HEV TCP ANNUAL REPORT

2020

THE ELECTRIC DRIVE SCALES UP

Austria
Belgium
Canada
China
Denmark
Finland
France
Germany
Ireland
Italy
Netherlands
Norway
Republic of Korea
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

THE ELECTRIC DRIVE SCALES UP

HEV TCP
ANNUAL REPORT
2020

IEA INTERNATIONAL ENERGY AGENCY
HYBRID & ELECTRIC VEHICLE
TECHNOLOGY COLLABORATION PROGRAMME

Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV TCP) is an international membership group formed to produce and disseminate balanced, objective information about advanced electric, hybrid, and fuel cell vehicles. It enables member countries to discuss their respective needs, share key information, and learn from an ever-growing pool of experience from the development and deployment of hybrid and electric vehicles.

ieahev.org

EDITORS

Kate Palmer, Task 1 OA
Urban Foresight

Paul Blakeman
Urban Foresight

CONTRIBUTING AUTHORS

AUSTRIA

Mauritsch Walter, Austria Tech
Gerfried Jungmeier, Joanneum Research
Maria Hingsamer, Joanneum Research
Andreas Dorda, BMK
Kiener Constanze, BMK

BELGIUM

Carlo Mol, VITO
Bert Witkamp, Valuad

CANADA

Carol Burelle, Natural Resources Canada

CHINA

Rujie Yu, CATARC
Huan Renhuan, CATARC
Chuan Chen, CATARC

DENMARK

Michael Rask, Raskgreentech

FINLAND

Mikko Koskue, Business Finland
Mikko Pihlatie, VTT
Joel Anttila, VTT

FRANCE

Maxime Pasquier, ADEME
Jérémie Almosni, ADEME
Ariane Rozo, ADEME

GERMANY

Hannes Neupert, EnergyBus e.V.
Anke Torkuhl, EnergyBus e.V.
Gereon Meyer, VDI/VDE-IT
Stephan Schmid, DLR
Oezcan Deniz, DLR
Amelie Ewert, DLR
Matthias Laske, FZ Jülich

IRELAND

Graham Brennan, SEAI
Declan Meally, SEAI

ITALY

Francesco Velluci, ENEA
Federico Karagulian, ENEA
Antonino Genovese, ENEA

JAPAN

Hideki Kamitatara, IEA
Yoshinobu Sato, METI

MOROCCO

Mouad Boulakhbar, IRESEN

NETHERLANDS

Sonja Munnix, Netherlands Enterprise Agency

NORWAY

Andreas Bratland, The Research Council of Norway
Erik Figenbaum, TOI
Jon Suul, Sintef

REPUBLIC OF KOREA

Ock-Taek Lim, Univery of Ulsan

SPAIN

Cristina Corchero, IREC
Manel Sanmarti, IREC
Isabel del Olmo Florez, IDEA
Juan Francisco Larrazábal Roche, IDEA
Dirección Ahorro y Eficiencia, IDEA

SWEDEN

Peter Kasche, Sweden Energy Agency
Martina Wikström, Sweden Energy Agency
Peter Kasche, Sweden Energy Agency

SWITZERLAND

Stephan Walter, Swiss Federal Office of Energy
Men Wirz, Swiss Federal Office of Energy

TURKEY

Abdulkadir Balikci, TÜBİTAK
Ahmet Avsar, TÜBİTAK

UNITED KINGDOM

David Beeton, Urban Foresight
Tim Ward, OLEV
Rob Gould, OLEV

UNITED STATES

Steven Boyd, US Department of Energy
David Howell, US Department of Energy
James F. Miller, Argonne National Laboratory
Burak Ozpineci, Oak Ridge National Laboratory

CONTENTS

SECTION A

ABOUT HEV TCP

SECTION B

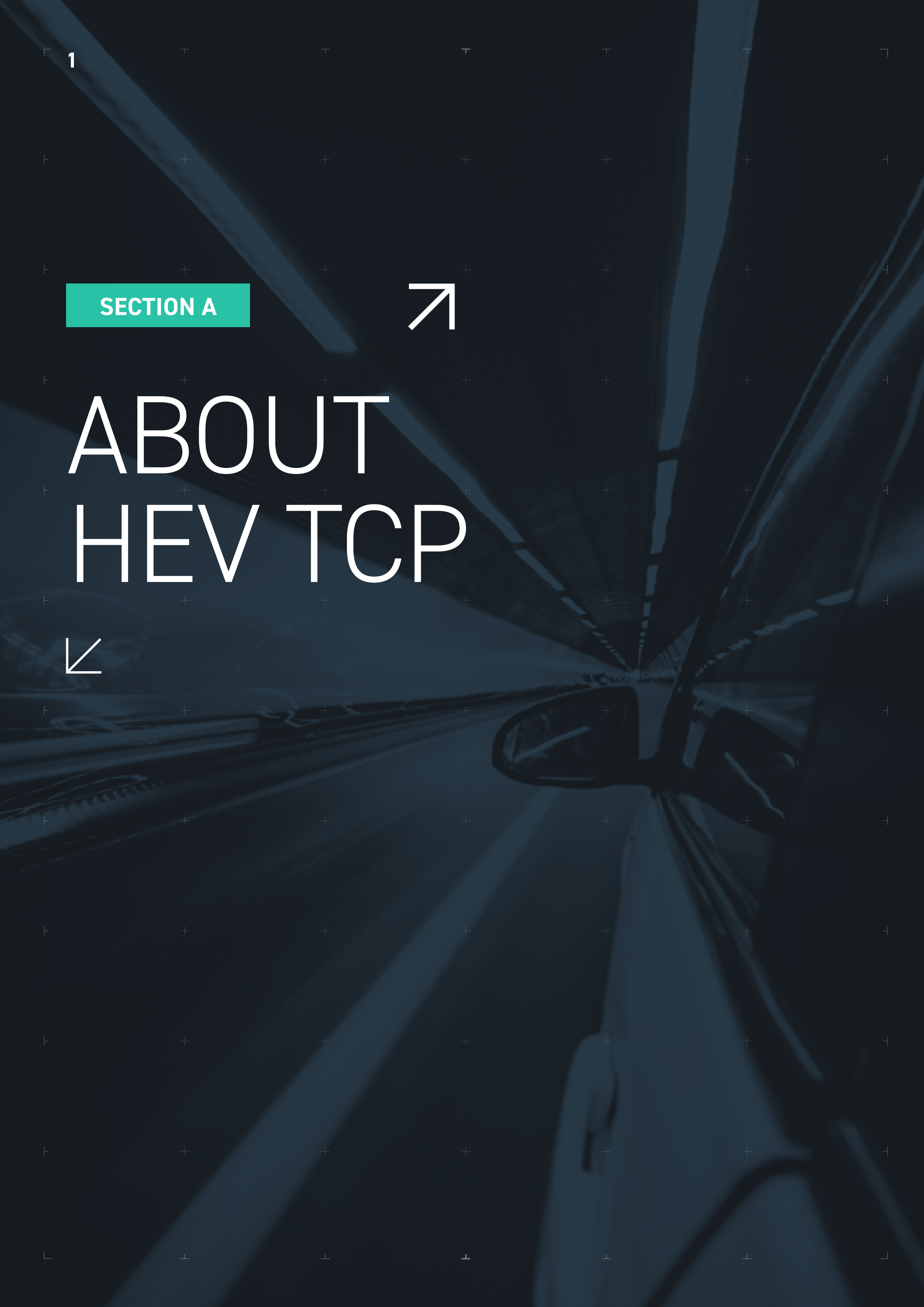
HEV TCP TASKS

SECTION C

HEV TCP WORLDWIDE

SECTION D

CONTACT INFORMATION



SECTION A

ABOUT HEV TCP

CHAIRPERSON'S MESSAGE

AS THE CHAIRPERSON OF THE HYBRID AND ELECTRIC VEHICLE TECHNOLOGY COLLABORATION PROGRAMME (HEV TCP), A PART OF THE INTERNATIONAL ENERGY AGENCY'S ENERGY TECHNOLOGY NETWORK, I HAVE THE PLEASURE TO INTRODUCE THE 2020 ANNUAL REPORT.

In November 2019, the International Energy Agency approved another five-year term of the HEV-TCP, for the period March 2020 to February 2025. Although electric vehicles are commercially available and accepted in today's society, a number of challenges remain for mass adoption and the work of the TCP continues to be very relevant. During the new term, our focus will expand beyond on-road vehicles, to include the electrification of other transport modes and will include future mobility systems, such as shared, connected and automated mobility.

The HEV TCP, with a membership of 19 countries, collaborates on shared projects (Tasks) to better understand and address technical and non-technical challenges, and provide guidance to policy makers. The TCP currently manages a total of 18 Tasks. The following new Tasks were initiated in 2019:

- **Task 42:** Scaling Up EV Markets and EV City Casebook
- **Task 43:** Vehicle/Grid Integration
- **Task 44:** Impact of Connectivity and Automation on Electrified Vehicle Usage and Benefits
- **Task 45:** Electrified Roadways (e-Roads)

Also in 2019, the TCP closed the following Tasks, for which final reports (where indicated) are available for download on HEV-TCP website at www.ieahev.org:

- **Task 25:** Plug-In Electric Vehicles
- **Task 26:** Wireless Charging
- **Task 28:** Home Grids and V2X Technologies (Final Report and V2X Roadmap)

At the end of 2019, the global plug-in electric vehicle (PEV) population for the light-vehicle sector was approximately 7.5 million. Global deliveries of PEVs in 2019 passed the 2.2 million mark and represents a share of approximately 2.5% of all light-vehicle sales. This is up from the 2.2% share in 2018, but below anticipated projections. As shown in Figure 1, global deliveries of PEVs did not follow the same trend in growth rate as the previous six years, with only a 9% growth over 2018. Figure 2 shows that this change was more significant in the second half of 2019, where monthly global PEV sales saw a decline compared to the same period in 2018. According to EV-volumes.com, China and the USA experienced the greatest decline in sales, while Europe saw increased growth overall for the sector. Some of the contributing factors include reduced subsidies and more stringent technical regulations in China starting in July 2019, and a decrease of deliveries in the USA compared to the boom in the second half of 2018.[1]

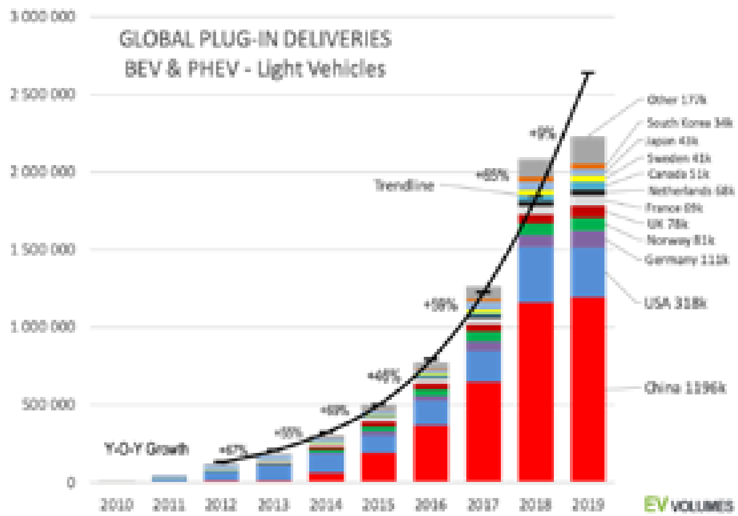


Figure 1:
Global Plug-In Deliveries

Source: http://www.ev-volumes.com/country/total-world-plug-in-vehicle-volumes/

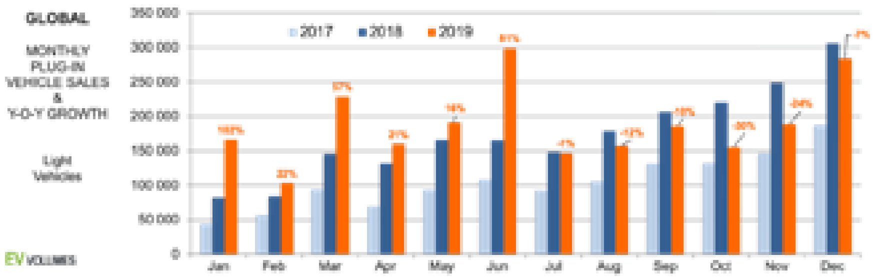


Figure 2:
Global Monthly Plug-In Vehicle Sales

Source: http://www.ev-volumes.com/country/total-world-plug-in-vehicle-volumes/

Notwithstanding the departure from the projected growth rate of PEVs sales in 2019, the recent unprecedented global outbreak of the novel coronavirus has paralyzed key parts of the economy in China, Europe and North America. The outlook for global PEV sales for the coming year is extremely difficult to predict in such uncertain times. As a result of the pandemic, factories across the globe have experienced closures or retooling to manufacture essential medical equipment. Mandated quarantines and self-distancing requirements means that consumers are not buying cars. Although oil prices are at an all-time low, people have nowhere to go. But if oil prices stay low, some consumers may purchase an internal combustion engine vehicle instead of paying a premium for a PEV. It is impossible to know how long the crisis will last, to what extent the industry will

[1] http://www.ev-volumes.com/country/total-world-plug-in-vehicle-volumes/

be impacted, or how long the economy will take to recover. The electrification of transportation is essential to meet a clear commitment to become carbon neutral by 2050, it may just take a little longer to get back on the path.

The spring meeting of the HEV TCP Executive Committee (ExCo) was schedule to take place on Jeju Island, South Korea at the end of April 2020. In an abundance of caution, the meeting was cancelled early. I would like to thank South Korea for offering to host the meeting and for all the efforts made to welcome us. We look forward to working with South Korea to host a meeting at some time in the future. The next face-to-face meeting of the HEV TCP ExCo will be held in Dundee, Scotland, in November 2020. At this meeting, we will formally welcome China as the newest member of the TCP, as of January 2020. China is a recognized global leader in the adoption of EVs, and is a great addition to the TCP.

ADMINISTRATIVE CHANGES AND ACKNOWLEDGEMENTS

2019 saw changes to two key positions in the TCP. Firstly, David Howell (USA) stepped down from the position of Deputy Chair of the ExCo after many years and Sonja Munnix (the Netherlands) was elected as a new Deputy Chair late in 2019. Secondly, effective January 2020, the responsibility of Operating Agent for Task 1 on Information Exchange has transitioned from VDI/VDE-IT (Germany) to Urban Foresight (United Kingdom).

As the Chairperson for the HEV TCP, I would like to recognize the excellent support provided by Dr. James Miller (Argonne National Laboratory) as the HEV TCP Secretary, and the generous contribution from the US Department of Energy for financing the position of the Secretary.

I would like to express my sincere thanks to both David Howell (USA) and Ock Taeck Lim (South Korea) for their support as Deputy Chairs, as well as to Gereon Meyer, Jadranka Dokic, and Heike Jürgens from VDI/VDE-IT for their excellent work with Task 1 over the past five years. I would also like to recognize the generous contribution by the German Government in support of Task 1 for the last five years.

In addition to the ExCo, the management of the TCP includes the work of two sub-committees, the Strategic Planning Group and the Technical Committee, which count on the participation of various ExCo members. My appreciation goes out to the Operating Agents running the Tasks for their excellent leadership and hard work, as well as to the Task participants for their continued involvement.

As Chairperson, finally yet importantly, I wish to thank the member country delegates for their strong participation in ExCo meetings and other activities of the TCP.

CAROL BURELLE
Chairperson of the Executive Committee,
Hybrid and Electric Vehicle Technology Collaboration Programme.

THE IEA & THE HEV TCP

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)[1].

INTRODUCTION

The IEA acts as energy policy advisor for the governments of its 30 member countries (see Figure 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.

Since the 1980s, the IEA has engaged in establishing relationships with countries and international organisations beyond its membership. Of particular interest to the IEA are the major energy consuming, producing and transit countries (including the Association countries Brazil, China, India, Indonesia, Morocco, Singapore, South Africa and Thailand). Because of this, the IEA puts serious effort into gathering all stakeholders – from policy makers to business leaders – with a truly international view of the world's energy system.

[1] In 2015, the IEA started rebranding the Implementing Agreements as Technology Collaboration Programmes (TCPs).

FIGURE 1: IEA MEMBER COUNTRIES

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

With the evolution of global 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. The IEA has held over a hundred 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.

The IEA plays an active role in discussions with both producer countries and the Organization of the Petroleum Exporting Countries (OPEC), particularly within the International Energy Forum (IEF). The IEA also supports energy-related work of the Clean Energy Ministerial (CEM) along with the Group of 20 (G20), Group of Seven (G7), and Group of Eight (G8). Additionally, the IEA supports and contributes 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).

The IEA is a founding partner of the Joint Organisations Data Initiative (JODI), working alongside APEC (Asia-Pacific Economic Countries), 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 that 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.

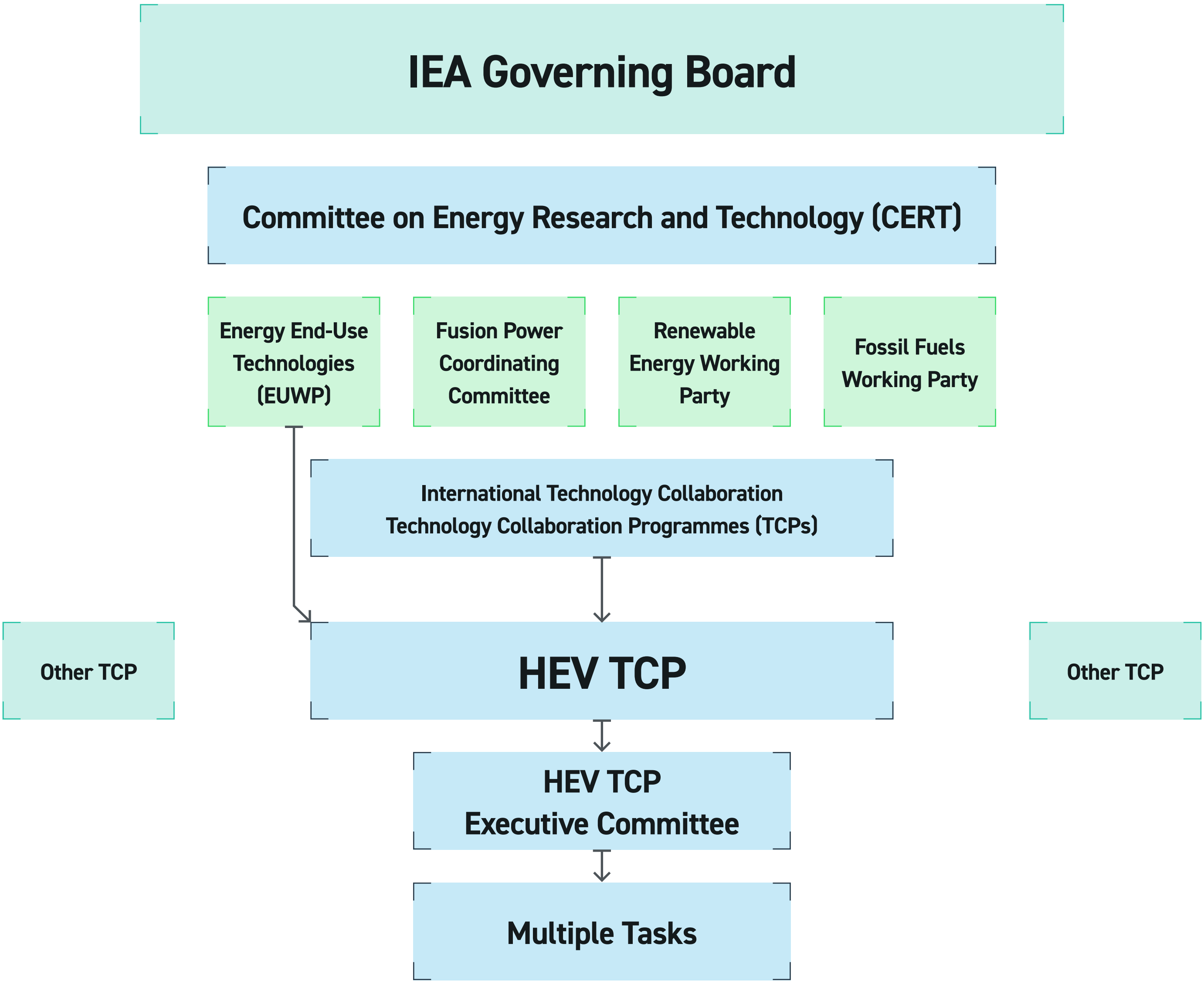
- **Economic growth:** Ensure the stable supply of energy to IEA member countries and promote free markets in order to foster economic growth.

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. The IEA experience has shown that international collaboration on these activities avoids duplication of effort, cuts costs, and accelerates 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 in the context of priority setting and evaluation; and oil and gas (Figure 2).

Figure 2:
The IEA energy technology networks



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 collaborate. There are currently 39 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 is the TCP 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 activities and recent accomplishments of all the TCPs is available on the IEA web site.

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 experiences on energy technology issues. Through published studies and workshops, these activities are designed to enhance policy approaches, improve the effectiveness of research programmes and reduce costs.

Over three decades of experience have shown that 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, such as 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 non-member countries, the private sector, and 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 non-member countries (or entities nominated by them). They can also be international organisations in which governments of OECD member and/or 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 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.

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” (ETP), which is an annual publication that gives updates on roadmaps for the technologies addressed by TCPs. The ETP has been published since 2006 and, there is a much anticipated edition in 2020. 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.

TECHNOLOGY COLLABORATION PROGRAMME ON HYBRID AND ELECTRIC VEHICLES

Most IEA countries have issues with urban air quality, and all IEA countries have issues 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. There is a strong case for the existence of an IEA TCP dedicated to developing and deploying these vehicles.

The HEV TCP was created in 1993 to collaborate on pre-competitive research and to produce and disseminate information. HEV TCP is now in its sixth five-year term of operation that runs from March 2020 until March 2025. The 19 active Contracting Parties (member countries) as of May 2020 are Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Ireland, Italy, The Netherlands, Norway, Republic of Korea, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

Compared to the automotive industry and certain research institutes, HEV TCP is a relatively small 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 OA, 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 2019 and in early 2020 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 few subsections briefly report on HEV TCP activities and results in the different phases of operation.The activites for the current phase of operations can be found in Phase 6 (2020 - 2025).

HEV TCP PHASE 2, 1999-2004

Description and Achievements

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 only considered suitable only for some market niches. 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 which ran in Phase 2 were:

- Task 1: Structured information exchange and collection of statistics.
- Task 7: Hybrid vehicles.
- Task8: Deployment strategies for hybrid, electric, and alternative fuel vehicles.
- Task 9: Clean city vehicles.
- Task 10: Electrochemical systems.

HEV TCP PHASE 3, 2004-2009

Description and Achievements

The emphasis during Phase 3 of the Agreement, from 2004 to 2009, was on collecting information on hybrid, electric, and fuel cell vehicles, with the same value-added aspects as in the previous phase. 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.

HEV TCP's other achievements during Phase 3 included 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, which contain transportation as an item in their work programme.

The Tasks which ran in Phase 3 were:

- Task 1: Information Exchange - The work includes country reports, census data, technical data, behavioural data, and information on non-IEA countries.
- Task 10: Electrochemical Systems.
- Task 11: Electric Bicycles, Scooters, and Lightweight Vehicles.
- Task 12: HEVs and EVs in Mass Transport and Heavy-Duty Vehicles.
- Task 13: Market Aspects of Fuel Cell Electric Vehicles.
- Task 14: Market Deployment of Electric Vehicles.
- Task 15: Plug-in Hybrid Electric Vehicles.

HEV TCP PHASE 4, 2009-2015

Description and Achievements

Interest in hybrid and electric vehicles as a means to reduce energy consumption and emissions from road transport increased significantly worldwide. At the same time, many questions remain still to be answered regarding 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.

The Tasks which ran in Phase 4 were:

- Task 1: 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.

HEV TCP PHASE 5, 2015-2020

Description and Strategy

This phase of the HEV TCP focused on producing 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. By general studies, assessments, demonstrations, comparative evaluations of various options of application, market studies, technology evaluations, the HEV TCP focused in on being a platform for reliable information on hybrid and electric vehicles.

The Tasks which ran in Phase 5 were:

- 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.
- Task 31: Fuels and Energy Carriers for Transport.
- Task 39: Interoperability of E-mobility Services.
- Task 40: Critical Raw Material for Electric Vehicles (CRM4EV).
- Task 41: Electric Freight Vehicles.
- Task 42: Scaling Up EV Markets and EV City Casebook.
- Task 43: Vehicle/Grid Integration.

HEV TCP PHASE 6, 2020-2025

Description and Strategy

In November 2019, the IEA Committee on Energy Research and Technology (CERT) approved the sixth phase of operation for HEV TCP, which is scheduled to run from 1 March 2020 until 29 February 2025. In the strategic plan for Phase 6, the participants in HEV TCP have formulated their expectations for the time frame 2020-2025.

The HEV TCP ExCo considers the target audience for its work to be policy/decision makers in governmental bodies at national, regional and city levels, the utility sector, and the automotive industry and its component suppliers. These include the HEV TCP Contracting Parties, which are representing national governments. The HEV TCP mission is defined as to advance the mass adoption of the electric drive by: supplying objective information to support decision making; facilitating international collaboration in pre-competitive research and development (R&D), demonstration and deployment projects; identifying future research areas; fostering international exchange of information and experiences; and identifying and removing barriers.

Against this background and to fulfil its mission, the HEV TCP has formulated the following strategic objectives for Phase 6 (2020-2025):

- Maintain and expand its network of experts to provide meaningful contributions to technology development and policy analyses in the face of mass adoption;
- Expand focus towards electrification of other transport modes and e-mobility in a broad sense, and strengthen the research on links with future mobility systems, such as shared, connected and automated mobility;
- Strengthen its collaborations with other TCPs and other relevant research/ policy groups; and
- Involve industry in its tasks to a greater extent to provide a broader network of experts and business expertise.

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 sixth phase.

HEV TCP Tasks which are active at the start of Phase 6 are:

- Task 1: Information Exchange.
- Task 23: Light electric vehicle parking and charging infrastructure.
- Task 29: Electric, connected, and automated vehicles.
- Task 30: Assessment of environmental effects of electric vehicles.
- Task 32: Small electric vehicles.
- Task 33: Battery electric buses.
- Task 34: Batteries.
- Task 35: Fuel cell electric vehicles.
- Task 37: Extreme fast charging.
- Task 39: Interoperability of e-mobility services.
- Task 40: Critical raw materials for EVs (CRM4EV).
- Task 41: Electric freight vehicles.
- Task 42: EV Cities casebook.

- Task 43: Vehicle/grid integration.
- Task 44: Impact of Connectivity and Automation on Electrified Vehicle Usage and Benefits.
- Task 45: Electrified Roadways – eRoads.

IEA ENGAGEMENT IN OTHER ACTIVITIES RELATED WITH ELECTRIC VEHICLES: THE ELECTRIC VEHICLE INITIATIVE

The Electric Vehicle Initiative (EVI, http://www.cleanenergyministerial.org/initiative-clean-energy-ministerial/electric-vehicles-initiative and https://www.iea.org/topics/transport/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. It 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. As of early 2020, governments currently active in the EVI include Canada, France, Japan, Norway, Chile, Germany, the Netherlands, Sweden, China, India, New Zealand, United Kingdom, and Finland. This group includes the largest and most rapidly growing EV markets worldwide and accounts for the vast majority of global EV sales. Canada and China are the co-leads of the initiative. The International Energy Agency serves as the EVI co-ordinator. Its EV30@30 Campaign, launched at the Eighth Clean Energy Ministerial in 2017 and subscribed by most of the EVI members, 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 passenger cars, light commercial vehicles, buses and trucks by 2030.

The implementing actions included in the EV30@30 Campaign largely define today’s EVI programme of work. 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 (https://www.iea.org/topics/transport/evi/pcp/).

To date, the EVI has developed analytical outputs that include the Global EV Outlook series with annual editions since 2015 and the Nordic EV Outlook 2018. The EVI has also successfully engaged private sector stakeholders in roundtables in Paris in 2010, in Stuttgart in 2012, at the annual COP meetings since 2015 and at the 2019 Paris Peace Forum to discuss the roles of industry and government in EV development as well as the opportunities and challenges ahead for EVs.

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 TCP). 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.

The HEV TCP and the EVI work together on annual data collection, and several HEV members support the development of analytical activities in the IEA, with direct implications for the EVI deliverables, starting from the Global EV Outlook.

Key examples include the close cooperation established between the IEA and the Argonne National Laboratory on battery cost and the assessment of the greenhouse gas emissions resulting from battery manufacturing. This allows better alignment of HEV TCP and EVI data analysis and messages throughout their respective publications.

SECTION B

HEV TCP TASKS

TASK 01 INFORMATION EXCHANGE

INTRODUCTION

Information exchange is at the core of HEV TCP's work, enabling members to share key policy insights and best deployment practices, as well as to identify common research interests in the rapidly growing international hybrid and electric vehicle field. Task 1 began in the first phase of 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 as well as identifying common research interests in the rapidly growing international hybrid and electric vehicle field.

The HEV TCP strategic plan for Phase 6 states that "[The HEV TCP] will aim to communicate and engage with key influencers of technology acceptance and deployment. The main communication vehicles will remain the same (public website, HEV TCP annual reports, workshop reports, and Task final reports), with additional journal articles and conference papers." Task 1 enables this through the following key objectives.

Key Objectives

- 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.

OBJECTIVES

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

Information exchange focuses on these topics:

- Research and technology development;
- Commercialization, marketing, sales, and procurement;
- Regulation, standards, and policies;

- Awareness raising measures; and
- Activities of HEV TCP Tasks.

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 (ExCo) 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 (OA) 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 OA is responsible for coordinating and leading the biannual experts' meetings, compiling the minutes of these meetings, maintaining the HEV TCP website, and editing and supervising the production of the newsletter and the 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 start of 2020, the responsibility for Task 1 has been transferred to Kate Palmer of Urban Foresight (United Kingdom) 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 and electric vehicles 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 nongovernmental 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.

RESULTS

Notable events in 2019 included the following:

- Task 1 Information Exchange meetings were held in Lyon, France, in April 2019, and in Rome, Italy, in October 2019.
- The HEV TCP Annual Report on 2018 entitled Hybrid and Electric Vehicles – The Electric Drive Hauls was published in 2019. Postcards with the cover page and the download link for the report were provided to all participants of the EVS-32 Conference in Lyon (France).

NEXT STEPS

With the OA responsibility for Task 1 moving to Urban Foresight at the start to 2020, there are some aspects of the running of communications which are planned for improvement.

- The internal members-only website is currently being migrated to to a new platform for increased functionality.
- The external-facing website will be redeveloped. The aim of the project will be to modernise and improve the current HEV TCP website, including its accessibility, ease of maintenance and user experience. This will constitute rebuilding and restructuring the current website, which will be facilitated by Urban Foresight and the assistance of a web development contractor.
- The biannual HEV TCP Newsletter is being reinstated. The first issue is planned for release this summer and we would welcome any contributions from HEV TCP members.

Talks have started regarding the organisation of the HEV TCP ExCo meeting in Dundee (Scotland) in November 2020.

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 1 OA:

OPERATING AGENT
Dr. Kate Palmer
Urban Foresight
Flour Mill, 34 Commercial Street,
Dundee, DD1 3EJ
Scotland

Kate.Palmer@UrbanForesight.org

TASK

23

LIGHT-ELECTRIC-VEHICLE PARKING & CHARGING INFRASTRUCTURE

MEMBER COUNTRIES
SPAIN
GERMANY
BELGIUM
TURKEY

INTRODUCTION

Today the global population of electric Light Duty Vehicles (eLDVs) is estimated at more than 260 million units – with more than 40 million new vehicles brought to the market annually. The rapid growth in the last 20 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 versions of all of them (electric and non-electric) has created issues to be addressed related to parking and charging infrastructure.

This includes the development of harmonised charging standards which are embedded in public parking space management solutions. 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 sharing schemes and private usage (parking and charging) of bicycles, e-scooters and pedelecs.

Figure 1: Competition for public space – example of free floating pedelecs and e-scooters as well as station-based sharing bicycles in Brussels (BE).

Source: Hannes Neupert

Figure 2:
Sharing scooters on the streets of Wrocalw (PL) forming obstacles for pedestrians.

Source: Hannes Neupert

OBJECTIVES

To representing the interests of local governments in the standardisation of Light Electric Vehicle system architectures, infrastructure, communications and interchangeable batteries. This will be achieved through following the IEC TC69-WG10 61851-3-1/7 series, as well as other related IEC and ISO committees. The key objective of Task 23 in standardisation is to ensure that there are no gaps within the technical infrastructure defined by IEC and ISO standards. These standards could then be used as a good starting point for international GTRs (Governmental Technical Regulations) in defining that pedelecs may be considered equivalent to bicycles in regard to traffic laws. In 2016, EN 50604-1 was published, the first battery safety standard from the European standardisation body CENELEC. This set the lead globally and was followed by ISO 18243, also referencing the interface connector defined by IEC SC23h and the communication protocol defined by IEC TC69-WG10. This means that when EN 50604-1 is harmonised (listed in the Official Journal as meeting the essential safety requirements of the relevant directives) it will not only define the technical state of the art, it will be almost essential for manufacturers to comply with it. This will enable easy infrastructure interconnection down the road.

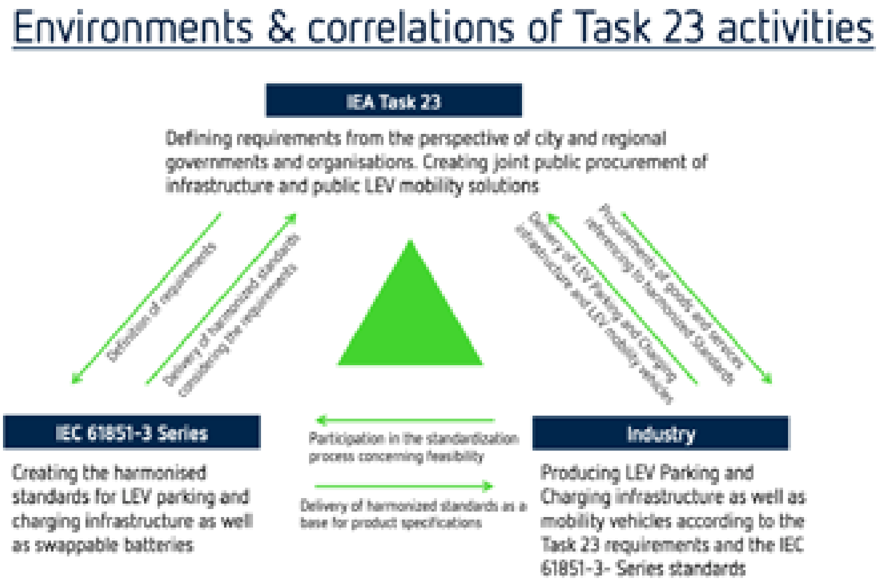


Figure 3:
The interaction between Task 23, the standardization/ governmental regulation and industry supply.

Source: Anke Torkuhl

Figure 4:
The IEC standardized socket which will be used around the world by all kinds of privately owned as well by shared LEVs and bicycles to park them in accordance to public interests regulated by non-moving traffic management regulations.

Source: Anke Torkuhl

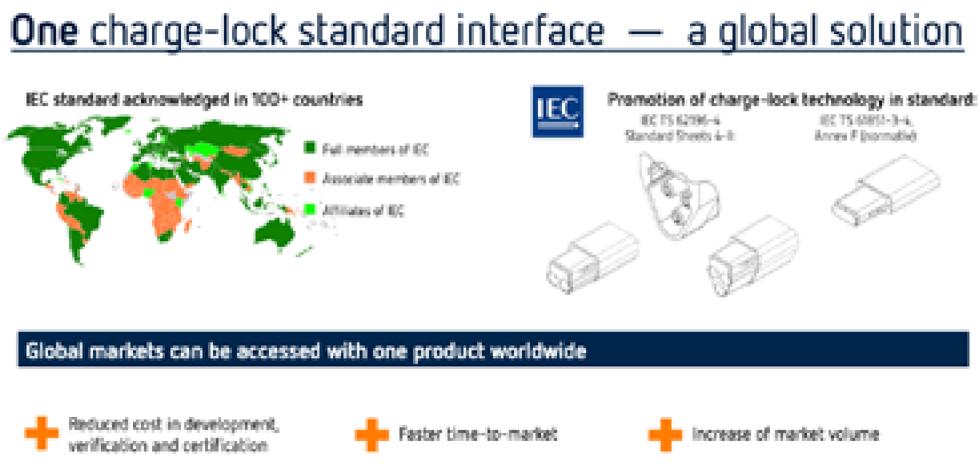
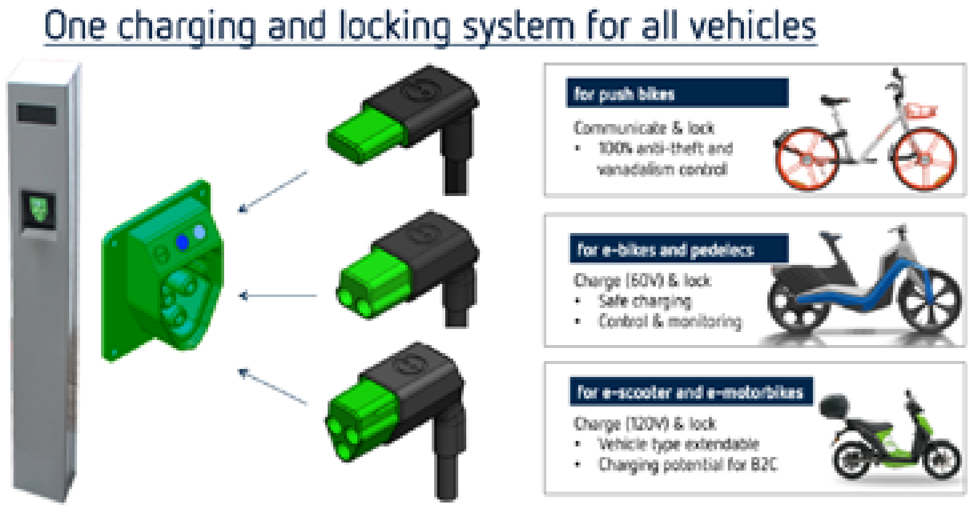


Figure 5:
The three versions of the IEC connectors for public charging of LEVs, all fitting into the same sockets to be installed in public and semi-public locations. The three pin connector version is meant for larger motor scooters or LEVs – this connector can handle up to 7.2 kW charge current at voltages up to 120 V DC. The two 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 zero pin connector could be used for non electric cycles which also use bicycle parking facilities.

Source: Anke Torkuhl



TARGET A BLUEPRINT FOR PUBLIC TENDERS FOR LEV INFRASTRUCTURE

In 2019, IEC TS 61851-3-1/2/4/6/7 received a positive vote and was therefore due to be published as an IEC Technical Specification. However, the IEC changed the result in the aftermath of the vote, which reversed the result on two items so that they were rejected. That is why IEC TS 61851-3-1/2 is due to be voted on again in 2020. A legal investigation into that unusual procedure is still ongoing.

Nonetheless, the first public tender which makes reference to these standards for the acquisition of public infrastructure, for parking space management of LEVs and sharing bicycles, and of course for charging infrastructure, went live in March 2020 in the County of Thuringia/DE in the context of pedelec usage for tourism.

Future tenders will 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, recently became very obvious in many cities around the world. In 2019, extremely popular sharing bikes and scooters literally flooded city sidewalks and streets. This frequently caused serious chaos on sidewalks, and spurred local governments to regulate this effectively. For this purpose the Charge and Lock Cable system is perfectly suited to free dense urban areas from uncontrolled flooding by sharing as well as private vehicles. Lock cables without the integration of the charging function are widely popular in Japan proving the approach to be a viable business case.

Figure 6:
One interface but many possibilities to create consumer convenience and security, and at the same time to help to manage public space and create opportunities for business models which enable such infrastructure to create a return of investment – which is uncommon for cycle parking infrastructure.

Source: Anke Torkuhl

CREATING EVENTS FOR INFORMATION EXCHANGE ON LEV INFRASTRUCTURE

Events will be organised such as expert workshops and conferences on the subject of LEV infrastructure, as well as suitable vehicles. These events will involve stakeholders such as: governments, city planners, public transportation experts, operating companies, consumer organisations, standardisation bodies and the vehicle and infrastructure industries. A number of activities have been organised to date in : Taipei (TW), Kirchberg (AT), Antwerp (BE), Malbrok (PL), Istambul (TK), Oslo (NO), Grenoble, Nante, Lyon (FR), Rome, Milano, Turin (IT), Prague (CZ), Osaka, Kyoto, Tokyo (JP) Tianjin, Beijing, Shenzhen, Tianjin, Shanghai, Chengdu (CN) Zürich (CH), New Delhi, Lithuania (IN) Cologne, Frankfurt, Rostock, Schleiz, Tanna, Bad Soden, Essen, Munich, Baden-Baden, Berlin (DE).

BEST PRACTICE SHARING STUDY TRIPS

Experts will be gathered in cities where local governments have established successful LEV infrastructure systems. The study trips will share findings and summarise positive and negative experiences – distilling the findings into easy-to-follow recommendations.

PUBLICATIONS WITH RECOMMENDATIONS ON LEV INFRASTRUCTURE

Publications will be created summarising key findings and listing recommendations on how to establish the most suitable LEV infrastructure. Numerous lectures have been presented from 2017 until today.

PROMOTING THE NEEDS TO POTENTIAL SUPPLIERS

Joint presentations have been made at relevant trade shows and conferences, explaining how to implement suitable LEV models, whilst meeting the requirements of local governments, potential manufacturers and providers of LEV infrastructure and rental vehicles. During 2019 and 2020 such presentations have been made at BtoB and BtoC trade shows in DE, TW, CN and IN.

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 also 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.

Subsection

In 2019 and 2020 two workshops were organised in India by local industry and governmental stakeholders. The first public tender for public parking and charging infrastructure in a tourism context was placed in March 2020.

Figure 7:
Workshop in New Delhi (IN) on the 2nd April 2019 with two ministries and the EEPC Scientist “G” Mr. Sajid Mubashir, consultant to Premiere Minister Modi of India, giving the keynote speech. Follow up workshops have been held in February 2020 and more are scheduled.

Source: Hannes Neupert

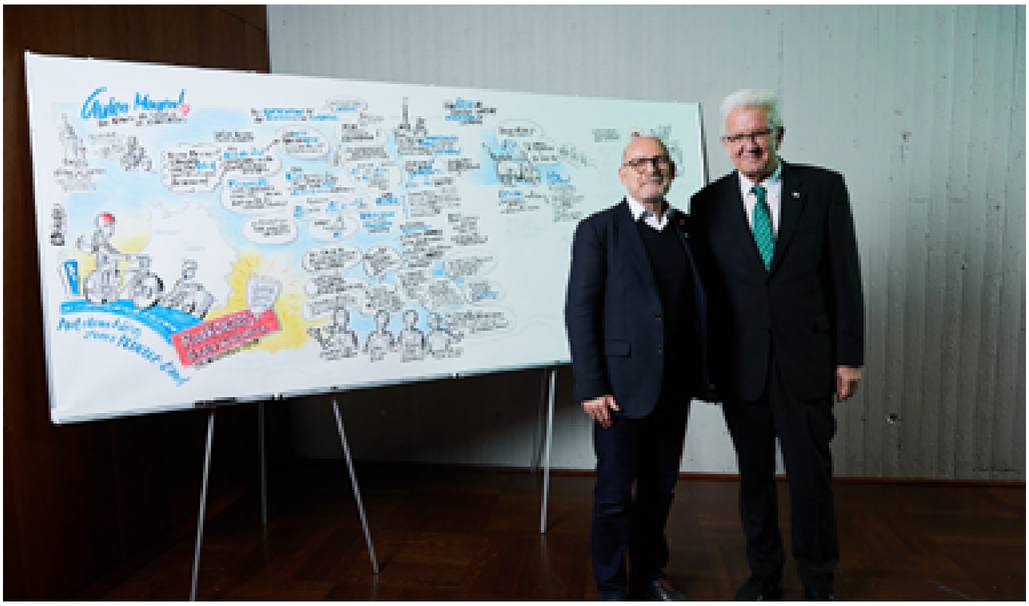


Figure 8:
2019: Minister of Transportation of the County of Baden-Württemberg (DE) Mr. Winfried Herrmann and Minister President Winfried Kretschmann present their bicycle strategy including a plan to build 5000 new bicycle and electric bicycle parking facilities every year, at connection points to public transport. Charging posts have been explicitly emphasized.

Source: Ministry of Transport BW

RESULTS

Publications summarising the key findings and listing recommendations on how to establish the most suitable LEV infrastructure will be created. Numerous lectures have been held since 2017 until today summarising Task 23 activities and findings. A best practice sharing guide which summarises all findings since the beginning of Task 23 will be published in 2020. The 1st tender blueprint is to be included.

In 2019, Task 23 became part of the EU Horizon2020 Project SELECTRIFIC which is scheduled to run with partners from 10 EU countries until the scheduled closing date of Task 23 in 2024.]

NEXT STEPS

Task 23 plans to further acquire members, cities and regional governments to create as large a public tender base as possible for the procurement standards, with high level buy-in and negotiating power, of LEV infrastructure and LEV rental fleet solutions. Beside the focus on standardisation, 2020 will be mainly focused on pilot applications in China, India and Europe as well as industrialisation with industrial and governmental partners.

A political activity started in July 2018 in a petition to initiate a change the historic UN vehicle definition which was defined 50 years ago in Vienna. The target aims to redefine the bicycle to include electric assisted bicycles as well as new kinds of micro mobility for safety reasons. The proposed definition is based on the IEA HEV Task 11 Results presented in 2012.

Figure 9: 2019/d 2020: Following several workshops the local tourism board of the Saale-Orla region of Thuringia/DE developed a specification for a state-of-the-art parking and charging infrastructure in a tourism context within the Task 23 tendering process. The first sample stations are to be set up in April 2020 and about 120 stations are to be set up by spring 2021.

Source: Right - Hannes Neupert. Left - Ziegler Metallbau.

OPERATING AGENT CONTACT DETAILS

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

OPERATING AGENT
Hannes Neupert
EnergyBus e.V. / EnergyBus Operations GmbH
Koskauer Str. 100, 07922 Tanna, Germany

hannes.neupert@EnergyBus.org

CO-OPERATING AGENT
Carlo Mol
VITO – Vlaamse Instelling voor Technologisch Onderzoek
Boeretang 200, BE-2400 Mol, Belgium

carlo.mol@vito.be

TASK 26 WIRELESS POWER TRANSFER FOR ELECTRIC VEHICLES

MEMBER COUNTRIES

DENMARK
FRANCE
GERMANY
NETHERLANDS
REPUBLIC OF KOREA
SPAIN
SWEDEN
SWITZERLAND
UNITED KINGDOM
UNITED STATES

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 vehicle range for the same size battery if, in the future, the vehicles can be charged while in motion. 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, and in some countries no standards currently exist, which limits the interoperability among systems and slows the maturation of this technology. This task concluded in 2019 with a final report submitted to the ExCo and Task 1 Operating Agent. During the last five years, Task 26 developed 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 included a study of country-based standards (JARI, SAE, ISO/IEC), technical approaches, grid interactions, interoperability, and safety codes for WPT.

OBJECTIVES

The Task coordinated a study of various country-based standards, technical approaches, grid interactions, and regulatory policy for WPT for EVs, and addressed interoperability, power levels, alignment, and safety. In addition, there were many fields of interest in WPT that this task addressed. As there were ongoing efforts in many of these areas, in “bullet” form, the objectives were:

- Categorise 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 summarise safety issues regarding misalignment, leakage fields, and debris tolerance and response.

WORKING METHOD

The task conducted bi-annual workshops and supporting conference calls, which included visiting locations of WPT research or deployment activities to gain first-hand knowledge of how this technology was progressing and to inform the committee of new work.Based on information gathered from participating countries, specific areas were identified as being of critical interest for off-line research. The task was completed in 2019 with a final report submitted to HEV TCP ExCo in December.

PROCESS

The process for how this task operated was as follows:

- Develop an understanding of the challenges faced in various countries or markets by categorising deployment approaches and requirements for WPT technologies.
- Compare current WPT technology development and address interoperability concerns for both static and dynamic systems.
- Summarise 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 task members.

RESULTS

Task 26 sponsored one meeting in 2019 in conjunction with the 2019 Wireless Power Week in London, UK with a focus on the final report for Task 26. Each section of the final report was reviewed. A list of sections that are in the Final Report follows.

1. Introduction
 1.1. Objectives
 1.2. Working method

2. Approach
3. Wireless Charging Technology Overview
4. Current Status of Wireless Charging
5. Task- Specific Topic Discussions
- 5.1. Leading applications
- 5.2. Power levels and frequencies
- 5.3. Interoperability and standards
- 5.4. Safety
- 5.5. Installations and alignment
- 5.6. Bi-directional systems
- 5.7. Dynamic wireless charging
- 5.8. Cybersecurity of EV wireless charging

6. Country-Specific Programs
- 6.1. France
- 6.2. Germany
- 6.3. South Korea
- 6.4. Spain
- 6.5. Switzerland
- 6.6. The Netherlands
- 6.7. United Kingdom
- 6.8. United States
- 6.9. Non-member countries
  - 6.9.1. Italy
  - 6.9.2. Latvia
  - 6.9.3. Greece
  - 6.9.4. European Union

7. Conclusions and Recommendations

The conclusions of the final report are:

- Through various demonstrations and research programmes, in countries throughout the world, WPT technologies have been shown to be a promising method of powering/charging vehicles in multiple scenarios.

- Demonstrations of High power WPT technologies (100 -- 1,000kW) change the previous application boundaries.

- Dynamic WPT feasibility studies have shown that large scale deployment has substantial benefit potential with large resource commitments .
  - » FABRIC results establish recommendations in socio-economic areas as well as technology.
  - » KAIST dynamic WPT-enabled bus routes highlight the ability to reduce battery storage requirements and weight.

- WPT centre operating frequency agreement (85kHz for power levels below 11kW) will allow for multiple providers to bring technologies to market.

- The complexity of integrating WPT technologies into an existing transportation system is typically understated. Currently only BMW offers a production vehicle WPT charging option (at 3.3 kW).

- Current state of the WPT related standards are not adequate and require international support.
- Higher power WPT deployments such as those for commercial vehicle applications have additional consideration areas including grid impacts, bi-directional charging and peak demand timing.

NEXT STEPS

Task 26 concluded in 2019 with a final report submitted to the ExCo and Task 1 Operating Agent. The report will be made available on the HEV-TCP website. As a follow on to Task 26, Task 45 was proposed to focus on Electrified Roadways (e-Roads). Task 45 will focus on the various technologies which allow EVs to charge while in motion. This will include wireless charging technologies and conductive methods as well as identifying R&D which might be applicable to e-Roads but developed for static charging infrastructure.

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 26 OA:

OPERATING AGENT
Burak Ozpineci, PhD
Oak Ridge National Laboratory
2360 Cherahala Blvd.
Knoxville, TN 37932 USA

burak@ornl.gov
+01-865-946-1329

TASK 30 ASSESSMENT OF ENVIRONMENTAL EFFECTS OF ELECTRIC VEHICLES

MEMBER COUNTRIES
AUSTRIA
CANADA
GERMANY
SPAIN
REPUBLIC OF KOREA
TURKEY
UNITED STATES

INTRODUCTION

Electric vehicles (EVs) have the potential to substitute conventional vehicles to contribute to the sustainable development of the transportation sector worldwide, for example, in the reduction of greenhouse gas (GHG) emissions, fossil energy consumption and particle emissions. There is international consensus that the improvement of the sustainability of EVs can only be analysed based on life cycle assessment (LCA), which includes the production, operation and end-of-life (EoL) management of the vehicles, and the fuel cycle (Figure 1). All environmental impacts must be included within 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.

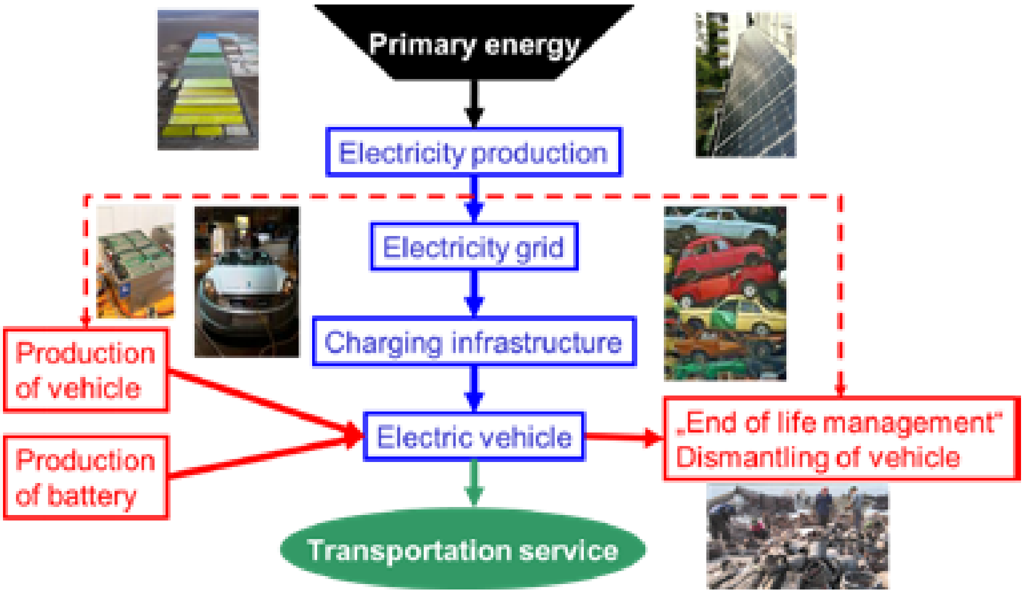


Figure 1: System boundaries for life cycle assessment of EVs

OBJECTIVES

The aim of Task 30 (2016 – 2020) is to analyse and assess environmental effects of EVs on water, land use, resources and air based on LCA and in cooperation with participating countries in the HEV TCP.

Task 30 is using the results of the completed Task 19 "Life Cycle Assessment

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

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 LCA. Observing the three phases of LCA, namely production, operation and dismantling of EVs, various environmental effects of EVs on water, land use, resources and air, among others, are analysed and assessed. Thereby a strong emphasis is put on the comparison of environmental effects between pure battery EVs (BEVs) and Plug-in hybrids (PHEVs) and conventional internal combustion engine (ICE) vehicles using gasoline and diesel.

In recent years, the focus in environmental assessments of EVs was on global warming and primary energy consumption. But now it is recognised 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 focuses also 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 air (local emissions and effects of NOx, PM and CxHy, human health effect and non-energy related emissions from tires and brakes).
- Effects on EVs on land use – resources - waste (land use, occupation and degradation, demand of renewable and fossil resources, recycling).
- Overall environmental effects and their assessment (comparing and assessing different impact categories, single score methodologies, stakeholder involvement).

WORKING METHOD

Within the Task, methodologies are being developed to assist countries in implementing EVs, by identifying opportunities to maximise the environmental benefits. In addition, various case studies are to be analysed, and shared with networking and information exchange, which is supported within the Task's structure (Figure 2). The Task proceeds by organising a series of expert workshops addressing the following objectives:

- methodologies on assessment of environmental effects,
- analysis of necessary and available data,
- overview of international studies/literature,
- analysis of current knowledge and future challenges,
- overview of key actors and stakeholders and their involvement,
- communication strategies to stakeholders, and
- summarising further R&D demand.

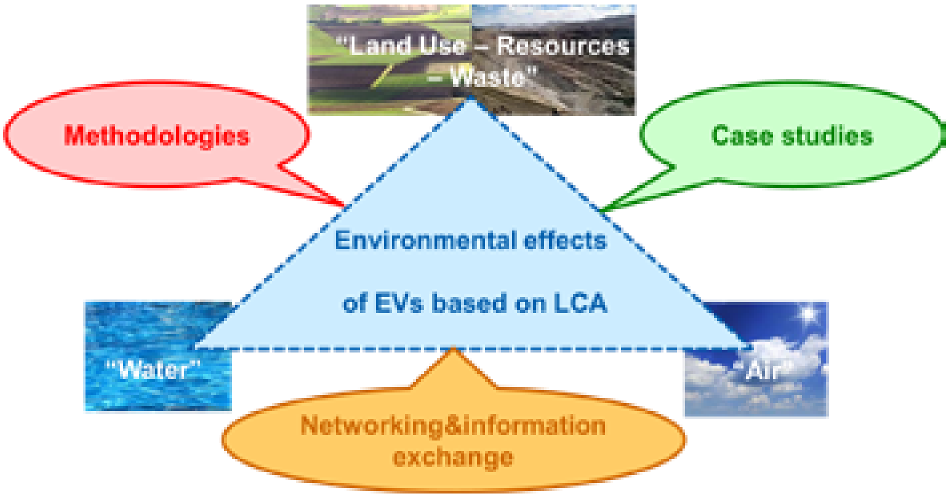


Figure 2:
Working method in Task 30

RESULTS

EXPECTED FINAL RESULTS

The members in this Task compile a list, including facts and figures, of the environmental benefits and impacts of EVs, with the goal to increase their overall acceptance. Thus, numerous advantages of EVs compared to conventional vehicles are shown. These results will help the industry and government to support the further development and employment of EVs in all transport modes. The results will document and summarise 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 air,
- effects of electric vehicles on land use – resources – waste,
- overall environmental effects and their assessment of EVs, and
- R&D demand.

In addition to these technical and scientific results, a framework for communication strategies to stakeholders and dissemination activities (e.g. proceedings, reports, papers, notes, presentations) will also be made available.

In the previous annual IEA HEV reports the results on water and air are already documented.

RESULTS ON RESOURCES, WASTE AND LAND USE

In June 2019, Task 30 held an expert workshop on the effects of EVs on land use, resources and waste in Washington D.C., USA. The aim of this expert workshop was to analyse and assess the environmental effects of EVs on land use, resources and waste based on LCA in a cooperation of the participating countries in the IEA. The current status and the future perspectives of an EV's LCA on these issues in comparison to that of a conventional vehicle, an ICE, were presented and discussed. The focus was on BEVs and PHEVs.

In a group of relevant stakeholders from government, industry, research and NGOs, the relevant issues of effects on land use, resources and waste were identified and discussed referring to the ongoing large-scale market introduction of EVs.

Resources and waste

CoConcerning the effects of resources and waste the following topics were discussed:

a) LCA of battery production,
b) LCA of battery recycling,
c) LCA of electric motor recycling (mainly magnets), and
d) LCA of power electronics recycling.

LCA of battery production

The following key battery materials were updated in GREET (LCA model):

- cobalt: shares of Co coproduced with Ni/Cu; shares of sulphide/laterite; ore grade,
- nickel: shares of sulphide/laterite; ore grades; SOx emissions control,
- lithium: shares of lithium produced form brine/minerals,
- graphite: shares of natural/synthetic graphite.

The most relevant categories on energy demand and emissions of an NMC111 LIB under baseline condition are:

- NMC111 Cathode: Cobalt (sulfate production); Nickel (refining); other cathode steps (NMC11 precursor & powder production),
- aluminum: alumina reduction & SF4/S2F6 abatement,
- battery management system (BMS): electricity source, and
- cell assembly: heat and electricity source.

As an example in Figure 3 the Cradle-to-Gate environmental impacts of a 1 kWh NMC111 battery are shown, where cathode, production energy and aluminum are notable contributors:

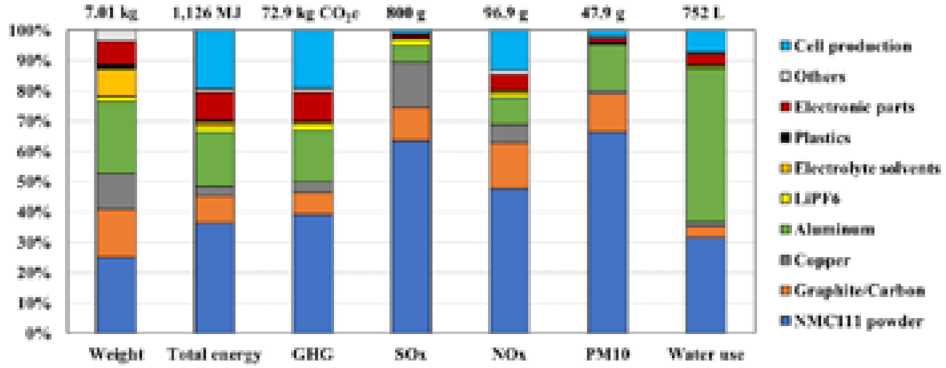


Figure 3: Cradle-to-Gate environmental impacts of 1 kWh NMC111 battery[1]

LCA of battery recycling

Actually, there are three main processes for the recycling of batteries:

1. pyro process for recycling of batteries,
2. hydro process for recycling of batteries, and
3. direct recycling of batteries (under development).

Based on current experiences in Germany initial conclusions on battery recycling are drawn:

[1] L Gaines: LCA and Direct Recycling for Lithium Ion Batteries, Presentation at Task 30 workshop, June 2019

- A careful dismantling offers significant environmental benefits.
- Major credits are possible from housing materials and other components (e.g. from recycling of steel, aluminium, copper, precious metals).
- Recycling of battery cells offers credits for Co, Ni, Cu; furthermore lithium recycling would be possible, but a further process development is necessary.
- Huge importance for attenuating pressure on primary demand for key materials.

LCA of electric motor recycling (magnets)
An LCA was performed within the German project “MORE – Recycling of components and strategic metals from electric motors”. The following three different processing routes were analysed with the major interest to recover neodymium (Nd) and dysprosium (Dy):

1. direct reuse (cleaning): production of 1 kg magnet via reuse,
2. remelt (closed loop magnet remelting): production of 1 kg secondary magnet (70% primary and 30% secondary materials), and
3. feedstock recycling (recovery of “rare earth” oxides from EoL-magnets): production of 1 kg “rare earth” oxide (mixed or separated).

The initial conclusions regarding LCA of electric motor recycling (magnets) are:

- Major GHG emission credits for recovery of “rare earth” oxides, also remelting with secondary share of 30% offers benefits.
- GHG emissions of recovery effort generally well outweighed by credits for Nd and Dy oxides, magnitude strongly depends on allocation method (economic or mass based).
- In addition, other categories show strong credits for recovery of “rare earth” oxides.
- Data availability for assessment of primary production of RE, especially Dy, is very limited and uncertain.

LCA of power electronics recycling
An LCA was performed within the German project “ElmoRel 2020 – Electric vehicle recycling 2020 – key component power electronics”. The following three different processing routes were analysed

1. conventional car shredder (reference route),
2. dismantling & Waste of Electrical and Electronic Equipment (WEEE) recycling of power electronics, and
3. dismantling & WEEE recycling of power electronics incl. chemical dissection of polychlorinated biphenyls (PCB).

The initial conclusions in relation to LCA of power electronics systems are:

- In comparison to the conventional car shredder, route extraction of power electronics unit enables high recovery rates for gold, silver and palladium; recovery rates of tin and copper can also be increased.
- LCA shows good results for both routes, with dedicated WEEE recycling providing additional benefits from some higher recovery rates and corresponding credits.
- Main benefit of dedicated WEEE recycling from a resource conservation

perspective.
- The effort for the additional recovery of tantalum (Ta) from PCB seems to be too high as to be environmentally attractive.
- The WEEE recycling route is economically viable, but offers a lower profit margin than the car shredder route.

Land use

The possible environmental effects of land use are relevant because:

- more than half of the earth's terrestrial land is actively being used by humans,
- the resulting loss of biodiversity and soil functions expressed by ecosystem services is of scientific, political, societal and economic concern,
- there are many methods that can be developed to address land use impacts in LCA, and
- therefore, country and region specific characterisation factors should be a mandatory requirement.

Land use is correlated to occupation of land and transformation of land. In relation to LCA, the inventory data are relevant for land occupation [m^2*a] and land transformation [m^2]. However, especially for mining processes these input data are often not known exactly and are therefore estimated. So far, there is no consistent comparison of possible land use effects of EVs and ICEs available. For EVs, the mining activities for battery materials resources and the generation of renewable electricity, mainly, might be relevant for land use, whereas for conventional ICEs the extraction of oil might be relevant.

Finally, the main issues of resources, waste, and land use that should be addressed in an LCA of EVs were identified in the workshop discussions. These are:

- **Resources:**
  - o minerals,
  - o fossil fuels,
  - o resource criticality,
  - o resource depletion not a primary environmental concern,
  - o virgin,
  - o recycled,
  - o no consensus on impact assessment methodology in LCA,

- **Waste:**
  - o reuse,
  - o recycling,

- **Land use:**
  - o land transformation [m^2],
  - o land occupation [m2*a],
  - o ecosystem services.

In Figure 4 a mind map on “Land Use – Resources – Waste in LCA of EVs”, with further details on the key issues, is shown.

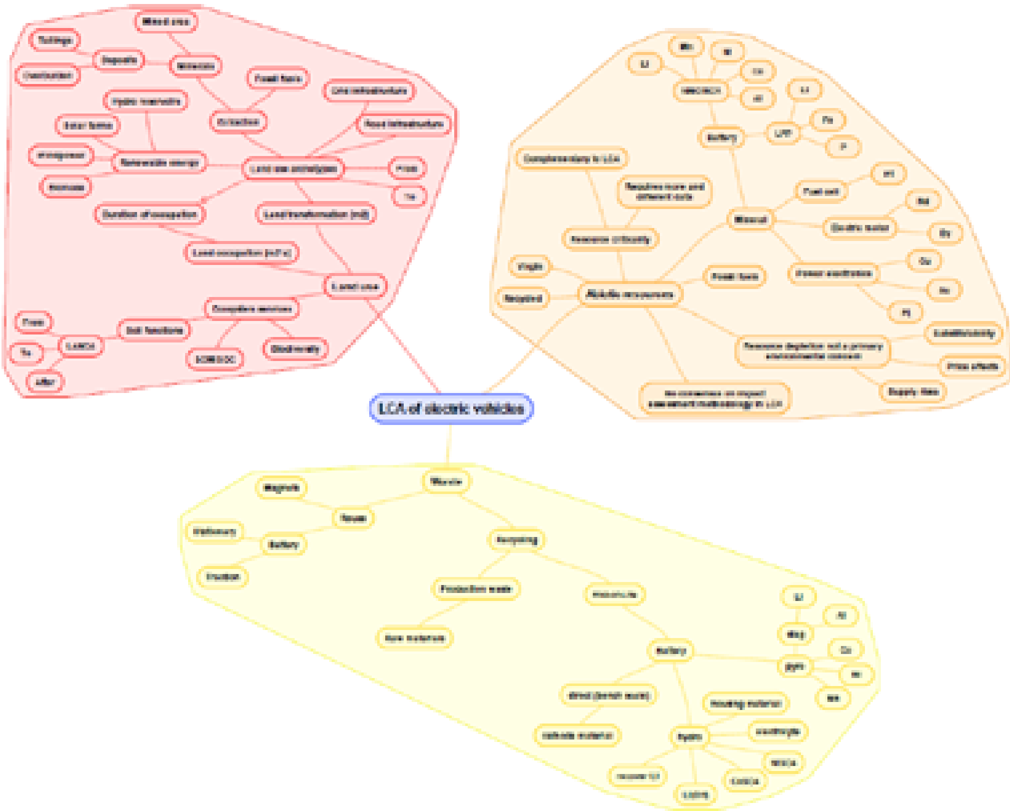


Figure 4:
Mind map on "Land Use – Resources – Waste in LCA of EVs"

RESULTS ON AUTONOMOUS VEHICLES

A special topic at the above mentioned workshop was on LCA of autonomous vehicles. The aim of this special topic was to present and discuss the evaluation of autonomous vehicles on LCA. Key issues on the LCA of autonomous vehicles were discussed and summarised within an interactive group looking at the rapid development of autonomous vehicles.

The vehicle automation is defined at multiple levels; the Society of Automotive Engineers (SAE) gives 5 levels, with level 0 for no automation:

- Level 1 – 2 require significant human interaction/monitoring of the environment all times, and the human driver will serve as the fall back plan; this only applies to some driving modes, e.g. cruise control, lane keeping, parking.
- Level 3 – 5 have increasing degrees of "full automation" where the vehicle system is responsible for sensing, actuation, and environment monitoring:
  - o Level 3: certain driving conditions automated, but driver must be able to intervene,
  - o Level 4: certain driving conditions automated, no driver intervention,
  - o Level 5: all conditions automated, no intervention.

The promises of vehicle automation are:

- convenience for drivers and passengers,
- reduced congestion,
- increased safety,
- increased productivity,
- faster travel,

- vehicle platooning (improved efficiency),
- lower “taxi” costs (taxi here is inclusive of mobility as a service companies),
- drive smoothing (less abrupt start and stops), and
- right vehicle for the trip (mode matching).

The challenges of vehicle automation are:
- rebound effect for distance lived from work,
- increased number of trips, especially taxi trips,
- empty miles (dead-heading),
- automated hunting for parking,
- safety concerns, and
- equity and less jobs.

The key parameters possibly affected by autonomous vehicles in an LCA are:
- fuel consumption affecting the operating of vehicles,
- the vehicle size and composition affecting the vehicle manufacturing, and
- lifetime of the distance travelled affecting per kilometre/miles from manufacturing the vehicle.

Due to the additional necessary equipment of an autonomous vehicle, the vehicle mass and the additional load are increasing. Current estimations for the additional load are between 200 W and 2 kW. The additional mass can also be compensated by lightweight structures; a typical rule of thumb is that light weighting can offer about 7% energy decrease by 10% mass reduction. The smoother driving might reduce energy consumption by up to 15%.

The five main areas of LCA of autonomous vehicles were identified as:
- vehicle level (e.g. energy consumption, vehicle mass changes, level of automation, vehicle lifetime mileage),
- operating conditions (e.g. climate, fleet composition, driving cycles),
- behaviour (e.g. user acceptance, user misuse),
- infrastructure (e.g. V2I/V2V – vehicle to infrastructure/vehicle to vehicle, energy consumption, traffic lights, parking space), and
- system level (e.g. rebound effect, mode shift, ride sharing, ride smoothing).

ESTIMATED ENVIRONMENTAL EFFECTS OF WORLDWIDE EV-FLEET

Since 2014, the Task has estimated the LCA based environmental effects of the worldwide electric vehicle fleet in 38 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 1. The key parameters influencing the environmental effects of vehicles with electric drivetrains are the electricity demand per distance travelled,the mix of technology for electricity generation, and the substitution factor of ICE vehicles by EVs in a globally increasing vehicle stock.

The analysis is done for each of the 38 countries separately and the main country specific results are summarised in "Country Factsheets on Estimated Environmental Impacts of Current EV-Fleet" documenting:

- "Basic data" on electricity generation and size of electric vehicle fleet,
  - o share of generation technologies supplying the national electricity grid,
  - o estimated environmental effects of electricity at charging point,
  - o current situation and future development of national electricity market (incl. import & export),
  - o size of electric vehicle fleet: number of BEV and PHEV,

- "Estimation of LCA based environmental effects" by substituting conventional ICE,
  - o absolute annual change,
  - o relative annual change (referring to substituted ICE vehicles).

There are approximately 5 million electric vehicles in 38 countries worldwide in 2018[2,3], of which:

- 3.2 million are BEVs and 1.8 million are PHEVs,
- 45% are in China, 22% in the USA, 5% in Japan and 5% in Norway in 2018.

Based on the country specific results the total global environmental effects in 2014 to 2018 of the globally increasing EV fleet are estimated finally. Figure 5 shows the total reduction of GHG emissions with approx. 5 Mt CO2-eq in 2018, mainly resulting from the EVs fleet in IEA HEV countries, whereas the sum of the non IEA HEV countries has nearly no effect in changing the GHG emissions. The estimated cumulative primary energy change of the global EV fleet gives a reduction of approx. 5,000 GWh/a, which is shown in Figure 6. The IEA HEV countries substantially contribute to this reduction, where the non IEA HEV countries even result in an increase of cumulated primary energy demand.

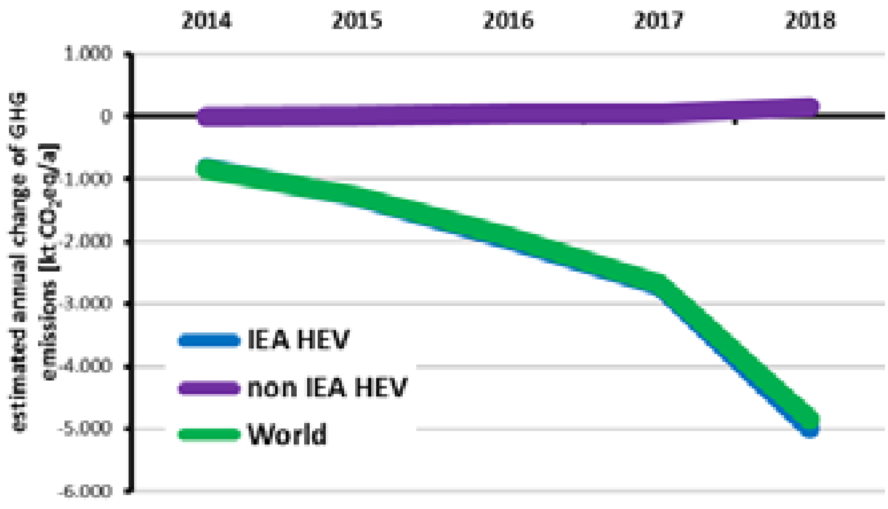
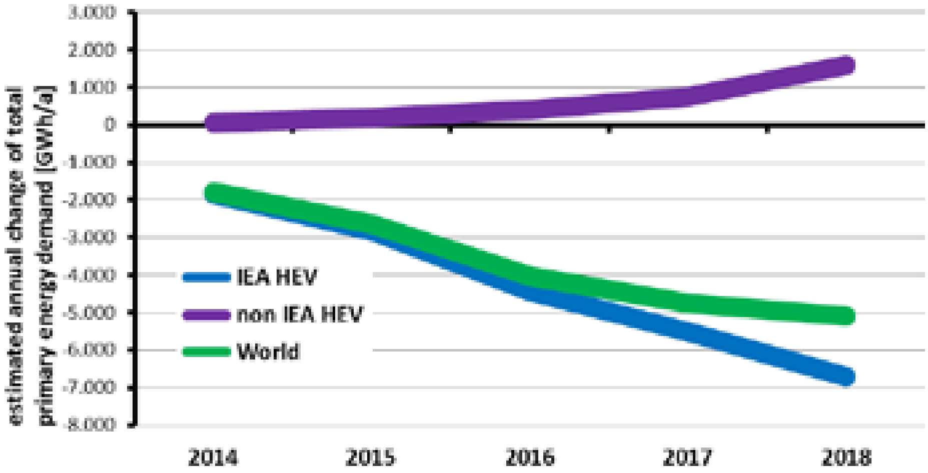


Figure 5: Estimated range of increasing GHG reduction of EVs substituting ICE vehicles globally (2014 – 2018)

[2] IEA 2019: Global EV Outlook - Scaling-up the transition to electric mobility, https://webstore.iea.org/global-ev-outlook-2019

[3] IEA-HEV 2019: Annual Reports 2014 – 2019, http://www.ieahev.org/news/annual-reports/

Figure 6:
Estimated range of change in cumulative primary energy consumption of EVs substituting ICE vehicles globally (2014 – 2018)



The share of electricity produced from fossil fuel has a substantial influence on the EV related emissions. A relatively large share of renewable or/and nuclear electricity contributes to substantial environmental benefits in the affected countries (e.g., NO, FR, AT). On the other hand, a relatively large share of fossil electricity contributed to an increase of impacts in the relevant countries (e.g., PL, CN).

Concluding on the environmental assessment of the global EV fleet, based on LCA compared to the substituted conventional ICE vehicles leads to the following key issues:

- The environmental effects depend on the national framework condition, e.g. national grid electricity generation mix.
- The broad ranges of possible environmental effects are caused by the:
  - o emissions of the national electricity production and distribution,
  - o electricity consumption of EVs at charging point, and
  - o fuel consumption of substituted conventional ICE vehicles.
- The highest environmental benefits can be reached by using additional installed renewable electricity, which is synchronised with the charging of the EVs.
- The adequate loading strategies for EVs to integrate additional renewable electricity effectively will create further significant environmental benefits.

NEXT STEPS

The next workshop "Overall Environmental Assessment of EVs", is scheduled in 2020, Barcelona (Spain) organized by IREC (Catalonia Institute for Energy Research).

The dissemination activities were:

- Paper & presentation: Time and Rebound Effects in the LCA of Electric Vehicles - Methodological Approach and Examples, IEWT 2019, Vienna University of Technology, Vienna, Austria, February 13 – 15, 2019
- Presentation & paper "Evaluation of the Environmental Benefits of The Global EV-Fleet in 40 Countries – A LCA Based Estimation in IEA HEV", EVS32 – Electric Vehicle Symposium Lyon, France, May. 19 – 22, 2019

- Key note presentation in Plenary session "Life Cycle Assessment of Electric Vehicle - Experiences of in the IEA Collaboration Program on Hybrid and Electric Vehicles (HEV)", EV2019 - Electric Vehicles International Conference & Show, October 3-4, 2019 in Bucuresti, Romania
- Reviewed Publication "An international dialogue about electric vehicle deployment to bring energy and greenhouse gas benefits through 2030 on a well-to-wheels basis, Transportation Research Part D 74 (2019) 245–254"

OPERATING AGENT CONTACT DETAILS

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

OPERATING AGENT

Dr. Gerfried Jungmeier
JOANNEUM RESEARCH Forschungsgesellschaft mbH
LIFE – Institute for Climate, Energy and Society
Waagner Biro Strasse 100
A-8020 Graz, Austria

gerfried.jungmeier@joanneum.at
+43 316 876 7630

TASK 32 SMALL ELECTRIC VEHICLES

MEMBER COUNTRIES
GERMANY
SWITZERLAND
REPUBLIC OF KOREA
BELGIUM
UNITED KINGDOM

INTRODUCTION

Pressure on reconsidering transport options is increasing. Growing global population, motorisation rate and urbanisation as well as increasing 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 vehicles (SEV) could effectively support reaching the targets. The variety of SEV models for passenger and commercial transport has increased in recent years, including a few models from established OEMs (e.g. Renault Twizy, Toyota i-Road) as well as many models offered by small companies (e.g. Alkè ATX, Aixam eCity Pack). However, in many parts of the world SEVs still constitute a very low share of the existing vehicle fleet and vehicle registrations.

Small electric vehicles considered in this task include three- and four wheeled vehicles that are propelled by a locally emission free technology and are classified in one of the L-categories L2e, L5e, L6e and L7e according to UNECE Regulation Nr. 168/2013[1]. The task additionally comprises locally emission free vehicles that do not exceed 3.5 m, a maximum drive power of 55 kW and an unladen weight up to 1,200 kg. Examples for that type of vehicle are the Smart fortwo ED or Mitsubishi i-MiEV.

OBJECTIVES

The objective of this task is to promote broader commercialisation, acceptance and further development of SEVs by collecting and sharing pre-competitive information, exchanges about framing conditions, best practices and ideas, and 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 such as regulations, transport policies and mobility concepts.

The key aspects are SEV concepts, status of technologies and needs for research as well as the conditions to put them on the market. Apart from the vehicles

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

themselves, the focus is on the potential future role of SEVs within advanced mobility concepts, including e.g. their role in concepts of sharing, increased automation and new public transport.

WORKING METHOD

The main approach of Task 32 is to collect and exchange information in workshops aimed at professionals from research, enterprises and policy makers, depending on the individual topics. The concept of presentations from individual stakeholders together with more interactive parts has proven to be attractive. While the Task partnership constitutes individuals from academic institutions, NGOs and policy makers, contributions from industry and their participation in workshops were explicitly welcomed.

In addition to the workshops, information was gained by surveys and special sessions at conferences to gather interested stakeholders and exchange knowledge. Results are published by writing papers, providing presentations or attending conferences.

RESULTS

Results of the Task 32 include outcomes of three workshops and one round table. Furthermore, results of an international survey with experts in the field of SEVs were generated. The compiled knowledge was disseminated in conferences and through publications.

WORKSHOPS

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

- EU regulations relevant for small 4-wheeled road vehicles
- RAK e - concept presentation from Opel
- 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 on the main difficulties in homologation and options for improvement. The second workshop “Market Conditions and Mobility Concepts” took place in Brussels, Belgium, on September 18th, 2017 at the German Aerospace Centre (DLR) Brussels Office. The main topic of the workshop was the exchange on common interests and future activities of SEV lobby organisations and key stakeholders.

The third 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 20th, 2017. The workshop focused on vehicle manufacturers from six European countries and one from the United States. Topics were regulatory framework, safety and policy activities with identification of needs for action. Amongst the main conclusions, especially on ultra-lightweight vehicles, were:

- The regulation was the primary focus as well as the in-use phase.
- There was consensus that there is limited consolidation in this area, which is detrimental.
- Attendees are looking for support to understand how the regulatory landscape will develop.
- There is a requirement for a comprehensive assessment of the regulatory landscape.

ROUND TABLE

An international Round Table was held at the Micromobility Expo in May 2019 in Hannover (Germany) with the participation of Task 32. The aim was to share best practices from different countries and talk about challenges within each country. Sharing schemes were seen as a viable option for passenger transport. For commercial transport, opportunities were seen especially in postal (newspaper) delivery because the deployment of SEVs can cut down overall costs in comparison to e.g. vans.

Figure 1: Round Table at the Micromobility Expo in Hanover, 2nd May 2019

INTERNATIONAL SURVEY

From March to October 2018 a survey combining interviews and an online questionnaire were conducted, acquiring qualitative and quantitative data about the following main topics:

- Knowledge about SEVs
- Target Groups and Usage Concepts

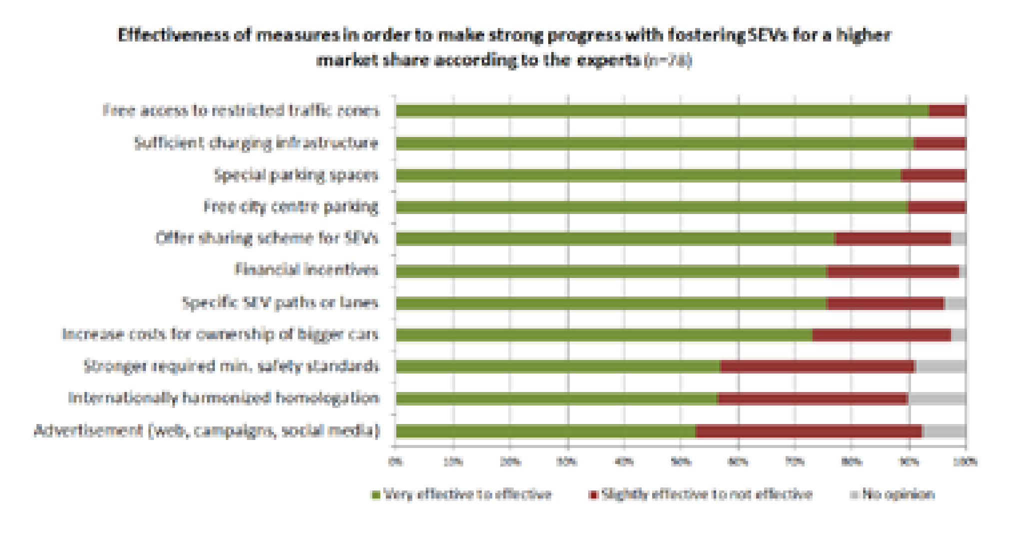
- Obstacles and Chances

The survey collects assessments of international experts from municipalities, research institutes, consultants, associations and manufacturers. We held 32 interviews and received answers from a total of 90 participants from Asia, USA and Europe in the online questionnaire.

Taking into account the barriers to market acceptance, the lack of a dedicated transport infrastructure is the most critical aspect. An appeal can only be made by measures such as separate lanes or access to restricted traffic zones in order to create an advantage over cars. Furthermore, the lack of knowledge about SEVs within the urban population is a major factor to overcome and may be a result of the small variety of models to choose from, when compared to cars. Another important aspect is safety, as the requirements for type approval are low and no crash tests are required.

Overall, there are a number of hurdles that stand in the way of a wider market acceptance. However, they indicate that there are measures to foster SEVs in municipalities especially with the help of public bodies. Therefore, charging and transport infrastructure including parking management are seen as the most effective ways to achieve good results. In addition to incentives, however, restrictions on the use of larger vehicles must also be created (see Figure 2). Ultimately, only a combination of various measures leads to a promising outcome.

Figure 2: Measures to foster SEV, Online survey



DISSEMINATION ACTIVITIES

Journal Paper

Ewert, A., M. Brost and S. Schmid (2020): Framework Conditions and Potential Measures for Small Electric Vehicles on a Municipal Level. World Electric Vehicle Journal, 11 (1). Multidisciplinary Digital Publishing Institute (MDPI). ISSN 2032-6653

Presentation & Conference Paper

Ewert, A., M. Brost and S. Schmid (2019): Fostering small electric vehicles on a municipal level, 32nd Electric Vehicle Symposium (EVS32), Lyon, France, May 19-22, 2019.

This contribution was awarded best paper in the category dialogue paper out of 224 submitted papers.

Presentation

Ewert, A. (2018): Prospects for Small Electric Vehicles (SEVs) in the Transition of Urban Mobility Concepts, AEC 2018 - Avere E-Mobility Conference, Brussels, Belgium, October 17-18, 2018.

Presentation

Davies, H., L. Vinckx, S. Gloger, M. Brost and C. Bastien (2018): Challenges and Opportunities for Improving the Safety of Occupants in Small Electric Vehicles (SEVs), Low Carbon Vehicle 2018, Millbrook, United Kingdom, 12-13 September, 2018.

Presentation & Conference Paper

Schmid, S., M. Brost, U. Muntwyler und O. Lim (2016): "Small Electric Vehicles" – A new Taskforce by IEA Hybrid & Electric Vehicle TCP, 1st World Light Electric Vehicle Summit, Barcelona, Spain, September, 2016.

NEXT STEPS

Currently an edited book is prepared with authors from science, industry, public institutions and similar. The book aims for a comprehensive international view on chances and obstacles for SEVs as well as new research and developments in the area. Topics comprise an interdisciplinary view on the subject in the areas of:

- Policy and regulations
- Environmental effects and impact studies
- Case studies and applications
- Vehicle concepts and technological aspects

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 32 Operating Agent:

OPERATING AGENT

Dr. Stephan Schmid
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Pfaffenwaldring 38-40
D-70569 Stuttgart, Germany

Stephan.Schmid@DLR.de
+49 711 6862 533

TASK 33 BATTERY ELECTRIC BUSES

MEMBER COUNTRIES

AUSTRIA
CANADA
FINLAND
GERMANY
SPAIN
REPUBLIC OF KOREA

ACKNOWLEDGEMENT

The work of the Austrian participation (2016 – 2019) is financed by the Austrian Climate and Energy Fund and the FFG.

INTRODUCTION

Battery electric bus systems have received increased attention in the past few years. After several years of testing battery electric buses in demonstration projects, several cities and urban bus operators have started to electrify their bus fleets partially or completely. Recent developments show that new charging strategies and advanced energy storage technologies enable full-day operation of battery electric buses, e.g. using the opportunity of fast charging concepts. Significant purchase cost reductions have been reached and are further expected due to technology standardisation and economies of scale. More than 20 bus manufacturers in Europe already offer various types of battery electric buses. The main bus companies have started serial production of battery electric buses, with the realisation that battery electric bus systems have the potential to substitute diesel buses in cities in the near future.

Numerous innovative projects have been initiated in recent years, especially in central European countries, from pilot projects to commercial use (e.g. Geneva, Amsterdam – Figure 1, Helsinki). They tested and demonstrated various types of battery electric buses, charging methods and strategies as well as energy storage systems. Based on the daily collection of experiences in operating battery electric buses, an evaluation and analysis of key aspects from worldwide electric bus projects (e.g. charging strategies, electric energy storage systems) is ongoing. Urban public transport is a promising starting sector for the implementation of battery electric buses, in collaboration with already existing electric infrastructure.

Figure 1: Battery electric buses at charging station in Schiphol Airport

OBJECTIVES

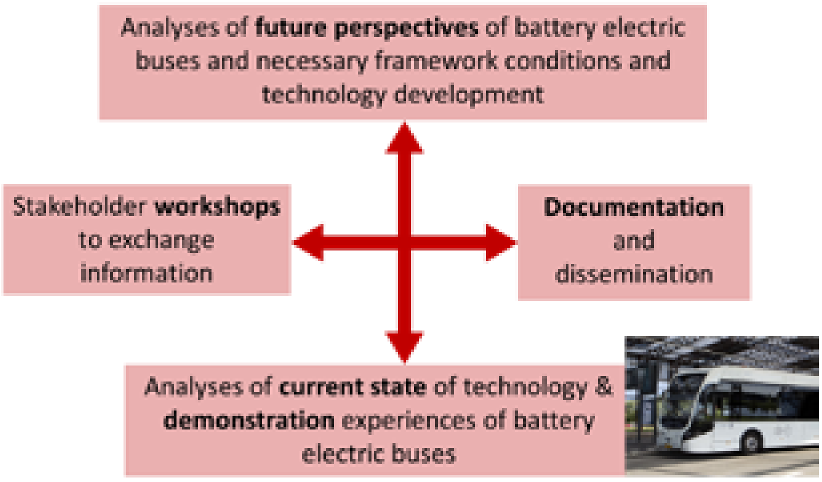
The objective of the Task 33 (2016 – 2019, Figure 2) is to analyse and assess the current state of technology and demonstration experiences of battery electric buses towards a broad market roll out. This covers on one hand the bus technology, e.g. battery or capacitor system, and on the other hand the charging infrastructure, e.g. fast charging stations at the bus stop and its optimal integration in an urban infrastructure, e.g. synergies with trams, metro or trolley bus systems. The task work is to be achieved with analysis of ongoing demonstration projects and the start of the roll out phase of battery electric buses worldwide. Based on this, the future perspectives and challenges for battery electric buses are to be analysed and described. This includes the identification of major challenges e.g. technology, costs, public acceptance and the necessary R&D demand. Finally, the key aspects for a successful broad introduction of battery electric buses and the necessary framework conditions are concluded.

The work is to be done in close collaboration of the relevant stakeholders from the three focus groups:

1. providers of public transportation services,
2. system and technology providers, and
3. research institutions.

The outputs are to be continuously documented and disseminated via presentations, workshops, conference contributions and publications.

Figure 2:
Objectives of Task 33



The major activities are:

- identify and analyse the state of technology and systems of battery electric buses,
- collect and document “International Success Stories“ in a common format,
- provide an overview of systems and technology providers with characteristic data,
- stakeholder involvement in workshops, in combination with site visit,
- analyse the combination of trolley and battery bus systems,
- analyse the integration and use of existing infrastructure of trams, trolleys

and metro,
- identify success factors, e.g. size of bus, distances between bus stops,
- describe and define various loading strategies,
- analyse sustainability issues – economic, environmental and social aspects,
- identify R&D demand,
- conclude and summarise future perspectives, and
- presentations and contributions at conferences.

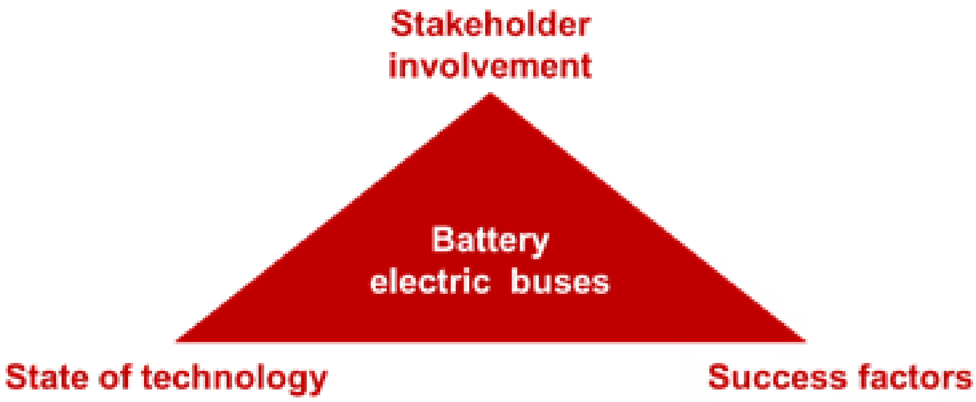
WORKING METHOD

The most important activity of the working method (Figure 3) is the organisation of workshops in different member countries to involve the stakeholders in the value chain of battery electric buses, e.g. providers of public transportation services, system and technology providers, research institutions. The organisation of workshops with participation from industry, research organisations, 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 analyse, discuss and document two areas:

1. The state of technology for battery electric buses, and
2. Future perspectives of battery electric buses.

The workshops are to be combined with site visits to demonstrate on-going activities of battery electric buses in daily life application.

Figure 3:
Working Method



RESULTS

WORKSHOP "FUTURE PERSPECTIVES OF BATTERY ELECTRIC BUSES"

The expert workshop "Future Perspectives of Battery Electric Buses" took place in Amsterdam and Eindhoven (NL) in autumn 2019. The aim of the Task 33 workshop was to analyse, discuss and assess the future perspectives for battery electric bus systems. The main topics of the workshop were:

- key notes covering views from Public Transport Operators (PTOs), bus manufacturers and charging infrastructure providers,
- future perspectives on battery electric bus systems in urban environments,
- overall system of buses and charging technologies,
- lessons learnt from demonstration projects,
- market aspects: charging system and bus providers,
- economic aspects,
- environmental aspects,
- comparison to hydrogen fuel cell buses,
- upscaling to large fleets, e.g. electric grid connection,
- summarising key issues incl. R&D demand, and
- business models and procurement procedure.

KEY DRIVERS FOR BATTERY ELECTRIC BUSES

The system of battery electric buses in combination with adequate charging infrastructure has been demonstrated globally in various European, Asian and American countries. Within the workshop, the different main drivers for the now broad market introduction of battery electric buses were identified. These are:

- climate protection and decarbonisation of the transportation sector,
- diminishing local air pollution,
- expanding the supply of more public transport services for climate friendly mobility, to motivate more people to use public transport especially in the countryside,
- establishing new bus lines are the most rapid short-term option to increase public transport services compared to installing new tram and metro lines,
- from supply to demand orientation in public transport, new public mobility services are necessary,
- initiate first systems for a so called "hybrid public transport" in the future which is the integration of autonomous vehicles in public transport,
- the European Green Vehicle Directive – further information below,
- "Green deal" in Europe: significant GHG reduction until 2030 and climate neutrality in 2050,
- innovation of new vehicle and propulsion systems,
- development of new value chains and business models,
- technology and industry development for global market,
- digitalization and mobility as a service (MaaS),
- increasing renewable electricity generation,
- sector coupling: excess renewable power,
- circular economy, and
- the expectation that 2020 – 2030 will be the "century of battery electric buses in urban environments".

CLEAN VEHICLES DIRECTIVE

In Europe the Directive (EU) 2019/1161 of the European Parliament and of the Council of 20th June 2019, amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles[1], now pushes the market

[1] Directive (EU) 2019/1161 of the European Parliament and of the Council of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles, https://eur-lex.europa.eu/eli/dir/2019/1161/oj

introduction of clean vehicles significantly. The “Clean Vehicles Directive” promotes clean mobility solutions in public procurement tenders, providing a solid boost to the demand and further deployment of low- and zero-emission vehicles. This Directive defines “clean vehicles” and sets national targets for their public procurement. It applies to different means of public procurement, including purchase, lease, rent and relevant services contracts. The Directive needs to be transposed into national law in EU member countries by 2nd August 2021.[2]

The Directive defines a “clean vehicle” as follows:

- Clean light-duty vehicle: any car or van meeting the following emission thresholds:
    - o until 31 December 2025: no more than 50g/km CO2 and up to 80% of applicable real driving emission (RDE) limits for NOx and PM;
    - o from 1 January 2026: only zero-emission vehicles.

- Clean heavy-duty vehicle: any truck or bus using one of the following alternative fuels: hydrogen, battery electric (including plug-in hybrids), natural gas (both CNG and LNG, including biomethane), liquid biofuels, synthetic and paraffinic fuels, LPG.[2]

The Directive also sets a separate definition for “zero-emission heavy-duty vehicles” (clean vehicle without an internal combustion engine, or with an internal combustion engine that emits less than 1 g CO2/kWh), as a sub-category of clean heavy-duty vehicles.

The Directive sets out mandatory minimum procurement targets in each Member State as national targets for clean light-duty vehicles, trucks and buses. On buses, 50% of the minimum target for the share of clean buses has to be fulfilled by procuring zero-emission buses. The national targets are set for two periods and are for buses:

- for 2021 -2025 between 24 – 45%, and
- for 2026 – 2030 between 33 – 65%.

CHARGING SYSTEMS

The charging systems are an essential component, when discussing battery electric bus implementation. Harmonised charging systems are necessary for fast and/or opportunity charging on the route or in the depot. Figure 4 below shows a qualitative assessment based on experts on the two different charging systems – opportunity charging (OC) and depot charging (DC), looking at charging technology, operation and vehicles. Currently there is no “one size fits all” charging solution as the site specific framework conditions have to be considered. For depot charging (110 kV with 25 MVA operation) of a big fleet of battery electric buses the grid connection is a challenge; grid availability is quite high in European cities/countries. For effective grid load management, a charging management of the bus fleet is essential; furthermore, a system approach combining bus operation and charging strategies is necessary – bus and charging infrastructure must be optimally linked.

[2] European Commission, 2019: Clean transport, Urban transport - Clean Vehicles Directive, https://ec.europa.eu/transport/themes/urban/clean-vehicles-directive_en

Figure 4: Assessment of charging technologies

Aspect	Opportunity charging (OC)	Depot charging (DC)	Remarks
Charging technology			
In depot	o	o	Both system topologies can utilize same depot charging solutions
On route	+	-	OC systems utilize automated connection devices, while DC systems typically have manual connection interface
Power grid connection	o	-	OC: 350 – 500 kW each charger; DC: 10 – 15 MW (100 – 200 buses) each charger 30 – 50 kW
Personnel demand	o	o	-
Investment cost Small fleet Big fleet	 - +	 + -	Low TCO is possible (scalability) - DC with low/mid utilization - OC with high utilization
Operation			
Line management	o	+	OC more sensitive to charging system disruptions but higher battery capacity solves that DC has smaller but more reliable operational range requiring adaptation in operation schedule.
Turn times	o	+	OC charging time at turn
Circulation	+	-	-
Personnel demand	o	-	More drivers for more buses
Rail replacement traffic	+	-	-
Vehicle			
Number of buses	+	-	More buses needed for DC
Zero emissions	+	o	Often fuel heating for DC and OC in some Northern countries
Technology	o	o	-
Personnel qualification	o	o	-

FLEET MANAGEMENT

One very important aspect for the further future development of battery bus systems is advanced fleet management. Fleet management can be utilised to optimise the operation of electric bus systems. Especially when high scale OC bus systems are considered, fleet management has functions to ensure optimal charging operations. For example, system reliability can potentially improve by charging prioritisation, which ensures the buses should always have sufficient charge before departure. Moreover, the utilisation of the existing infrastructure and electric bus component (battery) aging can also be improved by smart charging applications, avoiding unnecessary high charging powers. For instance, if a bus has a relatively high state of charge and long turnaround time, lower charging power may be used to decrease the charging stress on its battery and even out power demand from the grid. In addition, fleet management could perform active monitoring of certain indicators on the fleet. In addition, fleet management could perform active monitoring on certain indicators on the fleet. For example, tracking component state of health, suggest more optimal duty cycle circulation to even out the wear of the fleet. Fleet management applications are still mostly in the development phase at this time.

PERFORMANCE INDICATORS

The key performance indicators for battery electric bus systems are:

- Operating costs and energy consumption.
  o Energy costs for driving (€/km): including electricity (from grid) and heater fuel.
  o Operational driving distance (%/km): operational (on route) distance driven compared to the planned bus circulation.
  o Total electricity consumption (kWh/km): total charged external energy (from charger) / kilometres driven (both on route and total km's).

- Charging system performance.
  o Time required positioning the bus at the charger (s): time to manoeuvre the bus to the charger. From arrival at the charger proximity to the point when the driver initiates the charging.
  o Total charging time (s): charging duration per sequence step from the charging start command to bus being ready to leave.
  o Charging node utilisation (%): time when the charging position is occupied / time available. Time occupied includes the active and inactive time periods.

- System performance.
  o Depart on schedule (%): percentage of departures left on schedule.
  o Availability of the vehicles (%): percentage of the time that the vehicles have been available for service.
  o Availability of the infrastructure (%): percentage of time when charging service is available / calendar time.

As additional indicators the following are relevant:

- Powertrain electricity consumption (kWh/km): inverter consumed electricity / kilometres driven (on route)
- Heating electricity consumption (kWh/km): electricity consumed by the HVAC system (both on route and total)
- Auxiliaries electricity consumption (kWh/km): electricity consumed by other electric auxiliaries, such as power steering, air compressor and DC/DC (on route)
- Fuel consumption (l/h): fuel heater fuel consumption vs. temperature
- Charging efficiency (%): electricity from the grid / Electricity into the battery
- Dead time in charging (%): Dead time in charging / total charging time
- Battery efficiency (%): electricity out from the battery / Electricity into the battery
- Total system energy efficiency (%): electricity out from the battery / Electricity from the grid
- Minimum SoC in operation: lowest battery state of charge in operation
- Average delta SoC in operation: estimate from operational data
- Battery health, SOH (%): Percentage of the remaining battery capacity versus battery nominal capacity

OTHER LOW- OR ZERO-EMISSION BUS SYSTEMS

Besides battery electric buses, hydrogen fuel cell buses, and synthetic biofuels and E-fuels (made from CO_2 and electricity) with an internal combustion engine (ICE) are also future options for low- or zero-emissions bus systems. The application of biomethane and hydrotreated vegetable oil (HVO) is an option; in future the application of synthetic biofuels is also possible. Battery electric buses have a limited range by charging, but can be applied in urban areas. If there is the need for longer range buses hydrogen fuel cell buses and biofuel ICE buses might be a suitable alternative. In many countries hydrogen strategies are available, but the provision of green hydrogen is still very challenging. However, just as with the battery electric bus, further technical developments and significantly lower procurement costs for H_2 vehicles or tax incentives for the use of renewable fuels are needed here.

Below Figure 5 shows a qualitative assessment, based on expert judgements on the different bus technology systems compared to diesel covering the aspects of fuel/energy supply –charging/fuelling systems and bus technologies. Currently there is no "one fits all" bus technology, but battery electric buses have strong advantages in terms of technology and short term introduction.

Figure 5: Assessment of different bus system technologies

Aspect	Battery electric bus	Hydrogen fuel cell bus	Synthetic biofuel ICE bus	E-fuel ICE bus	Diesel ICE bus
Fuel/energy supply					
State of technology	+	o	-	-	+
Renewable energy	+	o	o	-	-
Efficiency (WtT)	+	o	o	-	o
Investment costs	o	o	-	-	+
Integration in existing infrastructure	+	o	o	-	+
Charging/fueling system					
Integration in existing infrastructure	o	o	+	+	+
Driving distance per charging/fuel	-	o	+	+	+
Investment costs	o	-	+	+	+
Bus technology					
State of technology	+	o	+	+	+
Market availability	+	-	+	+	+
Efficiency (TtW)	+	o	-	-	-
Local emissions	+	+	-	-	-
Heating	o	+	+	+	+
Cooling	o	+	+	+	+
Investment costs	o	-	+	+	+
Operational costs	+	-	-	-	o

„+" solved
„-" challenging
„o" neutral

ENVIRONMENTAL ASPECTS

The environmental aspects of battery electric buses can only be assessed on the basis of Life Cycle Assessment (LCA) taking the entire life cycle into account – production of the bus (incl. battery) and the infrastructure, operation of the bus including the supply of the electricity and the end of life management of the facilities, e.g. recycling, reuse. The environmental effects deriving from LCA must be compared to a diesel bus (and hydrogen fuel cell bus if of interest). The environmental benefits of battery electric buses can be maximised if additional renewable electricity is used and if future battery production reaches high production capacity, realising economies of scale efficiency potentials and using renewable energy. The current battery production mainly in Asia is associated with relevant GHG emissions and fossil energy demand in the LCA of current bus systems. By using a high share of renewable electricity for battery buses, the total GHG emissions (Figure 6) and fossil energy demand (Figure 7) are lower than for diesel buses, and hydrogen buses. Battery electric buses have no local emission (e.g. PM, NOx) and contribute to the improvement of air quality in cities.

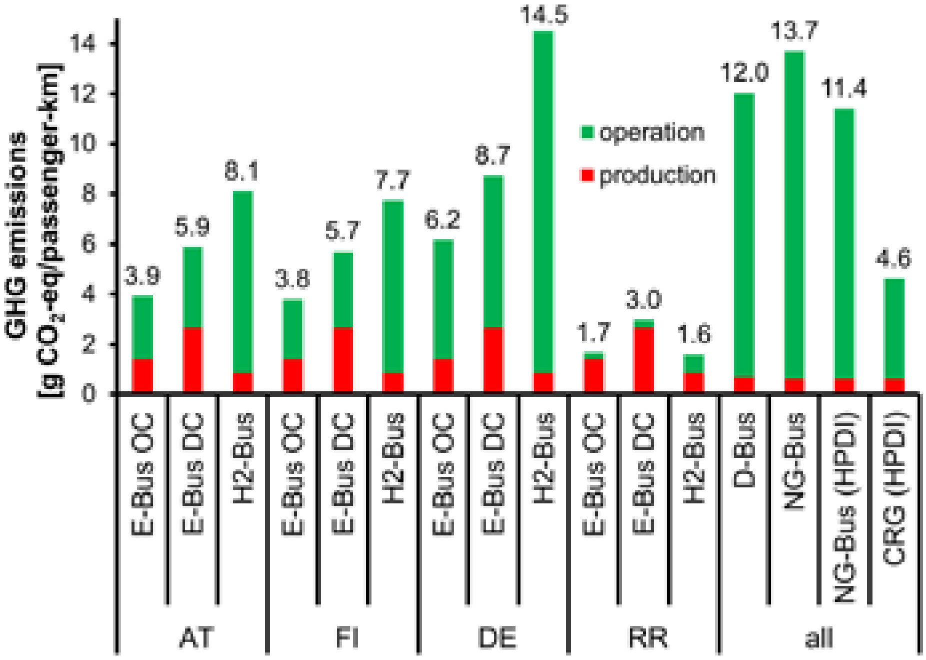


Figure 6:
GHG emissions: LCA based comparison per passenger capacity kilometre

OC: opportunity charging;
DC: depot charging overnight;
RR: "Renewable Republic": fictive country with 100% renewable electricity;
NG: Natural Gas
HPDI: high pressure direct injection;
CRG: Compressed renewable gas (biomethan 40% residues and 60% maize)

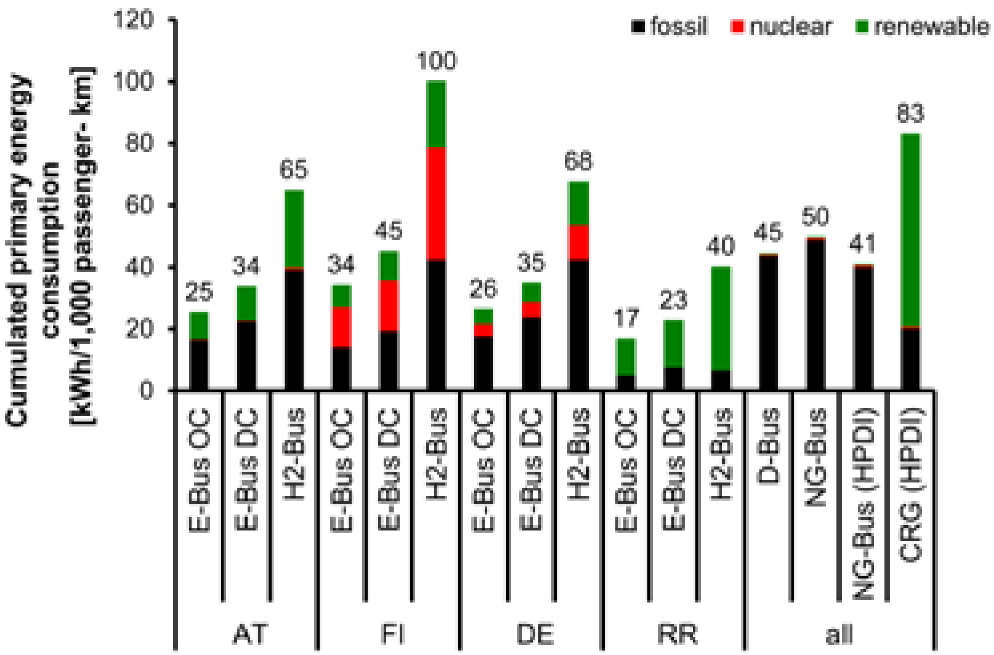


Figure 7:
Primary energy consumption: LCA based comparison per passenger capacity kilometre

OC: opportunity charging;
DC: depot charging overnight;
RR: "Renewable Republic": fictive country with 100% renewable electricity;
NG: Natural Gas
HPDI: high pressure direct injection;
CRG: Compressed renewable gas (biomethan 40% residues and 60% maize)

CURRENT TRENDS

Focusing on current trends it can be observed that the battery capacity of both OC and DC buses is continuously increasing (Figure 8). Over the last 2 years, the increase is especially big in OC buses that increased from ~60 kWh up to +200 kWh. E.g. in the Nordics, 12 m OC buses with battery capacity of over 200 kWh have already entered the service. The manufacturers are forecasting further increases in battery performance. In urban use, battery buses with ranges of 150 to 250 km can already be used on around one third of regular routes. The next generation is expected in 2021, and could then cover more than 300 km at a stretch. Regarding DC buses, high-capacity solid-state batteries are entering the markets. For example, Mercedes Benz has started offering bus models with up to 441kWh solid-state battery from 2020.

Different sizes of battery electric buses are available, ranging from 12, 15 and 18 m buses. All major bus producers in Europe and in China are also producing battery electric 12 and 18 m buses, but also new comers can be found on the market. Chinese manufactured buses are expected to enter the European markets. Currently, Chinese buses are not allowed to be sold to US, and since China has reduced the domestic incentives for battery electric buses, and as European countries have big pressure to decrease public transport related emissions, it is expected that the market amount of Chinese buses in EU will probably increase significantly. The European manufacturers have to significantly increase their production capacity, to meet the expected strongly increasing market demand. Many European bus manufacturers now invest or are starting to invest in new production facilities, e.g. VDL. The Chinese buses have traditionally been DC buses, however, the new generation Chinese buses (esp. made by BYD) can also be OC buses with small/medium sized batteries.

For the design of new light weight battery electric buses, more aluminium and plastic components are set to be developed and integrated in innovative new use concepts.

A mass roll out phase of battery electric buses has begun, as projects are achieved by rolling out 100s of battery electric buses at once. Examples are:

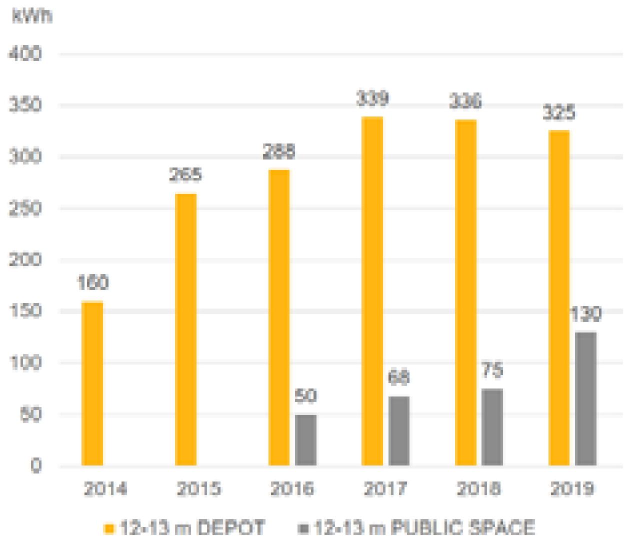
- Helsinki aims for 30% of city buses electrified by 2025 (equals to about 400 battery electric buses),
- cities of Athens, Paris and Madrid, and the country of Norway, plan to remove diesel vehicles by 2025,
- other cities and regions have announced plans to stop purchasing conventionally fuelled buses, including Copenhagen (in place since 2014), London (announced for 2018), Berlin (announced for 2020) or Oslo (announced for 2020),
- UITP (Union Internationale des Transports Publics) has stated that more than 13 public transport operators and authorities in a further 18 European cities have a strategy up to 2025; by then, they are expected to have more than 6,100 battery electric buses in service, representing 43% of their total fleet of 14,000, and
- according to one source, the amount of battery electric buses in Western Europe (+Poland) jumped to 1,687 in 2019[3] (from 548 in 2018).

[3] Sustainable bus, 2019: Record year 2019. The big leap forward of e-bus market in Western Europe, link: http://www.sustainable-bus.com/news/record-year-2019-the-big-leap-forward-of-e-bus-market-in-western-europe/

This mass roll out of battery electric buses does however come with some main challenges:

- availability of battery electric buses and charges in daily operation (as less/ no diesel buses are there for backup),
- integration of fleet management,
- energy and charging management to reduce cost and power capacity, and
- grid stability and quality.

Figure 8:
Average battery capacity, 12 – 13 m electric bus [4]



R&D ISSUES

Focusing on the further development of battery electric buses, R&D needs are identified in the following fields:

- heating and cooling systems and strategies,
- inductive charging at stations/road,
- high power charging 1 MW and higher,
- light weight vehicles, e.g. plastic and aluminium,
- additional capacities to batteries for very quick charging,
- bus to grid (B2G) concepts, applications and business models, and
- integration of 2nd life batteries in depot charging system for peak shaving and additional renewable electricity storage.

This summarised the main future challenge, of developing an advanced fleet management systems for battery electric buses to provide an optimal daily fleet operation.

[4] Danchell, Joachim, 2019: An overview of zero emission buses in the Nordic countries – by the end of 2019, link: https://zero.no/wp-content/uploads/2019/09/03.1-Overview-of-zero-emission-bus-in-the-nordic-Joachim-Danchell-Movia.pdf

NEXT STEPS

The Task 33 was finished in 2019; therefore, there are no next steps. The dissemination activities were:

- Key note presentation in Plenary session Life Cycle Assessment of Electric Vehicle - Experiences of in the IEA Collaboration Program on Hybrid and Electric Vehicles (HEV), EV2019 - Electric Vehicles International Conference & Show, October 3-4, 2019 in Bucuresti, Romania
- Presentation LCA of Battery Electric Buses and Comparison to Diesel and Fuel Cell Buses – What is the Functional Unit, expert workshop Effects of EVs on Land Use – Resources – Waste incl. special topic: LCA of Autonomous Vehicles; June 13 – 14, 2019; Washington D.C., USA
- Presentation Current Status of Battery Electric Buses, Austrian Expert Workshop “Future of Battery Electric Buses in Austria”, October 8, 2019 in Graz, Austria
- Documentation of expert workshop Battery Electric Buses – State of Technologies and Practical Experiences, December 11&12, 2018; Espoo, Helsinki, Finland
- Documentation of expert workshop Battery Electric Buses – Future Perspectives in Urban Environment, November 20&21, 2019, Amsterdam and Eindhoven, The Netherlands

OPERATING AGENT CONTACT DETAILS

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

OPERATING AGENT
Dr. Gerfried Jungmeier
JOANNEUM RESEARCH Forschungsgesellschaft mbH
LIFE – Institute for Climate, Energy and Society
Waagner Biro Strasse 100
A-8020 Graz, Austria

gerfried.jungmeier@joanneum.at
+43 316 876 7630

TASK 34 BATTERIES

MEMBER COUNTRIES
CANADA
GERMANY
SWEDEN

INTRODUCTION

Task 34 deals with topics related to the chemistry and performance of electrochemical energy storage devices of interest to those working on electric drive vehicles. Electric vehicles are important because they reduce our reliance on petroleum, thereby increasing economic security, and providing an opportunity to improve air quality with increased fuel economy while reducing, or eliminating, tail-pipe emissions. Since batteries account for a significant part of the total cost of electric vehicles (EVs); R&D continues world-wide to develop higher energy density, abuse-tolerant and affordable batteries – i.e., batteries that would cost less, weigh less, last longer, avoid range anxiety, and lead to widespread electrification of the transportation sector.

OBJECTIVES

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

WORKING METHOD

The primary focus of this task is 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.

RESULTS

LITHIUM BATTERY RECYCLING R&D CENTER (RECELL)

Advantages of Lithium Battery Recycling

Currently, lithium-ion batteries contain a substantial amount of cobalt, a critical material that is both expensive (in 2017, average annual cobalt prices more than doubled) and dependent on foreign sources for production.[1] The Democratic Republic of Congo supplies nearly 60% of the world's cobalt with 60% going

[1] U.S. Geological Survey, Mineral Commodity Summaries, Cobalt, January 2018, https://minerals.usgs.gov/minerals/pubs/commodity/cobalt/mcs-2018-cobal.pdf

to China. China is the world's leading producer of refined cobalt and a leading supplier of cobalt imports to the United States[2]; this dependency could become a concern for U.S. end-users. The growth in demand for lithium-ion batteries for EVs will establish EVs as the largest end-user of cobalt and lithium, and could potentially create a cobalt and lithium supply risk.[3,4,5]

In addition to addressing supply security issues with cobalt, there are substantial environmental benefits to recycling because of resource preservation itself. When key battery materials (e.g., cobalt or lithium) are derived from natural resources as compared to from spent batteries, the environmental footprint is a lot larger (see Figure 2) and therefore less benign. The benefits of recycling lithium-ion batteries are considerable, both from an economic and a national security perspective.

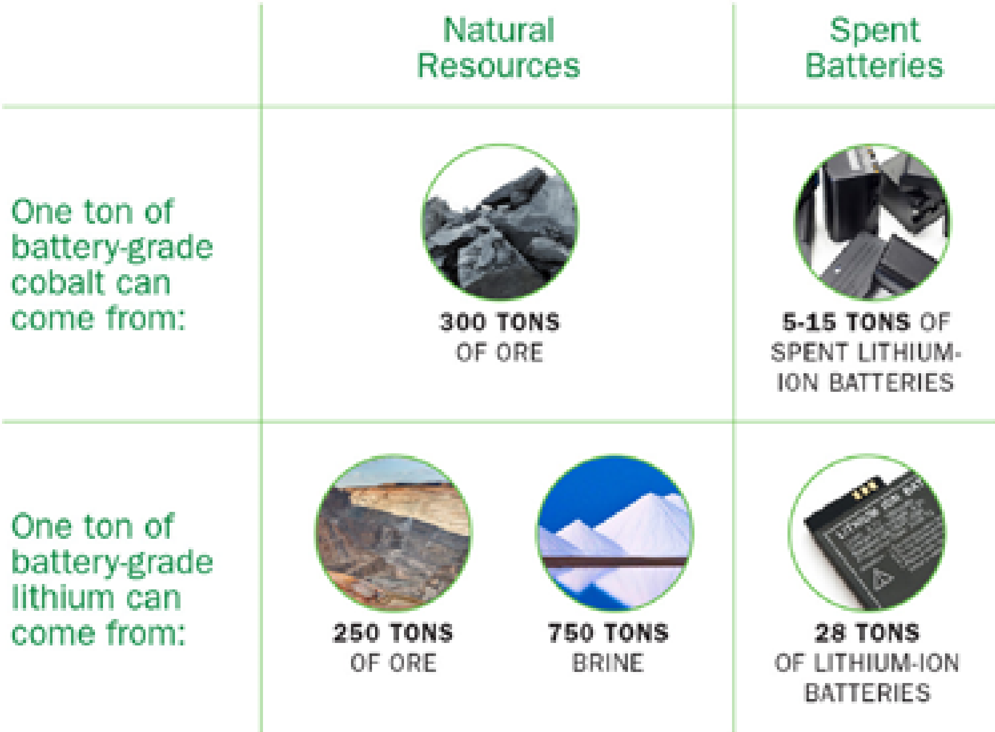


Figure 1: Potential Material Supply from Recycled Li-Ion Batteries

Source: Argonne National Laboratory

Lithium Battery Recycling Challenges

As the United States tries to reduce its dependence on foreign sources for batteries and raw materials for their construction, and to diminish environmental impact of spent batteries, scientists and industry leaders are looking for new ways to recycle and recover lithium-ion battery components. More than 15 cathode chemistries are used in lithium-ion batteries that make them practical for more applications and therefore increases demand for materials. As new chemistries become commercially available, the need arises to develop flexible and reliable processes to maximise economic value to the recycler. Advanced recycling approaches can significantly meet the demand for materials.

Battery recycling and sustainability projects investigate the material and energy flows pertaining to battery material production, battery manufacturing and assembly, and battery recycling, to characterise the life-cycle energy and environmental burdens of lithium-ion batteries (LIBs). By interacting with battery

[2] M. Mann, A. Mayyas, D. Steward, Impact of Li-Ion Recycling on the Supply Chain, NREL, presented at the International Li-Ion Battery Recycling Work

[3] Hype Meets Reality as Electric Car Dreams Run Into Metal Crunch, Bloomberg, January 2018, https://www.bloomberg.com/graphics/2018-cobalt-batteries/?cmpId=flipboard

[4] Lithium-Ion Batteries: Examining Material Demand and Recycling Issues, L. Gaines and P. Nelson, TMS 2010 Annual Meeting and Exhibition, Seattle, WA (February 2010)

[5] National Renewable Energy Laboratory analysis, utilizing data published by Bloomberg New Energy Finance, 2018, https://www.bloomberg.com/news/articles/2018-06-10/cobalt-battery-boom-wavers-as-china-demand-lull-brings-out-bears

manufacturers and recyclers, researchers obtain primary data on the energy and water use for commercialised LIB production and recycling, and identify environmental impact drivers, production bottlenecks, and other barriers, for LIB production and recycling. Challenges to be faced for Li-ion battery recycling are shown in Table 1, along with suggested R&D areas for addressing them. Detailed understanding of recycling processes will be necessary to maximise material recovery.

Table 1: 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

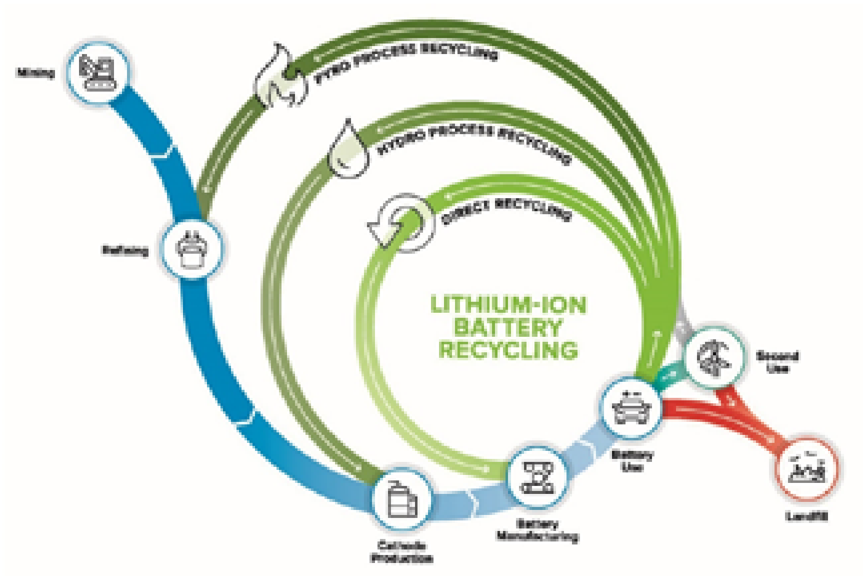
ReCell Center officially launched

The U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO) invests in early-stage research to develop recycling technologies for extraction and reuse of the main components and materials in lithium-ion batteries that would be economical and have lower energy and environmental impacts. As part of this effort, it has launched the ReCell Battery Recycling R&D Center, a $4M/year effort involving a multiple-lab consortium (in addition to Argonne, ReCell includes Oak Ridge National Laboratory and the National Renewable Energy Laboratory, as well as Worcester Polytechnic Institute, Michigan Technological University, and University of California-San Diego) which focuses on novel approaches to recycling in order to maximise economic yield of batteries at their end of life. Current lithium-ion recycling methods, such as hydrometallurgical and pyrometallurgical processes, only enable the recovery of specific metals, and in a form that is of low-value to battery manufacturers (See Figure 2). To make lithium-ion recycling profitable, without large service fees, and to encourage its growth as an industry, methods of direct recycling need to be developed. The focus areas of the ReCell Center therefore include direct recovery of cathode material, separation methods, battery design for recycling, recovery of other materials, and advanced characterization of recycled material. The ReCell Centre was officially launched on January 17, 2019.[6]

[6] https://www.energy.gov/articles/energy-department-announces-battery-recycling-prize-and-battery-recycling-rd-center

Figure 2:
Direct recycling recovers cathode material instead of metal salts, offering the most potential for cost effectiveness.

Source: Argonne National Laboratory



Industry Collaboration Meeting

A ReCell Industry Collaboration Meeting was held Nov. 7-8, 2019 at the Argonne National Laboratory, where representatives from industry, government, and academia discussed innovative approaches for lithium-ion battery recycling. David Howell, Deputy Director of DOE's Energy Efficiency and Renewable Energy's Vehicle Technologies Office (VTO) gave the keynote talk at the event.

The meeting drew representatives from a wide range of companies that focus on different parts of the battery life cycle. Attendees from automotive original equipment manufacturers (OEM) for instance, are not directly involved in the recycling process but need to make sure that there are available pathways for their batteries to be recycled. Other attendees represented battery recycling start-ups, materials suppliers, battery manufacturers, etc.

Electric car owners are unable to simply recycle their batteries at the end of the vehicle's lifetime; they must pay for a service if they choose to do so. The potential of direct recycling technology, which seeks to convert spent batteries to higher-value products as opposed to the current products of lesser value, could offer a more cost-effective way to reuse batteries than today's methods.

Argonne is demonstrating these new direct recycling technologies to determine if the techniques could be viable on industrial scale.

The ReCell Industry Collaboration Meeting also addressed ways to derive more value from recycling electrolyte and foil materials as well as improvements that could be made in supply chain analysis. Although most of the cost savings for battery recycling would come from a move to direct recycling, these additional areas of research could provide other benefits that would make battery recycling more attractive as a whole.

LITHIUM BATTERY RECYCLING PRIZE

Lithium Battery Recycling Prize Established

To address the lack of a well distributed, efficient, and profitable infrastructure to enable recycling of lithium-ion batteries, VTO has established a Battery Recycling Prize (amounting to $5.5-million) to incentivise American entrepreneurs to find innovative solutions to solve current challenges associated with collecting, storing, and transporting spent or discarded lithium-ion batteries for eventual recycling. The goal of the Battery Recycling Prize is to develop innovative business and technology strategies with the potential to capture 90% of all lithium-based battery technologies (consumer electronics, stationary, and transportation applications) in the United States; and that make collecting, sorting, storing, and transporting lithium-based batteries safe, efficient, and profitable.
The prize will facilitate entrepreneurs to leverage the resources of incubators, universities, and the national labs to transform innovative early-stage concepts into prototypes primed for industry adoption. Successful concepts must consider cost-effective methods or technologies such as separation and sorting of various collected battery types and sizes; rendering lithium-based batteries safe or inert during storage; or reducing the hazardous classification of lithium-based batteries in order to reduce shipping costs.

The three consecutive innovation phases of the Battery Recycling Prize (see Figure 3) will accelerate entrepreneurs' efforts to create disruptive solutions to collect, store, and transport 90% of spent or discarded lithium-ion batteries. In each phase, the winners are determined by a panel of expert judges evaluating concepts based on feasibility, cost to implement, and potential impact.

Figure 3: The areas of interest for the Lithium-ion Battery Recycling Prize.[7]

Lithium Battery Recycling Prize Phase I Winners Declared

NREL was selected as the Battery Recycling Prize administrator to support DOE with implementation and execution of the prize elements. Over 50 submissions were received for Phase I of the Prize. After review from industry experts and the Federal Consensus Panel, DOE determined that 15 of the submissions (see Table 2) adequately met the criteria for innovativeness, impact, feasibility, and technical approach outlined in the Prize Rules.[8] Assistant Secretary Daniel Simmons presented the winner announcement at NREL on September 25, 2019.[9]

[7] Energy Storage Division, Transportation Research, National Renewable Energy Laboratory (NREL), Golden, CO, 80401, USA

[8] https://americanmadechallenges.org/batteryrecycling

[9] https://www.energy.gov/eere/articles/energy-department-announces-phase-1-winners-battery-recycling-prize

Table 2: Lithium-ion battery recycling prize Phase I contest winners

Winner	Project Title
Admiral Instruments	Battery Sorting with Voltammetry and Impedance Data
EEDD	Battery Self-Cooling for Safe Recycling
Holman Parts Distribution	Holman Parts Reverse Logistics Recycling Solution
Li Industries	Smart Battery Sorting System
LIBIoT	Innovative Battery Collection System by Lithium-Ion Battery Internet-of-Things (LIBIoT)
OnTo Technology	Li-Ion Identification
Powering the Future	Banking Today's Materials to Power Tomorrow
Renewance	Reverse Logistics Marketplace
Smartville	Distributed Battery Conditioning HUB
SNT Laser Focused	Utilizing Laser Cutting for Efficient Battery Pack Dismantling
Store Packs Umicore	Development of Four U.S. Collection and Storage Sites for Lithium-Ion Automotive Battery Packs
Team EVBs	A Circular Economy for Electric Vehicle Batteries
Team Portables	Reward to Recycle – Closing the Loop on Portables
Team RRCO	Composite Discharge Media
Titan AES	IonView-Ultrasonic LIB Automated State of Health (SoH) 1 Second Test

US-GERMANY COLLABORATION ON BATTERY INTERFACES

On March 26th and 27th 2018, leading battery researchers from the United States and Germany met at the Argonne site office in Washington DC for a day and a half meeting to discuss the latest developments in the area of battery interfaces, the challenges, and the research needs to dramatically improving the understanding of electrochemical interfaces. The discussions were focused around next-generation battery chemistries, with emphasis on Li-metal as an anode material. Li-metal based batteries are a key enabler for ushering in a new era of battery development leapfrogging the presently used Li-ion batteries and enabling low cost, long range EV's. Here, interfaces play a crucial role in dictating the performance of the battery: interfaces are responsible for battery degradation, their resistance dictates the power capability, and reactions at the interface are known to lead to safety issues. Understanding the interface and designing methods to control reactivity remains a crucial need for developing better batteries.

The workshop presentations focused on describing the state of the knowledge in liquid electrolytes, polymer electrolytes and hard solid ceramic and glass electrolyte systems. Presentations related to mathematical model across length scales, from the atomistic to the continuum-scale described what can be predicted today and the needs for the future. The future needs in

characterisation techniques needed to probe the interface under in situ operando conditions were also discussed. The workshop showed that while a lot is known about the interface, there is a need for more sophisticated tools and techniques in order to explore this rich research topic. Moreover, it was clear that there was synergistic research expertise in the two countries and that a close collaboration between the research can result in the total being a sum of the parts.
The workshop resulted in the identification of key areas of study related to interfaces in next-generation Li-metal based battery chemistries (see Table 3).

Table 3: Key areas of study for interfaces in next-generation Li-metal based battery chemistries

Area	Topics
Li metal/liquid electrolyte interface	Understand reactivity and formation of SEI layers in Li and its changes with time.
	Role of the electrolyte composition on reactivity and dendrite formation.
	Experimental and modeling tools that can track dynamics changes at the interface.
Li metal/solid (polymer, ceramic) electrolyte interface	Role of grains and grain boundaries on charge transport and transfer
	Clarify the role of SEI on the evolution of the interface in polymer and ceramics.
	Determine the mechanical properties of the interface layers (Li, polymer, ceramic), and changes during cycling
Cathode/solid (polymer, ceramic) electrolyte interface	Determine the impact of electro-chemo-mechanical changes at the solid-solid interface
	Determine the mechanism of transport and the role of interface coherence on performance.
	Develop tools to probe the buried interface including visualization methods, electrochemistry, and theory across length scales.

Following the workshop, discussions continued between researchers from the two countries. The group reassembled on 14th-15th November, 2018 in Munster, Germany to firm up the details of the collaboration and determine goals and milestones for specific research topics. In addition, plans were drawn to strengthen the collaboration via short-term (<1 month) exchange of personnel and of samples. A summer school was planned to disseminate the knowledge gained from the research to students and early-career researchers from the two countries. A formal kick-off meeting took place on 10th -11th July, 2019, at the Argonne National Laboratory.

NOBEL PRIZES IN CHEMISTRY AWARDED TO BATTERY RESEARCHERS

On the 9th October, 2019, the Royal Swedish Academy of Sciences awarded the 2019 Nobel Prize in Chemistry to three scientists who developed lithium-ion batteries. The scientists include Prof. John B. Goodenough at the University of Texas at Austin, Prof. M. Stanley Whittingham at Binghamton University and Prof. Akira Yoshino at the Meijo University in Nagoya, Japan. VTO has partially funded the R&D for the first two researchers (see Figure 4) over the long term. The U.S. DOE Secretary of Energy congratulated the researchers in a statement issued by DOE. Descriptions of their VTO-supported projects have been regularly included in all VTO Batteries R&D annual progress reports over the past 20-plus years.

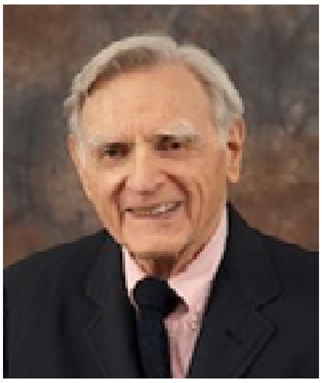



Figure 4:
2019 Nobel Laureate battery researchers partially funded by VTO

Left: John B. Goodenough, University of Texas, Austin

Right: Stanley Whittingham, Binghamton University

NEXT STEPS

The OA, in conjunction with other colleagues in the field, is planning the next discussion 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.

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 34 OA:

OPERATING AGENT
Mr. David Howell
Vehicle Technologies Office
United States Department of Energy
1000 Independence Avenue SW
Washington, DC 20585, USA

David.Howell@ee.doe.gov

TASK 35 FUEL CELL EVS

MEMBER COUNTRIES
AUSTRIA
REPUBLIC OF KOREA

INTRODUCTION

The motivation behind Task 35 is the current international transport system that has significant impacts on the environment and consumes between 20% and 25% of the world's energy, whilst producing carbon dioxide emissions. The majority of the emissions from transport are created by directly burning 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, therefore lowering 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 FCVs to be competitive with conventional vehicles, but their potential benefits are substantial. FCVs operated with hydrogen can be represented as one of the most sustainable mobility modes. The interest in hydrogen as an alternative fuel descended from the ability to power fuel cells in zero-emission electric vehicles; hydrogen's potential for domestic production together with the fuel cell's potential for high efficiency minimises public distance anxiety, which is a common barrier to overcome with electric vehicles. A fuel cell coupled with an electric motor is two to three times more efficient than an internal combustion engine running on gasoline.

Figure 1: Hyundai NEXO is charging hydrogen.

Source: Hyundai Motor Company

However, FCVs still have limitations because there are a limited number of hydrogen filling stations available. For this reason, the major manufacturers such as Hyundai and Toyota, for example, are exclusively offering their FCVs, for sale or lease, to customers located where hydrogen fuel stations are available. Therefore, it will be very useful to look in detail at FCVs and its energy infrastructure as a sustainable mobility representative , including technology concepts, prospects, research needs, market condition, and hydrogen stations (international differences and best practices).

OBJECTIVES

The objectives of Task 35 are to analyse the technology required for FCVs and hydrogen stations and to disseminate the policy of FCVs and hydrogen stations. As a result, the Task will share the information about related technology amongst stakeholders through workshops, conferences, and document and disseminate these related topics.

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.

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

- What technologies are available to improve FCVs, their efficiency, range, comfort and how to lower their costs?
- What 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 to be shared with the public, as agreed with the workshop participants. Literature citations of a company’s representative may be excluded by mutual 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 summarising the overall results of the Task will be prepared by the operating agents with the contributions from the Task partners.

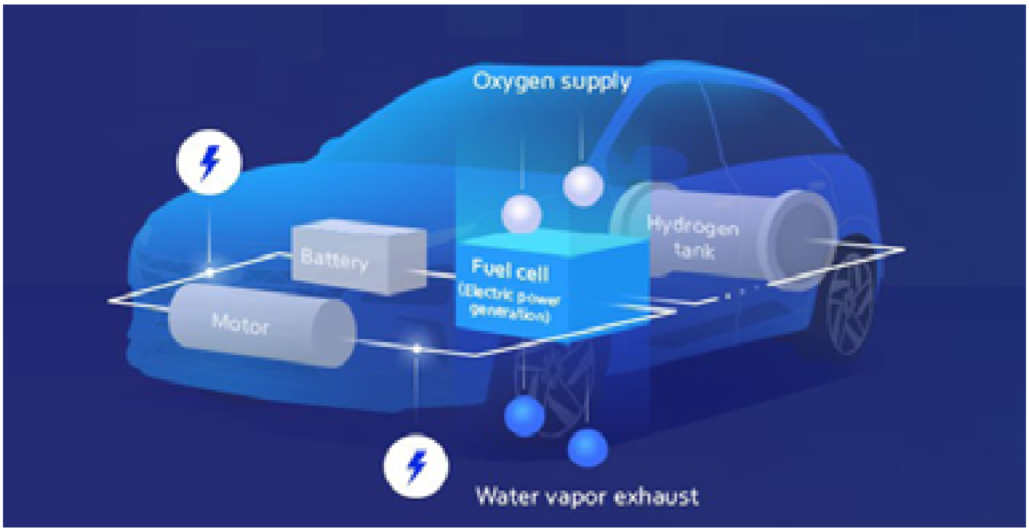
RESULTS

WHAT POWERS AN FCEV?

A Fuel Cell Electric Vehicle (FCEV) is powered by electricity generated from the electrochemical reactions between hydrogen and oxygen. The only by-product is pure, distilled water.[1]

Figure 2:
Schematic of FCEVs.

Source: Hyundai Motor Company



The oxygen necessary to react with hydrogen is drawn from the atmosphere. Such air drawn into the FCEV passes through a 3-stage air purification system which cleans it of particulates, carbon-oxides, and other unwanted matter, leaving the air cleaner. In a way, it has an atmospheric "scrubbing' effect.

Figure 3:
FCEVs Air Purification System.

Source: Hyundai Motor Company

[1] Hyundai Motor Group, 'All About FCEVs: 1. What Powers an FCEV?', Hyundai Motor Group newsroom, 2020.02.28, https://news.hyundaimotorgroup.com/Article/All-About-FCEVs-1-What-powers-an-FCEV?null

HOW IS AN FCEV DIFFERENT FROM OTHER GREEN VEHICLES?

EVs and HCEVs are environmentally sustainable vehicles with no exhaust emission. FCEVs take it a step further by scrubbing the air wherever they go, and are considered the most environmentally friendly vehicles.

In 1 year, a medium-sized SUV will emit about 2.2 tons of CO_2. Offsetting that with an emission-free FCEV can be the equivalent of planting 600,000 trees (a single tree absorbs about 35kgs of CO_2 in a year).

Figure 4: CO2 Absorption Effect of FCEVs

Source: Hyundai Motor Company

Driving an FCEV for an hour can scrub enough air for about 42.6 adults. (calculations based on Hyundai NEXO).

Figure 5: Air purification effect of FCEVs

Source: Hyundai Motor Company

[2] Hyundai Motor Group, 'All About FCEVs: 2. How Safe are Fuel Cell Electric Vehicles?', Hyundai Motor Group newsroom, 2020.02.28, https://news.hyundaimotorgroup.com/Article/How-safe-are-Fuel-Cell-Electric-Vehicles?null

HOW SAFE ARE FUEL CELL ELECTRIC VEHICLES?

Hydrogen is a relatively new and unfamiliar energy source to a majority of the public, but it has been a staple element used across industries for a long time. Safety as a source of fuel is one of its key features. [2]

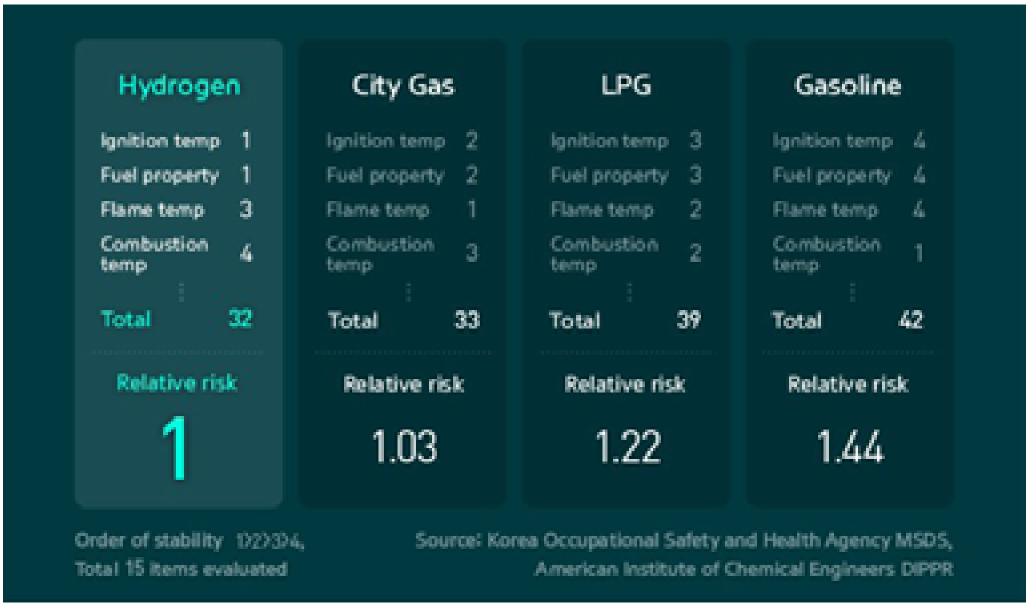


Figure 6:
Relative risks by fuel type.

Source: Hyundai Motor Company

A FCEV's hydrogen tank undergoes various tests to receive international safety certification, including drop impact tests, bullet penetration tests, and bonfire tests.

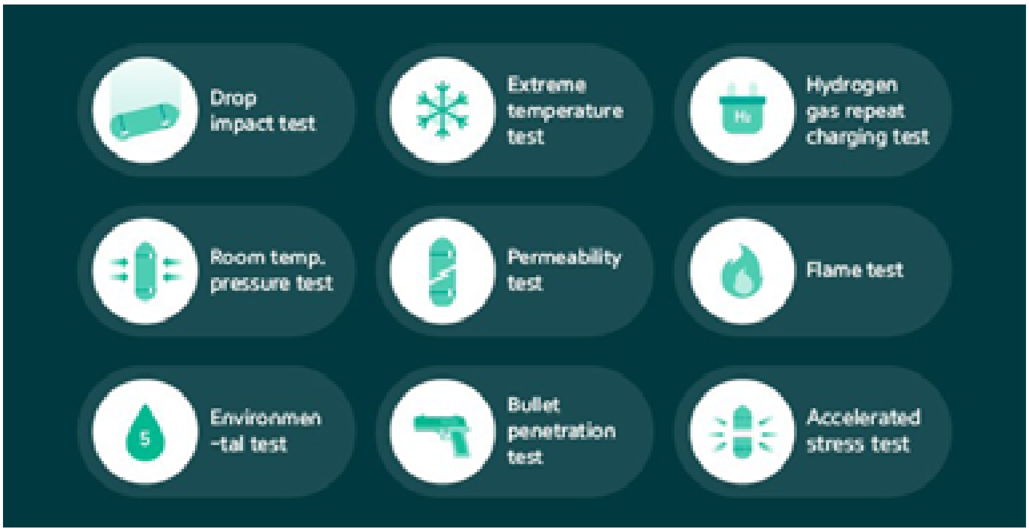


Figure 7:
Key tests for hydrogen tank safety.

Source: Hyundai Motor Company

FCEVS STATUS

FCEV adoption has already gained impressive traction in countries that have implemented pro-hydrogen policies and infrastructure. [3]

The prevalence of FCEVs is growing rapidly around the world. [4]

[3] Hyundai, 'H2 Economy Today', Bloomberg, 2020.02.28, https://sponsored.bloomberg.com/news/sponsors/features/hyundai/h2-economy-today/?adv=16713&prx_t=aXwFAAAAAAZ6MQA&prx_ro=s

[4] 2019년 12월 자동차 등록자료 통계, 국토교통부 통계누리, 2019

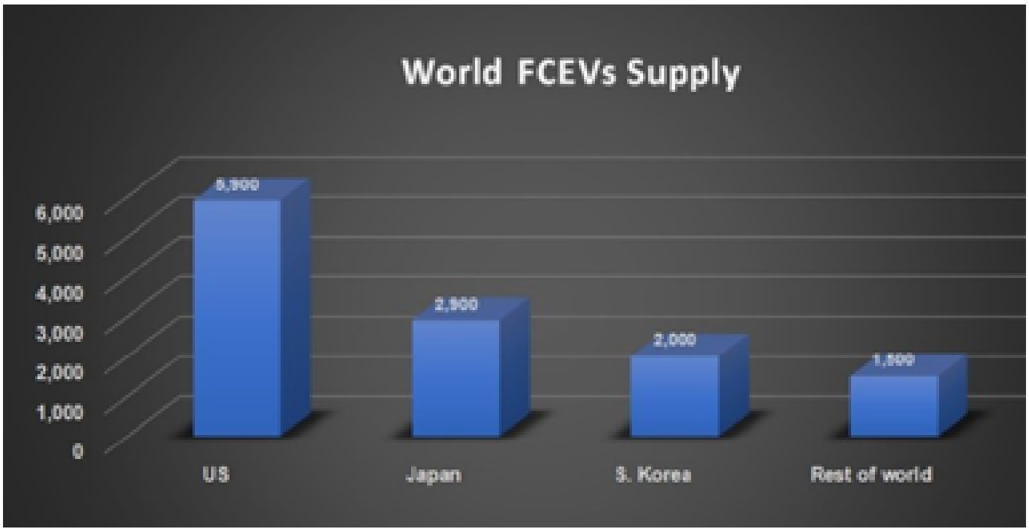


Figure 8:
World FCEVs Supply

Source: Hyundai Motor Company

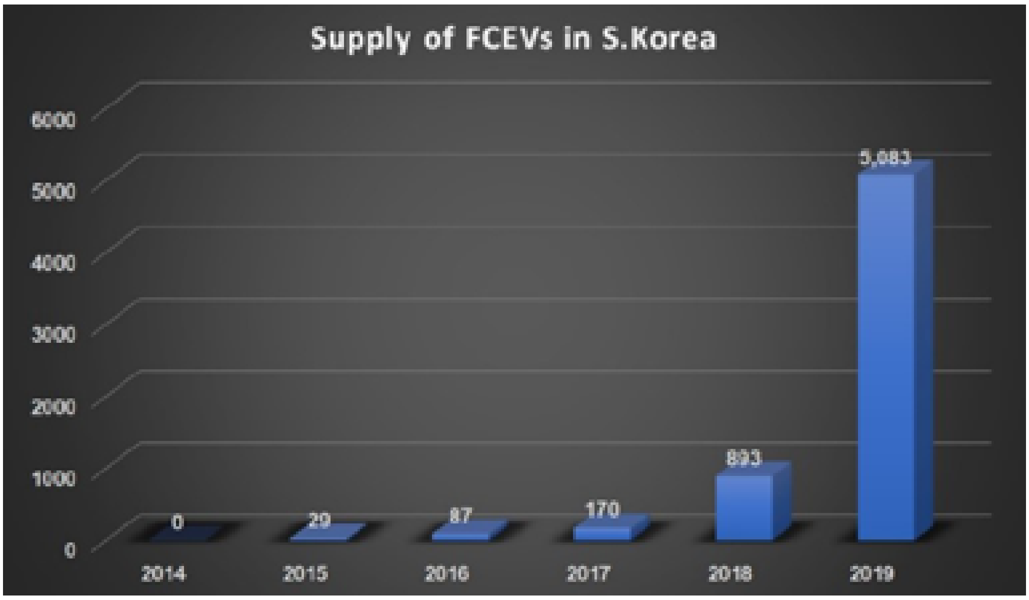


Figure 9:
Supply of FCEVs in S. Korea

Source: Ministry of Land, Infrastructure and Transport

SUPPLY OF HYDROGEN STATIONS

Currently, there is 1 ICE fuel station for every 1,814 vehicles and 1 LPG gas station at 1,037 vehicles. To build a hydrogen station at a similar level, 2,000 hydrogen stations will be needed by 2040, when the cumulative distribution of hydrogen-electric vehicles is estimated to be 2.9 million.

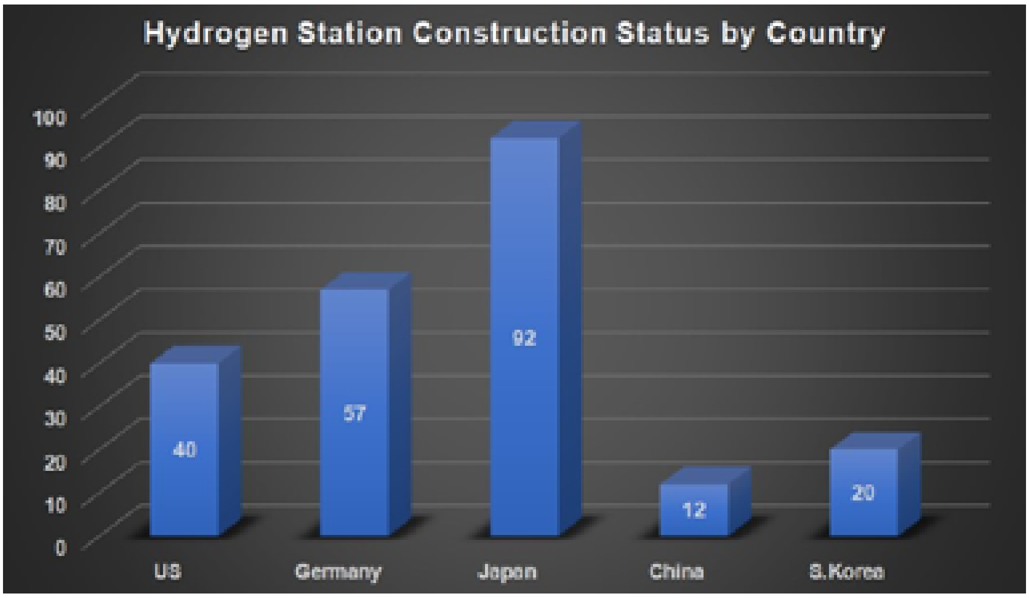


Figure 8: Hydrogen Station Construction Status by Country

Source: Hyundai Motor Company

FCEVS SEMINARS SUPPLY OF HYDROGEN STATIONS

In 2019, four Task 35 seminars were held.

The first Task 35 seminar was held at University of Ulsan, Ulsan, Republic of Korea on 26th April, 2019. The topics presented and discussed at the seminar were:

- Research Trends of Advanced Fuel Cell Technology and Applied Technology.
- Research Trends on the Materials of Fuel Cell Electrolytes.

The second Task 35 seminar was held on 30th April, 2019 in Ulsan Science and Technology Promotion Centre, Ulsan, Republic of Korea. The topics presented and discussed at the seminar were:

- Current Status of Electric Bus Technology in Thailand.
- Republic of Korea's fuel cell electric vehicle technology exchange.

The third Task 35 seminar was held at University of Ulsan, Ulsan, Republic of Korea on 3rd July, 2019. Seminars were held for relevant companies and students. The topics presented and discussed at the seminar were:

- Research Trends of vehicle component performance about FCVs.
- FCVs Thermal Management System Analysis and Optimisation.
- Performance Improvement of FCVs Technology and Vehicle Parts.

The fourth Task 35 seminar was held on the 24th September, 2019 at the Hyundai Hotel, Ulsan, Republic of Korea. The seminar was attended by fuel cell companies, researchers, professors and students from Republic of Korea and Vietnam. The topics presented and discussed at the seminar were:

- Improvement of Environmental Problems of FCVs.
- Performance and convenience of FCVs.

Table 1:
Seminar schedule for 2019

Date	Content	Place
26.04.2019	• Research Trends of Advanced Fuel Cell Technology and Applied Technology • Research Trends on the Materials of Fuel Cell Electrolytes	University of Ulsan, Ulsan, Republic of Korea
30.04.2019	• Current Status of Electric Bus Technology in Thailand • Republic of Korea's fuel cell electric vehicle technology exchange	Ulsan Science and Technology Promotion Centre, Ulsan, Republic of Korea
03.07.2019	• Research Trends of vehicle component performance about FCVs • FCVs Thermal Management System Analysis and Optimization • Performance Improvement of FCVs Technology and Vehicle Parts	University of Ulsan, Ulsan, Republic of Korea
24.09.2019	• Improvement of Environmental Problems of FCVs • Performance and convenience of FCVs	Hyundai Hotel, Ulsan, Republic of Korea

NEXT STEPS

The next workshop held will be discuss “Fuel cell vehicles (FCVs) and technologies”.

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 35 OA:

OPERATING AGENT
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

otlim@ulsan.ac.kr
+82-52-259-2852

TASK 37

EXTREME FAST CHARGING

MEMBER COUNTRIES

UNITED STATES

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. Currently 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 travelled increased by over 25%, even in cases where fast charging was used for 1% to 5% of total charging events [1, 2]. 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.

OBJECTIVES

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

[1] 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.

[2] 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

WORKING METHOD

Task 37 continues to finalise member countries, and is currently reporting out XFC related activities and reports from the United States. The task plans to organise a series of workshops scheduled in conjunction with dedicated conferences and IEA-HEV 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 analyse challenges and opportunities, and to deliver conclusions for future actions.

RESULTS

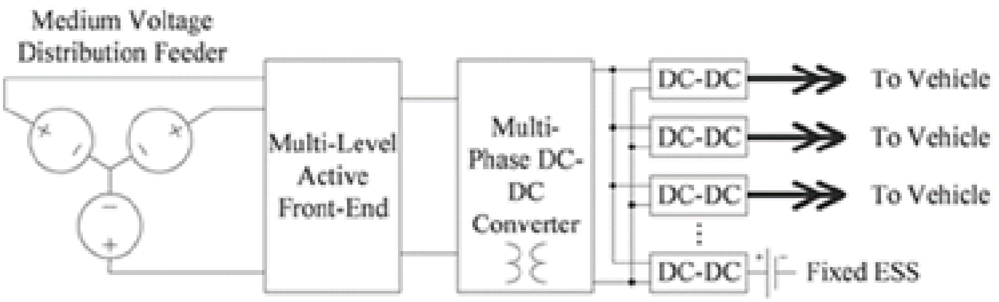
Charging infrastructure for vehicle charging at 400 kW and beyond from a multi-port refuelling hub similar to today's ICE fuel stations will reasonably require at least 1 MW of power conversion capability. A load of this magnitude is expected to require a primary voltage service from the electrical distribution infrastructure. While this could be served by onsite low-frequency transformers, this has been identified as an opportunity to investigate medium voltage connected power electronics. The following sections provide a summary of US Department of Energy (DOE) industry-led efforts which are developing designs for light-duty vehicle charging stations to deliver at least 1 MW of combined load or connect directly to medium voltage grid feeds.

SYSTEM ARCHITECTURES

Vehicle charging at power levels from 350 to 400 kW per vehicle at a refuelling hub with 4 to 12 charging ports would lead to a site design with a power conversion and grid capacity of between 1.4 and 4.8 MW. This calculation implies that the power conversion at all ports would occur at peak power at the same time; however, this might only be between 33% and 47% of the peak rating based on the charging profile and coincidence arrival times of the vehicles [3]. In consideration of the coincident peak power from all charging ports and a desire to include integration with local distributed energy resources (DER), such as photovoltaics or stationary electrochemical energy storage, leads to a design in which the required input power conversion from the grid can be lower than the sum of the charging ports. A similar power conversion architecture has resulted from these constraints in the DOE industry-led efforts as shown in Figure 1. This architecture includes an input solid-state transformer (SST) conversion from medium voltage AC at the grid to a common dc bus in which DC-DC converters for each vehicle charging port and the DER are connected.

[3] E. Ucer, I. Koyuncu, M. C. Kisacikoglu, M. Yavuz, A. Meintz and C. Rames, "Modeling and Analysis of a Fast Charging Station and Evaluation of Service Quality for Electric Vehicles," in IEEE Transactions on Transportation Electrification, vol. 5, no. 1, pp. 215-225, March 2019.

Figure 1:
Block diagram schematic of an XFC refueling plaza [4]



The SST portion of the system is the medium voltage input from the grid to the common DC bus that consists of three conversion stages in these systems. The stages (1) AC-DC conversion in the Active Front End (AFE), (2) a dual active bridge DC-DC primary-side stage and (3) secondary side stage with a high frequency transformer in between for galvanic isolation. These stages are configured in an input-series output-parallel approach to allow for the input ac grid voltage to be divided into a smaller voltage and lower power rating for conversion to a common output. This division allows for a modular approach in which the conversion hardware can be configured for all possible medium voltage inputs from 4.16kV up to 13.8V at scalable power conversion levels based on the site (or port count) requirements. The following table provides a comparison of the topology, switching devices, and voltage of each stage of the SSTs in the DOE industry-led efforts.

Table 1:
Solid-State Transformer Designs for Extreme Fast Charging R&D Projects

Project	AC/DC (AFE)	DC/DC Primary	DC/DC Secondary
High-Efficiency, MV-Input, Solid-State-Transformer-Based 400-kW/1000V/400A Extreme Fast Charger for Electric Vehicles	Diode Neutral Point Clamped (DNPC) Full Bridge	Half Bridge	Full Bridge
	1.2 kV SiC MOSFET	1.2 kV SiC MOSFET	1.7 kV SiC MOSFET
	Input: 0.8 to 1 kV	2 kV	Output: 1 kV
Intelligent, Grid-Friendly, Modular Extreme Fast Charging System with Solid-State DC Protection	Neutral Point Clamped (NPC) Full Bridge	Neutral Point Clamped (NPC) Full Bridge	Full Bridge
	1.7 kV SiC MOSFET	1.7 kV SiC MOSFET	1.2 kV SiC MOSFET
	-	1.6 kV	Output: 0.75 kV
DC Conversion Equipment Connected to the Medium-Voltage Grid for XFC Utilizing Modular and Interoperable Architecture	Full Bridge	Full Bridge	Full Bridge
	-	-	-
	-	-	Output: 1 kV
Enabling Extreme Fast Charging with Energy Storage	Full Bridge	Full Bridge	Full Bridge
	-	-	-
	-	-	Output: 1.15 kV

[4] Jonathan Kimball, 2019, "Enabling Extreme Fast Charging with Energy Storage" Vehicle Technologies Office Annual Merit Review, Washington DC.

SYSTEM PERFORMANCE

The medium voltage connected power electronics explored in these efforts is a new approach to XFC systems which would traditionally be served by an onsite low-frequency transformer stepping the voltage down to 480V. The primary benefits of this approach are the removal of bulky transformers and reductions in the associated AC wiring as the higher voltage allows for smaller conductor sizes. This high-frequency approach has been investigated and shows promise in reducing the volume, mass, efficiency, and equipment footprint as seen in Figure 2. The conventional system in the figure is composed from left to right with a transformer, AC switchboard, and the charging hardware. The proposed system is composed from left to right with a medium voltage fuse metering enclosure, switch gear, and the charging hardware.

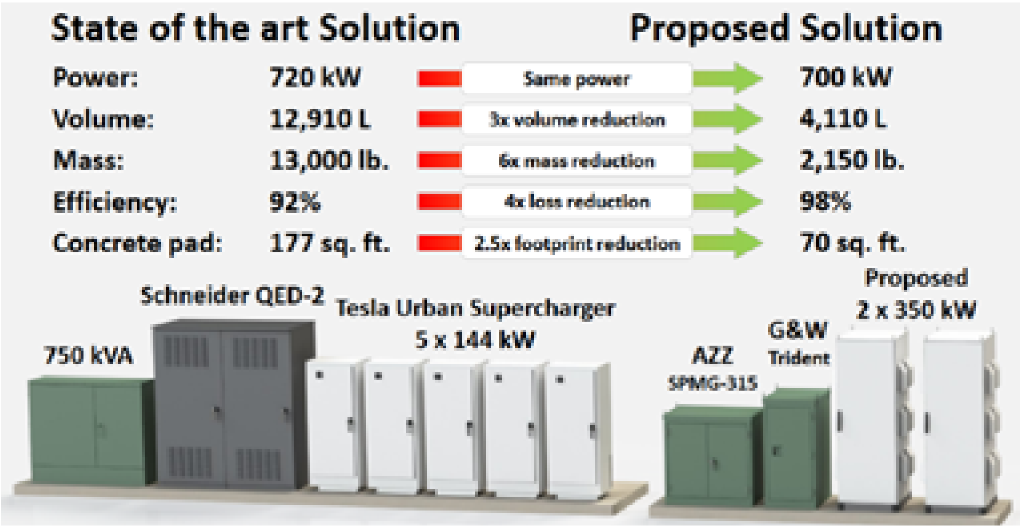


Figure 2: Benefits of Medium Voltage Extreme Fast Charging [5]

NEXT STEPS

Thus far, Task 37 has identified the following key challenges for the task to investigate critical barriers to the widespread deployment of extreme fast charging:

- Medium-voltage power conversion equipment - Design of charging equipment that directly connects to the MV distribution may improve operating cost through more efficient power conversion and reduce capital costs by reducing the footprint of the installed equipment on the site.

- Integrated charging sites - Charging sites that incorporate onsite generation and storage technologies may benefit from reduced electricity costs by shifting load. Development of these sites in conjunction with existing large load facilities may prove beneficial if controllable load, generation, and storage resources can be leveraged across the site.

- Grid interaction and interconnection - Connection of highly dynamic large (>1 MW) non-linear load will require utility assessment and may require costly infrastructure improvements to ensure stable operation of the distribution system. A foundational understating of the grid integration of

[5] Srdjan Lukic, 2019, "Intelligent, grid-friendly, modular extreme fast charging system with solid-state DC protection" Vehicle Technologies Office Annual Merit Review, Washington DC.

extreme fast chargers is needed to develop a harmonised interaction of the charging hardware and support rapid growth of extreme fast charging sites.

The task is working to gain participation from other countries to further investigate and refine these objectives. Future meetings and workshops will be scheduled with input from members.

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 37 OA:

OPERATING AGENT

Mr. Steven Boyd
Program Manager, Batteries and Electrification
Vehicle Technologies Office
United States Department of Energy
1000 Independence Avenue SW
Washington, DC 20585
USA

steven.boyd@ee.doe.gov

[6] Watson Collins, 2019, "DC Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture" Vehicle Technologies Office Annual Merit Review, Washington DC

[7] Charles Zhu, 2019, "High-Efficiency, Medium-Voltage-Input, Solid-State-Transformer-Based 400-kW/1000-V/400-A Extreme Fast Charger for Electric Vehicles" Vehicle Technologies Office Annual Merit Review, Washington DC

TASK 39 INTEROPERABILITY OF E-MOBILITY SERVICES

MEMBER COUNTRIES
BELGIUM
CANADA
FRANCE
NETHERLANDS
SPAIN
SWITZERLAND
UNITED STATES

INTRODUCTION

The IEA TCP HEV Executive Committee (ExCo) unanimously approved Task 39 at the 48th ExCo meeting held in April 2018 in Dublin, Ireland. Task 39 was foreseen to run for two years from 01/04/2018 until 30/03/2020. At the 51st ExCo meeting held in October 2019 in Rome, Italy, an extension of maximum 1 year was requested to be able to finish all foreseen activities.

Belgium initiated Task 39 and The Netherlands officially joined from the start. During the first year, many countries expressed an interest to join Task 39 including: Switzerland, United States, Spain, Canada, Germany, UK, Sweden and France. Most of them also joined officially. Also, European Commission contacts are ongoing with the aim to share experiences related to their interoperability activities within the European Interoperability Centre for Electric Vehicles and Smart Grids.

Task 39 will focus on user friendly charging infrastructure and more specifically the interoperability aspects for charging passenger cars in the public and semi-public domain. Smart charging is also within the scope of 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 are becoming 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. The main barriers to adoption, to be addressed, are the higher purchase cost, limited driving range and limited charging infrastructure.

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 incentivise end users to make the switch. 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; it is important to consider the quality of the charging service offered to the end user. A charging service needs to be easy to use, reliable and cost transparent. Information such as: the location and availability of charging points, charge point accessibility and tariff information are crucial in ensuring the end user is confident enough to make the step the 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, such as with 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 back office management systems of the different stakeholders, like charge point operators and mobility service providers, is an important aspect. Having an open and interoperable solution can have a positive impact on the business case and flexibility to offer higher quality and/or combined e-mobility services to the end user.

OBJECTIVES

Today, EV drivers do not have readily available access to all necessary information about the charging possibilities in their region. Many initiatives are being taken to improve this situation, but 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 EV enthusiasts will make this effort, whilst 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,apps, ..?
- How to know the real-time status of the charging station: free, in use, defect, .. ?
- 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, ..?
- Pricing and payment information: which tariff scheme is applicable for you on that specific charging station?

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 organisation (market players & supporting policy measures), which will be very valuable information for the EV drivers in that specific country.

Ultimately, Task 39 will set-up recommendations for governments and industry to improve the interoperability of charging services. The main focus in Task 39 will be “standard” charging services, but additional aspects of “smart” charging and its interoperability aspects will be considered.

WORKING METHOD

Task 39 will be executed in a pragmatic way and will make use of mainly telephone conferences and two workshops to collect, discuss and note the existing knowledge available from the experts of member countries. This information will be complemented by additional desktop research and contacts with different initiatives to collate the most recent information.

All collected information will be stored in the IEA TCP HEV SharePoint site and will be accessible to the member countries.

Putting the available information on paper in a clear and concise way and sharing 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 TCP HEV.

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

RESULTS

The first period of Task 39 focused on contacting the interested member countries to exchange further information and to fine-tune the workplan. A greater number of member countries will lead to larger volumes of higher quality information being exchanged and ultimately better recommendations to stimulate interoperability of e-mobility services, not only within one country but also cross-border.

Task 39 started with the collection of relevant information via desktop research and contacts with experts in the field. Many projects dealing with interoperability and roaming have been detected.

The focus at the start of the desktop research was mainly on Europe, as a majority of the ongoing projects detected have been set-up with European funding (FP7, H2020 or Interreg). Thanks to member countries Canada and United States, information from outside of Europe is also available.

The funded projects selected in the desktop research, study the interoperability aspects from different perspectives. Examples of European funded projects:

- H2020 - NeMo: http://nemo-emobility.eu/: NeMo’s vision is to create a Hyper-Network of new and existing tools, models and services which will provide seamless interoperability of electro mobility services, creating an open, distributed and widely accepted ecosystem for electro-mobility. The lack of interoperability gave rise to the recent concept of electro-mobility roaming platforms, often called e-roaming or eRoaming. The problem of interoperability between platforms still remains. In order to tackle this, the pan-European eRoaming initiative was announced in 2015 and its objective, namely the interconnection of existing eRoaming platforms, will be specifically pursued within the NeMo Hyper-Network for electro mobility.

- Interreg - evRoaming4EU: https://www.evroaming4.eu: The main objective of the project is to facilitate roaming services for charging electric vehicles and provide transparent information to consumers about charging locations and prices of charging in Europe, by making use of the open independent Open Charge Point Interface (OCPI) protocol. The ultimate goal is to allow any EV driver to charge at any charging station in the EU.

- PF7 – Cotevos: http://cotevos.eu: Concepts, capacities and Methods for Testing EV Systems and their Interoperability within the Smart Grids

Besides funded projects, we also see market players joining forces in initiatives like eMI3 “eMobility ICT Interoperability Innovation Group” (www.emi3group.com). Under the umbrella of ERTICO, the eMI3 Group is an open interest group of global market players to enable global EV service interoperability by harmonising existing standards and preparing standardisation of future ICT data standards and protocols, including security and authentication. Examples of members of eMI3 are roaming platforms like Hubject (www.hubject.com) and Gireve (www.gireve.com) and also Task 39 partner ElaadNL is member of eMI3.

The EC-DG MOVE also launched a Programme Support Action on data collection related to Alternative Fuels infrastructure and unique identification codes of e-mobility actors. This call was addressed to EU member states. The objective is the collection of data related to alternative fuels infrastructure and coordination and establishment of a repository concerning unique Identification Codes (IDs) of e-mobility actors, which are an essential part for a future harmonised development of electromobility services in Europe. The primary focus is on electric charging points & hydrogen.

The EU “Clean Power for Transport” directive (2014/94/EU) also requested all European countries to set-up a national action plan to stimulate the roll-out of public charging infrastructure. User friendliness and interoperability is an important aspect as mentioned in the report of SGEMS “Sub-Group to foster an Electro-Mobility Market of Services”. The CPT-directive triggered further national initiatives to stimulate interoperability.

One of the first countries taking interoperability seriously on a national and cross-border level is The Netherlands. They have invested in many years of work to reach an open and interoperable charging infrastructure market. Task 39 is very pleased that The Netherlands joined with 3 experts so that their experience can be shared with the other member countries:

- ElaadNL: www.elaad.nl: ElaadNL is the knowledge and innovation centre in the field of (smart) charging infrastructure in the Netherlands. ElaadNL actively contributes to the development of open standards like OCPP, OSCP and OCPI. Open standards or open protocols ensure that EV charging systems speak the same language. By providing rules and guidelines for data communication, open standards unleash new market opportunities. ElaadNL also actively contributes to roaming through its platform www.e-clearing.net, a platform with the purpose to exchange roaming authorisation, charge transaction and charge point information data.

- eViolin.nl: www.eViolin.nl: eViolin is an association of charging station operators and service providers, pursuing national roaming with an international connection, using open standards. eViolin is not responsible for price information on using charging infrastructure. Providing transparent and accurate pricing information is the responsibility of the individual operators and service providers.

- NKL: www.nklnederland.com: The Netherlands Knowledge Platform for Public Charging Infrastructure EV is the platform where government, knowledge institutions and companies come together to achieve affordable public charging of electric vehicles. NKL stimulates development in the public charging sector, facilitates innovative projects, supports various initiatives and ensures the exchange of knowledge. NKL's current programs are Sector Optimization, Protocols and Standards and Smart Charging.

Interoperability is of course not only a national or European issue, it is also important that some aspects are being discussed on an international level. Thanks to member countries Canada and United States, information from outside of Europe is also exchanged within Task39.

The European Commission's Joint Research Centre (JRC) and U.S. Department of Energy's Argonne National Laboratory already work together via their EV-Smart Grid Interoperability Centre. They provide a venue for global industry-government cooperation that is focused on the joint development of EV standards and test procedures. The objective is to study interoperability issues between the electric vehicles and the charging infrastructure, covering hardware and information exchange protocols. Furthermore, interoperability of the EV fleet and the smart grid are being investigated. Pre-normative research is conducted to identify gaps in standards or technology and to support to the formulation of regulations addressing interoperability issues.

The information collected via desktop research and direct contacts will be stored in a dedicated Task 39 SharePoint site which is accessible for all member countries.

NEXT STEPS

In 2020, Task 39 will focus on organising 2 workshops and work towards finalising the country chapters and the final report.

The first period of Task 39 focused mainly on performing a desktop study on interoperability related projects and initiatives. The member countries also shared information via bi-lateral or group telcos.

In 2020, the goal is to organise 2 workshops in close cooperation with IEA TCP HEV Task 43 on Vehicle Grid Integration. The first workshop will be organised in the United States linked to EVS33 and the second workshop will be organised in Europe. Workshops will allow to exchange the latest information and best practices on interoperability between the member countries but the workshops will also be open to other interested countries. The information from the workshops will be used as input for the Task 39 final report.

The country chapters will be finalised by the respective member countries and will describe the current local market organisation (market players & supporting policy measures), which will be very valuable information for the EV drivers in that specific country. The country chapters will be disseminated via the next IEA TCP HEV Annual Report and website.

The final report of Task 39 will contain recommendations for governments and industry on how to improve the interoperability of charging services. This report will be written with support from all member countries and will be based on the information collected via desktop research, workshops and experts contacts.

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 39 OA:

OPERATING AGENT
Carlo Mol
VITO / EnergyVille
THOR Park
3600 Genk
Belgium

carlo.mol@vito.be
+32 492 58 61 24

TASK

40

CRM4EV: CRITICAL RAW MATERIALS FOR ELECTRIC VEHICLES

MEMBER COUNTRIES
AUSTRIA
FRANCE
GERMANY
NETHERLANDS
NORWAY
REPUBLIC OF KOREA
SPAIN
SWEDEN
USA

EXTERNAL MEMBERS
Government of Western Australia,
JOGMEC (Japan),
Anglo American,
AVERE,
Chinese Academy of Sciences - Institute of Process Engineering,
Botree,
Cobalt Institute,
Copper Alliance,
IGO,
Nickel Institute,
Umicore,
Vale,
Valuad

INTRODUCTION

Task 40 "Critical Raw Materials for Electric Vehicles" of the IEA TCP "Hybrid and Electric Vehicle" (HEV) aims to provide accurate, credible and up to date information on materials which are considered as (potentially) critical for the uptake of electric vehicles sales.

Issues covered, include:

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

The Raw Materials included in the scope of Task 40 CRM4EV are those materials which are economically and strategically important for the mass deployment of Electric Vehicles, but have a high-risk associated with their supply.

It is important to note that these materials can be classified as 'critical' for various reasons:

- They have a high-supply risk due to limited mining (refining/smelting) capacity and/or a high level of concentration in particular countries.
- There is a lack of (viable) substitutes, due to the very unique and relevant properties of these materials, as well as future applications for EVs.
- There can be significant environmental impacts through the supply chain of these materials and intermediate products.
- There can be significant issues concerning responsible sourcing of the materials and/or its intermediate products.

Materials like Lithium, Cobalt, Graphite, Rare Earth Elements and others are already frequently in the news related to their (presumed) scarcity, environmental or social issues. Less discussed materials like Nickel and Copper will probably be in the scope of Task 40 as well as other materials which may play an important role for EV deployment in the future, such as, Niobium.

Conflicting information makes it difficult for policymakers to get fact based and reliable information. This is especially the case for both ongoing and potential future discussions related to the future mass deployment of EVs. In fact, internal combustion engine technologies also require critical materials, which is often overlooked or already accepted in these debates. Fuel Cells currently use PGMs (Platinum Group Metals) as do catalysts for diesel cars.

The Task will review the impacts of mass BEV deployment on the currently critical raw materials as well from a material availability point of view.

OBJECTIVES

The overall objective of Task 40 is to generate and continuously update relevant evidence and CRM4EV participants regarding critical raw materials. This includes:

- Publications in the form of easily accessible and digestible, “infographics” to inform stakeholders on the current status for the relevant materials or issues, while, also providing scenario-based information related to mass EV deployment.
- Continuous data collection and (scenario) analysis, including validation through various discussions within the workshops.
- Developing global views as well as regional or country perspectives, based on the stakeholder needs (information, analysis, scenarios).

To achieve this, the Task is building 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. External experts are to be involved as well.

Figure 1: Task 40 CRM4EV participants and representative organisations delegated by IEA HEV pariticpants

The network meets twice per annum through workshops, with several sub-groups for different critical materials/topics. The data and analysis from the participants will be used as a basis to define the detailed tasks to be conducted. The IEA HEV TCP participating countries will lead this work.

WORKING METHOD

- Define and maintain a list of Critical Raw Materials to include in the scope of the Task CRM4EV.
- Define the 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 CRM 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 products?).
- 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. The costs of recycling and impacts of legislation.
- Evaluate LCA impacts, variations by region, source, refining processes and other parameters.
- Review existing (and ongoing) recycling processes and collection of materials for recycling, obligations (legislation), costs.
- Define and analyse scenarios for future requirements and needs for CRMs for EVs.

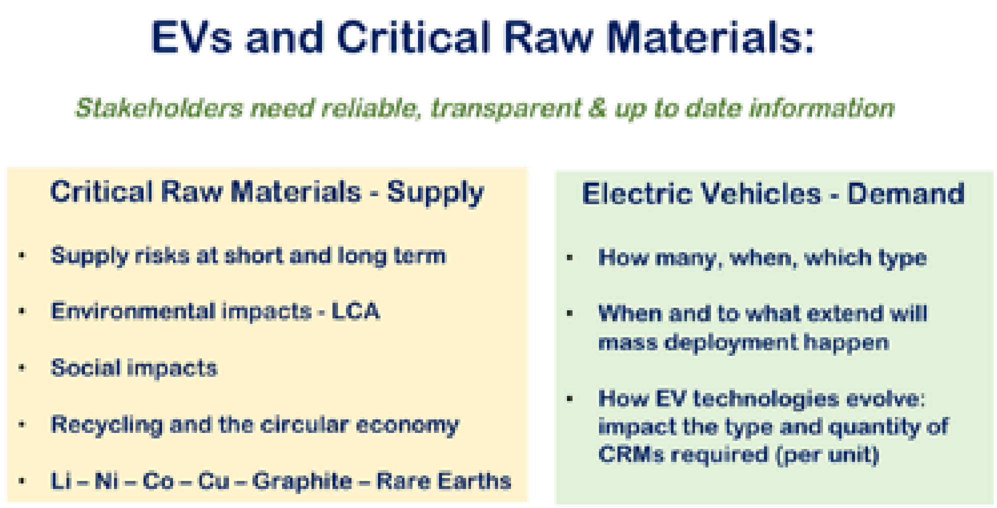


Figure 2: Key supply & demand issues for raw materials important for electric vehicles.

REPORTING AND DELIVERABLES

Priority has been given to the development of “Factsheets” for the raw materials and topics (i.e. recycling of Lithium-ion batteries and Environmental impacts of Li-ion batteries). The factsheets are easy to understand, up to date infographic-style documents aimed at non-expert stakeholders like politicians, journalists, policymakers, NGOs etc. The factsheets will describe the current situation, but also highlight some scenarios for possible mass deployment of EVs and the impact thereof on the raw material needs and impacts.

Other possible deliverables which are considered are listed below.

- List of EV Critical Raw Materials and the key facts for these CRMs
- List of transport (vehicles) CRMs impacted by EVs (replacement)
- Short summary in the form of Fact Sheets on CRMs and CRM4EV topics (like recycling, LCA)
- Insights in the current mining, refining, main applications of the CRMs
- Insight in planned and potential mining and refining capacities
- Insight in current and projected (scenarios) needs of the CRMs
- 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
- CRM4EV Casebook

RESULTS

WORKSHOPS AND SITE VISITS

Workshops: The Task has held 3 workshops so far and has planned the 4th workshop in June 2020 to be hosted by Argonne National Laboratory (USA).

Workshop 1: November 2018, Brussels, hosted by Umicore
Workshop 2: May 2019, Lyon, hosted by AVERE at the EVS32
Workshop 3: November 2019, Shanghai, hosted by Botree, CAS-IPE &

Attendance of the workshops has been 30-40 people (each) from Task 40 CRM4EV participants and external experts and companies.

Site visits: 9th-12th November 2019: Huayou Cobalt, AIWAYS EV manufacturer and CATL (Li-ion battery manufacturer)

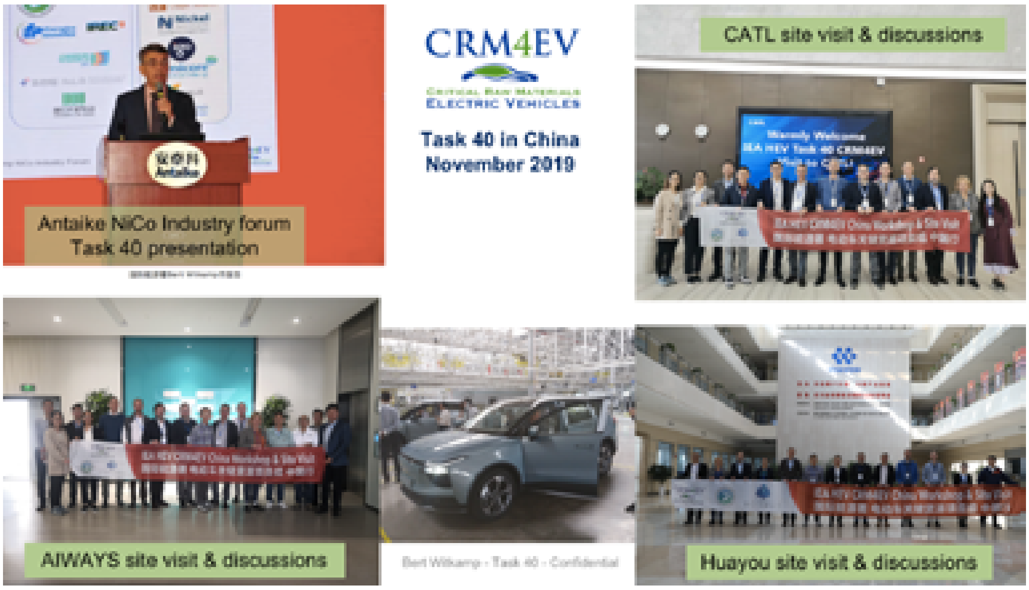


Figure 3: Site visits and Nico Industry forum presentation - China, November 2019

TASK 40 CRM4EV PRESENTATIONS AT CONFERENCES AND EVENTS

The IEA HEV Task 40 CRM4EV has been presented at the following conferences and events:

- Argus Conference “Batteries in Automotive”, Wiesbaden, 18th September 2018.
- EIT Raw Materials Expert Forum – Sustainable Materials for Future Mobility: E-drives, Magnets, Batteries, 23rd October 2018, Darmstadt, Germany (The European Institute of Innovation and Technology (EIT) is an independent EU entity).
- DEMETER Final Symposium, 6th February, 2019 – Leuven, Belgium (DEMETER is an EU H2020 project on the recycling of Rare Earths from permanent magnets).
- Paydirt’s Battery Minerals Conference, 12th March, Perth, Australia.
- CRM Alliance event, “Transitioning to a low carbon and energy efficient economy: Battery Raw Materials vs CRMs behind the scene”, Brussels, Belgium 20th March 2018.
- Mineral and Investment week, 2nd Annual Lithium & Battery Metals Conference, 21st March, Perth, Australia
- International Nickel Study Group, 6th May, 2019, Lisbon, Portugal
- The Cobalt Conference 2019, 15-16th May, Hong Kong
- International Conference on Advanced Automotive Technology (ICAT), 20th-22nd June, 2019, Gwangju, Republic of Korea
- China International Ni & Co Industry Forum 2019, 4th -7th November, 2019, Yichang City, Hubei Province, China
- Huayou Cobalt, 9th November, 2019, Quzhou, China
- AIWAYS, 11th November 2019; ShangRao, China
- CATL, 12th November 2019, Ningde, China
- Clean Energy Ministerial Electric Vehicles Initiative, 13th November 2019, Advisory Board Meeting Guangzhou, China,

TASK 40 CRM4EV WEBSITE

A website dedicated to Task 40 CRM4EV (www.crm4ev.org) has gone live in March 2019 and serves for external and internal (Task 40) communication and platforms to share outputs.

Figure 4: Dedicated Task 40 CRM4EV website

STUDIES & REPORTS

Studies executed in 2019:

- EV mass deployment scenarios have been developed in the first half 2019.
- A Battery assumptions paper - a peer reviewed analysis of the development of the batteries for electric vehicles 2020-2035 and beyond. In this report the different battery technologies and chemistries are detailed and a base case for the use of the different technologies (and their “market share”) for electric cars has been made and which is used as input for the different raw material requirement scenarios. A “low cobalt” scenario has been made as well.
- Data collections for cobalt and nickel have conducted detailing the current supply and uses of materials, potential future demand and supply issues and environmental impacts.
- Raw material (demand) forecasting scenarios 2020-2050 for the key battery materials.

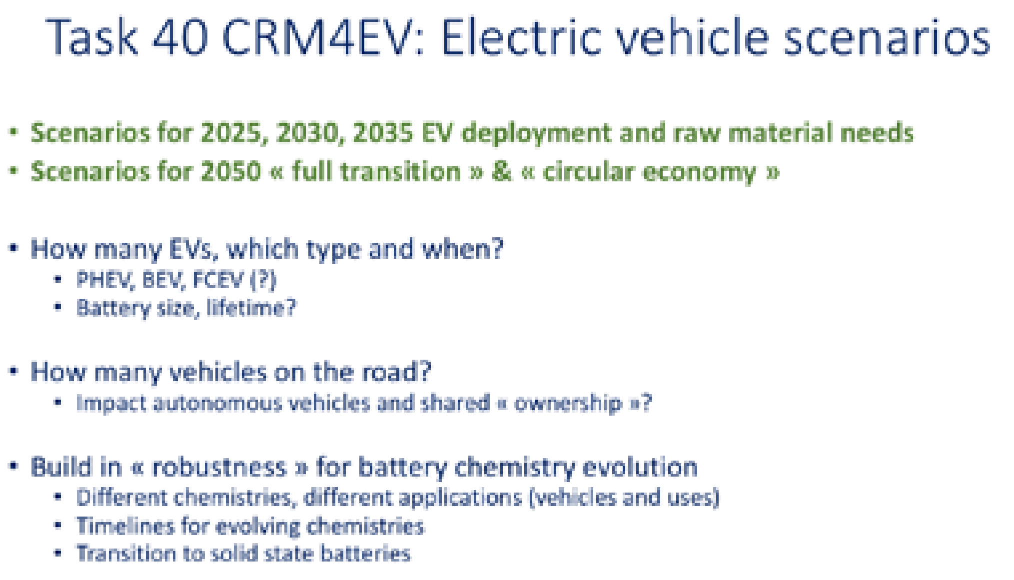


Figure 5: Approach for the raw material scenarios for electric vehicles

ONGOING ACTIVITIES

A coordinated action to review the environmental (LCA) impacts and recycling of Lithium-ion batteries started in 2019 and is expected to be finalised in 2020.

Regular communications are on-going discussing the key global developments in the area of EV demand and key developments for relevant raw materials.

NEXT STEPS

An update of the battery technologies and chemistries paper is currently being made, as the international developments and insights change rapidly.

Two page infographics are currently being developed for external communication. The target is to publish the first “Task 40 CRM4EV Infographics” in 2020.

The raw material scenarios will be further developed to reflect the changes in battery chemistries, use of critical raw materials, and the developments in electric vehicle demand.

Task 40 CRM4EV will also continue to be presented at relevant conferences and events.

OPERATING AGENT CONTACT DETAILS

For further information, please contact:

OPERATING AGENT

Mr. Bert Witkamp
Valuad
Belgium

b.witkamp@valuad-expert.com

CO-OPERATING AGENT

Mr. Stephan Schmid
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Germany

Stephan.schmid@dlr.de

TASK 41

ELECTRIC FREIGHT VEHICLES

MEMBER COUNTRIES
AUSTRIA
GERMANY
REPUBLIC OF KOREA
SWITZERLAND
TURKEY
UNITED KINGDOM

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. Global trends such as growing population, urbanisation and booming e-commerce have almost doubled the worldwide road freight activity and energy use in the last two decades[1]. Furthermore, higher gradients are observed for freight emissions compared to passenger travel emissions for most of the IEA countries[2]. Fleet CO2 emission targets have recently been set by the European Union for light and heavy freight vehicles aimed at reducing the increase in freight emissions[3]. 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 emphasis is on incremental technology developments to reduce fuel consumption of conventional vehicles. However, there are potentials for (near) zero tailpipe emission vehicles that could result in the large-scale GHG reduction that is needed. In addition to global impacts, air pollutants are emitted locally through combustion of fossil fuels. This is a major problem in densely populated cities since road freight transport is responsible for the last mile delivery in these areas. Alternative delivery concepts can have an important contribution to sustainable urban logistics.

PROSPECTS OF ELECTRIC FREIGHT VEHICLES

The International Motor Show in 2018 characterised an increasing electrification strategy for commercial vehicles. Different manufacturers showcased their first battery-electric vehicle concepts.. Especially in the light segment, vans from Volkswagen, Daimler, MAN, IVECO, Nissan and Renault are already in series production. Prototypical BEVs have also been developed for the medium and heavy-duty segments and are currently being tested in various pilot projects with customers. For example, Daimler is testing its electrified Actros model with different logistic companies like DACHSER and Hermes[4]. Since 2018, MAN Truck & Bus has also been testing the eTGM model in cooperation with its Austrian partner, the Council for sustainable logistics (CNL)[5]. The SOP of these medium and heavy freight vehicles is set for 2021[6].

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

[2] 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

[3] https://ec.europa.eu/clima/policies/transport/vehicles_en

[4] https://www.daimler.com/produkte/lkw/mercedes-benz/eactros.html

[5] https://www.truck.man.eu/de/de/man-etruck.html

[6] https://media.daimler.com/marsMediaSite/de/instance/ko/Praxistest-des-eActros-startet-in-Mannheim-Mercedes-Benz-Trucks-uebergibt-Elektro-Lkw-an-TBS.xhtml?oid=41514787

Figure 1:
Renault Master Z.E. at the IAA Nfz fair 2018

However, electric heavy articulated tractors and semitrailer trucks are currently manufactured and sold primarily by small suppliers such as the Swiss E-Force One AG and the German Framo GmbH. These are so-called electric vehicle converters, which replace the combustion engine of trucks from MAN, Daimler and Co. with their electric drivetrain. In the future the heavy freight vehicle market may also be shaped by American start-ups such as Tesla, Thor and Nikola Motors. Their vehicle concepts promise higher ranges for sustainable and reliable long-distance transport.

Figure 2:
Volkswagen Caminhões e Ônibus e-Delivery electric truck (left) and Mercedes-benz eActros (right) at the IAA Nfz fair 2018

Nonetheless, current BEV concepts do not show long-distance suitability compared to conventional vehicles. Higher electrical ranges are in conflict here with additional battery weight. A solution for this can be offered by electric trolley trucks which are powered on the road with overhead wires. On various test tracks in Germany, Sweden and the USA (California), these are currently being tested in traffic. Trolley trucks are also being tested today with a plug-in hybrid powertrain.

Figure 3:
Scania plug-in hybrid trolley truck at the IAA Nfz fair 2018 (left) and electric converted DAF Truck tested in the eRoadArlanda (Sweden) project (right)

PROSPECTS OF FUEL CELL ELECTRIC FREIGHT VEHICLES

Potential for sustainable long-distance transport is also seen in fuel cell electric vehicles. Asian manufacturers such as Toyota and Hyundai have developed first concepts which are currently being tested in practice.

Hyundai is set to enter into the first customer application of fuel cell trucks in Europe starting from 2020 in cooperation with the H2-Mobility development association in Switzerland. Initially, 50 Fuel Cell Electric Freight Vehicles - FCEV - (H2 Xcient Fuel Cell, 35 tons Gross Vehicle Weight) will be delivered to the logistics companies in Switzerland. By 2023, 1000 trucks are to be delivered and then 1600 by 2025.

However, the potential and challenges of the fuel cell, especially for long haul transport, depends on how the hydrogen refueling infrastructure network around the world will develop. Therefore, the project in Switzerland is being accompanied by Swiss hydrogen specialists H2-Energy-Hydrospider and H2-Energy (joint venture of energy provider Alpiq and Linde Group), who are ensuring the widespread expansion of the H2 refueling infrastructure and the necessary local hydrogen electrolysis in Switzerland for the FCEV in order to operate them completely CO2-free.

OBJECTIVES

The task's main objectives are to monitor progress and review relevant aspects for a successful introduction of electric freight vehicles (EFV) into the market. Three focus areas are included for this purpose.

The first area "technology development of EFV" addresses the technical viability of EFV. Based on current available EFVs on the market, performances as well as standards and norms for EFV are described to monitor technical advances of EFV. The development of the charging infrastructure, in particular with regard to costs and availability, is also in focus.

The second area of interest deals with "best practice and suitability aspects of

EFV" to identify potential application areas for EFV. Based on best practice pilot projects, successful examples of EFV implementations will be described. This includes analysis of their opportunities and barriers for market introduction.

The third area looks at demand-side issues and is linked both to end customers and to policies. In view of the different suitability of EFV technologies for replacing conventional diesel engines, economic and ecological aspects of EFV will be evaluated. By using existing models, fleet Total Cost of Ownership and CO2-emission calculations for promising "vehicle - transport task" combinations with close-to-reality data are undertaken.

The topics of each focus area are presented in form of short fact sheets (1-2 pages), which will provide the base to review the aspects for a successful introduction of EFV into the market.

The scope of Task 41 includes vehicles of the size classes N1, N2 and N3 and all types of electrified or electric powertrains like hybrid, plugin-hybrid, battery electric, fuel cell electric and electric road powertrains.

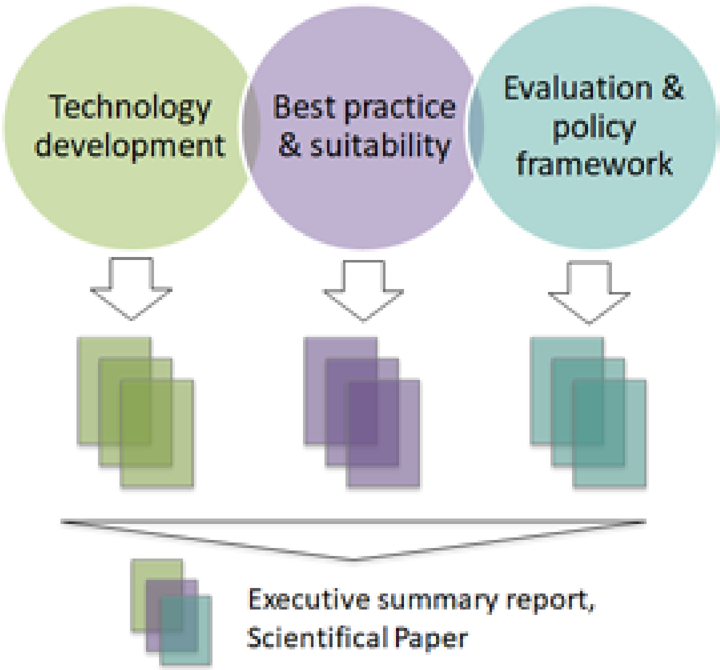


Figure 4: Program of work

WORKING METHOD

The working method comprises desk research, workshops and public outreach.

The main approach is to collect and exchange information in workshops and through contacts to other international networks. According to the objectives, the workshops are aimed at professionals from manufacturers, TIER1 suppliers, researchers, project managers, city planners, policy makers and other stakeholders. The topics and the individual orientation of the workshops are determined by the task partners. There are both public and non-public workshops planned. Individual contributions/sessions can be treated confidentially at the request of the participants. It is expected that the partners actively participate at the workshops.

Desk research will provide information for discussion e.g. vehicle technology and cost developments will be presented in several fact sheets (1-2 pages). The desk researchers should be reflecting through networking activities and the exchange of information and answers to questions from participating members.

Public outreach activities such as presentations, scientific publications and flyers will be prepared to disseminate the findings to a wider audience.

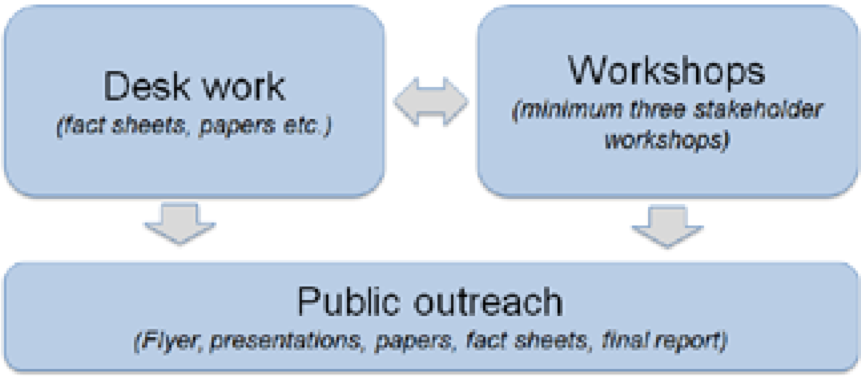


Figure 5: Overview of working method

FINANCING AND SPONSORSHIP

Task 41 is a fee-based Task. Parties may join using an HEV-TCP voucher from the Secretariat. If no voucher is available, the fee to join the Task is 7,500 Euro (2,500 Euro per year). A concept for sponsors is available.

RESULTS

The first Task 41 workshop "battery-electric freight vehicles in urban logistic" was held in Stuttgart (Germany) on October 15th 2019. Dedicated topics at the workshop were:

- Current technical characteristics of battery-electric freight vehicle.
- Development of the charging infrastructure: costs and availability.
- Practical experience and knowledge from pilot projects and initial applications.

24 local and international guests from logistics backgrounds such as: logistics associations, vehicle industry, charging-infrastructure suppliers, city administration and researchers took part and discussed the opportunities and hurdles for the successful implementation of battery-electric freight vehicles in urban logistics.

The workshop was introduced with presentations by companies from the vehicle, infrastructure and logistics sectors. The first session "current technical characteristics of battery-electric freight vehicle" was held by the vehicle manufacture Daimler, with insights on their current electrification strategy. In the second session "development of the charging infrastructure: costs and availability" three key charging infrastructure suppliers in Germany:

ABB, ChargeHere by EnBW and EBG compleo, introduced dedicated AC and DC charging stations for commercial vehicle application with information on suitable power ranges and current available charging points in Germany. The third session "practical experience and knowledge from pilot projects and initial applications" was introduced with presentations from the logistic company Dachser in Stuttgart, Germany and Fier Automotive from Helmond, the Netherlands. Dachser shared their experiences with the Fuso eCanter and Mercedes-Benz eActros in Stuttgart and Fier Automotive presented the results from the EU-Project ElectricGreenLastMile.

On the basis of the technical and experience reports, the guests of the workshop discussed the problems and solutions for the implementation of vehicles and suitable charging infrastructure in urban logistics in two interactive groups.

The main topics of the group discussions were; the ongoing uncertainty in battery-electric as well as fuel cell technologies, the lack of space for electric charging stations and loading stations in urban areas and the uncertainty about necessary charging capacities for different transport applications. Furthermore, the discussion with the participants showed that there is no business case for fast charging solution in commercial vehicles. It could be useful for the logistic and fleet operators to learn more about current applications with battery-electric freight vehicles including information on their total cost of ownership.
In addition, Task 41 is participating in the international action group "Zero Emission Freight Vehicles"[7] and has planned a technical exchange with the IEA TCP AMF Annex 57 "Heavy Duty Vehicle Evaluation"[8]. The work of the cooperation´s will be documented in the Task 41 fact sheets.

NEXT STEPS

A kick-off meeting is planned in spring/summer 2020 as well as a second workshop in the second half of the year.

Participation is by invitation only and free of charge for all Task 41 workshops.

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 41 OA:

OPERATING AGENT
Mr. Özcan Deniz
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Pfaffenwaldring 38-40
D-70569 Stuttgart
Germany

Oezcan.Deniz@dlr.de
+49 711 6862 8120

[7] http://tda-mobility.org/zero-emission-freight-vehicles/

[8] https://www.iea-amf.org/content/projects/map_projects/57

TASK 42 EV CITY CASEBOOK

MEMBER COUNTRIES
CANADA
DENMARK
GERMANY
IRELAND
NETHERLANDS
REPUBLIC OF KOREA
SWEDEN
UNITED KINGDOM

INTRODUCTION

The EV City Casebook (Task 42) is focusing on at-scale deployment of electric vehicles using cities across the globe as case studies. This Task explores the incentives, investments and infrastructure needed to support this growth and how policymakers should respond to this changing market.

Task 42 builds upon the success of the EV City Casebook 2012 and 2014 editions. These previous publications focused on global trends, breakthrough technologies, and new business models, that were identified as key in shaping the future of electric mobility. The case studies in these publications are illustrative examples of how pioneering cities are preparing the ground for mass market EV deployment. Both editions of the Casebook received global press coverage, including Forbes, Fast Company, New York Times and notable publications in China and India. The 2014 edition was also named “Outstanding Publication of the Year” at the Low Carbon Vehicle Partnerships Annual awards ceremony in 2015.

Task 42 collects learning and best practices from existing and planned large scale deployments of EVs around the world and across different road transport modes. The task also explores the role of governments in supporting this growth, including requirements to ramp-up supportive policies and how best to phase-out incentives and financial support. These studies seek to enhance understanding of the most effective policy measures to foster the uptake of electric vehicles in urban areas.

OBJECTIVES

Task 42 aims to collect learning and best practice from existing and planned large scale deployments of EVs around the world. The objective of the task is to highlight key global developments, provide insights on the role of policymakers in accelerating the uptake of EVs and offer guidance on how best to ramp-up and phase out public support. This involves answering three key questions:

1. What are the incentives, investments and infrastructure that will drive growth in markets for EVs?

2. How can the public and private sector work together to accelerate widespread uptake of electric vehicles?

3. How will public policy need to change over time?

WORKING METHOD

The Task will build on the approach and learning from previous successful Tasks (Task 18: EV Ecosystems and Task 22: EV Business Models).

The scope will include different vehicle applications (private cars, ride-hailing and taxis, car sharing, fleet and delivery vehicles, buses) as well as different models of infrastructure deployment and different financing mechanisms.

Data is first collected through desk research which informs targeted interviews to city representatives. In addition, an online survey will be launched to ensure cities have an input into the process and they can put forward potential case studies. At least two workshops will be held (depending on the impact of travel restrictions in the coming months) to validate our findings towards the end of the process.

RESULTS

Task 42 will produce two key deliverables:

- An EV City Casebook that summarises key global developments in concise, accessible, and visually appealing format. The Casebook will be structured around deployment themes (e.g. taxis, buses, car sharing), with key case studies from mass-scale projects around the world. Many of the cities have already been identified, with shortlisting and more targeted interviews taking place.

- A Policy Guide which will produce a clear guide for cities and metropolitan areas aiming to benchmark their progress to date and seeking policy guidance to advance electrification. This document is a collaboration between the HEV TCP and EVI (Electric Vehicles Initiative which is an initiative by the Clean Energy Ministerial and run by the IEA). This collaboration will enable input from the cities in the EVI Pilot City Program. The Policy Guide will allow cities to benchmark themselves against a maturity model, this will establish the next steps for cities in different areas such as: deployment levels of EVs (e.g. light duty vehicles, buses, two-wheelers and trucks); availability of infrastructure such as charging stations; and supporting policies to promote EVs.

NEXT STEPS

- An online survey will be launched to ensure cities can provide additional insights and that there is extensive coverage of projects in terms of scope and geographic area in the Casebook and Policy Guide.
- A programme of interviews with shortlisted projects has already started to build on the initial desk research, this will continue to dig deeper into the shortlisted case studies.
- The EV City Casebook and Policy Guide will both be launched before the end of 2020.

OPERATING AGENT CONTACT DETAILS

For further information, please contact the Task 42 OA:

OPERATING AGENT
Dr. Kate Palmer
Urban Foresight
Flour Mill, 34 Commercial Street,
Dundee, DD1 3EJ
Scotland

kate.palmer@urbanforesight.org
+44(0)1382 549946

SECTION C

HEV TCP WORLDWIDE

AUSTRIA

MAJOR DEVELOPMENTS IN 2019

NEW REGISTRATIONS OF ELECTRIC CARS INCREASED BY MORE THAN A THIRD

In 2019 the number of newly registered Battery Electric Vehicles (BEVs) increased by 36.8 % to 9,242. The share of BEVs related to all new registered passenger cars rose from 2.0 % (2018) to 2.8 %. Registrations were predominantly undertaken by legal entities, companies, and regional authorities (80.9 % of new BEV registrations), while the share of private registrations declined from 19.9 % in 2018 to 19.1 % in 2019. The overall Electric Vehicle (EV) share rose from 2.54 % to 3.45 % (Figure 1).

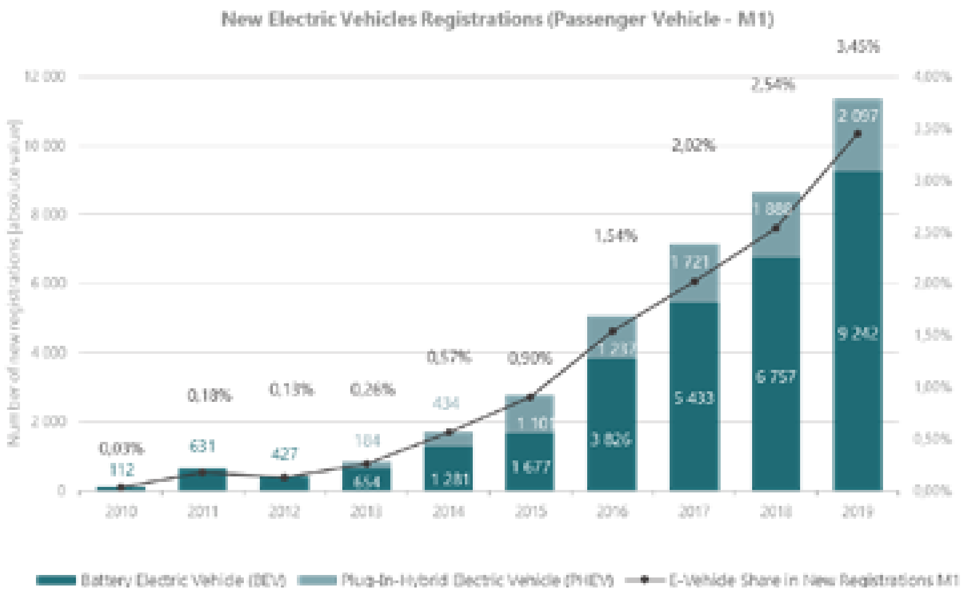


Figure 1: Development of BEV/ PHEV vehicle registration in Austria (2010-2019)

Source: https://www.bmk.gv.at/en/topics/alternative_transport/electromobility/facts.html

TARGET PATH TO REACH 14 % OF RENEWABLE ENERGY IN TRANSPORT (2021 TO 2030)

An increasing market penetration of electromobility, coupled with a high proportion of renewable energy in the electricity mix and a slight increase in the use of sustainably produced biofuels, will increase the proportion of renewable energy in transport and will allow us to reach the minimum target of 14 % in 2030 (9.5 % in 2017). Specifically, bioethanol in petrol is planned to be increased from the current 5% to 7-10% and a blend of synthetic diesel fuels from renewable sources of around 3% is planned to be introduced.

NEW POLICIES, LEGISLATION, INCENTIVES, FUNDING, RESEARCH, AND TAXATION

Integrated National Energy and Climate Plan (NECP) adoption

The NECP is a new planning and monitoring instrument of the European Union and its Member States. It contributes to an improved coordination of European energy and climate policy and is the central instrument for implementing the EU's renewable energy and energy efficiency targets for 2030. Austria adopted the NECP in December 2019. It includes instruments for a mobility decarbonisation, which aims , (1) to support a e-mobility offensive, which has been set up in order to promote vehicle conversion to zero and ultra-low emission vehicles (purely electric, plug-in, hydrogen/fuel cell) and the establishment of corresponding charging infrastructure, (2) to strengthen electromobility through an official directory of all publicly accessible charging facilities for electric vehicles and (3) to prepare the national vehicle industry for the technological transition towards alternative drive train technologies through RID funding within the National Battery Initiative and through a strong Austrian industry participation in the Important Project of Common European Interest "European Battery Innovation Supporting A Circular Economy From Material To Recycling".

E-mobility offensive

The initiative runs in the years 2019/2020 and makes 92 million EUR available for the purchase of EVs and charging infrastructure. The initiative provides funding for electric vehicles, such as e-bikes, e-scooters, e-cars, e-buses and light and heavy-duty e-vehicles as well as funding for the expansion of charging infrastructure and for investments in e-mobility management, e-fleets and e-logistics. The initiative is the successor of a previous 2-years funding program, in which 14,300 funding applications for electric passenger cars and electric 2-wheelers had been submitted.

Austrian National Battery Initiative and participation in the Important Project of Common European Interest (IPCEI)

The development and production of battery cells, modules and packs and electric vehicles is of utmost importance for Austria due to its strong automotive supply industry. Hence, the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK)[1] set up the Austrian National Battery Initiative[2] complimentary to the European Battery Alliance in close cooperation with industry and research. The initiative covers the whole value chain from raw materials to the production of battery cells up to the module and battery pack and its integration in the vehicle taking recycling and sustainability in energy and battery production as well as efficient industry 4.0 processes. The initiative focuses on two main action lines, firstly, to establish a Pre-Production Centre for Producing Battery Cells, -Modules and -Packs and secondly, to support the set-up of a Cluster for Battery-Systems, -Integration and -Management. Until the end of 2019 two battery calls have been published. Parallel to the battery initiative, the Austrian industry participates in the IPCEI "European Battery Innovation Supporting A Circular Economy From Material To Recycling" in order to establish battery cell production throughout Europe.

[1] Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK): https://www.bmk.gv.at/en.html

[2] Austrian National Battery Initiative: https://www.ffg.at/mobilitaetderzukunft_call2019as14

HEVS, PHEVS, AND EVS ON THE ROAD

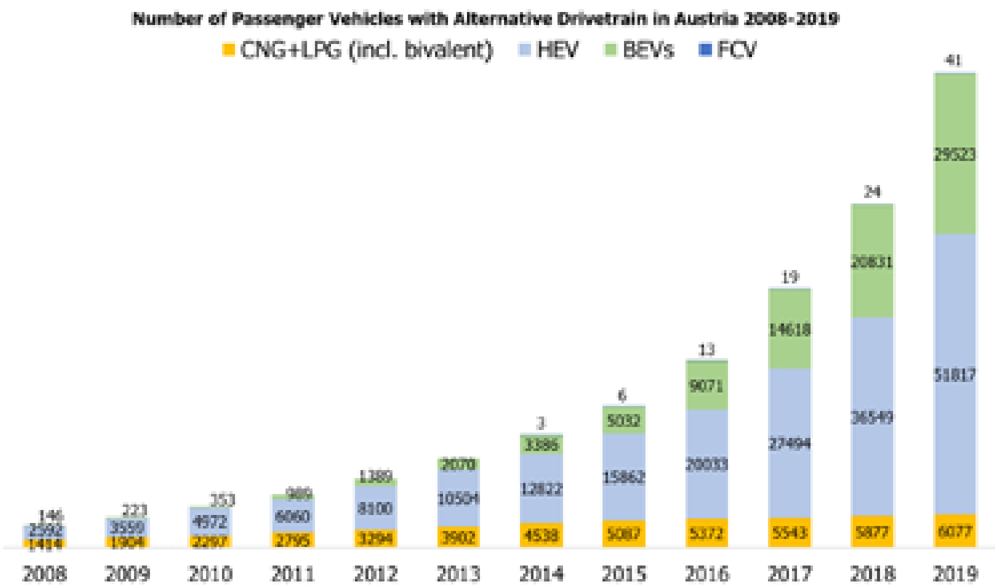
FLEET DISTRIBUTION AND NUMBER OF VEHICLES IN AUSTRIA

According to provisional figures, the total fleet of motor vehicles registered in Austria accounted to about 7.0 million, that is, 1.5 % more than in 2018. Passenger cars, the most important type of vehicle (share: 72.0%), showed an increase by 1.2 % to 5.04 million vehicles and crossed the 5 million mark for the first time in history.

Figure 2 shows the continuous trend toward advanced alternative propulsion systems, especially for battery electric vehicles and hybrid electric vehicles. With numbers of 29,523 and 51,817, respectively, the positive trend follows an exponential trajectory. The number of vehicles driven by CNG and liquefied petroleum gas (LPG), including bivalent ones, shows a stable linear, but very moderate increase to 6,077. With 41 vehicles, the fuel cell electric vehicle fleet is still negligible.

Figure 2:
Trends for vehicles with alternative drivetrains in Austria, 2008–2019

Source: Statistik Austria



FEWER NEW GASOLINE AND DIESEL CARS, ALTERNATIVELY POWERED CARS ARE BECOMING INCREASINGLY POPULAR

329,363 total new passenger car registrations in 2019 were 11,705 below the previous year's figure (341,068), but well above the 20-year average (316,332). Compared to 2018, new registrations of petrol cars (share: 53.7 %) fell by 4.0 % and diesel cars (share: 38.4 %) fell by 9.8 %. Although the share of alternatively powered passenger cars - electric, natural gas, bivalent, combined (hybrid) and hydrogen (fuel cell) - remained comparatively low at 8.0 % or 26,346 new registrations (2018: 4.9 % or 16,807), the relative growth was 56.8 % (2018: +18.7 %). The number of new registrations of gasoline-hybrid passenger cars - the most important alternative fuel type for passenger cars - increased by 47.8 % to 12,348.

AVERAGE CO2 EMISSION OF PASSENGER CARS RISES AGAIN

In 2019, CO2 emissions for newly registered passenger cars including BEV, HEVs and FCVs documented an average of 126 g/km (2018: 123 g/km). For gasoline-powered passenger cars, the value rose from 125 g/km to 128 g/km. Diesel cars recorded an increase in CO2 emissions from 126 g/km in 2017 to 133 g/km in 2019.

Table 1

Table key:
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

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	9,413	10		0	828,578
B Passenger vehicles	29,253	44,010	7,807	41	5,039,548
C Buses and Minibuses	161	43		0	10,148
D Light Commercial vehicles	2,605	2		0	440,582
E Medium and Heavy Weight Trucks	12	9		0	54,003

Table 2

Table key:
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

Total Sales During 2019

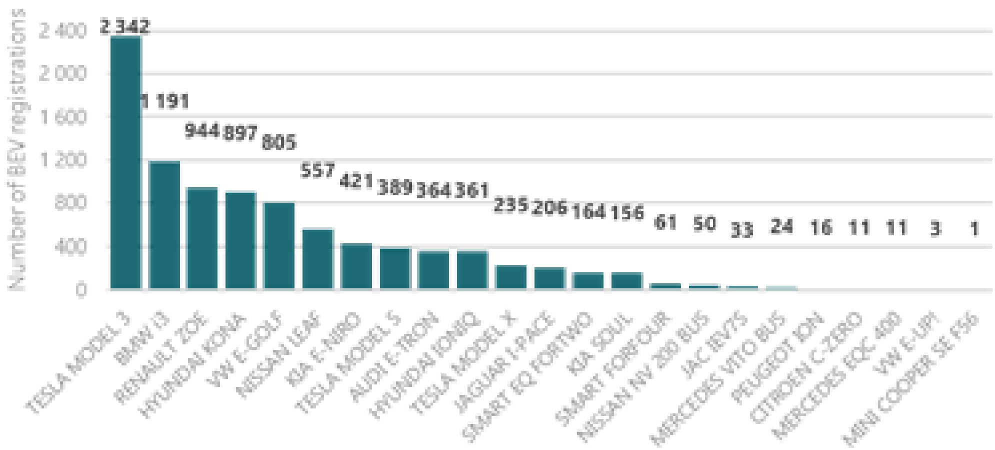
Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	2,481	0	0	0	41,014
B Passenger vehicles	9,242	14,408	2,097	19	329,363
C Buses and Minibuses	22	38		0	1,163
D Light Commercial vehicles	500	2		0	43,425
E Medium and Heavy Weight Trucks	0	0	0	0	531

BEV M1 BRAND DISTRIBUTION

According to BEV registrations numbers for 2019 (figure 3) the most popular model was the Tesla Model 3 with 2,342 units sold, followed by the BMW i3 with 1,191 units and the Renault Zoe with 944 units. In the Austrian BEV market Tesla takes first place with around 32%, followed by Hyundai with around 14% and then BMW with around 13% market share.

Figure 3:
BEV M1 registrations by model (2019)

Source: Statistik Austria
Illustration: AustriaTech

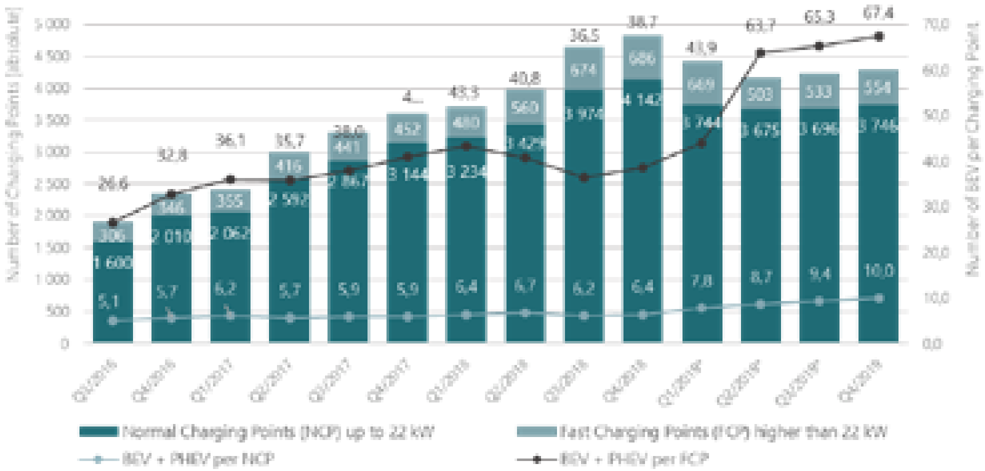


CHARGING INFRASTRUCTURE OR EVSE

Figure 4 shows the number of publicly available normal (NCP) and fast charging points (FCP). In total in Austria 3,746 normal charging points and 554 fast charging points were accessible at the end of the fourth quarter of 2019. This means ten electric cars (BEV and PHEV) per NCP and about 67 per FCP.

Figure 4:
Publicly available normal and fast charging points (2016–2019)

Source: http://e-tankstellen-finder.com
Illustration: AustriaTech



PUBLICLY ACCESSIBLE CHARGING FACILITIES DIRECTORY[3]

The degree of diffusion and the availability of publicly accessible charging infrastructure are decisive factors influencing its user-friendliness and thus success factors for the establishment of electromobility. In order to create a reliable reference for publicly accessible charging infrastructure, an official directory of all publicly accessible charging facilities for electric vehicles in Austria has been created and has been made available online. This directory contains information on the technical equipment, the charging possibilities and the charging capacity available. The charging point directory is designed to make the availability of publicly accessible charging infrastructure more transparent, to promote competition between charging infrastructure operators, to strengthen the confidence of potential vehicle buyers in electromobility and to counteract the fear of coverage

[3] Publicly accessible charging facilities directory: https://www.ladestellen.at/#/electric

Table 3

Type of Public EVSE	Number of Charging Points
AC Slow Chargers (≤ 3.7 kW)	n.a.
AC Slow Chargers (>3.7 kW, ≤ 22 kW)	3,746
Fast Chargers (> 22 kW, ≤ 43.5 kW) Superchargers (> 43.5 kW)	554
Inductive Chargers	n.a.

EV DEMONSTRATION PROJECTS

KLIMAAKTIV MOBIL PROGRAM

The national action program for mobility management, called klimaaktiv mobil[4], supports the development and implementation of mobility projects and transport initiatives that aim to reduce CO2 emissions, for example, by vehicles with alternative drivetrains or electric mobility. Since 2004, financial support for about 34,300 alternative vehicles, including more than 31,600 electric vehicles, has been provided. The klimaaktiv mobil website offers a map with the details to each project. In total the financial support amounted to 122 million EUR (133 million USD) until the end of 2018. In 2018, 13.9 million EUR (15.2 million USD) funding was made available.

ZERO EMISSION MOBILITY PROGRAM

The Zero Emission Mobility[5] program forms the core of pilot projects for implementing the e-mobility initiative of the Austrian Federal Government. The focus of the program is on zero emission mobility projects in road transport with integrated demonstration and a clear implementation perspective. The calls are technology neutral encompassing the three pillars, vehicle – infrastructure – user, from the predecessor program, the Austrian Electric Mobility Flagship Projects. Under the flagship program, 36 projects with 320 project partners and an overall funding of 68 million EUR with a total investment of 217 million EUR have been initiated.

MOBILITY OF THE FUTURE PROGRAM

The research program Mobilität der Zukunft[6] (Mobility of the Future) is an Austrian national transportation R&D-funding program for the period 2012–2020. The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) is fully in charge of the program content and the four complimentary thematic fields: Personal Mobility, Mobility of Goods, Vehicle Technology and Transport Infrastructure. The annual budget of Mobility of the Future is between 13 and 19 million EUR.

[4] klimaaktiv mobil: https://www.bmlrt.gv.at/umwelt/luft-laerm-verkehr/klimaaktivmobil.html

[5] Zero Emission Mobility projects: https://www.klimafonds.gv.at/wp-content/uploads/sites/6/Klien_Emobilitaet18_englisch.pdf

[6] Mobility of the Future: https://mobilitaetderzukunft.at/en/

Austrian Association for Advanced Propulsion Systems (A3PS)

In 2006 the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) founded the "Austrian Association for Advanced Propulsion Systems (A3PS)[7]" 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 advanced powertrain and vehicle technologies such as advanced Internal Combustion Engine (ICE) technologies, hybrid, battery electric and fuel cell vehicles as well as advanced fuel technologies including biofuels and active safety measures such as Advanced Driver Assistance Systems (ADAS).

OUTLOOK

The current government set in January 2020 the ambitious goal for Austria to become carbon neutral by 2040. The path to climate-neutrality in 2040 - ten years earlier than the EU's goal – is outlined in the supporting Government Program. Alternative energy will play a crucial role for reaching the ambitious goals. Focus points of the Government Program in the transport sector are (1) further RID funding in the e-mobility sector, (2) a strategy for the use of alternative energy sources in mobility (e-mobility, hydrogen, synthetic fuels) with a focus on total climate balance and for transport policy innovations such as drive technologies (e.g. fuel cell) and digitalisation (e. g. Platooning) and (3) the promotion of the electric and hydrogen passenger cars acquisition.

Based on the political goal and the outlined focus points the Austrian Climate and Energy Strategy and the Austrian Integrated National Energy and Climate Plan (NECP) are expected to be updated in the course of 2020.

[7] A3PS: https://www.a3ps.at/

BELGIUM

ELECTRIC MOBILITY IN BELGIUM

INTRODUCTION

The vehicle industry in Belgium is in a transition to a clean and smart mobility industry. The vehicle industry has always been an important industrial sector in Belgium, but especially the car assembly was under severe pressure during the past years. For future job creation, our industry must 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 within the framework of IEA HEV TCP Task 24 “Economic Impact Assessment of E-Mobility”. It 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/economicimpact-assessment-of-e-mobility-task-24/.

In March 2018, Agoria also started a one-year-study called “LIFEBAT”, with the goal to map out the opportunities and challenges for the companies in the Flemish Region in the complete value chain of the Lithium-ion battery. This study aims at concrete recommendations regarding actions and initiatives that are needed from the industry, from the government and from knowledge centres in order to strengthen the position of the Flemish Region in the complete Lithium-ion battery value chain.

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 is 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 September 2018, Audi Brussels began mass production of the Audi e-tron, the first full-electrical model from the brand with the four rings. The sporty SUV combines the space and comfort of a typical luxury class automobile with a range suitable for everyday use, catapulting the driver into a new era with the electrical all-wheel drive. With a charging capacity of up to 150 kW at quick-charging stations, it is ready for the next long-distance stage in about 30 minutes. Audi presented the unveiled electric car for the first time at its world premiere in San Francisco on 17 September 2018.

Since summer 2016, the Audi Brussels plant has extensively rebuilt its body shop, paint shop and assembly line step by step, and has set up its own battery production. Driverless transport systems bring the batteries for the electric cars to the assembly line just in sequence. The employees in Brussels have received more than 200,000 hours of training for the first all-electric Audi and are thus perfectly prepared for the start of production.

Audi attaches great importance to resource-conserving production. As the first of its kind, the e-tron will be produced completely CO2-neutrally at the converted Brussels plant, where also the model’s batteries are 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 %) or environmental projects (approximately 5 %). Audi Brussels thus operates the world’s first certified CO2-neutral high-volume production plant in the premium segment.

Volvo Car Gent has been producing cars in Ghent since 1965. For the ninth year in a row, Volvo Car Gent is reporting volumes in excess of 200,000 cars. 2018 was a challenging year for Volvo Car Gent. The production of the XC40, European car of the year, reached cruising speed with over 89,000 vehicles made. The new V60 was introduced in September 2018 and over 5,000 were produced in the last four months of the year.

Volvo Car Gent is preparing for its role in the electrification strategy of Volvo Cars. As regards to technical and logistical aspects, all preparations are being made to be able to produce hybrid and electric vehicles. Besides the end assembly of the vehicles, the building of a battery assembly plant has started, and first assembly of battery packs is expected in 2020.

Volvo Cars is stimulating its end customers to drive on green electricity via the “Volts by Volvo Cars” offer in Belgium.

Volvo’s sustainability goal of achieving climate-neutral production by 2025 also remains a priority for Volvo Car Gent. All the electricity used in the plant is already green energy and further steps are being taken in this direction. In addition to previous initiatives such as installing wind turbines and solar panels, the vehicle spraying process is to be made more environmentally friendly and studies have begun to look at ways of using the wastewater from the plant.

Besides car assembly, Belgium has a lot of other activities in the automotive sector. Toyota Motor Europe has its European headquarter, logistics centres, and technical R&D centre in Belgium. 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 is an independent Belgian manufacturer of buses, coaches, and industrial vehicles. The company, founded in 1947, is established in Koningshooikt. The vast majority of its production goes to Europe and the United States. Van Hool has over 4,400 employees worldwide, of whom the largest share work at the production sites in Koningshooikt (Belgium) and Skopje (Macedonia).

Van Hool is very active in electric and fuel cell buses. Van Hool presented its inductively charged electric buses driving in the city of Bruges already at Busworld 2015. With EquiCity, the so-called tram bus, Van Hool developed an innovative concept for sustainable public transport in which hybrid, battery electric or fuel cell powertrain can be integrated. Van Hool is the coordinator for 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. At 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.

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 Group and has supplied its products to numerous European projects, e.g. 43 articulated buses in Eindhoven (NL) and 100 articulated buses in Amsterdam (NL).

The VDL Citea is available in 9, 12 and 18m length-variants of which the latter two are produced in Roeselare. VDL Bus Roeselare has supplied its hybrid and electric buses to cities in Norway, Sweden, Finland, Denmark Germany, the Netherlands, Switzerland, Belgium, Luxembourg, and France.

ELECTRIC MOTORCYCLES

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 has been focusing on the development and production of high-performance electric two-wheelers and electric drivetrains. This Belgian factory was established in 1850 by Joseph Saroléa. As of 2008, Saroléa has been focusing 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 22kWh 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 drivetrains for automotive, nautical, and aerospace applications.

SUPPLIERS

Belgium hosts about 300 suppliers to the automotive industry. A lot of the innovations in the automotive are taking place on the supplier's side. In Belgium we have renowned suppliers like e.g. Umicore, Siemens, ABB, Melexis, PEC, Leclanché, DAF, Borit, Punch Metals, Solvay, 3M, JSR Micro, and Punch Powertrain. Most of these companies are active in electric mobility.

Umicore, the Belgian materials technology and recycling group, is uniquely positioned in clean mobility materials, having focused its products and services on technologies that address the key global challenges of clean air (automotive catalysts), electrified transport (rechargeable battery materials) and resource scarcity (recycling). Umicore's innovation pipeline spans the next 20 years and beyond, aiming for higher energy density and longer driving range in electrified vehicles.

From 2016 to 2018, Umicore invested a total of 460 million EUR to further increase its production of rechargeable battery materials used in Lithium-ion batteries for electrified transport. These investments led to the construction of a new facility in Korea and a brownfield expansion in China, both completed ahead of schedule in 2018.

Given Umicore's roadmap for European rechargeable battery materials and the surging demand from its customers, a further investment of 660 million EUR was announced in February 2018 for a new facility in China and a first production facility in Europe. Located in Nysa, Poland, this European plant is expected to come on-stream in late 2020.

One of the key elements in rechargeable battery materials is cobalt. In 2015, Umicore invested 25 million EUR to upgrade and expand its cobalt-refining and recycling plant in Olen. Since December 2016, Umicore has obtained third-party validation for its sustainable procurement framework for cobalt. Leading the way in ethical sourcing as early as 2004, Umicore was the first company to introduce a sustainable procurement framework and the first to obtain external validation for its ethical and sustainable procurement approach.

Punch Powertrain continued its efforts to develop its hybrid electric powertrain which 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. In parallel additional application projects are targeted with other customers. Punch Powertrain also elaborated an electric trike demonstrator and developed an electric powertrain for an electric race car which had its world premiere on EEVC (Geneva). The Punch Powertrain Solar Team was very successful in 2018 by winning the very severe solar car race “Carrera Solar Atacama” in Chile.

PEC (http://www.peccorp.com) delivers the building blocks for the development and manufacturing of large format cells and modules used in electric mobility. 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 4000 Amps. 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.

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: the higher purchase price of alternative fuel vehicles, the lack of recharging infrastructure, the 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, etc., 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 for 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.	/

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 AFVs (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 18 December 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 refuelling 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-organised 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.

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 become 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).

BRUSSELS POLICY FRAMEWORK

Especially the numerous diesel vehicles daily entering and circulating the roads contribute strongly to the emissions of particulate matter and nitrogen oxides, causing immense health problems, as well as damage to ecosystems and cultural heritage.

To reach the BCR's targets regarding air quality and climate change, additional actions are necessary. These actions have been defined by the 'AirClimate-Energy Plan' (ACE plan), adopted on 2 June 2016 by the Brussels' regional government. Besides rationalising 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) in 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 fuelled vehicles form an interesting solution for the nuisance caused by conventional diesel and petrol vehicles, although these vehicles will not resolve the problem of congested roads. Seen the urban context of the BCR and the fact that on average only five kilometres 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. a quota on electric cars in 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.

FEDERAL POLICY FRAMEWORK

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

The federal part of the Belgian policy framework describes the main federal policy measures/competences which directly or indirectly regard alternative fuels

/ vehicles / infrastructure. The federal part goes beyond the scope of Directive 2014/94.

The federal government of Belgium however played an important role in support actions like the coordination of the national policy framework. The Federal Public Service of Economy and the Federal Public Service of Mobility & 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”.

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, standardisation (CEN – NBN) and security.

CHARGING INFRASTRUCTURE OR EVSE

INTRODUCTION

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 more 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 electrics 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 the information is scattered over different databases/websites/apps and not always up to-date and certainly not available in a standardised way. So big improvements are needed in user-friendly access to charging infrastructure information.

STATISTICS ON CHARGING INFRASTRUCTURE IN FLANDERS

For this annual report we will focus in more detail on the statistics on charging infrastructure in Flanders. The ambition is to have 7,400 publicly accessible charging points in 2020 in Flanders. Currently, 3,047 normal charging points are registered in Flanders.

Part of the ambition will be realised 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. 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).

The number of fast and ultra-fast chargers is also rising as a result of European projects like Fast-E, Ultra-E, Mega-E, and BENEFIC, among others. BENEFIC (www.benefic.eu) is an innovative cross-border project for the development of charging and refuelling infrastructure for alternative fuels for transport initiated by the Flemish Government in partnership with the Brussels Capital Region and the Netherlands. Through open calls for proposals, the partners selected about 30 infrastructure projects for (ultra)(fast)chargers for electric vehicles, electric taxis and electric buses, CNG and LNG infrastructure, hydrogen refuelling infrastructure and onshore electricity supply facilities for inland navigation. The projects must be realised in the summer of 2020. Currently, 72 fast chargers are registered in Flanders spread over 38 locations.

Triggered by the end customer needs and by the European and national/regional governments, the market for charging infrastructure is trying to organise 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 reading 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 centralised on the following website: https://www.milieuvriendelijkevoertuigen.be/laadpalen-in-kaart

EV DEMONSTRATION PROJECTS

E-BUSES IN BELGIUM

ZEB Platform

The Flemish Zero Emission Bus Platform (ZEB Platform) has been running from 2017 until mid-2018 (http://www.platformzeb.be/).
The Zero Emission Bus project aimed 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 (www.zeeus.eu), to translate the huge amount of knowledge build up by ZeEUS on the European level to the local situation in Flanders.

At Busworld 2017, the first intermediate results have been presented and the final ZEB report with conclusions and policy recommendations (in Dutch) has been presented during an event in the Flemish Parliament mid-2018 and at the final event at Multiobus, one of the active partners of the ZEB Platform.

De Lijn

The Flemish public transport company – Vlaamse Vervoermaatschappij De Lijn – has been running daily services with hybrid buses and also electric and hydrogen vehicles for several years.

In 2010 – 2011, 79 hybrid buses build by Van Hool, came into service. These buses use ultracapacitors as an energy storage system, the diesel engine produces the mechanical power for the generator to feed the traction motors and to drive other auxiliary equipment. This series of buses allowed De Lijn to gain the first experience in electric drive technology, including the necessary maintenance and safety competences. These buses are in service mainly in Ghent (articulated hybrid buses) and Leuven (12m electric buses), but also Antwerp, Bruges, and Hasselt have this kind of hybrids.

Next steps in the path towards cleaner public transportation were the orders of hybrid buses in 2013 and 2014, were 120 VDL 12m buses (type Citea SLF) and 18 Van Hool city buses (type A309 H) were ordered. In the evolution of the hybrids it became 'all electric vehicles', where all the auxiliary equipment is electrically driven and they are equipped with batteries. The big advantages are better energy management and the start-stop functionality which allows to stop the diesel engine at stops and to run on the battery over a few 100 meters. The energy management is focused on fuel saving, and results in an overall value of 25 % reduction calculated over all seasons and includes the fuel consumption of auxiliaries such as the water heater in winter.

Several optimisations were needed and are successfully executed by Van Hool and VDL. Since the technology is continuously improving in this field a next generation of hybrid buses are coming into operation. In 2017-2018 De Lijn ordered a total of 150 VDL 12m hybrid buses (type Citea SLE) and 36 Van Hool city buses (type A309 H). A first order of 14 double articulated so called tram-buses (BRT-buses) has been placed at Van Hool (ExquiCity) to run on the corridor around the Brussels Region towards the airport in Zaventem. The basics of these 12m buses are in fact electric buses equipped with a diesel engine. They are prepared to receive fast charging equipment and to be turned into real electric buses with a range extender when charging stations will be available. The Van Hool buses could also be extended to be rechargeable buses (PHEV).

STIB / MIVB

STIB / MIVB, the Public Transport company of the Brussels Capital Region, is currently testing electric buses (37 electric buses from different types) as to prepare the transition for an electric bus fleet as from 2030.

TEC Group

TEC Group, the Public Transport company of the Walloon Region, has very ambitious plans in the electrification of its bus fleet.

TEC is currently using 101 electric buses (Volvo 7900 Electric Hybrid buses) and 12 ABB charging stations in Charleroi and Namur.

Platform Electric Company Cars (PEB)

The 'Platform Elektrische Bedrijfswagens' (Platform Electric Company Cars or 'PEB') aims at accelerating the adoption of electric vehicles in Belgian company fleets. PEB offers a platform for fleet/mobility managers, market players (energy providers, car manufacturers, lease companies and other EV market providers) and policy makers to exchange knowledge and challenge each other to further enhance the implementation of EV's on the road. PEB is an initiative from Fleet & Mobility (the Belgian organisation of fleet owners), Traxio (the Belgian umbrella organisation of mobility retailers), The New Drive (management consultants in emobility) and Bond Beter Leefmilieu (environmental NGO). The platform is supported and co-financed by the Flemish government through the Clean Power for Transport program and started on 1 January 2017.

Clean Power for 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 taxi's driving electrically in 2020. The "Clean Power for Taxis" further builds 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.

OUTLOOK

AUTONOMOUS VEHICLE AND INFRASTRUCTURE COOPERATIVE ARCHITECTURE

In March 2018, Flanders' government adopted a policy note on connected and automated mobility to realise investment priorities for a smart and safe transport system in Flanders, including regulatory aspects.

Research for autonomous vehicles (functional safety, path planning, control and ADAS information functions) is carried out by Strategic Research Centres, amongst others the AVICA program (Autonomous Vehicle and Infrastructure Cooperative Architecture), enabling Flemish OEMs, tier1, infrastructure, component, and service provides to provide proof of concept of their products on system level.

Field Operational Tests on connected and autonomous driving are implemented by knowledge partners imec in the European (CEF) project CONCORDA, complemented with the Flanders' publicly funded innovation project SmartHighway, and a recent public private innovation partnership MobiliData (for cloud service applications for smart traffic infrastructure), other C-ITS projects Citrus, Intercor.

AUTONOMOUS DRIVING @DE LIJN

De Lijn, the Public Transport company of the Flemish Region, expects self-driving vehicles to transform mobility and offer the society important challenges and opportunities.

The challenges connected to the introduction of autonomous driving are mainly a result of the induced increase of transport demand which could raise congestion levels significantly. This increase in transport demand will mainly be the result of people being willing to travel more often and longer when the in-vehicle time is no longer perceived as time lost because the driver is freed from steering or monitoring the vehicle. Furthermore, in the future new groups of customers (-18y/+80y/disabled) will be offered flexible means of efficient transport and new services will arise.

On the other hand, new mobility concepts also offer valuable new opportunities to the society. De Lijn believes autonomous mobility can and should create large societal benefits by leading to the rise of flexible efficient and very attractive forms of shared transport with smaller shuttle bus vehicles operating with short waiting times and transporting groups of customers along flexible trajectories. An important role for the government is to guarantee that this mobility revolution results in the development of such shared and thus sustainable transport. Pilot projects are necessary to gain learning effects in order to be able to steer this revolution in the right direction and maximise public benefits.

Therefore, De Lijn works on several pilot projects with autonomous shuttles.

In a first project in Brussels Airport, the pilot stage was recently launched, in which the transport system provider 2getthere aims to demonstrate the safe functioning of a first electric autonomous shuttle vehicle in mixed traffic. According to the current timeline, the implementation of a large-scale transport system for passengers can start in mid-2020 after a successful pilot stage. Mid 2021 the first passengers can then be transported. In collaboration with the cities Antwerp, Genk, Leuven and Mechelen, De Lijn is now finalising feasibility studies which serve as a preparation for a second wave of pilot projects with autonomous shuttle vehicles.

BRUSSELS AIRPORT – ELECTRIC BUSES

Brussels Airport is one of the largest airports in Europe, handling 25,7 million passengers and 732,000 tons of freight annually.

Over the years, a wide number of measures have been put in place, including in terms of the airport's vehicle fleet. In addition to our investment in CNG-powered service vehicles, Brussels Airport is gradually replacing buses used to carry passengers between the terminals and the aircraft with modern e-buses. In 2020, the majority of the buses that take passengers to and from the aircraft at Brussels Airport will be powered by electricity. These buses will be built by the European branch of the Chinese company BYD. The charging infrastructure for this project is co-funded by the financing instrument of the European Union, Connecting Europe Facility (CEF), through BENEFIC. The electric bus project fits in with Brussels Airport's ambition to drive down its carbon dioxide emissions by 40 % by 2030 (compared to 2010).

CANADA

INTRODUCTION

The transportation sector accounts for almost one quarter of total national GHG emissions and represents the second largest source in Canada. Of this, approximately 50% comes from passenger cars and light trucks and another 34% from freight trucks.[1]

Canada's electricity supply mix is one of the cleanest and most renewable in the world. Hydroelectricity, the largest renewable energy source in Canada, accounts for approximately 60% of Canada's electricity generation, making Canada the world's second largest producer of hydro power. Along with energy sources such as nuclear, wind, and solar, approximately 82% of Canada's electricity was from non-GHG emitting sources in 2017.[2] As a result, the potential to reduce GHG emissions by electrifying the transportation system is significant.

MAJOR DEVELOPMENTS IN 2019

NATIONAL DEVELOPMENTS

In January 2019, the Government of Canada set ambitious federal targets for zero-emission vehicles (ZEV) to reach 10% of new light-duty vehicle sales by 2025, 30% by 2030, and 100% by 2040. ZEVs include Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Hydrogen Fuel Cell Vehicles (FCVs).

In December 2019, the Government of Canada announced commitments to further strengthen existing and introduce new GHG reducing measures to exceed the 2030 Paris target. In addition, Canada will develop a plan to achieve net-zero emissions by 2050 and will set legally-binding, five-year emissions reduction milestones, based on the advice of experts and consultations with Canadians. The government has committed to efforts to increase clean electricity, invest in greener buildings and communities, and accelerate the electrification of transportation.[3]

The Federal Budget 2019 included a number of strategic investments that will make it easier and more affordable for Canadians to choose ZEVs.[4]

[1] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions

[2] https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/electricity-facts/20068

[3] https://www.canada.ca/en/environment-climate-change/news/2019/12/government-of-canada-releases-emissions-projections-showing-progress-towards-climate-target.html

[4] https://www.budget.gc.ca/2019/docs/plan/chap-02-en.html

[5] https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/zero-emission-vehicle-infrastructure-program/21876

Zero Emission Vehicle Infrastructure Program (ZEVIP)[5]

An additional 98 million USD over five years (2019-2024) to deploy new EV charging and hydrogen refuelling stations at workplaces, commercial and multi-unit residential buildings (MURBs), public places, on-street and projects for commercial fleets (e.g. taxis, car sharing), mass transit, and inner city delivery. This amount is in addition to the existing resources of 138 million USD over 6 years (2016-2022) for the Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (EVAFIDI) and the Electric Vehicle Infrastructure Demonstration (EVID) program, to support the establishment of a network of electric vehicle fast chargers along the National Highway System, natural gas refuelling stations along key freight corridors and hydrogen refuelling stations in metropolitan centres, demonstrate next generation and innovative charging technologies and solutions to address barriers to EV adoption, and support the development of enabling binational (Canada and the United States) codes and standards for low-carbon vehicles and infrastructure.

iZEV Program[6]

226 million USD for a new federal ZEV purchase and lease incentive of up to 3,770 USD for a BEV, longer range PHEV, or FCV or 1,885 USD for PHEVs with a shorter range. The incentive, effective May 1, 2019, is only available for vehicles where the base model Manufacturer's Suggested Retail Price is less than 33,910 USD, 41,450 USD, or 45,220 USD depending on the number of seats and the model version. The federal incentive is in addition to any provincial/territorial incentive offered.

Tax incentive

To support adoption by businesses, since March 2019, on-road passenger ZEVs are eligible for a full tax write-off, up to a limit of 41,450 USD, in the year they are put in use. This includes light-, medium- and heavy-duty vehicles purchased by a business (e.g. taxi, school bus). An intention to expand this program to off-road vehicles and automotive equipment was announced by the government on March 2nd, 2020.[7] This new incentive will be aimed at mining, transportation, and agriculture businesses, allowing a 100% tax write off for eligible off-road and heavy-duty electric vehicles.

Federal Greening Government Strategy - Mobility and Fleets[8]

The federal government is adopting low-carbon mobility solutions, deploying supporting infrastructure in its facilities, and modernizing its fleet. Starting in 2019-20, 75% of new light-duty unmodified administrative fleet vehicle purchases will be ZEVs or hybrids, with the objective that the government's administrative fleet comprises at least 80% ZEVs by 2030. Priority is to be given to purchasing ZEVs. Since 2018-19, all new executive vehicle purchases are to be ZEVs or hybrids.

Federal Research, Development and Demonstration

Impact Canada - Charging the Future Challenge[9]: In July 2019 Natural Resources Canada (NRCan) announced a new 3.39 million USD challenge aimed at accelerating made-in-Canada battery innovation to better position the country in the highly competitive global market. During the 18-month challenge, five finalists will pitch their concepts to a jury of experts to win up to 525,000 USD each to develop their battery prototype. Ultimately, the most promising battery breakthrough will be awarded a 753,600 USD grand prize.

[6] https://www.tc.gc.ca/en/services/road/innovative-technologies/zero-emission-vehicles.html

[7] https://pm.gc.ca/en/news/news-releases/2020/03/02/making-zero-emissions-vehicles-more-affordable

[8] https://www.canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/strategy.html

[9] https://impact.canada.ca/en/challenges/charging-the-future

[10] https://www.nrcan.gc.ca/science-data/funding-partnerships/funding-opportunities/funding-grants-incentives/energy-innovation-program/breakthrough-energy-solutions-canada/21913

Breakthrough Energy Solutions Canada[10]: This program, which was launched at the Clean Energy Ministerial-10 / Mission Innovation-4 meeting in Vancouver, aims to support Canadian entrepreneurs and firms to advance clean energy technologies which could significantly reduce global GHG emissions in 4 areas, including transportation. The program is delivered in partnership with Breakthrough Energy and the Business Development Bank of Canada. A total initial investment of up to 30.1 million USD is available. Two of the ten finalists are for transportation EV-related projects. The first, receiving 2.08 million USD, is with GBatteries for the project "Ultra-fast charging of lithium-ion cells for the mass global adoption of electric vehicles", and the second, receiving 2.26 million USD, is with Havelaar Canada Industrial R&D Laboratory Ltd for the project "Havelaar R&D Collaboration with Purolator, Bell Canada & Cornerstone Hydro-Electric Concepts".

Clean Growth Program[11]: A 116.8 million USD investment in clean technology research, development and demonstration projects in three Canadian sectors: energy, mining and forestry. A total of 50 projects have been selected for funding, including three projects related to electrification of heavy-duty or off-road transportation in the mining and forestry sectors.

PROVINCIAL/TERRITORIAL DEVELOPMENTS

Quebec

Quebec's Transportation Electrification Action Plan (TEAP) is nearing the end (2015-2020). The TEAP, with a total budget of more than 750 million USD, includes three main areas: promotion of transportation electrification, development of the industrial sector, and creation of a favourable environment. By December 31st, 2020, Quebec plans to have 100,000 EVs registered, reducing GHG emissions by 150,000 tons.

In April 2019, Quebec launched a new component of its Roulez vert[12] rebate program for new and used EVs and for charging stations. The new component subsidizes the purchase, installation or rental of charging stations in multi-unit residential buildings (MURBs). The financial assistance granted is equal to 50% of eligible expenses up to a maximum of 3,770 USD per charging station and a maximum of 18,840 USD per building per fiscal year.

British Columbia (BC)

BC's Zero-Emission Vehicles Act (ZEVA) legislates that 10% of all new light-duty vehicle sales must be ZEV by 2025, 30% by 2030, and 100% by 2040. As of September 2019, the CleanBC – Go Electric EV Charger Rebate Program[13] provides rebates for the purchase and installation of eligible EV charging equipment and support services for MURBs and workplaces seeking solutions for their EV charging needs. The total program funding is 3.62 million USD until March 31, 2020 and 3.77 million USD from April 1, 2020 to March 31, 2021 or when funding runs out. At least 1.13 million USD will be reserved for MURBs and workplace EV charging installations.

The combined federal and provincial vehicle purchase incentives have increased the popularity of BC's clean energy vehicle rebate program (CEVforBC), resulting in two to three times higher demand than in 2018. In June 2019, the government

[11] https://www.nrcan.gc.ca/climate-change/canadas-green-future/clean-growth-programs/20254

[12] https://vehiculeselectriques.gouv.qc.ca/english/

[13] https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/electric-vehicles/EV-incentive-program-guide.pdf

of BC announced changes to the CEVforBC program. The maximum price eligibility threshold was lowered to 41,450 USD to ensure the program supports the most affordable vehicles. The provincial rebate was reduced to 2,260 USD for battery, fuel-cell, and PHEVs with a battery range of 85 km and to 1,130 USD for PHEVs with a battery range less than 85 km.[14]

Table 1: Overview of Provincial Policy Instruments

British Columbia	
ZEV mandate	Zero-Emission Vehicles Act (ZEVA) – New LDV sales and leases to reach 10% by 2025, 30% by 2030, and 100% by 2040.
ZEV incentives	Passenger vehicles: - 2,260 USD – BEV or FCV or longer range PHEV (> 85 km) - 1,130 USD – shorter range PHEV (< 85 km) - Manufacturer's suggested retail price (MSRP) < 41,450 USD Specialty-use vehicles: incentives for ZEVs including electric or hydrogen fuel cell motorcycles, low-speed utility trucks, heavy-duty transport trucks, passenger buses, and airport and port service vehicles.
ZEV infrastructure	Incentives for purchase and installation: - 50% rebate up to 260 USD – Level 2 in single family homes - 50% rebate up to 1,510 USD – Level 2 in condos, apartments, townhouses, and workplaces
EV ready building codes	Several cities have zoning, parking, or building bylaws requiring some percentage of "EV ready" parking spaces in new buildings.
Other incentives	Rebates for scrapping old ICE vehicle: - 4,520 USD for new BEV - 2,260 USD for used BEV - 640 USD for new electric bicycle HOV lane access for EVs registered with a green licence plate
RD&D	Go Electric Advanced Research and Commercialization Program
Ontario	
ZEV incentives	Plug'n Drive (NGO) used EV incentive: - 750 USD towards the purchase of a used BEV or PHEV - Additional 754 USD to scrap an old ICE car and purchase a used BEV or PHEV
Other incentives	HOV lane access for ZEVs eligible for green vehicle licence plate

[14] https://archive.news.gov.bc.ca/releases/news_releases_2017-2021/2019EMPR0025-001302.htm

Quebec	
ZEV mandate	2015-2020 Transportation Electrification Action Plan – set a target of 100,000 plug-in vehicles by 2020. The Zero-Emission Vehicle (ZEV) standard – manufacturers subject to it are required to earn credits through the sale and/or lease of ZEV and LEV motor vehicles in the Quebec market. The percentage of credits required for each manufacturer is based on the total number of new cars it sells or leases in Quebec. The ZEV standard will provide consumers access to a wider range of ZEVs within the province. The regulation also makes used vehicles that are reconditioned by automakers and registered in Quebec for the first time eligible for credits, providing low-income households with the opportunity to purchase a ZEV.
ZEV incentives	Effective April 1, 2020, the following incentives apply only to ZEVs with a maximum MSRP of less than 45,220 USD - 6,030 USD for BEVs and FCVs - 375 USD, 3,015 USD or 6,030 USD for PHEVs depending on capacity of the battery - 750 USD for Low-speed EVs - 1,500 USD for Electric motorcycles - 375 USD for Limited-speed electric motorcycles (electric scooters) - All-electric used vehicle rebate of up to 3,015 USD
ZEV infrastructure	Home charging station rebate: - Up to 450 USD for the installation of a 240-volt home charging station for an owner or long-term lessee of an EV. MURB charging station rebate: acquisition and installation - 50% of eligible expenses, or - 3,770 USD per wireless charging station, or - 3,770 USD per connector for charging stations with one or more connectors that allow the equivalent number of EV to be charged simultaneously MURB charging station rebate: lease and installation - 375 USD per wireless charging station, or - 375 USD per connector for charging stations with one or more connectors that allow the equivalent number of EVs to be charged simultaneously, and - 50% of eligible expenses related to the installation.
EV ready building codes	Each new individual dwelling unit with a garage, carport or parking space is required to be EV ready with the installation of the required infrastructure (i.e. cable or conduit).

Other incentives	For ZEVs registered with a green vehicle licence plate: - Free access to several ferries - Privileged access to reserved lanes where posted - As part of pilot, certain tolls (i.e. bridge, highway) waved upon obtaining a transponder - Free parking in certain municipalities
Nova Scotia	
ZEV campaign	The Next Ride[15] EV engagement campaign was initiated in 209 by the Department of Energy and Mines and is run by the Clean Foundation.
Prince Edward Island	
ZEV mandate	State of the Province speech announcement that the province will be electrifying the entire Provincial school bus fleet, and possibly using this fleet in a rural public transportation system.
Other incentives	It is free to register an EV in Prince Edward Island, a cost savings of 75 USD annually, and the province offers half-price registration for hybrid vehicles.[16]

HEVS, PHEVS, AND EVS ON THE ROAD

Increased consumer awareness, greater availability of charging infrastructure, improvements in vehicle technology, more PHEV and BEV choices offered by vehicle manufacturers, federal and provincial purchase incentives, and infrastructure support from all levels of government, have all contributed to record breaking ZEV sales in Canada in 2019.

According to Transport Canada, overall sales of ZEVs have increased by 30% since the federal incentive was introduced (compared to the same period in 2018). Between May 1, 2019 and December 31, 2019, over 33,000 Canadians have received incentives, and in the first two months of 2020, an additional 6,000 Canadians benefitted from the iZEV incentive program.

[15] https://nextridens.com

[16] https://www.princeedwardisland.ca/en/information/transportation-infrastructure-and-energy/electric-vehicles

Table 2:
Distribution of EVs, HEVs, PHEVs, and FCVs in 2019 in Canada

Table key:
N/A: not available
A: Category includes motorcycles and mopeds
B: Category includes Class 1 and Class 2a light duty vehicles
C: Category is comprised of buses including trolley buses
D: Category includes Class 3-8 trucks

Fleet Totals as of December 31st 2019

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	TOTAL[17]
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	729,627
B Passenger vehicles [18]	88,772	278,583	66,837	110	23,137,203
C Buses and Minibuses [18 19 20]	318	1.654	0	0	91,906
D Medium and Heavy Weight Trucks	0	93	0	0	1,101,663

As illustrated in Table 2, at the end of 2019, Canada had 155,719 ZEVs on the road. The growth in sales of BEVs have outpaced PHEVs in the last year, with BEV sales increasing 59% while PHEVs have decreased by 6% from the previous year. Overall, sales of ZEVs in 2019 increased 27% from 2018. Among provinces, Quebec leads total ZEV sales with 27,005 EVs registered in 2019, representing 48% of the total ZEV registrations in the year. Also notable is the fact that sales of plug-in EVs (56,128) have surpassed sales of HEVs (47,231) for the second straight year. The Canadian EV market reached a milestone in 2019, with the ZEV market share reaching 3% of the light-duty passenger vehicle market, increasing from 2.2% the previous year.

The four top selling ZEV models in 2019, representing 57% of sales in 2019, were the Tesla Model 3 (29.9%), Toyota Prius Prime (11.9%), Mitsubishi Outlander PHEV (7.8%), and Chevrolet Bolt (7.5%).

Table 3:
Sales of EVs, HEVs, PHEVs, and FCVs in 2019 in Canada

Total Sales During 2019 [21]

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	N/A
B Passenger vehicles	35,937	47,231	20,191	85	1,840,239
C Buses and Minibuses	10	639	0	0	4,408
D Medium and Heavy Weight Trucks	0	5	0	0	154,374

[17] 2018 data from Statistics Canada (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310006701)

[18] IHS Markit Catalyst for Insight

[19] Canadian Urban Transit Research & Innovation Consortium (CUTRIC)

[20] https://www.plugincanada.ca/e-bus-background/ (Ref. for trolley buses)

[21] IHS Markit Catalyst for Insight

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 was a total of 11,586 EVSEs in Canada as of December 31, 2019, of which 9,717 were Level, 2, 971 were fast chargers, and 898 were Tesla Superchargers. This represents a 42 % increase in public charging infrastructure in 2019.

NRCan's Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (EVAFIDI) has supported the deployment of 40% of the fast chargers currently open to the public (see Table 4), representing 358 fast chargers, as well as 2 of the 3 hydrogen stations. To date, projects are in place to deliver an additional 479 fast chargers and 6 hydrogen stations by the summer of 2021. Figures 1 and 2 are two of the installations supported by EVAFIDI.

Figure 1:
Filling of a Toyota Mirai at Harnois Groupe Petrolier hydrogen station in Quebec City, QC

Courtesy of Hydrogrenics

Figure 2:
New Brunswick Power networked fast charger installed in Tracadie - Sheila, NB

Courtesy of NB Power

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 charging 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 chargers are not reported on since this infrastructure typically relates to charging via a residential wall outlet.

Table 4: Charging infrastructure in operation in Canada in 2019[22]

Type of Public EVSE	Number of Outlets	Number of Locations
AC Level 2 Chargers	9,717	4,496
Fast Chargers	971	679
Superchargers (Tesla)	898	93
Inductive Chargers	0	0
Hydrogen	3	3
TOTALS	11,589	5,271

EV DEMONSTRATION PROJECTS

NRCan's Electric Vehicle Infrastructure Demonstration (EVID) program supports demonstrations of next-generation and innovative EV charging and hydrogen refuelling infrastructure that address technical and non-technical barriers to the installation, operation and management of EV charging and hydrogen refuelling technologies.

PAN-CANADIAN ELECTRIC BUS DEMONSTRATION AND INTEGRATION TRIAL

NRCan's EVID program contributed a total of 4.26 million USD towards the Pan-Canadian Electric Bus Demonstration and Integration Trial. This project aims to demonstrate interoperable overhead bus charging systems with electric buses and will displace diesel buses in three municipalities: Vancouver (British Columbia), Brampton (Ontario) and York Region (Ontario). Charging systems from two different suppliers and buses from two different manufacturers will be integrated to demonstrate the interoperability. During the trial, data will be gathered and analysed to determine the overall performance of seven charging stations and the efficiency of eighteen electric-battery buses. This project will accelerate the development of international standards for overhead charging systems associated with heavy-duty buses. It will also provide utilities, transit agencies, bus manufacturers, and charging system developers, new knowledge that informs their respective organizations about the commercial and technical potential for integrated, standardized electric bus charging systems.

[22] https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation-and-alternative-fuels/electric-charging-alternative-fuelling-stationslocator-map/20487#/find/nearest

Figure 3:
Overhead bus charger operated by TransLink in Vancouver, BC

Courtesy of TransLink

DEMONSTRATING EV RANGE AND CHARGING EFFICIENCY IN A VERY COLD CLIMATE

NRCan's EVID program is contributing 283,000 USD towards a project led by the Yukon Government for the demonstration of five Level III DC 480V EV charging stations that will enable the uptake of EV ownership in Yukon and provide insight into the true performance of fast chargers in cold Canadian climates. Two chargers have been installed in the city of Whitehorse, one has been installed in the town of Carcross, and the remaining two are scheduled to be installed in summer 2020 at Haines Junction and Marsh Lake. Results of the project will provide independent data and EV user experiences in a cold climate, as well as data on fast-charger functionality. This will encourage other communities to move forward with electrification of transportation and expand EV infrastructure in Northern communities.

Figure 4:
Networked fast charger installed in Whitehorse, YT

Courtesy of Government of Yukon

ELECTRIC VEHICLE AUTOMATIC PARKING (EVAP)

S2E Technologies Inc. received 2.58 million USD from NRCan's EVID program for the Electric Vehicle Automatic Parking project to provide clean and convenient transportation for a sustainable community in London Ontario. The project will demonstrate community-shared EVs and the integration of innovative technologies including robotics, wireless charging, autonomous vehicles, automated parking towers and vehicle to grid charging in an urban area. The project will address barriers to EV adoption by validating convenient automated charging infrastructure while addressing utility concerns regarding grid destabilization. The operation of a pool of autonomous EVs on private roads will also allow the safe testing of novel technologies in a controlled environment and provide a charging solution in MURBs.

Figure 5a: Artistic rendering of automatic parking garage

Courtesy of S2E Technologies Inc.

Figure 5b: Automated parking tower demo unit

Courtesy of S2E Technologies Inc.

CHINA

MAJOR DEVELOPMENTS IN 2019

The new energy vehicle (NEV)[1] industry in China has gradually shifted from a policy-oriented to a market-oriented one. Measures including the macro industry planning, research and development support, scientific and technological innovation, fiscal and taxation support, production incentives, ease of use, and infrastructure are constantly improved to promote the healthy and sustainable development of the NEV industry in China.

All major automotive companies have intensified their efforts in research and development of NEV technologies. At present, battery electric vehicles are still dominating the NEV market, plug-in hybrid technology tends to be mature, and fuel cell vehicle technology is just starting its development.

MACRO INDUSTRY PLANNING

On December 3, 2019, the People's Republic of China issued the New Energy Vehicle Industry Development Plan (2021-2035) (Exposure Draft). The plan makes overall deployment from three aspects (general idea, basic principles, and development vision), clarifies the development direction of the “New four trends — electrification, intelligence, connectivity and sharing”, and proposes sales objectives and technical objectives in the future.

The general idea

It is required to: deepen the structural reform on the supply side as the main line; stick to the development direction of the “New four trends”; focus on integration and innovation; promote high-quality development.

The development vision

Battery electric passenger cars become mainstream, while fuel cell commercial vehicles realise commercial applications; electric vehicles are fully applied in the public sector and highly connected automated vehicles tend to be more popular. By 2025, the market competitiveness of NEVs will be significantly improved, and major breakthroughs will be made in key technologies such as power batteries, drive motors, and onboard operating systems. NEVs account for about 25% of new vehicle sales, while intelligent connected vehicles account for 30% of new vehicle sales. Highly connected automated vehicles realise commercial applications in limited areas and specific scenarios.

[1] New energy vehicle includes battery electric vehicle, plug-in electric vehicle, and fuel cell electric vehicle in China.

FISCAL AND TAX POLICIES

On March 27, 2019, the Ministry of Industry and Information Technology, Ministry of Science and Technology and National Development and Reform Commission jointly issued the "Notice on Further Completing the Financial Subsidy Policy for Promotion" and "Application of New Energy Vehicles" to specify the subsidy measures for NEVs in 2019. The policy points out that during the transitional period from March 26, 2019, to June 25, 2019, it will continue to provide subsidies to all kinds of NEVs, but with less effort on subsidies. Local authorities are required to stop subsidising the purchase of NEVs (except for buses and fuel cell vehicles) after the end of the transitional period in 2019, and centralise purchase subsidies for supporting construction of charging (hydrogen filling) facilities, etc. as well as the construction of supporting operation services. Meanwhile, for new energy passenger cars with the non-private purchase or operation purposes, subsidies shall be given at 70% the corresponding subsidy amount.

Table 1:
Subsidy Standard for Battery Electric Passenger Cars in 2018 and 2019 ($1 = ¥6.9122)

Item	Scope of technical indicators	Subsidy standard/coefficient	
		2018	2019
Upper limit of unit electricity subsidy ($/KWh)	/	$173.6	$79.6
Subsidy standard for e-range per vehicle	100 - 150km	/	/
	150 - 200km	$2170.1	/
	200 - 250km	$3472.1	/
	250 - 300km	$4918.8	$2604.1
	300 - 400km	$6510.2	$2604.1
	≥400km	$7233.6	$3616.8
Adjustment coefficient of battery system energy density	90 - 105	/	/
	105 - 120 Wh/kg	60%	/
	125 - 140 Wh/kg	100%	80%
	140 - 160 Wh/kg	110%	90%
	≥160 Wh/kg	120%	100%

[2] Ministry of Finance of the People's Republic of China, 2019, Notice on Further Completing the Financial Subsidy Policy for Promotion and Application of New Energy Vehicles, http://jjs.mof.gov.cn/zhengcefagui/201903/t20190326_3204190.htm

Item	Scope of technical indicators	Subsidy standard/coefficient	
		2018	2019
Adjustment coefficient of vehicle energy consumption	Better than the limit value by[2] 0-5% in the power consumption per 100 kilometres	50%	/
	Better than the limit value by 5-10% in the power consumption per 100 kilometres	100%	/
	Better than the limit value by 10-20% in the power consumption per 100 kilometres	100%	80%
	Better than the limit value by 20-25% in the power consumption per 100 kilometres	100%	100%
	Better than the limit value by 25-35% in the power consumption per 100 kilometres	110%	100%
	Better than the limit value by 35% in the power consumption per 100 kilometres	110%	110%

Calculation method of subsidy standard for battery electric vehicles:
Subsidy amount for each battery electric passenger car = Min {e-range subsidy standard, vehicle energy capacity × Upper limit of unit electricity subsidy} × adjustment coefficient of battery system energy density × adjustment coefficient of vehicle energy consumption

Table 2:
Subsidy Standards for Plug-in Hybrid Electric Passenger Cars (Including E-REV) in 2018 and 2019

Item	Technical requirements		Subsidy standard	
			2018	2019
Subsidy base per vehicle	E-range R≥50		$3182.8	$1446.7
Adjustment coefficient	E-range is less than 80km (the ratio of fuel consumption to the limit value of conventional fuel consumption under state B in assessment)	Ratio less than 55%	100%	100%
		Ratio between 55% (inclusive) and 60%	100%	50%
		Ratio between 60% (inclusive) and 65%	50%	/
	E-range is greater than 80km (the limit value of energy consumption per 100 kilometres under state A in assessment)	The electricity consumption per 100 kilometres under state A meet the requirements on the power consumption threshold of battery electric passenger cars	100%	100%

Calculation method of subsidy standard for plug-in hybrid electric passenger cars (including E-REV):

Subsidy amount for each plug-in hybrid electric passenger car (including E-REV) = **Subsidy base per vehicle** X **Adjustment coefficient**

PRODUCTION INCENTIVES

The Measures for the Parallel Management of Corporate Average Fuel Consumption and New Energy Vehicle Credits for Passenger Vehicles (hereinafter referred to as the "Dual Credit Policy") promulgated in 2017 establishes a mechanism for corporate average fuel consumption (CAFC) and NEV credits management. Automotive companies need to produce NEVs or buy NEV credit for the compliance of the regulation. The market-oriented allocation of resources is enabled through credit trading so that companies with better development of NEVs can obtain considerable economic benefits.

The current Dual Credit Policy will be implemented until 2020. In July and September 2019, the Ministry of Industry and Information Technology publicly solicited two rounds of opinions on “Amending the Dual Credit Policy” (hereinafter referred to as the "Amendment") and proposed the credit target and management plan for 2021 to 2023. The key amendments include the following aspects:

First, updating the credit targets and calculation methods according to the requirements of the national development goals. The Amendment is based on ensuring the achievement of two major goals for 2025, that is, the average fuel consumption of 4.6L/100km (tested under WLTC) for new passenger vehicles and the NEVs penetration rate of more than 20%. The Amendment updates the requirements for CAFC and NEV credits for 2021 to 2023, and appropriately reduces the NEV reference credit by about 20%-30% compared with the current dual credit policy. Specifically, the targets of NEV credit for 2021-2023 are required to be 14%, 16%, and 18%.

Table 3: Comparison of the 2017 dual credit policy and the Amendment

Note:
1) R is the e-range of electric vehicles (km)

2) P is the power of fuel cell system (kW).

	Requirements of the 2017 dual credit policy	Requirements of the Amendment
Energy-saving and NEV goals for passenger vehicles	2020: Fuel consumption target of 5L/100km (tested under NEDC), production and sales volume of 2 million units	2025: Fuel consumption target of 4.6L/100km (tested under WLTC), NEV production and sales accounting for more than 20%
Multipliers for BEV in calculating the CAFC	2016-2017: 5; 2018-2019: 3; 2020: 2.	2021-2025: 2, 1.8, 1.6, 1.3, 1.
NEV credit target	2019-2020: 10%, 12%	2021-2023: 14%, 16%, 18%

	Requirements of the 2017 dual credit policy	Requirements of the Amendment
Reference credit for battery electric passenger vehicle	0.012 × R+0.8	0.006 × R+0.4
Reference credit for plug-in hybrid passenger vehicle	2	1.6
Reference credit for fuel cell passenger vehicle	0.16 × P	0.08 × P

Second, enhancing the encouragement for fuel-efficient technologies to achieve fleet average fuel consumption goals. Since 2015, the average fuel consumption of conventional vehicles has decreased annually by only 2%. Hence, the Amendment adds an encourage measure for advanced fuel-efficient vehicles which are defined as the models with the fuel consumption rate lower than the fuel consumption target in the target year. A coefficient of 50% can be given to advanced fuel-efficient vehicles to reduce the calculation base of conventional vehicles when calculating the NEV credit target of the carmakers. This measure can lower the NEV credit target requirements for carmakers.

Third, increasing the flexibility of credit compliance for carmakers. When the average fuel consumption of conventional vehicles is less than 123% of the CAFC target for carmakers, their NEV credits are allowed to be carried forward in a discount of 50%, which is valid for 3 years, thus effectively alleviating the risk of credit supply and demand imbalance among carmakers.

HEVS, PHEVS, AND EVS ON THE ROAD

The number of electric vehicles on-road in China continues to grow, increasing by more than 1 million in 2019. Table 4 shows the number of vehicles on-road in China from 2017 to 2019. In 2019, the number of NEVs on-road reached 3.81 million. Among them, the number of battery electric vehicles accounted for 81%, reaching 3.1 million. The hybrid vehicles on the road was 1.08 million. FCV is currently in its initial stage of development, mainly for demonstrative operation, with only about 4,000 vehicles on road, of which about 60% are logistics trucks.

Table key:
a: UNECE categories M1, M2, M3, N1, N2, N3
b: The data of HEVs and FCVs in operation is based on CATARC statistic specification, while the numbers of FCVs are relatively small.

Table 4:
Number of Electric Vehicles on-road in China from 2017 to 2019 (in millions)

Source: Ministry of Public Security of the People's Republic of China

Fleets Totals at the End of 2017 - 2019 [a]

	2017	2018	2019
HEVs [b]	0.46	0.71	1.08
EVs	1.53	2.11	3.10
PHEVs		0.50	0.71
FCVs [b]	0.001	0.002	0.004
TOTALS	217	240	260

Table 5 shows the annual sales of vehicles in China from 2017 to 2019. The sales of new vehicles in China went down in 2019 by 8% compared with 2018. The sales of NEVs in 2019 also decreased by 4%. The sales of hybrid vehicles increased by 47% to 382 thousand. 2.7 thousand FCVs were sold in 2019, about 80% more than in 2018.

Table 5:
Sales of Electric Vehicles in China from 2017 to 2019 (in thousands)

Source: CAAM

Table key:
a: UNECE categories M1, M2, M3, N1, N2, N3
b: Data source: CATARC

Total Sales During Years Between 2017 - 2019 [a]

	2017	2018	2019
HEVs [b]	183	260	382
EVs	652	984	972
PHEVs	124	271	232
FCVs [b]	1.1	1.5	2.7
TOTALS	28,879	28,081	25,769

Although the NEVs are becoming cheaper, the manufacturer suggested retail price (MSRP) is still higher than that of conventional vehicles. Table 6 lists the MSRP of some mainstream NEVs in 2019. The MSRP of the gasoline version of BYD Qin pro is between $11,500 and $16,800. The MSRP of the corresponding battery-electric version is between $25,300 and $32,500, which is almost twice the price of the gasoline version. The price of the plug-in version is between $19,800 and $29,900, which is still more than $10,000 higher than the gasoline version.

Table 6:
The prices of som mainstream NEVs in 2019 (USD 1 = RMB 6.9122)

Table key:
N/A: There were no sales in the corresponding e-range segment in 2019
a: The e-range is tested under NEDC.

MSRP of Selected BEVs in China (in 1,000 $)

Class	Model	E-Range (km)[a]			
		200 - 300	300 - 400	400 - 500	≥500
A00 Sedan	Chery EQ1	N/A	8.7 - 11	N/A	N/A
A00 Sedan	Baojun E100	7.2 - 8.7	N/A	N/A	N/A
A00 Sedan	Ora R1	N/A	10.1 - 11.5	N/A	N/A
A0 Sedan	Neta N01	N/A	9.7 - 11.6	N/A	N/A
A0 Sedan	Trumpchi GE3	N/A	N/A	22.4 - 26.2	N/A
A Sedan	BAIC EU5	N/A	N/A	19.2 - 20.1	N/A
A Sedan	Emgrand EV	N/A	N/A	19.6 - 21.1	N/A
A Sedan	BYD Qin Pro	N/A	N/A	25.3 - 31.1	N/A
B Sedan	BAIC EU7	N/A	N/A	23.1 - 25.4	N/A
A0 SUV	BYD Yuan	N/A	13 - 15.9	15.9 - 20.2	N/A
A SUV	Xpeng G3	N/A	N/A	20.8 - 26.2	23.1 - 28.5
A SUV	Weltmeister EX5	N/A	N/A	20.2 - 24.6	24.6 - 27.5
B SUV	BYD Tang	N/A	N/A	N/A	37.6 – 52.1
B SUV	Nio ES6	N/A	N/A	51.8 – 72.0	64.8 - 79.3

MSRP of Selected PHEVs in China (in 1,000 $)				
Class	Model	E-Range (km)[a]		
		50 - 80	80 - 100	≥100
A Sedan	Roewe ei6	21.4 - 25.9	N/A	N/A
A Sedan	BYD Qin Pro	19.8 - 29.6	21.7 - 29.9	N/A
A Sedan	Carola	30.1 - 33.4	N/A	N/A
B Sedan	PASSAT	35.3 - 41.5	N/A	N/A
B Sedan	KIA K5	32.2 - 34.7	N/A	N/A
B Sedan	Borui GE	26.3 - 30.4	N/A	N/A
C Sedan	BMW 5 Series	72.3 - 77.7	72.3 - 77.7	N/A
A SUV	Roewe ERX5	28.3 - 34.1	N/A	N/A
A SUV	BYD Song	N/A	25.6 - 29.9	N/A
A SUV	Lynk&Co 01	27.9 - 32.2	N/A	N/A
A SUV	BMW X1	N/A	N/A	57.8
B SUV	BYD Tang	N/A	33.3 - 37.6	39.8 - 47.7
B SUV	TIGUAN	45.6 - 47.1	N/A	N/A
B SUV	WEY P8	37.6 - 40.5	N/A	N/A

CHARGING INFRASTRUCTURE OR EVSE

According to the data submitted by companies and organizations of China Electric Vehicle Charging Infrastructure Promotion Alliance, by the end of 2019, there were 1.219 million charging pillars, which increased by 50.8% from 2018. The ratio of NEVs to charging pillars is about 3.5:1. Charging pillars consisted of 516 thousand public and 703 thousand private, which increased 55.9% and 47.4% compared with 2018, respectively. Moreover, the number of charging stations had reached 35,849 in 2019. Battery swapping stations for EV had begun to take shape, with a scale of 306 nationwide.

Table 7: Public Charging Infrastructure on 31 December 2019

Type of Public EVSE	Quantity
AC Charging pillars	301,238
DC Charging pillars	214,670
Total charing pillars	515,908
Charging stations	35,849
Battery Swapping Station	306

From the perspective of geographical distribution, the Yangtze River Delta, Beijing-Tianjin-Hebei, and the Pearl River Delta are the main concentrations of public charging pillars. The construction of public charging pillars in the eastern region is generally more common, whereas the northeast, northwest, and southwest areas have fewer facilities. The distribution of public charging pillars in China is shown as follows.

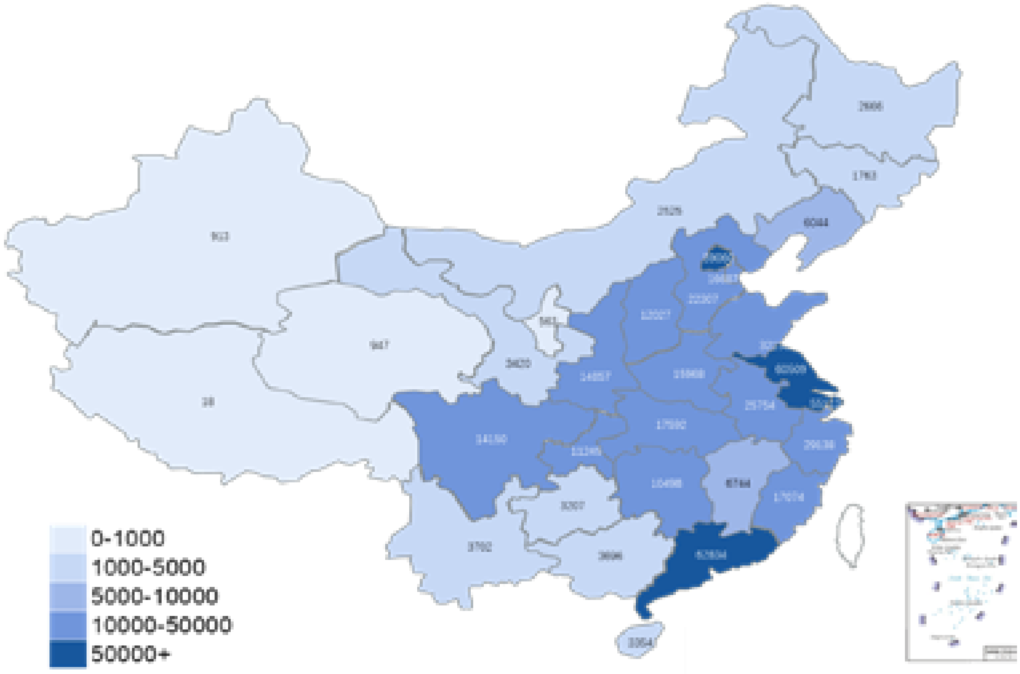


Figure 1: Distribution of the Public Charging pillars in China on 31 December 2019

Source: China Electric Vehicle Charging Infrastructure Promotion Alliance

As for charging operators, a large-scale operator-dominated market with small and micro-operators as the complement has been formed. In 2019, there were 22 large-scale operators (charging pillars ≥1000) of public charging facilities nationwide, including 8 operators with more than 10,000 units, whose market share reached 90%.

EV DEMONSTRATION PROJECTS

With the support of the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP), in 2003-2011, the Ministry of Science and Technology of the People's Republic of China held hands with Beijing and Shanghai Municipal Governments to organise and implement the first and second phases of commercial demonstration projects of fuel cell buses in China, and carry out commercial demonstration operation of fuel cell vehicles in Beijing and Shanghai respectively. Now, the third phase of the project is currently being implemented, with a cycle of four years from 2016 to 2020. The project aims to promote the commercial development of fuel cell vehicles in China through the improvement of the production and application of fuel cells and fuel cell vehicles, reduction of the cost of hydrogen refuelling stations and improvement of the development environment, the commercial policy and regulatory framework for fuel cell vehicles, information communication activities and capacity building. Meanwhile, the commercial demonstration operation involving more than 100 fuel cell buses, cars, logistics vehicles, and postal vehicles have been carried out in 7 cities including Beijing, Shanghai, Zhengzhou, Foshan, Yancheng, Changshu, and Zhangjiakou. In terms of infrastructure, demonstration cities will employ low-carbon or renewable energy technologies to build and transform hydrogen energy infrastructure according to their actual conditions. Through the demonstrative operation of vehicles and hydrogen refuelling stations, operation data of complete vehicles and hydrogen refuelling facilities can be collected and analysed to further improve the technical level of fuel cells in China and reduce the cost. Different commercial operation modes are summarized to put forward the roadmap and incentive policies for the industrialization of fuel cell vehicles in China; Relevant technical standards and certification systems are improved to create a good social atmosphere and an environment for industrial development and promote the large-scale development of fuel cell vehicles in China.

OUTLOOK

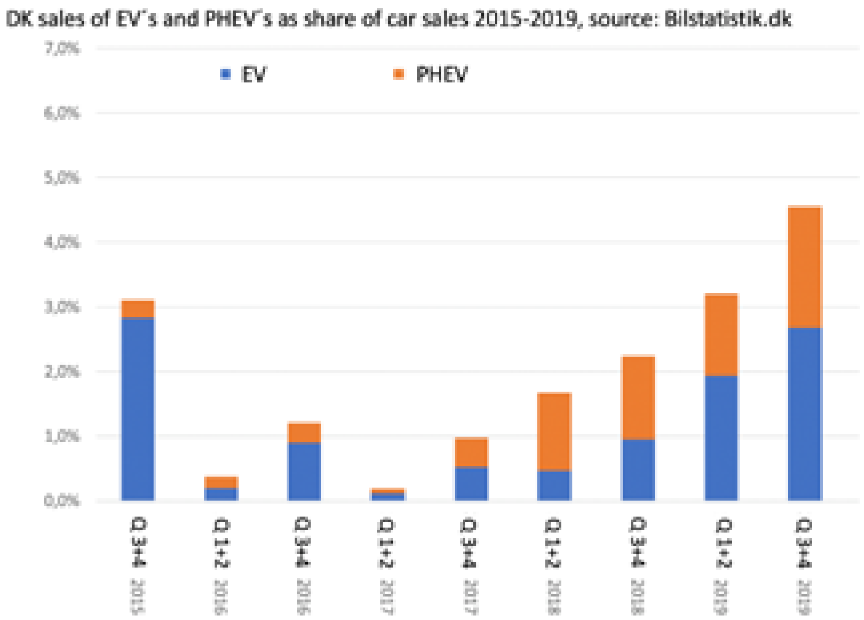
In 2020, China's New Energy Vehicle Industry Development Plan (2021-2035) will be officially released, and the medium and long-term development goals of China's NEVs will be clarified. In 2020, the purchase subsidies of NEVs are expected to be cancelled, but there is still some uncertainty. At the end of 2020, the NEV purchase tax deduction will expire, and the follow-up policy will be released in 2020. The dual credit policy for 2021-2023 will be released in 2020, which will further clarify China's passenger car fuel consumption and NEV credit requirement for 2021to 2023.

DENMARK

MAJOR DEVELOPMENTS IN 2019

In the first half of 2019, electric vehicles (EVs) and plug-in hybrid vehicles (PHEVs) accounted for 3.2 percent of total car sales. In the second half of 2019, electric cars and electric vehicles' share of total sales increased to 4.6 percent.

2019 sales significantly increased from previous years, arriving at the highest share since 2015, which was just before sales dropped due to public supporting schemes ending and taxes introduced on EVs and PHEVs for the first time. To compare, in 2018 EVs and PHEVs accounted for 1.9 percent of total passenger car sales[1]



The sales development reflects the stepwise increased taxation of EVs introduced from 2016. Furthermore, EV taxation in 2017 was reduced to revitalise EV market by extending the 20 % registration tax break until end of 2018 or until 5000 additional sales. These changes created "stop and go" effects where consumers expected taxation and prices to rise the following year. 2018 was to the first year where sales grew on top of last year sales, which has continued in 2019. 2018 sales of PHEVs seem to increase more than EVs, with the opposite being the case in 2019.

[1] Dansk Bilstatistik.dk

The development of DK sales of EVs is detailed below on brands from 2016-2019. The best-selling EV brands in Denmark in 2019 were Tesla, Hyundai and Renault with markets shares of 50, 16 and 10 pct. respectively.

Table 1:
Source: Bilstatistik.dk

EV Sale	2016	2017	2018	2019
AUDI	0	0	0	224
BMW	227	26	87	434
HYUNDAI	0	28	158	854
JAGUAR	0	0	12	96
KIA	18	9	4	187
MERCEDES-BENZ	1	1	0	19
NISSAN	112	31	654	331
RENAULT	612	387	421	568
TESLA	176	98	95	2,734
VOLKSWAGEN	72	82	53	42
TOTAL	**1,218**	**662**	**1,484**	**5,489**

The development of DK sales of PHEVs is detailed below on brands from 2016-2019. The best-selling PHEV brands in Denmark in 2019 were Kia, Mitsubishi and Hyundai with markets shares of 51, 14 and 11 pct. respectively.

Table 2:
Source: Bilstatistik.dk

PHEV Sale	2016	2017	2018	2019
BMW	115	50	83	96
HYUNDAI	0	0	363	436
KIA	0	205	1,448	1,987
LAND ROVER	0	0	3	11
MERCEDES-BENZ	137	85	100	122
MINI	0	5	15	42
MITSUBISHI	0	0	24	552
PORSCHE	2	5	14	12
TOYOTA	0	0	207	261
VOLKSWAGEN	266	202	657	155
VOLVO	44	68	213	207
TOTAL	**564**	**620**	**3,127**	**3,881**

The development in fleet stock for EVs, PHEV and FCEV passenger cars (fuel cell electric vehicle) are shown below. The development reflects the drastically reduced sales from 2016, slowly growing sales from 2018 and effects of import and exports.

Table 3:
Source: Bilstatistik.dk

Passenger car stock end of year	2016	2017	2018	2019
EV	8,154	8,420	9,658	15,088
PHEV	1,107	1,773	5,166	9,847
FCEV (fuel cell car)	69	84	83	76
TOTAL	**9,330**	**10,277**	**14,907**	**25,011**

NEW POLICIES, LEGISLATION, INCENTIVES, FUNDING, RESEARCH, AND TAXATION

General policy status

December 6, 2019, a broad majority of Danish parliament signed an agreement on a new Climate Act for Denmark, replacing the existing Danish climate law from 2014. Most importantly, it introduces binding sub-targets every five years with a 70 per cent reduction in 2030 towards 100 per cent climate neutrality in 2050.

In 2030, Denmark will reduce its greenhouse gas emissions by 70 per cent compared to the level in 1990. This is the first time that Denmark sets targets for the Danish CO2 emissions by law, and the targets represent a new direction for Danish climate policy. Achieving a 70 percent reduction in 2030, will require significant efforts in all sectors, including transport. In the first 30 years since 1990, Denmark reduced emissions by 38 per cent, leaving almost half of the task to be solved within the next ten years. A very considerable reduction effort will be needed in the present decade, which will impact all parts of Danish society.

Danish greenhouse gas emissions in the 1990 base year, in accordance with the UN's calculations[2], were 75.7 million tons CO2e (CO2-equivalents). The 70 per cent target requires emissions in 2030 to be reduced to 22.7 million tons CO2e. Denmark has reduced emissions by an average of 1.5 million tons CO2e annually from 2010 to 2020. In this decade - from 2021 to 2030 - the rate of change must be significantly increased to 2.4 million tons CO2e per year for the 70 per cent target to be achieved[3].

The new Climate Act is expected to be adopted in spring 2020. The act will be supplemented by a national Climate Action Plan, with concrete measures to ensure the first sub-targets in 2025 and 2030 to be met. The Climate Action Plan will include sectoral strategies and indicators for a number of key sectors such as energy, agriculture, transport sector, construction and industry.

To reach the targets, it is now broadly recognised that electricity must play a key role as an energy carrier and replace fossil energy and fuels in a wide range of sectors.This Includes transport, where electric cars are expected to be a winning technology, with potential also in electric-powered vans and trucks, with battery,

[2] Not including international emissions, Energistyrelsen, Basisfremskrivning 2018+2019

[3] Klimarådet, Kendte veje og nye spor til 70 procents reduktion, March 2020

induction or overhead lines. Indirect electrification with hydrogen or electric fuels can become an alternative for the heaviest vehicles as well as ships and aircraft. Electricity-based fuels are produced by converting electricity into hydrogen via electrolysis, which can subsequently be combined with carbon or nitrogen to create synthetic fuels with ammonia as possible candidate for very large and long-range container ships.

The Danish transport sector emitted 13.5 million. tons CO2e in 2017. Road transport accounts for 90 per cent of these emissions, of which passenger cars accounted for 49 per cent, and vans and heavy transport (trucks and buses) accounted for 13 and 28 per cent respectively.

The technical potential for electric cars' ability to displace fossil cars by 2030 is limited by the relatively long service life of cars, which in Denmark on average, is around 15 years. Focus is on how to phase in large numbers of electric cars and introduce significantly more charging infrastructure. Vans are expected to follow the same development as the electric cars to a large extent, while it seems more uncertain to what extend batteries and electro-fuels will be possible before 2030 in heavy road freight transport. Electrification of trains will continue, and public bus transportation is on the move towards more electric busses, but also challenged by the long service life of public busses, usually around 12 years.

In 2020 the new Climate Act will be supplemented by the Climate Action Plan, with concrete measures to ensure the first sub-targets in 2025 and the very ambitious 70 per cent reduction in 2030 to be met, including sectoral strategies and indicators for the transport sector.

Status on legislation, incentives, funding, research, and taxation

Until 1 January 2016, EVs were exempt from the relatively high registration tax. Thus, exemption was a strong incentive, which together with national and regional activities brought Denmark in the e-mobility forefront at the time. The taxation lead to disproportionate incentives towards expensive EVs and 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 % 2020.

This dropped sales of EVs in 2016, with tax phased in with a 20-pct. first step. Due to continuously low EV sales, taxation was changed a number of times during 2017-2019. The result being that registration tax on all non-premium EVs and PHEVs is low in 2019 and 2020 (25 pct. VAT is still applied).

In 2019 it was furthermore decided to extend the low registration tax for EVs and PHEVs in 2020 and also extend the exemption for electricity tax to 2020 and 2021. As a new initiative, green company cars have a tax 2020 deduction of 5.350 EUR.

In addition, the following funding has been decided:

- 13,4 Million EUR per year in 2020-2024 to promote green transport
- 10 Million EUR in 2020 to promote green buses
- 1,33 Million EUR has been allocated in 2020 and 2021 to promote electric ferries

In Copenhagen from January 1, 2020, electric cars, hydrogen cars and electric motorcycles will be able to park free of charge in all public street parking spaces.

HEVS, PHEVS, AND EVS ON THE ROAD

EV and PHEV passenger car stock increased from approx. 9.658 EVs in 2018 to 15.088 in 2019 and from 5.166 PHEVs in 2018 to 9.847 in 2019. New passenger EV registrations increased from 1.484 in 2018 to 5.489 in 2019. New passenger PHEV registrations rose from 3.127 in 2018 to 3.881 in 2019.

Table 4:
Source: Bilstatistik.dk

Table key:
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

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	N/A
B Passenger vehicles	15,088	33,376	9,847	76	2,658,400
C Buses and Minibuses	86	0	24	0	8,891
D Light Commercial vehicles	897	2,076	256	0	377,748
E Medium and Heavy Weight Trucks	12	0	0	3	42,492

Table 5:
Source: Bilstatistik.dk

Table key:
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

Total Sales During 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	N/A
B Passenger vehicles	5,489	8,246	3,881	8	225,589
C Buses and Minibuses	83	0	17	0	546
D Light Commercial vehicles	231	451	33	0	33,095
E Medium and Heavy Weight Trucks	2	0	0	1	5,023

CHARGING INFRASTRUCTURE OR EVSE

The Danish market for charging is dominated by home charging, but in international comparison there are relatively numerous public chargers in Denmark. Several e-mobility providers including, CLEVER, E.ON, Tesla, Spirii, Flexcharge, Virta and others, provide publicly accessible recharging network countrywide.

Table 5:
Source: Danish EV Alliance

Type of Public EVSE	Number of Charging Points
AC Slow Chargers (≤ 3.7 kW)	0
AC Slow Chargers (>3.7 kW, ≤ 22 kW)	3,152
Fast Chargers (> 22 kW, ≤ 43.5 kW)	474
Superchargers (> 43.5 kW)	170
Inductive Chargers	0

By September 2019 there were 1,789 public charging stations, some having the option of charging several cars at a time, giving a total of 3,648 charging points.[4] This corresponds to 6 electric cars per public charging point, whereas Norway as an example has 24 electric cars per public charging point.[5]

With 68 per cent of population able to park on their own driveway, carport or similar, home charging is expected to cover a significant part of charging needs[6]. Others will need public charging or destination charging at workplace etc. This is especially true in large cities and city areas, with parking either on public roads or parking lots.

3 types of charging could be relevant here. Overnight charging, which requires many public charging stations to be installed. Destination charging which requires companies or operators to offer chargers at company locations. Fast charging, requiring operators to put up infrastructure at relevant hot spots, highway corridors etc.

CHALLENGES ON INFRASTRUCTURE

Electric cars are needed for private companies to invest in charging stations, but a well-developed charging infrastructure is also a prerequisite for consumers to buy electric cars. This is a classic chicken-and-egg challenge where the public can help more consumers want to buy an electric car by securing the charging infrastructure.

Regulation of the charging infrastructure could contribute to a well-functioning market for consumers which is easy and transparent to use and where barriers for competition and interoperability are prevented.

Charging stations on public roads or motorways requires involvement in various ways from the authorities, which may be delaying deployment of charging

[4] Transportministeriet, Rapport om Danmarks etablering af infrastruktur for alternative drivmidler, 2019

[5] European Alternative Fuels Observatory, Norway, 2020

[6] DTU og Dansk Elbil Alliance, Sådan skaber Danmark grøn infrastruktur til e?n million elbiler, 2019

infrastructure, if not handled timely.

With very ambitious Danish climate sub-targets in 2025 and 2030 to be met, focus will also be on establishing a well-functioning market for charging for all consumers segments, in cities, for apartments and on the move. This also includes ensuring the necessary public infrastructure in terms of volume and geography.

New business models could also be needed. As an example, Danish CARPOW[7] is an open cooperative company jointly owned by the users, providing charging network for housing associations, businesses and homeowners as well as other communities.

EV DEMONSTRATION PROJECTS

ELECTRIC TAXIS

The number of electric taxis in Copenhagen increased from 2-3 to 220 (March 2020) and are expected to reach 500 at the end of 2020. This change is the result of a corporation between the Danish Taxi industry, the local, regional and national authorities including Copenhagen Airport (CPH), Copenhagen Municipality, Capital Region of Copenhagen, and E.ON, the Ecological Council and Raskgreentech.

Focus has been on improving the EV taxi business case to outperform a fossil taxi and at the same time creating reassurance on range and charging availability.

The initiatives that have been implemented are:
- EV taxi study tour to Amsterdam, Den Haag and Schiphol Airport.
- Launch of dedicated taxi fast chargers at CPH airport, Copenhagen and hotels.
- Timesaving priority approach for EV taxis at CPH airport.
- Favorable charging packages for the taxi industry.
- Dialogue with government officials and politicians about benefits and priority to taxi permits for electric taxis.

[7] http://www.carpow.dk

- Testing of small electric cars for taxi use.

In addition, the following actions are still being implemented:
- Prioritised access at traffic hubs in Copenhagen.
- Prioritised access to hospitals.
- Green requirements in public tenders.
- Collaboration with hotels and large companies to prioritize zero-emission taxes.
- Copenhagen City has allocated budget to establish 50 electric taxi waiting stations at main traffic sites in the city.

One of the important results is that 300 out of 1,500 new taxi permits issued by the state in 2018-2020 are reserved to green taxis. 100 was issued in 2019. The last 200 will be issued during 2020.

ELECTRIC BUSES IN DANISH PUBLIC TRANSPORT

From December 2019, 48 electric buses have run in ordinary operation in Copenhagen. The future plan for implementation of zero emission buses in the City of Copenhagen is 25% in 2021, 60% in 2023 and 100% in 2025.

Since operators is uncertain about charging infrastructure, in particular costs and obtaining necessary permits, Movia Public Transport prepares the tendering of charging infrastructure for end-station charging, and if the operator wants to use rapid charging at terminals, this is included in the tender. By this, the risk for the operator is significantly reduced.

December 2019, Movia Public Transport is in regular scheduled operation with these busses (are partly overlapping the above-mentioned Copenhagen busses):

- 21 18 m VDL Citea SLFA electric buses (288 kWh) charged at 4 Siemens 450 kW OppCharge charger in the city
- 8 12m VDL Citea SLF electric buses (288 kWh)
- 27 12 m BYD K9 electric buses (348 kWh)
- 20 12 m Yutong E12 (274 kWh)

Aarhus Sporveje runs 4 Volvo 7900 Electric charged at 1 pc. ABB 300 kW OppCharge charger in the city. NT conducts an experiment with 3 12 m Van Hool A330 hydrogen buses.

PROJECT ON LIFE CYCLE ASSESSMENT OF BUSES

The public transport authorities of the Nordic capital areas (Stockholm La?ns Landsting, Helsinki Regional Transport Authority, Ruter, Movia Public Transport and Stræto?) have decided to initiate development of a methodology for life cycle assessment of buses with focus on electric buses. The project concludes in 2021.

WORLD’S FIRST FULL-ELECTRIC, HEAVY GOODS VEHICLE FOR REFUSE COLLECTION

Odense and Aabenraa municipalities and Banke Electromotive have developed a fully electric, heavy vehicle for refuse collection. Internal combustion versions on diesel or compressed natural gas are noisy, emit CO2 and many start-stops cycles each day result in very low energy efficiency. The electric version has no CO2 emissions, high energy efficiency and reduced noise levels for crew and citizens, at a lower total cost of ownership than fossil fuels versions.

LARGE DANISH COMPANIES WITH FLEETS TO BE EVS IN 2025

Large Danish companies Ørsted and Grundfos have decided to phase out cars that run on fossil fuels. From 2021 Ørsted will no longer buy or lease cars running on fossil fuels, and in 2025 the entire Orsted car fleet will be electric. All Grundfos company vehicles will be replaced over the next years as all Grundfos light company vehicles battery electric will be electric by the end of 2025. Both Ørsted and Grundfos are members of the global EV100 collaboration.

OUTLOOK

The new Climate Act and national Climate Action Plan, with concrete measures to ensure the first sub-targets in 2025 and a 70 per cent reduction in 2030, will be an immense task for all Danish sectors.

This includes the transport sector, which has increased emissions since 1990. The transformation must happen within a decade and is probably the world's most ambitious national target at the moment.

It will have to build on a massive shift towards renewable energy and in the transport sector direct and indirect electrification will play a key role as an energy carrier for replacing fossil fuels.

Direct electrification via batteries, overhead powerlines and induction are expected to be the longer-term main technology in cars, vans, busses, short range trucks, ferries, and even short-range air traffic in time.

Indirect electrification with hydrogen or electro-fuels can become an alternative for the heaviest and longest ranged vehicles as well as ships and aircrafts. Electricity-based fuels are produced by converting electricity into hydrogen via electrolysis, which can subsequently be combined with carbon or nitrogen to create synthetic fuels. Ammonia is an example as a candidate for segments like very large and long-range container ships.

FINLAND

MAJOR DEVELOPMENTS IN 2019

CONTINUING GROWTH IN EV SALES

Year 2019 showed a continuing growth in EV sales, with plug-in hybrids still leading the sales with a clear margin. In total 13,866 new electric vehicles were sold in 2019, including 2,257 battery electric vehicles (16 % of total EV sales). The market share of EVs sold during 2019 increased to 12 % of all new registrations. The imports of used EVs also increased during 2019, forming 45 % of all new EV registrations. Growth in total EV sales year-over-year was 89 %, which is following the trend from 2017 and 2018 with close to 100 % annual growth.

The total fleet of EVs in Finland at the end of 2019 was 29,365, including both plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV). In 2019, most of the EVs were concentrated in the capital region of Helsinki and around larger cities; 52 % of PHEVs and 55 % of BEVs were in the capital region.

NEW POLICIES TO ACCELERATE GROWTH

Incentives introduced in 2018 were continued in 2019 to further increase the growth of the EV market. There are now two different subsidies for building charging infrastructure.

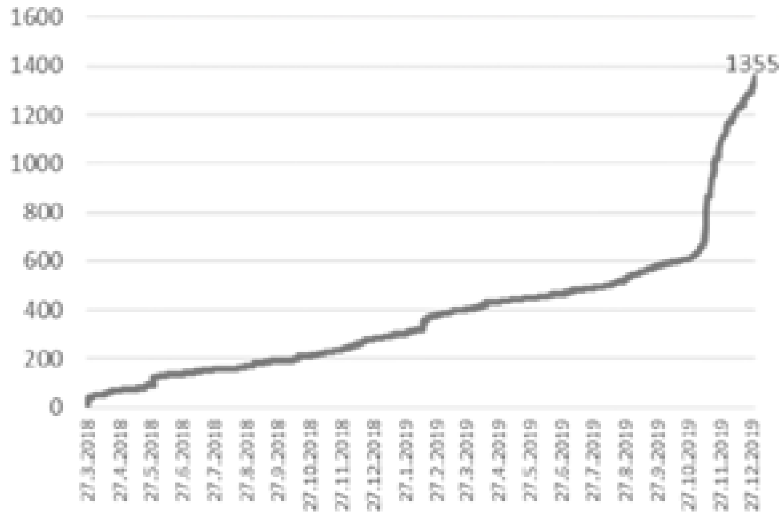
- The tender for alternative fuels infrastructure, including biogas vehicle refuelling and electric vehicle charging, was continued. The subsidy is available for commercial, municipal or community provided infrastructure. The total annual amount available for the tendering is 3 million EUR. The second round of tendering was performed in September 2019. In total, 76 petitions were submitted, out of which 42 were accepted, which resulted in an allocation of 2.7 million EUR of the annual budget.

- Subsidy for housing companies to support building of EV charging infrastructure was also continued. In the year 2019, another 1.5 million EUR was reserved in addition to the 1.5 million EUR budgeted in 2018. The subsidy covers 35 % of the costs incurred from building electrical system surveys, wiring installations, and charging equipment. Alternatively, the subsidy covers 50 % of the costs in case at least half of the equipment have power unit output of 11 kW or higher. The minimum requirement is to build readiness for five charging points and maximum subsidy is limited to 90,000 EUR including taxes. Annual budget for 2020 has been increased to 5.5 million EUR.

In addition to the charging infrastructure subsidies, the purchase incentive introduced in the beginning of 2018 was continued. The subsidy is granted for a purchase of at least 3-year lease of a battery electric vehicles, with a maximum purchase price of 50,000.00 EUR (including taxes). Used import vehicles newly registered in Finland are excluded. The amount of the subsidy is 2,000.00 EUR. A total of 6 million EUR is reserved for the subsidy, including a conversion subsidy to convert gasoline and diesel-powered vehicles to run on gas or ethanol. By Q4/2019, a total of 1,355 incentive petitions, worth 2.71 million EUR, were submitted. Over 50 % of the petitions were received in the Q4 of 2019 as seen in Figure 1.

Figure 1: Cumulative BEV purchase incentive petitions

Source: : The Finnish Information Centre of Automobile Sector



NEW RESEARCH RESULTS

In December 2019, the Finnish Climate Change Panel published Autokalkulaattori[1], an online tool to support consumer-level decision making for purchasing new vehicles. The tool calculates and lists cumulative life cycle CO2-emissions and total costs over a span of 15 years. Different propulsion options can be included in the comparison: diesel, electric, ethanol, gas, gasoline, and hybrids. The user is able to adjust the variables used in the calculations; however, generalised initial values are offered based on research and statistics. The results obtained with Autokalkulaattori suggest emission and cost advantages for electric propulsion. For instance, considering a 15-year lifespan with the average yearly mileage, vehicle costs, consumptions, and emissions, a mid-sized electric car would produce about 60 % less life cycle emissions compared to gasoline-powered vehicle, while having 4 % lower total costs.

The Finnish Information Centre of Automobile Sector (AuT) investigated usage and charging habits of EVs in Finland. The research was conducted through surveys distributed to 5,000 EV users. Results show that EV-owning households tend to have multiple cars; 60% of BEV owners had a second, typically an ICE-powered car. Two most important reasons behind the EV acquisitions were low emissions and the possibility to charge at home. Yearly mileage with EVs was

[1] The Finnish Climate Change Panel, ,,Autokalkulaattori“", (in Finnish), https://www.ilmastopaneeli.fi/autokalkulaattori/

high and well above the national average of 14,000 km; BEVs were driven 23,000 km per year on average, while PHEVs were driven 19,000 km per year. Full-electric mode covered 53 % of the driving with PHEVs and almost 85 % of PHEV users charged the car at least three times in a week, with over 70% charging the car every day. Respectively, 60 % of BEV users charged the car at least three times a week, which is most likely explained by higher battery capacity. Most of the charging was performed at home or workplaces, while public charging stations were utilised only sporadically.

The Prime Minister's office procured a research study, coordinated by VTT Technology Research Centre of Finland (VTT), for identifying cost effective means for advancing the electric vehicle market[2]. The research included identifying obstacles in home charging and EVSE market situation, electric vehicle market review, and system dynamics modelling of identified incentives for advancing the EV market. According to the modelling performed by VTT, the current incentives are leading into reaching the government's energy and climate strategy goal of 250,000 EVs by 2030. By taking into use multiple new incentives, it would be possible to double the number of EVs by 2030.

Tampere University of Technology, in collaboration with ETH Zürich, modelled the potential for BEVs in Finland and in Switzerland, according to the current passenger vehicle usage needs[3]. The study found out that 85% of the current car trips could already be performed using BEVs, utilising the current vehicle models and charging infrastructure.

The Finnish Innovation Fund Sitra funded research[4] performed by McKinsey & Company on finding cost-effective emission pathways for Finland for 2030. The research suggests large-scale electrification of the transport sector is the most cost-effective single method to cut emissions. With a fleet of 800,000 EVs (including BEVs and PHEVs) in 2030, the emissions abatement would reach 4.6 MtCO2, with a cost of -90 EUR/tCO2, indicating that the EV adaptation would also be economically reasonable.

The Ministry of Transport and Communications in Finland released a proposal for an action program[5] for carbon-free transport by 2045, based on the work by Transport Climate Policy working group. The report assesses different means, including incentives and restrictions, to promote low- or zero-emission mobility. The report suggests stopping sales of gasoline and diesel-powered vehicles by 2035. The most effective methods found in this report for advancing the EV market were the EV purchase price subsidies and increasing the taxation on fossil-based fuels.

CHARGING AT WORK GETS A FIXED TAX BENEFIT VALUE

Charging at work has been considered as a taxable benefit, if the employer has been providing employees charging for EVs. To be able to charge at work, the value of the charged electricity is required to be paid back to the employer, which has required either electricity measurements at charging stations or utilising commercial charging service providers. This had proven to be complicating the arrangement for workplace charging and inhibiting the uptake of charging points at workplaces.

[2] Cost-effective means for advancing electric vehicle market in Finland - GASELLI, final report, VTT (in Finnish): http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/161364/3-2019-GASELLI_loppuraportti_.pdf

[3] Tampere University of Technology, „Anxiety vs reality – Sufficiency of battery electric vehicle range in Switzerland and Finland", https://tutcris.tut.fi/portal/files/16484199/1_s2.0_S1361920917310295_main.pdf

[4] Sitra, „Cost-efficient emission reduction pathway to 2030 for Finland: Opportunities in electrification and beyond", https://media.sitra.fi/2018/11/30103309/cost-efficient-emission-reduction-pathway-to-2030-for-finland1.pdf

[5] Ministry of Transport and Communications, "Toimenpideohjelma hiilettömään liikenteeseen 2045 Liikenteen ilmastopolitiikan työryhmän loppuraportti", 2018, http://julkaisut.valtioneuvosto.fi/handle/10024/161210

A new law was set in practice from the beginning of 2019, where the workplace charging benefit has been valued at a fixed value of 30.00 EUR. This is expected to simplify the workplace charging arrangement.

HEVS, PHEVS AND EVS ON THE ROAD

Tesla was maintaining the market leader position in battery electric vehicles in 2019, with Nissan following as second. These two brands held roughly two thirds of the Finnish electric vehicle fleet in total. For plug-in hybrids, Volvo was the market leader in 2019. Figure 2 shows the distribution of the sales according to brand in the battery electric vehicles and PHEVs.

Finland has statistics readily available for PHEVs and BEVs, however HEVs without electric charging option are classified based on the main propulsion mode. For example, gasoline-HEVs are currently classified in gasoline category. Table 1 lists sales and total fleet of vehicles by vehicle type in 2019. The sales figures also include imported used vehicles.

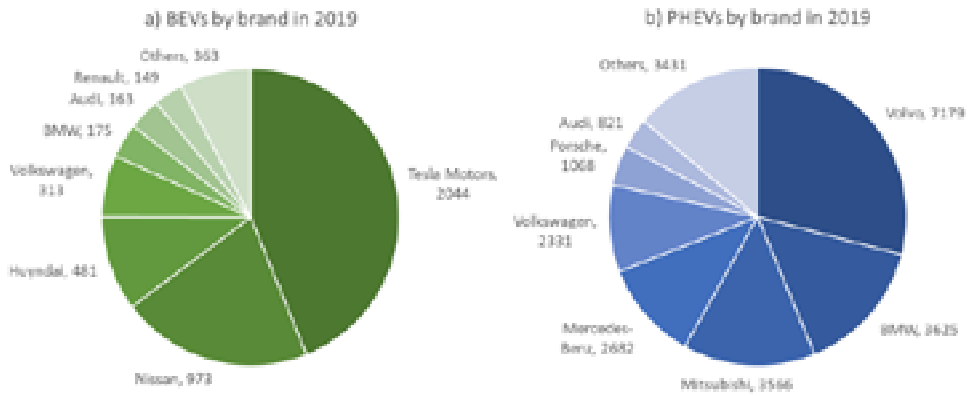


Figure 2:
Number of registered passenger a) BEVs for specific OEM's and b) PHEVs for specific OEM's

Source: Technology Industries of Finland

Table 1:
Distribution and sales of EVs, PHEVs and HEVs in 2019, Fleet Sales include imported second-hand vehicles

Source: Traficom, Autoalan tiedotuskeskus

Fleet Totals on Q4/2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL FLEET*
Bicycles	N/A	N/A	N/A	N/A	N/A
A Mopeds	1,800	N/A	0	0	114,745
B Motorbikes	46	N/A	0	0	148,656
C Quadricycles	138	N/A	0	0	13,019
D Passenger vehicles	4,661	N/A	24,704	1	2,720,307
F Commercial vehicles	312	N/A	39	0	330,671
E Buses	62	N/A	3	0	12,577
G Trucks	2	N/A	0	0	95,141
Totals **(without bicycles)**	**7,021**	**N/A**	**24,746**	**1**	**3,435,116**

Table key:
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

*** Including both conventional & alternative technologies**

Table 2

Table key:
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

*** Including both conventional & alternative technologies**

Fleet Total Sales on Q4/2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL SALES*
Bicycles	N/A	N/A	N/A	N/A	N/A
A Mopeds	758	N/A	0	0	6,293
B Motorbikes	7	N/A	0	0	5,162
C Quadricycles	14	N/A	0	0	89
D Passenger vehicles	2,356	N/A	11,843	0	160,114
F Commercial vehicles	67	N/A	7	0	19,738
E Buses	41	N/A	3	0	1,002
G Trucks	0	N/A	1	0	6,555
Totals (without bicycles)	**3,243**	**N/A**	**11,854**	**0**	**198,953**

Table 3:
Available vehicles and prices

Source: VTT Technology Research Centre of Finland, "Cost-effective means for advancing electric vehicle market in Finland - GASELLI final report", 2018 and 2019 revision

Notes: The vehicle untaxed prices have been retrieved by first deducting the value added tax (24%) and then the vehicle registration tax (3,3% in 2018 for <50 gCO2/km) from the vehicle prices collected for VTT's report. Pricing for Renault Twizy and Kangoo from Renault (www.renault.fi).

Market-Price Comparison of Selected EVs and PHEVs in Finland

Available Passenger Vehicles	Untaxed, Unsubsidized Sales Price (in EUR)	Prices from year
Audi A3 e-tron	32,048.00	2018
Audi Q7 e-tron Quattro	77,749.00	2018
BMW 225xe	31,598.00	2018
BMW 330e	37,395.00	2018
BMW 530e iPerformance	48,605.00	2018
BMW i3 94Ah	32,654.00	2018
BMW i8	123,921.00	2018
Hyundai Ioniq electric	28,722.00	2018
Hyundai Kona electric	27,626.00	2019
Jaguar I-Pace	65,874.00	2018
KIA Soul EV	27,572.00	2018
KIA e-Niro	30,534.00	2019
KIA Niro plug-in	28,487.00	2018
KIA Optima plug-in	34,343.00	2018
Mercedes Benz EQ C	43,620.00	2019

Mercedes Benz GLC 350e 4Matic	47,716.00	2018
Mini Countryman S E ALL4	31,929.00	2018
Mitsubishi Outlander PHEV	38,208.00	2018
Nissan e-NV200 evalia	33,975.00	2018
Nissan Leaf Acenta 40kWh	29,588.00	2018
Opel Ampera-e	32,715.00	2019
Porsche Panamera 4 E-Hybrid	96,908.00	2018
Porsche Taycan	61,795.00	2019
Renault Kangoo Z.E.1	25,130.00	2018
Renault Twizy 45 Life2	9,126.00	2018
Renault Zoe R903	26,067.00	2018
Smart Fortwo Electric Drive4	20,180.00	2018
Tesla Model 3 Long Range	43,983.50	2019
Tesla Model 3 Performance	51,398.90	2019
Tesla Model 3 Mid-range	39,258.00	2019
Tesla Model 3 Standard	30,534.00	2019
Tesla Model S 75D	71,836.00	2018
Tesla Model X 75D	77,437.00	2018
Toyota Prius Plug-In Lounge	31,147.00	2018
Volvo S90 T8 plug-in hybrid	52,423.00	2018
Volvo V60 plug-in hybrid	45,847.00	2018
Volvo V90 T8 plug-in hybrid	54,508.00	2018
Volvo XC40 EV	36,350.00	2019
Volvo XC60 plug-in hybrid	54,590.00	2018
Volvo XC90 T8 plug-in hybrid	71,147.00	2018
VW e-Golf	33,219.00	2018
VW e-up!	22,645.00	2018
VW Golf GTE	32,602.00	2018
VW Neo (I.D.)	18,175.00	2019
VW Passat GTE	38,087.00	2018

CHARGING INFRASTRUCTURE

In 2019, the total number of chargers in Finland increased to 1,444, corresponding to an increase of 44 % from last year. Table 3 specifies the amount of charging points in 2019, which increased to 3,791, a raise of 58 % from the previous year. The proportion between AC Level 2 charging points and EVs was 1:9.4 and between fast-charging CCS/CHAdeMO and BEVs it was 1:17. Thus, Finland meets with the directive 2014/94/EU recommendations on the amount of available charging points. Approximately half of the charging points are in the three major growth areas in the capital Helsinki region, Tampere region and Turku region.

Market-Price Comparison of Selected EVs and PHEVs in Finland

Table 4:
Information on charging infrastructure in 2019

Source: Technology Industries of Finland, Q4/2019 e-mobility update report

Chargers	Quantity
AC Level 1 Chargers	N/A
AC Level 2 Chargers	3,113
CHAdeMO	272
CCS	274
Tesla Dest. Charger	78
Tesla Supercharger	54
Inductive Charging	N/A
Totals	**3,791**

EV DEMONSTRATION PROJECTS

ELECTRIC TRUCKS

The city of Helsinki, in co-operation with Forum Virium Helsinki, University of Applied Sciences Tampere, and VTT Technical Research Centre of Finland is investigating electrification of the fleet of Helsinki City Construction Services (Stara). The Stara eRetrofit project launched in September 2019 aims to assess the effects and costs of the electrification of Stara's operational fleet. The focus of the assessment is on electrification retrofits and the project plan includes development of technical electrification plans and actual electrification of one heavy-duty truck.

Helsinki Region Environmental Services Authority (HSY) is going to pilot electric refuse truck operation in autumn 2020. The pilot will last until spring of 2022, including two winters, with the aim to investigate the operation of a battery electric refuse truck in artic conditions. Low noise-levels and lack of tailpipe emissions in the narrow city streets are some of the foreseen benefits of the electrification of refuse truck operation.

Niinivirta European Cargo Oy currently has the only two registered electric trucks in Finland. Both vehicles are conversion vehicles, built by Emoss, and are used in city logistics in Tampere and Helsinki.

ELECTRIC BUSES

The electric bus pilot demonstrations are ending in Q4/2019 or Q1/2020 in four cities: Helsinki, Espoo, Tampere and Turku. For after the pilot demonstration, the Helsinki Region Transport, the greater Helsinki Public Transport Authority (HSL), has started commercial tenders including requirements for electric bus systems in the Greater Helsinki area. At the end of 2019, a total of 45 electric buses were operating in the Helsinki region, out of which 15 are fast-charging capable buses and 30 are slow-charged buses. In coming years, a significant share of the city bus fleet will be fully electric.

Turku Region Public Transport Föli is continuing their first all-electric bus operation that started autumn 2016. The agreement includes a service agreement for the buses and charging equipment for a period of seven years. Six electric buses manufactured by Linkker are running on line 1 by Turku City Transport. Turku Energia provides quick-charge stations with inverted pantographs for the electric buses at the harbour and the airport.

In the city of Tampere, the operation with electric buses, which started in end of 2017, is continuing. Four buses manufactured by Solaris are running on line 2. The buses are equipped with roof-mounted pantographs, and as well as fast-charging at the terminal, slow-charging is provided at the depot.

OUTLOOK

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).

ELECTRIC PASSENGER AND LIGHT COMMERCIAL VEHICLES

The Ministry of Transport and Communications in Finland released a monitoring report regarding the plans of carbon-free road transport by 2050. The plans include a milestone for 2030, when all cars on the market should be able to utilise alternative, low-emission propulsion options. Target amount of EVs in 2020 is 20,000 and 250,000 in 2030. Moreover, the target number of public charging stations for 2020 is 2,000 and 25,000 for 2030.

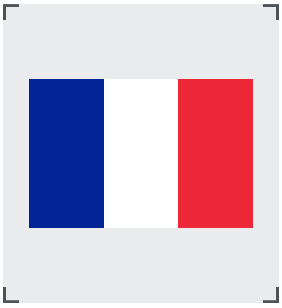
The Clean Vehicles Directive 2019/1161 (CVD) obligates public bodies to include a minimum share of clean vehicles in their vehicle acquisitions from 2021 onwards. In the first phase between 2021 and 2025, 38.5 % of new passenger or light commercial vehicles acquired by public bodies must be either BEVs or PHEVs. CVD puts pressure on public bodies to familiarise with the new technology, which may lead to increased EV acquisitions beforehand. However, highest impact is expected to occur when the national laws complying with the directive are enforced.

Taking the WLTP test method into use caused some disturbance in the passenger car market, especially in the PHEV market. This did not affect the BEV market, which has maintained a steady growth. It is expected that the similar market sales growth will continue in 2020. Most of the hurdles in the growth are expected to be related to the still high purchase cost, low production volumes and long delivery times of the current vehicles, and in arranging home charging in housing companies.

ELECTRIC BUSES

The CVD is also affecting heavy-duty vehicle acquisitions of public bodies. From 2021 onwards, at least 20.5 % of new city buses must be battery electric. Due to the novelty and limitations posed by a single-charge range, electric bus systems tend to require more attention in the system planning. Thus, it is expected that especially municipalities without previous electric mobility related experience would already start preparing for the adaptation of electric vehicles. Pilot operations and testing can increase the uptake of heavy-duty EVs already in 2020.

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, which corresponds to about 400 electric city buses. The number of electric buses will increase in 2020, as a further 18 buses will enter operation during the year in the Helsinki region. Moreover, at least 132 additional electric buses are expected to enter operations in Q3/2021.



FRANCE

MAJOR DEVELOPMENTS IN 2019

To reduce the impact of transport on the environment and achieve the objective of carbon neutrality in 2050, the French Government is committed to the development of electric mobility. France put in place many tools, including the recent Mobility Law (LOM), which sets the objective of ending the sale of new passenger cars and light commercial vehicles using fossil fuels by 2040.

Concrete tools support the French Government's commitment, such as the conversion bonus, the ecological bonus and the possibility offered to everyone to recharge their electric vehicle throughout the territory. To support EV adoption, additional charging infrastructure will be installed to bring the total provision to four times the current provision by 2022. To achieve this, there will be compulsory equipment in certain car parks, simplification and strengthening of the right to install a charging point, and a sharp reduction in the cost of installation.

To guarantee this transition to electric mobility, the Government is also mobilising the automotive sector, which, through its 2018-2022 strategic contract, has pledged to multiply the annual sales of 100% electric vehicles by 5 by 2022 and to guarantee a ratio of one charging station for every ten vehicles in circulation.

NEW POLICIES, LEGISLATION, INCENTIVES, FUNDING, RESEARCH, AND TAXATION

Fleet renewal

The Energy Transition Law for Green Growth (LTECV) obliges certain players (State, Public establishments, communities, national companies) to integrate a share of environmentally virtuous vehicles (low emission vehicle) for the acquisition or use of vehicles.

Obligations to purchase or use low-emission vehicles by vehicle fleet managers, motor vehicle rental companies, taxi operators and operators of chauffeur-driven transport vehicles are also imposed.

Traffic and parking conditions

The LTECV law also offers certain particularly environmentally virtuous vehicles (vehicles with very low emissions) the possibility of benefiting from privileged traffic and parking conditions.

Company Vehicle Tax (TVS)

Companies are subject to the company vehicle tax (TVS).
The TVS is applied according to a progressive scale based on the amount of CO2 emitted by the vehicle. This progressiveness aims to encourage companies to renew their fleet of vehicles in favour of less polluting vehicles.

Ecological bonus / malus

Through the automobile bonus / malus system, and in the more general framework of its policy in favour of ecological transition, the Government wishes to favour, through aid for the acquisition and rental of low-emission vehicles, the choice of "a new vehicle with low CO2 emissions and discouraging, via a penalty, the purchase of more polluting models".

The amount of the bonus is established according to the level of CO2 emissions of the new vehicle:

- € 6,000 (within the limit of 27% of the acquisition cost) for the purchase or long-term rental (more than 2 years) of a private car or a van emitting 0 to 20 grams of CO2 / km (electric vehicle).
- € 1,000 for the purchase or long-term rental (more than 2 years) of a private car or a van emitting 21 to 60 grams of CO2 / km (PHEV).
- Please note: Diesel vehicles are not eligible for the bonus.

Conversion bonus

A conversion bonus can be cumulated with the bonus. The aid can thus reach € 10,000, if the purchase of a vehicle entails the scrapping of an old Diesel vehicle:

- € 4,000 for a new vehicle purchased emitting 0 to 20 grams of CO2 / km (electric vehicle).
- € 2,500 for a new vehicle purchased emitting 21 to 60 grams of CO2 / km (PHEV).

HEVS, PHEVS, AND EVS ON THE ROAD

In total, 42,763 passenger vehicles (+ 38%), 7,958 light commercial vehicles 100% electric (- 2%) and 18,582 plug-in hybrids (+ 38%) were put on the road in 2019, i.e. almost 70,000 units (2.6% of all registrations).

Table 1

Table key:
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

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs
A 2 and 3 Wheelers	35,886	0	0	0
B Passenger vehicles	166,092	534,000	61,289	139
C Buses and Minibuses	545	1,660	0	0
D Light Commercial vehicles	48,627	N/A	22	274
E Medium and Heavy Weight Trucks	0	N/A	0	0

Table 2

Table key:
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

Total Sales During 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs
A 2 and 3 Wheelers	11,436	N/A	N/A	N/A
B Passenger vehicles	42,763	125,437	18,582	63
C Buses and Minibuses	55	0	0	0
D Light Commercial vehicles	7,958	N/A	N/A	N/A
E Medium and Heavy Weight Trucks	N/A	N/A	N/A	N/A

CHARGING INFRASTRUCTURE OR EVSE

One of the essential conditions for the development of electric mobility is the availability and ease of use by all of charging infrastructures.

At the end of 2019, more than 27,000 charging points open to the public were installed in France. The government has set a target of 7 million public and private charging points by 2030. In comparison, France has just over 11,000 service stations in 2019.

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 project owner, there are different financial aids for the installation of a charging point:

For communities

The Investment for the Future (PIA) Program have enabled €61 million to help projects for the installation of more than 20,000 recharging points, largely supported by local authorities.

For SMEs

The ADVENIR program encourages the installation of 12,000 private charging stations in car parks (shops or businesses) and in collective housing through financial assistance.
Individuals can also benefit from a 30% energy transition tax credit for the installation of a private charging station.

The Ministry of Ecological and Solidarity Transition, the Ministry of Economy and Finance, and ADEME conducted a study on charging infrastructures. The study shows in particular that despite a significant deployment in recent years, large disparities exist in France and additional measures are necessary to densify the network, adapt it to needs and simplify the act of recharging. The study notes in particular the preponderant role of developing home charging and recommends improving local programs for charging stations.

Table 3

Type of Public EVSE	Number of Charging Points
AC Slow Chargers (≤ 3.7 kW) AC Slow Chargers (>3.7 kW, ≤ 22 kW)	27,661
Fast Chargers (> 22 kW, ≤ 43.5 kW) Superchargers (> 43.5 kW)	2,040
Inductive Chargers	Data unavailable

GERMANY

MAJOR DEVELOPMENTS IN 2019

In 2019, Germany has made great leaps in the field of electric mobility, both in terms of market development and forward-looking framework conditions, thus underpinning its leading role in electric mobility, climate action and sustainable development.

New registrations of plug-in electric vehicles in 2019 increased by more than 60% compared to 2018. The total number in the car fleet on the road reached almost 240,000 vehicles. The environmental bonus, with a focus on BEV and which was extended until the end of 2020, is increasingly stimulating the market. The growing variety of models will also support this. At present, 57 models are available to customers in Germany from German car manufacturers alone, with more than 100 models from all manufacturers.

Germany has taken comprehensive climate measures. In 2019 the new 'Climate Action Programme 2030' has been adopted. By 2030 Germany wants to reduce greenhouse gas emissions by at least 55 percent. To this end, the Federal Government is the first government in the world to set out its national climate protection target in a binding way in a climate protection law. It entered into force on 18 December 2019. The foundations for this have already been laid in the Federal Government's Climate Action Plan 2050 in 2016.

Figure 1: Overview of the German Climate Action Programme 2030[1]

[1] https://www.bundesregierung.de/breg-en/issues/climate-action

POLICIES AND FINANCIAL SUPPORT

The German government has agreed on numerous specific measures to achieve the 2030 target of reduced greenhouse gas emissions by at least 55 percent compared to 1990. Regarding traffic and transport, the transport-related emissions must be cut by between 40 and 42 per cent. A package of measures to encourage electric mobility, promote the railways and introduce CO2 pricing is to achieve this[2].

Expanding the charging infrastructure for electric mobility

In Germany, a total of one million charging stations are to be available by 2030. The German government will promote the development of a network of public charging stations by 2025, and produce a master plan for the charging station infrastructure. It will make it mandatory for all petrol stations in Germany to provide charging stations. And more charging stations are to be installed on customer car parks. Most charging will, however, take place at home or at the workplace. A buyer's premium will thus also be made available for private and commercial charging infrastructure.[3]

The legal provisions regarding the installation of charging infrastructure are to be simplified in the Act on the Ownership of Apartments and the Permanent Residential Right (Wohneigentumsgesetz, WEG) and in legal provisions governing renting properties. Landlords will be required to tolerate the installation of charging infrastructure.

More attractive local public transport

The German government has raised federal funding for local public transport to one billion euros a year as of 2021. The additional funding is to be used to expand local public transport networks. As of 2025 the funding is to rise to 2 billion euros a year. Incentives are, for instance, to encourage bus fleets to switch to electric, hydrogen- and biogas-powered technology. By 2030, 50 per cent of inner-city buses are to be electric.

Purchase Premiums for PEV extended

At the end of 2019, the German government decided to extend the premium scheme for people buying electric, hybrid and fuel cell vehicles until 31st December 2025 and to increase it significantly. The aim of the German government is to have between 7 and 10 million electric vehicles registered in Germany by 2030. With the green light from Brussels, the adapted funding directive will be published in the Federal Gazette before the end of February 2020 and thus come into force.

The environmental bonus will be significantly increased: by 50 percent for vehicles up to a net list price of 40,000 euros and by 25 percent for vehicles above a net list price of 40,000 euros. This applies both to pure battery electric vehicles (BEVs) and plug-in hybrids (PHEVs) up to a net list price of 65,000 euros (previously 60,000 euros). This means that another 650,000 to 700,000 or so electric vehicles will be promoted. Industry will continue to contribute half of the environmental bonus.

The new incentive rates apply retroactively to all vehicles registered after 4 November 2019, so the cut-off date is 5 November 2019. It is supplemented by

[2] https://www.bundesregierung.de/breg-en/issues/climate-action/verkehr-1674024

[3] https://www.bundesregierung.de/breg-en/issues/climate-action/verkehr-1674024 (last access: 28. April 2020)

a purchase premium for young used vehicles (not older than one year, less than 15,000 km driven) at the second sale.

Purchase Premiums in 2019

In 2016, the "Umweltbonus"-programme has started. The Federal Government has set the goal of promoting the sale of new electric vehicles with the help of an environmental bonus. This will make a significant contribution to reducing air pollution while at the same time increasing demand for environmentally friendly electric vehicles by at least 300,000 vehicles. The subsidy supports the rapid market penetration of electrically powered vehicles.

Until end of January 2020 in total 173,841 applications have been handed in which distributes among the vehicle categories as follows [4]:

- 114,738 for BEV (66%)
- 58,991 for PHEV (33,9%)
- 112 for FCEV.

The bonus is restricted to BEV, FCV or PHEV (CO2 emission ≤ 50 g CO2/km) listed by the Federal Office for Economic Affairs and Export Control [5]. Requirements included until November 2019 [6]:

- initial vehicle registration
- category M1, N1 or N2[7] vehicles (L-category vehicles are excluded)
- models with a net list price ≤ 60,000 EUR (basic version).

Among the Top10 applications per manufacturer are 18% for BMW, about 14% each for Volkswagen and Renault, followed by smart with 11%. The vast majority of applications were submitted by private individuals and companies: 42% and 57% respectively. The most popular models were Renault Zoe, BMW i3&i3s, Misubishi Outlander and VW e-Golf closely followed by Smart Fortwo, Streetscooter Work and Tesla Model 3.

AUTOMOTIVE INDUSTRY

At the end of 2019, 57 PEV models were offered by German car manufacturers. By 2020, the model range and availability of competitive vehicles in the individual segments will be noticeably expanded[8].

Audi offers the Audi e-tron as a pure electric car since March 2019 in addition to Audi plug-in hybrids. The new Audi e-tron Sportback combines a spacious SUV with the the progressive character of an electric car. The battery system of the stores 95 kWh of gross energy (86.5 kWh net) and operates at a rated voltage of 396 volts. 36 cell modules are arranged on two levels, as a long lower "floor" with 31 modules and a short upper floor with five modules. Each module integrates twelve 'pouch cells'. The cooling system is located beneath the cell chamber. The Audi e-tron Sportback offers up to 300 kW of power and a range of up to 446 kilometers (WLTP cycle) (combined electric power consumption in kWh/100 km: 26.3 - 21.6.

[4] https://www.bafa.de/SharedDocs/Downloads/DE/Energie/emob_zwischenbilanz.pdf

[5] http://www.bafa.de/SharedDocs/Downloads/DE/Energie/emob_liste_foerderfaehige_fahrzeuge.pdf

[6] https://www.bafa.de/SharedDocs/Downloads/DE/Energie/emob_liste_foerderfaehige_fahrzeuge.pdf

[7] if covered by a category B driver's license

[8] www.vda.de, last accessed 29th June 2020

Figure 2:
Audi e-tron Sportback

Source:
audi-mediacenter.com

In 2019, Mercedes-Benz put the first EQ model into series production on 6 May at the Mercedes-Benz plant in Bremen. The new EQC as a fully electric vehicle is highly flexibly integrated into ongoing series production. Production of batteries for the EQC is coming on stream at the expanded battery plant in Kamenz.
The EQC has a combined power consumption of 20.8 - 19.7 kWh/100 km. It is equipped with a water-cooled onboard charger with a capacity of 7.4 kW, making it suitable for AC charging at home or at public charging stations. The market launch in China and the USA will take place at the end of 2019 respectively beginning of 2020.

Figure 3:
Mercedes-Benz EQC

Source:
media.daimler.com

Marketing focus of the GLC F-CELL fuel cell vehicle 2019 is on H_2 cities. Vehicles have been handed over to selected customers with a focus on major cities which are well equipped with hydrogen filling stations: Berlin, Hamburg, Frankfurt, Stuttgart, Munich, Cologne and Düsseldorf. Long range and short refuelling times make the GLC F-CELL a vehicle of high everyday practicality. Two carbon-fibre-encased tanks hold 4.4 kg of hydrogen. Thanks to 700-bar tank technology, the supply of hydrogen can be replenished within just three minutes. With a hydrogen consumption of around 1 kg/100 km, the GLC F-CELL achieves 400 hydrogen-based kilometres (NEDC); in hybrid mode it additionally delivers up to 50 km on a fully charged battery. The GLC F-CELL is presently available in the form of a full-service rental model. This includes all maintenance and possible repairs together with a comprehensive warranty package covering the entire rental period.[9]

The Porsche Taycan had its US premiere at the LA Auto Show on November 20, 2019. The all-electric, four-door sports sedan offers the performance and

[9] https://www.daimler.com/products/passenger-cars/mercedes-benz/glc-f-cell.html, last accessed 29th June 2020

connectivity expected of a Porsche, with everyday usability.

Figure 4:
The Porsche Taycan on the road.

Source:
press.porsche.com

The Taycan 4S is available with two battery sizes: A single-layer Performance Battery with a capacity of 79.2 kWh is fitted as standard and generates up to 390 kW/522 hp, while the two-layer Performance Battery Plus (93.4 kWh) is available as an option and delivers up to 420 kW/571 hp. Both variants of the Taycan 4S accelerate to 60 mph in 3.8 seconds and top track speed is 155 mph. Maximum charging power (peak) is 225 kW and 270 kW respectively [10].

Smart presented in 2019 the revised EQ family. Smart speaks of a "new generation" with the facelift for the Fortwo and Forfour models, which are known to be available only with electric drive. The rear-mounted electric motor produces 60 kW, the battery holds 17.6 kWh. The range is between 140 and 159 kilometres - according to NEDC. A 22 kW on-board charger is available as an option; Smart cooperates with Plugsurfing when charging at public charging points. Billing is done via the newly designed smart EQ control app which also includes the functionality of pre-air conditioning when the car is connected to the charging cable [11].

Figure 5:
The new generation Smart: ground-breaking, digital, urban.

[10] https://press.porsche.com, last accessed 29th June 2020

[11] https://www.electrive.net/2019/09/05/smart-zeigt-ueberarbeitete-eq-modelle/

HEVS, PHEVS, AND EVS ON THE ROAD

New car sales in Germany in 2019 have cumulated to 3,607,258. After a slight decline of -0.2 % in 2018, this was an increase of 5% compared to the previous year. BEV sales experienced a strong growth of +75.5 % year-on-year from 36,062 to 63,281. HEV sales increased by +96.2 % to 193,902 vehicles. PHEV sales increased by 44.2 % year-on-year from 31,442 in 2018 to 45,348 vehicles. New registrations of diesel-powered passenger cars increased slightly by 3.7% after falling last year by -16.9% and had a market share of 31.6 %. The number of new registrations of gasoline powered passenger cars rose to over 2.14 million, a share of 58.5 %[12].

As of 1 January 2020, 58.2 million motorised vehicles were on the road in Germany, including 47.7 million passenger cars, 4.5 million motor bikes, 3.5 million trucks and 81 thousand buses. The stock of BEV (cars) amounted to 136,617 (83,175 in 2018), that of HEV to 437,208 (274,414 in 2018). This corresponds to a year-on-year growth by a factor of 1.64 and of 1.59, respectively.

Table key:
N/A: not available
A: UNECE categories L1-L5
B: UNECE categories M1
C: UNECE categories M2-M3
D: UNECE categories N1 (included in passenger vehicles M1)
E: UNECE categories N2-N3, including semitrailer-tractors

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	12,145	236	2	0	4,506,410
B Passenger vehicles	136,617	437,208	102,175	504	47,715,977
C Buses and Minibuses	385	1,007	1	24	81,364
D Light Commercial vehicles	N/A	N/A	N/A	N/A	N/A
E Medium and Heavy Weight Trucks	24,398	325	42	1	3,495,242

Table key:
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

Total Sales During 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	N/A
B Passenger vehicles	63,281	193,902	45,348	N/A	3,607,258
C Buses and Minibuses	N/A	N/A	N/A	N/A	N/A
D Light Commercial vehicles	N/A	N/A	N/A	N/A	N/A
E Medium and Heavy Weight Trucks	N/A	N/A	N/A	N/A	N/A

[12] Numbers taken from Kraftfahrt-Bundesamt (KBA) – Federal Motor Transport Authority, www.kba.de, last accessed 6th April 2020

CHARGING INFRASTRUCTURE OR EVSE

Since April 2017, the Federal Network Agency has published an interactive overview map of charging points for electric vehicles. This map is updated monthly and contains the locations and technical characteristics of the loading points, which are registered as mandatory. The map is published under the URL: http://www.bundesnetzagentur.de/ladesaeulenkarte. The map shows the charging stations of all operators who have successfully completed the notification procedure of the Federal Network Agency and agreed to publication on the Internet. As of January 2020, the map contained 22,784 charging points, of which 20,042 are normal and 2,742 are fast charging points at a total of 11,606 publicly accessible charging facilities. At the beginning of 2019, there were only around 16,300 charging points. This is an increase of nearly 6,500 charge points - i.e. 40 % - within one year.

Type of Public EVSE	Number of Charging Points
AC Level 1 Chargers (≤ 3.7 kW)	596
AC Level 2 Chargers (>3.7 kW, ≤ 22 kW)	19808
Fast Chargers (> 22 kW, ≤ 43.5 kW)	889
Super Chargers (> 43.5 kW, ≤ 120 kW)	1172
Ultra-fast Chargers (>120 kW)	319
Inductive Chargers	N/A

GERMANY: A CONTINUOUS INCREASE IN H2 FILLING STATIONS

As of 28 February 2020, there were 82 hydrogen fueling stations in Germany, 22 stations more than one year ago[13]. A total of 83 hydrogen filling stations have been put to operation worldwide in 2019. 36 were opened in Europe, 38 in Asia, eight in North America and one in the Arab region.

At the end of 2019, 432 H2 filling stations were in operation worldwide, 330 of which were publicly accessible. This means that the number of public hydrogen filling stations has more than quadrupled in the last five years. There are already plans for 226 filling stations at specific locations. In Europe, there were a total of 177 H2 filling stations at the end of last year, 87 of which were in Germany. In the course of 2020, 100 public hydrogen stations for passenger cars will be available in Germany.

[13] https://h2.live/ accessed 28.02.2020; Original source: www.h2stations.org/

IRELAND

MAJOR DEVELOPMENTS IN 2019

EV sales grew by 148% from 2018 to 2019. Dealers reported difficulty with securing vehicles to sell.

The Government released a Climate Action Plan which set the objective of delivering 840,000 passenger EVs on Irish roads by 2030. The Government has committed to banning the sale of new non-zero emission vehicles from 2030 onwards.

New supports were introduced to help with the development of On-Street Chargers and Fast Chargers. Pricing was introduced for the first time for use of public chargers in Ireland.

POLICIES AND INCENTIVES

The primary support mechanisms for the EV market include both 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. Note, the capital grant for commercially owned passenger cars was removed in October 2019 in order to gradually reduce the subsidies provided to the market and in light of the benefit in kind tax relief. The CO_2 criteria for PHEV capital grant was also tightened.

A grant of 600 EUR is provided towards the installation of home chargers for applicants with their own private off-street parking. This programme will be extended in 2020 to support apartment type solutions.

In 2019 a new programme was launched to provide up to 10,000 EUR support towards the installation of On-Street AC chargers, this programme is intended to run for 5 years and is available to Local Authorities. It is intended to support home owners who must rely on on-street parking in public streets.

Fast charging is being supported via the Climate Action Fund and a figure of 10m EUR was awarded in 2019 to ESB Ecars to build up the Fast Charging network with hubs containing 8 x 150kW units and to upgrade other existing chargers.

Other benefits available include:

- Up to 50% reduction in tolls for EVs.
- Relief from Benefit in Kind tax for company owned BEVs capped at 50,000 EUR available until 2022.
- Accelerated Capital Allowances are provided to commercial purchasers of EVs and chargers.
- A grant of up to €7,000 or €3,500 towards the purchase of a BEV or PHEV respectively for vehicles in the taxi/hackney/limousine sector. Increasing to a maximum of €10,000 and €5,000 in 2020.

HEVS, PHEVS AND BEVS ON THE ROAD

The cumulative number of Passenger EVs (BEV and PHEV) on Irish roads was 14,859 vehicles as of the end of 2019. While EV sales in Ireland in 2019 totaled 4,788 vehicles, a further 3,080 EVs were imported privately second hand from the UK market. This is attributable to the good currency exchange rate and the availability of EVs. Ireland and the UK both drive on the left hand side of the road therefore the UK market is the primary market available to Irish consumers looking for good car deals in Europe.

Table 1:
Fleet Totals of BEVs, PHEVs and HEVs in 2019

Source: SEAI

*Note: Only “Goods” vehicle summary available which includes all commercial types of vehicles.

Fleet Totals on 31 December 2019

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	TOTAL FLEET
Bicycles	N/A	N/A	N/A	N/A	N/A
Mopeds	N/A	N/A	N/A	N/A	N/A
Motorbikes	70	15	8	N/A	42,492
Quadricycles	N/A	N/A	N/A	N/A	N/A
Passenger vehicles	8,535	47,586	6,324	N/A	2,197,243
*Commercial vehicles	454	70	57	N/A	366,760
Buses	0	0	0	N/A	12,988
*Trucks	N/A	N/A	N/A	N/A	N/A
Totals **(without bicycles)**	**9,059**	**47,671**	**6,389**	**N/A**	**2,619,483**

Table 2:
Distribution and sales of BEVs, PHEVs and HEVs in 2019

Source: SIMI

Fleet Sales on 31 December 2019

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	TOTAL FLEET
Bicycles	N/A	N/A	N/A	N/A	N/A
Mopeds	N/A	N/A	N/A	N/A	N/A
Motorbikes	N/A	N/A	N/A	N/A	N/A
Quadricycles	N/A	N/A	N/A	N/A	N/A
Passenger vehicles	3,443	10,192	1,345	N/A	117,047
Commercial vehicles	327	1	5	N/A	25,296
Buses	N/A	N/A	N/A	N/A	N/A
Trucks	0	0	0	N/A	2,536
Totals (without bicycles)	**3,770**	**10,193**	**1,350**	**n/a**	**144,879**

CHARGING INFRASTRUCTURE

The number of chargers available in Ireland in 2019 is indicated in the table below. In 2019, ESB Ecar (installer and operator of the majority of charging infrastructure in Ireland) introduced the first pricing for use of their public charging infrastructure in November 2019. Pricing has only been introduced for the use of Fast Charging infrastructure at present and charging for use of On-Street chargers will be introduced in 2020.

Under the new pricing scheme, there will be two price plans available for Fast Chargers - Pay As You Go or Membership, the latter designed for drivers who typically use the network over five times per month:

- Pay As You Go is charged at 33c per kWh
- Membership is a €5 monthly subscription fee and a reduced charge of 29c per kWh

Overstay prices are also applicable on top of these fees. While the majority of Ireland's Fast Chargers are 50kW units, the upgrade programme will see the roll out of 150kW units in 2020. It is expected different fee structures will be applied to these higher powered units.

Early indications suggest that pricing has reduced the use of charging infrastructure (which was free up until then) which means infrastructure is being used more efficiently now and people are using their home chargers rather than tying up public chargers unnecessarily.

In addition to this work, there has been welcome development of Fast Charging infrastructure from Tesla, Ionity and Easygo.

Table 3:
Number of Chargers in 2019

Source: SEAI

*Note: Some chargers contain both ports but only one port can operate at a time.

Charging Infrastructure on 31 December 2019

Chargers	Quantity
AC Level 1 Chargers	0
AC Level 2 Chargers	650
CHAdeMO*	72
CCS*	61
Tesla	24
Ionity 350kW	14
Inductive Charging	0
Totals	**821**

Figure 1:
Ionity 350kW charging infrastructure in Ireland

Source: SEAI

Table 4:
Available vehicles and prices in Ireland

Source: SEAI - basic entry level price shown for each model

Market-Price Comparison of Selected EVs and PHEVs in Ireland

Available Passenger Vehicles	Untaxed, Unsubsidized Sales Price (in EUR)
Nissan LEAF 40kWh	€28,345
Nissan LEAF 62kWh	€33,993
Nissan eNV200 40kWh	€26,545
Mitsubishi Outlander	€34,037
Renault Master ZE	€53,659
Renault Kangoo ZE	€26,780
Renault Zoe 52kWh	€27,616
BMW 330e	€35,931
BMW X5	€58,307
BMW 530e	€44,878
Volkswagen E-Golf	€32,578
Volkswagen Passat	€38,244
Audi E-Tron	€53,115
Mercedes Benz EQC	€62,854
Mercedes Benz EVito	€39,995
Hyundai Ioniq BEV 38kWh	€32,335
Hyundai Kona BEV 64kWh	€36,581
Tesla S Standard Range	€60,228
Tesla X Standard Range	€65,350
Tesla Model 3 Long Range	€30,369
Peugeot E208	€26,288
Opel Corsa-e	€26,291

OUTLOOK

There was the expectation that 2020 would see another doubling in the sale of EVs in Ireland, however, early indications are showing less growth in EV sales than was expected. However, a major swing towards HEVs was observed.

Reasons for this may be linked to consumers becoming aware of the Government's plans to ban petrol and diesel car sales from 2030 onwards and recognising the importance of electric drive technologies and the need to move towards electric vehicles. There is probably lots of confusion for consumers on the distinction between HEV, PHEV and BEV therefore work must be done to educate the consumer on the benefits and differences of each.

Another reason for the lower growth may be linked to the lack of Fast Charging infrastructure in sufficient numbers together with reports from some EV drivers of incidents of queuing at some motorway locations.

Pricing will reduce wasteful using of charging infrastructure which has been noticeable at Fast Charger locations, however, motorists will want to see multiple chargers available for use.

ITALY

MAJOR DEVELOPMENTS IN 2019

The most appropriate element characterising the year 2019 was the introduction of direct incentives to purchase new low emission cars. This brought a remarkable increase of sales of rechargeable electric cars compared to the previous year. The transport sector is getting more and more attention from the Government as shown by the new version of the Integrated National Plan for Energy and Climate submitted to the European Commission at the end of 2019. This plan highlighted alternative mobility, in particular electric and hydrogen mobility, as essential instruments to reach the targets of the decarbonisation strategy and energy efficiency set by the European Union for the end of 2030. Thanks to the National financial support and to private investments, Italy is carrying on the installation of public charging stations for electric vehicles, including an increasing number of fast-charging stations.

Italy is among the countries notifying the Europe Commission of the Important Project of Common European Interest on batteries. This project was approved on December 2019 and is about research and innovation in all sectors of the battery value-chain.

NEW POLICIES, LEGISLATION, INCENTIVES, FUNDING, RESEARCH, AND TAXATION

In Italy, the 2019 “Budget Law” introduced a bonus-malus system providing incentives in the form of a bonus up to 6,000 EUR or a tax up to 2,500 EUR to purchase new cars: the amount will depend from the value of CO2 emitted by the vehicle per kilometre.

Direct incentives for purchasing new cars

Customers who register a new electric, hybrid or natural gas car will receive a monetary contribution up to 6,000 EUR, as shown in Table 1. The dealer will apply a discount to the customer at the time of purchasing the vehicle. Afterwards, he will get money back from the car maker or from the company importing the vehicle. Instead the latter one will get a tax debate from the Italian Government. The monetary contribution is not cumulative with other National incentives, but it can be added to other local incentives.

Taxation for purchasing polluting cars

Customers who register a car fed by conventional fuels could pay a tax up to

2,500 EUR. This tax will be not applied to city cars and vehicles used for special purposes.

The tax, whose amount is calculated according to four CO2 emissions levels, as shown in Table 2, must be directly paid by the customer or by the agency who is going to register the vehicle. On the other hand, new cars with CO2 emission values between 71 g/km and 160 g/km are exempt from the incentive as well as from the taxation.

Table 1: Monetary contribution for the Ecobonus in force in Italy from the year

CO_2 emissions	Without scrapping	With scrapping a Euro 1 ÷ Euro 4 vehicle
00 – 20 g/km	4,000 €	6,000 €
21 – 70 g/km	1,500 €	2,500 €

Table 2: Ecotax applied in Italy in 2019 when purchasing a new vehicle

CO_2 emissions	Amount
161 – 175 g/km	1,100 €
176 – 200 g/km	1,600 €
201 – 250 g/km	2,000 €
> 250 g/km	2,500 €

Indirect incentives

When purchasing a car, indirect incentives are mainly released at a regional level. The reduction of the annual circulation tax is the most used type of indirect incentive. Usually, electric vehicles are exempt from the annual circulation tax for a time-period of five years starting from the date of first registration. After this initial five years' time, the tax reduction consists in 75 % reduction of the annual circulation tax that would be applied to the equivalent petrol vehicles of the same power. On the other hand, hybrid vehicles are exempt from the yearly registration tax for a time-period of two-five (usually three) years from the date of first registration. After this period, the full conventional tax is applied.

In some Municipalities, electric vehicles have free access to limited traffic zones and have free parking in reserved areas. Certain Municipalities such as Florence, Milan, and Rome, are gradually introducing restrictions to conventional fuelled vehicles. For instance, in Rome, a restricted zone has been introduced to ban the circulation of diesel vehicles up to "Euro category 3" and to petrol vehicles up to "Euro category 2" from Monday to Friday. However, exceptional time-windows allow the circulation of commercial vehicles in the restricted zone.

Incentives on charging stations

The 2019 Budget Law includes a 50 % tax deduction on the purchasing and installing costs of recharging stations for electric vehicles. This fiscal deduction is also valid for condominiums.

Integrated National Plan for Energy and Climate

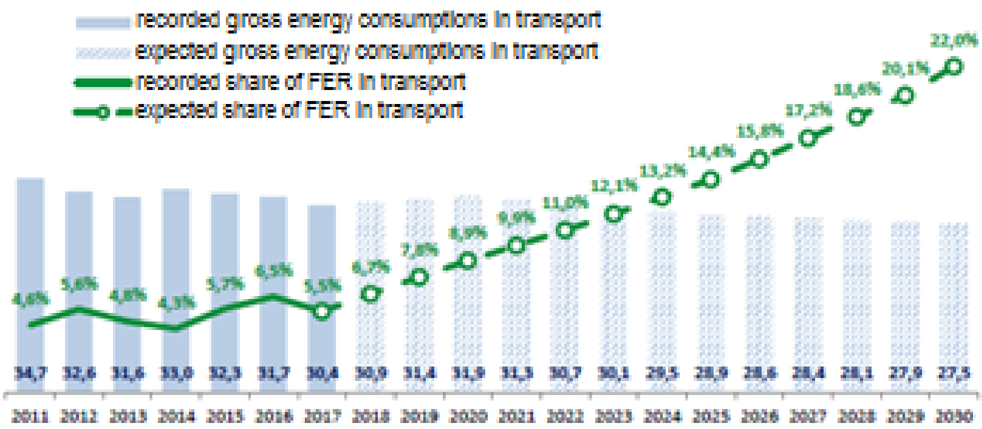
At the end of December 2019, a revised proposal of the Integrated National Plan for Energy and Climate was submitted by the Government to the European Commission. This plan foresees the following actions:

- promoting alternative fuels and reducing polluting emissions from the transport sector;
- increasing funding to replace old buses with electric ones to reach target quotas of green vehicles for public transportation;
- purchasing alternative fuel vehicles at low-emission impact to be used by the public administration;
- progressive review of the vehicle taxation system (e.g. registration tax, fuel tax), environmental bonus-malus for purchasing new cars, and a tax reduction for installing charging stations for electric vehicles (as discussed above) to increase the number of refuelling points for alternative fuels.

By 2030, it is expected that we will observe an important decrease in carbon content in the air due to the diffusion of electric vehicles and plug-in hybrid vehicles. This might represent a solution to be adopted in the private urban mobility that could also improve the production of electricity from renewable sources. Between 2025-2030 it is expected a return from the above actions with a diffusion of almost 6 million vehicles powered by electricity including about 4 million of full electric vehicles (BEV). One of the main targets of this policy is to use up to 22 % of the energy from renewable sources (FER) as fraction of the gross energy consumptions in the transport sector. Figure 1 shows the forecast of the share of FER in the transport sector.

Figure 1:
Trend of the share of FER in the transport sector

Source: GSE, RSE



Other regulations to promote the use of electric and hybrid vehicles in the cities are also under consideration by the Italian Government. The plan is to adopt some local measures about electric mobility also at national level. For electric vehicles users, new policy measures will include free access to limited traffic areas, the introduction of priority lanes and reserved parking spots.
As of 2021, metropolitan cities, municipalities with over 100,000 inhabitants, and towns with high levels of pollution will have to provide Urban Plans for Sustainable Mobility.

In Italy there is an increasing interest in hydrogen as a future energy carrier especially for the transport and integration of renewable sources into the electric system. In November 2019, the "Italian Hydrogen and Fuel Cell Association" (H2IT) drafted a new version of the National Development Plan for mobility with hydrogen in Italy ("Piano Nazionale di Sviluppo – Mobilità Idrogeno Italia"). This plan will be included in the update of the National Legislative Decree regulating the implementation of the European Directive about the realization of an infrastructure for alternative fuels ("Directive Alternative Fuel Initiative" - DAFI).

Research

As mentioned in the National Plan for Energy and Climate about experimental measures to use charging station as a "Vehicle to Grid" (V2G) service, Italy is ready to make a step forward. Tests about bidirectional recharge of electric vehicles will be carried out at commercial level. This topic has been included among the main subjects of the new Triennial Plan (2019-2021) for the National Research Program for the Electric System financed by the Ministry of Economic Development. To date, legislative measures are under review in order to establish criteria and direction to push this technology through a synergy between the bidirectional recharge system and the grid within the management of the provision of renewable energies.

The National Research Council of Italy (CNR) has been studying for years the development of an integrated system between electric mobility and energy production from renewable energy 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, infrastructure 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: this gives information about building simulation models of the energetic flows and generation of pollutants. This study aims 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 super- capacitors) for electric vehicles.

In 2019, The Italian National Agency on New Technologies, Energy and Sustainable Economic Development (ENEA) continued its activities relating to the "Sustainable Electric Mobility" project, included in the National Research Program for the Electric System funded by the Ministry of Economic Development. These activities include studies and research to realise supporting instruments for planning and/or evaluating electric mobility. Additional activities are foreseen to develop innovative technologies for charging infrastructure, especially for the investigation of the impacts of electric mobility on the transport system in urban contexts and the development of useful instruments for Local Public Transport (LPT) Companies or Local Administrations. In the following there is a list of the activities accomplished by ENEA in 2019:

- research activity in collaboration with the University of Florence for the realisation of an innovative system for LPT. In that system, a bus has been equipped with a hybrid storage device composed by supercapacitors (SCs) and batteries. SCs are used to supply the powertrain during the movement of the bus. Instead the batteries are used to supply auxiliary systems and the powertrain itself during the transfer of the bus from the depot to the bus terminal or to supply the bus in case of emergency. The charging connection has been automated by a pantograph, as shown in Figure 2 left, and the charging station has also been equipped with SCs. The SCs on board can be charged very quickly (less than 30 s) at each location of the bus stop by a simple energy transfer between the SCs housed in a charging station and the ones located on board. The transfer of energy between the SCs takes places without any electronic device intervention but only with an inductance. The SCs in the stations can be slowly charged from the grid during the time before the next bus arrival. This simple and cheap method makes it possible to perform a flash charge without demanding high power from the power grid that, on the other hands, is not strongly affected by the charging service;

- studies on storage solutions by flywheels;
- studies on dynamic wireless charging. Studies have been carried out on system design and its implementation on a medium-sized vehicle;
- safety of Li-ion batteries. The activity program includes the design and implementation of electrical and thermal abuse testing of Lithium-ion pouch cells with cathodic chemistry NMC (Nickel Cobalt Manganese);
- studies about the ageing of Li-ion battery cells (commercial NMC - graphite, NMC - Lithium Titanium Oxide, an example is given in Figure 2 right) focused on fast charge and development of data-based models to predict life-time under specific operating conditions;
- studies about new batteries spanning from advanced Li-ion batteries to beyond Li-ion batteries. Particular research is focused on the “3a” generation batteries (cathode: NMC and anode: carbon and silicon 5 ÷ 10 %), the “3b” generation batteries (cathode: high energy NMC, high voltage spinel, anode: silicon/carbon), the “4” generation batteries (all solid state batteries, lithium anode batteries, lithium-sulphur batteries) and the “5” generation batteries (lithium-air).

Figure 2:
Bus equipped with pantograph (left) and test on battery cells (right)

Source: University of Florence, ENEA

Besides carrying out activities on the impact on the grid due to the circulation of electric vehicles, the Research on Energetic System (RSE - “Ricerca sul Sistema Energetico”), another main National research institute, together with National

Research Council (CNR) and ENEA, started the following new activities on electric mobility:

- Life Cycle Analysis and Air Quality. Environmental impact of electric vehicles (not only cars) compared with the traditional vehicles fed with fossil fuels, an example of results is given in Figure 3;

- V2G (vehicle to grid), impact on the grid and dynamic pricing. Interaction between electric mobility and electro-energetic systems with focus on problems and synergies;

- analysis of the evolution of sustainable mobility. Study of scenarios about electrification and techno-economic evaluations in support of commercial operators and policy makers.

RSE's activities are mainly oriented in the National Research Program for the Electric System ("Ricerca di Sistema Elettrico").

In agreement of the European legislation about State aid, the European Commission has approved an Important Project of Common European Interest (IPCEI) involving Belgium, Finland, France, Germany, Italy, Poland, and Sweden. This project is about the support in research and innovation within the battery sector. In the following years, the above Member States will release funds of about 3.2 billion Euros on behalf of this project. Consequently, it is expected to see a further investment of 5 billion coming from the private sector. The ending of this project is foreseen for the year 2031 (with different time-schedules depending on subtasks). 17 participants from the industrial sector, including small and medium enterprises (SMEs), will be directly involved in the project.

Main participants will work closely between one another and with over 70 external partners including SMEs and public research Institutes across all Europe. This project supports the development of highly innovative and sustainable technologies for lithium-ion batteries (liquid electrolyte and solid state) having a longer life-time, shorter recharging times, increased safety, and ecological compatibility, compared with the ones already in commerce. In addition, this project will be oriented to new ambitious research initiatives to realise innovations beyond the state-of-the-art in the whole battery value-chain. In details these innovations will deal with:

- extraction and processing of raw materials;

- production of advanced chemical compound;

- design of battery cells and modules of batteries together with the integration into intelligent systems;

- recycling and reuse of used batteries.

The above innovations will be focused to improve the environmental sustainably in all sectors of the batteries value-chain with the goal to reduce the carbon footprint and the waste generated in different production processes. Besides that, efforts will be also oriented to study new dismantling processes, recycling, and sustainable refinement in line with the principle of circular economy.

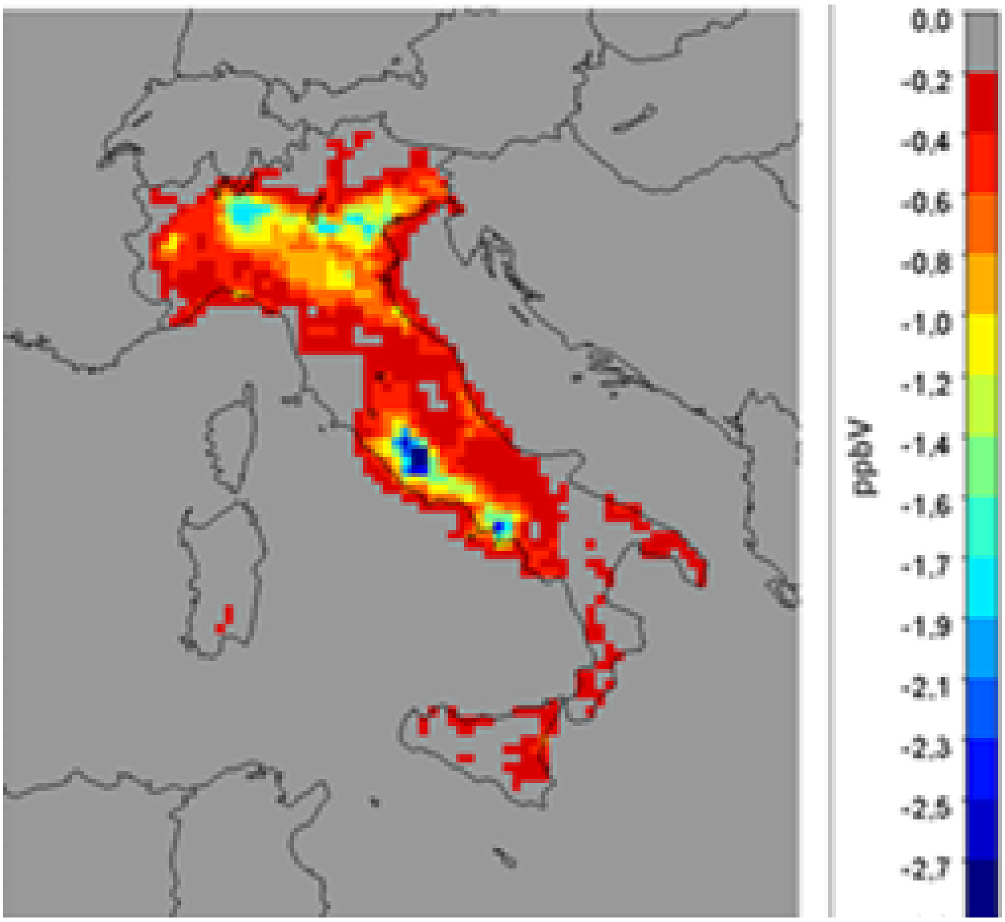


Figure 3:
Example of NO2 concentration as result of a simulated scenario according to particular policy directives

Source: RSE

HEVS, PHEVS, AND EVS ON THE ROAD

Compared to the previous year 2018, in 2019 a decrease in sales was observed only for diesel cars (- 22 %), while an increase was observed for petrol (+ 26 %), liquefied petroleum gas LPG (+ 9 %), methane (+ 3 %), electric (+ 113 %), and hybrid (+ 34 %) cars. Therefore, sales of diesel cars lost over 11 % (current 39.8 % against 51.2 % from 2018), petrol cars gained an additional 9 % (current 44.5 % against 35.5 % from 2018) LPG cars gained 0,6 % (current 7.1 % against 6.5 % from 2018) while methane cars remained at 2 % as in 2018. Finally, sales of hybrid and electric vehicles gained almost 2 % (current 0.6 % against 0.3 % for electric cars and, 6.1 % against 4.5 % for hybrid cars).

The legislative measure of the Eco Bonus has rewarded the sector of rechargeable cars that jumped from 0.5 % in 2018 to 0.9 % in 21019 (0.2 % in 2017). By the end of 2019, sales of solely electric cars doubled compared those ones recorded in 2018 (+ 113 %), while hybrid plug-in cars increased by 36,3 % compared to 2018.

Among the BEV models, mostly sold for private transportation, we find Tesla Model 3, followed by Renault Zoe, Smart Fortwo and Nissan Leaf.

In 2020, FCA will start the electrification chain with two historical bestsellers: Fiat Panda and Fiat 500 (180,000 cars sold in 2019 in Italy) that will be equipped with hybrid technology and that will be available from February 2020. These two super city cars will contribute to making hybrid motorisation accessible to a large number of customers. This will also contribute to having more sustainable mobility across Italy and Europe. In 2019, FCA also started the implementation of hybrid engine for the Jeep Renegade and the Jeep Compass. Finally, 2019 will also be remembered for the news about the alliance between the car maker groups FCA and PSA. This alliance will bring the creation of the fourth car maker global group with almost 10 million vehicles produced in 2019 and second in Europe behind the VW Group.

Table 3 and Table 4 report the statistics about fleet totals and total sales, respectively. Data relative to the total volume of two and three wheeled vehicles, include 35 million bicycles (500,000 electric), 2 million mopeds and 6,8 million motorcycles. The total sales of two and three wheeled vehicles includes 1,6 million bicycles (200,000 electric), 5,875 quadricycles (628 electric) 20,371 mopeds (4,029 electric) and 231,937 motorcycles (1,810 electric).

Data relative to trucks (light, medium and heavy) do not include special trucks and the articulated trailer truck.

Table key:
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

Table 3:
Statistics about fleets

Sources:
[1] ANCMA estimate
[2] ENEA elaboration on ACI official data as at 31 December 2018
[3] ENEA elaboration
[4] ACI official data

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	43,800,000 [1]
B Passenger vehicles	12,062 [2]	244,484 [2]	94 [2]	15 [3]	39,018,170 [4]
C Buses and Minibuses	N/A	N/A	N/A	13 [3]	100,042 [4]
D Light Commercial vehicles	4,534 [2]	1,027 [2]	N/A	N/A	3,606,733 [2]
E Medium and Heavy Weight Trucks	29 [2]	3 [2]	N/A	N/A	521,192 [2]

Table 4:
Statistics about sales

Sources:
[1] ANCMA estimate
[2] ACEA official data
[3] UNRAE official data
[4] ACEA provisional data

Total Sales During 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	206,467 [1]	N/A	N/A	N/A	1,858,183 [1]
B Passenger vehicles	10,663 [2]	109,789 [2]	6,471 [2]	7 [3]	1,916,320 [4]
C Buses and Minibuses	N/A	N/A	N/A	N/A	4,249 [2]
D Light Commercial vehicles	N/A	N/A	N/A	N/A	187,725 [2]
E Medium and Heavy Weight Trucks	N/A	N/A	N/A	N/A	23,622 [2]

CHARGING INFRASTRUCTURE OR EVSE

The National Infrastructural Plan on the Recharge of electric vehicles (PNIRE), approved in 2012 and updated in 2016, was setup in agreement with main specialised State departments and stakeholders working in this sector. The main goal for this plan, during the year 2020, is the realisation of up to 13,000 slow/ fast charging points (with power up to 22 kW), 6,000 fast charging stations (with power bigger than 22 kW) with an implementation of 1 public charging point every 8 private charging points. For this purpose, in 2017 an Agreement Program was subscribed to between the Ministry of Infrastructure and Transportation and the Region/Local Authorities for the realisation of several networks to charge electric vehicles. This Agreement wanted to prioritise interventions based on the actual regional needs by promoting and valorising the participation of public and private partners. Overall, funding of about 72.2 million EUR has been anticipated together with State co-funding of about 28.7 million EUR. The PNIRE plan was improved in order to consider other measures in support of the demand of electric vehicles and usability of charging infrastructure. In addition, the PNRE included the possibility to coordinate the development of charging infrastructure together with rationalisation of fuel distribution.

The Italian Budget Law for the year 2019 has also introduced tax deductions when purchasing and installing charging points for electric vehicles from 2019 to 2021. The tax deduction is set at 50 % of the total fees that are paid back in the following 10 fiscal years.

In 2017, Enel, the largest Italian provider of electric energy, launched its plan to install appropriate charging infrastructure over the whole of Italy. Target objectives for Enel's Plan are shown in Figure 4 and are as follows:

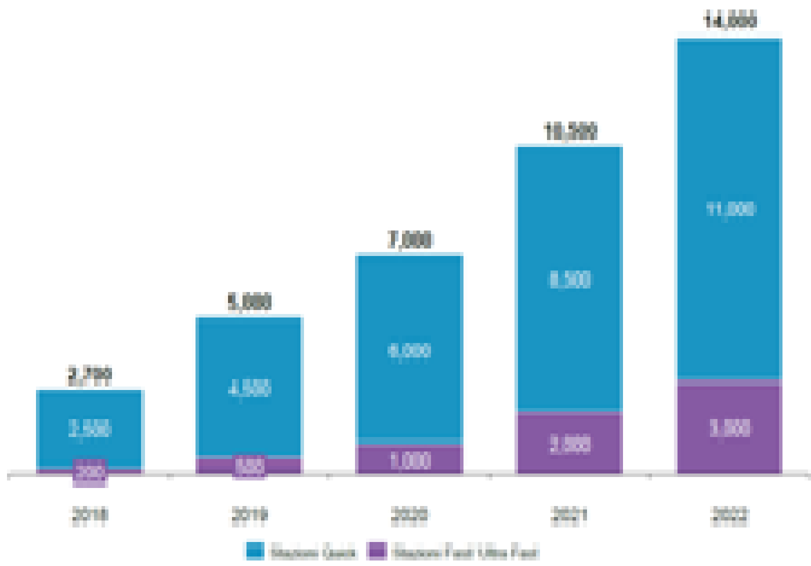
- 7,000 charging stations (6,000 quick @ 22 kW; 1,000 fast/ultrafast @ 50/150 kW) by 2020;
- 14,000 charging stations (11,000 quick @ 22 kW; 3,000 fast/ultrafast @ 50/150 kW) by 2022.

To realise its plan, Enel will invest between 100 and 300 million EUR coming from company assets, European funds, and drivers' contributions. These funds will not affect the electricity bill. Additionally, an agreement between the European Investment Bank (BEI) and Enel X Mobility to support Enel's Plan was signed in 2018. During the next 10 years, Enel X Mobility will receive 115 million EUR to finance about 50 % of its total investment. This financial support falls under one of BEI's main action streams about funding projects on innovation and sustainable mobility for climate change mitigation.

As a consequence, a general upward trend in the diffusion of electric vehicle charging stations was registered. On the other hand, the inventory of charging infrastructures is particularly complicated. However, a complete inventory comes from the European Alternative Fuel Observatory (EAFO) that is continually updated by the Italian Commission for Battery, Hybrid, and Fuel cell Electric Vehicles (CIVES).

Figure 4:
Enel's Plan for electric vehicle charging stations

Source: Enel X



Among chargers with power bigger than 22 kW we find: the 275 Type 2 AC, the 322 CHAdeMO, the 329 CCS and, the 268 Tesla Supercharger. We must point out that most of DC (direct current) charging stations (CHAdeMO or CCS) are also equipped with a Type 2 AC charging point. However, these charging stations are considered as one charging point because they can only work alternatively, employing their DC or AC charging point. Therefore, the 275 Type 2 AC charging points shown in Table 5 must be considered as DC charging stations and belong to the type of chargers with power bigger than 22 kW. As shown in Table 5, there are 919 of these fast charging points across Italy.

Table 5:
Number of charging points in public areas

Type of Public EVSE	Number of Charging Points [1]
AC Slow Chargers (≤ 3.7 kW) AC Slow Chargers (>3.7 kW, ≤ 22 kW)	3,542 [2]
Fast Chargers (> 22 kW, ≤ 43.5 kW) Superchargers (> 43.5 kW)	919 [3]
Inductive Chargers	N/A

[1] a station with more charging sockets is equivalent to several charging points where many cars can be simultaneously charged. For instance, an infrastructure equipped with two or more sockets allowing the charge of only one vehicle at once is considered only one charging point.

[2] charging points AC ≤ 22 kW in public areas.

[3] charging points AC > 22 kW, DC CHAdeMO, CCS and Tesla Superchargers in public areas.

EV DEMONSTRATION PROJECTS

Several projects about sustainable transport, in which Italian companies are involved, got co-funding from the European Program "Connecting Europe Facility".

Enel X and the Austrian electricity distributor Verbund are collaborating on the fast-recharging network project "Electric Vehicle Arteries" (EVA+), with Enel X as main coordinator. Other large EV global carmakers such as, Renault, Nissan, BMW and Volkswagen Group Italia are working on the EVA+ project. Indeed, the purpose of project EVA+ is to create a fast charging infrastructure for electric vehicles on main roads/motorways in Italy and Austria (see Figure 5, left). The

EVA+ project, started in July 2017, will last for three years where 200 multi-standard fast charge stations will be installed over Italy and Austria. Each of these stations will be able to offer several fast charging standards options such as CSS Combo 2, CHAdeMO or AC charging (see Figure 5, right). Out of the 200 charging stations, 180 will be of the type Fast Recharge Plus, a technology developed by Enel, enabling two vehicles to be simultaneously fast charged in about 20 minutes. These stations will be installed in Italy by Enel, while the remaining 20 stations, also offering fast charging standards, will be installed by the Verbund's subsidiary SMATRICS in Austria. EVA+'s total project's budget is 8.5 million EUR, of which 50 % is co-funded by European Commission under the "Connecting Europe Facility" Program.

Figure 5:
(left) Locations in Italy and Austria where fast charging stations will be installed within the EVA+ project. (right) Typical fast charging station

Source: Enel X

Enel X is also the coordinator of the "E-VIA - FLEX-E" Project for the installation of 14 multi-standard Ultra-Fast Charging Stations ranging from 150 kW to 350 kW in Europe, with 8 of them in Italy, 4 in Spain, and 2 in France. The project has a total budget of 6.69 million EUR and is co-financed by the European Commission in the framework of the Program "Connecting Europe Facility".

There is also the project "Ambra-Electrify Europe" aimed at creating an interoperable pan-European charging network for normal, fast and ultra-fast charging stations. By December 2022 (deadline of the project) 3,169 charging stations will be installed in Europe, with 1,783 in Italy, 729 in Spain and 657 in Romania. In this project, Enel X is the unique beneficiary with a budget of 70.75 million EUR and financial support of 14.15 million EUR from the European Union.

Finally, Enel X is involved in the "Central European Ultra Charging" Project (with a total budget of 61.7 million EUR) aimed to facilitate long-distance travels with EVs and the connection of urban nodes. This will be accomplished ensuring the interoperability of charging infrastructure between EU Member States and supporting a technology standard for ultra-fast charging in Europe. 118 High Power Charging stations will be installed in Austria, Czech Republic, Hungary, Italy, and Slovakia along the Trans European Transport Network (TEN-T), 38 of these stations will be located in Italy.

RSE is leading the "e-Smart", a project funded by the European Program "Interreg

Alpine Space" to test an operational model about the management of charging stations and e-mobility in the transports of goods (intermodal transports, last miles and city logistic) and local public passenger transport. This project held its kick-off in the month of November 2019.

The city of Verona began the experimentation of a new generation of "smart" light poles equipped with an internal socket for fast charging electric cars at 22 kW. These structures were built by AGSM, the municipal multi-utility of the city of Verona. The "smart" light poles were also equipped with a Wi-Fi antenna and a webcam for the urban traffic and parking management in real time. The experimentation of the "smart" light poles is part of the program "Electrify Verona" started by the City Council in partnership with Volkswagen and AGSM. The goal of this project is to reach 100 charging points by the end of 2021.

Italian Organisations take parts in several projects about fuel cell buses financed by Fuel Cells and Hydrogen Joint Undertaking (FCH) that we list as follow:

- the project "Clean Hydrogen in European Cities"(CHIC) sees the involvement of the cities of Bolzano and Milano with the testing of 5 fuel cell buses in both cities;

- the Project "Joint Initiative for hydrogen vehicles across Europe" (JIVE) about the experimentation of 15 fuel cell buses of which some of them will be tested in the city of Bolzano;

- the Project "High.V.Lo-City" aimed to accelerate the integration of hydrogen buses in public fleets across Europe. Within this project, the Italian city of San Remo will test 3 fuel cell buses.

At Capo d'Orlando, in Sicily, the CNR has put into service a fuel cell bus and a charging station. Instead, in Ferrara, Cesab/Toyota has installed its own hydrogen refuelling station and is going to implement a fleet of forklifts powered with hydrogen.

FCH is also funding several projects about the use of hydrogen in mobility applications other than buses for public transportation. For instance, the project "Clean Efficient Power for Material Handling" (HYLIFT-EUROPE), in which the Italian company Fast, that develops and tests hydrogen fuel cell forklifts, takes part, and the project "Refuse Vehicle Innovation and Validation in Europe" (REVIVE), in which the city of Bolzano takes part for the development of Fuel Cell Refuse trucks.

OUTLOOK

Policy scenarios have been elaborated in 2017 by Enel and the "European House – Ambrosetti" Consulting Group in the context of the "E-Mobility Revolution – Impacts on Italy and its industrial value chain". An agenda was drafted on the hypothesis of possible different scenarios about the penetration of electric vehicles. For each scenario, the number of electric cars registered by the end of 2030 as well as the availability of charging columns/stations was estimated. The projections up to the year 2030, resumed in Table 6, forecasted about 2 million electric cars (pure and hybrid plug-in) in the “lower scenario” with a presence of 29,000 charging columns. Instead, in the “accelerated scenario” the projections forecasted the presence of 9 million electric cars and 45,000 charging columns. The impact on the number of circulating cars represents a variation between 5 % and 24 %. The “medium scenario” forecasted about 3 million total circulating electric cars, corresponding to the 30 % of the sold cars and to the 8 % of the total fleet. In addition to that, the “medium scenario” also forecasted the presence of 30,000 charging columns.

Table 6:
Diffusion scenarios of electric cars and of the charging stations from 2025 to 2030

Source: European House – Ambrosetti Consulting Group

Scenario	Total fleet electric cars @ 2025 [Thousands]	EV charging stations @ 2025 [Number]	Total fleet electric cars @ 2030 [Thousands]	EV charging stations @ 2030 [Number]
Inertial	133	10,470	500	25,000
Lower	700	23,300	2,000	28,600
Middle	1,000	25,000	3,000	30,000
Upper	1,500	27,500	5,000	33,000
Accelerated	3,000	30,000	9,000	45,000

The study “Electrify 2030”, realized on 2018 by the “European House – Ambrosetti” Consulting Group in collaboration with Enel X and the Foundation “Centro Studi Enel”, updated the above scenario analysis about future electrification in Italy for other type of vehicles, as shown in Table 7. This was accomplished through the elaboration of the following scenarios:

- two wheelers electric vehicles: it was forecasted an increase from 240,000 to 1.6 million of vehicles with a consequent increase of charging stations from 857 to 2,000;
- electric buses: it was forecasted and increase from 3,307 to 10,188 vehicles together with an increase of charging stations from 413 to 637;
- commercial vehicles: it was forecasted and increase from 202,763 to 630,478 vehicles with an increase of public charging station from 724 to 1,051;
- electric trucks: it was forecasted and increase up to 34,336 vehicles together with about 8,500 public charging stations.

Table 7:
Scenarios from the study "Electrify 2030"

Source: European House – Ambrosetti Consulting Group and Enel X

Scenario	Total fleet electric passenger cars [Thousands]	Total fleet electric 2-wheelers [Thousands]	Total fleet electric buses [Thousands]	Total fleet electric commercial vehicles [Thousands]	Total fleet electric trucks [Thousands]
Base	2,000	240	3.3	203	0
Middle	5,000	850	8.0	350	23
Accelerated	9,000	1,600	10.2	630	34

In September 2019, the Italian Polytechnic Institute in Milano published the "Smart Mobility Report" that, beside reporting a detailed analysis of technologies, regulations and current car market, presented results from 3 market scenarios about electric cars from 2025 to 2030 that can be summarised as follows:

- "base" scenario: this is a development scenario foreseeing an implementation of the number of electric vehicles up to 2.5 million by the end of 2030, with a peak in the registration of new vehicle of 30 % with respect to the total vehicle registrations;

- "moderate" scenario: this is a scenario of middle development where electric vehicles are foreseen reaching up the 23 % of the new car registrations by 2025 and with an increase up to 50 % on 2030. In that year, the registered electric vehicles should be more than 5 million (about 13 % of the registered cars);

- "accelerate" scenario: this is the major development scenario with an increase of car registrations already starting before 2025, when electric vehicle registrations should reach the 30 % of the total registered cars with a total number of almost 2 million vehicles. By 2030, vehicle registrations should settle around 65 % reaching about 7 million vehicles (about 20 % of the total registered vehicles).

Finally, it is worth reporting the forecasts elaborated within more recent European and National programs. Among the main objectives of these programs there is the decarbonisation, energy efficiency, and electrification of all the utility consumptions. In particular, according to National strategic documents reporting the results of "objective" scenarios, the Energy National Strategy (SEN) forecasts 5 million electric vehicles circulating by 2030. On the other hand, the PNIEC estimates the presence of about 6 million electric vehicles of which 4 million will be fed by pure electricity. In both cases, there is the hypothesis that these targets could be reached also thanks to policy measures promoting the diffusion of electric mobility.

As a conclusion, Table 8 reports a summary showing the more significant forecasts about the diffusion of electric vehicles in Italy.

Table 8:
Summary of the more significant forecasts about the diffusion of electric vehicles in Italy

Author	Document	Publication year	Scenario	Total fleet @ 2030 Passenger cars [BEV + PHEV] [Thousands]
Ambrosetti	E-Mobility Revolution ...	2017	Inertial	500
			Lower	2,000
			Middle	3,000
			Upper	5,000
			Accelerated	9,000
Ambrosetti	Electrify 2030	2018	Base	2,000
			Middle	5,000
			Accelerated	9,000
Polytechnic of Milan	Smart Mobility Report	2019	Base	2,500
			Middle	5,000
			Accelerated	7,000
Various Ministries [1]	SEN	2017	Policy	5,000
Various Ministries [1]	PNIEC	2019	Policy	6,000

[1] Ministry of Economic Development, Ministry of Infrastructures and Transport, Ministry of the Environment and Protection of Land and Sea

NETHERLANDS

MAJOR DEVELOPMENTS IN 2019

By 2030, only zero emission passenger cars will be sold in the Netherlands. That is the ambition of the Dutch government. With this goal in mind central, regional, and local governments work together with business, social institutions, and knowledge institutions to advance electro-mobility. The Formula E-Team is the Dutch public-private platform to promote e-mobility and accelerate the transition to electric vehicles. The aim is to meet the climate targets and, in addition, to take advantage of the associated economic opportunities.

The efforts were successful again in 2019. The number of full electric passenger cars more than doubled and passed the threshold of 100,000 vehicles. Almost 15% of new registrations were electric vehicles. The economic activity around electro-mobility showed a versatile and quickly growing sector, with a joint turnover of more than 1 billion euros and almost 5,000 jobs directly related to electro-mobility.

The Dutch Minister for the Environment and Housing, Stientje van Veldhoven, became the chair of the global Transport Decarbonisation Alliance. The TDA brings together countries, cities/regions, and companies as the major drivers in decarbonised transport. One of TDA's actions in 2019 was the launch of an Open Call to vehicle manufacturers to produce more zero emission freight vehicles. It has already been signed by over 75 organisations with aggregate demand for over 263,000 freight vehicles.

POLICY DEVELOPMENTS

In the National Climate Law, the Dutch climate goals have been determined:

- 49% reduction of greenhouse gas emissions in 2030 compared to 1990 levels;
- 95% reduction of greenhouse gas emissions in 2050 compared to 1990 levels.

In order to reach the 2030 goals, a National Climate Agreement was presented in June 2019 by the Dutch government. It is an agreement between many organisations and companies in the Netherlands to combat climate change. The Agreement comprises 5 sectoral agreements: Agriculture and land-use, Built

Environment, Electricity, Industry, and Mobility. Figure 1 shows the focal areas for mobility.

The climate agreement includes fiscal and financial instruments to stimulate zero emission vehicles, a National Agenda on Charging Infrastructure to make sure charging infrastructure will be ready for the uptake of all electric vehicles and several other industry led activities like communication campaigns to promote electric vehicles and a battery guarantee for second hand cars.

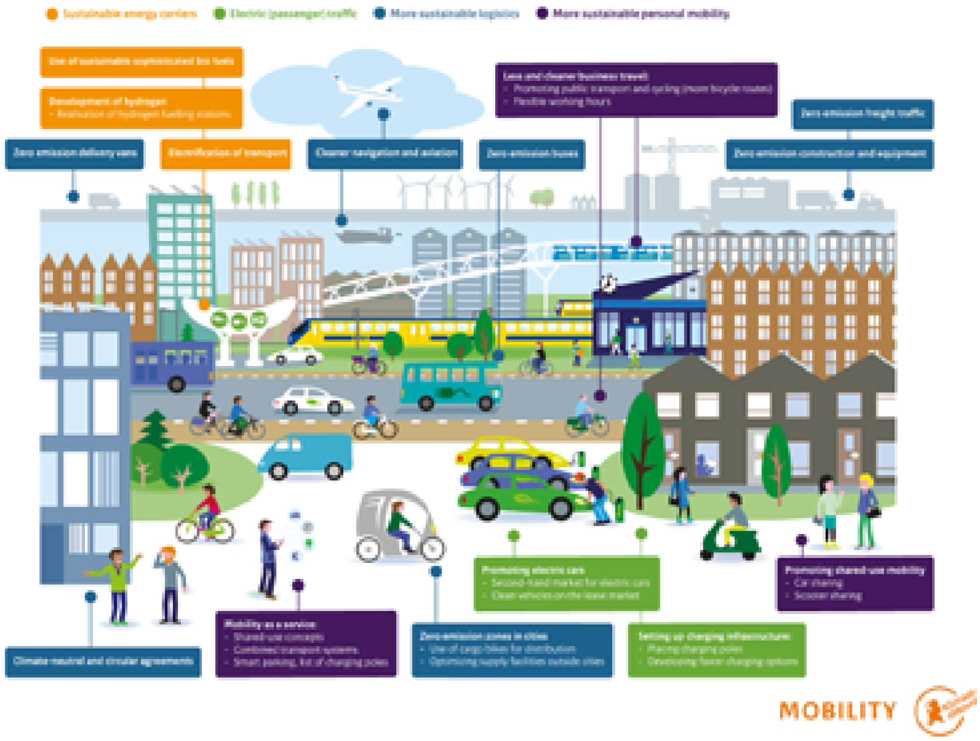


Figure 1:
Mobility focal areas in climate agreement

Source: klimaatakkoord.nl

The National Agenda for Charging Infrastructure was drawn up by stakeholders of municipalities, provinces and regions, the national government, grid operators, energy suppliers, vehicle manufacturers, charge point operators,and other market parties. The guiding principle is that all new passenger cars will be zero emission in 2030. This amounts to an electric fleet of 1.9 million passenger cars by 2030 – calculated to be needing 7,100 GWh of electricity or 1.7 million charging points. The Agenda is a complete approach to charging infrastructure and handles charging on street, at home and at work. It concerns both regular and fast charging and all modalities (including logistics vehicles) and addresses smart charging.

The Climate Agreement also states the ambition that 30-40 larger municipalities will implement a zero-emission zone for commercial vehicles by 2025, this means that only zero emission logistical vehicles (e-vans, e-trucks, cargobikes) will be allowed to enter the 30-40 largest cities in The Netherlands. This is unique in the world, as most cities have a target date of 2030 and beyond. The borders of the zones will be defined in 2020, so the market can prepare itself in time. Central government facilitates the process to define zero-emission zones. Amsterdam has taken this ambition even further and wants to create a full zero emission zone in its city centre by 2030, also including passenger cars.

Cities are also looking to transform their own (contracted) transport and have agreed to transform all busses to zero emission by 2030 and The Ministry of Infrastructure and Water Management, several municipalities and refuse companies have signed a covenant which aims to do the same for all refuse (waste) trucks.

FINANCIAL AND FISCAL INCENTIVES

One of the drivers behind the increase of electric vehicles in the Netherlands is fiscal stimulation. The focus is on stimulating zero emission vehicles, tax measures for plug-in hybrid vehicles will gradually be reduced to the same level as conventional cars. Table 1 provides an overview of the incentives that were in place in 2019.

Table 1: Fiscal incentives in the Netherlands 2019

Policy measure	Details
Registration tax	Zero emission cars are exempt from paying registration tax. For conventional cars, the system is progressive, with a starting tariff and 5 levels of CO_2 emissions and amounts of registration tax. Plug-in hybrid cars get a discount compared to conventional cars, they do not have a starting tariff and have 3 levels of CO_2 emissions and amounts of registration tax.
Road tax	Zero emission cars are exempt from paying road tax. Plug-in hybrid cars < 51 gr CO_2/km pay half the tariff (until 2020). For conventional cars, this tax is € 400 to € 1.200 (depending on fuel, weight, and address).
Surcharge on income tax for the private use of company cars	In the Netherlands, income tax must be paid on the private use of a company car. This is implemented by imposing a surcharge of 4 or 22% of the catalogue value on the taxable income. For zero emission cars this percentage is 4%. For all other cars, including plug-in hybrid cars, it is 22%.
Tax deductible investments	The Netherlands has a system of facilitating investments in clean technology, by making these investments partially deductible from corporate and income taxes. Zero emission and plug-in hybrid cars < 31 gr CO_2/km (no diesel engine) are on the list of deductible investments, as are the accompanying charging points.

Next to these national tax incentives, various municipalities and regions offer different grants and schemes for electric vehicles. Some examples:

- Rotterdam: subsidy for electric driving to and from construction sites and for electric commercial vehicles;
- Amsterdam: subsidy for electric commercial vehicles and taxis;
- Brabant province: subsidy for electric shared passenger cars.

The Ministry of Infrastructure and Water Management published a € 5 million subsidy for smart charging plazas. The money will be used in 21 Dutch municipalities throughout the Netherlands for loading bays, with a total of 472 smart charging points. The charging points will also be able to store locally generated electricity and later returning it to the electricity grid, thus contributing to the energy transition.

MARKET DEVELOPMENTS

Lightyear has presented the prototype of its efficient and solar power driven fully electric family car. The solar car has a range of 725 km. Lightyear will be ramping up production of the Lightyear One in 2021, now preparing for it by, amongst others, building the factory. The first 100 cars have already been pre-ordered. Lightyear was founded in 2016 by alumni of Solar Team Eindhoven, which won the World Solar Challenge several times with the family sized solar car Stella.

Figure 2: Lightyear One

Source: Lightyear

The number of electric buses in the Netherlands keeps growing. Already 15% of the total public transport fleet is electric. Many cities have several electric buses in operation, both for regional and for city services. Groningen and Drenthe are by far the most electrified provinces in terms of public bus transport, with Groningen also investing in hydrogen buses. In the north of the Netherlands, 47% of buses are electric. Limburg (37%) and North Holland (31%) hold second and third place[1] respectively.

At the end of 2019, more than 2,000 electric taxis drove in the Netherlands, the majority BEVs. Amsterdam celebrated its 1,000st electric taxi in 2019. The Hague has 35 hydrogen taxis in use as WMO transport under the Social Support Act for anyone who is unable to use public transport.

Rotterdam and Amsterdam have several hundreds of electric shared scooters, supplied by felyx. The number of shared passenger cars in the Netherlands has risen to over 50,000, 6.8% of these are electric. 515,000 people use car sharing services.

KNOWLEDGE, INNOVATION AND RESEARCH

The Netherlands Knowledge Platform for Public Charging Infrastructure (NKL) is a partnership dedicated to the rapid expansion of a cost-efficient and future-proof charging network for electric transport. In 2019, NKL has amongst others,

[1] https://www.ebusco.com/dutch-forerunner-in-europe-switching-to-electric-buses/

published guidelines for 'charging differently' (charging in other ways than by regular charging points, such as subterranean charging, charging integrated in other objects etc.), charging plazas and a vision and policy on charging infrastructure. In addition, an independent management organisation has been set up for OCPI, the Open Charge Point Interface protocol (please refer to [X].3).

Netherlands Enterprise Agency commissioned a report on different aspects of Vehicle-to-Everything (V2X) in the Netherlands. Conclusion was that V2X has a lot of potential. Due to current institutional bottlenecks, Vehicle-to-Home will not be adopted on a large scale the coming years. Vehicle-to-Building behind the meter is expected to be the first commercial application of V2X since it is not limited by these bottlenecks. Vehicle-to-Grid is currently in the pilot phase: several pilot projects around the Netherlands to proof the V2X-potential in a real-world-situation.

ElaadNL, the Knowledge and Innovation Centre for e-mobility from the Dutch DSOs, research and tests together with partners the possibilities of Smart Charging. In 2019 they published Smart Charging Terms. It is important that the charging stations and the back office are suitable for dealing with different supporting protocols. They can be future proofed by taking care of five pillars that are described in these terms.

For planning purposes for the National Agenda for Charging Infrastructure (please refer to [X].1.1] ElaadNL has drawn up a prognosis (to be updated yearly) of the expected number of electric vehicles for every neighbourhood in the Netherlands. Municipalities can check and add to the data. The prognosis is matched with prognoses of the electrification of neighbourhoods for heating amongst others. This will give the grid operators an insight in all relevant developments for the energy transition.

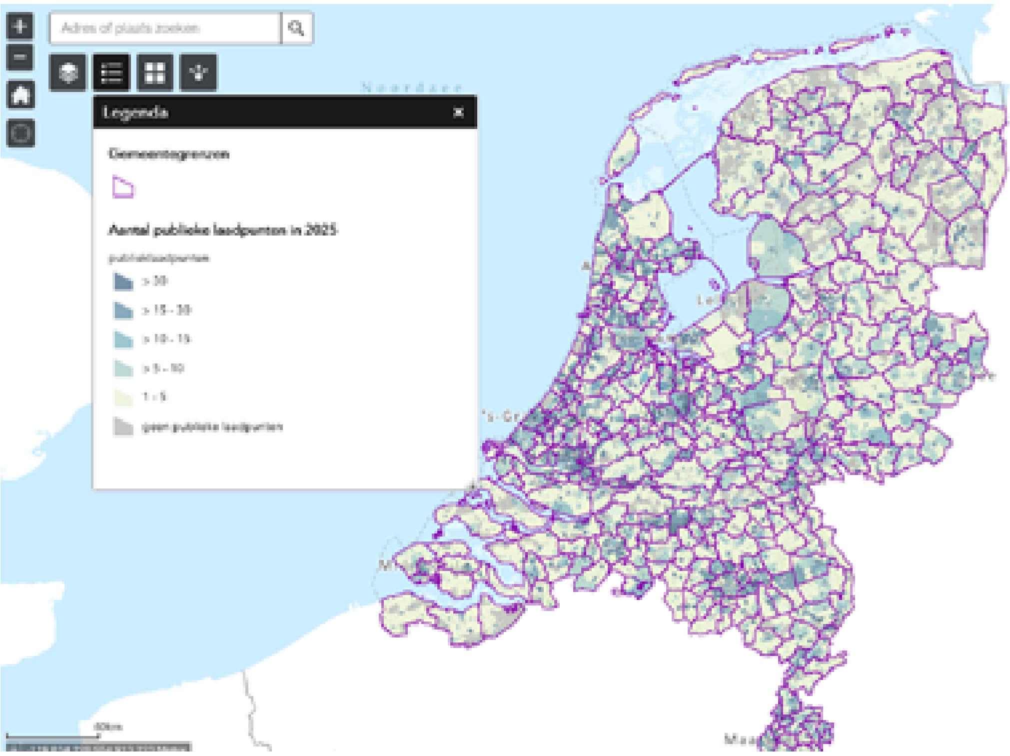


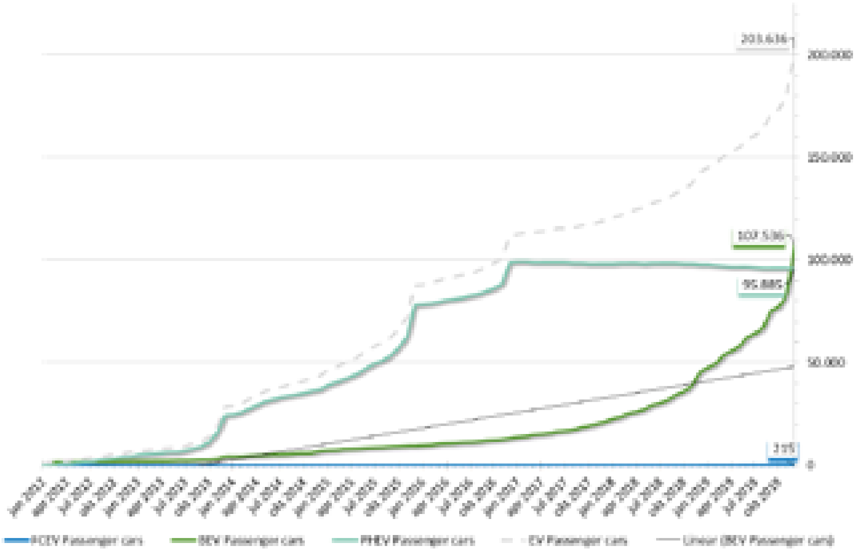
Figure 3: Screenshot of prognosis of EVs

HEVS, PHEVS, AND EVS ON THE ROAD

The number of battery electric vehicles (BEVs) in the Netherlands grew considerably in 2019, as is shown in figure 4 and table 2. between December 2018 and December 2019, the number of full electric cars more than doubled. At the end of 2018, there were 44,984 BEV passenger cars and at the end of 2019, the number was 107,536 – an increase of 139%. The electric passenger car fleet is quickly becoming more fully electric. BEVs made up 53% at the end of 2019, whereas at the end of 2018 only 32% of all electric passenger vehicles were BEVs. At the end of 2019, there were 156 fuel cell electric passenger cars in the Netherlands, compared to 50 FCEVs at the end of 2018.

Figure 4: Development of the electric vehicles fleet in the Netherlands 2012-2019

Source: Dutch Road Authority, edited by RVO



The total number of PHEVs in the Dutch fleet decreased a bit again over the year by almost 2% to 95,885 passenger cars at the end of 2019. New PHEVs were still registered, but some older ones were exported, thus resulting in a somewhat negative fleet balance.

Over the year 2019, 14.8% of total new passenger car registrations were electric. Of these the majority was full electric: 13.7%. In 2018, 6.5% of new registrations were electric vehicles. In the total Dutch fleet of passenger cars electric vehicles (BEVs/FCEVs/PHEVs) accounted for 2.2%.

There were 210,642 HEV passenger cars on the road at the end of December 2019, an increase of 17% compared to the end of December 2018.

Other vehicle types also steadily increased in numbers, as can be seen from table 2.

Table 2:
Distribution and registrations of EVs, PHEVs and HEVs in 2019

Source: Dutch Road Authority, edited by RVO

Table key:
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
[1] Clarification: mopeds, 3-wheeled motor vehicles, motorcycles, speed pedelecs and trikes

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers [1]	60,918	72	0	0	2,029,761
B Passenger vehicles	107,537	210,642	95,882	215	9,140,549
C Buses and Minibuses	785	52	0	8	10,881
D Light Commercial vehicles	4,523	7	4	7	1,052,473
E Medium and Heavy Weight Trucks	169	59	0	5	176,417

Total Registrations During 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers [1]	13,081	0	0	0	77,025
B Passenger vehicles	61,303	28,725	5,090	156	450,006
C Buses and Minibuses	374	32	0	0	912
D Light Commercial vehicles	1,297	4	1	0	74,552
E Medium and Heavy Weight Trucks	73	5	0	2	15,028

In 2019 Tesla sold almost 30,000 vehicles of its Model 3, making it the best sold car in the Netherlands (of all passenger cars!). Figures 5 and 6 show the most popular car models in the total Dutch BEV and PHEV fleet.

Figure 5:
BEV fleet in the Netherlands, 31 December 2019

Source: Dutch Road Authority, edited by RVO

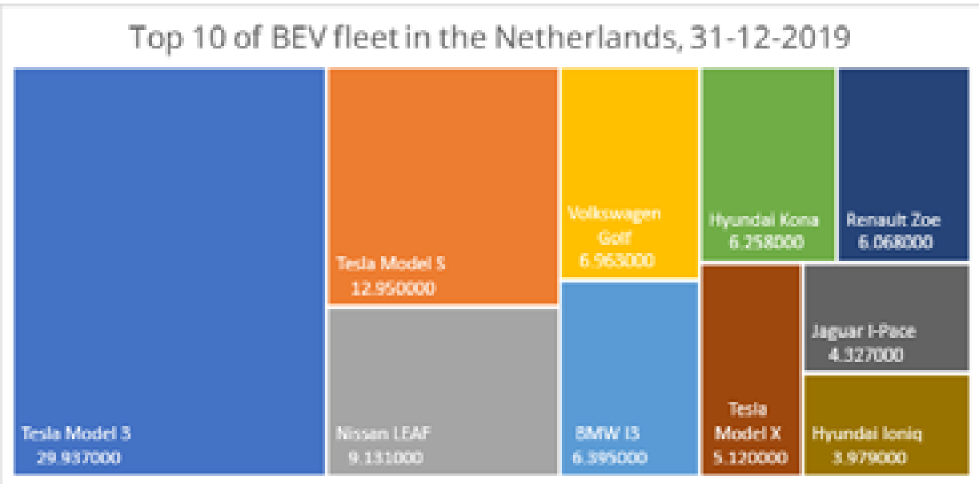
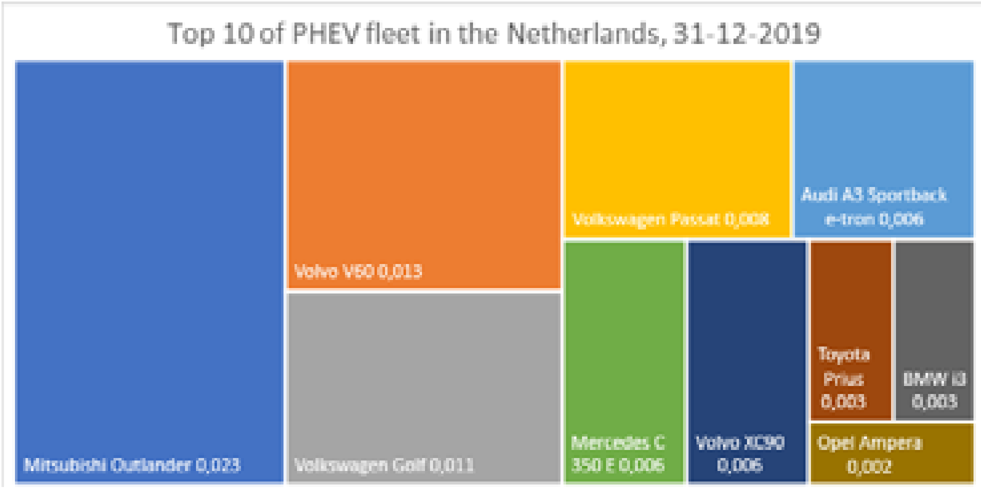


Figure 6:
HEV fleet in the Netherlands, 31 December 2019

Source: Dutch Road Authority, edited by RVO



CHARGING INFRASTRUCTURE OR EVSE

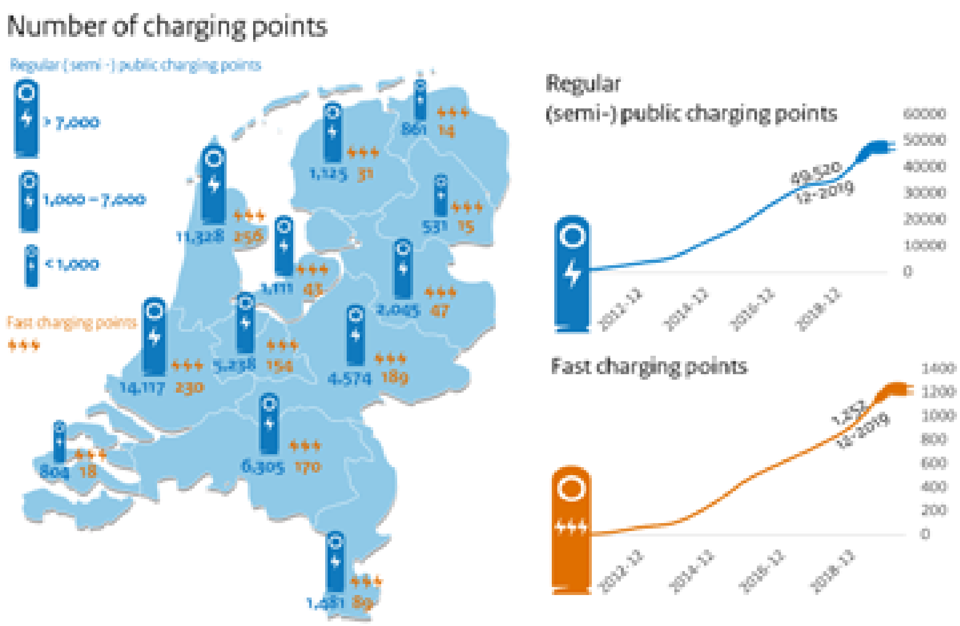
The Netherlands has a well-developed charging network, as is illustrated in figure 7, that shows the division of charging points over the provinces.

All charging is interoperable in the Netherlands, as has been the case since 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, CPO 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 protocols in charging infrastructure, so as to stimulate innovation and global access – thus stimulating EV uptake.

Figure 7:
Division of (semi)public regular and fast charging points in the Netherlands, 2019

Source: oplaadpalen.nl, edited by RVO



In November 2019, the milestone of public charge point number 50,000 was reached. Compared to the end of 2018, the number of (semi) public charging points increased by 38% in 2019. Fast charging can be done at 339 locations, mostly along highways but also some in cities.

Table 3: Number of charging points in the Netherlands, 2019

Source: oplaadpalen.nl, edited by RVO

Type of Public EVSE	Number of Charging Points
AC Slow Chargers (≤ 3.7 kW)	2,936
AC Slow Chargers (>3.7 kW, ≤ 22 kW)	46,586
Fast Chargers (> 22 kW, ≤ 43.5 kW)	174
Superchargers (> 43.5 kW)	981
Inductive Chargers	97
Inductive Chargers	1

EV DEMONSTRATION PROJECTS

There is a great number of projects going on. This is only a small selection.

The Dutch police force has started a pilot on zero emission. They will test various emission less vehicles, such as electric cars, motors, and speed pedelecs. The vehicles will be circulated around several police units and tested on operational management aspects.

King Willem-Alexander officially launched a new bidirectional energy and mobility ecosystem in Utrecht that was developed by "We Drive Solar" in cooperation with Renault. The system uses Renault ZOE shared cars and bidirectional charging poles.

Figure 8: Official launch of bidirectional pole

Source: WeDriveSolar

The University of Utrecht is the first university campus in the world where bidirectional charging is possible. The university terrain is a living lab and one of the 6 research locations for the Smart Solar Charging project. 32 Charging points are combined with 8,000 solar panels already in place on campus. The project collects data on the exact amount of energy a car uses and can supply back to the grid.

The Partners for International Business-programme on zero emission mobility between Netherlands and Austria has demonstrated that emission free conditioned transport for longer distances can be achieved. It is still necessary, though, to use several modalities (train and e-truck).

The demonstration scheme on Climate Technologies and Innovations in Transport (DKTI-transport)[2] focuses specifically on entrepreneurs and partners in the transport chain who want to invest in low carbon solutions. To accelerate the transition, the development of low carbon vehicles and vessels, and the deployment of corresponding charging and refuelling infrastructure, is supported. In 2019, 43 projects were co-funded with a total investment of € 87 million (by the government, the companies, and the EU). Two examples of projects:

- Holthausen will build hydrogen and battery-electric sweepers, small ones for shopping centres and large ones for street cleaning.
- Vlot Logistics and Breytner will build an electric heavy breakdown lorry with trailer and a semi-trailer with a crane to transport stones; combined with mobile fast chargers that can charge the battery during loading and unloading.

A project from last year's DKTI round, DAF Trucks, started the in-service test to gain practical experience with the CF Hybrid. Dutch transporter Peter Appel uses two of these innovative trucks to supply supermarkets. The truck drives fully electric in urban areas and uses clean diesel technology outside of cities.

Figure 9:
DAF CF Hybrid truck

Source: DAF Trucks

[2] Demonstration scheme: Climate Technologies and Innovations in Transport – www.rvo.nl/DKTI-Transport

OUTLOOK

New, more affordable electric cars and cars with larger battery capacities are expected to be introduced to the market in 2020 and further. Next to that, the market for used electric cars will need to develop further as many people buy second-hand cars. Ultimately in July 2020 a purchase subsidy will be introduced in the Netherlands. The subsidy is one of the EV stimulation instruments named in the National Climate Agreement. The subsidy will apply both to new and second-hand cars. In addition, a subsidy for electric vans will probably be introduced. A form of financial stimulation for electric trucks is investigated as well.

To keep up with the growing demand for charging infrastructure, the National Agenda on Charging Infrastructure will be the leading method. Further integration of various electricity needs will have to be streamlined with a regional approach. The governance will be further clarified and established, and specific stakeholders will be made responsible for implementation of certain tasks. € 15 million has been committed to support the regions in establishing project offices. In 2020, 5 working groups will start: speeding up installation, open protocols, smart charging, logistics and safety.

Price transparency of charging is an important aspect for the Dutch government. It is important that EV drivers have insight in the charging tariff: before, during and after charging. The Netherlands has many different subscriptions, which makes it impossible to mention a fixed price at the charging pole. Instead of that, the aim is to make the charging price digitally available, so insights in tariff is provided for every charging pass (subscription).

For the zero emission zones in the 30- to 40 largest cities of the Netherlands it is expected that the zones will be identified in 2020 and that they will be medium or large in size (beyond just the commercial centres). National harmonisation of implementation of the zones will be important to ensure a smooth transition. Also, topics like enforcement and how to monitor the hybrid vehicles will be an issue. Internationally there will be an invitation for other cities to also “start with freight” when aiming for zero emission zones in the future.

Finally, the availability of zero emission freight vehicles is identified (also internationally) as one of the main bottlenecks in the transition to zero emission freight. The Netherlands aims to address this topic internationally through various partnerships (like the Transport Decarbonisation Alliance).

NORWAY

MAJOR DEVELOPMENTS IN 2019

The total number of BEVs in the passenger vehicle fleet reached 260,581 in 2019, and the share of the total fleet was 9.4 %. The PHEV share of the total fleet reached 4.2%, which is higher than the share of HEVs. Only 149 FCEVs were in the fleet at the end of 2019. The BEV market share of new vehicle sales reached 41.3 %, while PHEVs accounted for another 13.2%, hence, 50 % of vehicles sold new had a plug.

For new small Light Commercial Vehicles, the Battery Electric market share reached 10.3% in 2019. For large Light Commercial Vehicles, the market share reached 2.7%. The fleet shares reached 2.9% and 0.1 % respectively. Battery Electric Heavy duty trucks continue to be a rare sight, only 21 where in the fleet at the end of 2019. Battery Electric Buses are on the brink of a major breakthrough with a close to five-fold increase in the fleet during 2019.

NEW POLICIES, LEGISLATION, INCENTIVES, FUNDING, RESEARCH, AND TAXATION.

Norway has very large incentives for electric vehicles. BEVs and FCEVs are exempt from the registration tax and the Value Added Tax (VAT) which are levied on fossil fuel powered vehicles upon purchase. These exemptions make BEVs a cheaper option than ICEVs in most vehicle segments. In addition, BEVs have zero annual tax (the annual tax has been converted to a tax on the car insurance), and several driver privileges with substantial economic value. An overview of the incentives is shown in table 1. The incentives and the BEV policy is stable but a gradual revision of some of the user privileges has started. The user privileges include reduced parking charges and ferry rates and full or partial toll road exemptions. The energy taxes are much lower and BEVs have access to bus lanes. BEV owners have been fully exempted from Toll roads, but the exemption is being phased out as the Parliament decided in 2017 that BEVs can be levied 50 % of the rate that ICEVs pay. The same goes for parking charges and ferry rates. Several toll road companies started to introduce small charges for BEV owners in 2019, for instance the city of Oslo. Parking charges have been introduced in many municipalities already. Access to bus lanes have been restricted to BEVs with at least one passenger in addition to the driver in the rush hours in some areas around Oslo. FCEVs have had the same incentives as BEVs, but has the added advantage of still being 100 % exempted from parking charges and toll roads, and FCEVs still have unrestricted access to bus lanes.

Norway is not part of the European Union but closely connected through the European Economic Area agreement (EEA). The Norwegian Parliament decided in December 2018 that Norway should incorporate the EU legislation for fleet average CO2-emission, requiring a fleet average of 95 g CO2/km for new vehicles sold in 2021, into the Norwegian legislation. The regulation became part of the Norwegian law from 01.01.2019[1] and makes the Norwegian market more attractive for vehicle producers. Norwegian BEV sales thus counts towards the EU 2021 95 g/km target.

For light commercial vehicles, Enova, a Government Agency supporting the transition towards a low-emission society, introduced a purchase incentive for Battery Electric Light Commercial Vehicles, ranging from 1,500-5,000 Euros/vehicle depending on the vehicle size. Installation of accompanying charging infrastructure can also be supported. Enova also provide support to battery electric and hydrogen HDV demonstrations, and charging and hydrogen infrastructure. LCVs also have exemptions from purchase taxes and benefit from the same local incentives as passenger cars. The purchase taxes are however lower on diesel LCVs than diesel passenger cars. The VAT deduction for battery electric vehicles has no effect on LCVs used by enterprises as they can deduct incoming VAT.

The research on EVs follows a five-pronged path; (1) research on batteries and battery materials, (2) research on hydrogen components such as fuel cells and storage systems, (3) research on system solutions especially for maritime applications, (4) research on charging infrastructure, and (5) social sciences based interdisciplinary research on users, markets and policies. The budget for research allocated to these areas increased from approx. 9 million to 13 million Euros between 2017 and 2019. The Mobility Zero Emission Energy Solutions (MoZEES) research centre focusing on battery electric and hydrogen solutions for heavy duty vehicles, vessels and railways, was established as a collaboration between several leading Norwegian research institutes and companies in 2017.

Table 1: Relative advantage of BEV incentives in Norway.

Source: Figenbaum (2018)

Incentives	Intro year	BEV buyers - relative advantage	Future plans
Fiscal incentives: Reduction of purchase price/yearly cost gives competitive prices			
Exemption from registration tax	1990/ 1996	The tax is based on ICEV emissions and weight and is progressively increasing. Example ICEV taxes: VW Up 3000 €. VW Golf: 6000 €	To be continued until 2020.
VAT exemption	2001	Vehicles competing with BEVs are levied a VAT of 25% on sales price	To be continued until 2020.
Zero annual tax (formally a tax in vehicle insurance)	1996/ 2004	BEVs and hydrogen vehicles 0 €, diesel/petrol: 288-336 € (2019-figures).	To be continued indefinitely

[1] https://www.regjeringen.no/no/sub/eos-notatbasen/notatene/2014/apr/co2-utslipp-for-personbiler-endringsbestemmelser/id2433597/

Incentives	Intro year	BEV buyers - relative advantage	Future plans
Reduced company car tax	2000	The company-car tax is 40% reduced compared to ICEVs, but BEVs are seldom bought as company cars.	This incentive was up for revision in 2017/18 but remained in place.
Exemption from change of ownership tax	2018	Change of ownership tax: ICEVs 0-3 year-old vehicles +1200 kg: 630 Euros, 4-11 years 385 Euros.	
Direct subsidies to users: Reduction of variable costs and help solving range challenges			
Free toll roads	1997	In Oslo users save 600-1000 €/ year. Some places savings exceed 2,500 €	Law revised so that rates for battery electric vehicles on toll roads and ferries will be decided by local governments, up to a maximum rate of 50% of the ICEV rate.
Reduced fares on ferries	2009	Similar to toll roads, saving money for those using car ferries.	
Financial support normal chargers	2009	Reduce investors risk, reduce users range anxiety, expand usage.	National plan for charging infrastructure has been developed but is rather vague.
Financial support for fast chargers	2011-	More fast-charging stations influences BEV km driven & market shares.	ENOVA[2] have supported fast chargers along major corridors and in municipalities without chargers. City fast charging left to commercial actors.
Electricity tax: 1.62 €C/kWh. Much less than fuel taxes per km		Gasoline road use tax: 54 €C/litre Gasoline CO_2-tax:12 €C/litre Diesel: 39 + 14 €C/litre respectively [3]	Road use tax to be continued until it can be replaced by GPS road pricing
User privileges: Reduction of time costs and providing users with relative advantages			
Access to bus lanes	2003/ 2005	BEV users save time driving to work in the bus lane during rush hours.	Local authorities have been given the authority to introduce restrictions if BEVs delay buses.

[2] ENOVA, a Government agency, supports the introduction of energy saving and climate gas reduction technologies in Norway. In the transportation sector it supports charging infrastructure and refuelling infrastructure for alternative fuels.

[3] https://www.skatteetaten.no/bedrift-og-organisasjon/avgifter/saravgifter/om/mineralske-produkter/

Incentives	Intro year	BEV buyers - relative advantage	Future plans
Free parking	1999	Users get a parking space where these are expensive and save time.	Local authorities can since 2017 charge BEVs up to 50% of ICEV rates.
Free charging (some places)		Not regulated by national law, but often bundled with free municipal parking	Local authorities and parking operators decide whether this incentive continue.

HEVS, PHEVS, AND EVS ON THE ROAD

The total number of BEVs in the passenger vehicle fleet reached 260,581 in 2019. The BEV share of the fleet was 9.4 %. The PHEV share of the fleet reached 4.2%, and the number of registered PHEVs passed HEVs with 116,029 versus 110,665. Only 149 FCEVs were in the fleet at the end of 2019. The BEV fleet grew 34 % between from 2018 to 2019. The market for PHEVs was 28 % lower in 2019 than in 2018. Reasons for this development could be that more long range BEVs came on the market in 2019, and that several popular PHEV models were temporarily removed from the market due to complications related to the introduction of the WLTP.

The most numerous BEVs in the fleet are Nissan Leaf (58,266), Volkswagen E-Golf (41,980), BMW i3 (24,966), Tesla Model S (20,030) and, increasing rapidly, the Tesla Model 3 (15,592). In 2019, 50 % of the vehicles that were sold new had a plug. The BEV market share of new vehicle sales reached 41.3 % with 60,246 sold, while PHEVs accounted for another 13.2%, with total sales of 19,299. The best-selling BEV in 2019 was the Tesla Model 3, which also became the best-selling model overall regardless of propulsion system, with 15,683 sold, which represented 11% of the total passenger vehicle market. FCEVs are very low in numbers, only 149 are registered in the fleet, and only 28 were sold in 2019. The FCEV market has been turbulent since a major hydrogen station operator went bankrupt in 2018, and after an explosion in one of the remaining stations in June 2019 led to temporary closure of all remaining stations for the following 5 months.

The Battery Electric Light Commercial Vehicle market is less developed due to fever incentives. For new small Light Commercial Vehicles, the Battery Electric market share reached 10.3% in 2019. For large Light Commercial Vehicles, the market share reached 2.7%. The fleet shares reached 2.9% and 0.1 % respectively. In total, 7,057 are registered in the fleet of which 2,011 were sold new in 2019. Battery Electric Heavy-duty Trucks continue to be a rare sight, only 21 where in the fleet at the end of 2018. A new development was the registration of the first fuel cell hydrogen truck in December 2019. Battery electric buses are on the brink of a major breakthrough with a close to five-fold increase in the fleet during 2019, reaching a total of 199 in the fleet, and over 200 E-buses are on order for delivery in 2020. In addition, 5 fuel cell buses are on the roads in Oslo. The explosion in the hydrogen station in June also temporarily stopped the usage of these buses, and delayed the introduction of the hydrogen truck, as the refuelling stations for

[4] https://www.aftenposten.no/osloby/i/7lvAMK/Betaler-millioner-for-a-gjore-Nesoddbatene-miljovennlige-allerede-i-2019

these vehicles were also closed down for a period.

Oslo has decided to electrify three large ferries that service the inner parts of the Oslofjord, thus saving 6,000 tons of $CO2^4$. The first of these ferries was put into use from September 2019. The two others will be converted to battery electric propulsion during the winter/fall of 2020. In total, 17 battery electric ferries[5] were in use in Norway in 2019.

Table 2: Distribution and sales of EVs, PHEVs and HEVs in 2018.

Fleet Totals on 31 December 2019 [6]

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	Total fleet
Mopeds	1,884	0	0	0	158,711
Motorbikes	214	0	0	0	186,918
Quadricycles	1,555	0	0	0	12,294
Passenger vehicles	260,581	110,665	116,029	149	2,770,550
Commercial vehicles	7,057	78	39	1	485,742
Buses	199	154	64	5	15,850
Trucks	21	18	2		71,496
Totals (without bicycles)	**271,511**	**110,915**	**116,134**	**155**	**3,701,561**

Table 3 (below)

Fleet Sales (new) 01 January - 31 December 2019

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	Total fleet
Mopeds	623 [7]	0	0	0	3,370 [7]
Motorbikes	49 [7]	0	0	0	8,921 [7]
Quadricycles	234 [7]	0	0	0	254 [7]
Passenger vehicles	60,246 [7]	19,241 [7]	19,299 [7]	28 [7]	145,985 [7]
Commercial vehicles	2,011 [7]	23 [7]	5	0	35,628 [7]
Buses	158 [7]	0 [7]	63	0	2,314 [7]
Trucks	12 [7]	2 [7]	0	1	5,956 [7]
Totals (without bicycles)	**63,333**	**19,266**	**19,367**	**29**	**202,174**

[5] https://www.ks.no/globalassets/fagomrader/statistikk-og-analyse/status-kommune/KS-Status-Kommune-2020.pdf

[6] Data from the national vehicle registry 31.12.2019. Norwegian Public Roads Administration

[7] National vehicle registry, vehicles registered 2019, 2019 YM.

[8] Figenbaum E., Nordbakke S., 2019. Battery electric vehicle user experiences in Norway's maturing market. TØI report 1719/2019. https://www.toi.no/publications/battery-electric-vehicle-user-experiences-in-norway-s-maturing-market-article35709-29.html?deviceAdjustmentDone=1

[9] Figenbaum E., Kolbenstvedt M. 2016. Learning from Norwegian Battery Electric and Plug-in Hybrid Vehicle users. Results from a survey of vehicle owners. Institute of Transport Economics. TØI report 1492/2016.

CHARGING INFRASTRUCTURE

More than 9 out of 10 current BEV owners can charge their vehicle at home in a private parking space and 42 % use a dedicated wall box EVSE for charging[8], whereas only 9 % of PHEV owners use this type of charging connection[9]. Based on these percentages, and the number of registered BEVs and PHEVs, the installed number of wall box EVSE charge stations likely passed 120,000 by the end of 2019.

Public charging consists of AC level 2 chargers with type 2 connectors rated for 3.6-22 kW charge power, as well as some older installations with Schuko domestic type sockets. Most fast chargers are equipped with both a CCS and a Chademo cable but only one of these can be used at a time. A small number of fast chargers are single standard Chademo or CCS. The best estimate is therefore that there are 1,600 dual standard CCS/Chademo fast chargers in Norway and 770 Tesla Superchargers (number of plugs, up to two plugs can be connected to one physical charger).

During 2019 there was a significant rollout of superfast chargers rated 150kW and higher. The total had reached 226 by the end of 2019 (out of the 1600 CCS/Chademo chargers)[10]. Table 4 shows the estimated numbers of different types of chargers.

Table 4: Public charging infrastructure in 2018

Source: www.nobil.no

Charging Infrastructure on 31 December 2019 [11]

Chargers	Quantity
AC Mode 2 Charger 230V household plug (Schuko) with in cable EVSE	4,431
AC Mode 3 Chargers Type 2 connector	4,738
CHAdeMO	1,487
CCS	1,592
Tesla	770
Tesla Supercharger	54
Inductive Charging	N/A
Totals	**13,018**

[10] https://elbil.no/kraftig-vekst-i-antall-lynladere/

[11] https://nobil.no/widgets/statistikkphp?countrycode=nor&date=20200101&format=html

[12] NSB press release: https://www.nsb.no/om-nsb/for-presse/pressemeldinger/na-er-nsbs-bybiler-her

EV DEMONSTRATION PROJECTS

The BEV activities in Norway are mostly fully commercial and in the passenger vehicle market the early majority buyer group has been reached. The government has put in place incentives and support programs that private companies respond to by developing their businesses and introducing new business concepts and models. Therefore, there are few if any "demonstration projects" in Norway. In this section, an overview if different types of commercial activities will therefore be presented. Most of these are within new mobility services.

NSB, a national railroad operator, has together with GreenMobility put in place a fleet of 250 Renault Zoe BEVs in a free-floating car sharing scheme in Oslo, from January 2019[12]. Existing car sharing schemes such as "Bilkollektivet"[13] have introduced some BEVs, e-bikes and e-cargo-bikes in their fleet. Hyre[14] and Nabobil[15] are App-based broker services also renting out BEVs. Owners of vehicles can rent out vehicles to private and business customers in a safe manner with a special insurance included in these services. Move About[16] offers car sharing pools for businesses as well as traditional car sharing for consumers.

Battery electric buses have been tested out in the city of Oslo with 3 bus companies operating 2 buses each, but has now entered into a full roll-out with more than 158 E-buses put into service in 2019, and 224 to be introduced in 2020[17].

A project for inductive charging of taxis is under development in Oslo, with planned inauguration in 2020.

In Trondheim, the grocery distributor Asko is taking four hydrogen trucks into use, in a demonstration and development project with several partners, one being Scania. They have put up their own electrolyser for hydrogen production, and also use hydrogen-fuelled warehouse trucks.[18]

OUTLOOK

The BEV market in Norway will likely remain strong through 2020. The major purchase incentives, i.e. the exemption from registration taxes and the VAT, remain in place. Purchasing a BEV makes economic sense to consumers and in addition provides access to attractive and money saving driving-privileges. A number of new attractive BEV models and variants of existing models will come on the market, also in market segments without previous offerings, which will increase demand further.

The PHEV market could get an upswing when new models with longer range in E-mode become available, although BEVs will be cheaper than PHEVs in all market segments due to the incentive structure. A question is if PHEV sales will be additional to or replace some BEV sales, or if new long range BEVs will attract some of the PHEV buyers. The aftermath of the hydrogen fuel station explosion in 2019, and the lack of hydrogen vehicle models will lead to limited prospects for hydrogen passenger vehicles in 2020.

[13] https://bilkollektivet.no/nb/

[14] https://www.hyre.no/

[15] https://nabobil.no/

[16] http://www.moveabout.no/Hjem

[17] https://zero.no/wp-content/uploads/2019/12/Oversikt-utslippsfri-busser-Norge-2019-2020-detaljert-oppdatert-20des.pdf

[18] https://asko.no/nyhetsarkiv/asko-lanserer-verdens-forste-hydrogendrevne-lastebil/

[19] https://www.ks.no/globalassets/fagomrader/statistikk-og-analyse/status-kommune/KS-Status-Kommune-2020.pdf

In the commercial vehicle segment, the market share could increase with the availability of longer range and also larger battery electric LCVs. The ENOVA incentive for zero-emission LCVs should also help boost the market. The price of some of the heavier battery electric LCVs (VW e-Crafter, MAN e-TGE) was reduced by 17% during 2019 which should also help build that market.

Battery electric buses will continue to thrive. In Bærum, a municipality bordering Oslo with 130 000 inhabitants, a tender process will result in a 100 % battery electric bus service, starting with 23 battery electric buses from 2020 and scaling up to a full 151 battery electric bus fleet by 2025.

Within the maritime sector there are several passenger vessels and car ferries under conversion to battery electric propulsion. During 2020 an additional 37 battery electric ferries[19] will be put into use, bringing the total to 54. In Oslo, the 5 island ferries with a capacity for 236 passengers will be replaced in 2021/2022 with battery electric ferries with a capacity of 350 passengers.

Two hydrogen ferries are under development for use on the West Coast of Norway. One ferry will use liquid hydrogen for at least 50 % of the time (can use battery electric operation for the remaining 50 %) and will have capacity for 299 passengers and 80 vehicles[20]. The other one will be a smaller ferry with the capacity for 199 passengers and 60 vehicles. This ferry will use compressed hydrogen for propulsion[21].

[20] https://www.norled.no/nyheter/norled-velger-westcon-i-olen-for-bygging-av-verdens-forste-hydrogen-ferje/

[21] https://www.tu.no/artikler/norled-skal-bygge-hydrogenferge-nummer-to/465145

REPUBLIC OF KOREA

MAJOR DEVELOPMENTS IN 2019

The most notable change in 2019 is the incentives-related policy. The incentives for electric vehicles are reduced from $9,870.86 to $7,403.14, so the maximum incentives are $15,628.86, and the maximum incentives for hydrogen cars are $29,612.57.

However, the supply of electric cars continued to increase, expanding the number of electric buses from 150 in 2018 to 300 in 2019 and the electric cars from 20,000 units in 2018 to 42,000 units in 2019. As a result, Korea invested heavily in the construction of charging infrastructure, and the total number of charging stations was about 24,000 units.

POLICIES

Starting battery utilisation business after using electric vehicles

The Ministry of Trade, Industry and Energy (Minister Sung-Mo Sung), Ministry of Environment (Minister Sung-Lee Lee), Jeju-do (Governor Won Hee-ryong), Gyeongsangbuk-do (Governor Lee Chul-woo), Hyundai Motor Company (CEO Lee Won-hee) met at the Jeju Techno Park on June 26. A business agreement (MOU) was established to determine a resource circulation system, and the Jeju Battery, Battery Industrialisation Center, Korea's first used battery performance evaluation institution, was opened. As there is no method or standard for evaluating the residual value of electric vehicle batteries or guaranteeing safety, the government, local governments and private companies are planning to make joint efforts to prepare for reuse and recycling including battery performance evaluation.

Increasing anxiety for future EV charging costs due to the Denuclearisation policy

The current government's de-nuclear power policy is returning to a boomerang that raises electric vehicle charges. In order for electric vehicles to be successful, 'cheap electric charges' are necessary, but KEPCO, which is suffering large losses from de-power generation, has no room to discount electric vehicle charging rates. In the end, KEPCO decided to phase out the basic rate exemptions and discounts applied to electric vehicle chargers in December 2019.

On December 30, 2019, KEPCO held a meeting for the board of directors and exempted the basic charge for electric car chargers for three years from 2017 to 2019 ($2.08 per 7-speed slow charger, including VAT and power generation funds). 50% will be charged from July. 75% from July 2021 and 100% from July 2022. Fees for this charge will also phase out the existing 50% discount.

LEGISLATION

The Electric Vehicle Law in Korea is designated as the Law on the Resource Circulation of Electric, Electronic Products and Automobiles (Law 15657) in 2019. Article 24, the Act on Enforcement Decrees, is such as the Subsidy Management Act.

The Law on Resource Recycling of Electric, Electronic Products and Automobiles has been implemented since June 2018 without any further amendments, and the subsidy laws have been renewed and applied every year.

INCENTIVES

The subsidies for electric vehicle purchases were confirmed up to $15,628.86 in 2019 and up to $29,612.57 for hydrogen vehicles. The plug-in hybrid vehicle is up to $4,112.86 and the electric two-wheeled vehicle is up to $2,879.00.

It supports about 366 electric cars, 38 small electric cars, and 14 electric freight cars. It supports a total of 418 individuals, one for each household regardless of the type of car, and the maximum for the two years of operation. Up to three grants are available.

Subsidies are applied differently in different regions, and Daegu supported subsidies from $11,104.71 up to $12,338.57 from February 20 to 2019, and Jeju subsidies up to $11,516.00 and converts from internal combustion engine cars to electric cars. If you buy a car, the company is encouraging them to give $1,233.86 additional incentives.

In the case of charger installation, subsidies will be paid within $1,069.34 per unit for public use chargers and $2,879.00 per unit for public use chargers.

FUNDING

The charges for electric vehicle users are expected to double at least twice next year. This is because the Korea Electric Power Corporation (KEPCO) has been considering cancelling the special rate for electric vehicles. The charging rate can be as high as 2.5 times and up to 3 times from the current level of 80 ~ 100 per hr. Electric car usage charges, which were 10-20% of gasoline fuel costs, will rise to 40%.[1]

[1] Jeong-il Hwang, 2019, Joongang Ilbo, https://news.joins.com/article/23639695

RESEARCH

Accelerate electric truck research

In response to the regulation of old diesel cars, which are tightening year by year, the strategy is to strengthen the electric vehicle model in the commercial vehicle line-up and pre-empt the eco-friendly car market. Firstly, Hyundai mass-produced their 1T class small truck "Porter" electric car this year. The Porter electric car, which has already been developed, is a super-cap 2WD single trim and has an electric motor with a maximum output of 135kW (183 horsepower). The battery capacity is 58.5 mAh, which can run about 180 km on a single charge. The annual production target is 8000 units.

Research to improve battery

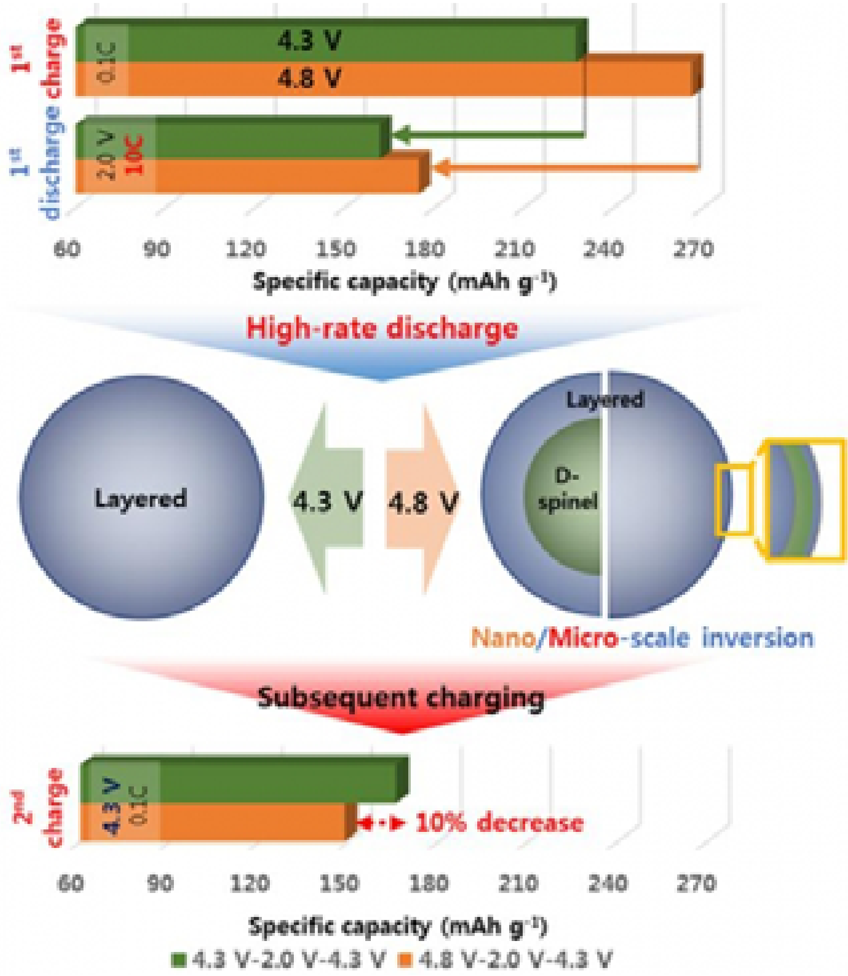


Figure 1: Battery Improvement draw by KIST[2]

Lithium-ion batteries for electric vehicles suffer from the problem of deforming the electrode material and deteriorating electrochemical performance during rapid battery use. Dr. Jang Won-young and Korea Research Institute of Science and Technology (KIST) and Kim Seung-min, a research team at the Carbon Convergence Materials Research Center, have established a platform to identify this. Dr. Won-Young Chang, Ph.D., KIST, analysed the deformation of electrode materials that can cause operational errors and safety accidents in various driving environments of electric vehicles such as rapid charging and discharging of lithium ion batteries. The team prepared a variety of transmission electron microscopy methods (high resolution imaging, electron energy spectroscopy,

[2] http://amenews.kr/m/view.php?idx=40947

electron diffraction, etc.). Using this, the electrode structure was observed and analysed on the micro and nano scale, respectively.

This led the team to find factors that reduce battery capacity and shorten lifespan. Rapid discharges, such as rapid acceleration, limit the amount of lithium ions that are delivered to the positive electrode (+). As a result, the incompletely recovered electrode material undergoes internal deformation. The team found that this eventually contributed to reduced battery capacity and reduced lifespan. The researchers found that the instability of the electrode structure is higher when charging and discharging at high voltage, especially for high capacity use.

Hyundai Motor Group launches hydrogen, electric and hybrid car control towers

Hyundai Motor Group launched the Motorisation Promotion Team as a control tower that coordinates the development and production of HMC, Kia's hydrogen, electric and hybrid vehicles. The company plans to develop standard models and systems for hydrogen fuel cell vehicles (hydrogen cars) and electric vehicles that cover the entire Hyundai Motor Group. The platform development method of the existing internal combustion engine automobile business will be dedicated to hydrogen cars and electric cars in earnest. According to Hyundai Motor officials, Hyundai Motor Group set up a "motorisation promotion team" that will play a key role as the central point for the group's electrification. The electrification team will formulate the electrification strategy for all vehicles produced by Hyundai and Kia. It is a kind of integrated command post.

Also, on May 13, 2019, Hyundai-Kia Motors will invest 100 billion KRW in Croatia's high-performance hyper electric vehicle maker `` Rimac Automobili " and cooperate with each other to develop high-performance electric vehicles. The collaboration with Leemak is expected to enable the rapid transfer of high-performance electric vehicle technology into electric vehicles.
Development of electric vehicle mileage improvement through alchemist project of Ministry of Industry

The Ministry of Industry selected the task of developing an electric car that runs 600 km on a 1-minute charge through the Alkymist Project in 2019. If the project succeeds, it is expected to reshape the automobile market centred on internal combustion engines, focusing on electric vehicles, and to spread to other fields such as electric and aviation.[3]

TAXATION

Electric vehicles in Korea are classified as "other cars" because they do not have any emissions. According to the law, $16.45 for business and $82.27 for non-business are charged. In addition, if 30% of education tax is applied, automobile tax of $106.95 will be paid annually. As the number of electric vehicles increases, it is pointed out that the necessity of restructuring the car tax is high. High-priced imported electric cars, which price more than $82,270.67, are taxed at just $82.27 a year.

[3] Jong-Hwa Park, 2019, E-Today, http://www.etoday.co.kr/news/view/1774096

HEVS, PHEVS, AND EVS ON THE ROAD

In Korea, buses are included in vans in the statistics, so there are no statistics on buses and minibuses on their own. The two-wheeled vehicle is managed by displacement, so statistics on the two- and three-wheeled electric and hydrogen fuels do not exist. The table includes buses and minibuses for Passenger Vehicles.

In 2019, Korea's electric car sales increased 250 units year-on-year and failed to achieve the 42,000 units subsidies in 2019. The total number of EVs in 2019 among the five Korean automakers totalled 29,683 units. Among them, Hyundai's Kona EV sold 13,587 units (up 21.4% compared to the previous year), Ionic 2,060 units (down 63.2% compared to the previous year), Kia's Niro EV increased by 5,999 units (up 74.7% compared to the previous year), and Soul EV 1,571 units (down 10.0% from the previous year). Others included 875 units of Renault Samsung SM3 Z.E., 4,037 units of Chevrolet Bolt EV and 1,554 units of Renault Samsung Tweed.

Electric buses were sold with 211 units Hyundai Motors, 168 units Edison Motors, 47 units Woojin Industrial Systems, and 10 units Giles Daewoo Buses. A total of 146 electric buses were sold in Chines bus, including 40 units Haiger and 40 units Greenus.4

Table 1

Table key:
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

*Estimated based on population and vehicle ownership rate.

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	-	-	-	-	23,389,000*
B Passenger vehicles	74,328	478,938	-	4,982	N/A
C Buses and Minibuses **D** Light Commercial vehicles	14,426	27,108	-	101	41,635
E Medium and Heavy Weight Trucks	1,164	-	-	-	1,164

Table 2

Total Sales During 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	1,540,889
B Passenger vehicles	N/A	N/A	N/A	N/A	N/A
C Buses and Minibuses **D** Light Commercial vehicles	N/A	N/A	N/A	N/A	583
E Medium and Heavy Weight Trucks	N/A	N/A	N/A	N/A	N/A

[4] MOLIT Ministry of Land, Infrastructure and Transport, 2019, Total Registered Moter Vehicles, http://stat.molit.go.kr/portal/cate/statMetaView.do?hRsId=58&hFormId=&hDivEng=&month_yn=

CHARGING INFRASTRUCTURE OR EVSE

Active charging station supply of refinery companies

As oil refiners are expanding their EV infrastructure, the domestic EV ecosystem is spreading rapidly. GS Caltex plans to increase total energy stations that can inject gasoline, diesel, liquefied petroleum gas (LPG), electricity and hydrogen in one place, starting in Gangdong-gu, Seoul, later this year. GS Caltex, which installed electric vehicle rapid chargers at seven gas stations in Seoul in May 2019 and started the charging business, operates 27 electric vehicle charging facilities at 23 gas stations nationwide.

Subsection

In Korea, chargers are divided into quick charging chargers and slow chargers. The quick charger takes 50kW and the charging time takes 15 to 30 minutes. The slow charger takes 3 ~ 7kW and the charging time is 4 ~. 5 hours. Rapid chargers are mainly installed in external places such as highway rest areas and public institutions. The charge is about $2.22 per 100km, but slow chargers are usually installed in houses or apartments, and electricity costs about $0.90 per 100km. [5]

Table 3

Type of Public EVSE	Number of Charging Points
AC Slow Chargers (≤ 3.7 kW)	-
AC Slow Chargers (>3.7 kW, ≤ 22 kW)	16,912
Fast Chargers (> 22 kW, ≤ 43.5 kW)	-
Superchargers (> 43.5 kW)	7,702
Inductive Chargers	-

EV DEMONSTRATION PROJECTS

Post Office Starts EV Testing in May

The Korea Postal Service announced on April 15, 2019, the small electric vehicle pilot project for the postal service in 2019 that transforms a postal delivery motorcycle into a small electric vehicle. As of August, it was paid to 235 post offices nationwide, with a quantity of about 1,000 units, a project size of about $1.028 million (based on five years of lease), and a maximum of five suppliers.[6]

[5] Ministry of Environment, https://www.ev.or.kr/portal/chargerkind?pMENUMST_ID=21629

[6] Ji-Seong Yun, 2019, Medialook, http://www.medialook.co.kr/news/articleView.html?idxno=20863

OUTLOOK

In 2019, eco-friendly car exports such as electric and hydrogen cars increased 25% year-on-year. The export countries of eco-friendly cars are expanding, and car models are diversifying.[7]

In addition, the types of eco-friendly cars exported are diversified not only with general cars but also with buses and trucks.

With the advent of the 'electric vehicle era', the demand for batteries is expected to increase significantly, leading to fierce competition in the market preoccupation of three domestic EV batteries such as LG Chem, SK Innovation, and Samsung SDI.

However, charging costs for electric vehicle users are expected to double at least from next year. This is because the Korea Electric Power Corporation (KEPCO) has been considering cancelling special rates for electric vehicle charging electricity from 2020. The charging rate can be as high as 2.5 times and up to 3 times from the current level of 80 ~ 100 per hr. Electric car usage fees (charges), which were 10-20% of gasoline fuel costs, will rise to 40%.

Although the infrastructure construction is secured and sales of electric vehicles have increased, the electric vehicle market is unlikely to increase in Korea in 2020 due to the possibility of the suspension of electric vehicle support policies.

[7] https://www.epnc.co.kr/news/articleView.html?idxno=92224

SPAIN

MAJOR DEVELOPMENTS IN 2019

VEA STRATEGY 2014-2020

On 26th, 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 (VEA Strategy).

Three main guidelines are considered in the VEA Strategy: to promote R&D and industrialisation measures regarding vehicles, components and infrastructure; to promote the demand of alternative energy vehicles and communication campaigns; and, to promote recharging and refuelling networks for alternative energy vehicles.

The VEA Strategy is congruent with the objectives of the Directive 2014/94/EU of 22nd October 2014, relative to promotion of infrastructure of alternative fuels and technologies. This Strategy establishes 30 key actions to place Spain as a reference country for the alternative energies applied to the transport sector: Electric, Liquid Petroleum Gas (LPG), Natural Gas, Biofuels, and Hydrogen vehicles, focusing on industrial development, in order to meet energy and environmental challenges.

In the frame of the VEA Strategy, the VEA website was created (http://www.vea.gob.es/), a Government official site for sharing relevant information of the different alternative fuels and technologies in the Transport sector. In this website, a database of alternative vehicles is also available where users can search the different models of vehicles available in the Spanish market and technical information on them.

DIRECTIVE 2014/94/EU AND SPANISH NATIONAL POLICY FRAMEWORK (MAN)

Directive 2014/94/EU of 22th October 2014 establishes that each Member State shall adopt a national policy framework for the development of the market regarded as alternative fuels in the transport sector and the deployment of the relevant infrastructure and notify them to the European Commission before the 18th November, 2016.

Directive 2014/94/EU was transposed into Spanish normative through Royal Decree 639/2016 of 9 December, and the Spanish National policy framework (Marco de Acción Nacional-MAN-), consistent with the VEA Strategy 2014-2020, was approved by Minister Council and delivered in time to EC, at the end of 2016 (https://industria.gob.es/es-ES/Servicios/Documents/national-action-framework.pdf).

According to article 10 of Directive 2014/94/UE of the European Parliament and Council, a first implementation report of the Spanish MAN (https://industria.gob.es/es-ES/Servicios/Documents/aplicacion-marco-energias-alternativas.pdf) was delivered to the European Commission by November 2019. This report must be updated every three years.

MOVALT PLANS: NATIONAL INCENTIVES PLANS FOR THE ACQUISITION OF ALTERNATIVE VEHICLES AND TO PROMOTE EV CHARGING INFRASTRUCTURE

“Plan MOVALT Vehicles” consisted in an incentives program for alternative vehicles acquisition at National scale, funded with an allocated budget of €20 Million and it was running in 2018.

Plan MOVALT Vehicles supported the acquisition of 2,977 alternative energy vehicles, powered by Electricity, NG and LPG energies, from which 1,583 were electric vehicles (1,286 BEVs; and 297 EREVs/PHEVs), with a finally budget applied to the whole Program of €16,059,000 and a specific budget of €6,921,500 for electric vehicle acquisition.

“Plan MOVALT Infrastructure”: consisted in an incentives program for infrastructure deployment for EV charging at National scale, funded with an allocated budget of €15 Million and it was running in 2018.

At the end of 2019 and in the frame of Plan MOVALT Infrastructure, there were 302 applications approved for incentives, resulting in the deployment of 694 charging points (60% for public use and 40% for private use), with a total budget applied of €5,849,061.

MOVES PROGRAM (INCENTIVES PROGRAM FOR EFFICIENT AND SUSTAINABLE MOBILITY)

In February 2019, it was approved Plan MOVES (Real Decreto, 72/2019 / Real Decreto 32/2019), a new direct incentives program funded with €45 Million and aimed to support projects and initiatives in the following lines of action:

1. Acquisition of alternative energy vehicles
2. Infrastructure deployment for EVs charging
3. Public sharing e-bikes systems
4. Activities in the frame of Transport Plans for workplaces and activity centres.

MOVES Program is a national scale incentives program, which was running for proposals until the end of 2019, coordinated by IDAE and directly managed by the different Regional Governments, in collaboration with IDAE.

In the frame of MOVES, there were 6,182 applications presented, accounting for a budget of €37,122,657 (table 1), so it was committed an 82,5 % of the total available budget for the program,

MOVES Applications and committed budget, at the end of the running period (31/12/2019)

Line of action	Applications recieved	Comitted budget
1 (Vehicles)*	2.680	13,286,604
2 (Infrastructure)**	3,446	22,081,652
3 (E-bikes systems)	37	962,417
4 (Other projects)	19	791,982
TOTAL	**6,182**	**37,122,657**

Table 1:
MOVES Program: applications and committed budget

* Applications could be for more than one vehicle

** Applications are for charging stations and so, could be for more than one charging point
Table 1 collects provisional data at 31/12/2019. Applications must be resolved in a period of 6 months and after that, executed in a period of 12 months

MOVES SINGULARES PROGRAM 2019 (INCENTIVES PROGRAM FOR ELECTROMOBILITY AND INNOVATIVE PROJECTS IN THE TRANSPORT SECTORS)

In July 2019, the Ministry of Ecological Transition and Demographic Challenge published the regulatory basis of the MOVES Singular Projects Program (Orden TEC/752/2019). This program is aimed at both public and private entities. It has an endowment of 15 million euros and is structured in two lines of financing:

1. Projects in urban settings: that is, those integrated management projects that contemplate changes in the mobility model and in the configuration of the city, betting on efficiency, sustainability, and the increase in the quality of urban life). Incentives of 40% of the eligible costs for companies and 50% for other entities.

2. Innovation projects on electromobility: that is, those technological development projects and innovative experiences in electromobility that serve to promote the technological leap towards the electric vehicle and encourage the development of experimental projects by Spanish companies, in order to achieve technological maturity that facilitates their marketing. Incentives of 25%-45% of the eligible costs for companies, depending on its size

This program, co-financed with FEDER founds (POCS 2014-2020), is directly managed by IDAE and establishes a requirement of a minimum investment of € 100,000 and a maximum incentive for each project of €3 Million.
This program, under the modality of competitive concurrence, was running for new applications from 24/09/2019 to 25/11/2019.

At the end of 2019, there were 130 requests, 86 of them being related to innovation in electromobility.

PROGRAMS SUPPORTED BY REGIONAL ADMINISTRATIONS

Though there is no database which collects this information, different Spanish regions publish incentives programs to promote the acquisition of alternative vehicles and recharge infrastructure. The information can be reached in the web platforms of each region.

SPANISH NATIONAL FRAMEWORK 2021-2030: PNIEC

According to Paris Agreement on Climate Change, the European Commission presented its “Winter package” in 2016 – Clean Energy for all Europeans, COM (2016) 860 final. Within this package, it is established that Member countries must present specific National Integrated Plans on Energy and Climate for the period 2021-2030, to meet the minimum objectives of 23% GHG reductions, respect 1990, 32% renewable energies introduction in primary energy and 32,5% of improvement on energy efficiency.

In this frame, the Spanish Government sent to the EC its National Integrated Plan for Energy and Climate –PNIEC 2021-2030 (https://www.idae.es/informacion)-y-publicaciones/plan-nacion al-integrado-de-energia-y-clima-pniec-2021-2030 . This Plan set the route to meet energy and climate goals by 2030, focusing on the objective of climate neutrality of the transport sector by 2050, with an intermediate objective of full decarbonising the Spanish market of new cars and vans by 2040, according to the key target of a progressive decarbonising of the economy.

In this way, PNIEC establishes an objective of 5,000,000 electric vehicles (cars, vans, busses, and motorbikes) on the road by 2030. A large amount of them, will be related to car sharing platforms-, which means around a 16% of the current Spanish fleet of vehicles will be of that category. This implies an accumulate energy savings of 3.524,2 ktoe for the period 2021-2030, representing a 25% from the total energy savings expected for the Transport sector (13.888 ktoe) in that period.

Also, in a context of increasing contribution of renewable energies to the electricity production, it will directly lead to a much bigger introduction of renewable energies in the transport sector. According to PNIEC`s objective, renewable energies will represent 28% in transport sector, doubling EC objective in this topic of 14% by 2030, which will allow the reduction of energy dependence of the country and improve energy supply and safety.

Public incentives focused to promote electric vehicle acquisition amounts to €200 Million per year over the period 2021-2025, accounting for a total of €1,000 Million in the period. It is estimated that in 2025 a price parity of EVs will be reached compared to combustion ones, so from 2025 onwards, it will not be necessary to give any more public funding for EVs.

EVS AND HEVS ON THE ROAD

In the year 2019, there were 34,210 electric vehicles registered in Spain, considering BEVs, PHEVs and REEVs (Table 2), representing an increase of 52% from the previous year, with a number of 22,586 EVs registrations at the end of 2018. This increase was supported by the National incentive's programs for EV acquisition (such as Plan MOVES launched by IDAE and managed by the Regional Administrations), and other programs from the different Regional and incentives measures from local Administrations.

In the specific case of electric passenger cars (BEVs, PHEV/EREVs), there were 19,166 vehicles registered, representing a market penetration of 1,4 % during 2019. In the case of both technologies, electric and conventional hybrid electric vehicles (HEVs), they accounted for 128,587 vehicles, resulting in a market penetration of 9,3 %.

The Electric Vehicles (BEVs, PHEVS and REEVs) fleet in Spain at the end of 2019, resulted in a total of 88,329 (Table 3), representing an increase of 56,2 % respect to the previous year 2018, which accounted for a total of 56,540 EVs on the road.

Focusing on conventional hybrid vehicles, the huge increase of the hybrid passenger car registrations is remarkable along the recent years 2016 to 2019, with a total of 109,421 registrations during the year of 2019, coming from a total of 7,759 registrations during the year of 2015 (almost 15 times the figures of 2015). It is remarkable that, at National scale, there are not any incentives programs running for the acquisition of these vehicles over the recent 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.

Figure 1:
EVs market evolution (annual sales of cars –M1- and vans -N1-) in Spain

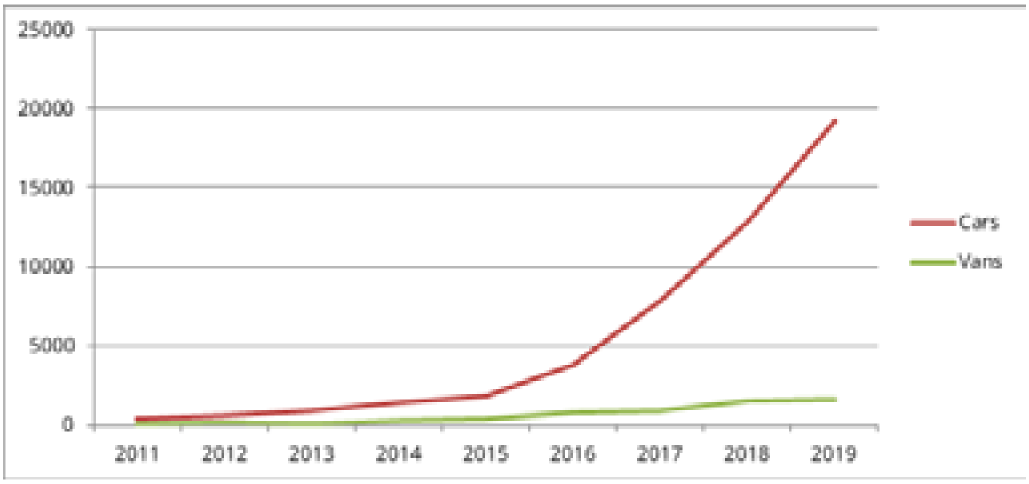


Figure 2:
HEVs market evolution (annual sales of passenger cars –M1-) in Spain

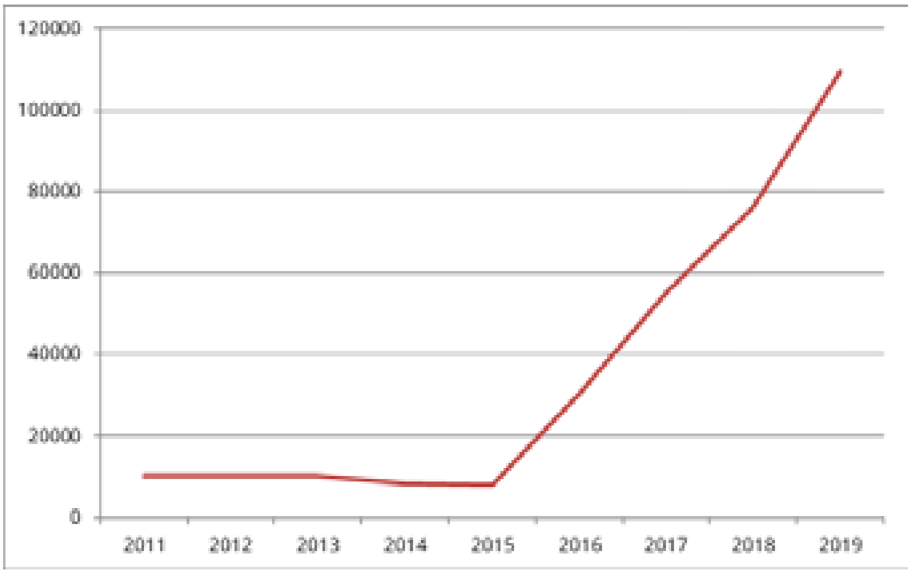


Table 2:
Total sales of EVs and HEVs, per category (2019)

Source: IDAE, based on registrations of Spanish Traffic Authorities (DGT)

* Including both conventional and alternative technologies

** Estimated data at the end of 2019 (Source: AMBE -Spanish Association of Bicycles and Brands-)

Total sales during 2019

Vehicle Type (UNECE category)	BEVs	HEVs	PHEVs	FCVs	Total sales*
Bicycles (assisted pedalling)	160,000	0	0	0	1,140,000**
Mopeds (L1, L2)	5,884	0	0	0	22,402
Motorbikes (L3, L4, L5)	7,041	0	0	0	183,820
Quadricycles (L6, L7)	278	0	0	0	2,928
Passenger vehicles (M1)	10,850	109,421	8,316	1	1,375,346
Commercial vehicles (N1)	1,654	247	9	0	190,972
Buses (M2, M3)	137	377	12	0	3,650
Trucks (N2, N3)	25	106	4	0	10,794
Totals **(without bicycles)**	**25,869**	**110,151**	**8,341**	**1**	**1,789,912**

Table 3:
Fleet totals of EVs and HEVs, per category (2019)

Source: IDAE, based on registrations of Spanish Traffic Authorities (DGT)

* Including both conventional and alternative technologies

** Estimated data at the end of 2019 (Source: AMBE -Spanish Association of Bicycles and Brands-)

Fleet Totals during 2019

Vehicle Type (UNECE category)	BEVs	HEVs	PHEVs	FCVs	Total sales*
Bicycles (assisted pedalling)	470,000	0	0	0	30,000,000 approx.**
Mopeds (L1, L2)	14,551	0	0	0	1,930,889
Motorbikes (L3, L4, L5)	16,527	36	0	0	3,479,431
Quadricycles (L6, L7)	3,378	0	0	0	117,184
Passenger vehicles (M1)	26,255	343,000	20,863	1	24,174,092
Commercial vehicles (N1)	6,414	259	17	0	4,652,079
Buses (M2, M3)	157	1,055	70	0	65,277
Trucks (N2, N3)	80	259	17	0	342.077
Totals (without bicycles)	**67,362**	**344,609**	**20,967**	**1**	**34,761,029**

CHARGING INFRASTRUCTURE OR EVSE

Up to now, official information about number of charging points in Spain is not available. However, National Government, through State Secretariat for Energy, works in a European project on the identification and placement of recharging points. According to estimations in the sector, there are currently around 5.100 charging points available for public use, covering all possible power ranges, which means an approximated ratio of 11 electric vehicles registered in Spain per charging point.

However, considering that charging at home and in fleet places could cover around 85% of the needs, the other 15-20% should be covered by public charging points, known as “opportunity charging”. According to the Spanish objective of 5,000,000 EVs by 2030, it is estimated that 200-250 fast and super-fast charging points, will be deployed all around the Spanish road network to cover the necessities of EVs for medium-long distance trips, considering current ranges of EVS (from 200 to more than 400 km).

Related to buildings, it must be pointed out that Spanish Government is working on the transposition of Directive UE 2018/44, associated to energy efficiency in buildings. This will facilitate the installation of a minimum of recharging points in the new buildings and those which have renovations.

EV DEMONSTRATION PROJECTS

Some demonstration projects, currently running are:

Cirve Project ("Iberian Rapid Recharge Infrastructure Corridors> 40kw of Electric Vehicles")

Since December 2016, the project "Iberian Corridors of Rapid Recharging Infrastructure for Electric Vehicles" (CIRVE) has been developed. It is a project co-financed by the European Commission, through the 2015 call of the CEF Mechanism. The consortium is made up of eight partners (Endesa, Iberdrola, EDP, Ibil, Gic, Renault, Aedive and the Portuguese technology centre CEIIA) and is supported by the governments of Spain (through the Ministry of Industry and the Ministry of Public Works). In Portugal there is a parallel project with other partners, although both share objectives.

Its objective is the installation of fast charging points (> 40 kW) for electric vehicles in strategic areas of the Atlantic and Mediterranean corridors that pass through Spain and Portugal.

E-Via Flex-E Project

E-VIA FLEX-E is a project co-financed by the European Commission, through the 2017 Blending call of the CEF Mechanism (Connecting Europe Facility), which aims to install ultra-fast charging points (from 150 kW to 350 kW) for electric vehicles in Southern Europe, specifically in Spain, France and Italy.

A pilot will be carried out to install recharging stations capable of providing 350 kW service to one vehicle or simultaneous charges to several vehicles with lower power recharging standards. In this sense, the pilot project includes the installation and operation of 14 ultra-fast recharging infrastructures.

AMBRA Project

AMBRA is a project co-financed by the European Commission, through the 2017 Blending call of the CEF Mechanism (Connecting Europe Facility), which aims to install high-power charging points (> 40 kW) for electric vehicles in Italy , Spain and Romania.

SWEDEN

MAJOR DEVELOPMENTS IN 2019

Sweden has the second largest market share of plug-in electric vehicles (PEVs) in the EU (EAFO, 2020). The overreaching target is for Sweden to reach net zero greenhouse gas emissions by 2045. The law requires all policy areas, not only environment, climate, transport, and energy, to contribute to achieve the targets. The transport sector has an intermediate target to reduce its GHG emissions by 70% by 2030, compared to 2010. Electrification, biofuels and a more transport-efficient society has been pointed out as key enablers to reach these goals.

In the 2019 autumn's budget proposition, there were several initiatives to accelerate the transition to a fossil-free transport sector, with focus on electrification.

Even though the deployment of public charging infrastructure in Sweden is relatively advanced as Sweden is a wide-spread county, the autumn's budget proposition allocated €5 million per year between 2020 and 2022, to support a nation-wide deployment of fast charging infrastructure. This is based upon the recommendations made by a previous governmental inquiry. In addition to this, the government will form an electrification commission, with focus on heavy transport and freight.

NEW POLICIES, LEGISLATION, INCENTIVES, FUNDING, RESEARCH, AND TAXATION

Bonus-malus scheme

In July 2018, the first bonus-malus scheme for light duty vehicles in Sweden was introduced. The bonus-malus scheme both included an element of increasing or decreasing the purchase cost, as well as the vehicle tax.

Battery electric vehicles (BEVs) and fuel cell vehicles (FCV) are eligible for the maximum bonus, which is €6,000. For plug-in electric vehicles (PHEVs), the bonus decreases linear until 70 grams of carbon dioxide (CO2) based on the WLTP. Vehicles with emission levels over 95 grams of CO2 are penalised with a malus in relation to the emission level up to 140 grams of CO2. Unlike the PEV rebate scheme, bonus-malus also include light duty vans, which is an important improvement for many fleet vehicles.

The vehicle tax system was revised as the bonus-malus scheme was introduced.

Previously, PEVs were tax exempted for the first 5 years but since July 2018 the tax exemption lasts for 3 years.

Reduced value of fringe benefits

Company cars can reduce the value of fringe benefits for PEVs compared to the equivalent, conventional, fossil-fuelled car. After adjustment, the value of fringe benefits is reduced by 40 %, to a maximum of €1,000. Given the PEV deployment among company cars, it constitutes for 75 % of the PEV ownerships, this has probably been the most important incentive to promote the use of PEVs in Sweden.

EV bus/trucks/work machines rebate

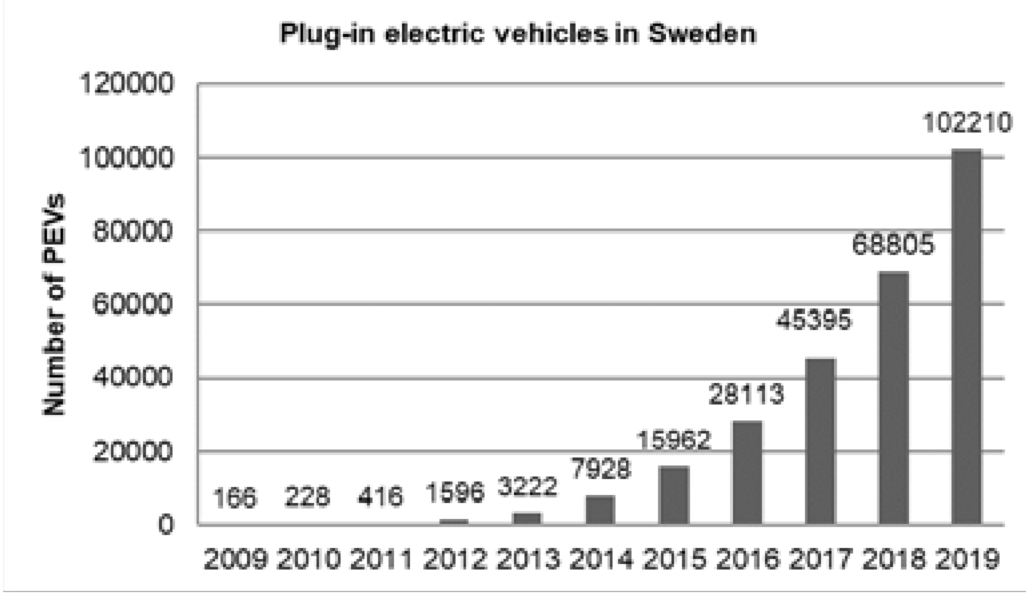
In 2016, the Government introduced a purchase subsidy specifically targeting electric buses. In the beginning, battery electric and plug-in hybrid buses could be granted rebate. In 2017, fuel cell buses using renewable hydrogen were also included in the scheme. In 2018, the EV bus scheme expanded to also entitle private transport companies the purchase rebate. In 2019, the government decided to also include electric trucks and working machines. In total €12 million is allocated to the scheme.

HEVS, PHEVS, AND EVS ON THE ROAD

Sweden has, after the Netherlands, the second largest market share of electric cars in the EU (EAFO, 2019). In 2019, PEVs constituted 11,2 % of the new-car sales. The total stock of PEVs in Sweden is over 102,000 (Swedish Transport Analysis, 2020[1]).

Figure 1:
Number of plug-in electric vehicles in Sweden 2009-2019

Source: Swedish Transport Analysis, 2020



There are no regional or local policies to promote PEVs, only variable levels of engagement. The cities and regions in Sweden with a high PEV uptake have often worked consistently with PEV promotion and EVSE deployment activities for many years. Even though the conditions for PEVs in Sweden are more favorable outside the dense cities, the three largest metropolitan areas – Stockholm, Gothenburg

[1] Swedish Transport Analysis, 2020 - Fordon i län och kommuner 2019

and Malmö – comprise about 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.

Approximately 65 % of the new-car sales in Sweden were fleet vehicles or company cars. The setup for company cars in Sweden ranges from financing models where the employer pays for all costs of the car and the employee is just taxed for the benefit, to operational leasing models where the employee pays for all costs for the car with a gross salary deduction. Given the PEV deployment among company cars, it constitutes for about 75 % of the PEV ownerships, this has probably been the most important incentive to promote the use of PEVs in Sweden.

Governmental fleets are governed by certain procurement policies in Sweden, which force them to particularly consider climate factors when acquiring cars and vans or other mobility services. The public procurement policies in Sweden also promote an increased use of renewable fuels, such as sustainable biofuels and electricity.

As mentioned, there has been an e-bus rebate since 2016 and by the end of 2019, there operated almost 300 electric buses in Sweden. The procured bus traffic in Sweden has already surpassed the Swedish 2030 climate goals and the sector already use over 85 % renewable fuels.

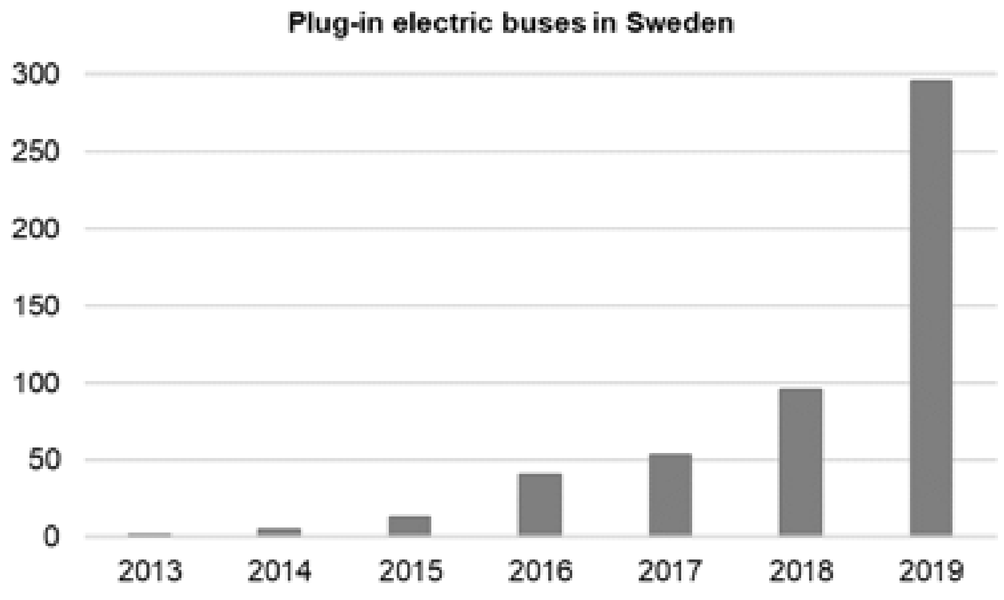


Figure 2:
Number of plug-in electric buses in Sweden

Source: Swedish Transport Analysis, 2020

Table 1:
Current stock and total sales of BEVs, PHEVs and HEVs in 2019

Source: Swedish Transport Analysis, 2020; BIL Sweden, 2020[2]

Table key:
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

Fleet Totals as of December 31st 2019

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	1 645	N/A	N/A	N/A	302 183
B Passenger vehicles	30 343	66 609	117 512	23	4 887 904
C Buses and Minibuses	264	32	152	N/A	14 914
D Light Commercial vehicles	3 946	4	65	N/A	585 091
E Medium and Heavy Weight Trucks	11	0	28	N/A	84 153

Total Sales During 2019

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	12 772
B Passenger vehicles	15 795	24 907	33 123	2	353 036
C Buses and Minibuses	153	0	N/A	N/A	1 467
D Light Commercial vehicles	1 289	N/A	N/A	N/A	53 816
E Medium and Heavy Weight Trucks	N/A	N/A	N/A	N/A	6 652

CHARGING INFRASTRUCTURE OR EVSE

The Swedish market for charging infrastructure is completely deregulated, which enables for almost anyone to become a charging point operator (CPO). This has created an ecosystem of charging infrastructure benefits from interactions between private and public efforts to deploy EVSE.

A non-public charging point is often considered as the enabler to switch from a conventional vehicle to a PEV. 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 for more than 600,000 outlets and even though it's 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.

The public charging infrastructure in Swedish today is the result of public and private actions, sometimes in joint forces, and constitute today for over 9,000, see Figure 3 (left). Klimatklivet have granted support to about 8,000 public charging points. Figure 3 (middle) shows the locations of granted charging points with a charging power below 23 kW, entitled here in Sweden as destination charging.

[2] BIL Sweden, 2020 http://www.bilsweden.se/statistik/nyregistreringar_per_manad_1/nyregistreringar-2019/definitiva-nyregistreringar-under-2019

Klimatklivet has also granted support to DC fast chargers, for example along motorways. See figure 3 (right).

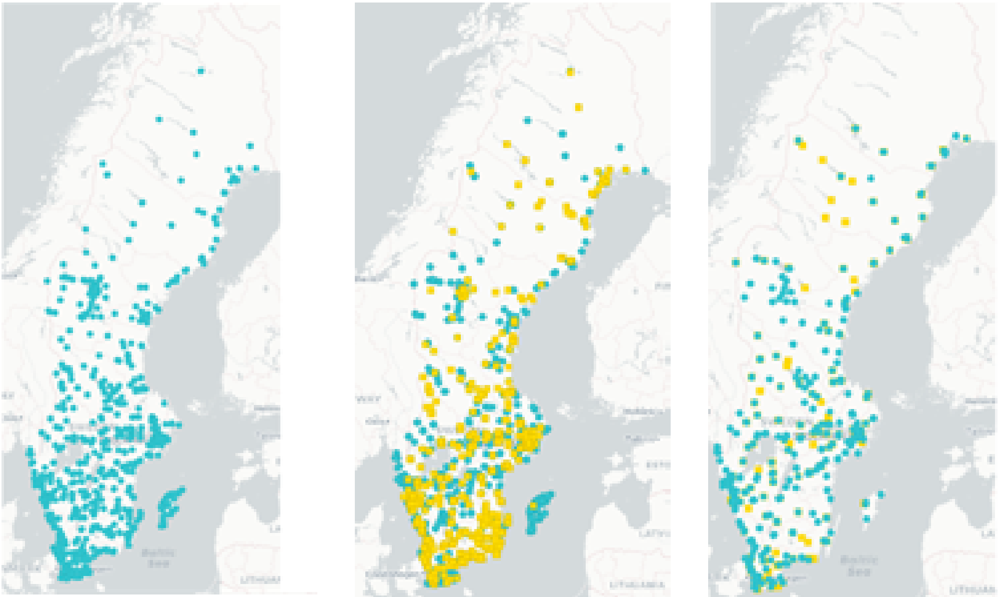


Figure 3:
Public charging EVSE infrastructure in compliance with the EU standard.

Blue Existing
Yellow Granted support through Klimatklivet

Left existing EVSE
Middle EVSE < 23kW
Right 50 kW DC

Klimatklivet – The Climate Leap

In September 2015, the Swedish government launched the investment support scheme Klimatklivet, the Climate Leap[3]. Klimatklivet is a general investment support scheme, not specifically aiming at charging infrastructure deployment, granting up to 50 % of the investment cost. Over 35,000 charging points had been granted support. The majority, 27,000 charging points, are non-public installations for company fleet vehicles or for residents in multi-family dwellings. Other measures that have been granted investment support through Klimatklivet were, for example, bike garages, biogas production plants, LBG refuelling stations.

Home-charging support scheme

In 2017, the Swedish government decided on a home-charging support scheme. From February 1st, 2018, private households are subsidised up to 1,000 Euros, or by 50 %, when installing an EVSE at their home[4].

Table 2:
Information on charging infrastructure in December 2019.

Source: nobil.no

Type of Public EVSE	Number of Charging Points
AC Slow Chargers (≤ 3.7 kW)	1035
AC Slow Chargers (>3.7 kW, ≤ 22 kW)	7244
Fast Chargers (> 22 kW, ≤ 43.5 kW)	N/A
Superchargers (> 43.5 kW)	1146 (890 50 kW and 256 >50 kW)
Inductive Chargers	0

[3] https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2015517-om-stod-till-lokala_sfs-2015-517

[4] https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20171318-om-bidrag-till_sfs-2017-1318

EV DEMONSTRATION PROJECTS

In Sweden, electrification has been demonstrated in more and more sectors. Today, there are examples of demonstrations ranging from small city vehicles to large mining trucks. In large mining vehicles, electrification is often already competitive today, while in the passenger car and city bus sectors, the technology is becoming more competitive and the support can probably be reduced afterwards.

Validation of an innovative mobility system for more energy-efficient cities
Bzzt AB is developing a mobility system consisting of small electric taxi pods, a smart app for ordering and an underlying system like digital optimises the operational efficiency of the fleet. The project aims at service development, development of the company's supporting platforms (operations, technology and software) and developing the interaction between the platforms to reach an optimised efficiency and capacity building in technology areas with great potential impact on business and competitive opportunities. This enables a successful expansion and an internationally established front-end mobility system, with a competitive and profitable services portfolio.

Figure 4:
Bzzt electric taxi pods

Electric trolley track Boliden

In 2018, the Swedish Energy Agency granted Boliden AB support of SEK 10 million for the demonstration project “Electrified mining transport in the Arctic climate in Aitik”. The project is about investigating whether it is possible to replace parts of Aitik's transport system with electrified trucks. Boliden will be able to reduce greenhouse gas emissions by up to 80 % on the routes where the technology can be implemented. The demonstration has now been going on for a year and Boliden announced in November 2019 that they are investing SEK 300 million in the expansion of the internal electric road systems in the Aitik and Kevitsa mines. The electric roads are expected to reduce greenhouse gas emissions by 10-15 %, respectively.

Figure 5:
Boliden electric trolley track in Aitik,

Source: Mats Hillblom

OUTLOOK

One factor that currently determines the deployment of PEVs in Sweden is the availability of PHEVs in family-sized market segments. In 2019, a number of new models will have the potential to increase the introduction of electric vehicles in this market segment.

SWITZERLAND

MAJOR DEVELOPMENTS IN 2019

NEW POLICIES, LEGISLATION, INCENTIVES, FUNDING, RESEARCH, AND TAXATION

Electromobility roadmap 2022

On December 18, 2018, at the invitation of Federal Councillor Doris Leuthard, 50 representatives of the automobile, electricity, property, and fleet vehicle branches and their associations as well as representatives of the federal government, cantons, cities and municipalities signed a joint roadmap[1] to promote electromobility. The aim of the roadmap is to increase the proportion of electric vehicles (BEVs and PHEVs) among newly registered motor cars by 15 percent by 2022. The approximately 75 measures specified in the roadmap have been implemented since the beginning of 2019, and various working groups have been formed. A further ten respected companies and organisations have been added since the roadmap was signed and they support it with their own measures. The process is being steered by the Swiss Federal Office of Energy SFOE and by the Federal Roads Office FEDRO. Many individual projects are being supported through a regular flow of information and by workshops and conferences. The Electromobility roadmap has been widely reported upon in the media since being launched and has received the support of figures in industry, and associations, and from the cantons and municipalities. It is also encouraging to note how the first cantons refer to the aims of the roadmap when promoting electromobility.

Figure 1: 1st event of the electromobility platform as part of the Electromobility roadmap

[1] www.roadmap2022.ch

Fast-charging points on trunk roads

The federal government supports the expansion of a network of fast-charging points on trunk roads. Operating companies in the sector were given the opportunity to tender by December 2018 to provide fast-charging points on 100 rest areas (bundled as five packages each for 20 rest areas). In 2019, the Federal Roads Office (FEDRO) accepted tenders submitted by four Swiss providers and one provider from the Netherlands. FEDRA will finance the necessary electrical infrastructure to make it possible to establish the charging points quickly. The first fast-charging points will be installed in spring 2020 and then each provider will have to equip at least five rest areas within the coming year.

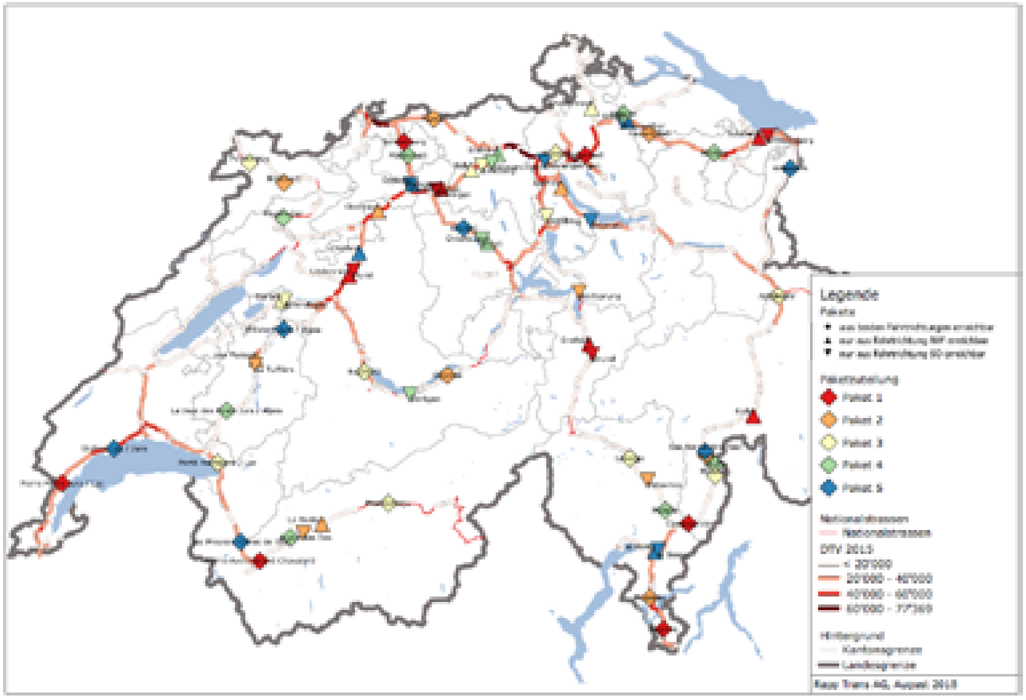


Figure 2:
The five packages of fast-charging stations at motorway service stations in the tendering procedure

Purchase premiums for vehicles and charging infrastructure

Since 2019 some cantons have granted purchase premiums for electric vehicles and some funding towards establishing charging infrastructure. The federal government does not provide such funds. Currently, within the framework of the complete revision of the CO2 Act, the national parliament is debating whether to provide support from the climate fund to help install charging infrastructure in apartment houses. No final decision has been reached yet. In Switzerland, electric vehicles are exempt from vehicle tax (4% of the value of the car) and such vehicles do not incur petroleum tax. This means electric cars do not at present make any contribution through the petroleum tax toward the financing of the road infrastructure. Most cantons offer a temporary, or permanent, reduction or even exemption from cantonal road tax.

Updated fact sheet on the environmental impact of cars

The fact sheet Environmental impact of cars: today and tomorrow2 has been revised by SwissEnergy. The findings are based on an updated study conducted by the Paul Scherrer Institute (PSI) in which the environmental pollution caused by different types of propulsion technology was compared. Current data on battery manufacture and the lifetime of batteries was consulted to arrive at the new findings. Taking the Swiss mixture of electricity into account, a modern battery-driven car saves about 30 tonnes of CO2 over a lifetime of

[2] www.bfe.admin.ch > Efficiency > Alternative drives > Brochures and reports

200,000 kilometres. Production of electric cars causes greater environmental pollution than the production of cars with internal combustion engines. Higher greenhouse gas emissions from the production of a battery driven car are compensated for by the lower emissions incurred after about 30,000 kilometres in operation on roads.

HEVS, PHEVS, AND EVS ON THE ROAD

Sales of energy efficient vehicles in 2019 in Switzerland broke all previous records with record numbers seen in sales of both electric cars and hybrid cars. Last year 305,498 new cars (+2.0 percent) were registered in Switzerland. Of these newly registered vehicles, 13.1 percent were equipped with alternative types of drive train. Compared to 2018, the proportion of such vehicles has almost doubled. In 2019, 12,991 cars solely equipped with electric drives were newly registered, which constitutes an increase of 154 percent. In April 2019, for the first time ever, an electric vehicle was the best-selling car in Switzerland. Sales of petrol and diesel hybrid vehicles (+8.4 percent) and plug-in hybrid vehicles (+1.4 percent) also benefited from the trend toward alternative types of drive.

Table 1

Table key:
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

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	11 842	52	0	0	678 491
B Passenger vehicles	33 045	92 061	16 597	66	4 641 029
C Buses and Minibuses	86	261	0	2	14 970
D Light Commercial vehicles	1 748	85	1	0	466 400
E Medium and Heavy Weight Trucks	43	24	0	0	53 108

Table 2

Table key:
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

Total Sales During 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	1 357	n.a.	n.a.	0	42 709
B Passenger vehicles	12 991	21 629	4 220	25	311 352
C Buses and Minibuses	13	n.a.	n.a.	0	547
D Light Commercial vehicles	401	n.a.	n.a.	0	29 136
E Medium and Heavy Weight Trucks	16	n.a.	n.a.	0	4 182

CHARGING INFRASTRUCTURE OR EVSE

As of 1 January 2020, there were 2,499 locations in Switzerland with publicly accessible charging stations (+176 compared to 1 January 2019).

Table 3

Type of Public EVSE	Number of locations with charging stations
AC Level 2 Chargers (>3.7 kW, ≤ 43 kW)	2454
DC Fast Chargers (≤ 50 kW)	296
Superchargers (≤ 150 kW)	43
Ultra-Fast Chargers (≤ 350 kW)	3

Expansion of the public charging infrastructure in Switzerland is predominantly in the hands of the private sector. The federal government takes on a supportive role with respect to coordination and planning of this expansion. Two significant projects launched by the federal government were concluded in 2019.

New overview of the charging infrastructure for electric vehicles

By means of an interactive application (www.ich-tanke-strom.ch), charging station operators, SwissEnergy, the Swiss Federal Office of Energy (SFOE), and, the Federal Office of Topography (swisstopo) provide a new overview of the publicly accessible charging infrastructure for electric vehicles in Switzerland. Among other things, the application shows in real time the availability of the charging stations. Data is freely available to be used in various ways under the "O-By-Ask" user licence. The application serves as National Access Point and will be developed progressively.

Figure 3: ich-tanke-strom.ch shows availability of charging stations for electric vehicles in real-time

New standards for infrastructure for electric vehicles in buildings

The Swiss Society of Engineers and Architects (SIA) elaborates standards, guidelines and recommendations which are binding on the Swiss building industry. In a new instruction sheet2 SIA 2060 entitled "Infrastructure for Electric-vehicles in Buildings" the society has elaborated a new standard to improve the situation for electromobility in the buildings sector (e.g., in apartment houses). This should ensure that electromobility is given the proper consideration when new buildings or refurbishments are planned. The instruction sheet provides guidelines for all target groups (engineers, architects, investors, building owners and operators) concerning the scope of the equipment shows which aspects must be considered in the planning stage. The intention is to establish planning security.

EV DEMONSTRATION PROJECTS

ELECTRIC BUSES

In 2019 new drive and charging systems were tested for public suburban buses in a number of demonstration projects. In Zurich, the trial phase for an innovative prototype trolley bus was concluded last year. In contrast to conventional trolley buses, this bus is an electric bus fitted with a powerful battery, which is charged over the trolley wire. In this manner, braking energy is recuperated by the bus regardless of the condition of the grid and parts of the route can be covered without using the trolley wire. The three-year trial phase demonstrated the technical reliability of the bus and energy savings of 15% were achieved in comparison to conventional trolley buses[3]. In the meantime, a production version of the prototype has been put into service in a number of cities, including Bern (Switzerland) and Salzburg (Austria) (figure 4).

Figure 4: Innovative trolley bus in Salzburg

Source: www.urban-transport-magazine.com

In Geneva, a similar drive system is being tested in a demonstration project. However, in this instance the battery is charged at fast-charging stations installed at bus stops along the bus route using the innovative "TOSA"[4] system made by ABB Sécheron SA. While passengers enter or leave the bus, the battery is charged for 20 seconds through a flexible arm. The relatively small battery installed leaves more room free for passengers than in conventional battery-driven buses. In addition to expanding the "TOSA" system in Geneva, it is already being employed in Nantes (France) and will soon go into operation in Brisbane (Australia) (figure 5).

[3] https://www.aramis.admin.ch/Texte/?ProjectID=36721

[4] https://www.ge.ch/dossier/bus-tosa-innovation-mobilite-au-service-genevois

Figure 5:
"TOSA" electric bus system in Brisbane

Source: www.brisbane.qld.gov.au

ELECTRIC FREIGHT VEHICLES

In 2019 a demonstration project for electric urban waste collection vehicles was concluded that had been initiated by the company Designwerk GmbH. Valuable experience could be gained in operational trials of four prototype 26-t battery-electric trucks (figure 6) in different regions in Switzerland (Lausanne, Murten, Neuchâtel and Thun). In the three year trial phase, significant savings in energy of between 76% and 83% were attained depending on the type of topography (urban/country, flat/hilly) in comparison to the consumption of conventional diesel vehicles.[5] In the trials the vehicles met the requirements for range, reduction of emissions (noise and pollutant emissions), and operational reliability. The project also showed how further optimisations in vehicle technology and in manufacturing could increase the economic viability of electric trucks. The experience gained from this and other projects seems to be winning over the users. The number of such electric trucks in Switzerland is expected to grow substantially in 2020.

Figure 6:
26-t electric waste collection vehicle in the town of Thun

Source: www.thun.ch

[5] https://www.aramis.admin.ch/Texte/?ProjectID=37266

In a further demonstration project completed in 2019, more experience was gained with a Esoro AG's 34-t truck powered with a hydrogen fuel cell drive. The vehicle equipped with the system tows trailers for Swiss retailer Coop and is tanked up at the first public hydrogen tank station in Switzerland at Hunzenschwil. By demonstrating how a complete hydrogen supply chain functions (hydrogen production, filling station logistics, fuel cell trucks) the basic principles could be established for a more extensive roll-out of hydrogen mobility. In 2020, the intention is to establish more hydrogen filling stations[6] and the first mass-produced fuel cell trucks will begin to operate. The plan is to employ a total of up to 1,600 of such vehicles manufactured by the Korean firm Hyundai (figure 7) in the coming years.

Figure 7:
Fuel cell trucks made by Hyundai

Source: www.hyundai.ch

VEHICLE-TO-X APPLICATIONS

In the Erlenmatt Ost area of Basel a new district has been developed according to the targets of the 2,000-Watt Society. Among other things, the area boasts a 580kW photovoltaic system, a local district heating system, and two bidirectional-charging electric vehicles used for car sharing (a Nissan Leaf and an e-NV200). Integration of car sharing into the area's energy management system has been the only major vehicle-to-X project in Switzerland up to now. As part of a research project[7] studies are being made into how residents' mobility behaviour and own consumption in the area can be optimised with an intelligent regulation and tariff system. Opportunities for new business models and for system services should also be identified.

Figure 8:
E-car sharing as a V2X application

Source: www.novatlantis.ch

[6] https://h2mobilitaet.ch/en/tankstellen/

[7] https://www.novatlantis.ch/fachveranstaltung-sektorkopplung

TURKEY

MAJOR DEVELOPMENTS IN 2019

Turkey's 2023 Industry and Technology Strategy document has been announced by the Republic of Turkey Ministry of Industry and Technology in 2019. Electrified, connected and autonomous transportation is part of the strategy document that states initiatives in these fields will be supported by funding and legislation.[1]

Regarded as one of the projects of strategic importance towards 2023, TOGG (Turkey's Automobile Initiative Group) introduced a preview version of the C-SUV models of Turkey's Automobile in the IT Valley in December 2019. C-Sedan concept was displayed along with the C-SUV model. As of the year 2022, the announced start date of production, TOGG will aim to take its place in the industry as Europe's first non-classical born electric SUV manufacturer. The C-SUV and sedan vehicles are shown in figure 1.

Figure 1:
The Turkey's Automobile: TOGG all-electric SUV, left, TOGG all-electric sedan

Source: TOGG

The Turkey's automobile will have Level 2+ autonomous driving capability and allow Holographic Assistant technology that transforms the in-car experience by replacing the 2-dimensional display technologies currently used in the cars with 3D imaging and augmented reality technologies. 0-100km/h acceleration target set to the 7.6 seconds with 200 HP RWD option and 4.8 seconds with 400 HP AWD option.[2]

Hybrid, electrified and autonomous vehicle research continued at numerous R&D centers in Turkey in 2019. Ford Otosan R&D center continued platooning technologies development with the AVL cooperation. Physical tests targeting emission, fuel economy and safety improvement on convoy trucks started with Otosan F-Max trucks in 2019. The final target of the project aims to realize SAE-Level 4 autonomous driving and hub-to-hub highway transportation. Ford Transit

[1] Ministry of Industry and Technology, 2019

[2] Press Release, TOGG website, 2019. www.togg.com.tr

Custom PHEV, IVOTY 2020 winner, made its debut in several exhibitions and 2 of these vehicles started their field testing in the Ankara Metropolitan Municipality fleet within the context of clean transportation projects developed under smart city applications.[3] The PHEV custom shown in figure 2.

Figure 2:
Ford Otosan introduces its PHEV serial production commercial vehicle to the Ankara Metropolitan Municipality fleet

Source: Ford Otosan

On the electrified public transportation solutions, major manufacturers launched their new buses and alternative solutions in 2019. Bozankaya continued to deliver its market leader electric buses “Sileo” to the several European countries as well as the municipalities in Turkey. Sileo offers 400 km range by 4 hour charging with battery capacity up to 650 kWh.

Karsan, a Turkish commercial vehicle manufacturer, introduced the Atak Electric bus at the global event of “New Definiton of Mobility” co-organized with BMW in Munich in 2019. It was announced that five BMW-i batteries with a total capacity of 220 kWh will run the Atak Electric bus, shown in figure 3 (right), up to 300 kilometers on a single charge. The batteries can be charged in 5 hours with double AC charging, and in 3 hours with fast DC charging units. Karsan also reported that 35 Jest Electric minibuses, with BMW-i powertrain, are already in use in a number of European countries including France, Germany and Greece in 2019.[4]

Another commercial vehicle manufacturer of Turkey, Otokar, highlighted the e-Kent C electric bus, shown in figure 3 (left), with batteries placed on the roof, equipped with 4 modules, each with 7 high-performance lithium-ion batteries, providing a total capacity up to 350 kWh/h and 250 kW max power.

Figure 3:
Electric buses for city transportation: Otokar e-Kent C, left, Karsan Atak Electric, right

Source: Otokar and Karsan

[3] Ford Otosan, 2019, https://blog.ford.com.tr/odullu-ford-custom-phev-ankarada

[4] Karsan,2019, https://www.karsan.com/en/press/current-news/karsan-showcases-new-atak-electric-in-germany

Also, startups and new entrants in the market continued to develop electrified solutions in order to meet the demands of municipalities and public places in 2019. Those solutions include electrical road sweepers, damping cars, floor scrubbers, golf cars, patrol cars and even electric phaetons designed for specific demands. Prince Island, a district of Istanbul, plans to change the transportation type from the traditional horse powered phaetons to the electrical carriages offered by domestic companies. Authorities imposed a temporary ban on horse-drawn phaetons and electric carriages started the test drive in the island.At Istanbul New Airport, refueling of the planes is performed with 50 zero emission electric trucks, developed by a company in Istanbul Technical University, ARI Teknokent, and a decrease of 2,500 tons of $CO2$ emissions and 750 tons of fuel saving is expected annually. The vehicle in refuel operation shown in figure 4.

Figure 4:
Electric truck fleet using for refuel of planes in new Istanbul Airport

Source: IGA Istanbul Airport

In October 2019, Rail Transport Technologies Institute, TUBITAK RUTE, founded in the TUBITAK Gebze campus that aims to develop new technologies for safe, fast and efficient rail transportation to make Turkey a pioneer in this field. Vehicle, system and component level research and development activities on electrification and hybridization will be one of the focuses of the institute with its research personnel and infrastructure. Electric motor, battery module, battery management system, inverter, electronic control units and complete powertrain system development efforts, previously conducted under TUBITAK MRC, will continue in the scope of different projects and wide range of vehicle applications within the RUTE organization.

NEW POLICIES, LEGISLATION, INCENTIVES, FUNDING, RESEARCH, AND TAXATION

Electrified, connected and autonomous transportation is one of the main fields of interest within the context of Turkey's 2023 Industry and Technology Strategy document that has been announced by the Republic of Turkey Ministry of Industry and Technology on the date of September 18, 2019. Research, development and infrastructure initiatives in these fields will be supported by funding, incentives and legislation.

Until June 2019, the so-called special consumption tax (SCT) incentives were effective on a large portion of passenger cars. This incentive resulted in 15% reduced SCT application to passenger cars with engine sizes that account for nearly 60% of the market.

Also, the price limits used on the taxation process of motor vehicles were reorganized for hybrid vehicles by the Ministry of Treasure and Finance of Turkey. The lowest tax rate of 45 percent levied on the base price at as much as 85,000 Turkish liras, and the mid-range defined between 85,000 and 135,000 Turkish liras (currency exchange is given on table 1).

Policy instruments to support the electrification of transportation to encourage the use of H&EVs and the apparent tax advantage for full EV vehicles were valid during 2019. The effects of tax advantage on the sales of EV vehicles were apparent in 2019 even with the radical decrease observed on the total automotive market. Table 1 and table 2 show the taxation policy, vehicle and powertrain categories for new passenger vehicles, motorbikes, and electric or hybrid vehicles, respectively.

Table 1: Special consumption tax classification categories for new conventional and all electric vehicles in 2019 [5]

*Currency: Turkish Lira (₺); 31 December 2019 TCMB exchange rate: 1 $ = 5.95 ₺

Special Consumption Tax (SCT) for Conventional and Electric Vehicles

	Conventional			Electric Only	
Vehicle Type	**Engine Cylinder Volume (cc)**	**Untaxed Price (₺)***	**SCT (%)**	**Electric Motor Power (kW)**	**SCT (%)**
Passenger Vehicle	<1,600	≤70,000	45	≤85	3
		70,000-120,000	50	85-120	7
		>120,000	60	>120	15
	1,600-2,000	≤170,000	100		
		>170,000	110		
	>2,000		160		
Motorbikes	<250		8	<20	3
	>250		37	>20	37

[5] Official Gazette of the Republic of Turkey, 2019

Table 2:
SCT categories for new hybrid vehicles in 2019 [6]

*Currency: Turkish Lira (₺); 31 December 2019 TCMB exchange rate: 1 $ = 5.95 ₺

Special Consumption Tax (SCT) for Hybrid Vehicles

Vehicle Type	Engine Cylinder Volume (cc)	Electric Motor Power (kW)	Untaxed Price (₺)*	SCT (%)
Passenger Vehicle	≤1,800	> 50 kW	<85,000	45
			85,000-135,000	50
			>135,000	60
	1800-2000		<170,000	100
			>170,000	110
	2,000-2,500	>100 kW	<170,000	100
	2,000-2,500	> 100 kW	>170,000	110
	>2,500			160

HEVS, PHEVS, AND EVS ON THE ROAD

FLEET

In Turkey, the total number of road motor vehicles in traffic increased by 291,054 in 2019 compared to the previous year and the negative trend on annual increase continued. When focusing on HEV market, hybrid and electric vehicles on the road increased remarkably in 2019 but the total EV fleet is still immature even as it reached this peak. Total number of full electric vehicles in Turkey passed 4 digits at the end of 2019 but still takes a negligible portion of the vehicle market. Hybrid and electric vehicles sold 12,196 units in 2019 and share on the sales increased to the 3.15% but the portion of HEVs on the fleet total is still low and expected to increase in a longer period of time.

Among all vehicles sold, passenger cars continue to dominate the fleet with 53%, followed by motorcycles and small trucks with 16.3%. An expected results of the market and sales, the average age of the total registered road motor vehicles increased to 13.8 years by the end of 2019. Table 3 shows the total vehicle fleet with respect to vehicle types from 2015 to 2019.

Table 4 show the sales of the new hybrid and electric vehicles with the conventional vehicle sales collected by the Automotive Distributors Association (ODD). Jaguar I-Pace, Renault Zoe and BMW i3 were the on the top of list of electric vehicles. Toyota Corolla hybrid, produced in Turkey, dominated the hybrid vehicle market with the Toyota C-HR.

[6] Official Gazette of the Republic of Turkey, 2019

Table 3:
Total vehicle fleet according to the vehicle types between 2015 and 2019 [7]

Fleet Total Sales as of December 31st 2019

Vehicle Type	2015	2016	2017	2018	2019
Passenger car	10,589,337	11,317,998	12,035,978	12,398,190	12,503,049
Minibus	449,213	463,933	478,618	487,527	493,373
Bus	217,056	220,361	221,885	218,523	213,358
Light commercial vehicle	3,255,299	3,442,483	3,642,625	3,755,580	3,796,919
Truck	804,319	825,334	838,718	845,462	844,481
Motorcycle	2,938,364	3,003,733	3,102,800	3,211,328	3,331,326
Special purpose Vehicle	45,732	50,818	60,099	63,359	65,470
Tractor	1,695,152	1,765,764	1,838,222	1,885,952	1,908,999
Totals	**19,994,472**	**21,090,424**	**22,218,945**	**22,865,921**	**23,156,975**

SALES

Although passenger car market continued to the shrinkage in 2019, hybrid and electric vehicle sales performed better than previous year. Passenger car sales went down by 20.37% in 2019 compared to 2018, to 387,256. In 2018, the sales were 486,321.

In 2019, a decrease of 21.9% in the sales of passenger cars below 1600cc and a decrease of 34.4% in the sales of passenger cars with a 1600-2000cc motor volume observed. As for the sales of the passenger cars over 2000cc, a decrease of 18.6% observed. As a fact of conventional passenger car market in Turkey, the biggest portion was taken by cars under 1600cc with a ratio of 94.32% and a number of 365,278. Passenger cars between 1600cc to 2000cc followed them with a ratio of 2.24% and passenger cars above 2000cc with a ratio of 0.29%. When Turkey passenger car market is reviewed by engine type, diesel car sales come first with 52.03%, petrol car share comes second with a share of 40.04%, hybrid car share is 3.09% and electric car share is 0.06% in 2019.

The jump in the hybrid car market share is noticeable in 2019. The number of hybrid models increased and the sales of hybrid vehicles increased almost three times of last year by reaching to 11,974. Also, even the numbers are still negligible, the electric vehicle sales increased 50% percent and reached 222 in 2019.

[7] TURKSTAT Road Motor Vehicle Statistics, December 2019

Table 4:
Passenger car market according to the engine/ electric motor size between 2018 and 2019 [8]

Total Sales During 2019

Engine Size	Engine Type	2018	2019	SCT (%)	VAT (%)
≤1,600 cc	Gas/diesel	467,693	365,278	45–50-60	18
>1,600 cc - ≤2,000 cc	Gas/diesel	13,202	8,665	100-110	18
>2,000 cc	Gas/diesel	1372	1,117	160	18
≤85 kW	Electric	80	53	3	18
>85 kW - ≤120 kW	Electric	0	0	7	18
>120 kW	Electric	75	169	15	18
≤1,600 cc	Hybrid	550	101	45-50-60	18
>1,600 cc - ≤1,800 cc	Hybrid (≤ 50 kW)	0	10	110	18
>1,601 cc - ≤1,800 cc	Hybrid (> 50 kW)	3011	10,212	45-50-60	18
>1,801 cc - ≤2,000 cc	Hybrid	59	1,194	100-110	18
>2,000 cc - ≤2,500 cc	Hybrid ≤ 100 kW	1	281	160	18
>2,000 cc - ≤2,500 cc	Hybrid > 100 kW	265	165	100-110	18
>2,500 cc	Hybrid	13	11	160	18
Totals		**486,321**	**387,256**		

When 2019 passenger car market is observed in terms of average emission values, passenger cars between 100-120 gr/km have the highest share of 40.07%. Also, percentage of the cars with the emission values between 120 g/km and 140 g/km continued to increase.

[8] ODD Press Summary, December 2019

Table 5:
Passenger car market according to average emission values in 2019 [9]

Passenger Car Sales during 2019 by Average Emission Values

Average Emission Values of CO_2 (g/km)	December 31, 2018		December 31, 2019		2019 / 2018
	Units	%	Units	%	%
<100 g/km	84,049	17.28	51,803	13.38	-38.37
≥100 <120 g/km	193,733	39.84	155,158	40.07	-19.91
≥120 <140 g/km	111,567	22.94	109,786	28.35	-1.60
≥140 <160 g/km	81,728	16.81	59,967	15.49	-26.63
≥160 g/km	13,905	03.13	10,542	02.72	-30.84
Total	**486,321**	**100.00**	**387,256**	**100.00**	**-20.37**

CHARGING INFRASTRUCTURE OR EVSE

In 2019, Turkey's automobile and mobility ecosystem project showcased and Turkey's 2023 Industry and Technology Strategy document declared. These events highlighted the importance of the mobility ecosystem and widespread adoption of electric vehicle and charging infrastructure in the near future. Efforts of private companies and startups supported by the government, increased the number of charging infrastructures and stations throughout Turkey in 2019. Zorlu Energy Solutions (ZES), a company which entered the market in 2018, increased the number of charging stations from 23 to 163 and capacity to 301 active charging points including CHAdeMO (50 kW), CCS/SAE (100 kW) and type 2 (22 kW and 43 kW) sockets at the end of 2019. ZES announced the fastest charging station of the Turkey in the Manisa highway O375 service area at the end of the year.[10]

Eşarj, owned by Enerjisa, increased the number of charging stations to 170 with the vehicle capacity of 300 in 2019. A newly entered company to the market, Sharz.net, peak to the 140 different locations with 180 charging points. Other companies on the electric vehicle charging market like Voltrun, Yeşilgüç, G-Charge continued their efforts to enlarge the access map throughout the country.

By new charging locations introduced in 2019, the coverage of Turkey highway map with electric vehicle charging stations increased significantly. Also, the number of stations offering fast charging options significantly increased in 2019 with the entrance of new infrastructure providers. Despite the declarations in recent years, there is no supercharger installed yet by Tesla Motors in Turkey.

Figure 6 shows the electric vehicle charging stations map of Turkey by the end of 2019. The orange colored stations in the map highlights the high power charging stations. Also, some examples of the active fast charging stations established by

[9] ODD Press Summary, December 2019

[10] ZES Energy Press Release, 2019

the charging infrastructure companies can be seen in figure 5.

Figure 5:
New fast charging station examples constructed at the shopping mall and gas station in İstanbul

Source: Voltrun and EŞarj

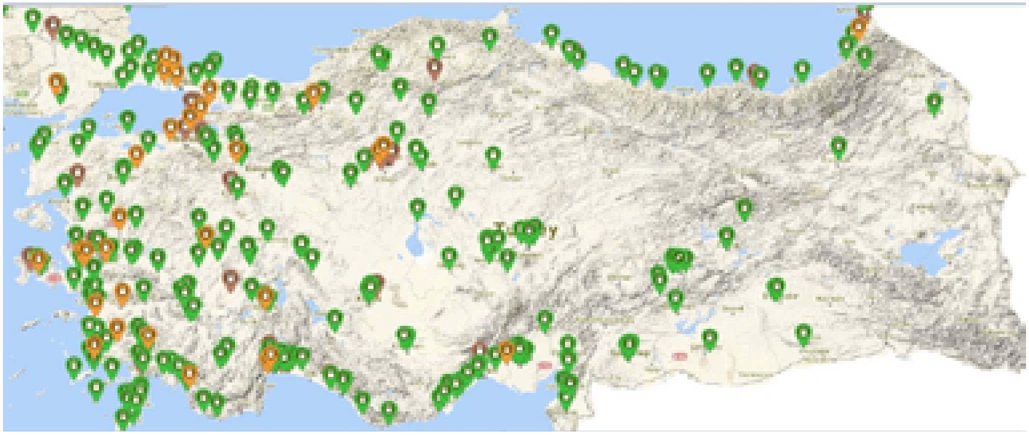


Figure 6:
Map of active charging stations throughout Turkey

Source: plugshare.com

EV DEMONSTRATIONS PROJECTS

On the demonstration projects side, The Cezeri Flying Car concept introduced by

Figure 7:
Cezeri Flying Car, concept

Source: Baykar

Baykar, aims to bring a radical change by providing green urban air transport. The Cezeri, shown in figure 7, is being developed to bring a solution to aerial delivery of time critical packages and medicines in congested urban cities, search & rescue activities and supply missions. It is expected to have 2000 m flight altitude, triple redundant full autonomous flight control system and 1 hour endurance time.

In 2019, Kodeco, a startup company, physically prototyped its Otomod and Ecomod, L class and 100 km range vehicle, alternative autonomous public transportation solutions with the joint effort of FEV Turkey. Otomod is funded by Tubitak Technology and Innovation Grant Directorate. The concept vehicle prototypes are shown in figure 8.

On the university side, 15th Efficiency Challenge Electric Vehicle competition was organized by TUBITAK Science and Society in September 2019. This event aims to increase environmental awareness of students. Çukurova University Elektromobil team won the competition by the minimum energy consumption of 681 Wh (including 50 Wh prize). AESK team from Yıldız Technical University took the 2nd place in this category, by completing the path with 715 Wh and won the efficiency record prize.[11]

Figure 8:
Alternative transportation solutions by Kodeco: Otomod, left, Ecomod, right

Source: Kodeco

Teams in Electromobile and Hydromobile categories were required to consume as minimum energy as possible and complete 30 laps (60 km) and 20 laps, respectively. AESK team hydromobile category vehicle won the Hydromobile competition with its hydrogen fuel cell and battery vehicle. Photos from the 2019 event shown in figure 9.

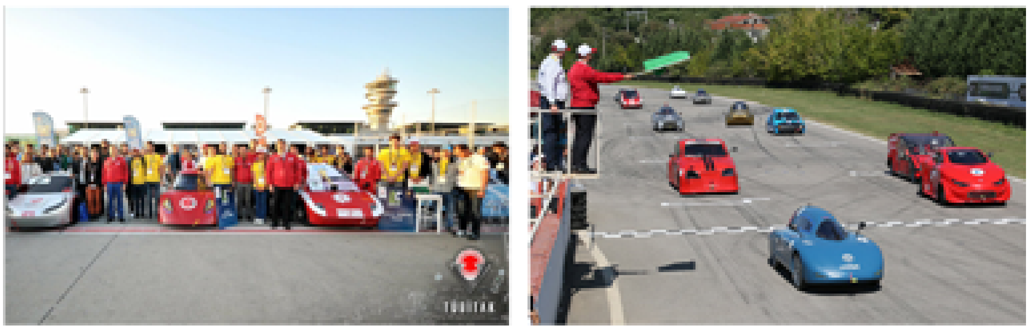
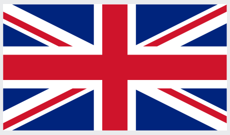


Figure 9:
Images on 15th Efficiency Challenge Electric Vehicle competition

Source: TUBITAK

[11] TUBITAK, 2019: https://challenge.tubitak.gov.tr/home_en.html



UNITED KINGDOM

MAJOR DEVELOPMENTS IN 2019

In June 2019 the UK became the first major global economy to pass a law[1] that requires the Government to achieve ‘net zero’ greenhouse gas emissions by 2050, ending the UK’s contribution to global warming within the next 30 years. Clearly, ending the sale of new conventional petrol and diesel cars and vans is a key part of the answer to our long-term transport air quality and greenhouse gas issues. Cars and vans accounted for 70% of domestic UK transport emissions in 2018.

In March 2020, the UK Government announced that it intended to work with others to develop a transport decarbonisation plan[2]. This will help them understand the challenge they need to meet to reduce transport emissions and ensure that the UK reaches net zero transport emissions by 2050. The transport decarbonisation plan will be published in later in 2020.

To achieve net zero emissions in 2050, the Committee on Climate Change[3] recommended an end to sales of new petrol and diesel cars and vans by 2035 at the latest, and preferably earlier (e.g. 2030). They also recommended that all new vehicles sold after that date should be zero emission. That is why the UK Prime Minister launched, in February 2020, a consultation[4] on bringing forward the end to the sale of new petrol and diesel cars and vans from 2040 to 2035, or earlier if a faster transition appears feasible, as well as including hybrids for the first time.

As part of this consultation, the UK Government are seeking views on what the accompanying package of support will need to be to enable the transition and minimise the impacts on businesses and consumers across the UK, building on the significant demand and supply side measures already in place. The plan is to conclude the consultation in the summer 2020.

STATE OF THE MARKET – PROGRESS TO DATE

In 2019 the UK was the third largest market for ultra-low emission vehicles, ULEVs, in Europe - over 3% of all new cars sold were ULEVs and the UK is a global leader in their development and manufacture. ULEV sales share of new cars continues to rise and in recent months has been around 6%.

There are over 240,000 battery electric, plug-in hybrid and fuel cell electric vehicles registered in the UK. Nearly 230,000 of these vehicles are cars, up from just over 1,300 ultra-low emission cars in 2010

[1] https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

[2] https://www.gov.uk/government/publications/creating-the-transport-decarbonisation-plan

[3] https://www.theccc.org.uk/publications/

[4] https://www.gov.uk/government/consultations/consulting-on-ending-the-sale-of-new-petrol-diesel-and-hybrid-cars-and-vans

POLICY INITIATIVES

During 2019-20 the UK has taken a number of steps to increase the uptake of ultra-low and zero emission vehicles, support innovation in zero emission vehicle technology, and create a fit for purpose charging infrastructure network.

In the March Budget, £532 million of extra funding to keep Plug in Vehicle Grants for another three years was announced. The UK government will provide £403 million for the Plug-in Car Grant[5], extending it to 2022-23. There were also changes to the scheme announced. From Thursday 12 March (2020), those making the switch to electric cars are eligible for a grant of up to £3,000, a reduction from the previous rate of £3,500 as well as excluding cars costing £50,000 or more. The UK Government believes that making these changes will allow more drivers to benefit from making the switch for longer.

The Government also announced a number of tax and duty measures in the 2020 Budget. Battery electric cars will pay no Company Car Tax[6] in 2020/21, just 1% in 2021/22 and 2% in 2022/23 through to 2024/25. The Budget exempted zero emission cars from the Vehicle Excise Duty (VED), 'Expensive car supplement' – meaning all fully electric cars are now exempt from VED. Until the March Budget the VED exemption was for cars costing under £40k, but there was a premium surcharge of £320 in years 2-6 for cars over £40k (i.e. £1600 in total). HMT, the UK's finance Ministry, has also published a call for evidence[7] on VED, including how it can be further used to reduce vehicle emissions.

Recognising that the market for other plug-in vehicles is still at an early stage of development, the Government is also providing £129.5 million to extend the plug-in grants for vans, taxis, and motorcycles to 2022-23. The grants to support the purchase of zero emission vans, taxis and motorbikes will remain at current levels. However, the rates of all plug-in vehicle grants are subject to review over time, depending on how the market develops.

The UK Government has already invested £240 million since 2010 to support the move to lower emission buses, with money to retrofit older buses several rounds of low emission bus funding. It has now launched a revolution in bus services by announcing a package worth £220 million, the UK's first-ever long-term bus strategy and funding settlement – including £50 million to deliver Britain's first all-electric bus town[8].

In February 2019, we announced the winners of the £48m Ultra-Low Emission Bus Scheme[9]. Funding has been awarded to 19 bidders to support the purchase of 263 ultra-low emission buses and includes £14.2m investment in charging infrastructure.

OTHER INITIATIVES

The UK Government endorsed the National Franchised Dealers Association (NFDA) Electric Vehicle Approved[10] (EVA) scheme which includes a set of standards for electric vehicle retail and aftersales that have been established to ensure that the automotive industry is prepared for the electrification of the UK car market.

[5] https://www.gov.uk/plug-in-car-van-grants

[6] https://www.gov.uk/tax-company-benefits/tax-on-company-cars

[7] https://www.gov.uk/government/publications/vehicle-excise-duty-call-for-evidence

[8] https://www.gov.uk/government/news/britains-first-all-electric-bus-town-to-pave-the-way-for-green-communities-of-the-future

[9] https://www.gov.uk/government/publications/ultra-low-emission-bus-scheme-successful-bidders

[10] https://www.nfda-uk.co.uk/press-room/press-releases/electric-vehicle-approved-scheme-launched-to-certify-excellence-in-ev-retail

The Government and industry co-funded Go Ultra Low communications campaign ran its 2019 multi-platform adverts 'The car'[11]. Go Ultra Low now has a wider consortium of members than ever before, including new vehicle manufacturer members and, for the first time, energy providers.

The UK Government consulted on the introduction of Green Number Plates[12] for ultra-low emission vehicles to raise awareness and help normalise cleaner vehicles and increase their uptake. The result of this consultation will be presented in due course.

HEVS, PHEVS, AND EVS ON THE ROAD

Table 1: Vehicle Registrations in December 2018/2019

Source: https://www.smmt.co.uk/2020/01/december-ev-registrations-3/

EV Registrations December 2018/2019

Vehicle Type	2019	2018	% Change	Mkt share 2019	Mkt share 2018
Diesel	33,884	41,846	-19.0%	22.7%	29.0%
Petrol	94,251	91,862	2.6%	63.3%	63.8%
BEV	4,939	1,540	220.7%	3.3%	1.1%
PHEV	4,480	3,679	21.8%	3.0%	2.6%
HEV	4,941	3,676	34.4%	3.3%	2.6%
MHEV diesel	3,322	617	438.4%	2.2%	0.4%
MHEV petrol	3,180	869	265.9%	2.1%	0.6%
TOTAL	**148,997**	**144,089**	**3.4%**		

Table 2: Vehicle Registrations Year to Date 2018/2019

Source: https://www.smmt.co.uk/2020/01/december-ev-registrations-3/

EV Registrations Year to Date 2018/2019

Vehicle Type	YTD 2019	YTD 2018	% Change	Mkt share 2019	Mkt share 2018
Diesel	583,488	746,332	-21.8%	25.2%	31.5%
Petrol	1,49,640	1,466,024	2.2%	64.8%	61.9%
BEV	37,850	15,510	144.0%	1.6%	0.7%
PHEV	34,734	42,232	-17.8%	1.5%	1.8%
HEV	97,850	83,528	17.1%	4.2%	3.5%
MHEV diesel	32,217	3,833	740.5%	1.4%	0.2%
MHEV petrol	26,361	9,688	172.1%	1.1%	0.4%
TOTAL	**2,311,140**	**2,367,147**	**-2.4%**		

[11] https://www.youtube.com/watch?v=XS_Se3k74U4

[12] https://www.gov.uk/government/consultations/introduction-of-green-number-plates-for-ultra-low-emission-vehicles

CHARGING INFRASTRUCTURE OR EVSE

Since 2010 the Government and industry have supported the installation of over 17,000 devices, providing over 24,000 publicly available chargepoints. This includes over 2,400 rapid chargepoints, one of the largest networks in Europe. In addition, the Office for Low Emission Vehicles (OLEV) have funded over 60 local authorities through the On-street Residential Chargepoint Scheme[13] - which provides grant funding to local authorities looking to install chargepoints for residents that lack off-street parking with around 2,000 chargepoints installed so far.

This funding will be doubled to £10 million for the installation on chargepoints on residential streets in 2020/21. This could help fund another 3,600 chargepoints across the UK and make charging at home and overnight easier for those without an off-street parking space.

The UK Government has supported the installation of over 120,000 domestic chargers through the Electric Vehicle Homecharge[14] and predecessor schemes. Businesses, charities, and the wider public sector can get grants for installing up to 20 charging sockets for their employees and fleets through the Workplace Charging Scheme[15]. To date over 1,000 installations have been made in over 300 organisations.

As from the 1 April 2020 the grant for these schemes will be set at £350 towards the cost of purchase and installation of a chargepoint at home through the Electric Vehicle Homecharge Scheme, and £350 towards a chargepoint socket at work through the Workplace Charging Scheme. This is a reduction from £500 to £350.

We are investing £20 million to deliver new dedicated chargepoints for electric taxis in local areas. In February 2019, we announced over £6m of funding in the second round of the scheme for 17 local authorities to install dedicated taxi and private hire vehicle chargepoints. £14m was awarded in 2017 across 10 local authorities in the first round of the scheme.

We are supporting people to charge their electric vehicles at home by ensuring the new homes we are building - including multi-occupancy dwellings and blocks of flats - are electric vehicle ready. We have consulted on plans to introduce a requirement for every new home to have a chargepoint[16], where there is an associated car parking space. England would be the first country to introduce mandatory chargepoints in new homes. Alongside requirements for new homes, we also consulted on setting minimum charging infrastructure provision in existing and new non-residential buildings. We will publish our consultation response in due course.

SUPPORTING THE DEVELOPMENT OF RAPID CHARGING INFRASTRUCTURE

The rollout of rapid charging is an opportunity to remove range anxiety for electric vehicle drivers across the roads network and it is vital that the UK's motorways and strategic roads are appropriately equipped for mass EV uptake

[13] https://energysavingtrust.org.uk/transport/local-authorities/street-residential-chargepoint-scheme

[14] https://www.gov.uk/government/publications/customer-guidance-electric-vehicle-homecharge-scheme

[15] https://www.gov.uk/government/publications/workplace-charging-scheme-guidance-for-applicants-installers-and-manufacturers

[16] https://www.gov.uk/government/news/electric-car-chargepoints-to-be-installed-in-all-future-homes-in-world-first

and meet the needs of drivers for use when they are undertaking longer journeys.

In the March 2020 Budget it was announced that the government is providing £500 million over the next five years to support the rollout of a fast-charging network for electric vehicles, ensuring that drivers will never be further than 30 miles from a rapid charging station. This will include a Rapid Charging Fund to help businesses with the cost of connecting fast charge points to the electricity grid.

OLEV will complete a comprehensive electric vehicle charging infrastructure review. Further details around the Rapid Charging Fund will be announced at a later date.

HMT launched the £400 million Charging Infrastructure Investment Fund[17] (CIIF). The fund will catalyse and diversify investment in public chargepoint infrastructure with £200 million from the Government to be match funded by private investment. The first investment of £70 million is expected to result in a further 3,000 new rapid chargepoints by 2024.

To improve customer experience of recharging, the Government announced that that they want new public rapid chargepoints to offer 'pay as you go' debit or credit card payment from spring 2020.

EVSE NUMBERS

The UK does not hold a central registry of all publicly accessible chargepoints in the UK, any chargepoints that are Government funded must be added to the National Chargepoint Registry[18].

Table 3: Public charging points in the UK

Note: This data is collected from a variety of sources and may not capture all EVSE in the UK.

Type of Public EVSE [19]	Number of Charging Points
AC Slow Chargers (≤ 3.7 kW)	5,947
AC Slow Chargers (>3.7 kW, ≤ 22 kW)	16,457
Fast Chargers (> 22 kW, ≤ 43.5 kW)	6,212
Superchargers (> 43.5 kW)	876 +
Inductive Chargers	N/A

[17] https://www.gov.uk/government/publications/charging-infrastructure-investment-fund

[18] https://www.national-charge-point-registry.uk/

[19] Data accessed from Zap Map for 2019

EV RESEARCH, DEVELOPMENT AND DEMONSTRATION PROJECTS

Since 2010, OLEV has awarded over £400m in R&D grants via Innovate UK[20] into a wide range of different low-carbon technologies, including vehicle light weighting, power electronics, and innovative charging infrastructure. This funding supports collaboration with vehicle manufacturers, technology companies, and academia, with all projects being co-funded with industry, and UK based.

Figure 1: Princes Street rapid charging hub in Dundee, Scotland

Source: Dundee City Council

Traditionally, UK's R&D competitions have supported on-vehicle development, with a focus on low and zero carbon technology. Recently, the scope has expanded to include a £30m Vehicle-to-Grid competition[21]. OLEV also launched a £40m fund for On Street and Wireless charging projects[22] in Summer 2019. The OLEVs R&D competition is run through Innovate UK (part of UKRI) and is currently focused on Technology Readiness Levels (TRL) 3-6 (technology demonstration through to prototype).

OLEV awarded £25m through the Integrated Delivery Platform 15 R&D competition in a number of projects focused on power electronics and motors which are key technologies for electric vehicles. In addition, we are investing £20m to demonstrate low emission freight technology.

The R&D programme complements the £1bn government and industry funding for the Advanced Propulsion Centre[23], £274m Faraday Battery[24], and £80m Driving the Electric Revolution[25] challenges.

The delivery of the Go Ultra Low Cities initiative continues. Bristol, London, Milton Keynes, and Nottingham are the UK's 'Go Ultra Low' cities, with ambitious plans to become global exemplars of ultra-low emission vehicle uptake. The £40 million scheme is also providing £5 million of development funding for specific initiatives in Dundee, Oxford, York, and the North East region.

[20] https://www.gov.uk/government/organisations/innovate-uk

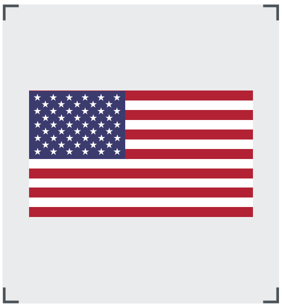
[21] https://www.gov.uk/government/news/30-million-investment-in-revolutionary-v2g-technologies

[22] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/826766/Competition_Results_-_Electric_Charging_for_Public_Spaces_-_Real_World_Demonstrators.pdf

[23] https://www.apcuk.co.uk/

[24] https://faraday.ac.uk/

[25] https://www.ukri.org/innovation/industrial-strategy-challenge-fund/driving-the-electric-revolution/



UNITED STATES OF AMERICA

MAJOR DEVELOPMENTS IN 2019

The United States (U.S.) population continues to rely on vehicles for personal transportation. Cumulative 2019 national vehicle miles travelled (VMT) exceeded the 2018 figures by 0.9% (through December 2019), reaching 3.3 trillion miles.[1] Sales of electric-drive vehicles in the U.S. in 2019 decreased slightly from their 2018 value (~325,000 compared to ~361,000), the cumulative total reached 1.44 million PEVs since December 2010. During 2019, there were 55 plug-in electric vehicle (PEV) models sold, including both plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs); as well as 60 hybrid electric vehicle (HEV) models, for total sales of ~726,000 units.[2]

INDUSTRY AND MARKET

Market developments:

- Ford and Webasto announced Mustang Lithium, an ultra-high-performance battery electric Mustang prototype (900 hp), with over 1,000 ft-lb of torque.[3]

- Volkswagen of America started construction for its electric vehicle production facility in Chattanooga, TN, where EV production will begin in 2022. VW also announced it intends to build a 198,000–square-foot plant for battery pack assembly for EVs at the Chattanooga site.[4]

- General Motors (GM) announced it is setting up a joint venture with South Korea’s LG Chem to mass-produce batteries for electric cars, investing a total of $2.3 billion to build a new facility, in Lordstown, Ohio, with an annual capacity of more than 30 GWh, manufacturing battery cells for 20 new GM EVs by 2023.[5]

- GM will invest $2.2 billion in its Detroit-Hamtramck assembly plant to build electric trucks and SUVs, creating 2,200 jobs. The company said its first electric pickup truck production will begin late in 2020, followed by a self-driving vehicle, Cruise Origin. GM also unveiled a prototype of a driverless vehicle for ride-sharing services.[6]

- GM announced it will build a second electric car for Chevrolet, alongside the Chevy Bolt EV, possibly a larger crossover SUV.[7]

- Ford demonstrated its 2020 Escape, a small SUV, at the New York International

Auto Show. Escape, which debuted the world's first hybrid SUV in 2005, brings two hybrid choices for 2020—a standard hybrid and a plug-in variant.[8]

Battery Technology

- Ford is teaming up with Solid Power to develop all solid-state batteries for next-generation EVs.[9]

- Canadian battery materials company Hydro-Québec is partnering with Mercedes-Benz for future EV technology R&D.[10]

- XALT Energy has launched the XPAND Low Profile (XLP) Pack, a high-energy-density battery pack for commercial EVs. The XLP Pack is designed to fit within the frame rails of trucks and buses, uses XALT Energy's large-format cells, and will offer energy densities in excess of 260Wh/l (specific energies greater than 210Wh/kg).[11]

- BMW is doubling is battery production capacity in preparation for producing two new plug-in hybrids at its South Carolina factory. It plans to begin producing the 2020 BMW X5 xDrive 45e plug-in hybrid SUV, followed by the new plug-in hybrid X3 xDrive 30e.[12]

Charging Infrastructure

- Charging network operator Electrify America opened its 400th EV charging station, setting a rapid pace for installation of DC fast-charging stations.[13] It also partnered with the fleet charging company Stable Auto to launch a robotic charging pilot for self-driving vehicles in San Francisco.[14]

- Tesla unveiled its third generation Supercharger charging stations at its Fremont, California headquarters. The new "V3" Supercharger is capable of charging some of the Model 3 vehicles at a rate of 250kW.[15]

- Fuel retailer Propel Fuels announced plans to launch an EV charging network in California.[16]

- Chevron announced it is partnering with EVgo to bring EV charging stations to its gas stations.[17]

POLICY AND GOVERNMENT

Federal Government

- The U.S. Department of Energy (DOE) announced $50 million for new and innovative research of technologies for trucks, off-road vehicles, and their fuels. Funded through the Office of Energy Efficiency and Renewable Energy (EERE), these selections highlight priorities in gaseous fuels research, including natural gas, biopower, and hydrogen; heavy-duty freight electrification; hydrogen infrastructure and fuel cell technologies for heavy-duty applications; and energy efficient off-road vehicles.[18] [19]

- DOE announced it is devoting $59 million to 43 projects that will explore advanced vehicle technology research. The projects, funded through EERE, address subjects ranging from electric driving systems and batteries to alternative fuels and powertrains. As part of it, $7 million was awarded to General Motors Co. for low-mass, high-efficiency engines for medium-duty truck applications.[20]

- The United States Advanced Battery Consortium LLC (USABC), a subsidiary of the United States Council for Automotive Research LLC (USCAR), and a collaborative organisation of FCA US LLC, Ford Motor Company and General Motors, awarded a $4.8-million technology development contract to Zenlabs Energy Inc. in Fremont, California for development of low-cost, fast-charge (LC/FC) battery technology for electric vehicles (EVs).[21]

- Magna was awarded a grant by DOE to develop and 'auto-qualify' advanced electric motor technologies for next-generation vehicle propulsion systems.[22]

- DOE launched the lithium-ion battery recycling centre (the ReCell Centre). Recycled materials from lithium-ion batteries can be reused in new batteries, reducing production costs by 10 to 30 percent, which could help lower the overall cost of EV batteries to the goal of $80 per kilowatt hour. A goal of the ReCell Centre is to drive toward closed-loop recycling, where materials from spent batteries are directly recycled, minimising energy use and waste by eliminating mining and processing steps.[23]

State & Local Governments

- Peninsula Clean Energy (PCE), in California's San Mateo County, is offering a $4,000 incentive toward the purchase of a used PHEV for lower-income customers.[24]

- The California Air Resources Board (CARB) approved a rule for airport shuttles at the 13 largest airports to transition entirely to ZEVs by 2035.[25]

- CARB also proposed regulation requiring that manufacturers sell a set percentage of zero-emissions battery-electric and fuel cell trucks beginning with model year 2024.[26]

- The Arizona Corporation Commission approved an EV Policy Implementation Plan under which utilities (Public Service Corporations) must present an EV pilot programs to the commission.[27]

- All eight Florida Turnpike service plazas will have fast-charging stations.[28]

- New Jersey Gov. Phil Murphy signed legislation to support EV use and charging infrastructure, to be installed along certain travel corridors and in community locations, such as town centres or commercial areas.[29]

Legislation

- Rep. Mike Doyle, D-Pa., introduced legislation to extend the income tax credit to all energy storage technologies. instead of only when connected to a solar project.[30] A bipartisan group of U.S. lawmakers introduced legislation to expand the electric vehicle tax credit by 400,000 vehicles per manufacturer.[31] U.S. senators also voiced bipartisan support for a national electric vehicle supply chain policy legislation.[32]

- U.S. Rep. Debbie Dingell introduced legislation entitled the USA Electrify Forward Act, which directs U.S. Transportation Secretary to "accelerate domestic manufacturing efforts directed toward the improvement of batteries, power electronics and other technologies for use in plug-in electric vehicles."[33]

HEVS, PHEVS AND EVS ON THE ROAD

This section provides the number of hybrid and electric vehicles on the road in the U.S. at the end of 2019. It also includes an overview of the prices of the most popular-selling hybrid and electric vehicles. Figure 1 shows the 2019 sales for the top 9 U.S. market leaders. It is observed that 2019 HEV sales increased 17% to 400,746 in 2019[34] from 343,219 in 2018. There were 60 different models sold across 23 manufacturers. The top-selling models include Toyota Prius, Ford Fusion & Milan, Toyota RAV4, and the Kira Niro, which account for 52% of the U.S. HEV market. The Toyota Prius line-up further shrank to 12% of the total market share (versus 18% in 2018), but Toyota and Lexus together still approach about half of the U.S. HEV market. Figure 2 illustrates cumulative sales for HEVs, BEVs, and PHEVs over January – December 2019. It is observed that all three curves show a steady rise throughout the year.

Figure 1:
2019 sales of electrified vehicles for market leaders (90% of U.S. electrified vehicle sales.

Source: Argonne National Laboratory

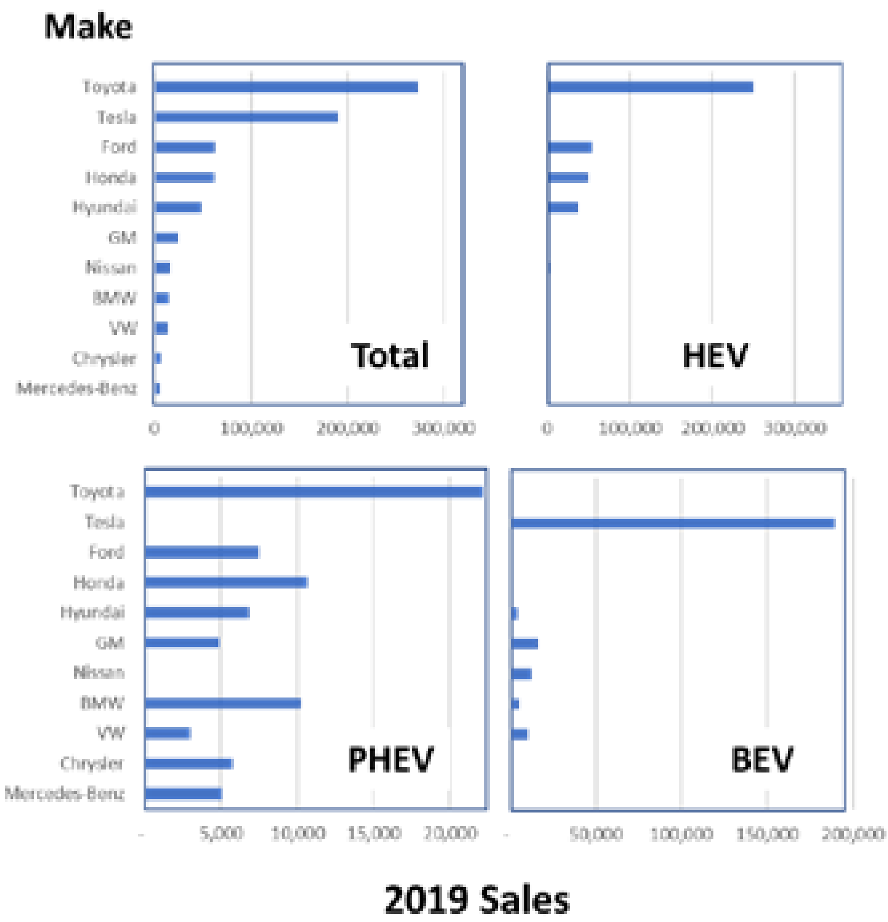


Figure 2:
Cumulative sales of electrified vehicles in 2019, not including FCEVs.

Source: Argonne National Laboratory

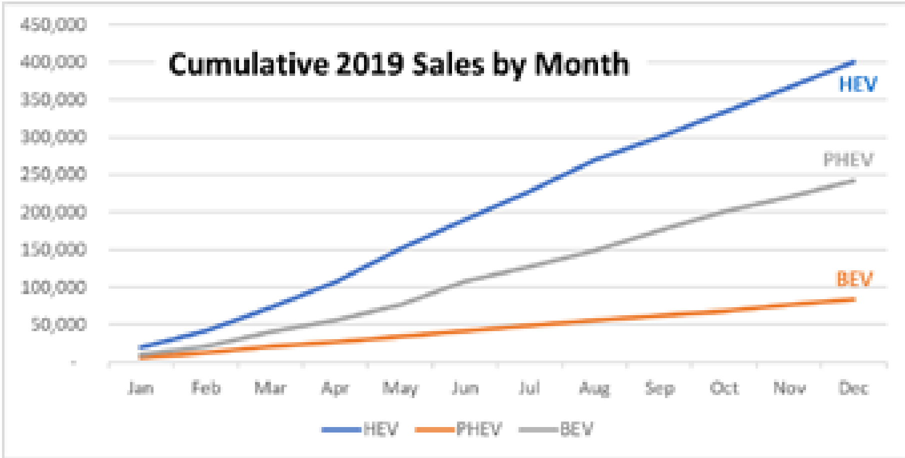


Figure 3 shows the evolution of the U.S. HEV market (over the past 15 years) for prominent manufacturers (only manufacturers with over 2% of the market for a given year are included). The corresponding information for the PEV market (over the last ten years) appears in Figure 4.

Figure 3:
Evolution of the U.S. HEV market over time. Only OEMs with over 2% of the HEV market are shown in detail.

Source: Argonne National Laboratory

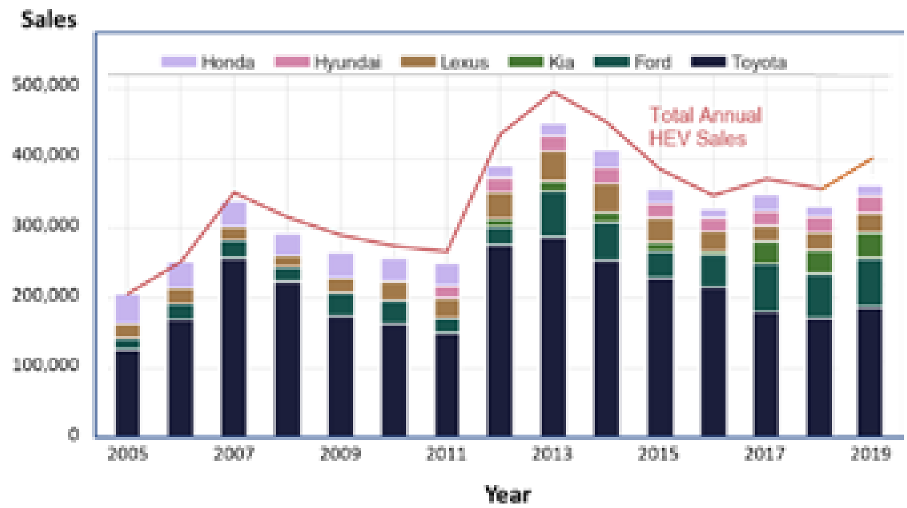
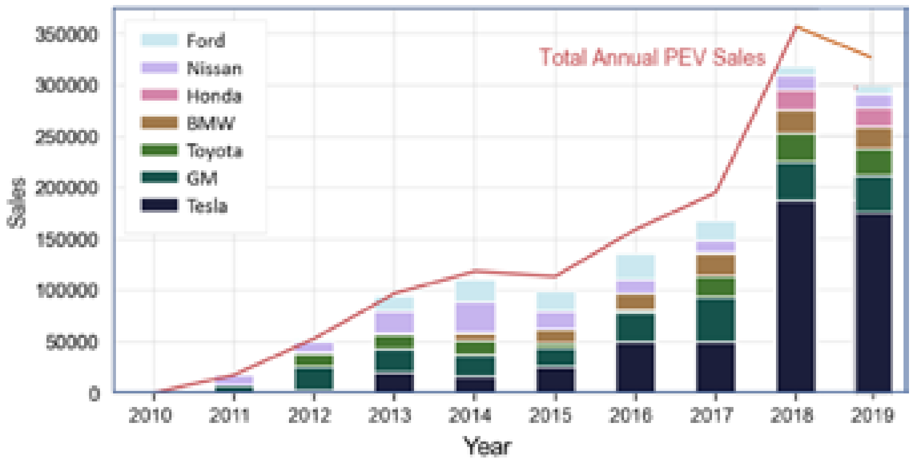


Figure 4:
Evolution of the U.S. PEV market over time. Only OEMs with over 2% of the PEV market are shown in detail.

Source: Argonne National Laboratory



In 2019, 54 PEV models were available for sale in the United States, including 23 all-electric (EV) models across 15 manufacturers and 31 plug-in hybrid EV (PHEV) models across 15 manufacturers. The total 2019 PEV sales reached around 325,000 units, ~7% below the total sales in 2018. Six of the PEV models sold over 10,000 units in 2018, including 4 BEVs and 2 PHEVs. The highest-selling 2019 models included the Tesla Model 3, Tesla Model X, Chevrolet Bolt, Tesla Model S, Nissan Leaf, Prius PHEV, Honda Clarity PHEV, and Ford Fusion Energi. Tesla, Chevrolet, Toyota, BMW, Honda, and Nissan cover over 86% of the full 2019 U.S. PEV market.

The 2019 sales data also demonstrate a steady dominance of Tesla's share of BEV sales; Tesla was responsible for 58% of BEV sales in 2019 compared to 79% in 2018. Figure 5 shows annual U.S. electrified vehicle sales over 2010-2019. It captures a spurt in the 2018 BEV sales then a correction (which had previously increased only at a rate similar to that for PHEV sales).

Table 1 provides estimated total stock and sales numbers for the electrified fleet, followed by a list of available vehicles and their respective prices in Table 2 and Table 3 for BEVs and PHEVs, respectively.

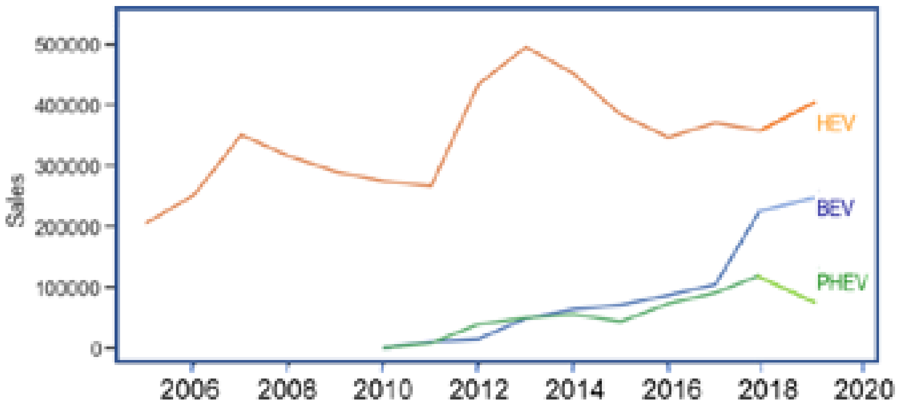


Figure 5: Annual U.S. electrified vehicle sales between 2010 and 2019.

Source: Argonne National Laboratory

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2019.

Fleet Totals on 31 December 2019

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	Total fleet*
A Passenger Vehicles	879,457 [35]	5,374,023 [35]	564,180 [35]	8,195 [35]	111,000,000 [36]
B Light Trucks					138,000,000 [36]
C Medium & Heavy Weight Trucks	N/A	N/A	N/A	N/A	12,229,000 [36]

Total Sales during 2019

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	Total Sales*
Electric Bicycles	260,000 [37]	N/A	N/A	N/A	N/A
A Passenger Vehicles	216,030 [35]	400,746 [35]	76,000 [35]	1,970 [35]	5,304,000 [35]
B Light Trucks	26,000 [35]		7,809 [35]	36 [35]	11,609,000 [35]
C Medium & Heavy Weight Trucks	N/A	N/A	N/A	N/A	732,000 [35]
Totals (without bicycles)	**242,030**	**400,746**	**83,809**	**2,006**	**17,645,000**

Table key:
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
*Including both conventional and alternative technologies

Table 2:
Market-Price Comparison of Available BEVs in the U.S.

BEV	Untaxed, Unsubsidized Sales Price (USD)
BMW i3	$44,450
Chevrolet Bolt	$36,620
Fiat 500e	$33,460
Hyundai Ioniq	$33,045
Jaguar I-Pace	$69,850
Mercedes B250e	$42,400
Nissan Leaf	$31,600
Smart ED	$23,900
Tesla Model 3	$35,000
Tesla Model S 75D AWD	$76,000
Tesla Model X 75D AWD	$82,000

Table 3:
Market-Price Comparison of Available PHEVs in the U.S.

PHEV	Untaxed, Unsubsidized Sales Price (USD)
Audi A3 PHEV	$33,000
BMW 330e	$44,550
BMW 530e	$53,900
BMW 740e	$92,245
BMW i3 w/ Range Extender	$48,300
BMW i8	$147,500
BMW X5 xDrive 40e	$63,750
Cadillac CT6	$58,995
Chevrolet Volt	$33,520
Chrysler Pacifica Hybrid	$44,285
Ford Fusion Energi	$34,595
Honda Clarity PHEV	$33,400
Hyundai Ioniq	$33,045
Hyundai Sonata PHEV	$25,500
Kia Niro	$38,500
Kia Optima	$36,090
Mercedes C350e	$47,900
Mercedes GLC 350e	$51,900
Mercedes S560e	$109,750

PHEV	Untaxed, Unsubsidized Sales Price (USD)
Mini Countryman SE	$31,895
Mitsubishi Outlander PHEV	$36,295
Porsche Cayenne S-E	$81,100
Porsche Panamera 4 E-Hybrid	$103,800
Subaru Crosstek	$35,145
Toyota Prius Prime	$27,900
Volvo XC90 T8 PHEV	$59,745
Volvo XC60 PHEV	$40,150

CHARGING INFRASTRUCTURE OR EVSE

Table 4 provides an overview of the number of public charging stations in the U.S. by type including Level 1 and 2 chargers, fast chargers, and Tesla superchargers. It is seen that from 2018 to 2019, the overall EV charging infrastructure availability in the U.S. grew steadily. The total number of available stations grew from 22,659 to 25,041, or by 10%. This total increase reflects the respective 10% and 35% increases in the number of Level 2 and DC fast-charging stations, which more than offsets the 39% decrease in Level 1 charging stations. The average number of plugs at each station increased by 32% for Level 2 chargers and by 41% for DC fast chargers from 2018 to 2019.

Table 4: Information on charging infrastructure in 2019, excluding non-public charging stations. Numbers represent the total installed stations while those in parentheses indicate the total number of available plugs.

Source: : U.S. DOE AFDC, accessed March 30, 2020

Note: This is the total number of chargepoints installed to date rather than number newly installed annually

Number of Charging Stations

Chargers	2018	2019	Change
AC Slow Chargers (≤ 3.7 kW)	1,031 (2,029)	667 (1,492)	-39% (-26%)
AC Slow Chargers (>3.7 kW, ≤ 22 kW)	19,008 (48,818)	20,857 (64,333)	+10% (+32%)
Fast Chargers (> 22 kW, ≤ 43.5 kW)	2,620 (9,626)	3,537 (13,576)	+35% (+41%)
Superchargers (> 43.5 kW)	594 (5,413)	801 (7,638)	+35% (+41%)
Totals	**22,659 (60,535)**	**25,041 (79,401)**	**+10% (+31%)**

Figure 6 shows the state-level distribution of charging stations and EVSE plugs respectively for the U.S. California leads other states in the number of charging stations by an order of magnitude. This information is continuously collected by the U.S. DOE's Alternative Fuels Data Centre (AFDC), and published on its website.[38]

The Edison Electric Institute (EEI) and the Institute for Electric Innovation (IEI) estimated that 9.6 million charging ports will be required in the U.S. by 2030 to support EV sales. As shown in Figure 7, the vast majority of those will be needed for Level 2 home charging.[39]

Over the next 10 years, Volkswagen's subsidiary Electrify America will invest $2 billion in ZEV infrastructure, access, and education programs in the U.S. This investment results from Volkswagen's emissions tests software settlement with U.S. federal regulators for diesel vehicles.[40] Electrify America is currently implementing the Cycle 1 National ZEV Investment Plan and Cycle 1 California ZEV Investment Plans. Over its first 30-month investment cycle (January 2017-June 2019), it will invest in ZEV infrastructure, education, and access to support increased adoption of ZEV technology.[41] It currently has 55 installed stations and 252 available plugs.

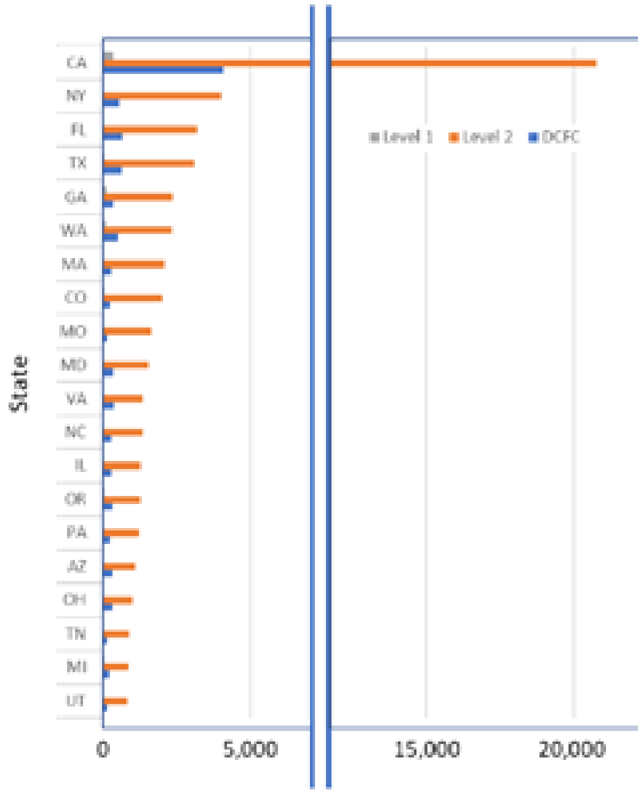


Figure 6: Number of EVSE plugs per U.S. State, grouped by charging level.

Source: U.S. DOE AFDC, accessed March 30,2020

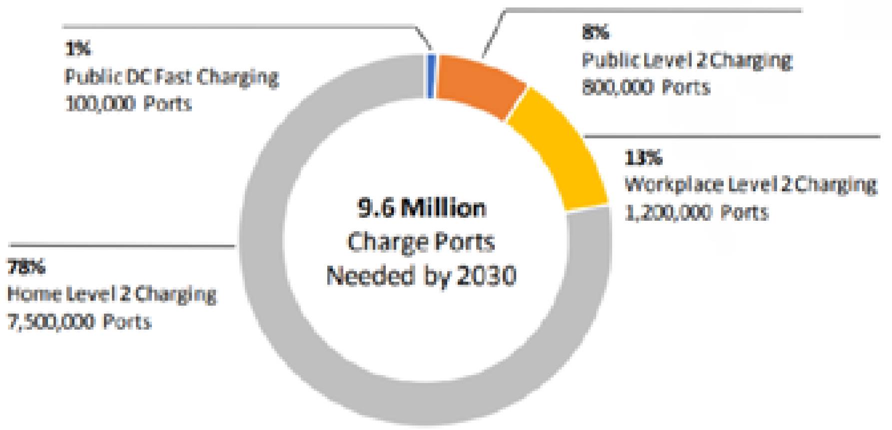


Figure 7: Projected EV charging infrastructure needs in 2030.

Source: EEI/IEI Forecast

OUTLOOK

California's transition to zero emission vehicles (ZEVs) will begin to save the state money by as early as 2030, according to a study by researchers at the Institute of Transportation Studies at the University of California, Davis (ITS-Davis). Although the transition will need to be rapid, and near-term costs and other barriers must be overcome, the report finds that reaching very low greenhouse gas emissions from road vehicles (cars and trucks) by 2050 appears feasible and ultimately cost-effective. Zero emissions vehicle versus business-as-usual scenarios. The study shows that the initial higher vehicle costs over the next decade in the ZEV scenario are eventually repaid through lower fuel costs, particularly for electric vehicles. After 2030, the cost savings from operating ZEVs will offset their higher initial capital costs.[42]

Another study by the research firm IHS Markit shows that U.S. demand for electric drive vehicles, including hybrids, could rise to 1.28 million by 2026, but most brands will have a low profit-margin on the new models. It forecasts that more than 130 models in the U.S. market, from 43 brands, will offer electrified propulsion systems, either pure battery electric or hybrid gasoline electric. But two-thirds of those sales will be registered by the top 10 brands, dominated by segment leader Tesla which will take up more than a quarter of those sales, according to IHS automotive analyst Stephanie Brinley. The remaining brands will account for an estimated 392,000 units, an average of just 11,900 cars per brand.[43]

Global sales of light, medium, and heavy duty PEVs are estimated to continue growing according to revised forecasts from Bloomberg New Energy Finance which forecasts that EVs will become cheaper to make than gasoline vehicles and will globally sell 30 million units in 2030.[44]

Electrification remains an integral feature of self-driving cars, as evidenced by ongoing test projects at Ford (currently testing it 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 other auto industry members. If this technology achieves the performance and cost claimed by its advocates and remains EV-based, the share of electrified vehicle miles travelled could increase substantially.

Footnotes

[1] U.S. Federal Highway Administration. "Traffic Volume Trends – December 2019," December 2019.

[2] Argonne National Laboratory, "Light Duty Electric Drive Vehicles Monthly Sales Updates".

[3] https://www.greencarcongress.com/2019/11/20191106-mustang.html

[4] https://www.greencarcongress.com/2019/11/20191114-vwev.html

[5] https://www.theverge.com/2019/12/5/20996866/gm-lg-ev-electric-vehicle-battery-joint-venture-chem-lordstown

[6] https://www.reuters.com/article/us-gm-electric/gm-to-invest-2-2-billion-at-detroit-factory-to-make-electric-trucks-suvs-idUSKBN1ZQ1LR

[7] https://www.greencarreports.com/news/1122244_chevrolet-bolt-ev-to-get-electric-sibling-with-michigan-plant-investment

[8] https://www.greencarcongress.com/2019/04/20190403-escape.html

[9] https://www.greencarcongress.com/2019/04/20190411-solidpower.html

[10] https://www.greencarcongress.com/2020/02/20200204-hq.html

[11] https://chargedevs.com/newswire/xalt-energy-launches-high-energy-density-battery-pack/

[12] https://www2.greencarreports.com/news/1124208_bmw-doubles-battery-production-in-us-for-coming-x3-and-x5-plug-in-hybrids

[13] https://www.greencarcongress.com/2020/02/20200205-ea.html

[14] https://chargedevs.com/newswire/electrify-america-to-deploy-commercial-robotic-chargers/

[15] https://www.theverge.com/2019/3/6/18253618/tesla-supercharger-250kw-v3-specs-location

[16] https://chargedevs.com/newswire/propel-fuels-to-launch-ev-charging-network-in-california/

[17] https://electrek.co/2019/05/20/chevron-ev-charging-gas-stations/

[18] https://www.energy.gov/articles/department-energy-announces-50-million-commercial-truck-road-vehicle-and-gaseous-fuels-0

[19] https://www.greencarcongress.com/2019/03/20190302-doe.html

[20] https://www.ttnews.com/articles/doe-announces-59-million-vehicle-technology-research

[21] https://www.greencarcongress.com/2019/04/20190410-zenlabs.html

[22] https://www.greencarcongress.com/2019/10/20191031-magna.html

[23] https://www.greencarcongress.com/2019/02/20190216-recell.html

[24] https://chargedevs.com/newswire/california-utility-offers-4000-purchase-incentive-for-used-phevs/

[25] https://chargedevs.com/newswire/californias-largest-airports-to-operate-only-zero-emission-shuttles-by-2035/

[26] https://www.ttnews.com/articles/carb-rule-would-set-sale-quotas-zero-emission-trucks

[27] https://electrek.co/2019/07/24/arizona-utilities-ev-projects/

[28] https://electrek.co/2019/07/25/florida-turnpike-charging-stations/

[29] https://www.ttnews.com/articles/new-jersey-gov-phil-murphy-signs-electric-vehicle-law

[30] https://electrek.co/2019/04/05/dems-energy-storage-credit/

[31] https://www.reuters.com/article/us-autos-electric-taxcredit-exclusive/exclusive-u-s-bill-to-boost-electric-car-tax-credits-could-rev-gm-tesla-idUSKCN1RM1NG

[32] https://www.reuters.com/article/us-usa-minerals-electric/u-s-senate-moves-forward-on-plan-to-develop-electric-vehicle-supply-chain-idUSKCN1SK0L7

[33] https://www.ttnews.com/articles/rep-debbie-dingell-introduces-electric-vehicle-bill

[34] Argonne National Laboratory, “Light Duty Electric Drive Vehicles Monthly Sales Updates“.

[35] Argonne National Laboratory, “Light Duty Electric Drive Vehicles Monthly Sales Updates“.

[36] Data from the Oak Ridge National Laboratory Transportation Energy Data Book: Edition 38, “Quick Facts”, January 2020. (Fleet data is for 2017)

[37] Estimate from the Light Electric Vehicle Association. Data is a 2017 estimate (latest available).

[38] U.S. DOE Alternative Fuels Data Center. Accessed March 30, 2020.

[39] Cooper, Adam, and Kellen Schefter. “Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030,” November 2018.

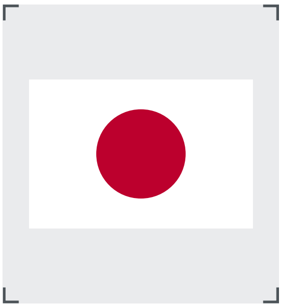
[40] “This is Volkswagen’s Plan to Electrify America.” AutoWeek. Accessed January 16, 2019.

[41] “Our Investment Plan.” Electrify America. Accessed January 16, 2019.

[42] https://www.greencarcongress.com/2019/09/20190927-zevs.html

[43] https://www.reuters.com/article/us-autos-electric-forecast/outside-of-tesla-future-ev-sales-in-u-s-may-be-thin-for-most-brands-study-idUSKCN1SZ20I

[44] Bloomberg New Energy Finance. “Electric Vehicle Outlook 2018.” Bloomberg NEF. Accessed January 22, 2019.



JAPAN

NON-MEMBER COUNTRY

MAJOR DEVELOPMENTS IN 2019

FUEL EFFICIENCY STANDARDS

Regarding passenger vehicles, to promote energy conservation and CO_2 emission reduction measures, the fuel efficiency standards were established with the target fiscal years being set at FY2010, FY2015 and FY2020, based on the Top Runner Program[1] under the “Act on the Rational Use of Energy” (Act No. 49 of 1979) (hereinafter referred to as “Energy Conservation Act”). In 2019, Japan set out the new goal for passenger vehicles targeting its success for 2030.

The scope of target vehicles of new fuel efficiency standards needs to include electric vehicles and plug-in hybrid vehicles which are expected to be substantially popularised in the future. Therefore, target vehicles of the new fuel efficiency standards shall include passenger vehicles fuelled by gasoline, diesel, or LPG as well as vehicles with engines powered by externally charged electricity that have a carrying capacity of up to 9 passengers or that have a carrying capacity of 10 or more passengers and a gross vehicle weight up to 3.5t.

Under the new fuel efficiency standards, electric vehicles and plug-in hybrid vehicles powered by externally charged electricity, in addition to vehicle fuelled by gasoline, diesel, or LPG, are included in the calculation of corporate average fuel efficiency. When evaluating the energy consumption of electricity-powered vehicles, it is necessary to take into consideration the electricity generation stage so that comparisons with vehicle fuelled by gasoline, diesel, or LPG can be made in a technologically neutral manner. Hence, under the new standards, the Well-to-Wheel (hereinafter referred to as “WtW”) approach is to be adopted for evaluating energy consumption efficiency, in lieu of the current Tank-to-Wheel (hereinafter referred to as “TtW”) approach.[2]

Fuel efficiency standard values (FE: km/L) are set as follows, depending on the vehicle weight (M: kg).

M: Less than 2,759 kg

$FE = -2.47 \times 10^{-6} \times M^2 - 8.52 \times 10^{-4} \times M + 30.65$

M: 2,759 kg or more

$FE = 9.5$

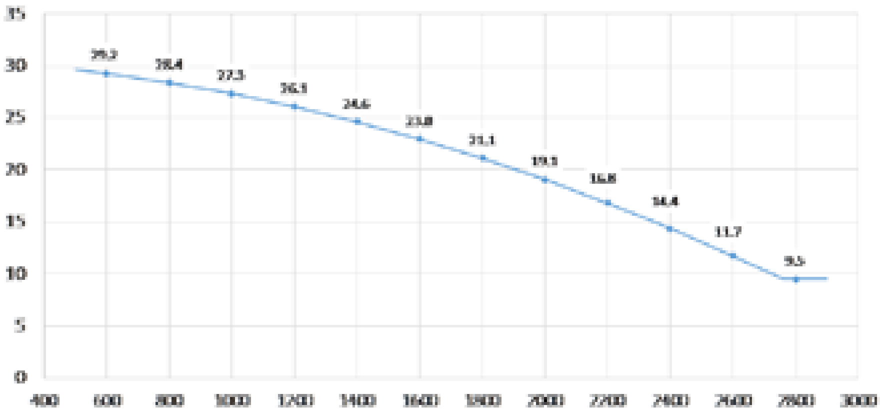
* FE value is rounded off to one decimal place.

[1] A program in which, for the “designated energy-consuming equipment, etc.” which especially needs to improve energy consumption performance, etc. among energy-consuming equipment, etc., the target standard values of energy consumption performance, etc. are set in consideration of forecast of future technological development based on products having best energy consumption performance, etc., and it requires manufacturers, etc. to achieve the standard.

[2] According to the GFEI’s working paper 20, 90% CO_2 reduction target can be achieved by incredible efforts by downstream (ICE improvement +EV penetration) with the upstream effort at grid. The combination of efforts at upstream and downstream would be key to achieving CO_2 reduction target. The WtW approach would balance the effort at upstream and downstream.

Figure 1:
X-Axis: Vehicle weight (kg)
Y-Axis: Fuel efficiency standard value (km/l)

The relational expression of fuel efficiency standard value and vehicle weight is shown below.



For the current fuel efficiency standards, the corporate average fuel efficiency standard method (CAFE method) has been introduced, with which an overall high energy conservation effect can be expected as manufacturers, etc. are able to flexibly select and concentrate technologies according to their own strengths and strategies. For the new fuel efficiency standards, the CAFE method shall also be adopted.

Assuming that the new fuel efficiency standards are achieved, the fuel efficiency in the target fiscal year (FY2030) is improved by 32.4% when compared to the actual value in FY2016.

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: up to 400,000 JPY (3,719 USD as of 4th March)
- PHEVs: up to 200,000 JPY (1,859 USD as of 4th March)
- CDVs: up to 150,000 JPY (1,394 USD as of 4th March)
- FCVs: up to 2,250,000 JPY (2,0922 USD as of 4th March)

TAXATION

EVs, PHVs, CDVs, and FCVs are exempt from paying “environmental performance excise” (which replaced automobile acquisition tax) (local tax: registered vehicles: 3 %; light motor vehicles: 2 %) and “motor vehicle tonnage tax” (national tax at 1st & 2nd inspection) and “automobile tax”(local tax: partial exemption).
HEVs are partially exempt from paying “environmental performance excise” (which replaced automobile acquisition tax) and “motor vehicle tonnage tax” and “automobile tax”.

HEVS, PHEVS, AND EVS ON THE ROAD

As of the end of FY2018, cumulative EVs/PHVs/FCVs sales were over 8.8 million in Japan. In 2019, there were about 1.55 million newly registered electric vehicles for passenger vehicles in Japan. Of this newly registered total sum, about 1.47 million were HEVs, about 21.3 thousand were EVs, about 17.6 thousand were PHEVs, and about 700 were FCVs.

Table 1

Table key:
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

Fleet Totals as of December 31st 2019 (thousands)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	0	0	0	0	0
B Passenger vehicles	105.9	8331.4	122.0	3.0	6214.1
C Buses and Minibuses	1.4	19.6	0	0	22.4
D Light Commercial vehicles	N/A	N/A	N/A	N/A	N/A
E Medium and Heavy Weight Trucks	N/A	N/A	N/A	N/A	N/A

Table 2

Table key:
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

Total Sales During 2019 (thousands)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	N/A	N/A	N/A	N/A	N/A
B Passenger vehicles	21.3	1472.3	17.6	0.7	4301.1
C Buses and Minibuses	N/A	N/A	N/A	N/A	N/A
D Light Commercial vehicles	N/A	N/A	N/A	N/A	N/A
E Medium and Heavy Weight Trucks	N/A	N/A	N/A	N/A	N/A

CHARGING INFRASTRUCTURE OR EVSE

The Ministry of Economy, Trade, and Industry (METI) has provided support for charging infrastructure by a subsidy of "Promotion Project to Develop Charging Infrastructure for Next-generation Vehicles". As of the end of 2019, over 30,000 public charging stations, including over 7,800 quick chargers were installed in Japan. Many private companies such as four Japanese car manufacturers' joint company[3] take an active role in installing quick chargers and normal chargers in response to the government goals.

[3] 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.

In addition, Japan and China agreed to develop a new, common standard on battery chargers in 2018 and the new common standard ChaoJi is under development until 2020.

Table 3

Type of Public EVSE	Number of Charging Points
AC Slow Chargers (≤ 3.7 kW) AC Slow Chargers (>3.7 kW, ≤ 22 kW)	22,536
Fast Chargers (> 22 kW, ≤ 43.5 kW)	7,858
Superchargers (> 43.5 kW)	Data unavailable
Inductive Chargers	Data unavailable

EV DEMONSTRATION PROJECTS

In July 2019, METI launched Council for Electrified Vehicle Society (CEVS) and started discussions on policy support and institutional development to improve the economics of electric vehicles. Its scope includes; efforts to use electric vehicles for power supply and demand adjustment, use of the V2H function as an emergency power source in the event of a disaster, methods for visualising the remaining capacity of used EV batteries, and reuse and recycling initiatives.

Providing an Information Guideline of in-vehicle battery performance is being formulated as one of the outcomes of the Council. The Guideline is designed to facilitate automakers to provide the basic methods which enable users to know the state of health of LIB, so that users can get rid of excessive anxiety over battery degradation and re-sale values of EVs (Electric vehicle) and PHVs (Plug-in Hybrid Electric vehicle) can be evaluated properly.

A utilisation promotion manual of electrified vehicles at the time of a disaster is provided as another one of the outcomes of the Council. It provides the information about the specification and performance of electrified vehicles as battery supplies and the power supplies connecting vehicle outlets to electrical appliances.

OUTLOOK

In April 2018, METI launched a Strategic Commission for the New Era of Automobiles. Since then, the commission has been holding discussions on strategies that the Japanese automobile industry, amid dramatic changes in business environments surrounding automobiles, should take to lead global innovations and proactively contribute to solutions to global issues including climate change. In August 2018, METI released an interim report based on the commission's discussion results. The report set a long-term goal that Japan should achieve by 2050, including:

- Advance the shift of vehicles produced by Japanese automakers in global markets to xEVs (electrified vehicles, including EVs, HEVs, PHEVs, FCVs)
- Bring about environmental performance at the world's highest level and contribute to realising a "Well-to-Wheel Zero Emission" policy (to reduce emissions of a vehicle's total emissions footprint to zero, from fuel and power production to automobile operation).

SECTION D

CONTACT INFORMATION

ieahev.org

EXECUTIVE COMMITTEE

CANADA

CHAIRPERSON & COUNTRY REPRESENTATIVE
Carol Burelle
Natural Resources Canada,
Office of Energy R&D
carol.burelle@canada.ca

AUSTRIA

Andreas Dorda
BMK
andreas.dorda@bmk.gv.at

Walter Mauritsch
AustriaTech
Mobility Innovation
walter.mauritsch@austriatech.at

BELGIUM

Carlo Mol
VITO
carlo.mol@vito.be

Daan Six
VITO
daan.six@vito.be

CHINA

Rujie Yu
China Automotive Technology & Research Center (CATARC)
yurujie@catarc.ac.cn

DENMARK

Michael Rask
Raskgreentech ApS
mr@raskgreentech.dk

FINLAND

Mikko Koskue
Business Finland
mikko.koskue@businessfinland.fi

FRANCE

Maxime Pasquier
ADEME
Service Transports et Mobilité
maxime.pasquier@ademe.fr

Ariane Rozo
ADEME
Service Transports et Mobilité
ariane.rozo@ademe.fr

GERMANY

Matthias Laske
Forschungszentrum Jülich GmbH
Project Management
m.laske@fz-juelich.de

Stephen Schmid
DLR - German Aerospace Center
Institute of Vehicle Concepts
stephan.schmid@dlr.de

IRELAND

Graham Brennan
Sustainable Energy Authority of Ireland
Sustainable Transport
graham.brennan@seai.ie

Declan Meally
Sustainable Energy Authority of Ireland
Energy Demand Management
declan.meally@seai.ie

ITALY

Francesco Vellucci
ENEA
Casaccia Research Centre DTE-PCU-STMA
francesco.vellucci@enea.it

NETHERLANDS

Sonja Munnix
Netherlands Enterprise Agency
sonja.munnix@rvo.nl

NORWAY

Andreas Bratland
Research Council of Norway
abr@rcn.no

REPUBLIC OF KOREA

Ock Taeck Lim
University of Ulsan
School of Mechanical and Automotive Engineering
otlim@ulsan.ac.kr

SPAIN

Isabel del Olmo
IDAE - Institute for the Diversification and Saving of Energy
Department of Transport
isabel_delolmo@idae.es

Juan Larrazábal
IDAE - Institute for the Diversification and Saving of Energy
Department of Transport
jlarrazabal@idae.es

SWEDEN

Peter Kasche
Swedish Energy Agency
Department for Energy Technology
peter.kasche@energimyndigheten.se

Mikael Fjallström
Swedish Energy Agency
mikael.fjallstrom@energimyndigheten.se

SWITZERLAND

Stephan Walter
Swiss Federal Office of Energy (SFOE)
stephan.walter@bfe.admin.ch

TURKEY

Ahmet Avsar
TÜBITAK RUTE (Rail Transport Technologies Institute)
ahmet.avsar@tubitak.gov.tr

UNITED KINGDOM

Tim Ward
Department for Transport
Office for Low Emission Vehicles
tim.ward@olev.gsi.gov.uk

UNITED STATES

David Howell
US Department of Energy
david.howell@ee.doe.gov

Steven J. Boyd
U.S. Department of Energy
Office of Vehicle Technologies
steven.boyd@ee.doe.gov

SUPPORT

SECRETARY
James Miller
Argonne National Laboratory
USA
james.miller@anl.gov

OPERATING AGENTS

TASK 01
Kate Palmer
Urban Foresight
United Kingdom
kate.palmer@UrbanForesight.org

TASK 23 (OA)
Hannes Neupert
EnergyBus e.V. / EnergyBus
Germany
hannes.neupert@EnergyBus.org

TASK 23 (CO-OA)
Carlo Mol
VITO
Belgium
carlo.mol@vito.be

TASK 26
Burak Ozpineci
Oak Ridge National Laboratory
USA
burak@ornl.gov

TASK 30
Gerfried Jungmeier
Joanneum Research
Forschungsgesellschaft mbH
Austria
gerfried.jungmeier@joanneum.at

TASK 32

Stephen Schmid
DLR - German Aerospace Center
Institute of Vehicle Concepts
stephan.schmid@dlr.de

TASK 33

Gerfried Jungmeier
Joanneum Research
Forschungsgesellschaft mbH
Austria
gerfried.jungmeier@joanneum.at

TASK 34

David Howell
US Department of Energy
david.howell@ee.doe.gov

TASK 35

Ock Taeck Lim
University of Ulsan
School of Mechanical and
Automotive Engineering
otlim@ulsan.ac.kr

TASK 37

Steven J. Boyd
U.S. Department of Energy
Office of Vehicle Technologies
steven.boyd@ee.doe.gov

TASK 39

Carlo Mol
VITO
carlo.mol@vito.be

TASK 40 (OA)

Bert Witkamp
Valuad
Belgium
b.witkamp@valuad-expert.com

TASK 40 (CO-OA)

Stephen Schmid
DLR - German Aerospace Center
Institute of Vehicle Concepts
stephan.schmid@dlr.de

TASK 41

Özcan Deniz
DLR - German Aerospace Center
Institute of Vehicle Concepts
Germany
oezcan.deniz@dlr.de

TASK 42

Kate Palmer
Urban Foresight
United Kingdom
kate.palmer@UrbanForesight.org

ieahev.org