Kingdom to preserve the environment.

The Moroccan government enacted the Finance Law[142] in which the hybrid and electric vehicles were declared exempt from annually circulating taxes. This development is considered as one step in a multi-phase process to create further incentives not only for EVs, but also for electric batteries. The several ministries involved are seriously studying the possibility of exempting HEV from customs duties.

38.3.4 Automotive Industry

PSA Open Lab

In July 2017, PSA, the French automotive manufacturer signed an agreement with five Moroccan universities and two American ones based in the kingdom in order to create the first Open Lab PSA-Morocco named “Sustainable mobility for Africa”. This “university-industry” scientific partnership is to play an important role in supporting the implementation of the PSA plant in the Rabat-Salé and Kenitra region and supporting the development of the PSA group in Africa[143].

The scientific program of the Moroccan Open Lab focuses on three areas: the electric vehicle of the future, renewable energies, and the supply chain management. Furthermore, this Moroccan Open lab is the first in Africa and Middle East Region and is part of 17 PSA active open labs in the world existing only in France, China, and Brazil[144].

[142] Finance Law of 2017, Loi de Finance 9 juin 2017

[143] The Moroccan ministry of equipment, transport and logistics

[144] PSA Media Space, http://media.groupe-psa.com

BYD in Morocco

The Moroccan roadmap for sustainable energy has set the goal of generating electric vehicles and jobs in the country. Morocco has taken advantage of the combination of low inflation and low-cost labor, generous tax incentives, an improved transportation infrastructure as well as economic and political stability to attract automotive companies. Therefore, the automotive industry in Morocco is expanding fast. After Renault and PSA, a Chinese global leader in electric vehicles "BYD" is now to be installed in the country. The partnership agreement signed in December 2017 between the Moroccan government and the automobile manufacturer aims to help Morocco create an ecosystem of E-Mobility in the kingdom. BYD, which is a market leader in EV production, is planning to build a production plant in Tangier in order to supply the domestic market. The information indicates that the project will create around 2,500 jobs and cover 50 hectares.

The factory will be in the new Mohamed VI Tangier Tech City, which is part of a project between China and Morocco to create what some are calling a North African Silicon Valley.

The BYD production plant intends to produce electric cars, buses, trucks and to supply the needed electric batteries to cover the demand in Morocco as well as in the MENA region and Africa.

38.3.5 HEVs, PHEVs and EVs on the Road

In Morocco, the electric vehicle market is not very large. There are few hybrid and electric vehicles on the road. Therefore, data and statistics about the exact number of these vehicles and the amount of sales are not available. The most popular electric vehicle in Morocco seems to be Renault ZOE.

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2017

<table>
<tr><th colspan="4">Fleet Totals on 31 December 2017</th></tr>
<tr><th>Vehicle Type</th><th>EVs</th><th>HEVs</th><th>Totals[f]</th></tr>
<tr><td>2- and 3-Wheelers[a]</td><td colspan="2">78</td><td>78</td></tr>
<tr><td>Passenger Vehicles[b]</td><td colspan="2">700</td><td>700</td></tr>
<tr><td>Buses and Minibuses[c]</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>Light commercial vehicles[d]</td><td colspan="2">12</td><td>12</td></tr>
<tr><td>Medium and Heavy Weight Trucks[e]</td><td colspan="2">10</td><td>10</td></tr>
<tr><td>Totals</td><td colspan="2">810</td><td>810</td></tr>
</table>

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

38.3.6 Charging Infrastructure or EVSE

Since 2015, social and economic studies were conducted in the Green Energy Park in order to evaluate the Moroccan customer behavior towards electric vehicles. The main obstacle preventing Moroccan people from buying EVs was found to be the lack of charging infrastructures. In the light of this, the Research Institute of Solar Energy and New Energies (IRESEN) formed an initiative to build the first Moroccan charging network for EVs: Green Miles. Even before this project, some temporary charging stations existed in Morocco. They were implemented, for the majority of them, in order to host the Light Us first Relay by bringing the photovoltaic Torch from Paris (COP21) to Marrakech (COP22) and then from Marrakech to Bonn (COP23). The Light Us Relay traveled on seven Tesla cars which had the opportunity to charge at several stations all the way from Marrakech to Tangier.

Table 2: Information on charging infrastructure in 2017-2018 in Morocco

Charging Infrastructure on 31 March 2018	
Chargers	**Quantity**
AC Level 1 Chargers	n.a
AC Level 2 Chargers	9* ; 20**
Fast Chargers	n.a
Superchargers	n.a
Inductive Charging	n.a
Totals	**29**

n.a. = not available
*Iresen; ** estimated

38.3.7 EV Demonstration Projects

Green Miles

Green Miles is a project initiated by IRESEN in partnership with Schneider Electric, the Motorway Service Areas and the Moroccan Network of Motorways (Autoroutes du Maroc) in early 2017. The aim of the project is to deploy charging stations for electric vehicles in the motorway service areas. In total, 37 charging stations will be deployed; this means 74 charging points since we have a double power socket in each station to cover 800 km on the motorway connecting Tangier to Agadir as seen on the map below in order to enhance the vehicle's reliability, a station will be implemented each 60 km. Furthermore, the charging stations will be equipped with smart meters and communication modules in order to centralize data and manage the charging process. The data collected and monitored will be a valuable asset for research purposes such as studying the impact of initial investment on electric mobility and traffic modeling. To make this project even more green, IRESEN is aiming to power the charging stations by a solar parking shading structure implemented inside the service area.

Figure 1: Electric vehicle charging stations being implemented within the Green Miles Project (Source :Iresen)

Figure 2: The first charging station implemented within the Green Miles Project, in Afriquia Settat near Casablanca. The charging station has a power of 22kW (2 x T2S) (Source Iresen)

Elec-Social Project

IRESEN, in collaboration with the region of Marrakech – Safi, Schneider Electric, and GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) has started the implementation of charging points in the city of Benguerir, deployed at the Green Energy Park, the municipality and the University Mohammed VI Polytechnic. The initiative is a first step towards providing the whole region with the needed infrastructure for electrical mobility using different capacities from 7 kW up to 22 kW. This will help the study on a larger scale of the impact of this infrastructure on the national grid, in collaboration with ONEE (National Office of Electricity and drinking water) and AMEE (Moroccan Agency for Energy Efficiency), as well as the different scenarios of use of EVs in a big city such as Marrakech. The city has already provided itself with electrical buses using renewable solar energy sources to make a first step towards developing electrical mobility.

Figure 3: Car charging in Green Energy Park, Benguerir (left) and one of the 5 charging stations available in the platform (right)

IRESEN has the vision via its research platforms to establish a research and development center that will generate innovative ideas, by promoting cooperation between academics and industrials, and by contributing to the transfer of knowledge from advanced foreign clusters to Morocco and the MENA region. IRESEN is determined to create test-beds and laboratories that will be a key driver to facilitate the commercialization of EVs in the Kingdom.

E-Buses

In September 2017, Marrakech was the first Moroccan and African city (with Cape Town) to introduce electric buses in its transportation system. The project, which cost 347 million dirhams, put into circulation 10 high quality electric buses. The first phase of this project consists in one route with eight stations connecting the city center to the town's peripheral districts. Three other routes are expected by 2019[145].

Today, barely 4 % of the population in Marrakech use buses. Through this new transportation system, the city hopes to raise this figure to 9 % and aims to encourage the use of an ecological public transport by creating a modern means of transport that meets the needs of the population.

Figure 4: Electric Bus in Marrakesh City (Source : http://www.2m.ma)

This project, besides its role in reducing the carbon footprint and preserving air quality, strengthens the position of Marrakech as a model city in the field of sustainable development. Furthermore, in order to guarantee the supply of these buses with clean energy, a solar energy production station has been set up in partnership with the World Bank at the entrance of the city in the district of Menara.

38.3.8 Outlook

Although it has just started, the electric mobility progress in Morocco is very motivating. Endorsed by the national energy strategy and the transport roadmap, sustainable mobility has many opportunities to grow in the country. Furthermore, the projects conducted by IRESEN and its research platform are playing an important role in concretizing the national directives and targets and driving the growth of HEV vehicles.

[145] Marrakech city infrastructure, http://www.ville-marrakech.ma/infrastructure-et-infrastructure-de-base/15/

HEV TCP Publications

HEV TCP Publications during the Fifth Term, 2015–2020
• Hybrid and Electric Vehicles. The Electric Drive Chauffeurs. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2016. Berlin. September 2017.
• Hybrid and Electric Vehicles. The Electric Drive Commutes. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2015. Berlin. June 2016.
• Hybrid and Electric Vehicles. The Electric Drive Delivers. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2014. Berlin. April 2015.
• Kleiner F.; Özdemir E. D.; Schmid S.; Beermann M.; Bülent C.; Moran B.; Lim O. T.; Horst E. F.: Electrification of transport logistic vehicles: A techno-economic assessment of battery and fuel cell electric transporter, EVS28 International Electric Vehicle Symposium and Exhibition, KINTEX. Korea, May 3-6, 2015.
• Martín Jiménez I., Arsuaga Carreras C., Fernández Aznar G., Sanz Osorio J.F., IA-HEV Task 20 Final Report, 2015.
• Özdemir E. D.; Kleiner F., Beermann M.; Bülent C.; Beers E.; Moran B.; Lim O. T.; Schmid S.: Status and trends for electrified transport logistic vehicles, EEVC - European Electric Vehicle Congress, Brussels, Belgium, December 2-4, 2015.
• Rousseau A.; Stephens T.; Brokate J.; Özdemir E. D.; Klötzke M.; Schmid S.; Plötz P.; Badin F.; Ward J.; Lim O. T.: Comparison of Energy Consumption and Costs of Different Plug-in Electric Vehicles in European and American Context, EVS28 International Electric Vehicle Symposium and Exhibition, KINTEX, Korea, May 3-6, 2015.
HEV TCP Publications during the Fourth Term, 2009–2015
• Hybrid and Electric Vehicles. The Electric Drive Advances. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2009. Washington, DC. March 2010.
• Hybrid and Electric Vehicles. The Electric Drive Plugs in. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2010. Washington, DC. June 2011.
• Hybrid and Electric Vehicles. The Electric Drive Captures the Imagination. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2011. Washington, DC. March 2012.
• Hybrid and Electric Vehicles. The Electric Drive Gains Traction. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2012. Washington, DC. May 2013.
• Hybrid and Electric Vehicles. The Electric Drive Accelerates. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and

Programmes for the year 2013. Washington, DC. September 2014.

- IA-HEV electronic newsletters issued in:
  May & October 2009
  August 2010
  July 2011
  March and July 2012
  January 2013
- IA-HEV website: www.ieahev.org, revised in January 2012.
- 2014 EV City Casebook Profiles 50 Big Ideas in Electric Mobility.
- Beeton, D., Meyer, G. (Eds.). Electric Vehicle Business Models – Global Perspective. Springer, Cham, 2015.
- Beeton, D. Electric Vehicle Cities of the Future: A Policy Framework for Electric Vehicle Ecosystems. Proceedings of EVS-26, Los Angeles, CA. May 6-9, 2012.
- Beeton, D., and B. Budde. Future of Markets for Electric Vehicles: Expectations, Constraints and Long-Term Strategies. Document IEA 130228. Urban Foresight Ltd., Newcastle, UK. 2013.
- Conte, M., et al. Performance and Life Testing Procedures for Lithium Batteries in an International Collaboration Context. Proceedings of EVS-25, Shenzhen, China. November 5-8, 2010. Also Journal of Automotive Safety and Energy, Vol. 2, No. 1, 2011.
- Da Costa, A., et al. Fuel Consumption Potential of Different Plug-in Hybrid Vehicle Architectures in the European and American Contexts. Proceedings of EVS-26, Los Angeles, CA. May 6-9, 2012.
- Dallinger, A., et al. Effect of Demand Response on the Marginal Electricity Used by Plug-in Electric Vehicles. Proceedings of EVS-26, Los Angeles, CA. May 6-9, 2012.
- Elgowainy, A., et al. Impact of Plug-in Hybrid Electric Vehicle Charging Choices in 2030 Scenario. Transportation Research Record TRB 12-3800, pp. 9-17, 2012.
- Elgowainy, A. et al. Impacts of PHEV Charging on Electric Demand and Greenhouse Gas Emissions in Illinois. Proceedings of EVS-26, Los Angeles, CA. May 6-9, 2012.
- EV City Casebook. Published by the Clean Energy Ministerial, Electric Vehicles Initiative, Rocky Mountain Institute, Project Get Ready, IA-HEV, C40 Cities, and International Energy Agency. 2012.
- ExtraEnergy e.V. (editor). Go Pedelec! Published in English, German, Dutch, Czech, Hungarian, and Italian by the Go Pedelec Project Consortium, Vienna, Austria. 2012.
- Gnann, T., et al. Vehicle Charging Infrastructure Demand for the Introduction of Plug-in Electric Vehicles in Germany and the U.S. Proceedings of EVS-26, Los Angeles, CA. May 6-9, 2012.
- Jungmeier, G., Dunn, J., Elgowainy, A., Gaines, L., Ehrenberger, S., Özdemir E. D., Althaus H. J., Widmer R. “Life cycle assessment of electric vehicles – Key issues of Task 19 of the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV)”, Conference Proceedings, TRA 2015 - 5th Conference Transport Solutions – From Research to Deployment, Paris, April 14-17, 2014.
- Jungmeier G., Dunn J.B., Elgowainy A., Özdemir E. D., Ehrenberger S., Althaus H. J., Widmer R. “Key Issues in Life Cycle Assessment of Electric Vehicles - Findings in the International Energy Agency (IEA) on Hybrid and Electric Vehicles (HEV)”, Conference Proceedings,. PRES 2013, 27th Electric Vehicle Symposium, Barcelona, November 17-20, 2013.
- Kleindienst Muntwyler, S. Market Deployment of Hybrid and Electric Vehicles: The Swiss Lessons Learned. Proceedings of EVS-25, Shenzhen, China. November 5-8, 2010.
- Mol, C., et al. Trends and Insight in Heavy-Duty Vehicle Electrification. Proceedings

of EVS 25. Shenzhen, China. November 5-8, 2010.

- Mol, C. Final end Report “Flemish Living Lab Electric Vehicles”, March, 2015.
- Mol, C. Presentation on the IEA-IA-HEV activities including Task 24, EEVC2014, Brussels, Belgium. December 2-5, 2014.
- Mol, C. “Smart Cities Module 1 - E–mobility in Smart Cities”, KIC InnoEnergy, Leuven, Belgium. January 31, 2014.
- Muntwyler, U. The International Energy Agency’s Transport Roadmap and the Strategy for the 4th Phase 2009–2014 of the Implementing Agreement “Hybrid and Electric Vehicle Technologies and Programmes.” Proceedings of EVS-25, Shenzhen, China. November 5-8, 2010.
- Nikowitz, M. “Eco-Mobility 2025+ - An A3PS-Roadmap for the Successful Development and Introduction of Advanced Propulsion Systems and Energy Carriers”, 2014.
- Plotz, P., et al. Optimal Battery Sizes for Plug-in Hybrid Electric Vehicles. Proceedings of EVS-26, Los Angeles, CA. May 6-9, 2012.
- Propfe, B., et al. Cost analysis of Plug-in Hybrid Electric Vehicles Including Maintenance and Repair Costs and Resale Values. Proceedings of EVS-26, Los Angeles, CA. May 6-9, 2012.
- Rask, E.M., et al. Analysis of Input Power, Energy Availability, and Efficiency during Deceleration for X-EV Vehicles. SAE 2013-01-1064. Presented at SAE World Congress, Detroit, MI. April 16-18, 2013.
- Rousseau, A., et al. Comparison of energy consumption, cost and market penetration potential of different plug-in electric vehicles in European and American Context. EVS-28, Goyang, Republic of Korea. May 3-6, 2015.
- Rousseau, A., et al. Comparison of Energy Consumption and Costs of Different HEVs and PHEVs in European and American Context. Presented at the European Electric Vehicle Congress, Brussels, Belgium. November 19-22, 2012.
- Santini, D.J. Electric Vehicle Waves of History: Lessons Learned about Market Deployment of Electric Vehicles. In Electric Vehicles – The Benefits and Barriers. Seref Soylu, editor. InTech. http://www.intechopen.com/books/electric-vehicles-the-benefits-and-barriers/plug-in-electric-vehicles-a-century-later-historical-lessons-on-what-is-different-what-is-not-. DOI: 10.5772/717. September 6, 2011.
- Santini, D., et al. An Analysis of Car and SUV Daytime Parking for Potential Opportunity Charging of Plug-in Electric Powertrains. Proceedings of EVS-26, Los Angeles, CA. May 6-9, 2012.
- Santini, D., et al. Deploying Plug-in Electric Cars Which Are Used for Work: Compatibility of Varying Daily Patterns of Use with Four Electric Powertrain Architectures. Paper TRB13-4925. Presented at Transportation Research Board Meeting, Washington, DC. January 2013.
- Santini, D.J., and A.J. Burnham. Reducing Light Duty Vehicle Fuel Consumption and Greenhouse Gas Emissions: The Combined Potential of Hybrid Technology and Behavioral Adaptation. SAE 2013-01-0069. Presented at SAE World Congress, Detroit, MI. April 16-18, 2013.
- Santini, D.J., et al. Cost Effective Annual Use and Charging Frequency for Four Different Plug-in Powertrains. SAE 2013-01-0494. Presented at SAE World Congress, Detroit, MI. April 16-18, 2013.
- Telias, G., et al. RD&D Cooperation for the Development of Fuel Cell, Hybrid, and Electric Vehicles within the International Energy Agency. Proceedings of EVS-25, Shenzhen, China. November 5-8, 2010.
- Van Walwijk, M. The International Energy Agency’s Hybrid and Electric Vehicle Work in a Landscape of Change. Presented at Green Vehicle Congress, Newcastle, UK.

March 24-25, 2010.

- Van Walwijk, M. IA-HEV Support for Policy and Decision Makers. Presented at IEA Advanced Vehicle Leadership Forum Workshop, Paris, France. September 30, 2010.
- Van Walwijk, M. Expanding International Collaboration. Presented at EV 2012 VÉ Conference & Trade Show, Montreal, Quebec, Canada. October 23-26, 2012.
- Zhou, Y., et al. Tracking National Household Vehicle Usage by Vehicle Type, Age and Area In Support of Market Assessments for Plug-in Electric Vehicles. Paper TRB12-4348. Presented at Transportation Research Board Meeting, Washington, DC. January 2012.

HEV TCP Publications during the Third Term, 2004–2009

- Annual Report 2004 – Final Report for Phase 2. Progress towards Sustainable Transportation. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2004. Angers, France. March 2005.
- Hybrid and Electric Vehicles 2006. Past – Present – Future. Progress towards Sustainable Transportation. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2005. Angers, France. February 2006.
- Hybrid and Electric Vehicles. The Electric Drive Takes off. Progress towards Sustainable Transportation. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2006. Angers, France. February 2007.
- Hybrid and Electric Vehicles. The Electric Drive Gains Momentum. Progress towards Sustainable Transportation. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2007. Angers, France. March 2008.
- Hybrid and Electric Vehicles. The Electric Drive Establishes a Market Foothold. Progress towards Sustainable Transportation. Annual report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2008. Angers, France. February 2009.
- IA-HEV electronic newsletters issued in:
  January, May, and November 2005
  September 2006
  March and November 2007
  May and October 2008
  May and October 2009
- Five press releases to announce the IA-HEV clean vehicle awards.
- Conte, F.V., et al. Components for Hybrid Vehicles: Results of the IEA Annex VII "Hybrid Vehicle" Phase III. Proceedings of EVS-22, Yokohama, Japan. October 23-28, 2006.
- Conte, F.V., et al. The IEA Annex VII "Hybrid Vehicle" Phase III Experience. Proceedings of EVS-23, Anaheim, CA. December 2-5, 2007.
- Dorda, A. IEA Striving for Fuel Cells in Vehicles. IA-HEV Annex XIII. Proceedings of EVS 22, Yokohama, Japan. October 23-28, 2006.
- Dorda, A., and B. Egger. New Annex XIII: "Fuel Cells for Vehicles." Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30-June 01, 2007.
- Dorda, A., and B. Egger. Worldwide Promotion and Development of Fuel Cell Vehicles. Proceedings of EVS-24, Stavanger, Norway. May 13-16, 2009.
- Kleindienst Muntwyler, S. Learning from Successful Market Introduction Programmes

for Clean City Vehicles. Proceedings of EET-2004, Portugal. March 17-20, 2004.

- Kleindienst Muntwyler, S. Market Introduction of Fuel Cell Vehicles: Lessons Learned by EV , HEV and Alternative Fuel Vehicles Promotion Programmes. Proceedings of EVS 21, Monaco. April 2-6, 2005.
- Kleindienst Muntwyler, S. Market Deployment of Hybrid and Electric Vehicles: Lessons Learned. Proceedings of EVS-22, Yokohama, Japan. October 23-28, 2006.
- Kleindienst Muntwyler, S. Market Deployment of Hybrid and Electric Vehicles: Lessons Learned. Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30-June 01, 2007.
- Kleindienst Muntwyler, S. Market Deployment of Hybrid and Electric Vehicles: Lessons Learned. Proceedings of EVS-23, Anaheim, CA. December 2-5, 2007.
- Kleindienst Muntwyler, S., and T. Turrentine. Lessons Learned from the Market Introduction of Electric Vehicles. Proceedings of the International Advanced Mobility Forum, Geneva, Switzerland, March 11-13, 2008.
- Laurikko, J. International Cooperation for Information Exchange on Electric Vehicle Technologies and Programmes – Annex I of IEA Implementing Agreement for Hybrid and Electric Vehicles. Proceedings of EVS-21, Monaco. April 2-6, 2005.
- Muntwyler, U. The IEA Hybrid and Electric Vehicle Agreement – Achievements of Phase 2 and Plans for Phase 3. Proceedings of EVS-21, Monaco. April 2-6, 2005.
- Muntwyler, U. Into the Focus of the Public and the Politics – The 3rd Phase of the Hybrid and Electric Vehicles Implementing Agreement of the International Energy Agency. Proceedings of EVS-22, Yokohama, Japan. October 23-28, 2006.
- Muntwyler, U. Politics and Sustainable Transportation – The Hybrid and Electric Vehicles Implementing Agreement of the International Energy Agency. Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30-June 1, 2007.
- Muntwyler, U. Politics and Sustainable Transportation – The Hybrid and Electric Vehicles Implementing Agreement of the International Energy Agency. Proceedings of EVS 23, Anaheim, CA. December 2-5, 2007.
- Muntwyler, U. The Future of the Transportation Is Electric and Solar. Proceedings of EVS 24, Stavanger, Norway. May 13-16, 2009.
- Passier, G., et al. Status Overview of Hybrid and Electric Vehicle Technology (2007). Final Report Phase III, Annex VII, IA-HEV, IEA. December 6, 2007.
- Schwegler, U. Electric Two Wheelers as a New IEA Task Force. Proceedings of EVS 21, Monaco. April 2-6, 2005.
- Smets, S. Overview of Battery Technology for HEV. IA-HEV Annex VII – Hybrid Vehicles. Presented at Global Powertrain Congress, Novi, MI. September 19-21, 2006.
- Smets, S., et al. Trends in Energy Storage Systems for HEVs. Results of IA-HEV Annex VII. Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30-June 1, 2007.
- Thibodeau, C. The International Energy Agency’s Implementing Agreement on Hybrid and Electric Vehicles. Presented at PHEV 2007 Conference, Winnipeg, Canada. November 2, 2007.
- Van Walwijk, M. Outlook for Hybrid and Electric Vehicles. Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30-June 1, 2007.
- Vergels, F., and U. Schwegler. Annex XI on Electric Cycles from the International Energy Agency Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes. Proceedings of EVS-22, Yokohama, Japan. October 23-28, 2006.

- Vergels, F., and U. Schwegler. Annex XI on Electric Cycles. Proceedings of the European Ele-Drive Conference EET-2007, Brussels, Belgium. May 30-June 1, 2007.
- Winkel, R., et al. Global Prospects of Plug-in Hybrids. Results of IA-HEV Annex VII. Proceedings of EVS-22, Yokohama, Japan. October 23-28, 2006.

Major HEV TCP Publications during the Second Term, 2000–2004

- IEA Hybrid and Electric Vehicle Implementing Agreement, Progress Towards Sustainable Transportation. Report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2000, Ottawa, Ontario, Canada. 2001.
- IEA Hybrid and Electric Vehicle Implementing Agreement, Progress Towards Sustainable Transportation. Report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2001, Ottawa, Ontario, Canada. 2002.
- IEA Hybrid and Electric Vehicle Implementing Agreement, Progress Towards Sustainable Transportation. Report by the IEA Implementing Agreement for Hybrid and Electric Vehicle Technologies and Programmes for the year 2002, Ottawa, Ontario, Canada. 2003.
- Koch, F. The IEA Agreement – Lessons Learned about Hybrid and Electric Vehicles. Proceedings of EVS-17, Montreal, Canada. October 2000.
- Hacker, V. Start-up of a New Annex “Electrochemical Power Sources and Energy Storage Systems” in the Implementing Agreement Hybrid and Electric Vehicles of the International Energy Agency. Proceedings of EVS-17, Montreal, Quebec, Canada. October 2000.
- Koch, F., et al. Renewable Primary Energy for Hybrid, Fuel Cell and Electric Vehicles. Proceedings of EVS-18, Berlin, Germany. October 2001.
- Muntwyler, U., and S. Kleindienst. Some Observations Concerning the Energy Consumption of Electric Vehicles in Real Traffic Conditions. Proceedings of EVS 18, Berlin, Germany. October 2001.
- Tomohiko, I., et al. International Cooperation for Information Exchange on Electric Vehicle Technologies and Programmes at Annex I of Implementing Agreement for Hybrid and Electric Vehicles in IEA. Proceedings of EVS 18, Berlin. Germany, October 2001.
- Kleindienst Muntwyler, S. Annex VIII “Deployment Strategies for Hybrid, Electric and Alternative Fuel Vehicles” of the IEA Implementing Agreement “Hybrid & Electric Vehicles.” Proceedings of EVS-18, Berlin, Germany. October 2001.
- Muntwyler, U., and F. Koch, Sustainable Transport — RE Supply Options and Resource Potential for Transportation, RE Focus. Kidlington, UK. July/August 2002.
- Kleindienst Muntwyler S. Government Deployment Strategies for Hybrid, Electric and Alternative Vehicles Examined. Proceedings of EVS-19, Busan, Korea. October 2002.
- Winkel, R., et al., Annex VII “Hybrid Vehicles” of the IEA Implementing Agreement “Hybrid & Electric Vehicles.” Proceedings of EVS-19, Busan, Korea. October 2002.
- Stelzer, N. IEA HEV Implementing Agreement Annex X Electrochemical Power Sources and Energy Storage Systems for Electric and Hybrid Vehicles, Proceedings of EVS 19, Busan, Korea. October 2002.
- Nakatsu, T., et al. International Cooperation for Information Exchange on Electric Vehicle Technologies and Programmes of Annex I of IEA Implementing Agreement for Hybrid and Electric Vehicles. Proceedings of EVS 19, Busan, Korea. October 2002.
- Kleindienst Muntwyler, S. Market Introduction Policy for Clean Vehicle Technologies.

Proceedings of EVS-20, Long Beach, CA. November 2003.

- Kleindienst Muntwyler, S. Learning from Successful Market Introduction Programs for Clean City Vehicles. Proceedings of the European Electric-Drive Transportation Conference, Estoril, Portugal. March 2004.
- Muntwyler, U., and F. Koch. International Energy Agency Prepares Third Phase of Its Hybrid and Electric Vehicle Agreement, Proceedings of the European Electric-Drive Transportation Conference, Estoril, Portugal. March 2004.
- Koch, F. The IEA Hybrid and Electric Vehicle Agreement. Presented at Windsor Workshop, Toronto, Ontario, Canada. June 2004.
- Koch, F. Deployment Strategies for Clean Vehicles and Fuels (Annex 8). Windsor Work- shop, Toronto, Ontario, Canada. June 2004.
- IA-HEV newsletter, 2000-2003.
- IA-HEV website: www.ieahev.org.

Vehicle Categories

In the "On the Road" sections of the country chapters, 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

HEV TCP Contact Information

The website of the IEA Technology Collaboration Programme on Hybrid and Electric Vehicles (HEV TCP) can be found at www.ieahev.org.

HEV TCP Executive Committee

Chairman
Mr. Urs Muntwyler
Bern University of Applied Sciences
Division of Electrical and Communications Engineering
Jlcoweg 1
3400 Burgdorf; Switzerland

Deputy Chairman and Country Delegate for the U.S.A
Mr. David Howell
Vehicle Technologies Office, EE-3V
U.S. Department of Energy,
1000 Independence Avenue, SW,
Washington, DC 20585; USA

Deputy Chairman and Country Delegate for Canada
Ms. Carol Burelle
Natural Resources Canada
Office of Energy R&D (OERD)
580 Booth Street, 14th Floor
Ottawa, Ontario K1A 0E4; Canada

Deputy Chairman and Country Delegate for Italy
Mr. Francesco Vellucci
ENEA – Italian National Agency for New Technologies, Energy and Sustainable Economic Development
Casaccia Research Centre
Via Anguillarese 301
00123 S.M. di Galeria, Rome; Italy

Austria
Mr. Andreas Dorda
Bundesministerium für Verkehr, Innovation und Technologie (BMVIT)
Abteilung Mobilität und Verkehrstechnologien
Renngasse 5
1010 Vienna; Austria

Belgium
Mr. Carlo Mol
VITO – Vlaamse Instelling voor Technologisch Onderzoek
Boeretang 200
2400 Mol; Belgium

HEV TCP Executive Committee (Cont.)

Denmark
Mr. Michael Rask
Danish Energy Agency - part of the Danish Ministry of Climate,
Energy and Building
Amaliegade 44
1256 Copenhagen K; Denmark

Finland
Mr. Martti Korkiakoski
TEKES - Finnish Funding Agency for Technology and Innovation
Energy and Environment
P.O. Box 69
00101 Helsinki, Finland

France
Mr. Johan Ransquin
ADEME - Agence de l'Environnement et de la Maîtrise de l'Energie
Service Transports et Mobilité
500, route des Lucioles Sophia Antipolis
06560 Valbonne; France

Germany
Mr. Matthias Laske
Projektträger Jülich
Geschäftsbereich Energietechnologien
Forschungszentrum Jülich GmbH
52428 Jülich; Germany

Ireland
Mr. Graham Brennan
Sustainable Energy Authority of Ireland
Wilton Park House, Wilton Place
Dublin 2; Ireland

The Netherlands
Ms. Sonja Munnix
Netherlands Enterprise Agency
Croeselaan 15, P.O. Box 8242
3503 RE Utrecht; The Netherlands

Republic of Korea
Mr. Hyun-choon Cho
KETEP – Korea Institute of Energy Technology Evaluation and Planning
Union Building Tehyeranro 114-11
Gangnam-gu, Seoul 135-280;
Republic of Korea

Spain
Mr. Juan Francisco Larrazábal Roche
Transport Department
IDAE – Institute for the Diversification and Saving of Energy
C/ Madera, 8
28004, Madrid; Spain

Sweden
Mr. Peter Kasche
Swedish Energy Agency
Department for Energy Technology
P.O. Box 310
631 04 Eskilstuna; Sweden

Switzerland
Mr. Martin Pulfer
Bundesamt für Energie (BFE)
Abteilung AEW/
Sektion Energieforschung
3003 Bern; Switzerland

Turkey
Mr. Halil S. Hamut
TÜBITAK Marmara Research Center
Energy Institute
P.K. 21, 41470 Gebze Kocaeli; Turkey

United Kingdom
Mr. Bob Moran
Office for Low Emission Vehicles (OLEV)
Great Minster House
76 Marsham Street
London SW1P 4DR; UK

HEV TCP Support

HEV TCP Secretary-General
Mr. James F. Miller
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439, USA
E-Mail: james.miller@anl.gov

HEV TCP, Desk Officer
Mr. Pierpaolo Cazzola
IEA - International Energy Agency
Energy Technology Policy Division
9, rue de la Fédération
75739 Paris Cedex 15; France
E-Mail: pierpaolo.cazzola@iea.org.

HEV TCP Operating Agents

Task 1 – Information Exchange
Mr. Gereon Meyer
VDI/VDE Innovation + Technik GmbH
Dept. Future Mobility and Europe
Steinplatz 1
10623 Berlin; Germany
E-Mail: gereon.meyer@vdivde-it.de

Task 23 – Light Electric Vehicle Parking and Charging Infrastructure
Mr. Hannes Neupert
EnergyBus e.V.
Koskauer Str. 100
07922 Tanna; Germany
E-Mail: hannes.neupert@EnergyBus.org

Task 25 – Plug-in Electric Vehicles
Mr. Aymeric Rousseau
Systems Modeling and Control Group
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60647; U.S.A.
E-Mail: arousseau@anl.gov

Task 26 – Wireless Power Transfer
Mr. Burak Ozpineci
Oak Ridge National Laboratory
2360 Cherahala Blvd.
Knoxville, TN 37932
USA
E-Mail: burak@ornl.gov

Task 27 – Light-Electric-Vehicle Parking and Charging Infrastructure

Mr. Florian Kleiner
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Pfaffenwaldring 38-40
70569 Stuttgart; Germany
E-Mail: Florian.Kleiner@dlr.de

Mr. Martin Beermann
Joanneum Research Forschungsgesellschaft GmbH
Elisabethstraße 18/II
8010 Graz; Austria
E-Mail: Martin.Beermann@joanneum.at

Task 28 – Home Grids and V2X Technologies
Ms. Cristina Corchero
Catalonia Institute for Energy Research (IREC)
Jardins de les Dones de Negre 1, 2a pl.
Sant Adrià de Besòs
08930 Barcelona;Spain
E-Mail: ccorchero@irec.cat

Task 29 – Electrified, Connected and Automated Vehicles
Mr. Gereon Meyer
VDI/VDE Innovation + Technik GmbH
Dept. Future Mobility and Europe
Steinplatz 1
10623 Berlin; Germany
E-Mail: gereon.meyer@vdivde-it.de

Task 30 – Assessment of Environmental Effects of Electric Vehicles

Mr. Gerfried Jungmeier
Joanneum Research
LIFE – Centre for Climate, Energy and Society
Wagner Biro Strasse 100
8010 Graz; Austria
E-Mail: gerfried.jungmeier@joanneum.at

Task 31 – Fuels and Energy Carriers for Transport

Mr. Bert Witkamp
Valuad
Rue de Maestricht 12
4600 Visé, Belgium
E-Mail: b.witkamp@valuad-expert.com

Task 32 – Small Electric Vehicles

Mr. Stephan Schmid
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Pfaffenwaldring 38-40
70569 Stuttgart; Germany
E-mail Stephan.Schmid@DLR.de

Task 33 – Battery Electric Buses

Mr. Gerfried Jungmeier
Joanneum Research
LIFE – Centre for Climate, Energy and Society
Wagner Biro Strasse 100
8010 Graz; Austria
E-Mail: gerfried.jungmeier@joanneum.at

Task 34 – Batteries

Mr. David Howell
Vehicle Technologies Office
United States Department of Energy
1000 Independence Avenue SW
Washington, DC 20585, USA
E-Mail: david.howell@ee.doe.gov

Task 35 – Fuel Cell Electric Vehicles

Mr. Ocktaeck Lim, Ph.D. Professor,
School of Mechanical and Automotive Engineering
University of Ulsan
93 Daehak-ro, Nam-gu,
44610 Ulsan, Republic of Korea
E-Mail: otlim@ulsan.ac.kr

Task 37 – Extreme Fast Charging

Mr. Steven Boyd
Vehicle Technologies Office, United States Department of Energy
1000 Independence Avenue SW
Washington, DC 20585, USA
E-Mail: steven.boyd@ee.doe.gov

Task 38 – E-Ships

Mr. Michael Rask
Raskgreentech
Gammel Lundtoftevej 34D
2800 Lyngby, Denmark
E-Mail: raskgreentech@gmail.com

Task 39 – Interoperability of E-Mobility Services
Mr. Carlo Mol
VITO – Vlaamse Instelling voor Technologisch Onderzoek
Boeretang 200
2400 Mol; Belgium
E-Mail: carlo.mol@vito.be

Task 40 – Critical Raw Material for Electric Vehicles
Mr. Bert Witkamp
Valuad
Rue de Maestricht 12
4600 Visé, Belgium
E-Mail: b.witkamp@valuad-expert.com

IEA INTERNATIONAL ENERGY AGENCY

HYBRID & ELECTRIC VEHICLE

TECHNOLOGY COLLABORATION PROGRAMME

iea Energy Technology Network

www.ieahev.org