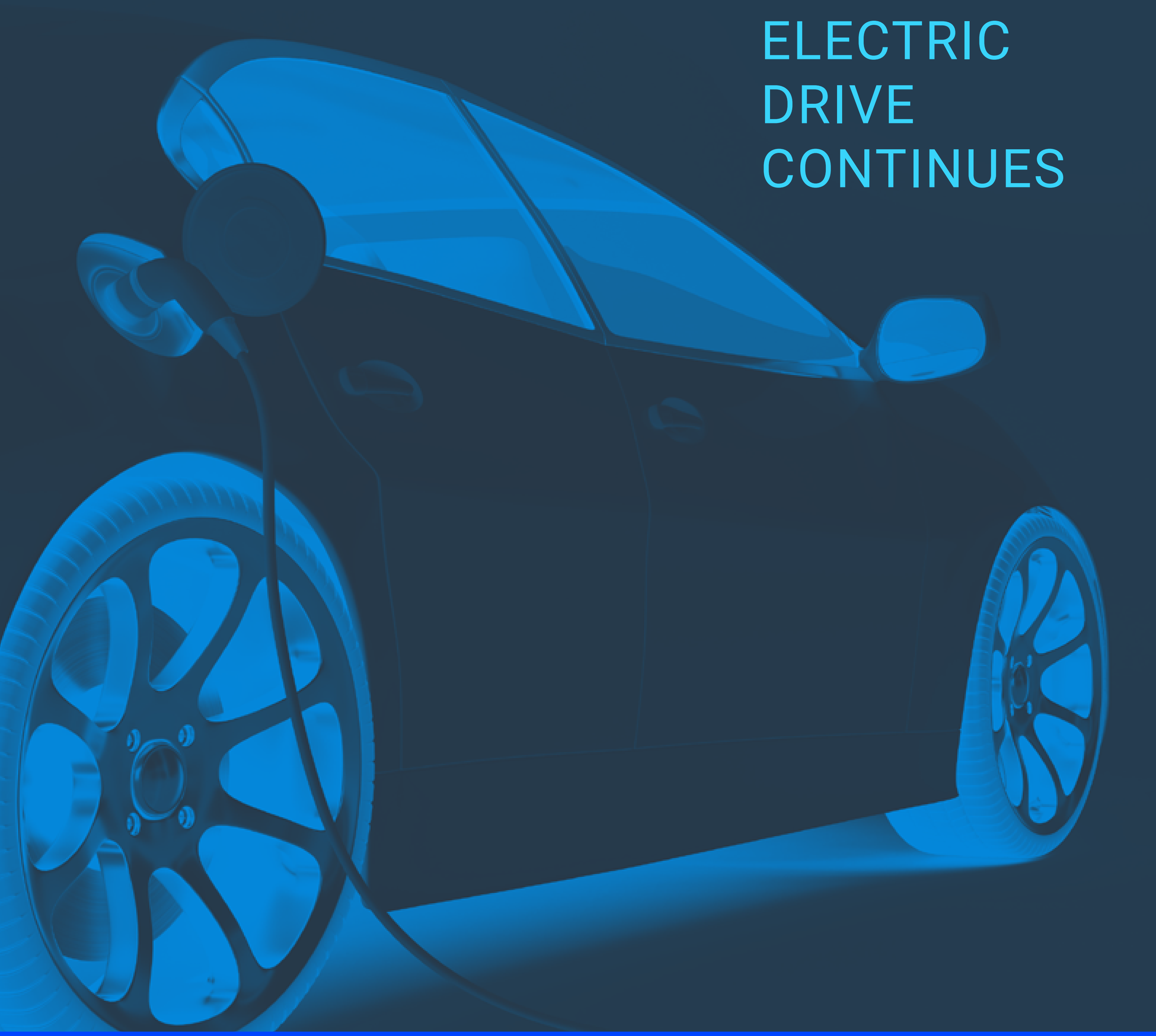
Annual Report 2021

THE ELECTRIC DRIVE CONTINUES



Technology Collaboration Programme
by iea

HEV TCP ANNUAL REPORT 2021

This is the 2021 Annual report for the HEV TCP – an international collaboration of 18 countries exploring cutting-edge questions in hybrid and electric vehicles. This report sets out the background to the partnership, gives updates on ongoing projects and on member countries' work, and gives a set of contact details for more information.

hevtcp

iea International Energy Agency

ieahev.org

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.

Editors

Kate Palmer, Task 1 OA
Urban Foresight

Lauren Kersley
Urban Foresight

Miles Prescott
Urban Foresight

Gordon Hector
Urban Foresight

Designer

Ismail Hewitt
Urban Foresight

Contributing Authors

AUSTRIA
Mauritsch Walter, Austria Tech
Gerfried Jungmeier, Joanneum Research
Andreas Dorda, BMK

BELGIUM
Carlo Mol, VITO
Bert Witkamp, Valuad

CANADA
Carol Burelle, Formerly Natural Resources Canada
René-Pierre Allard, Natural Resources Canada

CHINA
Rujie Yu, CATARC
Huanhuan Ren, CATARC
Chuan Chen, CATARC
Chunjia Ran, CATARC
Zelei Jiang, CATARC
Longze Cong, CATARC

DENMARK
Michael Rask, Heliac

FINLAND
Mikko Koskue, Business Finland

FRANCE
Ariane Rozo, ADEME
Jérémie Almosni, ADEME

GERMANY
Hannes Neupert, EnergyBus e.V
Stephan Schmid, DLR
Özcan Deniz, DLR
Matthias Laske, FZ Jülich

IRELAND
Graham Brennan, SEAI
Declan Meally, SEAI

ITALY
Francesco Velluci, ENEA

THE 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, University 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

SWITZERLAND
Luca Castiglioni, BFE
Stephan Walter, BFE

UNITED KINGDOM
Tim Ward, OZEV
Kate Palmer, Urban Foresight

UNITED STATES
Steven Boyd, US Department of Energy
David Howell, US Department of Energy
James F. Miller, Argonne National Laboratory
Aymeric Rousseau, Argonne National Laboratory
Burak Ozpineci, Oak Ridge National Laboratory
P T Jones, Oak Ridge National Laboratory

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SECTION A

Introduction

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 great pleasure of introducing the 2021 Annual Report.

The work of the HEV TCP has continued to make progress, despite these challenging times of the global pandemic. The HEV TCP Executive Committee (ExCo) continued to meet in 2020 but only virtually. In most cases, the work of the various tasks also advanced with virtual meetings and workshops. Several major studies were completed, and books and reports were published with the findings.

The EV market performed much better than that of conventional vehicles in 2020. As shown in Figure 1, the first six months of 2020 mostly saw reductions in monthly sales of plug-in vehicles compared to 2019. However, July to December 2020 saw significant increases in monthly EV sales, resulting in an overall annual increase of 43% globally, according to preliminary results presented by EV-volumes.com. This over a period when global sales of conventional vehicles decreased by 14%.[1]

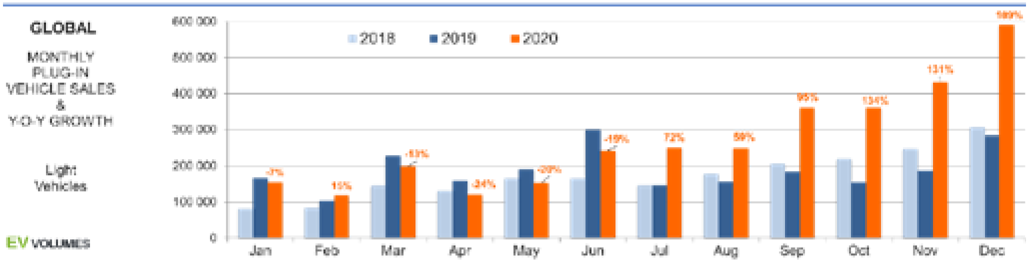


Figure 1: Global Monthly Plug-In Vehicle Sales & Y-O-Y Growth[2]

This is in line with EV sales data reported by HEV TCP member countries, representing an overall increase in passenger EV sales of 41% for 2020 over 2019. However, this development was not observed uniformly across the globe, and significant differences in performance were seen for Europe, Asia and North America. HEV TCP member countries in Europe saw a total overall increase in sales of 147%, member countries in Asia a total overall increase of 9%, and member countries in North America a total overall decrease of 8% compared to 2019. The electrification of transportation is essential to meet a clear commitment to become carbon neutral by 2050, and this performance in the second half of 2020 is a welcome boost to get us on the path.

The next ExCo meeting will again be virtual and is scheduled for May 2021. It remains to be seen when the present COVID-19 situation will improve enough to allow for a face-to-face meeting. I am hopeful that that time will come soon, but we must remain diligent as our health and safety is our greatest priority.

ACKNOWLEDGEMENTS

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 Sonja Munnix (the Netherlands) and Ock Taeck Lim (South Korea) for their support as Deputy Chairs, as well as to the team at Urban Foresight (Kate Palmer, Gary McRae, Ismail Hewitt) for their excellent work with Task 1, including the light rebranding and website modernization in their first year.

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 also goes out to the Operating Agents running the Tasks for their excellent leadership and hard work in keeping things going during the past year, as well as to the Task participants for their continued involvement.

Lastly yet importantly, I wish to thank the member country delegates and observers for their continued 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

REFERENCES

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

[2] Ibid

Executive Summary

By the end of 2020, the number of EVs on the road exceeded 10 million for the first time.

By the end of 2020, the number of EVs on the road exceeded 10 million vehicles. EV registrations increased by 41% in 2020 compared to 2019, despite the COVID-19 pandemic impacting vehicle manufacture and sales across the globe. In 2020, nearly 5% of new car sales were EVs which equates to approximately 3 million new EVs on the road. HEV TCP member countries represented approximately three quarters of these EV registrations in 2020. The IEA have attributed this resilience to supportive regulatory frameworks, additional incentives, and increasing numbers of EV models.

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. In 2020, the 19 countries that are currently members have continued to actively participate in tasks and pursue their transport electrification agenda.

The TCP currently manages a total of 14 Tasks (see Table below for details). No new tasks were initiated in 2020. In 2020, the TCP closed the following Tasks, for which final reports (where indicated) are available for download on the HEV-TCP website at www.ieahev.org:

- Task 33: Battery Electric Buses
- Task 36: Consumer Adoption and Use of EVs

Based on the work conducted under the HEV TCP, three books were published.

- Published a book on Task 36 results, "Who's Driving Electric Cars: Understanding Consumer Adoption and Use of Plug-in Electric Cars", M. Contestabile, G. Tal, and T. Turrentine (eds), Springer, 2020.

- Published "Small Electric Vehicles: An International View on Light Three- and Four-Wheelers", Amalie Evert et al, Springer, 2021. (based on Task 32)

- Released "3rd EV City Casebook and Policy Guide: Scaling Up to Mass Adoption", Urban Foresight, March 2021 (based on Task 42)

The following table provides a summary of the tasks in this report..

Task	Country Participants	Status	Period	Objectives
Task 23 **Light-Electric-Vehicle Parking and Charging Infrastructure**	Spain, Germany, Belgium, Turkey	Ongoing	Jan 2013 - Present	To represent the interests of local governments in the standardisation of Light Electric Vehicle system architectures, infrastructure, communications and interchangeable batteries.
Task 29 **Electrified, Connected and Automated Vehicles**	Austria, Germany, USA	Ongoing	Jan 2016 - Present	Analyse the potential technological synergies of electrification, connectivity and automation of road vehicles and derive research, development and standardisation needs.
Task 30 **Assessment of Environmental Effects of Electric Vehicles**	Austria, Canada, Germany, Spain, South Korea, Turkey, USA	Ongoing	April 2016 - Present	To analyse and assess the environmental effects of EVs on water, land use, resources, and air-based in an LCA.
Task 32 **Small Electric Vehicles**	Germany, Switzerland, Republic of Korea, Belgium, United Kingdom	Ongoing	April 2016 - Present	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 to develop the market conditions and mobility concepts further.
Task 34 **Batteries**	Canada, Germany, Sweden	Ongoing	April 2016 - Present	To encourage the sharing and dissemination of current information about battery topics of interest to the vehicle community.
Task 35 **Fuel Cell Electric Vehicles**	Austria, Republic of Korea	Ongoing	Jan 2017 - Present	To analyse the technology required for FCVs and hydrogen stations and to disseminate the policy of FCVs and hydrogen station.
Task 37 **Extreme Fast Charging**	USA	Ongoing	Jan 2017 - Present	To investigate station siting, quantify the costs of installation, document grid connection details, understand the implications of XFC on battery design, performance, and cost, and study consumer education methods and topics.

Task	Country Participants	Status	Period	Objectives
Task 38 **Marine Application (e-ships)**	Canada, China, Norway.	Restarted in 2021	Oct 2017 - Present	To provide an overview and encourage the development and deployment of e-Ships, by building and sharing key knowledge on projects, performance, segments, and demand.
Task 39 **Interoperability of e-mobility services**	Belgium, Canada, France, Spain, Switzerland, The Netherlands, United States	Ongoing	Jan 2018 - Present	To bring together experts from member countries to share information and best practices to improve the interoperability and accessibility of charging services.
Task 40 **CRM4EV: Critical Raw Materials for EVs**	Austria, France, Germany, Netherlands, Norway, Republic of Korea, Spain, Sweden, USA, UK;	Ongoing	April 2018 - Present	To build a global representative network on the topic "Critical Materials for EVs" with stakeholders from administrations, industry, policymakers, researchers, and other relevant stakeholders representing the different value chains of the identified "in-scope" critical materials.
Task 41 **Electric Freight Vehicles**	Austria, Germany, Switzerland, Turkey and United Kingdom.	Ongoing	April 2019 - Present	To monitor progress and review relevant aspects for a successful introduction of electric freight vehicles (EFV) into the market.
Task 42 **EV City Casebook**	Canada, Denmark, Germany, The Netherlands, United Kingdom	Closed	Nov 2018 – Mar 2021	To collect learnings and best practices from existing and planned large scale deployments of EVs around the world.

Task	Country Participants	Status	Period	Objectives
Task 43 **Vehicle-Grid Integration**	Belgium, Canada, Denmark, France, Germany, Ireland, Italy, the Netherlands, Republic of Korea, Spain, Switzerland, United Kingdom, United States	Ongoing	April 2019 - Present	To explore, identify, and give answers to the gaps preventing electric vehicles to be fully integrated into the electrical grid.
Task 45 **Electrified Roadways (E-Roads)**	USA, Norway, The Netherlands, Switzerland	Ongoing	Jan 2021 - Present	To develop a greater global understanding and awareness of ERoads, related deployment activities, and technologies developed to advance electric mobility.

In other news, the HEV TCP undertook a brand update where the logo, fonts and related design were updated. Our new logo is proudly displayed on the front of this annual report. Additionally, a HEV TCP newsletter was published in December, showcasing policy and deployment updates from selected member countries, this is available on the HEV TCP website. The next edition of this biannual newsletter will be released in June 2021, all contributions are welcomed.

The November 2020 meeting of the HEV TCP ExCo was planned to take place in Dundee, UK, around the same time as COP 26. Instead, the HEV TCP had its first fully virtual ExCo in November 2020, where we welcomed China to their first ExCo. Due to the increased accessibility this event was even better attended than non-virtual events. Without a host country, the knowledge sharing day focused on policy updates from several member countries with a great introduction to global EV developments in 2019/20 from Aleksandra O'Donovan (Bloomberg New Energy Finance).

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).

IEA TECHNOLOGY COLLABORATION PROGRAMMES

The IEA 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 38 TCPs covering fossil fuels, renewable energy, efficient energy use (in buildings, electricity, industry and transport), fusion power, and two cross-cutting TCPs dealing with technology systems modelling and women in energy. The TCP for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (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 TCPs have shown that they contribute significantly to achieving faster technological progress and innovation at a lower cost. Such international co-operation helps to eliminate technological risks and duplication of effort while facilitating processes, such as harmonisation of standards. Special provisions are applied to protect intellectual property rights.

The "IEA Framework for the Technology Collaboration Programme" defines the minimum set of rights and obligations of participants in IEA TCPs. Participants are welcomed from IEA member and non-member countries, the private sector, and international organisations.

Participants in TCPs fall into two categories: Contracting Parties and Sponsors.

- **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 Commission. Contracting Parties from OECD non-member countries or international organisations 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.

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 carry out their share of the work.

3. Combinations of cost and task sharing (such as in the case of the HEV TCP).

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

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 a range of technologies currently exist 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 18 active Contracting Parties (member countries) as of May 2021 are Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Ireland, Italy, The Netherlands, Norway, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, and the 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. 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 2020 and in early 2021 are described in part B of this report. The activities associated with hybrid and electric vehicles in individual HEV TCP member countries can be found in part C.

The next three subsections briefly report on HEV TCP activities and results in the different phases of operation. The strategy for the current term of operation, Phase 6 (2020-25), and its details are reported after these sections.

DESCRIPTION AND ACHIEVEMENTS OF HEV TCP

Phase 2, 1999-2004

Phase 2 of the HEV TCP started in November 1999 at a time when the first hybrid vehicle – the Prius – had just been introduced to the market, and battery electric vehicles were 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
- Task 8: Deployment strategies for hybrid, electric, and alternative fuel vehicles
- Task 9: Clean city vehicles
- Task 10: Electrochemical system

Phase 3, 2004-2009

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 the ongoing importance of 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 contains 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 Vehicle

Phase 4, 2009-2015

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 remained 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 17: System Optimization and Vehicle Integration - to study how EV system configurations (including vehicle components) could be optimized for enhanced overall EV performance
- Task 18: EV Ecosystems - to create a roadmap of the conditions required to support market growth needed for the mass adoption of EVs in cities
- Task 19: Life Cycle Assessment of EVs - to explore the sustainable manufacture and recycling of EVs
- Task 20: Quick Charging - to discuss the impacts and potential standards for EV quick charging
- Task 21: Accelerated Ageing Testing for Li-ion Batteries - for collaboration on such testing efforts
- Task 22: E-Mobility Business Models - to understand new revenue opportunities and ways to limit costs associated with EVs, recharging infrastructure, and associated links to energy systems
- Task 23: Light Electric Vehicle Parking and Charging Infrastructure
- Task 24: Economic Impact Assessment of E-Mobility

Phase 5, 2015-2020

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 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

Phase 6, 2020-2025

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 policy/decision makers in governmental bodies at national, regional and city levels, in the automotive industry, its component suppliers and utilities as the target audience for its work. These include the HEV TCP Contracting Parties, which are representing national governments. The HEV TCP mission is 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 (RD&D), demonstration and deployment projects; identifying future research areas; fostering the international exchange of information and experiences; and identifying and removing barriers.

Against this background and to fulfil its mission, the HEV TCP Executive Committee 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 www.cleanenergyministerial.org/initiative-clean-energy-ministerial/electric-vehicles-initiative and www.iea.org/areas-of-work/programmes-and-partnerships/electric-vehicles-initiative) 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 2021, governments currently active in the EVI include Canada, Chile, China, France, Germany, Finland, India, Japan, the Netherlands, New Zealand, Norway, Poland, Portugal, Sweden, and United Kingdom. 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 EVI Global Pilot City Programme (EVI-PCP), As one of the main pillars of the EV30@30 Campaign, the EVI-PCP aims to build a network of at least 100 cities over an initial period of 5 years, to work together on the promotion of electric mobility. In March 2021, EVI collaborated with the HEV TCP to release the

EV City Casebook and Policy Guide

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)
- Urban Foresight

The HEV TCP and the EVI worked 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 1

Information Exchange

INTRODUCTION

Information exchange is at the core of HEV TCP's work (formerly IA-HEV), enabling members to share key policy insights and best deployment practices, as well as to identify common research interests in the rapidly growing international hybrid and electric vehicle field. Task 1 began in the first phase of HEV TCP in 1993 and continues as the main forum and portal for announcing news and results to the broader International Energy Agency (IEA) community.

The HEV TCP strategic plan for phase 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." Key HEV TCP objectives include:

- 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 meetings. Country delegates also write country-specific information for HEV TCP publications, such as the country chapters in this annual report. Many country delegates also serve dual roles as the official Operating Agent for a specific Task. In this role, they may also represent HEV TCP to a public audience by presenting Task results at international conferences, such as the EVS (Electric Vehicle Symposium) meetings.

The Task 1 Operating Agent (OA) is responsible for coordinating and leading the bi-annual experts' meetings, compiling the minutes of these meetings, maintaining the HEV TCP website, and editing and supervising the production of the newsletter and the Executive Committee (ExCo) annual report. The OA also acts as liaison to the other Task OAs, the ExCo Chair (together with the Secretary-General), and the IEA Desk Officer. Since the 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 2020 included the following:

- The HEV TCP logo and branding were updated and finalised in February 2021.
- The HEV TCP Annual Report on 2019 entitled The Electric Drive Scales Up was published in 2020. A complete redesign of the report was carried out to make it more aesthetically pleasing and engaging to readers.
- The members website was migrated onto a Sharepoint site in July 2020 to allow for easier access and upload of files.
- A proposal was put forward and accepted by the ExCo in October 2020 to update

the HEV TCP external-facing website. The ExCo agreed the new site would contain information on Tasks and members countries as an invaluable resource for those new to the HEV TCP as well as those looking for up to date information of the status and results of tasks.

NEXT STEPS

With Urban Foresight's continued responsibility for Task 1, there are a range of planned improvements to communications:

- The external-facing website is being 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.
- The biannual HEV TCP Newsletter was instated and will continue through 2021. The first issue was released in winter 2020 and we welcome any contributions from HEV TCP members for the next issues in Summer 2021.

Talks have started regarding the organisation of the HEV TCP ExCo meeting in Dundee (Scotland) in November 2021.

FOR FURTHER INFORMATION, PLEASE CONTACT THE OPERATING AGENT

Dr. Kate Palmer
Urban Foresight
Flour Mill, 34 Commercial Street,
Dundee, DD1 3EJ
United Kingdom

kate.palmer@urbanforesight.org

TASK 30

Assessment of Environmental Effects of Electric Vehicles

MEMBER COUNTRIES
AUSTRIA
CANADA
GERMANY
SPAIN
REPUBLIC OF KOREA
TURKEY
USA

ACKNOWLEDGEMENT
The work of the Austrian participation (2018 – 2022) is financed by the Austrian Climate and Energy Fund and the FFG.

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 include the whole value chain and - if relevant - interactions from recycling in the dismantling phase to the production phase, if recycled material is used to produce new vehicles.

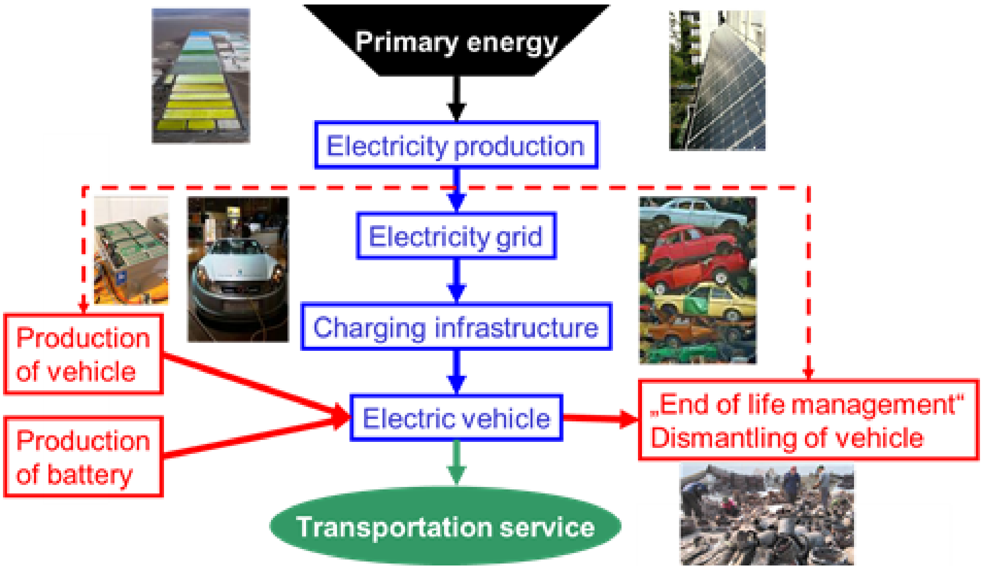


Figure 1: System boundaries for life cycle assessment of EVs

OBJECTIVES

The aim of Task 30 (2016 – 2021) is to analyse and assess the environmental effects of EVs on water, land use, resources, and air-based in an LCA in cooperation with the participating countries in the International Energy Agency (IEA) TCP.

Task 30 is using the results of the completed Task 19 "Life Cycle Assessment of Electric Vehicles" (2011 – 2015, www.ieahev.org/tasks/task-19-life-cycle-assessment-of-evs/, led by JOANNEUM RESEARCH) as a foundation to subsequently examine the environmental effects – benefits and impacts - of vehicles with an electric drivetrain

(EVs), based on LCA. Looking at the three phases of LCA - production, operation, and dismantling of EVs, the 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) on one hand and conventional internal combustion engine (ICE) vehicles using gasoline and diesel on the other hand.

In recent years, the focus on 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 particle matter (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, wastewater, “Water Footprint” of EVs),
- effects on EVs on the 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), and
- overall environmental effects and their assessment (comparing and assessing different impact categories, single score methodologies, stakeholder involvement).

WORKING METHOD

Within Task 30, methodologies are developed to help countries implement EVs by identifying possibilities to maximise environmental benefits. Furthermore, various case studies are analysed and networking combined with information exchange is supported within the Task’s frames (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 personnel and stakeholders and their involvement,
- communicating strategies to stakeholders, and
- summarising further R&D demand.

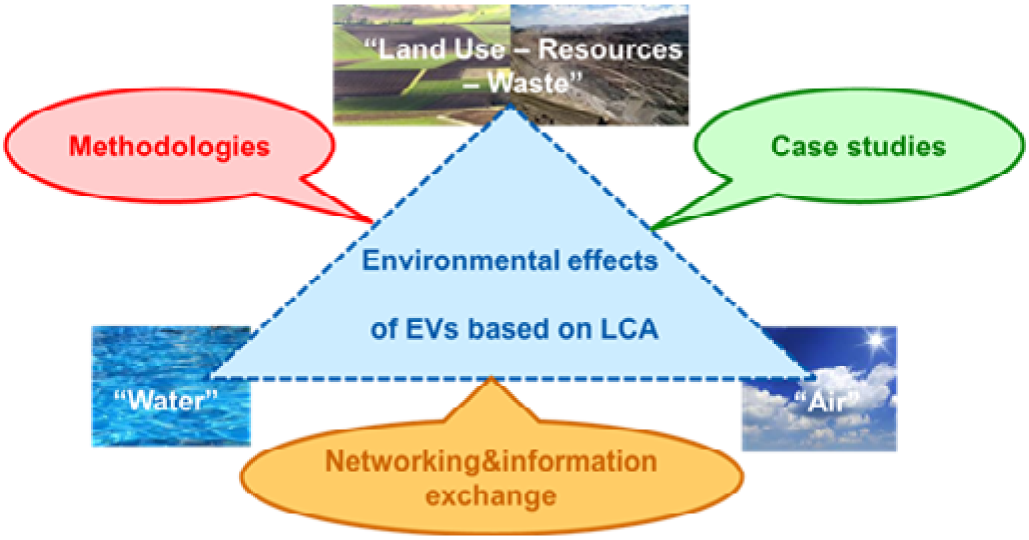


Figure 2: Working method in Task 30

RESULTS

After describing the expected final results the actual results are given on

- a new publication on the LCA of batteries,
- issues on dynamic LCA of vehicle fleets,
- LCA of supplying additional renewable electricity – with the example of Austria, and
- GHG emissions of BEV introduction in Austria.

Expected final results

The members in Task 30 compiled a list of environmental benefits and impacts of EVs with a goal of increasing their overall acceptance by providing facts and figures on the environmental effects of EVs. Thus, numerous advantages of EVs compared to conventional vehicles are shown. These results help the industry and government to support the further development and deployment of EVs in all transport modes. The results document and summarise the state of current knowledge and future challenges (including methodologies and case studies) on:

- effects of EVs on water,
- effects of EVs on air,
- effects of EVs 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) were also made available.

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

New publication on LCA of batteries

Task 30 collected LCA studies on automotive batteries. Afterwards, 50 publications were compiled from the years 2005–2020 about the LCA of Li-ion batteries to assess the environmental effects of production, use, and end of life for application in EVs, Figure 3 shows the different steps in the life cycle of batteries. Investigated LCAs showed that for the production of a battery pack per kWh battery capacity (bc), a median of 280 kWh/kWh_bc (25%-quantile–75%-quantile: 200–500 kWh/kWh_bc) for the primary energy consumption and a median of 120 kg CO2 eq/kWh_bc (25%-quantile–75%-quantile: 70–175 kg CO2-eq/kWh_bc) for GHG emissions. Task 30 expects that the results for current batteries are in the lower range. Over the lifetime of an electric vehicle, these emissions relate to 20 g CO2-eq/km (25%-quantile–75%-quantile: 10–50 g CO2-eq/km). Considering recycling processes, GHG savings outweigh the negative environmental impacts of recycling and can reduce the life cycle GHG emissions by a median value of 20 kg CO2-eq/kWh_bc (25%-quantile–75%-quantile: 5–29 kg CO2-eq/kWh_bc). Overall, many LCA results overestimated the environmental impact of cell manufacturing, due to the assessments of relatively small or underutilised production facilities. Material emissions, such as from mining and especially processing from metals and the cathode paste, could have been underestimated, due to process-based assumptions and non-regionalised primary data. Second-life applications were often not considered.

The publication "Environmental Life Cycle Impacts of Automotive Batteries Based on a Literature Review" is published in Energies 2020, 13(23), 6345; (www.doi.org/10.3390/en13236345).

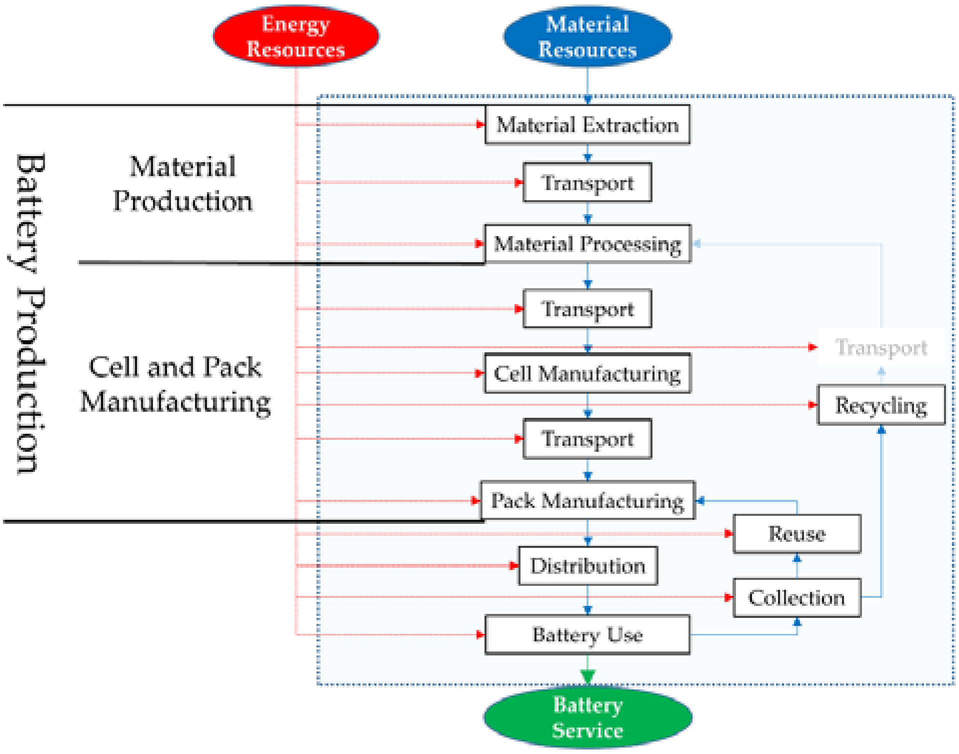


Figure 3: The life cycle of batteries (taken from publication)

Issues on dynamic LCA of vehicle fleets

Issues on dynamic LCA, e.g. annual environmental effects, become relevant for the rapid increase of EV-fleets combined with an additional generation of renewable electricity. For this, the Task identified the following relevant methodological aspects:

1. timing of environmental effects in the three lifecycle phases,

2. timing of environmental effects of increasing supply of renewable electricity,

3. timing of environmental effects of EVs, using an increasing supply of renewable electricity, and

4. substitution effects and timing of environmental effects of EVs, substituting for ICE vehicles.

The possible environmental effects of a system occur at different times during their lifetime. In LCA, the environmental effects are analysed for the three phases separately – production (for vehicles) or construction (for power plants), operation, and end of life – over the whole lifetime of a system. Then the cumulated environmental effects over the lifetime are allocated to the service provided by the system during the operation phase, which is the functional unit in LCA, e.g. per kilometre driven for vehicles and kWh generated for power plants. Therefore, the functional unit gives the average environmental effects over a lifetime by allocating the environmental effects for production and end of life over the lifetime to the service provided, independent of the time when they occur.

Another approach considered in the Task is to compare the cumulative environmental effects in a dynamic LCA.

In Figure 4, the possible courses of the cumulated environmental effects of three systems in their lifetime are shown for the three phases – production, operation, and end of life. All three systems – A, B and C - have the same lifetime and provide the same service but the courses of the environmental effects are quite different. System A has low environmental effects in the production/construction phase but high effects during the operation/use phase and again low effects at the end of life phase. While system B has very high effects in the production phase, it has very low further effects in the operation phase and declining environmental effects at the end of life phase due to the recycling of materials and a credit given for the supply of secondary materials for substituting primary material. System C has lower effects in the production/ construction phase than system B and no further effects during the operation phase, but significantly declining environmental effects at the end of life phase, which is due to the reuse of certain parts, facilities or materials for other further purposes.

Considering the total cumulated environmental effects, system C has the lowest and system A the highest effects in their lifetime. However, we can also analyse the times at which lifecycle system C has lower environmental effects. At t1, system C has lower cumulated environmental effects than system A; at the time t2, system B has lower cumulated effects than system A.

This timing of the environmental effects will become more relevant in the future when new innovative systems substitute for conventional systems to reduce the overall environmental effects. However, it might take some time until the real reduction of environmental effects takes place by the new innovative system. This aspect becomes more and more relevant in the context e.g. of the global necessary reduction of GHG emissions with increasing energy efficiency and renewable energy. Therefore, in dynamic LCA the course of the cumulated environmental effects have to be considered and addressed more adequately.

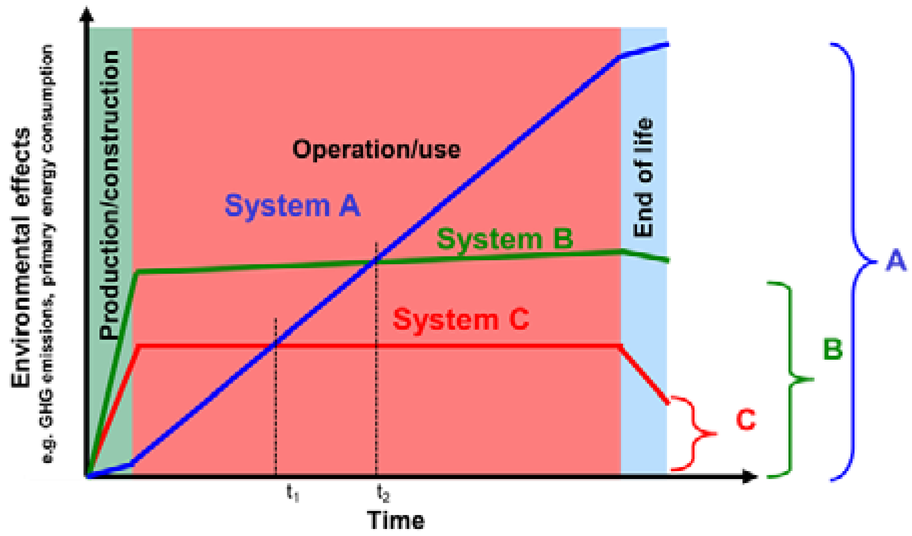


Figure 4: Timing of cumulated environmental effects of three systems with the same lifetime

In Figure 5, the timing of environmental effects of a BEV using renewable electricity substituting an ICE vehicle is shown. In total over the lifetime, the BEV has lower environmental effects (e.g. GHG emissions) than the ICE. Due to the higher environmental effects from the production of the BEV, the environmental effects are higher in the beginning, but after about 3 years the environmental benefits of substituting ICE vehicles start. An additional effect is that due to the rebound effect (for further details see the Task 30 working document), not every electric driven kilometre might substitute a fossil fuel driven kilometre. Therefore, the substitution rate might be lower than 100%. In the example below, the timing of environmental effects is shown for a substitution rate of 80% and 100%. Additionally, if the timing effects are analysed for a rapid annual increase of BEV, the annual environmental effect might still be higher than the substituted ICE vehicles. So depending on the annual growing size of the BEV fleet, it might take some time until the overall annual environmental effects decline by substitution of ICE vehicles.

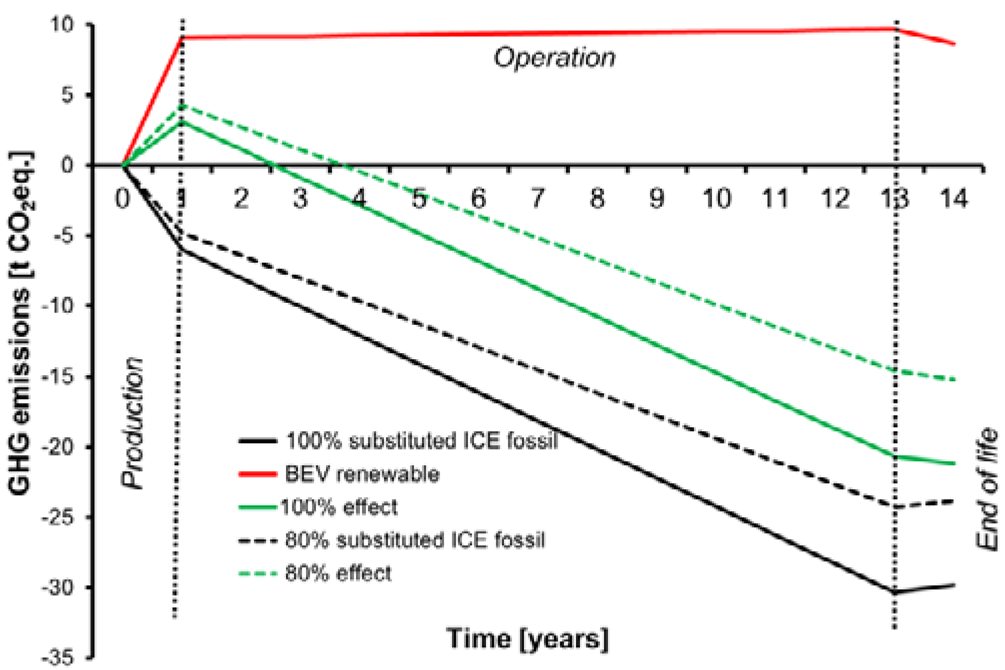


Figure 5: Timing of environmental effects of a BEV using renewable electricity substituting an ICE vehicle

LCA of supplying additional renewable electricity – Austria Case Study

It is relevant to analyse and assess the environmental effect of the increasing production of renewable electricity generation and its use, e.g. in BEV. The environmental effects, e.g, GHG emissions, of electricity from hydro, wind and solar power plants mainly occur in the construction and the end of life phases. In most countries, there are huge investments in new facilities to generate additional renewable electricity. Related to these investments, significant environmental effects are taking place, but the substitution of conventional electricity generation will lead to a reduction of environmental effects in the coming years.

To illustrate the timing of the environmental effects in a dynamic LCA perspective, the following example of Austria increasing the renewable electricity generation is described.

The additional renewable electricity generation in Austria increased between 0.2 and 2.2 TWh per year from 2005 up to 2020. In Figure 6, the total renewable electricity generation in Austria is shown from 2005 to 2020. As early as 2004, about 40 TWh of renewable electricity was generated – mainly in hydropower plants. Over the years, the generation from renewable electricity increased significantly from 41 TWh in 2005 up to 57 TWh in 2020. The share of renewable electricity in the Austrian grid mix (including imports) increased from about 60% in 2005 up to 75% in 2020.

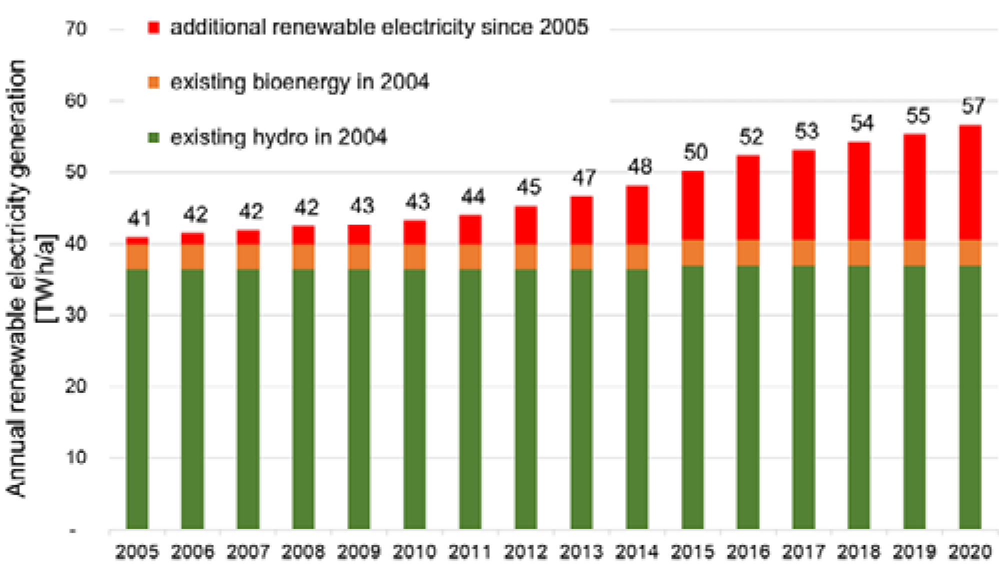


Figure 6: Renewable electricity generation in Austria (references are given in working document)

The annual GHG emissions due to the installation of new renewable electricity generation plants in Austria were between 100,000 up to 800,000 t CO2-eq from 2005 to 2020, depending on the annual installed generation capacity and the type of renewable energy. For example, the installation of a power plant to generate 1 GWh annually of PV produces GHG emissions of about 1,400 to 1,600 t CO2-eq, whereas a hydro and wind installation generating 1GWh annually will only produce GHG emissions of about 250 – 600 t CO2-eq.

Combining the annual GHG emissions and that of the additional electricity generation gives the specific GHG emissions of renewable electricity generation in Austria (Figure 7). Due to the chosen dynamic LCA approach here, the GHG emissions of the construction of renewable electricity generation plants before 2005 are not considered, only the relatively low GHG emissions of operating the plants for maintenance and the fuel supply for bioenergy are included. Thus the GHG emissions of renewable electricity generation in Austria in existing (before 2005) and newly installed power plants (since 2005) are in the range between 8 to 33 g CO2-eq/kWh, whereas the GHG emissions of the additionally installed renewable electricity generation is between 31 and 250 CO2-eq/kWh between 2005 and 2020.

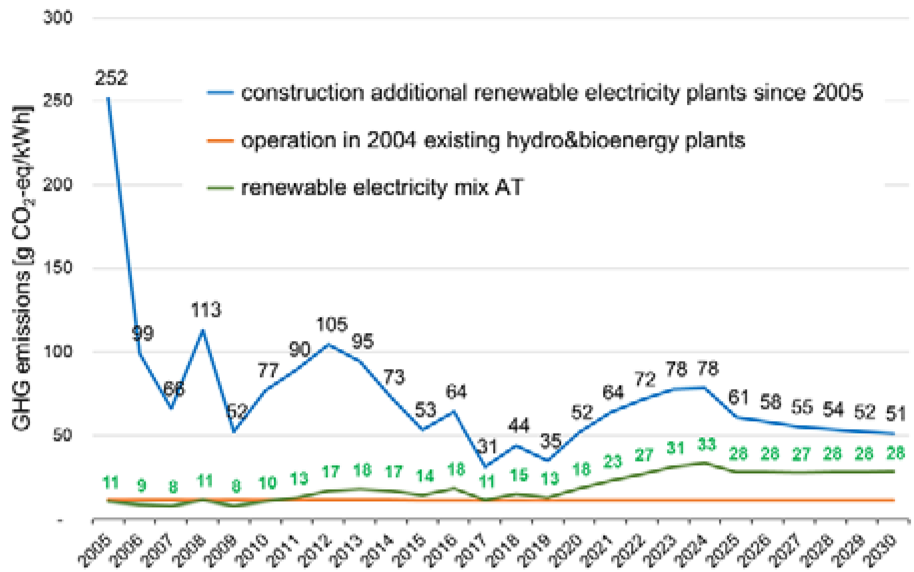


Figure 7: GHG emissions of renewable electricity generation in Austria

GHG emissions of BEV introduction in Austria

Since 2014, Task 30 has estimated the LCA based environmental effects of the worldwide EV 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 (CO2, CH4, N2O), acidification (NOx, SO2), ozone formation (NOx, CO, NMVOC, CH4), particle matter (PM) emissions, and primary energy consumption (total, fossil, nuclear, renewable) in comparison to conventional ICE vehicles.

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., the national grid electricity generation mix.

- The broad range of possible environmental effects is caused by the:
    - o emissions of the national electricity production and distribution,
    - o electricity consumption of EVs at a 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.

- Adequate loading strategies for EVs to integrate additional renewable electricity effectively will create further significant environmental benefits.

This approach was further developed by taking the dynamic effects of the introduction of BEV fleets and increasing the supply of renewable electricity.

The introduction of BEVs in Austria started in 2010. Additionally, PHEVs were introduced, but are not considered here. The annual registration of BEVs has increased significantly and reached nearly 16,000 new BEVs in 2020. The BEV fleet increased up to about 46,000 BEVs in 2020. The rapid increase of the BEV fleet in Austria was stimulated by public funding of up to €6,000 for BEV purchase and the increase in charging stations. The supply of renewable electricity for the operation of the BEV is guaranteed by a corresponding electricity purchase contract.

Assuming an electricity demand of about 0.22 kWh/km (incl. heating, cooling, and auxiliaries) and 10% grid and charging losses, the additional renewable electricity demand for the operation of the BEV fleet increased from 0.3 GWh in 2010 up to 142 GWh in 2020. Considering the increased renewable electricity generation since 2010 in Austria, the demand to operate the BEV fleet is in a range of 0.1 to 1.1% of the additional renewable electricity generated since 2010. Also in this system, it is evident that the Austrian BEV fleet is operated on renewable electricity, while the increasing electricity demand is met with an increasing supply of renewable electricity.

When considering the annual GHG emissions from renewable electricity generation in Austria, the GHG emissions of the operations of the BEV fleet in Austria are calculated using the GHG emission (2010 – 2020) between 10 to 18 g CO2-eq/kWh. The GHG emissions of BEV fleet operation using the renewable electricity mix in Austria are, on average, between 2.5 to 4.5 g CO2-eq/km without considering maintenance and spare parts. Therefore, between 2010 and 2020, the GHG emissions of a BEV operating in Austria are about 3.6 g CO2-eq/km.

Additionally, the GHG emissions from the production of the new registered BEV are calculated from an LCA perspective. The average GHG emissions of global battery production have decreased from about 100 kg CO2-eq per kWh battery capacity in 2010 to about 70 kg CO2-eq/kWh. In the same period, the battery capacity of a new BEV in Austria increased from about 30 kWh in 2010 to about 65 kWh in 2020 on average, due to the lower battery costs and the demand for higher driving ranges. Therefore, the production of a new BEV between 2010 and 2020 causes GHG emissions between 8.5 up to 10.5 t CO2-eq. In comparison, the production of a conventional new ICE vehicle causes about 6 t CO2-eq. However, the operation of a conventional substituted ICE vehicle has GHG emissions of about 145 g CO2-eq/km with an average fuel consumption of about 0.52 kWh/km.

The GHG emissions of the BEVs introduced since 2010 in Austria are calculated by considering the GHG emissions of the production from the annually new registered BEVs and the operation of the BEV fleet by taking the substituted conventional ICE vehicles into account.

In Figure 8, the change of GHG emissions of the BEV fleet substituting an ICE fleet in Austria is shown. In 2020, the GHG emissions of the production of the newly registered 16,000 BEVs are about 167,000 t CO2-eq and the GHG emissions of the BEV fleet operation of about 45,000 vehicles with renewable electricity are about 3,000 t CO2-eq. Assuming each BEV substitutes for an ICE, about 16,000 newly registered conventional ICE vehicle were substituted in 2020 avoiding GHG emissions from their production of about 96,000 t CO2-eq and avoiding GHG emissions of about 94,000 t

CO2-eq in the ICE fleet operation of about 45,000 conventional ICE vehicles. Therefore, in 2020 the BEV fleet in Austria emitted about 170,000 t CO2-eq and avoided about 190,000 t CO2-eq from substituting conventional ICE vehicles, which results in an overall GHG saving in 2020 of about 20,000 t CO2-eq.

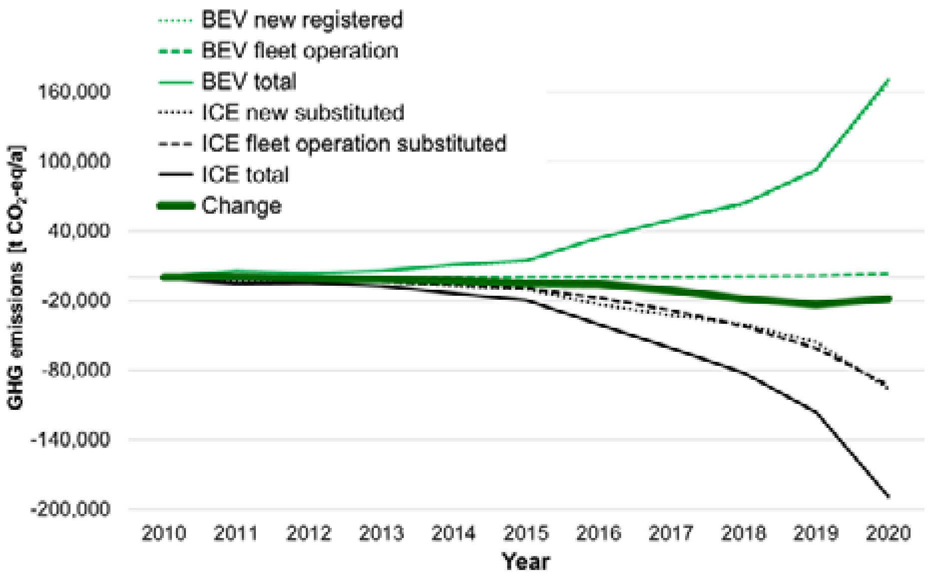


Figure 8: Change of GHG emissions of BEV fleet substituting ICE fleets in Austria

NEXT STEPS

The next workshop "Overall Environmental Assessment of EVs – From Inventory Analysis to Impact assessment" is scheduled for October 13 and 14, 2021 and will be virtually hosted and organised by IREC (Catalonia Institute for Energy Research) in Barcelona/Spain.

The aim of the expert workshop is to present, discuss, and conclude on the state of the art and experiences on the overall assessment of environmental effects in LCA of electric vehicles – from "Inventory Analysis to Impact Assessment of EVs".

The program will consist of presentations on

- impact assessment methodologies,
- case studies,
- available methodologies and data,
- news and highlights of LCA of EVs from Task 30 partners,
- and group work to conclude on impact assessment methodologies in LCA of EVs: current status and future perspectives.

The dissemination activities were:

Presentation: Prüfstand „Lebenszyklusanalyse“: Klima- und Energiebilanz von Transportsystemen (Test Bench „Life Cycle Assessment“ – GHG and Energy Balance of Transportation Systems), Symposium ZUKUNFT Gas-MOBILITÄT 2020; March 11 – 12, 2020

Presentation: Most Climate-Friendly Propulsion with Renewable Fuel - Biofuel, Electricity, Hydrogen or e-Fuels; ECO-Mobility – Virtual A3PS-Conference 2020

Presentation: Climate Friendly Biofuels in Comparison to Other Fuels, Renewables in Transport, Expert Talk, January 21, 2021, online

Lecture: Electric Vehicle Lecture - Environmental Impacts of Electric Transport, MSc Program “Renewable Energies” of Vienna University of Technology, online, February 13, 2021

Presentation and working document: LCA Application to Growing EV-Fleets with Increasing Supply of Renewable Electricity – Methodological Aspects and Assessment for GHG Emissions of BEV Introduction in Austria, IEA HEV Task 30 meeting, online, February 3, 2021

Reviewed Publication: Environmental Life Cycle Impacts of Automotive Batteries Based on a Literature Review, Energies 2020, 13(23), 6345; https://doi.org/10.3390/en13236345

Working document of Task 30: Rebound Effects of Electric Vehicles and Possible Implication on Environmental Effects in LCA of Electric Vehicle, status February 2021

Working document of Task 30: LCA Application to Growing EV-Fleets with Increasing Supply of Renewable Electricity – Methodological Aspects and Assessment for GHG Emissions of BEV Introduction in Austria, status February 2021

FOR FURTHER INFORMATION, PLEASE CONTACT THE 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 some 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 3.5m, a maximum drive power of 55 kW, and an unladen weight of up to 1,200 kg. Examples of that type of vehicle are the Smart ForTwo ED or Mitsubishi i-MiEV.

OBJECTIVES

The objective of this task is to promote the broader commercialisation, acceptance, and further development of SEVs by collecting and sharing pre-competitive information, discussing framing conditions, best practices and ideas, how to develop the market conditions and mobility concepts further. In this sense, the objectives are twofold:

- Increased safety, comfort and usability at lower costs for SEVs due to technological progress.
- 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, the status of technologies, and needs for research as well as the conditions to put them on the market. Apart from the vehicles themselves, the focus is on the potential future role of SEVs in advanced mobility concepts, including, for example, 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 policymakers, depending on individual topics. The concept of presentations from individual stakeholders together with more interactive parts has proven to be attractive. While the Task partnership comprises academic institutions, NGOs or, policymakers, contributions from industry and the 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.

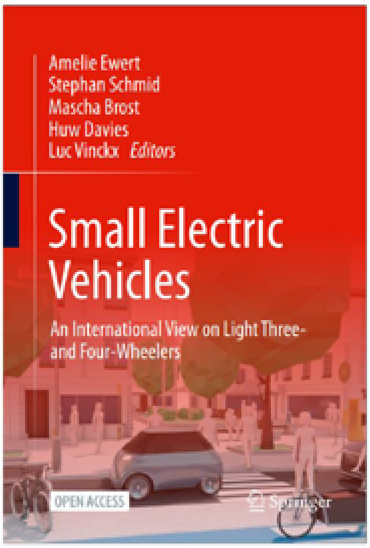
RESULTS

Results of Task 32 include the outcomes of three workshops and one round table. Furthermore, the results of an international survey with experts in the field of SEVs were generated. The compiled knowledge was disseminated in conferences and through publications. Additionally, an edited open access book that is scheduled for publication in spring 2021 will give a comprehensive overview of small and lightweight electric three- and four-wheel vehicles with an international scope.

Edited open access book on SEV

The book presents the status of SEV technologies, the market situation, and the main hindering factors for market success as well as options to attain a higher market share including new mobility concepts. Increased usage of SEVs can have different impacts which are highlighted in the book in regard to sustainable transport, congestion, electric grid, and transport-related potentials. To underline the effects these vehicles can have in urban areas or rural areas, several case studies are presented covering outcomes of pilot projects and studies in Europe. A study of the operation and usage in the Global South extends the scope to a global scale. Furthermore, several concept studies and vehicle concepts on the market give a more detailed overview and show the deployment in different applications.

The book contains fourteen reviewed articles that are structured in four chapters (see Figure 1). Fifty international authors contributed to the book. It will be published by Springer International Publishing and may be downloaded via: www.springer.com/gp/book/9783030658427



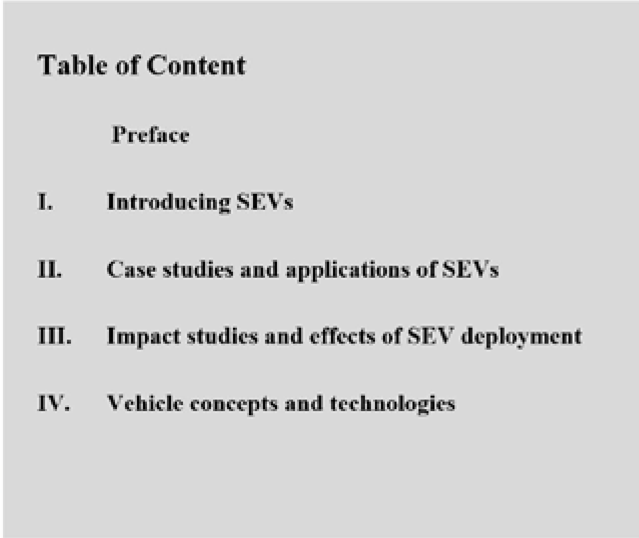


Table of Content

Preface

I. Introducing SEVs

II. Case studies and applications of SEVs

III. Impact studies and effects of SEV deployment

IV. Vehicle concepts and technologies

Figure 1: Edited open access book: “Small Electric Vehicles - An International View on Light Three- and Four-Wheelers” (image courtesy of Springer International)

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 Center. Experts from OEM and research institutions from Germany, Switzerland, Belgium, the United Kingdom and South Korea joined the Workshop. Topics presented and discussed at the Workshop were:

- 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

The second workshop “Market Conditions and Mobility Concepts” took place in Brussels, Belgium, on September 18th 2017 at the German Aerospace Center (DLR) Brussels Office. The main topic of the workshop was the exchange of 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 conclusion especially on ultra-lightweight vehicles were:

- The regulation was the primary focus as well as the in-use phase
- A consensus that there is limited consolidation in this area, which is detrimental
- Attendees look for support to understand how the regulatory landscape will develop
- Requirement for a comprehensive assessment of 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 talking 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 existing vehicles, like vans.

Figure 2: Round Table at the Micromobility Expo in Hanover, 2nd May 2019 (image courtesy of micro mobility expo)

International Survey

In 2018, a survey combining interviews and an online questionnaire was 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, the USA, and Europe in the online questionnaire.

Taking into account the barriers to market acceptance, the lack of dedicated transport infrastructure is the most critical aspect. An appeal can be made by measures such as separate lanes or access to restricted traffic zones in order to create an advantage over cars. Furthermore, the small variety of models compared to cars and relatively high prices resulting from low production numbers are hindering the market success of SEVs. Another important aspect is safety, as the requirements for type approval are low and no crash tests are required.

The survey results indicate that there are measures to foster SEVs in municipalities, especially with the help of public bodies. Charging and transport infrastructure including parking management are seen as the most effective ways to achieve good results by survey participants. In addition to incentives, however, restrictions on the use of larger vehicles must also be created (see Figure 3). Ultimately, only a combination of push and pull measures leads to a promising outcome.

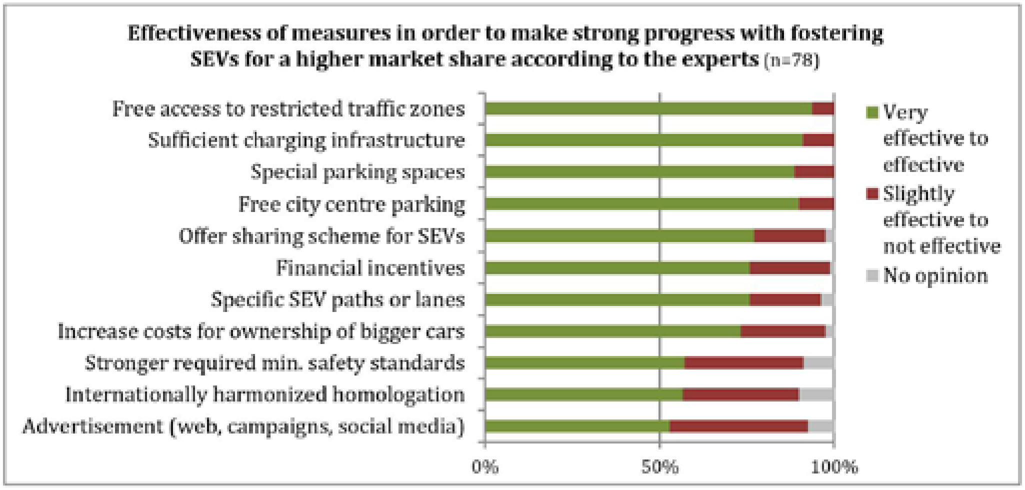


Figure 3: Measures to foster SEV, Online survey (image courtesy of DLR)

Dissemination activities

Journal Paper: Ewert, Amelie und Brost, Mascha und Eisenmann, Christine und Stieler, Sylvia (2020) Small and Light Electric Vehicles: An Analysis of Feasible Transport Impacts and Opportunities for Improved Urban Land Use. Sustainability (12(19)), Seite 8098. Multidisciplinary Digital Publishing Institute (MDPI). DOI: 10.3390/su12198098 ISSN 2071-1050

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.
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

Task 32 is scheduled to be completed in 2021.

FOR FURTHER INFORMATION, PLEASE CONTACT THE OPERATING AGENT:

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

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

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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 that are of interest to those working on electric drive vehicles. Since batteries account for a significant part of the total cost of electric vehicles; R&D continues world-wide to develop higher energy density, abuse-tolerant and affordable batteries – in other words, 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 the country to country information exchange and public meetings.

RESULTS

Next-generation NMC 811 cathode R&D

BACKGROUND

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% of that going 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]

Next-generation NCM 811 cathodes could be a crucial component of future advanced automotive batteries, enabling a significantly improved EV range. NMC (Ni-Mn-Co) cathodes with different Ni-Mn-Co compositions have been around for a relatively long time. Following the initial commercial success of NMC 111 (1/3 Ni, 1/3 Mn, 1/3 Co – also abbreviated as NMC 333), such cathodes have been used in several commercial vehicles (e.g., the BMW i3, Chevy Bolt, and Nissan Leaf). NMC 811 is a cathode composition with 80% nickel, 10% manganese, and 10% cobalt. Compared to a battery using the NMC 622 cathode (60% nickel, 20% manganese, and 20% cobalt), in NMC 811, the ratio of nickel is increased from 60% to 80% and the ratio of cobalt reduced from 20% to 10%. This has the advantage that on one hand the higher ratio of nickel increases the energy density and on the other hand, there is less use of cobalt. Therefore, the performance of the battery is improved and its price can be lowered based on less use of cobalt – which is both relatively expensive and may have significant price volatility.

HIGH-ENERGY COBALT-FREE CATHODES ENABLED BY THREE-DIMENSIONAL TARGETED DOPING

Although there have been numerous efforts to develop alternative cathode materials, layered lithium transition metal (TM) oxides based on the structure of LiTMO2, such as lithium nickel (Ni)-manganese (Mn)-cobalt (Co) oxide (NMC), remain the majority of cathode materials in commercialised lithium (Li)-ion batteries. As the cell chemistry of NMC811 reaches initial market penetration, one challenge is to find Co-free layered cathodes to reduce the reliance on high-cost and toxic Co. LiNiO2 (LNO) has a high capacity but is thermally unstable at a charged state and also has poor cycle life. To enhance its performance requires structure-stabilising elements such as Co. Despite its instability, LNO shares many of the problems of currently employed NMCs that have the potential to be resolved using specialised dopants or electrolytes to target the instability of the cathode/electrolyte interfaces.

The Low/No-cobalt project led by the University of California—Irvine, with team members from Virginia Tech, UC Berkeley, and Pacific Northwest National Lab have developed a three-dimensional targeted doping technology that can hierarchically combine surface and bulk doping with nanometer precision. The team uses computation-selected surface dopants and accurately delivers them to the surface of primary particles. They further introduce theory-rationalised bulk dopants to the interior of the particles to further enhance the oxygen stability and inhibit the H2-H3 phase transition in Co-free oxides under high-voltage and deep-discharging operating conditions.

As shown in Figure 1, the team has enabled 3D targeted doping on the surfaces of the cathode particle with nanometer precisions. In the meantime, the layered atomic structures are preserved without nearly any secondary phase on the surfaces. More importantly, the surface/bulk Ti/Mg doping significantly improve the cycling performance of the Co-free and extremely high-Ni chemistry

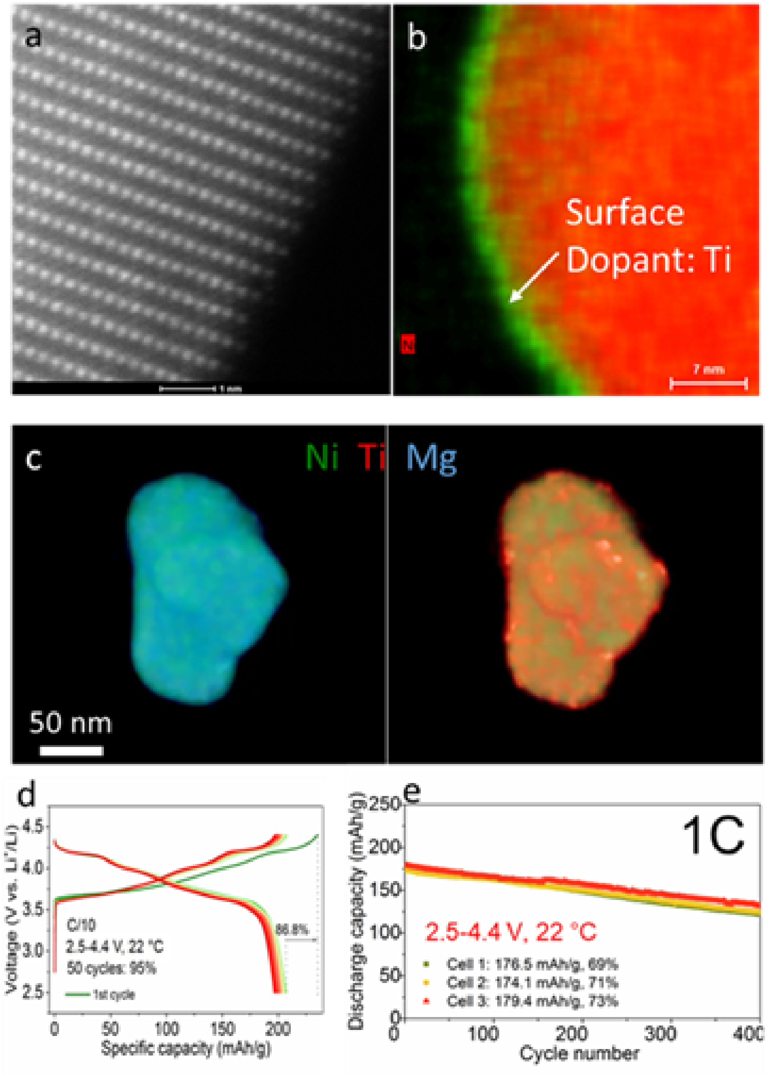

Figure 1: (a-b) Structure and chemical imaging of the Co-free cathode particles. (c) 3D nano-electron-tomography imaging of the dopant distribution. (d-e) The electrochemical performance of the Co-free cathode materials.

(LiNi0.96Ti0.02Mg0.02O2) reaching a cycle life of 400 cycles (2.5 – 4.4 V vs. Li).

Lithium Battery Recycling Prize

BACKGROUND

As part of its efforts to facilitate a well-distributed, efficient, and profitable infrastructure for the recycling of lithium-ion batteries and to incentivise American entrepreneurs to find innovative solutions to challenges associated with the collection, storage, and transportation of spent or discarded lithium-ion batteries, DOE established a $5.5 Million Battery Recycling Prize. Its goal is to develop innovative business and technology strategies to potentially capture 90% of all lithium-based battery technologies (consumer electronics, stationary, and transportation applications) and to make collecting, sorting, storing, and transporting lithium-based batteries safe, efficient, and profitable. The prize would facilitate entrepreneurs to leverage resources from incubators, universities, and national labs to transform innovative early-stage concepts into prototypes for industry adoption. The Prize spans three phases. In each phase, winners are determined by a panel of expert judges evaluating concepts based on feasibility, cost to implement, and potential impact. The National Renewable Energy Laboratory (NREL) was selected as the administrator for the implementation and execution of prize elements. In Phase I of the Prize, after a review by industry experts and a Federal Consensus Panel, DOE determined that 15 submissions adequately met the criteria for innovativeness, impact, feasibility, and technical approach outlined in the Prize Rules.[6]

PHASE II WINNERS FOR THE LITHIUM-ION BATTERY RECYCLING PRIZE ANNOUNCED

The Prize Administrators successfully launched its Phase II, entitled "Prototype and Partnering". In December 2019, its rules were released alongside a 30-minute webinar and later on, three additional 30-minute webinars on partnering expectations and the Voucher Guidelines. The Prize Administrators organised an in-person networking opportunity in partnership with the National Alliance for Advanced Transportation Batteries (NAATBatt) National Conference in February 2020. Phase II participating teams were invited to give a brief presentation to the NAATBatt conference attendees and battery industry experts to introduce their concepts. Twelve teams accepted the opportunity to attend and to present at the event. To ensure that Phase II participating teams were on-track with the continued development of their concepts, the Prize Administrators coordinated an interim "concept update" and review process. Each team in Phase II provided a 12-page update on its concept proposals and a Technical Assistance Request to outline areas of concept that may need additional support, from partners or vouchers. The Prize Administration team reviewed each proposal and provided feedback on the end-to-end solution approach, impact, team, and partnering. In view of the ongoing Covid-19 epidemic, the planned "Demo Day" was modified to a virtual format. The new virtual Demo Day refocused from prototype presentations to highlighting Voucher Service Providers (VSPs) within the American-Made Challenge Network, including both businesses and national labs. The prize Administrators coordinated 27 virtual presentations from Phase II participating teams and VSPs for the event. In addition, the Prize Administrators aimed to simulate the networking that occurs at in-person events by coordinating a day of one-on-one meetings between Phase II teams and VSPs they wanted to meet with personally. A total of 39 sessions were coordinated for this event. The list of Phase II key events and their dates for execution appear in Table 1.

Date	Scheduled Event
January 14, 2020	Phase II Rules and Voucher Guidelines released
January 27, 2020	Phase II Rules webinar
February 13, 2020	NAATBatt National Conference (12 teams participating)
March 11, 2020	Phase II Partnering webinar
April 20, 2020	Registration for Phase II closes (14 teams register to participate)
May 6, 2020	Phase II Concept Update deadline (teams to provide a concept status update and Prize Administrator to provide extensive feedback on validation plans and end-to-end solution)
July 6, 2020	Voucher Overview webinar
July 22, 2020	Virtual Demo Day
August 28, 2020	Statement of Work and Cooperative R&D Agreement (CRADA) webinar

Table 1: Lithium-ion battery recycling prize Phase II schedule

Date	Scheduled Event
October 13, 2020	Phase II Online Submission Deadline
December 20, 2020	Phase II winners announced

Throughout Phase II, NREL maintained support for the Prize website, answering questions and providing updates, as well as continuing its ongoing outreach efforts, including informational webinars. NREL further promoted Phase II through social media outreach, the NREL website, and e-newsletters. Fourteen submissions were received in Phase II of the Prize. These submissions furthered the development of the winning concepts from Phase I. Expert judges began their review of the Phase II Final Submissions in late September 2020 and the seven winners were announced in December. Phase II winners will each receive a $357,000 cash prize, in addition to receiving $100,000 in non-cash vouchers for use at National Labs and approved organisations within the American-Made Challenges Network. These winners (see Table 2) have thus advanced to the third and final phase of the Prize.

Table 2: Lithium-ion battery recycling prize Phase II winners

Team (Location)	Project Title
Li Industries (Blacksburg, VA)	Smart Battery Sorting System
OnTo Technologies (Bend, OR)	DISC: Deactivate, Identify, Sort, Cut
Powering the Future (Glendale, WI)	Powering the Future
Renewance (Chicago, IL)	Renewance Connect
Smartville (San Diego, CA)	Smartville Battery Reuse & Recycling HUB System
Team Portables (Seattle, WA)	Reward to Recycle – Closing the Loop on Portables
Titan Advanced Energy Solutions (Sommerville, MA)	Battago – Battery Market Intelligence Platform

Silicon-based High-Capacity Anodes for Next Generation of Li-Ion Batteries

BACKGROUND

Lithium-ion batteries are used everywhere in present-day electronic devices (e.g. smartphones, laptops) and are getting used more and more in electric vehicles. Their negative electrode (anode) material plays an important role in setting the battery capacity limits and the number of charge-discharge cycles the battery can handle (i.e., its cycle life). Synthetic Graphite with special coatings has served as the conventional anode material in such batteries for a long time. However, the capacity of Graphite to hold Li-ion is constrained by a need to add more layers of Graphite, leading to a bulky cell and increased cost. Silicon has received significant attention as an alternative active component to the graphitic carbon in those applications due to its much higher capacity and general availability. Compared to graphitic carbons, silicon has nearly an order of magnitude higher capacity (~3600 mAh/g silicon vs 372 mAh/g graphite), however, several problems limit its use in commercial cells including its large crystallographic expansion upon lithiation (~320%), slow lithium diffusion, and high reactivity with electrode constituents at high states of charge. Combined, these materials properties can result in particle cracking, particle isolation, electrolyte reactivity, and electrode delamination issues. Therefore, research continues to overcome those barriers and make it viable for commercial use.

DEVELOPMENT OF SI-BASED HIGH-CAPACITY ANODES

Porous Si has been widely used to mitigate the pulverisation of Si particles during battery cycling. However, the large surface area of these Si materials may lead to severe reactions between lithiated Si and electrolytes. These reactions will result in the continuous growth of the solid electrolyte interphase (SEI) layer, as well as shortened cycle and calendar battery lives. Therefore, minimising the surface area of Si and finding a stable electrolyte are critical for the cycling and calendar lives of Si-based lithium-ion batteries (Si-LIBs).

DOE's Pacific Northwest National Laboratory (PNNL) has developed a highly stable Si anode based on micron-sized porous Si with heterogeneous coating layers. Porous Si is first prepared by thermal decomposition of SiO and subsequent etching with HF solution. The as-prepared porous Si has a large surface area of ~1000 m2 g-1 and a large pore volume of 1.10 cc g-1 with nano-sized pores (~3.7 nm in diameter). For the homogeneous coating process, petroleum pitch is dissolved in toluene; the resulting pitch/toluene solution is impregnated into the porous Si under the vacuum. As shown in Figure 2, porous Si has an average particle size of ~5 ?m, which is similar to those of pristine porous Si. After carbonisation of pitch at 700 °C under an Ar atmosphere, the carbon content in the composite is ~45–48%. Using porous Si-C, Si||NMC532 coin cells have demonstrated excellent electrochemical performances with a baseline

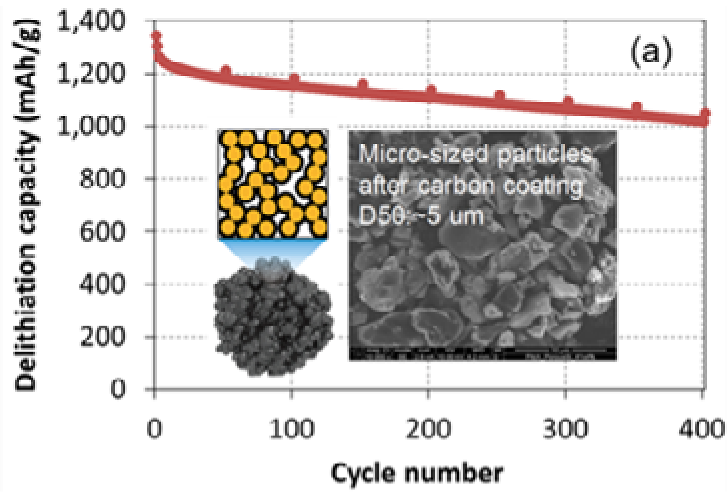

Figure 2: Cycling stability of Si||NMC622 cells using a porous Si anode and baseline electrolytes. The insert shows the schematic structure and scanning electron microscope image of porous Si.

electrolyte (1.2 M LiPF6 in EC/EMC [3/7 in weight] + 10% FEC). The cell retains 78% capacity after 400 cycles, with a stabilised 99.9% coulombic efficiency. The superior stability of the porous Si-C anode can be attributed to (1) mitigated volume expansion with sealed porosity; (2) improved overall conductivity of the composite; and (3) minimised electrolyte penetration into the porous Si.

To further improve the cycle life of Si-LIBs, PNNL researchers have developed several novel electrolytes based on the concept of the localised high-concentration electrolyte (LHCE). These electrolytes result in a significantly improved cycle life of Si||NMC532 cells (Figure 3). The cycle life of the cells can increase more than 50% when PNNL's LHCEs (LiFSI-DMC-BTFE [molar ratio = 0.51:1.1:2.2] + 1.0 wt% VC + 5 wt% FEC)

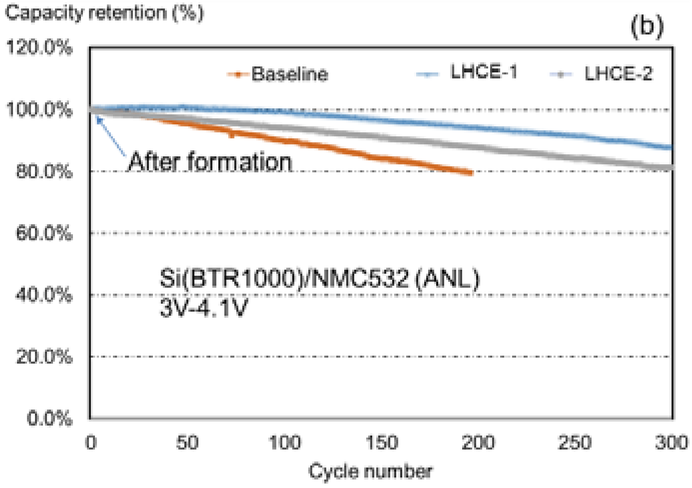

Figure 3: Cycling stability of Si||NMC532 cells using a porous Si anode and different electrolytes.

are used, compared to that produced using baseline electrolytes. Thus, porous Si and LHCE electrolytes developed at PNNL have great potential to enable the next generation of high-energy-density LIBs.

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.

FOR FURTHER INFORMATION, PLEASE CONTACT THE OPERATING AGENT:

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

david.howell@ee.doe.gov

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TASK 35

Fuel Cell Electric Vehicles

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 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 is derived 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.

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, are exclusively offering their FCVs to customers who are in the location of available hydrogen fuel stations. Therefore, it will be very useful to look in detail at FCVs and their 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 and conferences, and document and disseminate these related topics.

WORKING METHOD

The workshops aim to attract professionals from research, enterprises, and policymakers, depending on 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, which include:

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

RESULTS

The Republic of Korea ranked first in the hydrogen-electric passenger car market in 2020, with a market share of about 73%. Hyundai Motor's hydrogen-powered car "Nexo" sold three times more than Toyota's "Mirai". It was followed by the U.S. (957 units, 12.1%), Japan (750 units, 9.5%) and Europe (452 units, 5.7%) which all decreased compared to the previous year. Its share in Japan and Europe decreased by 0.2% and 0.3% respectively, while the United States decreased by 14.2%.

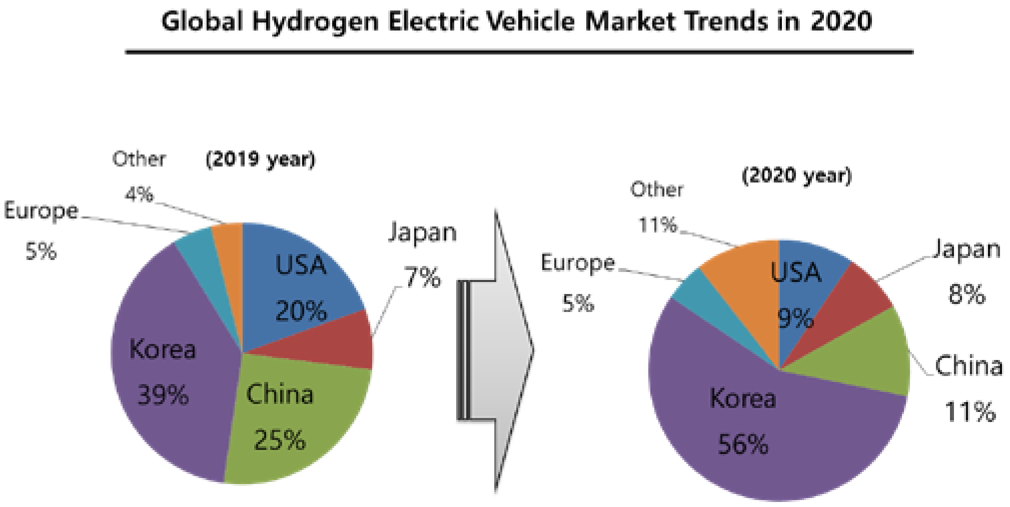

Figure 1 Global Hdrogen Electric Vehicle Market Trends in 2020

Table 1: Sales Trends of Hydrogen Electric Vehicles in Major Countries.

Classification	Share in 2019		Share in 2020	
Republic of Korea	4,194	52.9%	5786	72.9%
United Stares	2,089	26.3%	957	12.1%
Japan	772	9.7%	750	9.5%
Europe	479	6.0%	452	5.7%
Other	400	5.0%	1,079	13.6%
Total	**7,934**	**100%**	**9,024**	**100%**

Table 2: Sales trends by hydrogen electric vehicle companies.

Classification	Share in 2019		Share in 2020	
Hyundai (NEXO)	4,987	62.9%	6,781	75.1%
Toyota(Mirai)	2,494	31.4%	1,960	21.7%
Honda(Clarity)	430	5.4%	263	2.9%
Mercedes GLC F-Cell	23	0.3%	20	0.2%
Total	**7,934**	**100%**	**9,024**	**100%**

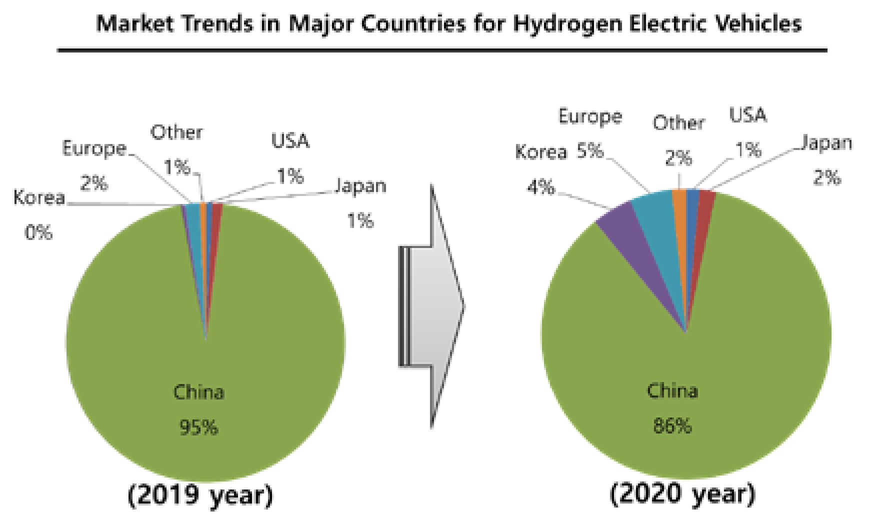

Figure 2 Market trends in major countries for hydrogen electric vehicles

Looking at each vendor, Hyundai Nexo, which sold a total of 6,781 units last year, topped the market with a 75.1% market share. Toyota's Mirai sales volume of Japan, which has been recognised as a rival of Nexo, recorded only 1,960 units, accounting for 21.7% of the market share. The difference in market share between the two companies is about four times. In Japan, Honda, which ranked in the third position, sold 263 hydrogen-electric vehicles last year, recording a market share of 2.9% as it focused on plug-in hybrids (PHEV).[1]

Year	Country
2020	Austria
2025	Norway
2030	Germany, India, Ireland, Netherlands, Israel (import suspended), Sweden
2032	United Kingdom
2040	China (Stop Production), France
2050	USA, 55 countries around the world aim to have net zero carbon emissions

Table 3: Diesel truck sales ban in major countries around the world

In the U.S., 15 states signed a memorandum of understanding in July 2020 stating that "the sale of all diesel trucks will be banned by 2050." Diesel trucks are already not sold in Austria (2020), and diesel truck sales in Norway (2025) and Germany (2030) are to be banned entirely within 10 years.[2]

GM of the United States established a cooperation system with Navista International, the largest commercial vehicle company in the United States, and began to develop a commercial truck for hydrogen fuel cells. The company plans to launch hydrogen fuel cell trucks powered by their own fuel cells by 2024. The target mileage is 500 miles (804 km) and with a target to provide hydrogen fueling within 15 minutes.[3]

China has announced plans to supply 10,000 hydrogen fuel cell trucks by 2023 and plans to expand 70 hydrogen fueling stations in Shanghai. Currently, it is known that China is operating 3,000 hydrogen-fueled electric vehicles and 80 charging stations. In addition, 50 hydrogen fuel cell buses were ordered in Wuhai City in November 2020. The introduced hydrogen fuel cell bus is equipped with a total of 8 hydrogen tanks. The mileage is known to be 350 km.[4]

Hyundai Motor Company established Hyundai Hydrogen Mobility in a joint venture with H2 Energy, a Swiss hydrogen solution company, and plans to supply 1600 hydrogen-electric trucks called Exient Hydrogen Trucks to Switzerland by 2025. Hyundai Hydrogen Mobility plans to enter the entire European and American markets, including Germany, starting with Switzerland. Through this, the goal is to supply 1600 units of hydrogen-electric trucks to the European market by 2025 and more than 25,000 units by 2030. In addition, the Swiss Hydrogen Mobility Association plans to build about 80 hydrogen charging stations across Switzerland by 2025. Hyundai Hydrogen Mobility will participate as a partner in the alliance of 21 companies formed to expand the hydrogen fueling station in Switzerland. From 2021, Hyundai Motor Company plans to conduct a pilot project for the operation of Exient hydrogen-electric trucks in the Gunpo-Okcheon section and the metropolitan area and plans to start mass production and supply of hydrogen-electric trucks in earnest from 2023 after performance improvement. In addition, in 2020, Hyundai Motor Company exported a total of 4 units to Saudi Arabia, 2 units of Nexo and 2 units of Elexity FCEV.

Country	Units
Germany	106
France	28
UK	18
Island	3
Denmark	8
Norway	4
Spain	3
Italy	4
Austria	5
Netherlands	14
Sweden	4
Swiss	10
Belgium	7
Croatia	7
Latvia	1
Czech Republic	3

Table 4: Hydrogen charging stations around the world in operation

Currently, hydrogen infrastructure is being built around the world, and Germany has the largest number of hydrogen charging stations with 106 stations. As of January 2021, Korea has built 73 aircraft and plans to build 450 units by 2025.[5]

NEXT STEPS

Korea is expected to supply 6.2 million hydrogen fuel cell vehicles by 2040, of which 3.3 million will be exported. In addition, there are plans to establish more than 1,200 hydrogen charging stations. Japan plans to build 800,000 hydrogen fuel cell vehicles and 900 hydrogen charging stations by 2030, and California, USA, plans to establish 1 million hydrogen fuel cell vehicles and 1,000 hydrogen charging stations by 2030.

In addition, Hyundai Motor Company is planning to complete the mid-to-long-term roadmap “FCEV Vision 2030,” with an annual production system of 500,000 hydrogen-electric vehicles by 2030.

FOR FURTHER INFORMATION, PLEASE CONTACT THE 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

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

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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 only 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 focusing 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.

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 would like to organise workshops scheduled in conjunction with dedicated in-person conferences and IA-HEV Executive Committee (ExCo) meetings. The workshops could 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, analyse challenges and opportunities, and deliver conclusions for future actions.

RESULTS

Charging infrastructure for vehicle charging at 400 kW and beyond from a multi-port refuelling plaza similar to today's gasoline 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 plaza 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.

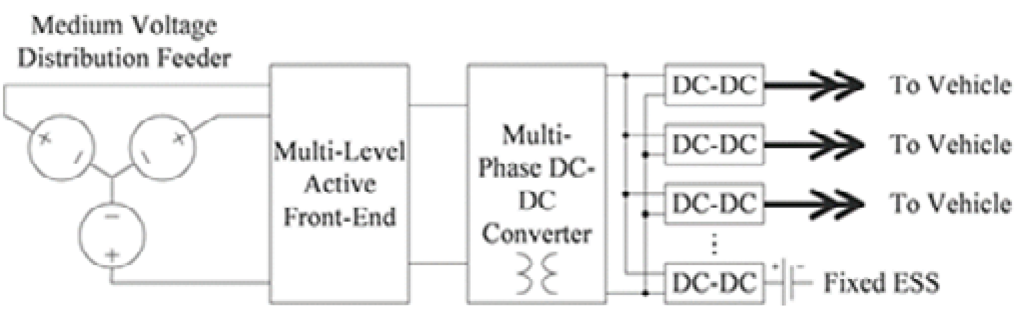

Figure 1: Block diagram schematic of an XFC refuelling plaza (Source: See Reference [4])

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 are (1) ac-dc conversion in the active front end, (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 13.8kV 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.

Vehicle Type	EVs	HEVs	PHEVs
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
	-	2 kV	Output: 0.75 kV
DC Conversion Equipment Connected to the Medium-Voltage Grid for XFC Utilising Modular and Interoperable Architecture	Full Bridge	Full Bridge	Full Bridge
	1.7 kV SiC MOSFET	-	-
	Input: 0.72 kV	1.2 kV	Output: 0.95 kV
Enabling Extreme Fast Charging with Energy Storage	Full Bridge	Full Bridge	Full Bridge
	1.2 kV IGBT		-
	-	1.8 kV-	Output: 1.15 kV

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

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 480 V. The primary benefits of this approach are the removal of the bulky transformer 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 charging hardware. The proposed system is composed from left to right with a medium voltage fuse metering enclosure, switch gear, and charging hardware.

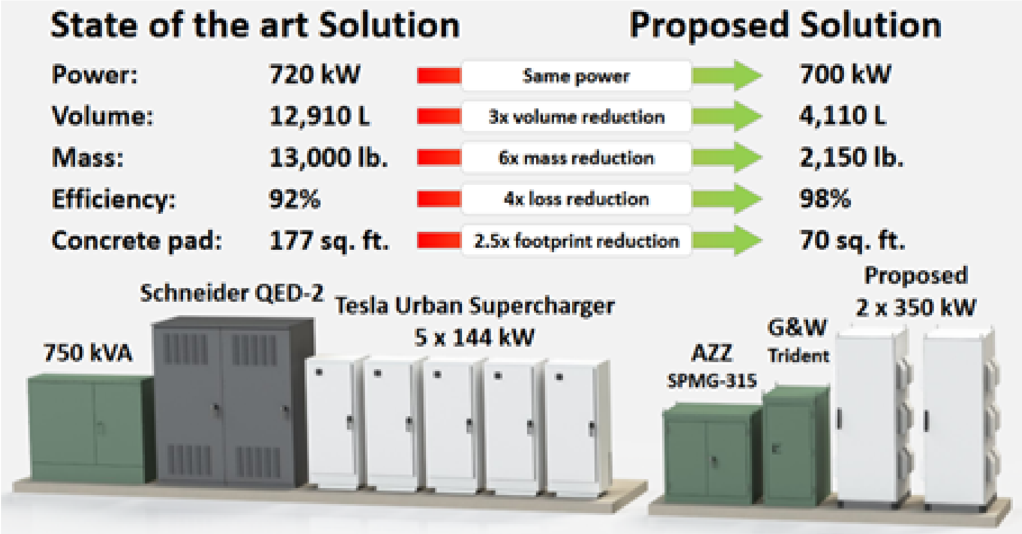

Figure 2: Benefits of Medium Voltage Extreme Fast Charging (Source: See Reference [5])

The High-Efficiency, MV-Input, Solid-State-Transformer-Based 400-kW/ 1000V/ 400A Extreme Fast Charger for Electric Vehicles project conducted a demonstration of their completed system on September 28, 2020, see Figure 3. This system contains the 13.2 kV medium voltage SST which is rated at 400 kW. The dimensions of the system are 3100x 1300x 2100 mm with an approximate mass of 3000 kg. The charger power cabinet is similarly rated at 400 kW with dimensions of 600x 400x 2400 mm and a mass of 800 kg. The combined system volume is 9039 L, the footprint is 4.27 m2 (46 sq. ft.), and the mass is 3800 kg (8379 lb.). Compared to the conventional solution shown in Figure 2, this represents about a 2x reduction in footprint and an increase of about 1.26x in volume and 1.16x in mass relative to the output power rating.

Figure 3: 400kW XFC (SST, Charger Power Cabinet, Dispenser, and DCE from left to right (Source: See Reference [12])

The peak system efficiency of the 400kW XFC system shown in figure 3 is over 96.5% for dc output voltages about 800V from 25% to 100% of full power, with a peak efficiency of 97.6%. For the SST by itself, this stage has a peak efficiency for medium voltage ac conversion to dc of 98.5%. Similarly, the Intelligent, Grid-Friendly, Modular Extreme Fast Charging System with Solid-State Direct-Current Protection project has found for its prototype SST at full power has an efficiency of 98.9%. These projects show that a medium voltage connected system when compared to a conventional system can achieve a 2x reduction in system losses.

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

The task is considering options for its continuation at this time.

FOR FURTHER INFORMATION, PLEASE CONTACT THE 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

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TASK 39

Interoperability of e-mobility services

MEMBER COUNTRIES
BELGIUM
CANADA
FRANCE
SPAIN
SWITZERLAND
THE NETHERLANDS
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). At the 52nd ExCo meeting held in November 2020 as an online meeting, an extension has been requested due to the impact of COVID-19 on the Task 39 planning. The extension has been approved and Task 39 is now running from 01.04.2018 until 30.03.2022.

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: Switzerland, United States, Spain, Canada, Germany, UK, Sweden, and France. Most of these countries have now joined officially. Also with the European Commission, contacts are ongoing to share experiences related to their interoperability activities within the "European Interoperability Centre for Electric Vehicles and Smart Grids" and related to the AFID directive on the deployment of alternative fuels infrastructure in Europe.

Task 39 will focus on user-friendly charging infrastructure and more specifically on 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 electric vehicle market 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 increasingly interested in the possible benefits of electric mobility since it offers great potential to solve many of our environmental, societal, and economic challenges. Therefore, policymakers are implementing supportive measures to facilitate the further uptake of electric mobility in their region. The main barriers to be addressed are the higher purchase cost, limited driving range, and limited charging infrastructure.

The European Green Deal, published by the European Commission in December 2019, states that by 2025 about 1 million public recharging points will be needed for the 13 million zero- and low-emission vehicles expected on the roads of the European Union (EU). By the end of 2020, there were about 2 million passenger cars (BEVs and PHEVs) in the 27 EU Member States.

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. Charging infrastructure will be needed at all locations: residential, workplace, and the semi-public and public domain. By the end of 2020, there were about 226,000 publicly accessible recharging points across the EU-27 Member States, mainly concentrated in a few countries (see Figure 1) and of which 89% were normal power recharging points (up to 22 kW) and 11% high power recharging points (above 22 kW) (source: EAFO - EAFO - European Alternative Fuels Observatory).

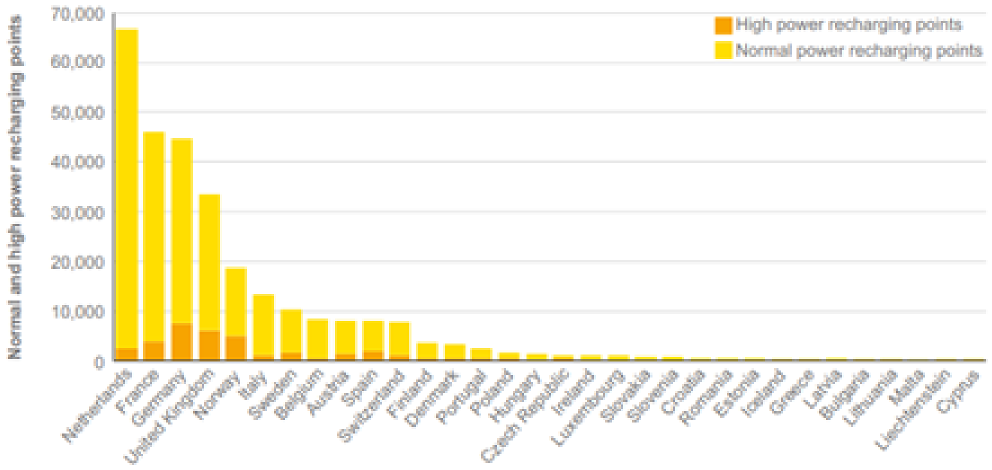

Figure 1: Electric vehicle public recharging infrastructure differentiated by normal and high power recharging points in European markets in 2020 (Source: EAFO - European Alternative Fuels Observatory)

However, it is not only about the quantity of available charging points in a region. Different studies refer to an indicative ratio that is needed of at least 1 charging point per 10-12 electric vehicles, but this ratio is of course very dependent on the local situation. Equally important to this ratio/quantity, is the quality of the charging service offered to the end users. This charging service needs to be easy to use, reliable, and cost transparent. Information about the location and availability of charging points, the way to get access to these charging points, the tariffs, etc., are crucial for the end user to be confident enough to make the switch to 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. However, interoperability is equally important for governments and companies making investments in charging infrastructure and services. Information exchange between the back offices of the different stakeholders like charge point operators and mobility service providers is an important aspect and having open and interoperable solutions can have a positive impact on the business case as well as on the flexibility to offer higher quality and/or combined e-mobility services to the end user.

OBJECTIVES

Today, most EV drivers are still lacking easy access to all necessary information about the charging possibilities in their region. Interoperability between countries is even a bigger problem. Many steps are being taken to improve information and interoperability, but today EV drivers still have to put a lot of time and effort into collecting this crucial information about the charging infrastructure (location, availability, accessibility, pricing, etc.) for their specific charging needs. Only the EV early-adopters will make this effort and most other people interested in electric mobility will wait until this situation improves. Steps for improvement are being made, but not all issues have been solved completely, for example, having a clear upfront view on the costs of charging at all locations.

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, etc.
- How to know the real-time status of the charging station: free, in use, defect, etc.
- How to reserve the charging station (optional)
- Which authentication is needed at the charging station: none, via RFID card, via an app, ad-hoc use possible, etc.
- Pricing and payment information: which tariff scheme is applicable for you on that specific charging station? The AFID-directive mentions “Member States shall ensure that prices charged by the operators of recharging points accessible to the public are reasonable, easily and clearly comparable, transparent and non-discriminatory”.

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

WORKING METHOD

Task 39 will be executed in a pragmatic way and will make use of mainly telephone conferences and 2 workshops to collect, discuss, and write down the existing knowledge available from the experts from the member countries. This information will be complemented by additional desktop research and contacts with different initiatives to collect 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 concisely to share it with the EV community (end users, governments, and industry) is the ultimate ambition of Task 39. The country reports and recommendations will be shared via the Annual Report and the website of IEA 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 work plan. A higher number of member countries leads to greater and higher quality information exchange and ultimately, to better recommendations to stimulate interoperability of e-mobility services, not only within one country but also cross-border.

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 to date.

In 2020, Task 39 organised two online workshops together with Task 43. Originally the workshop was scheduled for EVS33 in Portland (USA), but because the conference needed to be cancelled due to COVID-19, it was replaced by two online workshops, each held in June 2020.

The information collected via desktop research, workshops and direct contacts is stored in a dedicated Task 39 SharePoint site hosted at VITO and which is accessible for all Task 39 member countries. With the same login, the member countries also get access to the knowledge database of the Flemish Knowledge Platform Smart Charging with literature on smart charging.

The focus at the start of the desktop research was mainly on Europe because a lot of the ongoing projects detected have been set-up with European funding (FP7, H2020 or Interreg). Thanks to member countries Canada and the 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 studied in the first period of Task 39 are:

- 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 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

- 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 electric mobility services, creating an open, distributed, and widely accepted ecosystem for electro-mobility. The lack of interoperability gave rise to the recent concept of electric 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 electric mobility.

More recently, the H2020 call on “User centric charging infrastructure” (LC-GV-03-2019) was launched which focused on many Task 39 related topics. Three projects have been funded within this call:

- eCharge4Drivers:
  - o Electric Vehicle Charging Infrastructure for improved User Experience
  - o https://echarge4drivers.eu/
  - o As the popularity of electric vehicles (EV) grows, users' needs and expectations on charging solutions and services are increasing. The EU-funded eCharge4Drivers project will improve the user experience as it regards available charging options and services. Specifically, it will develop and demonstrate user-friendly charging stations, smart services, and charging solutions, including mobile charging and battery swapping stations. User-centric services such as route planning, booking, and charging location planning will be developed to further improve users' experience and foster e-mobility growth. The project’s user-friendly charging systems and interoperable services will be demonstrated in 10 areas, covering cities, the Trans-European Transport Network, and cross-border routes. The project will conclude with recommendations for legislative and regulatory amendments, as well as guidelines for the sustainability of charging infrastructure investments.

- INCIT-EV:
  - o Large demonstration of user centric urban and long-range charging solutions to boost an engaging deployment of Electric Vehicles in Europe
  - o https://www.incit-ev.eu/
  - o INCIT-EV aims to demonstrate an innovative set of charging infrastructures, technologies, and its associated business models, ready to improve the EV users experience beyond early adopters, thus, fostering the EV market share in the EU. The project will seek the emergence of EV users’ unconscious preferences relying on the latest neuroscience techniques to adapt the technological developments to the users’ subjective expectations. 5 demo environments at urban, semi-urban, and extra-urban conditions will be ready for the deployment of 7 use cases, addressing:
    - Smart and bi-directional charging optimised at different aggregation levels
    - Dynamic wireless charging lane in an urban area
    - Dynamic wireless charging for long distance (e-road prototype for TEN-T corridors)
    - Charging Hub in a park & ride facility
    - Superfast charging systems for EU corridors
    - Low power DC bidirectional charging infrastructure for EVs, including two-wheelers
    - Opportunity wireless charging for taxi queue lanes in airports & central stations
  - o INCIT-EV consortium consists of 33 partners, including 3 OEMs, 6 charging technology providers, 5 public authorities, 6 RTOs, 2 ICT companies, 2 road infrastructures companies, 4 DSOs, 2 TSOs, 2 SMEs with expertise in user behaviour and e-mobility exploitation, a car sharing services SME, and an EV users association. Finally, ENTSO-e or the TInnGo project on gender issues support the project.

- USER-CHI
  - o Innovative solutions for USER centric CHarging Infrastructure
  - o https://www.userchi.eu/
  - o The EU-funded USER-CHI project will promote large-scale electromobility market uptake in Europe through smart solutions, novel business models, and new regulatory framework conditions. The aim will be to integrate innovative charging technologies and put the user at the centre of the entire transition. The project will also exploit the synergies between electromobility and the process of greening and smartification of the grid. To pave the way for more EVs, the project will integrate the technological tools, business models, and regulatory measures to be tested and validated in five EU cities (Barcelona, Rome, Berlin, Budapest, and Turku).
  - o USER-CHI aims at unlocking the massive potential of electromobility in Europe. This will be achieved by
    1) integrating different innovative charging technologies with a holistic perspective
    2) putting the user at the centre and empowering them
    3) exploiting the synergies between electromobility and the process of greening and smartification of the grid which is taking place to achieve the energy transition in Europe
    4) integrating the technological tools, business models, and regulatory measures which will transform the elements cited above into an actual, working ecosystem that improves the user experience of EV drivers beyond the current levels of ICE vehicles drivers, whilst at the same time makes it financially attractive for the relevant private and public stakeholders for the large scale deployment of Europe's required user centric charging infrastructure.

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 services interoperability by harmonising existing ICT data and preparing standardisation of future data standards & protocols including security and authentication. Examples of members of eMI3 are roaming platforms like Hubject (www.hubject.com) and Gireve (www.gireve.com) – Task 39 partner ElaadNL is also a member of eMI3.

Task 39 is also following closely the activities around the AFID Directive 2014/94/EU on the deployment of alternative fuels infrastructure in Europe. The Sustainable Transport Forum (STF) was set up to assist the European Commission and serves as a platform for structural dialogue, exchange of technical knowledge, cooperation and coordination between Union Member States, and relevant public and private stakeholders. Its mandate has just been extended until 31 December 2030. DG MOVE may set up sub-groups that report to the STF plenary, for the purpose of examining specific questions based on terms of reference defined by DG MOVE.

The following Sustainable Transport Forum sub-groups are currently active or in the process of being set up:

- Sub-group on the implementation of Directive 2014/94/EU: this sub-group consists of the Member States only and discusses specific aspects related to the implementation of the Alternative Fuels Infrastructure Directive 2014/94/EU.

- Sub-group on governance and standards for communication exchange in the electromobility ecosystem (with particular focus on ISO 15118-20 and related PKI): this sub-group will propose minimum principles and a governance framework for communication between the electric vehicle and the recharging infrastructure, ensuring interoperability in the whole ecosystem. It will moreover prepare the ground for harmonisation and convergence of electromobility communication standards and protocols.

- Sub-group on a common data approach for electric mobility and other alternative fuels: building on the work of the Program Support Action (PSA) on data collection related to recharging/refuelling points for alternative fuels and the unique identification codes related to e-Mobility (IDACS). This sub-group will look into the different data dimensions (aggregation, quality, sharing, reusability, provision, etc.) and data types (location, availability, price, payment methods, etc.) required to enable the future creation of new digital services in the alternative fuels market. It will propose a framework for data collection and exchange, with the ultimate objective to provide better information to consumers of alternative fuels infrastructure and services.

- Sub-group on best practices of public authorities to support the deployment of recharging infrastructure: this sub-group, which consists of public authorities mainly, will further the work on the 2020 STF recommendations for public authorities for procuring, awarding concessions, licences, and/or granting support for electric recharging infrastructure, generating a (bi-)annual update to ensure the recommendations remain relevant for public authorities. The sub-group will moreover look into possibilities to harmonise permitting procedures for alternative fuels infrastructure in the EU.

Within the Task 39 member countries, one of the first countries to take interoperability seriously on a national and cross-border level was The Netherlands. The Dutch have a national agenda for charging infrastructure (https://english.rvo.nl/sites/default/files/2020/10/Factsheet%20The%20National%20Charging%20Infrastructure%20Agenda.pdf). One of the work packages is to create a national access point for dynamic data on all (semi) public charge points and ensure price transparency for e-drivers by making a deal between governments, Chargepoint Operators and Distribution System Operators. They will also develop open protocols and standards for the entire value chain of charging.

For many years, they have been working 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), eViolin.nl (www.eViolin.nl), and NKL(www.nklnederland.com). 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.

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 Centers. 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. The interoperability of the EV fleet and the smart grid is also investigated.

Pre-normative research is conducted to identify gaps in standards or technology and to support the formulation of regulations addressing interoperability issues.

The information collected via desktop research, workshops and direct contacts will be stored in a dedicated Task 39 SharePoint site hosted at VITO, which is accessible by all member countries.

NEXT STEPS

In 2021, Task 39 will organise its final workshop in close cooperation with Task 43 on “Vehicle Grid Integration”. The main efforts in 2021 will be focused on finalising the country chapters of the participating member countries and the Task 39 final report.

The final workshop will allow the exchange of the latest information and best practices on interoperability between the member countries, but the workshop will also be open to other interested countries. The information from the workshop will be used as input for the Task 39 final report.

The country chapters will be finalised by the respective member country 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 chapter of Canada was finalised by BCIT in May 2020. All country chapters will be disseminated via the next IEA TCP HEV Annual Report and website.

Figure 2: Task39 Country Chapter Canada (Source: BCIT)

The Task 39 final report 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. In the Task 39 final report, we will refer to the latest information available and make links to best practices and guidelines.

In 2020, the awareness of the importance of interoperability aspects studied within Task 39 became even more visible.

In June 2020, the eMI³ statement paper on “Quality of Service statement for EV charging on publicly accessible infrastructure” was published and can be found on the eMI3 website. Gilles Bernard, member of the eMI3 Steering Board and member of Task 39 underlined the importance of the proposed Quality of Service statement: “EV drivers will need to be reassured and confident in the possibilities of recharging their EVs wherever they drive. A sufficient number of charging stations is not enough if the service quality does not live up to the expectation, given the complexity of charging an EV and the need to use the services the same way everywhere”.

At the end of 2020, the Sustainable Transport Forum unanimously adopted a Report entitled “Recommendations for public authorities for procuring, awarding concessions, licences and/or granting support for electric recharging infrastructure for passenger cars and vans” as well as a summary Handbook, highlighting the main findings, recommendations, and examples of the main recommendations report. The STF detailed recommendations report is meant to provide practical guidelines for public authorities that are either looking to procure recharging infrastructure or to award concessions for their roll-out and/or operation, possibly linked to the granting of government support. By offering an overview of best and innovative practices by frontrunners, the STF aimed to develop a set of minimum recommendations to public authorities seeking to support the deployment of recharging infrastructure in their territories. Different Task 39 member countries gave input to this recommendations report and Task 39 partners like ElaadNL and NKL were core reviewers. Task 39 is happy to see specific chapters with recommendations for future tenders on making charging infrastructure more interoperable, future-proof and user-friendly.

FOR FURTHER INFORMATION, PLEASE CONTACT THE OPERATING AGENT:

Carlo Mol
VITO / EnergyVille
THOR Park
3600 Genk
Belgium

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

TASK 40

CRM4EV: Critical Raw Materials for Electric Vehicles

MEMBER COUNTRIES

IEA HEV MEMBERS

AUSTRIA
FRANCE
GERMANY
THE NETHERLANDS
NORWAY
REPUBLIC OF KOREA
SPAIN
SWEDEN
UNITED STATES
UNITED KINGDOM

EXTERNAL MEMBERS

GOVT. OF WESTERN AUSTRALIA,
JOGMEC (JAPAN),
ANGLO AMERICAN,
AVERE,
CHINESE ACADEMY OF SCIENCES – INSTITUTE OF PROCESS ENGINEERING, BOTREE (CHINA),
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 at providing accurate, credible, and up to date information on materials that are considered as potentially critical for increasing electric vehicles sales.

Issues covered include: Which are the (potentially) 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 permanent 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)?

Raw Materials under consideration in the scope of Task 40 CRM4EV are those materials that are economically and strategically important for the mass deployment of Electric Vehicles and have a high-risk associated with their supply. It is important to note that these materials can be classified as ‘critical’ for various reasons:

1. They have a high-supply risk due to limited mining (refining/smelting) capacity and/or a high level of concentration in particular countries,
2. 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,
3. There could be significant environmental impacts through the supply chain of these materials and intermediate products,
4. There could 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 in 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 the relevant information by and for Task 40 CRM4EV participants related to critical raw materials for EVs. This includes:

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

The network meets twice per year through workshops with several sub-groups for different critical materials/topics. The data needs and analyses from the participants will be used as the basis to define the detailed tasks to be conducted. The IEA HEV TCP participating countries will lead this work. In 2020 due to the COVID pandemic, no face-to-face workshops and meetings have been held, instead, teleconferencing and webinars tools have been used. We hope to resume face to face meetings as of October 2021.

WORKING METHOD

- Define and maintain a list of Critical Raw Materials to include in the scope of the Task CRM4EV.
- Define "criticality" of the Critical Raw Materials in scope:
  - Depending on geography
  - Depending on penetration rate in the EV application (scenarios)
  - Depending on the use of the CRM in EVs, cars and 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 the importance of recycling today, gap analyses in recovery and recycling technologies - including the costs of recycling and the 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 analyze scenarios for future requirements and needs for CRMs for EVs.

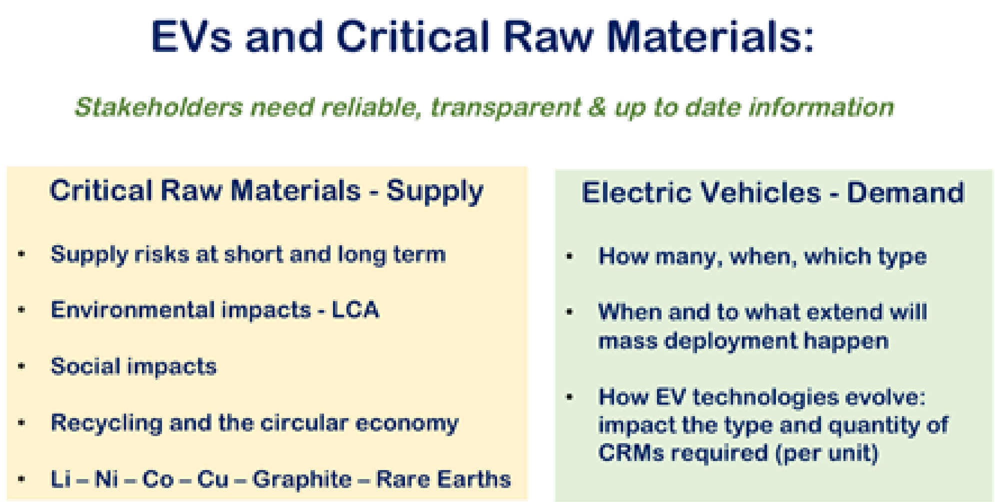

Figure 2 Key supply & demand issues for raw materials important for electric vehicles

REPORTING AND DELIVERABLES

A report will be written in 2021 to describe the updated scenarios and findings for the EV battery supply chain 2020 - 2030. Topics to be covered are battery chemistries, demand scenarios for EVs, raw materials demand in relation to current & future mining capacities, recycling of Li-ion batteries. Environmental and social impacts and the impacts of policies and regulations may be included as well.

The possibility to make a public report for Task 40 is currently being reviewed.

The battery chemistry study and the scenarios developed for EV deployment and raw material requirements will be updated in 2021 as well.

RESULTS

Workshops and site visits

Workshops: The Task has held 3 workshops and 5 webinars so far. The planned workshop for June 2020 at Argonne National Laboratory (US) had to be cancelled due to the COVID pandemic and has been replaced by a series of 3 webinars.

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

Webinars 1, 2, 3: June 2020, hosted by Argonne National Laboratory (USA)

Webinars 4, 5: March 2021, hosted by AVERE

Attendance of the workshops has been 30-40 people (each) from Task 40 CRM4EV participants and external experts and companies. The webinars were open to the public and have had an attendance of 80 – 190 people.

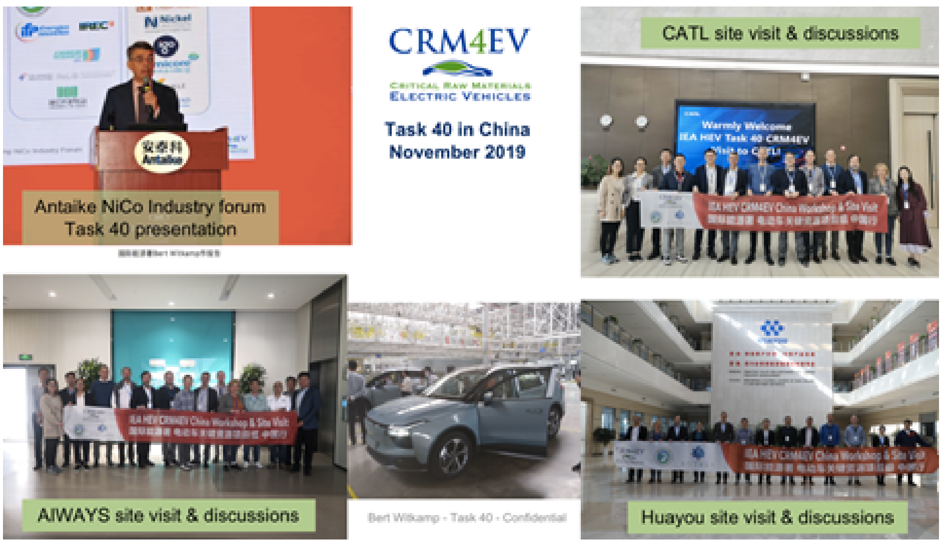

Figure 3 Site visits and Nico Industry forum presentation - China, November 2019

Task 40 CRM4EV presentations at external conferences, events and webinars

The IEA HEV Task 40 CRM4EV results have been presented at around 20 external conferences, events and as of 2021 in webinars and are listed on the CRM4EV website.

Task 40 CRM4EV website

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

Figure 4 Dedicated Task 40 CRM4EV website

Studies & Reports

Studies executed in 2019 & 2020:

- EV mass deployment scenarios were developed first half of 2019,
- Battery assumptions paper, 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 been made detailing the current supply and uses of the materials, potential future demand and supply, environmental impacts.
- Raw material (demand) scenarios 2020-2050 for the key battery materials.

In figure 5 several global EV deployments and battery demand scenarios are analysed. International initiatives like the Global Battery Alliance (GBA), CEM EVI 30@30

(Clean Ministerial Energy Electric Vehicle Initiative), IEA have published scenarios or ambitions for battery deployment (GBA) or EV deployment (EVI, IEA), as have the EU 27 (Green Deal) and several countries. These scenarios/ambitions are compared to each other and an EV growth rate, 2030 EV sales and the Li-ion battery demand in 2030 for cars have been calculated assuming constant growth year on year.

IEA HEV Task 40 CRM4EV - Impact of NEV/ZEV targets on EV growth and battery volume

Based on 2020 data	NEV / ZEV Targets passenger cars	Required NEV/ZEV growth YoY %	2030 NEV market share %	2030 ZEV market share %	2030 BEV sales (millions)	2030 Li-ion batteries for cars (GWh)
COP 21	1.5°C target - 100% ZEV fleet in 2050 - 100% ZEV sales in 2035	40%		75%	63	4095
GBA2019	Global Batttery Alliance base case	29%			22	1540
GBA2019	Global Batttery Alliance target case	33%			32	2230
IEA New Policies	Scenario 2030	20%			13	865
EV 30@30	Scenario 2030	30%			34	2236
EU 27	Green Deal (30 mio BEV fleet 2030)	30%			7	455
China	Strategic plan 50% NEV in 2035	19%	25%		8	520
China	Strategic plan 20% NEV in 2025	30%	50%		18	1170
Germany	Climate package (10 mio PEV fleet 2030)	16%	50%		1,7	111
Germany	Climate package (7 mio PEV fleet in 2030)	10%	29%		1,0	65
Netherlands	(Dutch) Green deal	20%		100%	0,5	33
UK	100% ZEV in 2032 (proposal)	30%		61%	1,4	91
UK	100% ZEV in 2035	24%		38%	0,9	59

NEV: New Energy Vehicles = PEV = BEV + PHEV ; ZEV: Zero Emission Vehicles = BEV (FCEV assumed 0)

CRM4EV scenario: "High Nickel - 65 kWh battery packs in 2030"

Figure 5 Impact of national and EU targets and ambitions on EV deployment and battery demand 2030

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 2021.

Using the updated battery chemistry development scenarios, raw material demand scenarios for 2030 will be made. These will be compared with current insights in raw material mining production and the potential to increase capacities.

Regular communication on key global developments in the area of EV demand and key developments for relevant raw materials is also part of the Task 40 output.

NEXT STEPS

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

The raw material scenarios will be further developed as well to reflect the changes in battery chemistries, use, and the developments on the electric vehicle demand side.

Task 40 CRM4EV will continue to be presented at seminars when planning has been made to return to face to face meeting. The Task 40 CRM4EV closing event is scheduled for June 2022 to coincide with EVS 35 in Oslo, Norway.

FOR FURTHER INFORMATION, PLEASE CONTACT:

OPERATING AGENT
Mr. Bert Witkamp
Valuad Ltd
Visé, Belgium

bert@crm4ev.org

CO-OPERATING AGENT
Mr. Stephan Schmid
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Germany

stephan.schmid@dlr.de

TASK 41

Electric Freight Vehicle

MEMBER COUNTRIES
AUSTRIA
GERMANY
REPUBLIC OF KOREA
SWITZERLAND
TURKEY
UNITED KINGDOM

INTRODUCTION

Road freight 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 worldwide road freight activity and energy use in the last two decades1 . In addition to global impacts, air pollutants are emitted locally through the combustion of fossil fuels – a major problem in densely-populate cities reliant on road freight for logistics and delivery. As a result, counties are looking at freight emissions reduction, and the European Union has set fleet targets for average CO2 emissions from light and heavy freight vehicles aimed at reducing freight emissions3 . 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. The current emphasis is on incremental technology developments to reduce the fuel consumption of conventional vehicles. However, there is potential for (near) zero tailpipe emission vehicles that could result in large-scale GHG reduction and meet challenging targets – and for alternative delivery concepts to achieve sustainable urban logistics.

Prospects of electric freight vehicles

The IAA Commercial Vehicle Fair in 2018 characterised an increasing electrification strategy for commercial vehicles. Different manufactures showcased their first battery-electric vehicle concepts. Especially in the LDV (Light Duty Vehicle) 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 start of production (SOP) of these medium and heavy-duty vehicles are set for 2021[6].

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

However, electric articulated and semitrailer tractors are currently manufactured and sold primarily by small suppliers such as the Swiss E-Force One AG and the German Framo GmbH[7,8] These are so-called electric vehicle converters, which replace the combustion engine of trucks from MAN, Daimler and Co. with their own electric powertrain. In the future, the heavy freight vehicle market may also be shaped by (American) start-ups such as Tesla, Thor, and Nikola Motors. They promise higher ranges for their vehicle concepts than the current market average in the respective vehicle segment.

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

Figure 3 shows the availability of different battery-electric commercial vehicles by brand and segment. The availability is characterised by the current status of production readiness and the announced year of market entry by the manufacturers.

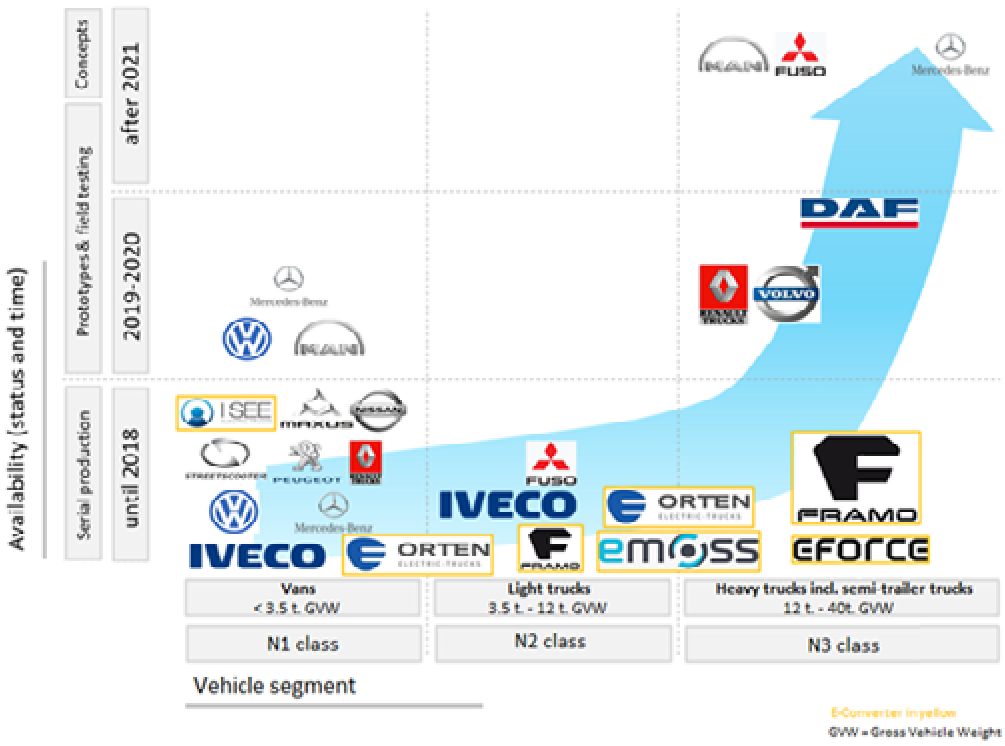

Figure 3: Roadmap battery-electric freight vehicles - Availability of battery-electric freight vehicles by brand and segment (Status mid-2020)

Nonetheless, current BEV concepts do not show long-distance suitability compared to conventional vehicles. Higher electrical ranges conflict with additional battery weight. A solution for this can be offered by electric trolley trucks (mostly as plug-in hybrids) 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.

Figure 4: 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

The 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 going to enter into the first customer application of fuel cell trucks in Europe 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 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 refuelling 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 (a joint venture of energy provider Alpiq and Linde Group), who are ensuring the widespread expansion of the H2 refuelling infrastructure and the necessary local hydrogen electrolysis in Switzerland for the FCEV in order to operate them completely CO2-free.

OBJECTIVES

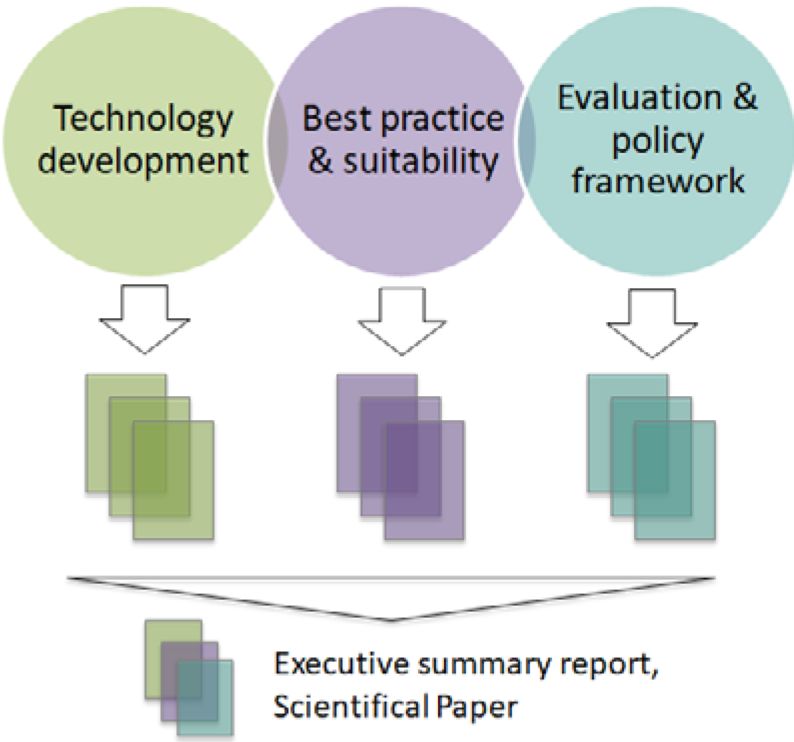

Figure 5: Program of work

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 EFVs. Based on the current availability of EFVs on the market, performances, as well as standards and norms for EFVs, are described to monitor the technical advances of EFVs. The development of the charging infrastructure, in particular concerning costs and availability, is also in focus.

The second area of interest deals with the “best practice and suitability aspects of EFV” to identify potential application areas for EFVs. Based on best practice pilot projects, successful examples of EFVs implementations will be described. This includes an 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. Given the different suitability of EFVs technologies for replacing conventional diesel engines, the economic and ecological aspects of EFVs 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 the form of short fact sheets, which will provide the base to review the aspects for a successful introduction of EFVs 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 such as hybrid, plugin-hybrid, battery electric, fuel cell electric, and electric road powertrains.

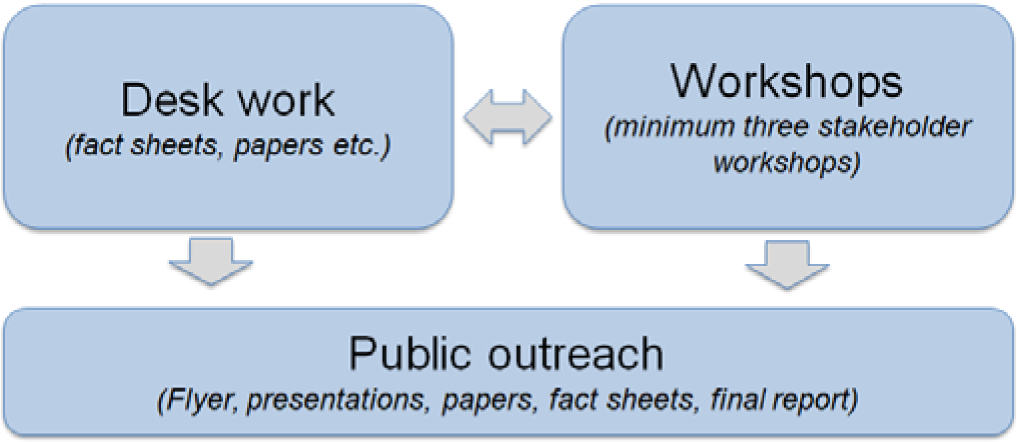

Figure 6: Overview of working method

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 contact with other international networks. In line with 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 in the workshops.

Desk research will provide information for discussion, e.g. on vehicle technology and cost developments, and are presented in several fact sheets. The desk research should reflect a networking activity by 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.

RESULTS

The electrification of freight is a direct response to the requirement to reduce GHG emissions from road transport. The challenge has been to introduce electrification whilst continuing to meet user requirements. This has given rise to numerous activities in the different vehicle segments of the freight sector with some uncertainty as to which solutions will be adopted in the longer term. Users are now urgently looking for information on how to navigate through the present, uncertain situation with a view to minimising the risk of stranded investments when envisaging extended operations with electric drive. In response to the challenge, the activities within Task 41 have resulted so far in the following products:

1st Workshop on EFV in urban logistics

The first Task 41 workshop on battery-electric freight vehicles in urban logistics was held in Stuttgart (Germany) on October 15th 2020. Dedicated topics at the workshop were:

- current technical characteristics of battery-electric freight vehicles
- development of the charging infrastructure: costs and availability
- practical experience and knowledge from pilot projects and initial applications

Twenty-four local and international guests from logistics as well logistics associations, vehicle industry, charging-infrastructure, city administration, and research took part in the discussion on opportunities and hurdles for the successful implementation of battery-electric freight vehicles in urban logistics. A presentation was given by the vehicle manufacture Daimler, and charging infrastructure suppliers in Germany ABB, ChargeHere by EnBW and EBG compleo, and from the logistic company Dachser in Stuttgart, Germany and Fier Automotive from Helmond, the Netherlands. Based on 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 discussion were the still 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 it could be very 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.

A summary of the results from the workshop can be found on the HEV-TCP website.[9]

2nd Workshop on EFV in long haul transport

On September 29th 2020, the Task 41 team hosted the 2nd online workshop/webinar on “Electrification of Heavy-Duty Vehicles in Long Haul Transport”. In three sessions, experts shared and discussed the present state of technologies, experiences, and best practices – covering alternatives including fuel cell electric, battery-electric, and catenary electric freight vehicles. In total, thirty-four attendants from industry, research, logistics, and governmental organisation joined the webinar.

Essential for the implementation of electric freight vehicles in long-haul transport is the new developments in battery and fuel cell technology. Akasol AG predicts that in the next four years the energy density of their high energy batteries for commercial vehicle applications would likely increase from 140 Wh/Kg today to 240 Wh/kg. For their high power batteries, which are especially suitable for fast charge and hybrid power applications, Akasol expects the charge capacity to increase from 500 W/kg today to 800 W/kg in 2024. However, many manufacturers and vehicle retrofitters such as Quantron AG criticise the present limited availability of battery cells. Quantron AG proposed that the European market needs a commitment for battery supply of five to ten years. As an alternative, or as an adjunct to the battery for energy storage there is also the option of using fuel cells. This is viewed as attractive for the long haul freight sector. However, there is a cost issue to overcome. To be successful with the deployment of any alternative, it is essential for the vehicle operation that infrastructure is in place and aligns with the specific needs of the vehicle.

The MAN Truck and Bus SE, together with logisticians from the Council for Sustainable Logistics, has been testing nine electric MAN-CNL trucks on Austrian roads since 2018. MAN summarised that electric mobility in trucks works and today it is more sufficient for the range in urban delivery. MAN expects that customers might be required to change their habits with the transition, but the extent of that change would be limited to certain cases.

Another best practice example for long-haul applications is the eHighways from Siemens AG. Siemens described that, in general, heavy-duty vehicles drive long distances and are often away from their base. Their transport tasks are highly concentrated to the highway network. Therefore, Siemens recommends using a dynamic charging approach, in this case, catenary portals on highways when this is possible and move to battery on the distributor routes. Other dynamic charging approaches, for example, infrastructure embedded in the highway, may also be possible and are under consideration. The development of the eHighways vehicle´s technology is currently in its 3rd generation, focusing on field trials.

In addition to pilot projects on battery electric trucks in inner-city delivery and on ehighways, Clean Logistics GmbH from Germany presented their first Fuel Cell Electric Vehicle concept on the last webinar, which they call Hybat-Truck. Clean logistics is planning to set up their own hydrogen supply network in the coming years to be able to fill and operate their Hybat-Truck emission-free with hydrogen.

In the discussion session, ICCT stated that access to capital is one of the key barriers they have seen in the past for fleets to invest in efficiency technologies. Thus, it will require innovative financing solutions to ensure that the barrier of upfront cost and access to capital can be overcome and depreciate over the vehicle operation time. The Transport Decarbonisation Alliance (TDA) stated that customers are also willing to pay for transportation and not only for the TCO. This requires new business models such as transport as services or leasing options. Nevertheless, there must be some frontrunners who are willing to pay a little extra for the TCO of electric freight vehicles.

A full summary of the results from the webinar can be found on the HEV-TCP website[10].

Fact sheet on the State of the Art of Electric Freight Vehicles

The main challenges in the technical performance of Electric Freight Vehicles (EFV) are the available range, payload, and charging time. The traction battery has a major influence on the indicators. In addition, the limited availability of EFV models and rapid technological development plays a major role in the attractiveness of EFV in the market[11]. However, the market is developing rapidly. The question therefore arises as to whether the current state of performance of EFVs is competitive with a conventional freight vehicle today. In the Task 41 fact sheet "The State of the Art of Electric Freight Vehicles" different technical indicators for EFVs were evaluated. The evaluation shows that some EFVs are potentially as efficient as conventional vehicles. With the rapid development in battery technology, further technological improvements in terms of range and payload of freight vehicles can still be expected. The fact sheet is available for download on the HEV-TCP website[12].

FACT SHEET ON THE EUROPEAN TRUCK MARKET AND POTENTIAL POWERTRAIN TECHNOLOGIES

In 2019, 2.48 million Light and Heavy-Duty Vehicles were newly registered in Europe, 85% of which were Light-Duty Vehicles (LDV) under 3.5 tons gross vehicle weight (GVW). Most of the vehicles are powered by a diesel engine (92.8% LDV, 97.9% HDV). Alternative fuels, like CNG, LPG, biofuels, and ethanol, had a share of approximately 1.4% in the overall commercial vehicle registration in 2019. The market niche is made up of Hybrid Electric Vehicles (HEV) with 0.2% of new registrations. However, the market share in the LDV has risen to almost 160% compared to the previous year (4,577 hybrid-electric vans in 2019). Another high increase was recorded by plug-in electric commercial vehicles (BEV, FCEV, REEV, PHEV) with 26,107 plug-in electric LDV and 747 plug-in electric HDV newly registered in 2019. The year-on-year increase was stronger in the HDV segment (+109%) than in the LDV segment. The main markets for these vehicles are primarily Germany, followed by the Netherlands and France.[13,14]
In the media, the first long-term strategies of the manufacturers have appeared with information on the planned investments. The Task 41 fact sheet "The European Truck Market and Potential Powertrain Technologies" gives an overview of the known short- and long-term powertrain strategies of the OEMs. In summary, the market developments show that electrification efforts are beginning to take hold in the entire commercial vehicle segment. However, compared to the passenger car market, the manufacturers' strategies differ in some respects. Mainly BEV, FCEV, or both are mentioned as the future powertrains for the truck market. The full fact sheet can be found on the HEV-TCP website[15].

Task 41 has been represented at various events and initiatives. A presentation was given at the TDI[16] event in February 2020. In addition, Task 41 members are actively participating in the regular UK commercial vehicle working group (UK CWWG) meetings and the regular meetings of the international action group "Call for Zero Emission Freight Vehicle"(an initiative of the Transport Decarbonisation Alliance)[17]. There was also close cooperation with the TCP AMF Annex 57 on the potentials of future powertrain systems for HDV[18].

NEXT STEPS

Task 41 will continue active participation in the ongoing working groups. The technical exchange with the AMF Annex 57 is already documented on the fact sheets "Evaluation of powertrain and fuel options for heavy-duty vehicles to meet the EU CO2 emission fleet target" and will be published on the HEV-TCP website soon.
A third online workshop/webinar will be planned for the second half of 2021. Participation is by invitation only and free of charge for all Task 41 members.

FOR FURTHER INFORMATION, PLEASE CONTACT THE OPERATING AGENT:

Mr. Özcan Deniz
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Pfaffenwaldring 38-40
D-70569 Stuttgart
Germany
+49 711 6862 8120
Oezcan.Deniz@dlr.de

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TASK 42

EV City Casebook

MEMBER COUNTRIES
CANADA
DENMARK
GERMANY
THE NETHERLANDS
UNITED KINGDOM

INTRODUCTION

Electric cars, buses, and taxis have rapidly increased in numbers, moving beyond early pilots and trials. New forms of micromobility and smartphone-based transport systems have grown in popularity. Cities have broken new ground in these innovative technologies and new policy ideas.

Currently, most governments have targets for continued EV growth. Many cities are planning to ban fossil-fueled vehicles altogether. There is unprecedented momentum around EVs, and a recognition of the role they play in cleaner, more sustainable cities. But this progress needs to be sustained. By any scenario, avoiding catastrophic climate change will require further reductions in greenhouse gas emissions from transport. In most countries, EVs still represent a minority of new vehicles sold. Some EV types, like buses and heavy goods vehicles, are developing quickly but are still a relatively nascent technology.

So, the task facing policymakers across the world is to accelerate the move to mass adoption – and step towards a future of total transport decarbonisation. What kind of policy, financial and legal tools can they use to speed up adoption? How do cities need to work with vehicle manufacturers, energy providers and their citizens to create support for faster change? How does policy on EVs need to link up with exciting developments in autonomous vehicles, connected devices, and mobility as a service? How can cities learn from their counterparts around the world, to move to mass EV adoption?

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?

The Casebook is designed for a large range of stakeholders including: city managers; city political leaders; national policy officials; national policy officials; managers in procurement, transport, and economic development; EV and transport industry; media; research; and other stakeholders.

WORKING METHOD

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

This casebook was informed by over 50 interviews with city managers and experts, covering cities in over 20 countries across the world. In total, these cities have populations of 160 million people. Insights were also drawn from desk research and the global networks of the Electric Vehicles Initiative (EVI), the Hybrid and Electric Vehicle Technology Collaboration Program (HEV TCP), and partners.

In addition, an online survey was run from May to September 2020 to ensure cities had an input into the process and put forward potential case studies. Two workshops were held virtually in September 2020 to validate our policy guidance findings, leading to our ten policy recommendations outlined in the Casebook.

RESULTS

Figure 1: The EV City Casebook was successfully launched in March 2021

The EV City Casebook was successfully launched in an online webinar in March 2021. This casebook highlights inspiring examples from around the world of cities which have taken actions to accelerate mass adoption of EVs (see Figure 2 for the selection of cities included). The first five chapters profile different vehicle modes. Each chapter presents case study cities, with a brief description of their approach and key insights from their journey towards mass electric vehicle use. An EV Policy Maturity Model is outlined, to provide guidance to cities in benchmarking progress and to help cities identify where to further develop their efforts.

Figure 2: Map showing distribution of cities included in the casebook

From our interviews, we identified five challenges to scaling up:

1. Long-term sustainability of incentives
2. Maturity of technology in larger vehicles
3. Social equity perceptions
4. Important policy levers at different levels of government
5. Need for integrated thinking with energy systems

We also established ten policy recommendations:

1. Set ambitious scale-up targets, backed up by achievable action plans.
2. Formal governance structures with a broad range of stakeholders working to a common vision.
3. Showing EV benefits across different aspects of public policy
4. Long-term planning in incentives
5. Leading by example
6. Direct relationships with manufacturers and technology providers
7. Adding responsive systems to infrastructure roll-out
8. Building resilience in infrastructure contracting and energy systems
9. Future-proofing for digital innovation.
10. Establishing social equity outcomes of EVs.

More information is available in the document which is available on the Urban Foresight website[1], as well as on the IEA and HEV TCP websites. This project 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 has enabled input from the cities in the EVI Pilot City Program.

NEXT STEPS

Task 42 has now been completed and closed. We will continue to disseminate the EV City Casebook across our networks, and engage with interested stakeholders.

FOR FURTHER INFORMATION, PLEASE CONTACT THE OPERATING AGENT:

Dr. Kate Palmer
Urban Foresight
Flour Mill, 34 Commercial Street,
Dundee, DD1 3EJ
United Kingdom

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

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TASK 43

Vehicle-Grid Integration

MEMBER COUNTRIES
BELGIUM
CANADA
DENMARK
FRANCE
GERMANY
IRELAND
ITALY
THE NETHERLANDS
REPUBLIC OF KOREA
SPAIN
SWITZERLAND
UNITED KINGDOM
UNITED STATES

INTRODUCTION

The IA-HEV Executive Committee unanimously approved Task 43 at the Executive Committee meeting in October 2018 held in Burgdorf, Switzerland. The Kick-off Meeting took place on the 23rd of May 2019 in Lyon, France.

OBJECTIVES

Task 43 aims to explore, identify, and give answers to the gaps preventing electric vehicles to be fully integrated into the electrical grid. In addition, it is also intended to improve the joint work between the electric sector and the mobility sector, which is a key point for the real energy transition.

The scope and basic approach of Task 43 are:

- Analyse all VGI aspects using expert workshop meetings with stakeholders involved in each of the identified gaps.
- Join stakeholders from different sectors to find global solutions to the current “chicken and egg” situation (meaning that there is no market because no users exist, and there are not sufficient users because there is no market).
- Interact with other tasks within the TCP (batteries, EV consumers, and interoperability) and in other TCPs (PV-EV, flexibility for buildings).

During the kick-off meeting of the task, the partners discussed the current and future challenges for vehicle-grid-integration. The conclusions were summarised and resulted in the list of challenges to be analysed within Task 43:

1. Charging technology and standards:
    a. Standards: open standards linked between EV, charger and third parties.
    b. Charging technology: security for users and global data protection (GDPR) and effective and smart access to AC and DC chargers.

2. Markets, Services and Regulation:
    a. Regulation: remove barriers to market entry, unity between national energy markets, and coordination in national and international regulatory changes.
    b. Services: technical feasibility to offer different services.
    c. Market: analyse new business models that allow a full VGI value chain.

3. Grid Infrastructure and Planning:
    a. Educate stakeholders about smart grid and data must be made accessible.
    b. Bring knowledge on VGI together: categoriser + address knowledge gaps.
    c. Provide easily accessible VGI solutions to DSO.

4. User Engagement:
    a. Convenient VGI: seamless experiences. Bundle transport services (cost of tech + electricity tariff…). Simple requirements from the user.
    b. Risk free: Avoid and or compensate risk. Meet driver requirements + ensure against battery degradation.
    c. Profitable: make financial sense. Reduce cost of access + cost of use

Task 43 aims at producing the following outputs:

- Knowledge exchange workshops:
- Tangible and targeted support for governments and standards agencies (position papers)
- Publications and participation in related events
- Support collaboration and projects between different stakeholders, such as DSO, TSO, OEM, regulators

WORKING METHOD

The main objective of Task 43 is to investigate the means to overcome the technical, economic, and policy challenges to allow full integration of electric vehicles into the electrical grid. As the main lesson learnt from previous tasks, the whole ecosystem of the electric vehicles will be considered in this process including power system operators, power electronics industry stakeholders, users, and the most relevant original equipment manufacturers (OEMs). Activity mainly consists of expert workshops for researchers, industry, and policy makers to work together in order to tackle the various technical, regulatory and social challenges of VGI.

Utilising the existing IA-HEV framework, Task 43 provides the opportunity to bring together the key stakeholders in the EV industry including research and industry players and energy policymakers in order to discuss all the challenges identified by expert partners.

Two annual meetings are programmed on different strategic topics.
In addition to expert workshops, a relationship and coordination between the expert members is planned to connect industry and research into different demonstration projects. The promotion of new demonstration projects will be done by collaborating with international organisations and call for proposals

RESULTS

Task 43 has organised two workshops: “Regulatory aspects of Vehicle-Grid Integration” and “Electric Vehicle: Grid and Market Integration” (joint workshop with Task 39). The main conclusions derived from the multiple expert contributions within these Workshops are detailed below.

Energy flexibility in connection to electric mobility- a Belgian viewpoint.

Flexibility in electricity grids may increase the capacity to reduce CO2 emissions by using a cleaner energy mix, and not by reducing energy consumption. There are several challenges to be addressed by the electricity market, related to energy balancing, security of supply, and congestion constraints. Combining traditional production and consumption with renewable production requires active energy changes either in the consumption profiles or need additional balancing capabilities. It has been shown that the energy market requires, at least, smart charging strategies in order to avoid LV grid congestion. Even if the grid is over-dimensioned (0.2-0.3 simultaneity factor), it may not be enough in particular points/conditions for large EV penetration scenarios (30% scenario studied). Belgium may require an additional 1GW of flexibility only during 61.5 h/year and one of the best sources for this type of flexibility is electric vehicles.

Policies supporting the electrification of transport in Norway

Public policy objectives for 2025 in Norway imply that all new passenger cars and light vans should be zero-emission, and all new city buses should be zero-emission or use biogas. By 2030, all new heavy vans, 75% of new long-distance busses, and 50% of new lorries should be zero-emission. The main CO2 emissions come from petroleum (15.1%), transport (16.7%), and industry (11.9%), which equates to a total of 10 ton CO2 eq/capita. The 2050 objective to reduce transport emissions to 1 ton CO2 eq/capita (total 2 ton CO2 eq/capita). The contributions from transport emissions are: private cars 39%, construction machinery 30%, heavy-duty vehicles (15%) and light freight vehicles (10%).

There are current policies supporting zero-emission vehicles focused on taxes (wholly exempted of VAT, one-off purchase, re-registration, annual circulation taxes; partially exempted of parking fees, ferry fees, road toll, fuel tax; bus lane access), while additional incentives for EVs are being discussed (new political platform, local municipalities to have more impact at local level, a national binding standard for EVs).

Regarding the V2G strategy in Norway, there is an ongoing study that focuses on the quantification of the degradation cost of V2G (battery focused) and the analysis value and impact of V2G in Scandinavia. The preliminary conclusions from the study are: (i) Large batteries have less degradation, (ii) the use of V2G increases with climate neutrality (low emission scenarios), (iii) V2G is only utilised in Denmark - Use of V2G depends on short-term price differences, (iv) V2G lowers fluctuations in electricity price, (v) V2G influences electricity generation capacity (more wind, less PV) and (vi) V2G reduces investments in electricity based heating capacity.

Policies for beneficial EV grid integration

EV grid integration is seen as an opportunity because smart electrical charging may enable renewable integration and reinforce energy transition policies. The definition of smart charging implies shifting EV charging when the energy price is lower without compromising EV owner needs. Additionally, the flexibility may not only lower the cost for the EV owner but also all end users.

According to RAP (Canada), EV grid integration advances the use of clean power and the transitions should be carried out in parallel with policymakers on a European, national and local level. These levels can address this opportunity jointly while the transition can start with smart tariffs, smart technology and smart infrastructure.

Current situation in The Netherlands

In the Netherlands, incentives for EV are reducing as the market is increasing, and the charging infrastructure is scaling up from a demand-driven to a supply-driven market. The energy transition towards electrification will be reached by combining solar PV, heat pumps, and EVs. The concept is now moving from EV charging to V2G and further V=G (vehicle is grid).

However, some technical issues remain for V=G. These include the impact of super harmonics effects on power quality when multiple cars (EV fleets) are charging, limiting capacity of invertors along with guaranteed security and functionality, and standards and protocols (V2G, ACPI 4V2G, Cybersecurity/PKI) are key issues. Business cases and regulatory analysis includes:

- Missing incentive to optimise consumption behind the meter in an electric vehicle
- Possible double energy tax for bi-directional charging
- No incentive for the roll-out of charging infrastructure with maximum charge capacity for Smart Charging
- It is unclear whether Smart Charging may be deployed for regional grid operators
- It is unclear who determines the use of the electric car for Smart Charging
- Risk of congestion at regional grid operator due to third party Smart Charging initiatives

Vehicle-Grid Integration Research at Federal Government Labs in Canada

From the last studies performed at Federal Government Labs in Canada, about 10 billion USD investments are needed in order to fully integrate electric vehicles into the grid. The bigger grid upgrade issues for mobility electrification are encountered for heavier buses and trucks which need more energy and higher power levels and more in centralised locations. For off-road vehicles, some locations have no grid at all sometimes or have a limited grid connection, which poses many unknowns. NRCAN is developing a pulse charging method for lower battery degradation that could be a game changer. Several start-up companies have started based on this technology.

Requirements for a smart charger

Based on a survey with 160,000 respondents, DTU has concluded that grid services should take place where the vehicle is parked for a long time. In Denmark, some recent projects combine the roll-out of charging infrastructure and grid impact studies. Several requirements for a smart charger have been identified, smart features get more and more stressed in brochures, while the standards that define what is smart are unclear. Some residential users still use standard plugs, which pose safety issues and are not able to perform smart charging. One important conclusion is that requirements need to be set in tenders only when enough suppliers are offering this feature on the market.

VGI work with Electric School Buses in the USA

School buses are common in North America, as 90% of school buses around the world are used in the USA. They do long distances and use 100-300 kWh batteries. The cost of electric buses is about 300-350k USD compared to 100k USD for diesel buses. California subsidises V2G buses, making a new school bus more economical. Buses are now seen as a grid asset. In Virginia, 1,000 V2G buses are leased monthly as grid assets. The buses are usually not affordable, but now a financing offer has become available and it is a viable option. Nuvve teams up with partners to offer a complete service via leasing the bus, charger, installation, V2G and servicing. The aim is to diminish the demand charge management behind the meter.

NEXT STEPS

The work within Task 43 will continue until the end of 2021. The COVID situation has altered the plans of the workshop performance and several task activities have become online. During the fall of 2021, a workshop focusing on business models and user engagement within the VGI ecosystem will be organised.

FOR FURTHER INFORMATION, PLEASE CONTACT THE OPERATING AGENT:

Dr. Cristina Corchero
Catalonia Institute for Energy Research
Jardins de les Dones de Negre 1, 2nd floor
08930 Sant Adrià del Besòs
Spain

+34 933 562 615
ccorchero@irec.cat

TASK 45

Electrified Roadways (E-Roads)

MEMBER COUNTRIES
UNITED STATES
NORWAY
THE NETHERLANDS
SWITZERLAND

INTRODUCTION

Task 45 is primarily a research and information gathering effort, focused on the complementary technologies, standards, and the various challenges & applications of Electrified Roadways (E-Roads) also called electrified roadway systems (ERS), and related transportation electrification. This task has a broad scope of vehicle deployments and will include E-Roads applications for light duty vehicles (LDVs) as well as commercial and transit vehicles. The inventory of pilot deployments of E-roads continues to expand and the interoperability for the technology between vehicle classes and other electrification technologies is a key focus of the project. The task will provide information critical for decision makers who are considering E-Roads deployments and educate stakeholders of the progress of the various technologies.

OBJECTIVES

The task will develop a greater global understanding and awareness of ERoads, related deployment activities, and technologies developed to advance electric mobility. Task 45 includes a study of international standards (JARI, SAE, ISO/IEC, etc.), various E-Roads technical approaches (listed below), as well as the integration of the power grid into the road infrastructure. The task will gather information regarding related national policy and the benefits/challenges related to E-Roads to gauge the global interest and commitment levels.

The four Technologies of Interest (TOI)s which Task 45 will focus on are:

- Dynamic Wireless Power Transfer (DWPT)
- Non-road Conductive (Overhead)
- Non-road Conductive (Side)
- In-road Conductive

WORKING METHOD

The task will conduct bi-annual meetings, which may include viewing locations of E-Roads research or deployment activities, to gain first-hand knowledge of how these technologies are progressing and to inform the HEV-TCP of advancements in E-Roads. Based on information gathered from participating countries, specific topics may be identified as critical areas (or R&D gaps) for further research. The member countries will report on related technology or analysis findings regarding the effectiveness of deployments or advancements in relevant technologies or safety & standards development.

Bi-Annual Meetings

The meetings and workshops coordinated by this task will focus on specific topics for each event. The order of workshop topics will be based on the priorities of the member countries and the timing of related deployments.

The task members will:

- Develop an understanding of the challenges faced in various countries or markets by categorising deployment approaches and requirements for E-Road technologies.
- Conduct a comparison of current technology development and address concerns for each of the TOIs.
- Catalogue and compare standards (JARI, SAE, ISO/IEC, etc.) in areas such as power transfer, alignment or other vehicle controls, data security, and communications.
- Summarise safety and operational issues arising from vehicle to E-Roads systems connections and possible E-Roads systems connections to the electric grid.
- Develop an understanding of the vehicle technology requirements and optimized E-Roads deployment at scale. This unbiased information is critical for decision makers considering E-Roads deployments.
- Catalogue potential grid impacts and understand grid requirements for at-scale deployment of E-Road systems.
- Generate a workshop report following each event to document findings, highlight progress or further identify gaps to E-Roads deployment at scale.

RESULTS

Member countries Switzerland, Norway, and the Netherlands joined the United States late in 2020 after a series of E-Roads informational webinars were held. The webinars were designed to obtain industry information to solidify the task scope. Due to recent travel and other operational restrictions, some planned task activities have been impacted. The member countries met early in 2021 and agreed to delay the Task 45 kick-off event to gain additional support from other HEV-TCP countries that are active in the E-Roads space.

The formation of a task specific page on the HEV TCP website (http://www.ieahev.org/task-45-electrified-roadway/) allows for the distribution of information to the general public. More information about the technologies of interest and notes from the webinars can be found there.

NEXT STEPS

The task will officially begin after the next HEV-TCP EXCO meeting currently planned for late Spring 2021.

FOR FURTHER INFORMATION, PLEASE CONTACT THE OPERATING AGENT:

P.T. Jones
Sr. Technical Staff
Oak Ridge National Laboratory
2360 Cherahal Blvd.
Knoxville, TN 37932
USA

+1 865-341-0119
jonesp@ornl.gov

SECTION C

HEV TCP Worldwide

Overview of Hybrid & Electric Vehicles in 2020

HEV TCP Member countries report new Hybrid and Electric Vehicle passenger vehicle registrations and total numbers of these vehicle types registered (e.g. stock). Table 1 shows the total registrations for passenger vehicles of these vehicle types over the last three years. The country chapters provide more detailed numbers for 2020.

	HEVS			EVs & PHEVS		
Country	**2018**	**2019**	**2020**	**2018**	**2019**	**2020**
Austria	30,839	44,010		26,541	37,060	
Belgium	62,617	/		43,681	/	
Canada	228,070	278,583	318,827	90,100	155,609	209,075
China	710,000	1,080,000	1,490,000	2,610,000	3,810,000	4,910,000
Denmark	24,970	33,376	41,705	14,965	24,935	61,610
Finland	40,374	/		15,499	29,365	
France	408,590	/	534,000	165,720	227,381	292,658
Germany	274,414	437,208	724,228	150,172	238,792	588,944
Ireland	32,271	47,586		7,362	14,859	
Italy	177,583	244,484	/	7,469	12,156	99,519
Japan	/	/	9,145,200	/	/	253,500
Netherlands	180,562	210,642	261,400	142,686	203,419	292,240
Norway	93,048	110,665	/	290,893	376,610	486,037
Rep. of Korea	404,759	478,938	522,735	55,417	74,328	47,677
South Africa	/	/	5,011	/	/	1,290
Spain	238,257	343,000	139,609	28,805	47,118	42,618
Sweden	90,273	66,609	122,290	66,058	147,855	186,195
Switzerland	72,346	92,061	126,175	33,091	49,642	83,329
Turkey	/	/	/	/	/	/
United Kingdom	/	/	/	198,048	/	/
United States	4,986,911	5,374,023	5,800,523	1,117,764	1,443,637	1,741,530
Totals	**8,055,884**	**8,841,185**	**19,231,703**	**5,064,271**	**6,892,766**	**9,296,222**

Austria

MAJOR DEVELOPMENTS IN 2020

FLEET OF ALTERNATIVE DRIVE TRAIN VEHICLES SHOWS A SIGNIFICANT INCREASE

In 2020, 19.0 % fewer new motor vehicles were registered than in 2019. The number of Battery Electric Vehicles (BEVs) increased by 50.8 %. The share of BEVs and Plug-In Hybrid Electric Vehicle (PHEVs) for all new registered passenger cars rose from 3.47 % to 9.50 % (see figure 1). The growth trajectory of natural gas and hydrogen powered vehicles remained constant. Although growth rates indicate an increasing consumer acceptance of alternative drive train vehicles, their contribution to GHG emissions reductions remains low with an overall M1 fleet share of 1.18%.

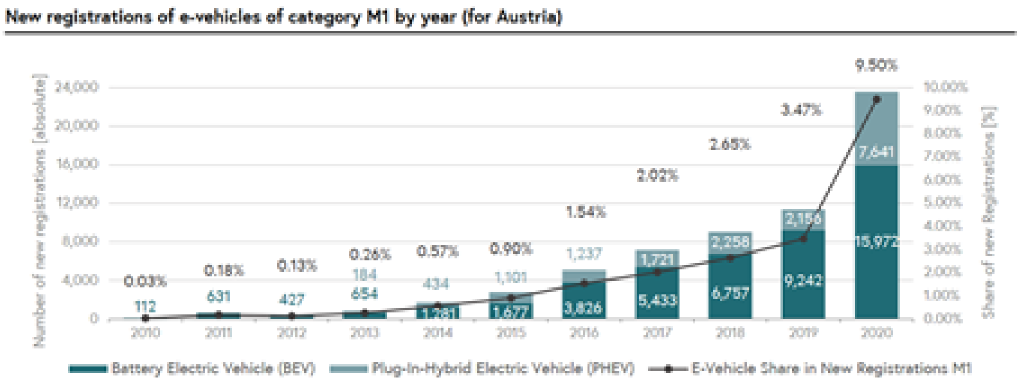

Figure 1: Development of BEV/ PHEV new vehicle registration in Austria (2010-2020); Source: Statistik Austria, Image courtesy of AustriaTech[1]

New policies, legislation, incentives, funding, research, and taxation

Austria offers a broad set of supporting measures to support e-mobility uptake such as purchase subsidies, registration tax benefits. ownership tax benefits, company tax benefits, VAT benefits, infrastructure incentives and free parking. Austria co-operates with the European Alternative Fuels Observatory[2] (EAFO), where an overview of the Austrian support measures are available.

RESEARCH AND INNOVATION - AUSTRIAN NATIONAL BATTERY INITIATIVE AND M-ERA.NET ACTIVITIES

The development and production of battery cells, modules and packs and electric vehicles are 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)[3] set up the Austrian National Battery Initiative[4] in close co-operation with industry and research. The initiative covers the whole value chain from raw materials to the production of battery cells and their integration in the vehicle. This initiative also takes into account battery recycling, sustainability in energy, battery production and efficient industry 4.0 processes. Until the end of 2020 three battery calls have been published.

In 2021, Austria will participate in a call on batteries in the M-ERA.NET, which allows the funding of ambitious transnational RTD projects. Austria strives to overcome research barriers and to intensify transnational cooperation.

Economy - Important Project of Common European Interest (IPCEI)
Austria joined forces with Belgium, Croatia, Finland, France, Germany, Greece, Italy, Poland, Slovakia, Spain and Sweden in setting up the “European Battery Innovation (EuBatIn)” IPCEI. The project covers the entire battery value chain from extraction of raw materials, design and manufacturing of battery cells and packs, and recycling and disposal with a strong focus on sustainability. Six Austrian partners will contribute their expertise to establish a sustainable battery cell production in Europe.

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 surpassed, for the first time in history, 7 million. 7.1 million motor vehicles were registered as of 31 December 2020. That is an increase of 102,592 (1.5 %) vehicles compared to 2019. Passenger vehicles, market share of 71.7%, had an increase of 1.0 %, to 5.09 million vehicles.

Sales figures indicate a continuous trend toward advanced alternative propulsion systems, especially battery electric vehicles and hybrid electric vehicles (Figure 2). The latter fleet numbers of 44,507 and 83,361, respectively, demonstrate the positive growth, which follows an exponential trajectory. The number of vehicles driven by compressed natural gas (CNG) and liquefied petroleum gas (LPG), including bivalent ones, shows a stable, but moderate fleet size of 6063 vehicles (2019: 6,078). Interestingly, the decrease of bivalent vehicles to 3,308 (2019: 3474) has been compensated by an increase in CNG vehicles 2,753 (2019: 2,602). The fuel cell electric vehicle (FCEV) fleet is still negligible at 45 (2019: 41).

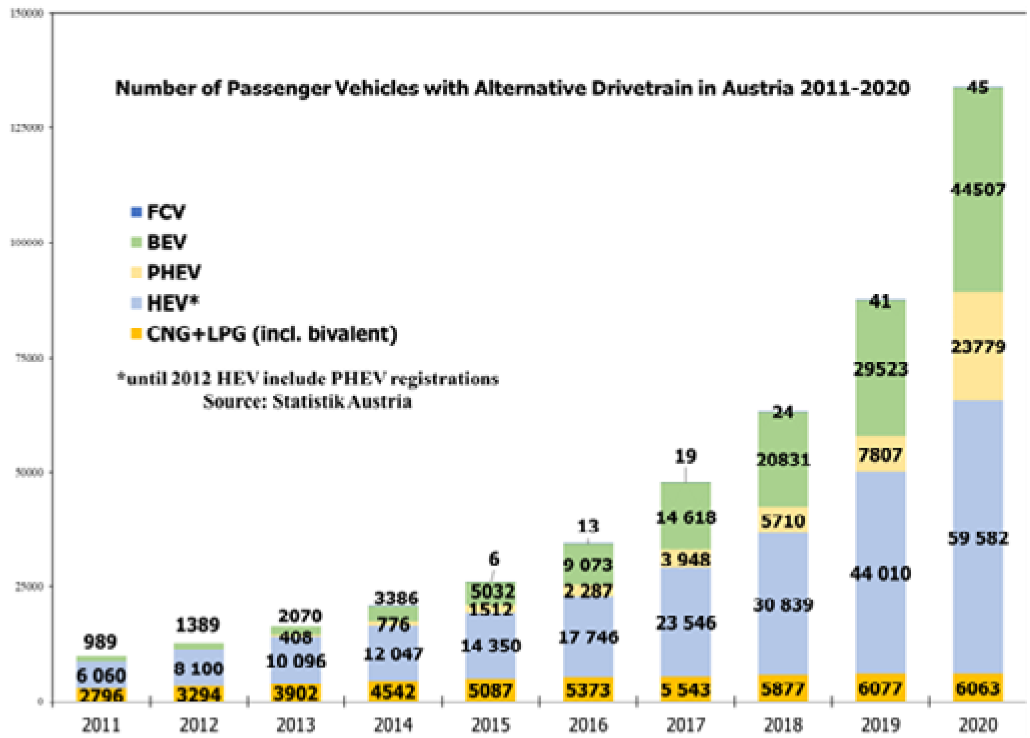

Figure 2: Trends for vehicles with alternative drivetrains in Austria, 2011–2020
Source: Statistik Austria

COVID, A GAME CHANGER?

In 2020, 353,179 new motor vehicles were registered, 19.0 % fewer than in 2019. New registrations of passenger cars decreased by 24.5% to 248,740 units. This decrease, a result of the COVID pandemic, affected solely petrol and diesel vehicles, while alternative drivetrain vehicles continued their strong growth presented in previous years. In this period, the diesel market share dropped extraordinarily to a share of 43.3 % (2019: 53.7 %), while petrol vehicles were subjected to a limited reduction to 36.5 % (2019: 38.4 %). The recent drop in the number of vehicles sold, and the minimal impact on the alternative fuel sources, opens a window of opportunity for consumer preference, supporting a faster uptake of alternative drivetrain vehicles.

AVERAGE CO2 EMISSION OF PASSENGER CARS RISES AGAIN

The average CO2-emissions of newly registered passenger cars in 2020 amounted to 136 g/km, based on the Worldwide Harmonised Light Vehicles Test Procedure (WLTP). The number includes electric and hydrogen vehicles. The average value for petrol-powered M1 vehicles is 143 g/km and diesel-powered passenger vehicles have an average of 156 g/km. Due to the switch from the New European Driving Cycle (NEDC) to the WLTP, no 2019 numbers have been included.

BEV M1 BRAND DISTRIBUTION

In 2020, the most popular model was the Tesla Model 3 with 2,892 units, followed by the Renault Zoe with 2,071 units and the VW ID.3 with 1,669 units. Tesla leads the overall market share with 20 %, followed by VW (15 %) and Renault (13 %).

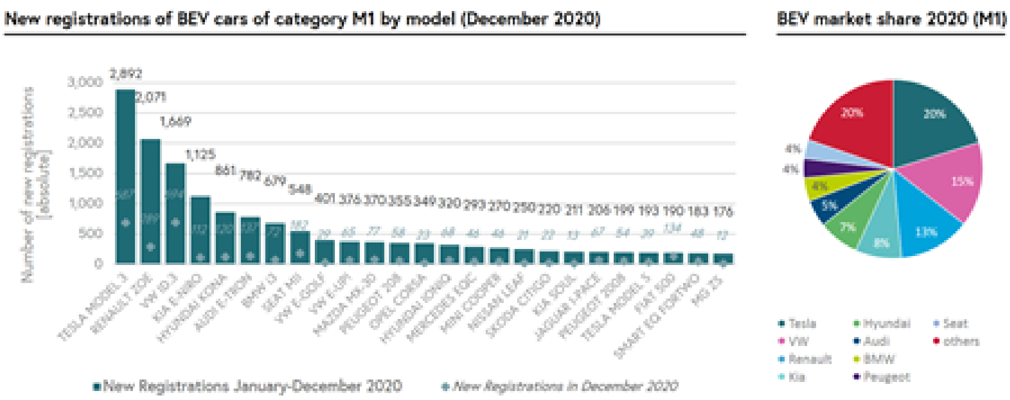

Figure 3: BEV M1 registrations by model (2020) Source: Statistik Austria; Image courtesy of AustriaTech

CHARGING INFRASTRUCTURE OR EVSE

The number of publicly available normal (NCP) and fast (FCP) charging points is continuously growing (see figure 4). In total 7,100 normal charging points and 1,295 fast-charging points were publicly accessible at the end of the third quarter of 2020. There are 9 electric cars (BEV and PHEV) for every NCP and 47 for every FCP.

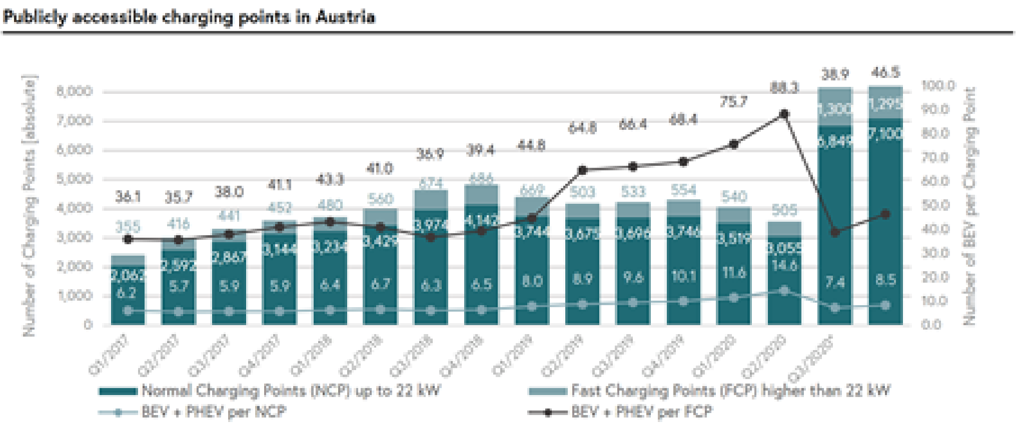

Figure 4: Publicly available normal and fast charging points (2017–2020) Source: E-Control; Image courtesy of AustriaTech

PUBLICLY ACCESSIBLE CHARGING FACILITIES DIRECTORY[5]

The degree of diffusion and the availability of publicly accessible charging infrastructure are decisive factors in influencing user confidence and thus the success in establishing widespread electric mobility adoption. In order to create a reliable reference for public 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 number of chargers and the charging capacity. The charge point directory is designed to inform about the availability of publicly accessible charging infrastructure, to promote competition between charging infrastructure operators, to strengthen the confidence of potential vehicle buyers in electromobility and to counteract the fear of lack of coverage.

EV DEMONSTRATION PROJECTS

ENERGY MODEL REGION[6]

As part of the “Energy Model Region” initiative, Austrian-made technologies are being developed and demonstrated with applications that have international visibility. In the coming years, the Austrian Climate and Energy Fund (KLIEN) will invest up to €120 million ($146 million US) in three Energy Model Regions. One such region—WIVA P&G— demonstrates the transition of the Austrian economy and energy production to an energy system based strongly on hydrogen. Particular emphasis is given toward the development of hydrogen transport applications like in the HyTruck – Hydrogen Truck Austria project[7].

KLIMAAKTIV MOBIL PROGRAM

Austria’s national action program for mobility management, called klimaaktiv mobil[8], supports the development and implementation of mobility projects and transport initiatives that aim to reduce CO2 emissions. Since 2014, 4,900 climate friendly mobility projects have received financial support. Financial support for about 12,000 alternative vehicles has been provided. The klimaaktiv mobil website offers a map with details of each project. Total financial support amounted to €67 million ($82 million US) upto the end of 2020.

FUTURE MOBILITY PROGRAM

The research program, Mobilität der Zukunft[9] (Future Mobility), is an Austrian national transportation research and development funding program for the period 2012–2022. The programme covers four complementary thematic fields: Personal Mobility, Mobility of Goods, Vehicle Technology, and Transport Infrastructure. The annual budget of Future Mobility is between €13 million and €19 million ($15 million and $24 million US). A project database is accessible via https://projekte.ffg.at/

ZERO EMISSION MOBILITY PROGRAM

The Zero Emission Mobility[10] programme forms the core of pilot projects for implementing the e-mobility initiative of the Austrian Federal Government. The programme focuses on zero-emission mobility demonstration projects in road transport with a clear implementation focus. The calls are technology-neutral encompassing the three pillars; vehicles, infrastructure and users. Under the flagship programme, 36 projects with 320 project partners and overall funding of 68 million EUR with a total investment of 217 million EUR have been initiated.

MEGAWATT – DEMONSTRATION PROJECT EXAMPLE

MegaWATT is carrying out a simultaneous field test for nine heavy goods vehicles, with a gross weight between 18 and 26 tonnes. Since September 2018, these electric trucks have been used in day-to-day operations in five different logistics operations, totalling around 266,000 kilometres. The trucks have been designed with a 185 kWh battery pack for a driving range between 120 and 180 kilometres.

Figure 5: MegaWATT electric truck, Image courtesy of CNL

The research project uses real-time data collected on the electric trucks to advise the seven logistics companies involved on a transition strategy to electric-only fleets for the different use cases. This includes technical and economic optimisation of charging infrastructure, novel routing strategies and developing new business models for all stakeholders including electric utilities and charge point operators.

OUTLOOK

Austria's ambitious goal to become carbon neutral by 2040 and seek concerted activities in all sectors. The transport sector requires novel approaches to reach carbon neutrality. Therefore, Austria is preparing a Mobility Master Plan, which will lay out a defined roadmap to climate neutrality in 2040. The mobility sector will seek to identify ways to avoid traffic, by shifting private vehicle traffic to public transport and active travel, and increasing energy efficiency and replacing fossil fuels with renewable energy sources. New solutions from research, technology, and innovation need to be brought swiftly to market for achieving the mobility-related climate targets.

International co-operation and learning from each other's experiences is key. The Technology Collaboration Programme is an international expert forum, where Austrian representatives actively participate and benefit. Austria is keen on continuing its previous activities such as the LCA Task in the framework of the HEV TCP.

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Belgium

ELECTRIC MOBILITY IN BELGIUM

Introduction

The automotive industry always played an essential role in the Belgian economy. High-quality cars, trucks, buses and other vehicles are developed and/or produced in Belgium. The automotive sector has an annual turnover of about 16 billion € and counts more than 300 companies with more than 45,000 direct jobs.

The automotive and mobility industry in Belgium is in transition towards an industry of clean, connected and smart mobility. In recent years, two Belgian car manufacturing plants have made important investments for electric car manufacturing as well as battery pack assembly. But also in the automotive suppliers industry, there are successful companies and new start-ups. For future job creation, our industry must continue to make the right choices and has to remain 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, seamless and affordable mobility service to the end customer.

Electric mobility is playing an increasingly important role towards a zero carbon society, especially when we combine it with the growth of renewable energy sources in our energy supply. The transport and energy sector will become more and more interlinked and this creates new business opportunities for companies in this new e-mobility value chain (batteries, vehicles, charging infrastructure, digital mobility applications, ICT, smart mobility and energy services).

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, established in 1949, is a key plant for electric mobility in the Audi Group. Since 2018, Audi produces the Audi e-tron, the brand’s first all-electric SUV. For the production of the Audi e-tron, the Brussels site also has its own battery manufacturing facility. Today, Audi Brussels is also producing Audi e-tron Sportback in its CO_2-neutral factory. Audi's Belgian subsidiary is the world’s first certified CO_2-neutral manufacturer in the premium segment. For example, the factory's roof is covered with the largest photovoltaic system in the Brussels region covering a total area of 91,000 m^2.

Figure 1: Audi Brussels “Factory of the future” Award (Source: Audi Brussels)

Audi Brussels, Figure 1, received the Agoria “Factory of the Future”- title given to factories that are investing in digitalisation, smart processes and products, and first-rate production. Additional requirements include the resource-saving use of energy and materials and look at the commitment, creativity and autonomy of employees. Audi Brussels is recognised as one of Belgium's best employers and has received numerous awards for its innovative HR processes. The company has consistently won the award for “Top Employer” every year from 2016 to 2020 and in 2019 won the award for “HR Team of the Year”.

Volvo Car Gent has been producing cars in Ghent since 1965. In 2020, the focus of the plant was mainly on the electrification of its models. Production of the Volvo XC40 Recharge, the first full electric model within the Volvo group, started in 2020. In March 2020, the battery assembly plant opened, Figure 2.

Figure 2: Battery assembly for electric vehicles at Volvo Cars' plant in Ghent, Belgium. (Source: Volvo Car Group)

Volvo Car, Ghent further announced it will triple its production capacity for electric vehicles, with the ambition that electric vehicles will reach 60% of the total production by 2022. The future new model Volvo C40 Recharge will be produced at Volvo Car Ghent starting in Autumn 2021.

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 the state-of-the-art Zaventem Proving Ground in Belgium.
- Belgium has about 300 local automotive suppliers.
- Belgium also plays an important role in automotive logistics. Thanks to its well-equipped ports with a good central location in Europe, Belgium is becoming a key player for electric vehicles logistics.
- The Port of Zeebrugge, already the world's largest port for the shipment of light vehicles, has become a key hub for e-cars as well. Thanks to International Car Operators (ICO), a Japanese leader in car transhipment, the port is fully equipped to import electric cars into Europe and have subsequently created a green terminal. This green terminal allows the e-cars arriving at the port to charge, through a large network of EV charge points (Figure 3), and supplies the necessary power through dedicated solar panels and onshore wind turbines.

Figure 3: ICO Zeebrugge – more than 300 charging points installed (Source: ICO and CKS)

Trucks

Volvo Europa Trucks, part of the Volvo Group, is the largest production facility of Volvo trucks in the world. The Ghent site of the Swedish truck builder is additionally planning to assemble batteries for the company's electric models. Batteries will be built to supply all of the Volvo Trucks' sites across Europe.

Volvo Trucks started manufacturing the Volvo FL Electric and Volvo FE Electric in 2019. Volvo Trucks announced hauliers in Europe will be able to order all-electric versions of Volvo's heavy-duty trucks in 2021. This means that Volvo Trucks will offer a complete heavy-duty range with electric drivetrains for distribution, refuse, regional transport and urban construction operations. Volvo Trucks will be offering holistic solutions that include route planning, correctly specified vehicles, charging equipment, financing and services.

In January 2021, the creation of a new business area was announced, Volvo Energy, aiming to strengthen the business flow of batteries over their life cycle as well as the offer for customer charging infrastructure. As a result, the environmental impact from electric and hybrid-electric commercial vehicles and machines will be reduced by giving used batteries a second life in different applications.

MOL CY, founded in 1944, is producing heavy-duty vehicles for different applications: Waste Systems, Rail Equipment, Special Trucks, and Terminal Tractors. Significant research is going into ecological solutions like hybrid refuse collection vehicles and full-electric terminal tractors.

Electric Buses

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 4,100 employees worldwide, of whom the largest share work at the production sites in Koningshooikt (Belgium) and Skopje (North Macedonia).

Van Hool has a long tradition of fuel cell bus innovation and was the coordinator of European fuel cell electric bus projects “High VLO City” and “3Emotion”. Significant contracts have been signed in previous years to supply hydrogen buses and hydrogen-powered vehicles throughout the USA and Europe.

Related to electric buses, Van Hool announced in 2020 the launch of the CX45E (Figure 4), a fully electric powered coach for the North American market. The CX45E is being commercially launched by Van Hool’s North American exclusive distributor ABC Bus Companies Inc.

Proterra, a leading American producer of battery technology for heavy-duty vehicles, was selected by Van Hool to supply the E2 battery technology. The 100% electric vehicle has a range of up to 500km (310 miles), depending on the climate conditions and the route’s topography.

Figure 4: Van Hool CX45E battery electric coach (Source: Van Hool)

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. VDL Bus Roeselare has about 700 employees and turnover of VDL Bus Roeselare doubled in 2019.

Figure 5: VDL Bus & Coach electric buses in Europe (Source: VDL Bus & Coach)

The number of VDL electric buses produced and in use in Europe puts VDL Bus & Coach as one of the front runners in electric bus mobility. Since the introduction of the first Citea SLF-120 Electric in Geneva in 2013, VDL Bus & Coach has focused strongly on electric mobility. More than 800 electric VDL Citeas buses are in operation in 65 projects in more than 55 cities all over Europe and the magic limit of 100 million electric kilometres has been reached. In 2021, VDL Bus & Coach will present the new generation of electric Citeas.

Suppliers

Belgium is home to about 300 suppliers in the automotive industry. Currently, a lot of the automotive industry innovations are taking place on the supplier's side, hence putting Belgium in a strong position for the future. Renowned suppliers include; 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.

NATIONAL POLICY FRAMEWORK - "ALTERNATIVE FUELS INFRASTRUCTURE DIRECTIVE (AFID)"

In response to 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 and infrastructure.

The introduction and roll out of alternative fuels in the Belgian transport sector could contribute significantly to the following objectives: the reduction of Belgium's oil dependence, the integration of more renewable energy in the transport sector, the strengthening of Belgium's economy & the creation of additional employment, the improvement of air and sound quality and the fight against climate change. However, the introduction of alternative fuel vehicles in Belgium has progressed relatively slowly over the past few years. This is mainly due to some persisting barriers that are difficult to overcome, 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 and finance 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.

	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 refuelling and charging infrastructure; - Vehicle inspection; - Homologation vehicles; - CNG/LNG/Shore Power installa-tions in ports and along inland water-ways; - 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 refuelling and charging points in petrol stations; - Development of a public network of refuelling and charging infrastructure; - Spatial planning.	/

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

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

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

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

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

Flemish Policy Framework

The Flemish policy framework regarding alternative fuels infrastructure for transport, in response to Directive 2014/94/EU, is based on the Flemish Action Plan on the deployment of alternative fuels infrastructure as adopted by the Flemish Government on 18 December 2015. With this Action Plan, the Flemish Government aims 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 to achieve maximum effect. Market support for green vehicles must be accompanied by the development of charging and refuelling infrastructure, whilst 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 focuses on four-wheelers and integrates 2020 objectives for electric vehicles, including 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 the market uptake for Clean Power vehicles and aim for a fast expansion of the infrastructure required. The actions should remove the currently perceived barriers to uptake, 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 in its region. While electric mobility has improved its ability to replace fossil fuels vehicles in recent years, we have reached a point where increased support for alternative fuels becomes essential. Recently, the Walloon Government has approved 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

The Brussels Policy Frameworks focus is on the numerous diesel vehicles, entering and circulating local roads daily, contributing 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 has 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 to 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 to prepare for an electric bus fleet transition 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 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.

Obtaining an up-to-date overview of all charging points available in a country is not an easy task as information is spread out over the different market stakeholders. But the charging infrastructure market is starting to organise itself in a more structured way and most charging infrastructure operators are now joined in a dedicated working group at AVERE Belgium.

Worldwide, drivers of electric vehicles require more detailed real-time information on the charging infrastructure: location, ways of access, availability, prices, etc. There is still a way significant improvements to be made, at present information is scattered over different databases/websites/apps and is not always up-to-date and is not available in a standardised format. Improvements are needed to achieve a more user-friendly access to charging infrastructure information. (For more details, please read the chapter on Task39.)

Statistics on Charging Infrastructure in Flanders

For this annual report, a detailed focus on charging infrastructure statistics in Flanders has been conducted. The ambition for 2020 was to have 7,400 publicly accessible charging points in Flanders. Currently, 4,262 normal charging points are registered in Flanders. At the end of 2020, a new ambition was announced aiming to install 30,000 extra charging points by 2025. The Flemish Government has foreseen a budget of 30 m€ and approved a concept note for the roll-out of charging infrastructure for the period 2021-2025.

Part of the initial ambition was foreseen to be realised via the obligation of the Distribution Grid Operators (DGOs) to install 5,000 publicly accessible charging points through public procurement in 2020. 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 website of the clean vehicles (www.milieuvriendelijkevoertuigen.be/laden).

As a result of European projects such as;Fast-E, Ultra-E, Mega-E, and BENEFIC, the number of fast and ultra-fast chargers is also increasing. 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, partners selected 30 infrastructure projects for (ultra)(fast)chargers for electric vehicles, electric taxis, 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.

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. An overview of all publicly accessible charging points is available on the website of the clean vehicle (www.milieuvriendelijkevoertuigen.be).

EV DEMONSTRATION PROJECTS

IPCEI for 'European Battery Innovation'

In January 2021, the European Commission approved a second project, under EU state aid rules, to support research and innovation in the battery value chain. The project, called 'European Battery Innovation', counts as an important project of common European interest, an IPCEI in short. It was prepared and notified jointly by Austria, Belgium, Croatia, Finland, France, Germany, Greece, Italy, Poland, Slovakia, Spain and Sweden. The twelve Member States will provide funding of up to 2.9 billion euros over the next few years, to be complemented by private investment of nine billion euros. The IPCEI project will involve 42 companies. The EU Commission said that the 42 companies would work closely together in nearly 300 planned collaborations and with more than 150 external partners such as universities, research institutes and SMEs across Europe. The overall project is expected to be completed by 2028, but each sub-project will follow its own timetables.

In December 2019, a first IPCEI on batteries was approved by the European Commission, in which seven member states (Belgium, Finland, France, Germany, Italy, Poland and Sweden) would provide up to approximately €3.2 billion in funding and which is expected to unlock an additional €5 billion in private investments in a European battery value chain.

Belgian companies involved in IPCEI projects:

- First IPCEI on batteries : Umicore, Solvay and Nanocyl.
- Second IPCEI on batteries: Hydrometal and Prayon.

First, in approving this IPCEI with an unprecedented total value of 12 billion euros, Europe is raising its game in ground-breaking research and innovation:

The IPCEI battery projects will help revolutionise the battery market in Europe by focusing on beyond-state-of-the-art lithium-ion batteries, as well as next-generation post-lithium-ion battery technologies. It will also adopt new manufacturing processes with higher energy efficiency and lower carbon footprint across the entire value chain. It is expected that the IPCEI battery projects will lead to some 30 pilot lines and will help to create more than 18-thousand new jobs across the Member States.

ReLiVe Project "Recycling and Remanufacturing of Li-ion batteries from end of life electric Vehicles"

The federation for the technology industry, Agoria, started a study called "LIFEBAT", with the goal of mapping out the opportunities and challenges for the companies in the Flemish Region in the complete value chain of the Lithium-ion battery. In 2019, the LIFEBAT study reported some 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.

Figure 6: ReLiVe Project "Recycling and Remanufacturing of Li-ion batteries from end of life electric Vehicles"(Source: Agoria)

LIFEBAT led to a follow-up project called Re2LiVe which is focussing on the collection, logistics, dismantling, remanufacturing, reuse and recycling of end of life Li-ion batteries from electric vehicles. In the framework of the Re2LiVe research project, VIL together with Sirris, VITO, and VUB, and with the support of SIM, Flux50 and Agoria, are investigating how Flemish companies can seize the opportunities in the growing market of used lithium-ion batteries from hybrid and electric vehicles. The recycling of lithium-ion batteries poses a number of challenges, but also offers opportunities for Flemish industry and logistics.

Canada

INTRODUCTION

Transportation is the second largest source of greenhouse gas (GHG) emissions in Canada, accounting for 25% of Canada's national emissions[1]. As a result, accelerated efforts are needed to reduce GHG emissions while continuing to enable the many essential services that an effective transportation system provides.

Canada has one of the cleanest electricity grids in the world as 67% of Canada's electricity comes from renewable sources and 82% from non-GHG emitting sources[2]. Canada is the world's third largest producer of hydroelectricity, which accounts for approximately 60% of Canada's electricity generation[3]. As a result, the potential to reduce GHG emissions by electrifying the transportation system is significant.

MAJOR DEVELOPMENTS IN 2020

National Developments

A HEALTHY ENVIRONMENT AND A HEALTHY ECONOMY

In December 2020, the Government of Canada announced its strengthened national climate plan: A Healthy Environment and a Healthy Economy. This plan builds on the work done to date and underway through the 2016 Pan-Canadian Framework on Clean Growth and Climate Change (PCF) to further put Canada's GHG emissions on a strong downward trend, exceed Canada's 2030 Paris Agreement emission targets and establish the building blocks to achieve net-zero by 2050.

In addition to key measures supporting clean transportation to date, the strengthened climate plan builds on existing and contains new measures for the transportation sector, such as:

- Investing an additional 225 million USD over two years, starting in 2020-21, to continue the incentives for zero-emission vehicles (iZEV) programme until March 2022, which provides rebates of up to 3,925 USD on a light-duty zero-emission vehicle (ZEV);
- Investing an additional 117 million USD over three years in charging and low-carbon refueling stations across Canada;
- Working with partners on supply-side policy options to achieve additional GHG reductions from Canada's LDV fleet;

- Aiming to align Canada's LDV regulations with the most stringent performance standards in North America post-2025;
- Expanding the current 100% tax write off to include commercial light-duty, medium- and heavy-duty ZEVs;
- Improving the efficiency of heavy-duty vehicles (HDV) standards for post-2025 by aligning with the most stringent standards in North America; and,
- Advancing the government's commitment to help procure 5,000 zero-emission public transit buses and school buses. To support this goal, the Canada Infrastructure Bank's Growth Plan has earmarked 1.18 billion USD to expand and accelerate the adoption of zero emission buses.

HYDROGEN STRATEGY FOR CANADA

In December 2020, the Government of Canada launched the Hydrogen Strategy for Canada, a framework that seeks to position Canada as a global hydrogen leader and as a key part of Canada's path to net-zero carbon emissions by 2050. The Strategy is a 1.18 billion USD federal investment designed to spur investment and partnerships to establish Canada as a global supplier of hydrogen, and to increase domestic production, which will transform Canada's energy sector. This will further support the decarbonisation of the transportation industry, particularly in the medium- and heavy-duty transportation sector. The recommendations of the Strategy are organised under eight pillars, including innovation, codes and standards, and international markets.

The Hydrogen Strategy supports the Government of Canada's recently announced strengthened climate plan, complements the Clean Fuel Standard to further drive investment and growth in Canada's fuel sector and builds on the development and launch of the Hydrogen Initiative by 23 countries at the 10th Clean Energy Ministerial (CEM) meeting in May 2019. Under Canada's leadership, the Initiative focused on accelerating the global commercialisation of hydrogen and fuel cell technologies across all sectors of the economy.

DEVELOPMENT OF CODES AND STANDARDS FOR ZEVS

The Government of Canada is contributing 1.33 million USD over 4 years to codes and standards development to help accelerate the demonstration, deployment and market entry of next-generation clean energy infrastructure. Through its Green Infrastructure Programme, Natural Resources Canada (NRCan) is supporting a project with the CSA Group to research, develop, adapt and update codes and standards for electric and alternative fuel vehicles and infrastructure. These codes and standards will improve performance and test requirements, as well as address system safety and key barriers to the uptake of ZEVs in Canada.

For more than a decade, Canada has been working with the United States Department of Energy (U.S. DOE) to develop and align codes and standards for zero-emission and alternative-fuelled vehicles, and refuelling infrastructure. Both parties recently finalised a 2020-2021 Regulatory Cooperation Council Workplan to update and harmonise codes and standards for all low carbon fuels, including ZEVs.

LAUNCH OF THE NET ZERO ACCELERATORS FUND

In December 2020, the Government of Canada announced that it will be investing 2.36 billion USD over 5 years through the Strategic Innovation Fund's (SIF) new Net

Zero Accelerator fund to rapidly expedite decarbonisation projects with large emitters, scale-up clean technology and accelerate Canada's industrial transformation across all sectors, including the automotive and aerospace sectors.

THE GLOBAL DRIVE TO ZERO LAUNCH

The Global Drive to Zero, launched at the 11th CEM in September 2020, aims to enable and accelerate the growth of global zero- and near-zero-emission commercial vehicles. The vision of the campaign is for ZEV technology to be commercially viable by 2025, and dominate by 2040 in specific vehicle segments and regions (China, United States led by California, the European Union, India, Canada, Japan, Mexico, and South America).

CHARGING THE FUTURE CHALLENGE

The Charging the Future Challenge, launched in July 2019, is delivered by NRCan as part of the Impact Canada Initiative. The Challenge aims to accelerate the most promising made-in-Canada innovation of battery technology from the laboratory towards the market. The five finalists of the Challenge announced in July 2020 received up to 550,000 USD to develop their technology prototype. The winner will be awarded a grand prize of 785,000 USD in fall 2021. The two finalists with a focus on ZEVs are: Calogy Solutions, which aims to develop a high-performance thermal management technology to improve the performance of EV batteries in cold-weather conditions; and G-Batteries whose objective is to address a key manufacturing step to significantly reduce costs and improve the performance of EV batteries and other lithium-ion batteries.

INVESTMENT INTO THE AUTOMOTIVE SECTOR TOWARD LOW AND ZERO-EMISSION VEHICLE PRODUCTION

While the COVID-19 pandemic had a disruptive effect felt strongly by the automotive sector, 2020 witnessed significant investments that will position the Canadian automotive sector to pivot to low- and zero-emission vehicle production, including:

- Ford Motor Company of Canada will invest 1.41 billion USD in Oakville to convert it into Canada’s first battery electric vehicle manufacturing facility, and 116 million USD in the Windsor engine plant;
- Stellantis (formally FCA) plans to invest up to 1.18 billion USD in Windsor for an electrified platform. The company will also invest 39 million USD in Brampton for new product variants; and
- General Motors plans to invest up to 1 billion USD to reopen the Oshawa facility for production, and add further production at their St. Catherines facility. St. Catherines also saw investment into a Renewable Energy Cogeneration project.

Provincial/Territorial Developments

BRITISH COLUMBIA

Zero-Emission Vehicles Regulation

The ZEV Regulation was approved in July 2020 to outline how British Columbia (B.C.) will achieve its 100% LDV ZEV sales target by 2040. While the Zero-Emission Vehicles Act, passed in 2019, provides the overarching framework for B.C.’s ZEV standard, the ZEV Regulation sets phased-in annual targets and other requirements to ensure that automakers increase the number of EVs they sell to meet consumer demand.

StrongerBC for everyone: B.C.'s Economic Recovery Plan
The Government of B.C. released an economy recovery plan in September 2020 to help build a stronger economy in response to the COVID-19 pandemic. The plan includes a 48.32 million USD investment in CleanBC Go Electric Programme, including: 24.56 million USD in the Specialty Use Vehicle Incentive Programme to provide post-purchase rebates on eligible commercial ZEVs, and 23.76 million USD toward a Commercial Vehicle Innovation Challenge in the ZEV space.

Launch of CleanBC Go Electric Public Charger Programme
The programme aims to increase the number of public Direct Current Fast Charger (DCFC) stations throughout B.C. with 4.28 million USD in funding. It aims to fill current gaps in the public DCFC network in B.C. such as Indigenous communities, rural and northern areas, and city centres experiencing long queues for DCFCs due to high ZEV uptake.

Figure 1: Fast charging station in Hope, B.C. Photo Courtesy of Plug In BC.

NEW BRUNSWICK
NB Power released an EV Education and Awareness Campaign to educate the public on the total cost of EV ownership, and the NB Lung Association launched a video campaign to bust myths about EVs.

ONTARIO
In October 2020, the Ontario government announced that it is matching a 231 million USD investment with the federal government to retool Ford Canada's Oakville Assembly Complex into a global hub for Battery Electric Vehicle (BEV) production, with the first EVs expected to roll off the production line in 2025.

QUÉBEC
The 2030 Plan for a Green Economy
The 2030 Plan is an electrification and climate change policy framework with an objective to invest 5.26 billion USD over five years (2021 – 2026) to build a resilient green economy and aims to reduce Québec's GHG emissions by 37.5% below 1990 levels by 2030. In particular, the plan invests 2.83 billion USD in the transportation sector, with the goal to put 1.5 million EVs on the roads, over 2500 fast charging stations and over 4500 standard charging stations in Québec by 2030. The plan also indicates its goals to electrify over half the city buses (55%) and school buses (65%) in the province, 40% of taxis as well as the government fleet (100% of cars, SUVs, vans

and minivans and 25% of vans electrified in 2030).

Report for the first compliance period of the Québec ZEV standard
In April 2020, the Ministry of the Environment and the Fight against Climate Change (Ministère de l'Environnement et de la Lutte contre les changements climatiques or MELCC) published the results of the first period of compliance with the provincial ZEV standard. By the end of this first period, all the key car manufacturers have complied with their regulatory obligations. The objective of this standard is to provide Québec consumers with access to a greater number and a wider range of plug-in vehicles, which are the cleanest and most technically advanced on the market. A consultation was launched in the summer of 2020 to update the ZEV standard and promote better alignment between transportation electrification and public policy implementation.

Greening of Government's fleet
The Québec government's procurement policy, whose objective was to replace 1,000 conventional government fleet vehicles with fully electric or hybrid rechargeable vehicles by December 31, 2020, was surpassed with 1,400 EVs by the end of December 2020.

SASKATCHEWAN

To increase public awareness of ZEVs and address barriers for uptake, SaskPower, the Saskatchewan Electric Vehicle Association (SEVA) and SaskEV launched campaigns including an EV driver experience survey and the "Ask an Expert" video campaign.

YUKON

In September 2020, the Government of Yukon released Our Clean Future: A Yukon strategy on climate change, energy and the green economy. The strategy sets emission reduction targets for the territory and commits the government to a suite of emission reducing actions, including an objective to increase the number of ZEVs on Yukon's roads. Since the release, the Government of Yukon offers rebates for purchasing new ZEVs (which can be combined with the federal rebate), shipping costs for used ZEVs, and the installation costs of smart Level 2 EV charging stations.

Additional commitments the Government of Yukon has made include the installation of fast-charging stations to connect all road accessible communities by 2027, requiring new residential buildings to support Level 2 EV charging, setting a territorial LDV ZEV sales target, ensuring at least half of all new LDVs purchased by the Government of Yukon between 2020 to 2030 are ZEVs, and drafting legislation by 2024 to enable private businesses and Yukon's public utilities to sell electricity for the purpose of EV charging.

Figure 2: The launch of Electric Vehicle Discovery Day by the Government of Yukon and the Yukon Transportation Museum and supported by the Government of Canada's Zero-Emission Vehicle Awareness Initiative. Photo courtesy of the Government of Yukon.

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, and federal and provincial purchase incentives, have all contributed to increased battery EV sales in Canada in 2020 for passenger vehicles. At the end of 2020, Canada had 209,203 LDV ZEVs on the road, a 34% increase from the previous year despite the impact from the COVID-19 pandemic. The sales of battery EVs in 2020 increased 3% from 2019 and 63% from 2018, although PHEV sales have decreased by 28% from 2018. Overall, the sales of LDV ZEVs in 2020 decreased 33% from 2019, however the sales of medium and heavy-duty EVs and HEVs increased in 2020.

Fleet Totals (as of December 31st 2020)[4]

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a.	n.a.	n.a.	n.a.	n.a.
B Electric moped (<50 kmph)	n.a.	n.a.	n.a.	n.a.	n.a.
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle	n.a.	n.a.	n.a.	n.a.	n.a.
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	127,487	318,827	81,588	128	25,135,358
H Buses and Minibuses	268	2293	0	0	72,379
I Light Commercial vehicles	n.a.	n.a.	n.a.	n.a.	n.a.
J Medium and Heavy Weight Trucks	7	156	0	0	2,407,913

Source: IHS Markit Vehicles in Operation, Canada, 2020

Source: IHS Markit Vehicles in Operation, Canada, 2020

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3
I: UNECE categories N1
J: UNECE categories N2-N3

Total Sales 1st Jan 2020 to 31st Dec 2020[4]

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a.	n.a.	n.a.	n.a.	n.a.
B Electric moped (<50 kmph)	n.a.	n.a.	n.a.	n.a.	n.a.
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle	n.a.	n.a.	n.a.	n.a.	n.a.
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	36,912	43,375	14,464	16	1,235,746
H Buses and Minibuses	63	346	0	0	993
I Light Commercial vehicles	1,575	7,499	1,432	7	207,822
J Medium and Heavy Weight Trucks	7	63	0	0	137,723

CHARGING INFRASTRUCTURE OR EVSE

The Government of Canada has invested over 235.6 million USD to support the demonstration and deployment of ZEV infrastructure to ensure Canadians can charge their ZEVs across the country through programmes such as the Zero Emission Vehicle Infrastructure Programme, the Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative, and the Electric Vehicle Infrastructure Demonstration Programme.

To date, the deployment projects have resulted in 13,196 EV chargers across the country[5], a 14% increase from the 11,589 chargers reported last year. Significantly, 1,266 of the public chargers are DC fast chargers, 990 are Tesla superchargers and two are Ultrafast-High power chargers (DC charging > 150 kW and ≤350 kW).

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.

Type of Public EVSE[6]	Number of charging outlets (as of December 31st 2020)	Number of locations (as of December 31st 2020)
AC Level 1 Chargers	n.a.	n.a.
AC Level 2 Chargers	10,936	5280
AC Fast Chargers	2	1
DC Fast Chargers	1266	891
Superchargers (Tesla)	990	104
Ultrafast-High power chargers	2	1
Inductive Chargers	0	0

EV DEMONSTRATION PROJECTS

The Government of Canada established the Electric Vehicle Infrastructure Demonstrations (EVID) programme to support the demonstration of next-generation and innovative EV charging and hydrogen refuelling infrastructure projects that address technical and non-technical barriers to the installation, operation and management of such technologies.

Nova Scotia Vehicle Grid Integration Pilot

In partnership with ChargePoint and Nova Scotia Community College, Nova Scotia Power Inc. received 860,000 USD from NRCan's EVID programme to demonstrate and assess the benefits of EV integration into the Nova Scotia grid, including the economic viability, benefits to the grid, and effects on EV user experience, using a utility-managed centralised control system.

Figure 3: Smart Grid in Nova Scotia. Photo courtesy of Nova Scotia Power Inc.

Decreasing Transactional EV Charging Costs and Enhancing Grid Efficiency
SWTCH Energy Inc. received 790,000 USD from NRCan's EVID programme to demonstrate a blockchain-based EV charging management platform in Toronto, Ontario, which aims to reduce the cost of EV charging transactions and enhance grid efficiency. The project will be accomplished through integration with transactive energy (TE) networks (energy saving) that leverage EVs as distributed energy resource (DER) assets using vehicle-to-grid (V2G) bi-directional charging and blockchain technologies.

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[1] Environment and Climate Change Canada (2020). National Inventory Report 1990-2018: Greenhouse Gas Sources and Sinks in Canada.
[2] Natural Resources Canada (2020). Electricity Facts.
[3] Ibid.
[4] Figures from IHS Markit (2020). Vehicles in Operation (VIO) & New Vehicle Registration Data for Canada. Figures and information sourced to IHS Markit within this report (the "IHS Markit Materials") are the copyrighted property and of IHS Markit Ltd. and its subsidiaries ("IHS Markit") and represent data, research, or opinions of IHS Markit, and are not representations of fact. The information and opinions expressed in the IHS Markit Materials are subject to change without notice and IHS Markit has no duty or responsibility to update the IHS Markit Materials.
[5] Natural Resources Canada (2020). Electric Charging and Alternative Fuelling Stations Locator.
[6] Ibid.

China

MAJOR DEVELOPMENTS IN 2020

In the first half of 2020, the production and sales of Chinese new energy vehicles (NEVs) decreased significantly, predominately as a result of the Covid-19 pandemic. However, since July, the production and sales have begun to increase, and the growth rate gradually improved. The annual production and sales of NEVs in 2020 increased by 7.5% and 10.9% respectively.

At the 75th session of the United Nations General Assembly, 2020, Chinese President Xi Jinping declared China will scale up its Intended Nationally Determined Contributions by adopting more vigorous policies and measures, and aim to have a carbon dioxide emissions peak before 2030 and achieve carbon neutrality before 2060.

Macro industry planning

On October 20, 2020, the General Office of the State Council of the People's Republic of China issued the New Energy Vehicle Industry Development Plan (2021-2035). The plan makes it clear to stay with the three vertical and three horizontal R&D layout. By 2025, the average power consumption of new battery electric passenger cars will be reduced to 12.0 kWh/100 km, and new NEV sales will account for about 20% of the total new vehicle sales. By 2035, the core technologies of NEVs will reach the advanced international level.

Credits Compliance Policies

To establish a long-term mechanism to promote the development of NEVs and fuel-efficient vehicles, the Ministry of Industry and Information Technology (MIIT) of China released the Parallel Management Regulation of Corporate Average Fuel Consumption and New Energy Vehicle Credits for Passenger Vehicles, in September 2017. On June 15, 2020, the Chinese government issued amendments to the Measures for the Parallel Administration of the Average Fuel Consumption and New Energy Vehicle Credits of Passenger Vehicle Enterprises (hereinafter referred to as the “Amendments”). The Amendments have specified that the credit ratios of new energy vehicles (NEVs) are respectively required to be 14%, 16% and 18% for the year of 2021, 2022 and 2023, rising from 10% and 12% formerly requested for 2019 and 2020. The policy further added preferential measures for low fuel consumption models and regulations that allow NEV credits to be carried forward.

Fiscal and Tax Policies

On January 25, 2020, the Ministry of Finance, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, and the National Development and Reform Commission jointly issued the Notice on Improving the Fiscal Subsidy Policies for the Promotion and Application of New Energy Vehicles. The policy clarified the subsidy measures for NEVs in 2020. The price of new energy passenger cars had to be less than $46,440 (including $46,440) to enjoy the subsidy. To encourage the development of the new business model of "Battery Swap" and accelerate the promotion of NEVs, "Battery Swap" vehicles are not subject to this regulation. The policy specified the period from April 23, 2020 to July 22, 2020 as the transition period. During the transition period, the sold and licensed vehicles that met the requirements of the technical indicators in 2019 but failed to meet the requirements of the technical indicators in 2020 shall be subsidised by 0.5 times the corresponding standard in the Notice on Further Improving the Fiscal Subsidy Policies for the Promotion and Application of New Energy Vehicles, and those that met the requirements of the technical indicators in 2020 shall be subsidised according to the 2020 standard.

Item	Scope of technical indicators	Subsidy standard/ coefficient 2019	2020
The upper limit of subsidy per unit electricity ($/KWh)	/	$85.14	$77.4
Subsidy standard for e-range per vehicle	100-250km	/	/
	250-300km	$2786.4	/
	300-400km	$2786.4	$2507.76
	≥400km	$3870	$3483
Adjustment coefficient of battery system energy density	90 (inclusive) -125 Wh/kg	/	/
	125 (inclusive) -140 Wh/kg	80%	80%
	140 (inclusive) -160 Wh/kg	90%	90%
	≥160 Wh/kg	100%	100%
Adjustment coefficient of vehicle energy consumption	Better than the limit value by 0-10% in terms of the power consumption per 100 kilometers	/	80%
	Better than the limit value by 10 (inclusive)-20% in terms of the power consumption per 100 kilometers	80%	100%
	Better than the limit value by 20 (inclusive)-25% in terms of the power consumption per 100 kilometers	100%	100%
	Better than the limit value by 25 (inclusive)-35% in terms of the power consumption per 100 kilometers	100%	110%
	Better than the limit value by 35% (inclusive) in terms of the power consumption per 100 kilometers	110%	110%

Table 1: Changes in Subsidy Standards for Battery Electric Passenger Cars in 2019 and 2020 ($1=¥6.4579)

The 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 × $77.4} × adjustment coefficient of battery system energy density × adjustment coefficient of vehicle energy consumption

Item	Technical requirements		Subsidy standard 2019	2020
The upper limit of subsidy per unit electricity ($/KWh)	E-range R≥50km		$1548	$1315.8
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%	50%	50%
	E-range is greater than 80km (the limit value of energy consumption per 100 kilometers under state A in assessment)	The electricity consumption per 100 kilometers under state A meets the requirements on the limit value of energy consumption of battery electric passenger cars	100%	100%

Table 2: Changes in Subsidy Standards for Plug-in Hybrid Electric Passenger Cars (Including E-REV) in 2019 and 2020 ($1=¥6.4579)

The calculation method of subsidy standard for plug-in hybrid electric passenger cars (including E-REV) is:
Subsidy amount for each plug-in hybrid electric passenger car (including E-REV) = Subsidy base per vehicle × Adjustment coefficient

HEVS, PHEVS, AND EVS ON THE ROAD

The stock of Chinese NEVs has increased by more than 1 million for three consecutive years. China also remains the world leader, for the sixth consecutive year, for the production and sales of NEVs. Table 3 shows the stock of electric vehicles on the road in China from 2017 to 2020. The stock of electric vehicles reached 6.41 million in 2020; BEVs accounted for 62.4% (4 million units), HEVs accounted for 23.3% (1.49 million units) and PHEVs accounted for 14.2% (0.91 million units) of the stock of electric vehicles. FCVs are mainly for demonstration operation and are in the trial stages, with a stock of around 6,000.

Table 3: Fleets Totals at the End of 2017-2020 a (Source: Ministry of Public Security of the people's Republic of China; in Million)

A: UNECE categories M1, M2, M3, N1, N2, N3
B: The data of HEVs in operation is based on CATARC statistic specification.

Fleets Totals at the End of 2017-2020[A]

Vehicle	2017	2018	2019	2020
HEVs[B]	0.46	0.71	1.08	1.49
BEVs	1.53	2.11	3.10	4.00
PHEVs		0.50	0.71	0.91
FCVs	0.001	0.002	0.004	0.006
Total	**217**	**240**	**260**	**281**

Table 4 shows the annual sales of electric vehicles in China from 2017 to 2020. The sales of electric vehicles increased by 19.0% in 2020 compared with the sales of electric vehicles in 2019. The sales of BEVs and PHEVs increased by 14.7% and 8.2%, respectively, compared with the sales in 2019. The annual sales of HEVs increased by 36.9%, reaching 523,000.

Table 4: Total Sales During Years Between 2017-2020 (Source: CAAM; in Thousand)

A: UNECE categories M1, M2, M3, N1, N2, N3
B: The data of HEVs in operation is based on CATARC statistic specification.

Total Sales During Years between 2017-2020[A]

Vehicle	2017	2018	2019	2020
HEVs[B]	183	260	382	523
BEVs	652	984	972	1115
PHEVs	124	271	232	251
FCVs	1.3	1.5	2.7	1.2
Total	**28879**	**28081**	**25769**	**25311**

With the explosive growth of China's NEV industry; the significant reduction of costs; the continuous improvement of the levels of charging infrastructure; the increase of consumer awareness and acceptance of NEVs; and the establishment of relevant policy systems, NEVs are reaching a critical point of large-scale market development, which is mainly manifested in the following three aspects:

Firstly, small battery electric vehicles, represented by Hongguang MINI, which are entirely independent of financial subsidies, are fully recognised in the market for their economical cars. The Hongguang Mini, with a 120km and 170km e-range, has sold 115,544 vehicles in less than half a year following its launch, nearly as many as Tesla's Model 3 sold in a year.

Secondly, intelligent electric vehicles, represented by Tesla Model 3, have formed strong product competitiveness and have been fully recognised in the market. The acceptance of Tesla Model 3 is even higher than that of traditional fuel vehicles at the same level.

Thirdly, middle-to-high end electric vehicles, represented by BYD Han and NIO ES6, have achieved initial market success. This series of China's independent brand NEVs ranging from $30,960 to $61,920 are selling well, reflecting the substantial jump in the cost performance of middle-to-high end NEVs to a certain extent, as well as the fresh look and valuable recognition of the brand value of China's independent automakers.

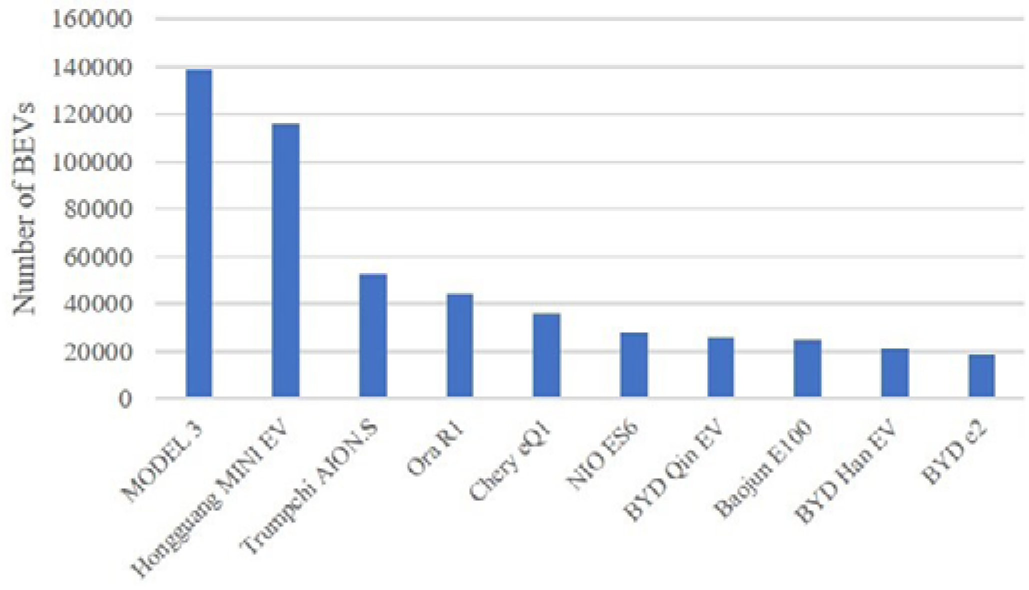


Figure 1: 2020 Sales of Battery Electric Passenger Cars for Market Leaders (Source: CATARC)

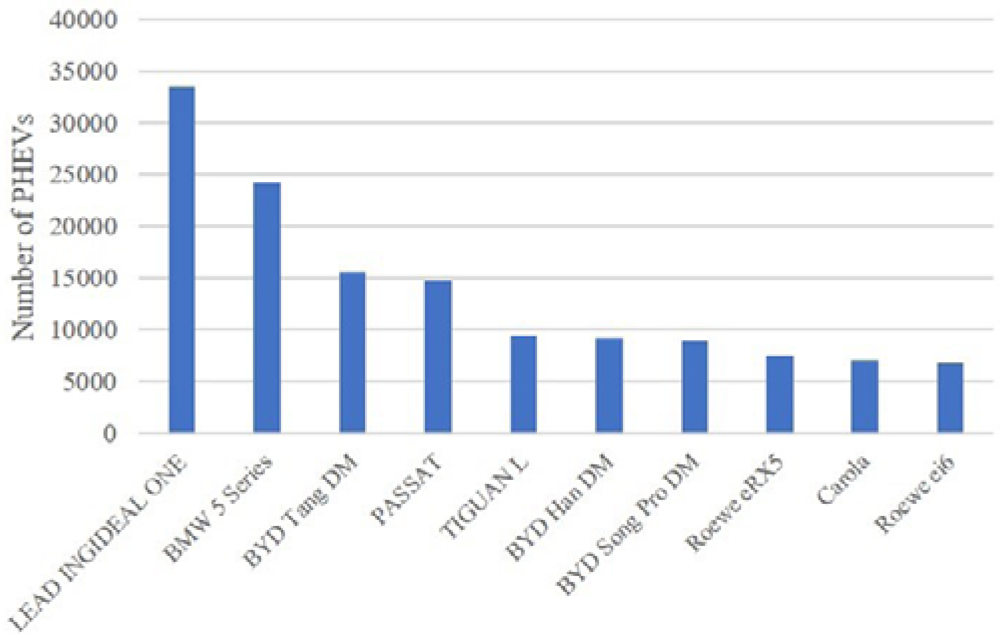


Figure 2: 2020 Sales of Plug-in Hybrid Electric Passenger Cars (Including E-REV) for Market Leaders (Source: CATARC)

CHARGING INFRASTRUCTURE OR EVSE

According to the data of China's Electric Vehicle Charging Infrastructure Promotion Alliance, by the end of 2020, there were 1.681 million charging pillars, which increased by 37.9% from 2019. The ratio of NEVs to charging pillars is about 3:1. There are 807,000 public charging pillars, which has increased by 56.4%, and 874,000 private charging pillars, which has increased by 24.3%. The number of charging stations further reached 63,600. The battery swapping operational model for EVs has begun to take shape, and the number of battery swapping stations has reached 555 nationwide.

Table 5: Public Charging Infrastructure on 31 December 2020 (Source: China Electric Vehicle Charging Infrastructure Promotion Alliance)

Type of Public EVSE	Quantity
AC Charging pillars	498,000
DC Charging pillars	309,000
Total charging pillars	**807,000**
Charging stations	63,600
Battery Swapping Station	555

From the perspective of geographical distribution, public charging infrastructure is concentrated in Beijing, Guangdong, Shanghai, Jiangsu, Zhejiang, Shandong, Anhui, Hubei, Henan and Hebei, with these provinces containing 72.3 percent of that infrastructure. The northeast, northwest, and southwest areas have fewer facilities. The distribution of public charging pillars in China is shown in Figure 3.

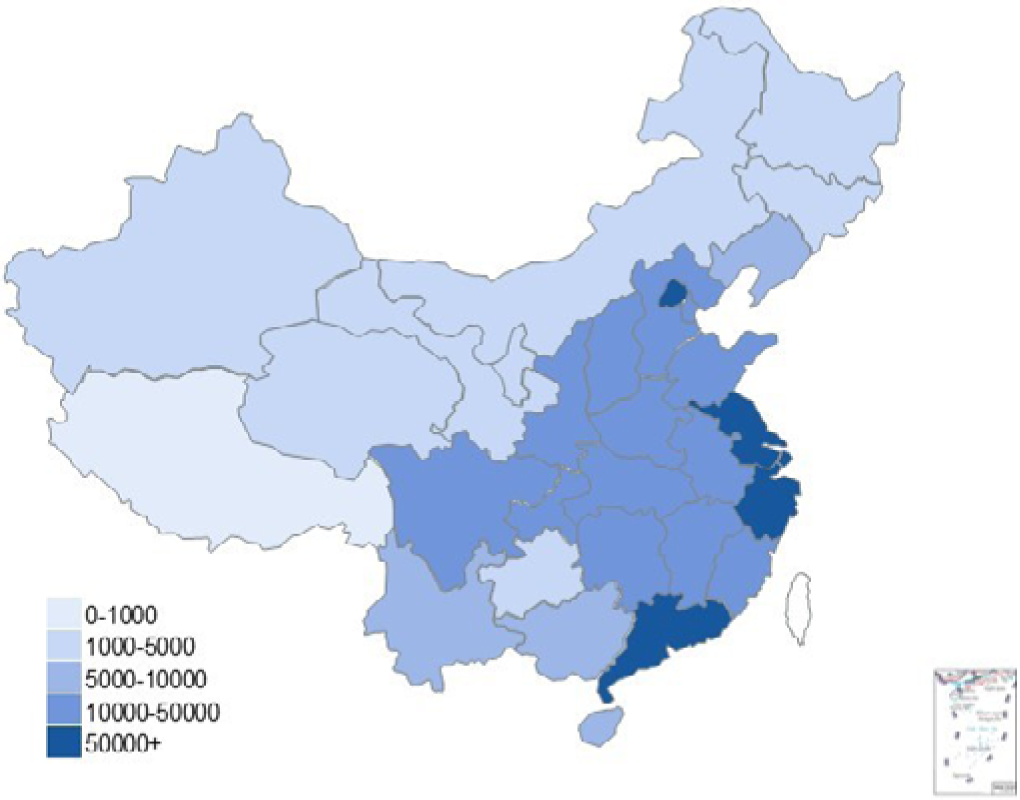


Figure 3: Distribution of the Public Charging pillars in China on 31 December 2020 (Source: China Electric Vehicle Charging Infrastructure Promotion Alliance)

As for charge point operators, a large-scale operator-dominated market with small and micro-operators as the complement has been formed. In 2020, there were 28 large-scale operators (charging pillars ≥1000) of charging facilities nationwide, including 9 operators with more than 10,000 units, whose market share reached 90.6%.

EV DEMONSTRATION PROJECTS

Battery Swap

In December 2017, NIO released a battery leasing product plan, kicking off the commercialisation of battery leasing for new energy passenger cars. On April 24, 2020, the Ministry of Industry and Information Technology approved the request for support of the pilot business model to separate the vehicle and the battery, submitted by NIO on January 13. On July 31, NIO completed the whole process to officially deliver the first internal pilot vehicle featuring the separation of vehicle and battery. On August 20, NIO launched the BaaS (Battery as a Service) model. NIO's unique service system with vehicle-battery separation and battery subscription enabled by chargeable, swappable and upgradable batteries is a breakthrough innovation in both technology and business model. Users do not need to buy battery packs when purchasing cars. Instead, they can choose to lease battery packs of different capacities, according to their actual needs. With the BaaS model, the car body is owned by the consumer, while the power battery is owned by the battery asset company.

From the user's perspective, the BaaS model reduces consumers' initial purchase cost, improves the residual value, allows consumers to benefit from the battery technology progress, and reduces the upgrade cost. From the industry's perspective, the BaaS model enables all batteries to be in the best operating condition to extend the battery life and increases the return on assets. The model further allows users to choose batteries based on their travel needs. Most importantly, it allows the cascade utilisation of batteries, after retirement, at the optimal time through unified management.

OUTLOOK

From the perspective of the development trend of the automobile industry, the consumer demand will speed up recovery with the steady rebound of the national economy. Also, the overall potential of the Chinese automobile market is still huge. Therefore, it is estimated that 2020 may be the year prior to the rapid growth of China's automobile market, and 2021 will realise the positive growth.

China's new energy vehicle industry has formed a complete industrial chain, including the supply of raw materials, the R&D and production of key components such as power batteries and drive motors, as well as the design and development of complete vehicles and the supporting construction of charging infrastructure. It is expected that China will have a number of world-class automobile and component enterprises in the whole industrial chain of new energy vehicles and power batteries, as the new energy vehicle industry has entered a period of rapid development.

Denmark

MAJOR DEVELOPMENTS IN 2020

In 2020, sales of BEVs and PHEVs increased significantly from previous years, reaching a 16.4% share of total new passenger cars registrations. This is significantly greater than the highest previous growth rate, from 2014 to 2015.

Denmark's EV and PHEV market substantially fluctuated between 2015 and 2020. In 2016, sales dropped drastically due to the closure of public support schemes and the introduction, for the first time, of taxes on EVs and PHEVs. The planned increase in EV taxation from 2017 was gradually reduced to revitalise a stalling EV market in Denmark. However, these changes had already created "stop and go" effects, where consumers could not foresee if taxation and prices would rise or fall the following year. From being a frontrunner, Denmark's EV sales significantly dropped. 2018 was the first year where EV sales grew on top of last year sales. In 2019 BEV and PHEV sales doubled. In 2020 sales more than tripled. Looking at BEV only the sale doubled in 2018, more than tripled in 2019 and almost tripled in 2020.

DK Passenger car new registrations by year[1]

Year	BEV	PHEV	HEV	BEV & PHEV	Total New	BEV & PHEV %
2020	14.232	18.246	9.222	32.478	198.123	16,4
2019	5.523	3.885	9.822	9.408	225.580	4,2
2018	1.545	3.127	8.666	4.672	218.479	2,1
2017	699	621	7.104	1.320	221.789	0,6
2016	1.314	572	5.759	1.886	222.822	0,8
2015	4.311	417	2.244	4.728	207.302	2,3
2014	1.567	90	1.212	1.657	188.879	0,9
2013	534	10	1.085	544	182.055	0,3
2012	529	12	380	541	170.619	0,3
2011	463	0	183	463	170.701	0,3
2010	49	2	78	51	154.611	0,0

The top 10 new vehicle sales of BEVs in 2020 is detailed in Table 1. The 3 best-selling BEV brands were Tesla, Volkswagen, and Hyundai. They hold markets shares of 33%, 19% and 10% respectively.

These 3 brands have a combined market share of more than 60% of the total sale of 14,232 BEV´s. In comparison, total sales of passenger cars in 2020 were 198,124 units, BEVs made up 7.2% of total passenger car sale.

Table 1: Top 10 BEV Brands sold in Denmark, 2020

Top 10 BEVs sold in Denmark in 2020[2]		Units	Share
1	TESLA	4.720	33%
2	VOLKSWAGEN	2.718	19%
3	HYUNDAI	1.364	10%
4	KIA	876	6%
5	RENAULT	704	5%
6	NISSAN	578	4%
7	PEUGEOT	514	4%
8	AUDI	492	3%
9	PORSCHE	327	2%
10	MERCEDES-BENZ	291	2%
Total units		**14.232**	**100,0%**

The top 10 BEVs in the passenger vehicle stock in Denmark is detailed in Table 2. The 3 leading brands are Tesla, Volkswagen, and Renault with market shares of 38%, 12% and 10% respectively.

In total the 3 brands have a combined market share of more than 60% of the total BEV stock of 31,892 units. In comparison, 2020 total passenger car stock was 2,720,256 units and BEV stock was below 1.2% of total passenger car stock.

Top 10 BEVs in stock in Denmark end 2020[3]		Units	Share
1	TESLA	12.219	38,3%
2	VOLKSWAGEN	3.945	12,4%
3	RENAULT	3.160	9,9%
4	HYUNDAI	2.493	7,8%
5	NISSAN	2.346	7,4%
6	BMW	1.526	4,8%
7	KIA	1.265	4,0%
8	AUDI	1.013	3,2%
9	PEUGEOT	632	2,0%
10	MERCEDES-BENZ	563	1,8%
Total units		**31.892**	**100,0%**

Table 2: Top 10 BEVs in Denmark's passenger vehicle stock,2020

The increasing EV sales in 2020 are encouraging, however, a concerted effort is still required to meet the national target of 1 million EV´s in 2030.

New policies, legislation, incentives, funding, research, and taxation

The Danish Climate Act and national Climate Action Plan set sub-targets in 2025 to meet a 70% reduction in 2030 on the way to 100% climate neutrality in 2050.

In December 2020, a majority in parliament agreed on which major climate steps to take in the transport sector[4]. The parties agreed to aim for 1 million ZEV on Danish roads by 2030. With the agreement, car taxes are set to be reorganised and based more on the car's value and CO2 emissions. Toll on heavy trucks will be kilometer-based and CO2-differentiated. Taxes on green cars will be eased and electricity tax for charging electric and hybrid cars will be low until and including 2030. As a new instrument, green sharing economy tax reductions is doubled for private rental out of electric and plug-in hybrid cars.

The agreement is funded by 336 M€ and with a range of concrete measures. Impact is expected to contribute to a stock of 775,000 new zero- and low-emission cars in 2030. Further initiatives will be needed, but overall, the agreement is set to reduce greenhouse gas by 1 mill. tons in 2025 and 2.1 mill. tons in 2030.

HEVS, PHEVS, AND EVS ON THE ROAD

EV AND PHEV – SMALL PERCENTAGES IN FLEETS (STOCK)

In the total fleet across all vehicle types, electric drivetrains are still represented by very small percentages of the total stock, for example BEV stock was below 1.2% in 2020. Considering the long lifetime of vehicles, reaching significant two-digit percentages of fleet stocks will be a significant long-term challenge.

Excluding n.a. in the table below, total drivetrain type stocks increased from 2019 to 2020:

	In 2019	In 2020
BEV	19,696	38,909
PHEV	10,154	30,172
HEV	35,457	44,082
FCV	93	135
Total	**65,400**	**113,328**

Fleet Totals (as of December 31st 2020)[5]

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	Total	Total incl. ICEVs
A Electric bike	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
B Electric moped (<50 kmph)	5,274	0	0	12	5,286	101,236
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle	303	0	0	2	305	165,797
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	31,892	41,705	29,718	113	103,428	2,720,256
H Buses and Minibuses	85	33	23	3	144	8.548
I Light Commercial vehicles	1,324	2,377	431	1	4,133	376,233
J Medium and Heavy Weight Trucks	28	0	0	4	32	42,266

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3
I: UNECE categories N1
J: UNECE categories N2-N3

EV AND PHEV – LARGE INCREASES IN SALE

When looking at sale developments from 2019 to 2020, BEVs have more than doubled, PHEVs have increased by a factor of 4.6, while the number of HEV sales is in decline. FCVs have more than quadrupled, but still remain a very few number of units. BEV's and PHEVs appear to have grown into the mainstream vehicle sales, BEV sale was 7.2% of total passenger car sale in 2020.

	In 2019	In 2020
BEV	7,243	17,312
PHEV	3,943	18,410
HEV	10,273	9,587
FCV	11	50
Total	**21,740**	**45,359**

Total Sales 1st Jan 2020 to 31st Dec 2020[6]

Vehicle Type	BEVs	HEVs	PHEVs	FCVs	Total	Total incl. ICEVs
A Electric bike	n.a.	n.a.	n.a.	n.a.		n.a.
B Electric moped (<50 kmph)	2,572	0	0	1	2,573	8,595
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle	30	0	0	0	30	3,715
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	14,232	9,222	18,246	45	41,745	198,124
H Buses and Minibuses	3	0	0	3	6	279
I Light Commercial vehicles	460	365	164	0	989	31,110
J Medium and Heavy Weight Trucks	15	0	0	1	16	3,726

CHARGING INFRASTRUCTURE OR EVSE

STATUS

Several operators including but not limited to; CLEVER, E.ON, Spirii, Flexcharge, Ionity, Sargo, Virta, Carpow, provide the publicly accessible recharging network nationwide. Tesla has established a nationwide charging network for Tesla vehicles.

There are currently about 3,000 publicly available charging points in Denmark spread across about 1,800 different locations. In addition, many charging points have been established at private residences of electric car owners.[7]

The DK EV Alliance has presented an industry agreement with ambitions to co-invest in chargers (1,000 ultrafast, 2,000 fast, 20,000 normal public) by 2025.[9]

In addition, Drivkraft DK has indicated that the gas stations industry is planning a significant expansion of electricity charging.[10]

EVSE Totals (as of December 31st 2020)[8]

Type of Public EVSE	Power	Charging outlets	Locations
AC Level 1 Chargers	AC charging ≤ 3.7 kW	n.a.	n.a.
AC Level 2 Chargers	AC charging >3.7 kW, ≤ 22 kW	4.000	n.a.
AC Fast Chargers	AC charging 43 kW	151	n.a.
DC Fast Chargers	DC charging ≤ 50 kW	151	n.a.
Superchargers	DC charging 120 kW	197	n.a.
Ultrafast-High power chargers	DC charging > 150 kW ≤ 350 kW	n.a.	n.a.
Inductive Chargers	EM charging	n.a.	n.a.

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 classical chicken-and-egg challenge where the public can influence more consumers to buy an electric car by securing the charging infrastructure.

Regulation of the charging infrastructure is also needed to 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 infrastructure is generally politically and technically recognised as a vital precondition for reaching national climate and e-mobility targets. At the same time, Denmark has a strong focus on intelligent charging strategies, which balance and facilitates smart integration of a strong and increasingly RE based energy system and a transport sector fuelled by electricity. Fulfilling the ambitious national climate change targets can only happen via integration between fluctuating renewable power capacity, grid capabilities and the vehicles seen as both electricity consumers and producers of flexibility and storage.

Charging infrastructure is also critical for electrification of new modes in transport sector. Induction charging, overhead lines and modular container-based solutions can be used for heavy transport modes on the road, sea and maybe also demanding off road applications such as in the agriculture and construction sectors. One example is large electric container barges powered by battery packs built into shipping containers, stored onboard, replaced on route, and exchanged with re-charged at the next harbor[11].

Generally, there are positive synergies between electrification and autonomous capabilities, including on charging, which could drive direct electrification.

Battery electric drivetrains are expected to come with longer ranges and reduced costs over time. But in very long-range sectors like international aviation and large container ships, direct electrification does not seem to be an option with known battery technology. Here, alternatives like ammonia for deep sea containerships and jetfuel produced from power from renewable energy sources (PtX) could be relevant.

NEXT STEP

The EV Commission[12], established by the Danish government, places particular emphasis on the following when building the future charging infrastructure:

- Ease of use and charging safety for electric car owners
- A market-based and cost-effective roll-out of charging stations
- Appropriate interaction with the electricity grid
- Good charging options regardless of geography and housing type
- A well-functioning competition in the charging market

The EV Commission finds that Denmark is in a favourable position to build a good and efficient charging network:

- Denmark is a country with modest distances (98% of all trips are less than 100 km)
- 50% of traffic, and many long trips, takes place on the state road network
- 75% of households with a car have access to their own residence parking space
- In addition, some car owners will have the opportunity to charge at work
- Hence, large parts of charging needs can relatively easily be met with home charging and loading in workplaces, supermarkets, etc.

The Commission stresses two areas for the public sector to take an active role:

- Possibility of charging when driving long distances
- Charging facilities for car owners without own parking (condominiums etc.)

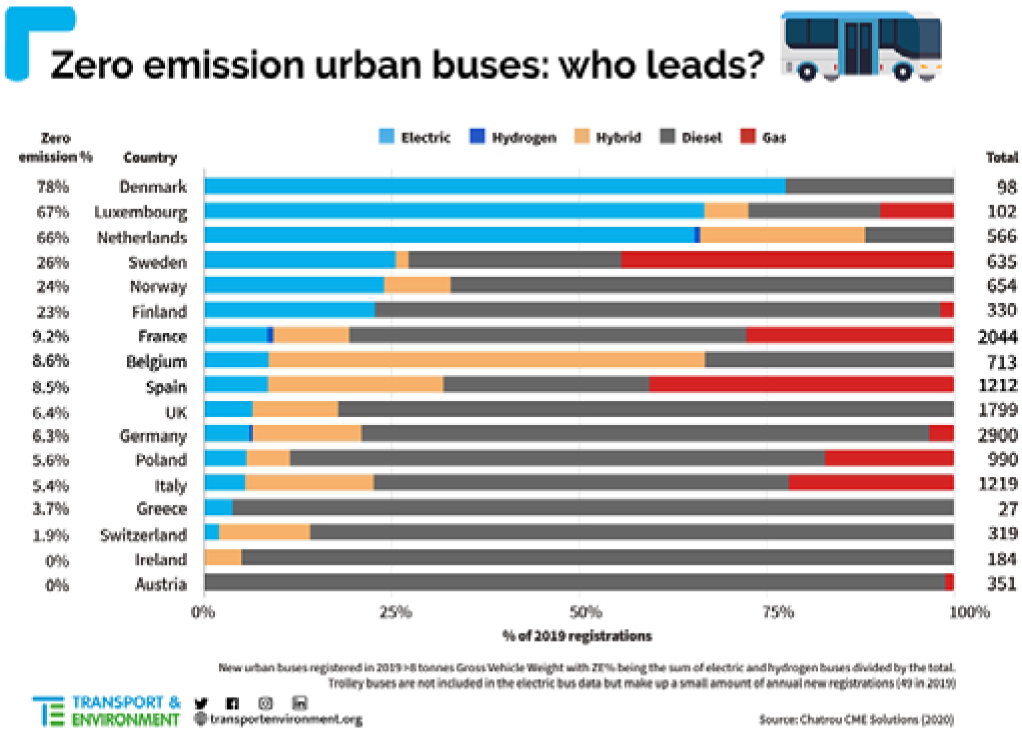
Several new funding programmes for EVSE deployment have been decided alongside tax reductions on electricity used for public charging. These topics together with more funding programmes for EVSE are now facing political negotiations on how to reach the overall Danish 70% reduction of GHG emissions by 2030.

EV DEMONSTRATION PROJECTS

ELECTRIC BUSES

In Denmark, Movia and other Public Transport Authorities have proven BEV buses to be a commercially attractive alternative to fossil-free bus operations, such as HVO and biogas. In some cases, electric bus operation can even be carried out at no extra cost compared to fossil-fuelled buses. The conversion of some regional bus routes has been undertaken without the need for extra buses, despite regional buses are completing a high number of km/day.

According to TE&E and Chartrou CME Solutions, Denmark leads the way in 2019 when it comes to implementing zero-emission urban buses on the streets, with 78% of new vehicles being electric[13].



Movia has learned how to get electric bus operation the same price as diesel. It has been crucial to reduce the risks of operators of electric buses in different aspects. One example is that electric bus technology is developing fast, and future ranges will increase and prices will be lower. The residual value of electric buses is uncertain and by providing bus operators a longer contract of at least 10 years, operators can write off the electric bus over the contract period.

At the end of 2020 there were a total of 3,900 buses in the Danish public transport system, of which:

- 81 BEV buses (12 metres)
- 3 BEV – driverless (4,75 metres)
- 3 FCEV buses (12 metres)
- 33 hybrid buses (of which 12 units are 18 metres the rest 12 metres).
- 7 BEV harbour (vessels/ships) buses
- No plugin hybrids
- February 2021, FynBus installed 20 BEV buses in Odense (12 m)

At the end of 2022, the number of BEV buses could reach 568 units (out of a total of 3,820). Expectations are that there will be no new hybrid or FCEV buses. The largest volume of electric buses can be found in Copenhagen. See overview below.

Public Transport Authority	Deployment (month + year)	buses	Bus model	Bus length (m)	Traction battery (kWh)	Opportunity charging public space	charging masts on route	Max charging power public space (kW)	Supplier	Max charging power (kW)
Movia	december 2019	28	BYD K9	12	348	No				80
Aalborg Municipality	oktober 2019	3	Navya Autonom Shuttle	4,75	33	No				22
Movia	december 2019	8	VDL Citea SLF-120 electric	12	288	No				150
Movia	december 2019	21	VDL Citea SLFA-180 electric	18	288	Yes	4	450	Siemens	30
Midttrafik	august 2019	4	Volvo 7900 Electric	12	200	Yes	1	300	ABB	50
Movia	april 2019	20	Yutong E12	12,17	374	No				150

Figure 1 shows Movias target, awarded and implemented zero-emissions buses, almost all are BEVs[14]

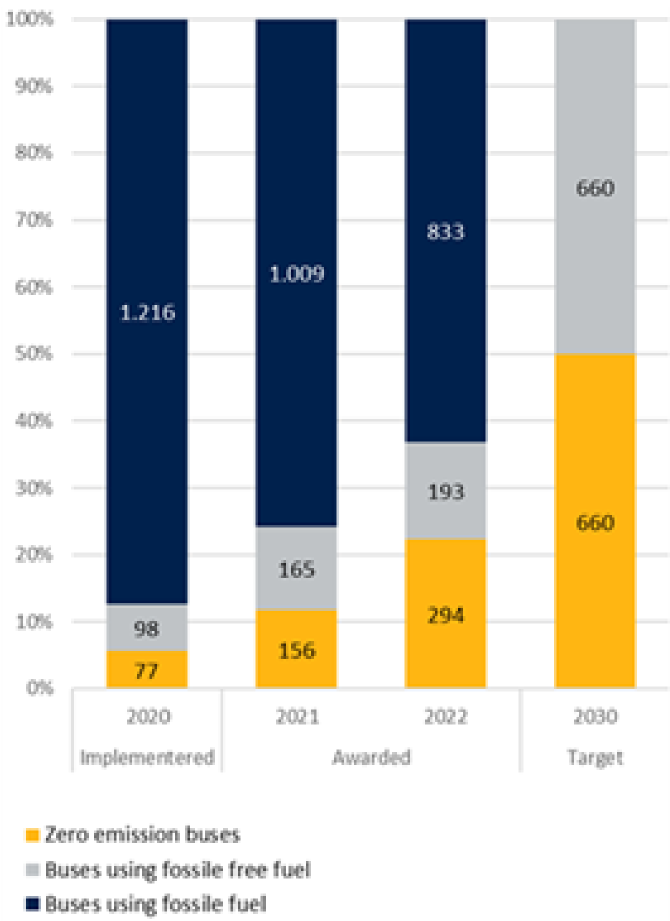
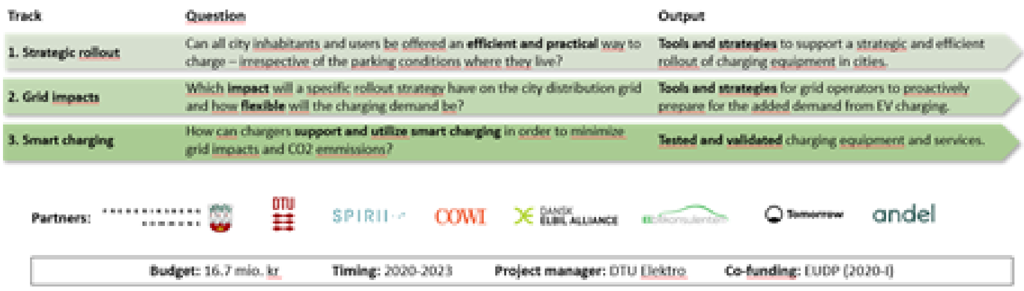


Figure 1: Movias Targets

FUSE – FREDERIKSBERG URBAN SMART ELECTROMOBILITY[15]

The objective is to accelerate investments in urban charging infrastructure by demonstrating an efficient rollout strategy and smart charging solutions.

- Efficient - Chargers are placed and dimensioned to be cost-efficient while maximising utilisation and user convenience
- Smart - Chargers being "smart from start" in terms of connectivity, interoperability, security, and metering to allow for smart charging services
- Demonstrations at Frederiksberg which has an ambitious e-mobility strategy – and is the most densely populated municipality in Denmark



Track	Question	Output
1. Strategic rollout	Can all city inhabitants and users be offered an **efficient and practical** way to charge – irrespective of the parking conditions where they live?	**Tools and strategies** to support a strategic and efficient rollout of charging equipment in cities.
2. Grid impacts	Which **impact** will a specific rollout strategy have on the city distribution grid and how **flexible** will the charging demand be?	**Tools and strategies** for grid operators to proactively prepare for the added demand from EV charging.
3. Smart charging	How can chargers **support and utilize smart charging** in order to minimize grid impacts and CO2 emmisions?	**Tested and validated** charging equipment and services.

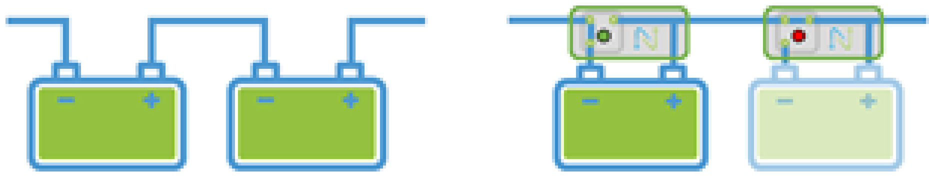
Partners: DTU, SPIRII, COWI, DANSK ELBIL ALLIANCE, Tomorrow, andel

Budget: 16.7 mio. kr **Timing:** 2020-2023 **Project manager:** DTU Elektro **Co-funding:** EUDP (2020-I)

NERVE SMART SYSTEMS – FOR BATTERY SYSTEMS AND ULTRA-FAST

CHARGING[16]

The new technology allows for individual control of each single battery cell, making it possible to adjust the energy output without expensive dc/dc power-electronics.



Traditional topology of Battery system

The *Nerve Switch*® is a disruptive single cell activation/bypass battery management system

Eliminating need for dc/dc power-electronics reduces energy loss by 50%, provides a 30% more affordable battery and energy storage system. Simultaneously it functions as a high-power charger delivering more than 350kW DC of power.

Variable Topology Battery System

- Allows controlled DC output for high-power charging
- Eliminates high power electronics for DC/DC conversion
- Eliminates chain reactions of single cell failures
- Eliminates SOC cell balancing
- Balancing of SOH, State Of Health

The system will be demonstrated at the danish island of Bornholm and in Aarhus during 2021 and Nerve Smart Systems can receive orders now for systems to be delivered during Q4-2021.

OUTLOOK

The Danish Climate Act and national Climate Action Plan, have specific measures to ensure the first sub-targets in 2025 and a 70% reduction in 2030 will be met. This will be an immense task for all Danish sectors, including the transport sector which has increased emissions since 1990. The transformation must happen within a decade and is probably the world most ambitious national target.

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 in time even in short-range air traffic. Short range heavy sectors like building, construction, agriculture could be electrified by batteries and modular battery swap

Indirect electrification with hydrogen or electro-fuels must be expected to primarily become an alternative for the heaviest and longest ranged modes as well as ships and aircrafts. Electricity-based fuels can be 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.

As a Danish-Dutch initiative, nine EU Member States sent a joint message to the European Commission for an accelerated transition to zero-emission vehicles, including a phase-out date for sale of new petrol and diesel cars in the EU[17].

To accelerate green transition, Denmark will establish the world's first offshore energy hubs and associated windfarms. One as an artificial island in the North Sea and one at the Danish island Bornholm. Their 5 GW capacity (expanded later to 12 GW) triples current installed offshore DK capacity. The energy hubs collect electricity from surrounding offshore windfarms and distributes electricity between countries connected via the power grid. Furthermore, offshore wind energy can be used to produce green fuels for heavy-duty and long range shipping and aviation[18].

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France

MAJOR DEVELOPMENTS IN 2020

Despite a difficult year for the automotive sector, the development of electric mobility in France continued to progress throughout the year. For the first time, the sales of electric vehicles represented more than 10% of all the vehicles sold in a month.

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.

Tangible measures have been introduced to support the French Government's commitment. The conversion bonus and the ecological bonus have been reset and upgraded in 2020, the latter now being available for second-hand vehicles. Some actions are linked to the propositions of the Citizens Convention for Climate, created in 2019, which released its conclusions in 2020. Decrees linked to the Mobility Law (LOW), voted in December 2019, were published in 2020. They notably edited the definition of low emission vehicles and helped the funding of the electrical connection to charging points. The LOM also set the objective of ending the sale of new passenger cars and light commercial vehicles using fossil fuels by 2040.

To accomplish the recently set objective of 100,000 charging points at the end of 2021, charging equipment have been made compulsory in certain car parks, and several financial supports help to reduce the cost of installation of the charging points.

To guarantee the transition to electric mobility, the Government is also mobilising the automotive sector, which, through its 2018-2022 strategic contract, has pledged by 2022 to increase annual sales of 100% electric vehicles fivefold 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 vehicles) for the acquisition or use of vehicles.

Since the Mobility Law, voted at the end of 2019, this integration is guided by new regulations. At least 50% of new vehicle acquisitions from the state and public establishments must be low-emissions vehicles. For communities and national companies, this proportion is set at 20% before July 2021 and 30% after that date.

France further imposed obligations on vehicle fleet managers, motor vehicle rental companies, taxi operators and operators of chauffeur-driven transport vehicles to purchase or use low-emission vehicles.

COMPANY VEHICLE TAX (TVS)

In France, 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. The nature of this progressive scale aims to encourage companies to renew their fleet of vehicles in favour of less polluting vehicles.

ECOLOGICAL BONUS / MALUS

Through the automotive bonus/malus system, and in the more general framework of French policy in favour of ecological transition, the Government aims to support, through financial aid, the acquisition and rental of low-emission vehicles, the choice of a new vehicle with low CO2 emissions and discourage, via a penalty, the purchase of more polluting vehicle models.

The amount of the bonus is established according to the level of CO2 emissions and the type of the new vehicle:

- Up to € 7,000 (within the limit of 27% of the acquisition cost) for the purchase of a new private car or a van emitting 20 grams of CO2 / km or less. In this range of emissions, the aid for a second-hand car can be up to € 1,000 .
- Up to € 2,000 for the purchase of a new private car or a van emitting between 21 grams of CO2 / km and 50 grams of CO2 / km.
- Up to € 1,000 for the purchase of a new electric 2-or 3-Wheeler.
- Up to € 50,000 (within the limit of 40 of the acquisition cost) for the purchase of a new electric of hydrogen heavy weigh vehicle.

CONVERSION BONUS

This aid is available when a new vehicle is bought to replace a Diesel vehicle older than 2011 or a Gasoline vehicle older than 2006. A conversion bonus can be cumulated with the Ecological bonus. The aid depends on the emission of the new vehicle acquired:

- € 5,000 for a new vehicle purchased emitting 0 to 50 grams of CO2 / km
- € 3,000 for a new vehicle purchased emitting 51 to 137 grams of CO2 / km (WLTP).
- € 1,100 for a new electric 2- or 3- Wheeler

HEVS, PHEVS, AND EVS ON THE ROAD

In total, 111,127 100% electric passenger vehicles (+ 159%), and 74,592 plug-in hybrids (+ 301%) were put on the road in 2020, i.e. more than 180,000 units (11.3% of all registrations).

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 June 30st 2020 (when available)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total
A 2- and 3- Wheelers	41,092	0	0	0	
B Passenger Vehicles	211,061	534,000 (2019 value)	61,28981,597	139 (2019 value)	
C Buses & Minibuses	545 (2019 value)	1,660 (2019 value)	0	0	
D Light Commercial vehicles	52,519	n.a.	22 (2019 value)	274 (2019 value)	
E Medium and Heavy Weight Trucks	0	n.a.	0	0	

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 (January to June 2020 when available)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total
A 2- and 3- Wheelers	11,436 (5,206)	n.a.	n.a.	n.a.	
B Passenger Vehicles	42,763 (44,969)	125,435	18,582 (20,308)	63	
C Buses & Minibuses	285	n.a.	n.a.	n.a.	
D Light Commercial vehicles	7,958 (3,892)	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 accessibility of charging infrastructures.

At the end of 2020, more than 31,000 charging points open to the public were installed in France (+15%). The French government has set a target of 7 million public and private charging points by 2030. It also set a short-term objective of 100,000 charging points at the end of 2021. This aim was at first an objective of the Automotive Sector Contract for 2022, but has since been modified in October 2020. In comparison, France has around 11,000 service stations in 2020.

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:

THE INVESTMENT FOR THE FUTURE PROGRAM

The Investment for the Future (PIA) Programme has provided around € 62 million to help projects install more than 20,000 recharging points, largely supported by local authorities.

THE ADVENIR PROGRAM

The ADVENIR programme has been reset. Its new target is to fund 45,000 private charging stations in car parks (shops or businesses) and collective housing through financial assistance for 2023. This programme benefits from a € 100M budget available during the 2020-2023 period. It is funded through energy-saving certificates.

The programme helps to install chargers for co-funded project from collective housing, for public and private parking lots, for fast charging stations. It is also available for the upgrading of old chargers.

OTHER FINANCIAL TOOLS

All individuals can access a €300 tax credit to contribute to the installation of a private charging point. This help can represent 75% of the cost of the charging point, to a maximum of 300€.

The reduction rate has been increased from 40% to 75% to take into account grid connection costs for publicly accessible chargers, until the end of 2021, and for electric bus chargers until the end of 2022. Additional financial support of € 100M will help the development of fast-charging stations on major national roads.

LEGAL TOOLS

Local authorities have to power to implement a charging infrastructure development plan. Individuals have the right to install a charger in collective buildings. Finally, there are obligations to pre-equip and equip parking lots with charging infrastructures.

Type of Public EVSE	Number of Charging Points
Normal chargers (<11kW)	7861
Accelerated chargers (14kW≤;≤22kW)	21260
Fast chargers (24kW≤;<150kW)	1237
“Superchargers” (1kW≤)	848

<table>
<tr><th>Type of Public EVSE</th><th>Number of Charging Points</th></tr>
<tr><td>AC Level 1 Chargers (≤ 3.7 kW)</td><td rowspan="2">29,121</td></tr>
<tr><td>AC Level 2 Chargers (>3.7 kW, ≤ 22 kW)</td></tr>
<tr><td>Fast Chargers (> 22 kW, ≤ 43.5 kW)</td><td rowspan="2">2,085</td></tr>
<tr><td>Superchargers (> 43.5 kW)</td></tr>
</table>

Germany

MAJOR DEVELOPMENTS IN 2020

In 2020 E-mobility in Germany gained greater acceptance than ever before, despite a roughly 20% drop in vehicle registration figures due to the COVID-19 pandemic. Alternative drives (battery electric, hybrid, plug-in, fuel cell, gas, hydrogen) claimed around a quarter of all new registrations. The number of newly registered passenger cars with purely electric drivetrains increased significantly, 206%, compared with the previous year[1].

The ‘environmental bonus’, a purchase premium for environmentally friendly electric vehicles has been significantly increased in 2020. First, in spring, up to 3,000 Euros was available from the Federal Government for a BEV, with a net list price of less than 40,000 Euros. This is payed when the manufacturer reduces the net list price by the same amount. Then in June, the Federal Government added the innovation premium, which doubled the federal share while the manufacturer’s share remains unchanged.

2020 saw record declines in CO2 emissions and coal-fired power generation in Germany. Greenhouse gas emissions were lower by 8.7% in 2020 compared to 2019. This is a 40.8% decrease since 1990. A good third of the reductions are due to the consequences of the Covid-19 pandemic response, mainly in the transport and energy sectors. The largest reduction in emissions was recorded in the energy sector (total emissions: 221 million metric tons). The largest share of this positive development was attributable to the decline in emissions from lignite-fired power generation. At 146 million metric tons of CO2, greenhouse gas emissions from transport are 19 million metric tons lower than in the previous year (down 11.4%). The main part of this reduction is due to the fact that fewer cars were driven during the first lockdown, especially on long routes. A smaller part of the reduction, around 2 million metric tons, is attributable to lower CO2 emissions from new passenger cars, partly due to the increase in new registrations of electric cars, and to more biofuels as a result of the higher blending rate[2].

Germany is working closely with other EU member states to develop battery cell production. The joint battery innovations and investments will be supported by 12 European member states within two IPCEI-projects („Important Project of Common European Interest“) in which 15 German companies are also involved. Five German projects on battery cell production have received their grant notification or started the project in 2020 under the first IPCEI, the so-called "IPCEI on Batteries"[3].

New policies, legislation, incentives, funding, research, and taxation

NATIONAL CENTRE FOR CHARGING INFRASTRUCTURE STARTS OPERATION

Andreas Scheuer, Federal Minister of Transport and Digital Infrastructure, launched on 6th October 2020 the operational phase of the National Centre for Charging Infrastructure. On behalf of the German Federal Ministry of Transport and Digital Infrastructure, the National Centre for Charging Infrastructure – under the umbrella of the federally owned NOW GmbH – coordinates and controls activities to expand the charging infrastructure in Germany. Key objectives include[4]:

- Development of a public fast charging network with 1000 sites by the end of 2023.
- The establishment of 50,000 publicly accessible fast and standard charging points by the end of 2021.
- The acceleration of the development of private charging infrastructure through financial support and better legal framework conditions.
- A user-friendly public charging infrastructure with easy-to-find charging stations that function reliably and charge transparently using standard payment methods.

NEW FUNDING LEVEL FOR THE ENVIRONMENTAL BONUS

In 2016, the “Umweltbonus”-programme begun. The Federal Government set itself the goal of promoting the sale of electric vehicles with the help of a so called ‘environmental bonus’. This is expected to make a notable contribution to reducing air pollution while at the same time strengthening the demand for environmentally friendly electric vehicles. The measures will support the rapid spread of electrically powered vehicles in the market.

The amended and significantly expanded ‘environmental bonus’ came into force on 18th February 2020 and runs until 31st December 2025. It applies retroactively for vehicles registered after November 4th 2019. Half of the financing of the environmental bonus is provided by the car manufacturer and half by a federal subsidy[5]. The existing environmental bonus increased for pure electric cars with a net list price of less than 40,000 Euros from 4,000 to 6,000 Euros. For cars with a net list price of up to 65,000 Euros, 5,000 Euros will still be subsidised. Plug-in hybrids are still in the scheme, with the rate rising from 3,000 to 4,500 Euros up to a net list price of 40,000 Euros. The bonus for PHEVs with a net list price between 40,000 and 65,000 Euros is increased to 3,750 Euros.

The amended procedure foresees now the application for the bonus only after vehicle registration. Until now, funding could be applied for after purchase for reason of a simplified process.

ENVIRONMENTAL BONUS FOR USED VEHICLES AND AVAS FOR THE FIRST TIME

Used vehicles that are still relatively new, are eligible for support for the first time: In the case of the second registration, the vehicle may have been registered for the first time for a maximum of twelve months. The vehicle in this case may have a maximum mileage of 15,000 km and must not yet have been subsidised by the environmental bonus or a comparable state subsidy in another EU state. In the case of a second registration, the subsidy rates for vehicles with a net list price for the base model in Germany of more than 40,000 euros up to a maximum of 65,000 euros apply accordingly.

Furthermore, the dangers posed specifically by electric vehicles to road users who rely on acoustic signals are to be compensated for by supporting the installation of an Acoustic Vehicle Alerting System (AVAS).

INNOVATION PREMIUM FOR PEV ON TOP

The environmental bonus has been increased with an innovation premium on 7th July 2020 (date of publication) and applies retroactively from June 3rd 2020. This premium doubles the federal share of the environmental bonus while the manufacturer's share remains unchanged. An application for funding with the innovation premium is possible up to and including 31 December 2021[6].

LEASING, COMBINED PROGRAMMES FOR THE FIRST TIME

The main innovations of the directive, which came into force on 16 November 2020 and replaces[6], are staggered subsidy rates for leasing and the possibility to combine the environmental bonus with another subsidy. With the new guideline, the amount of subsidy for leasing is staggered depending on the duration of the lease. Leasing contracts with a term of 23 months or more will continue to receive the full subsidy. For shorter contract terms, the subsidy is adjusted accordingly[7].

	Federal share Net list price below 40,000 euros	Federal share Net list price over 40,000 euros	Minimum holding period
Purchase	6,000 EUR	5000 EUR	6 months
Leasing term 6-11 months	1,500 EUR	1,250 EUR	6 months
Leasing term 12-23 months	3,000 EUR	2,500 EUR	12 months
Leasing term over 23 months	6,000 EUR	5,000 EUR	24 months

Table 1 Innovation premium for battery electric or fuel cell vehicle.[8]

SUCCESS OF UMWELTBONUS-PROGRAMME

The "Umweltbonus" programme has now been running for more than four years. In 2020 the number of applications increased significantly. The cumulative number of applications more than doubled for BEVs and more than tripled for PHEVs in 2020. Until 1st March 2021 in total 496,348 applications have been handed in which distributes among the vehicle categories as follows[9]:

- 288,076 for BEV (58%)
- 208,086 for PHEV (41,9%)
- 186 for FCEV.

Among the Top 10 applications per manufacturer/brand, 18.9% for Volkswagen, between 14.4% and 13.1% for Renault, BMW, Mercedes Benz, followed by smart with 8.3%. In June 2020 the incentives boosted the proportion of company cars in the electric segment to 39%, which was far higher than their 28% share of the overall car market [10]. In average until end of the year 2020, the vast majority of applications were submitted by private individuals and companies: 42% and 56% respectively.

The 10 most popular models supported were smart fortwo Model 2017 (15,413), Volkswagen e-Golf Model 2017 (13,671), Tesla Model 3 2020 (11,166), Volkswagen ID.3 Pro Performance (10.546), Renault Zoe Life (10,505), smart EQ forfour (9,419), Mitsubishi Outlander Plug-in Hybrid (8,118), BMW i3 (120 Ah) (7,871), Tesla Model 3 Long-Range Dual Motor (7,562) and Renault Zoe Intense (7,174).

AUTOMOTIVE INDUSTRY

The automotive industry also adjusted to the stricter EU climate policy. Volkswagen, BMW also stated their ambitions to electric car development. Worldwide, the German OEMs produced over 400,000 passenger cars with electric drive in 2019, nearly half of them (194,000) at their domestic plants. This makes Germany the third largest producer of electric cars in the world, after China and the US. Three out of four e-cars built in Germany are destined for export. German group brands already offer around 70 different electric models; by the end of 2023 they will have more than 150[10].

In early 2021, the BMW Group decided to change its electromobility strategy. By the end of the decade, the Group aims to deliver half of its cars with purely electric drive systems. BMW is bringing forward production of the "i4" and "iX" electric cars to 2021. By 2023, BMW plans to have 13 pure electric models on offer[11].

The BMW i4 is a fully electric 4 door Gran Coupé and will enter the market during the course of 2021. The i4 model line will be available in different versions covering ranges of up to 590km (WLTP) and up to 300 miles (EPA). With a power output of up to 390 kW the BMW i4 can accelerate from zero to 100 km/h in around 4 seconds.

Figure 1 MINI SE while charging. Image courtesy of BMW[12].

The MINI is to become an all-electric brand by early 2030. The fully electric MINI SE (combined power consumption: 17.6 - 15.2 kWh/100 km according to WLTP) is currently being manufactured at the Oxford plant. The successor to the MINI Countryman will be built at the Leipzig plant from 2023. MINI BEVs will also be produced in China in collaboration with Great Wall Motor from 2023 onwards. By 2027, fully electric vehicles will account for at least 50% of all MINI deliveries to customers. Vehicles of the BMW and MINI brands featuring electrified drive systems are now offered in 74 markets worldwide, where more than 500,000 electrified vehicles were sold by 2019.

The Volkswagen brand could more than double its global deliveries of electric vehicles in 2020 from 82,170 in 2019 to 212,000 in 2020. The share of BEVs rose from 55% to 63%. PEV reached thus a share of 4% of the 5.328 million vehicles delivered to customers in 2020[13].

Volkswagen is committed to delivering attractive and affordable e-mobility like no other company. Herbert Diess, Chairman of the Board of Management of the Volkswagen Group even said in March 2021: "E-mobility has become our core business. Now we are systematically integrating further stages in the value chain …". In 2030, Volkswagen aims to deliver at least sixty percent of its cars with electric drive systems. Volkswagen plans to invest up to 33 billion euros in e-mobility by 2024. The Group plans to launch up to 75 pure e-models by 2029.

Figure 2: Volkswagen ID.3 was lauched to the market in 2020. Image courtesy of Volkswagen

Volkswagen hands over the first ID.3 to customers in September 2020. The model jumps from a standing start to the top of the sales charts in many European countries. In Finland, Slovenia and Norway, for example, the ID.3 was the most frequently delivered BEV in each market in December. In Sweden, the ID.3 was even the best-selling car in absolute terms in December 2020 - regardless of the drive type. In total, around 68,800 ID.3s were ordered in 2020 and more than 56,500 have been delivered to customers in January 2021.

The ID.3 is available at the start with a 150 kW electric motor (Pro Performance), later on also with a 107 kW motor. The electricity consumption is rated 16.9 - 15.4 kWh/100 km (WLTP) and 15.4 - 14.5 (NEDC). Lithium-ion batteries with 58 kWh and 77 kWh net energy content are available for the ID.3. The range (in WLTP) is up to 549 km. A smaller battery is announced to follow later. The ID.3 can be charged with AC and DC and is fully fast-chargeable. The top version charges with up to 125 kW power in just

30 minutes for a good 350 km distance.

In December 2020, the production of the e-Golf, one of the most popular e-vehicles in Europe - especially with customers in Norway and the German home market- ended with the start of the production of the ID.3 in Dresden. The e-Golf was launched in 2013. A total of 145,561 left the two German production facilities in Wolfsburg and Dresden in more than seven years.

HEVS, PHEVS, AND EVS ON THE ROAD

New car registrations in Germany in 2020 have cumulated to 2,917,678. This is a roughly 20% drop in registration figures in the year of the COVID 19 pandemic. BEV sales experienced a strong growth of more than a factor of 3 year-on-year from 63,281 to 194,163. PHEV sales increased by a factor of 4.4 from 45,348 in 2019 to 200,469 vehicles in 2020. HEV sales increased by almost a factor of 1.7 to 327,395 vehicles. Two-thirds of the HEVs were gasoline-powered and one-third were diesel-powered. New registrations of conventional diesel-powered passenger cars decreased by almost 29 % and had a market share of 28 %. The number of new registrations of conventional gasoline powered passenger cars decreased by almost 17 % to 1.78 million, a market share of 61 %.

At 29.9 %, small cars with battery-electric drive represented the strongest segment in terms of new registrations in 2020. The SUV segment with battery-electric drive accounted for just under one-fifth (19.9%) of new registrations. The compact class achieved a similarly high share of 19.6% for this drive type[13].

As of 1 January 2021, 59.02 million motorised vehicles were on the road in Germany, including 48.25 million passenger cars, 4.66 million motor bikes, 3.41 million trucks and 75,550 buses. The stock of BEV (cars) amounted to 309,083 (136,617 in 2019), that of HEV to 724,228 (437,208 in 2019). This corresponds to a year-on-year growth by a factor of 2.26 and of 1.66, respectively.

The proportion of passenger cars with alternative drive systems rose from 2.4 % to 3.6 % (+54.0 %) in the course of the year 2020. This positive trend was even more pronounced in the case of cars with electric drive systems, where the share of the total portfolio rose from 0.5 % to 1.2 % (+147.1 %).

Around 70% of the battery-electric passenger car population was attributable to the small car (33%), compact class (19.6%) and mini (17.3%) segments. The number of battery-electric cars in the SUV segment, which has a high number of registrations, reached a share of 14.4%.

Table 1: Fleet totals[15]

** Without Tractors

Fleet Totals (as of December 31st 2020)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a.	n.a.	n.a.	n.a.	n.a.
B Electric moped (<50 kmph)	n.a.	n.a.	n.a.	n.a.	n.a.
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle					4,661,561
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	48,316
G Passenger vehicles	309,083	724,228	279,861	797	48,248,584
H Buses and Minibuses	727	2,232	3	50	75,548
I Light Commercial vehicles	3210	853	182	n.a.	2,880,870
J Medium and Heavy Weight Trucks					528,196 **

Table 2: Total Sales[15]

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3
I: UNECE categories N1
J: UNECE categories N2-N3

Total Sales 1st Jan 2020 to 31st Dec 2020

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a.	n.a.	n.a.	n.a.	n.a.
B Electric moped (<50 kmph)	n.a.	n.a.	n.a.	n.a.	n.a.
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle	n.a.	n.a.	n.a.	n.a.	221,994
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	194,163	327,395	200,469	308	2,917,678
H Buses and Minibuses	n.a.	n.a.	n.a.	n.a.	6,460
I Light Commercial vehicles	n.a.	n.a.	n.a.	n.a.	n.a.
J Medium and Heavy Weight Trucks	n.a.	n.a.	n.a.	n.a.	n.a.

CHARGING INFRASTRUCTURE OR EVSE

Since April 2017, the German Bundesnetzagentur 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 Bundesnetzagentur and agreed to publication on the Internet. At the end of 2020, in Germany, there are 35,964 charging points, of which 30,578 are normal and 5,386 are fast charging points at a total of 18,409 publicly accessible charging facilities. Given that at the beginning of 2020, there were around 27,148 charging points, the total number of charging points has been increased by nearly 32% in 2020.

Chargers as of 31st Dec 2020

Type of Public EVSE		Number of Charging Outlets	Number of Locations
AC Level 1 Chargers	AC charging ≤ 3.7 kW	479	323
AC Level 2 Chargers	AC charging >3.7 kW, ≤ 22 kW	30847	16205
AC Fast Chargers	AC charging 43 kW	1261	1208
DC Fast Chargers	DC charging ≤ 50 kW	1811	1679
Superchargers	DC charging 120 kW	329	232
Ultrafast-High power chargers	DC charging > 150 kW and ≤ 350 kW	1237	949
Inductive Chargers	EM charging	n.a.	n.a.

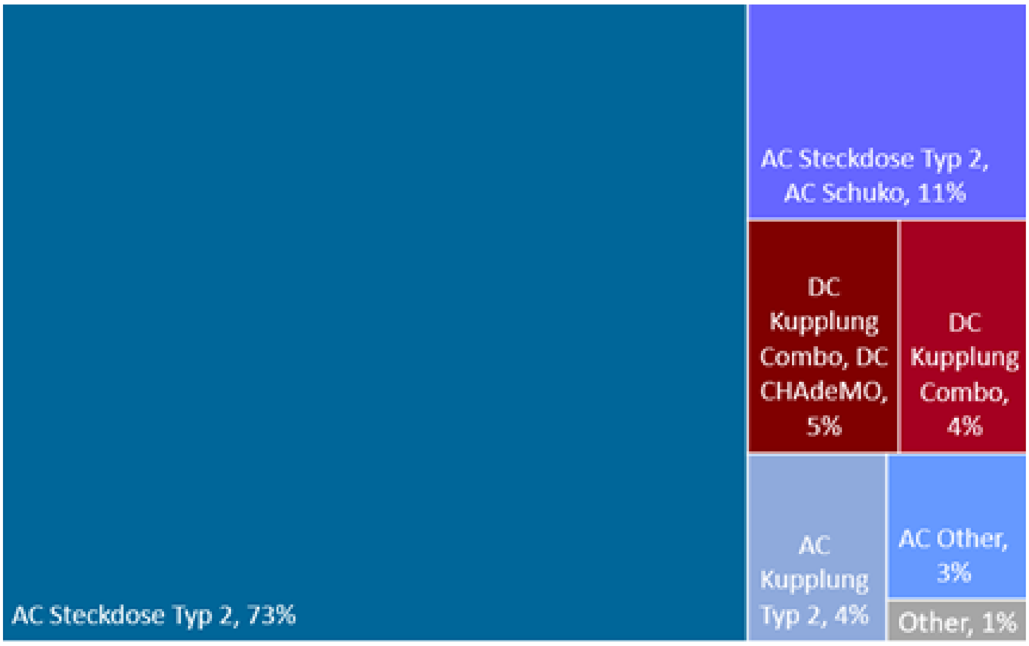

Figure 3: Plug types in German EVSE, 1.01.2021 (based on data from Bundesnetzagentur)

GERMANY: A CONTINUOUS INCREASE IN H2 FILLING STATIONS

As of 10 March 2021, there were 91 hydrogen fuelling stations in operation in Germany[16]. A total of 107 hydrogen filling stations have been put into operation worldwide in 2020. 29 were opened in Europe, 72 in Asia and 6 in North America. Four countries showed a particular dynamic expansion: Germany extended its network by 14 hydrogen stations, China by 18, Korea by 26, and Japan by 28. At the end of 2020, 553 hydrogen refuelling stations were in operation worldwide[17].

OUTLOOK

SUPPORT OF ELECTRIC MOBILITY CONCEPTS IN 2021

Starting in March 2021, municipalities, local authorities and, for the first time, commercial companies can apply for funding for electric mobility concepts. The Federal Ministry of Transport and Digital Infrastructure is thus supporting the development of electric vehicle fleets and their charging infrastructure.

New funding call for 2021 focuses on the following:

- Electrification of municipal and commercial fleets including charging infrastructure.
- Foundations for the development of a municipal/regional public charging infrastructure.
- Integration of municipal/commercial e-vehicles into intermodal transport and logistics concepts and mobility services.

A NEW POLICY TO ROLL OUT PUBLIC FAST-CHARGING INFRASTRUCTURE

Early 2021, the Federal Cabinet approved the bill for the provision of a nationwide fast-charging infrastructure for electric vehicles (Schnellladegesetz / Fast Charging Act). With this, the Government is creating the legal basis for the planned European-wide tender for the development of a public fast charging network with 1,000 locations[18].

Funding programmes so far have shown to be not sufficient on their own to ensure that the infrastructure is developed quickly, reliably, in line with demand, across the board and in a consumer-friendly manner - especially with regard to locations that are less frequently visited or are seasonal location (e.g. during vacation periods). The federal government intends to ensure the infrastructure development through long-term contracts with operators. HPC (High Power Charging) charging infrastructure with a capacity per charging point of at least 150 kW is to be put out to tender, ensuring fast charging for medium- and long-distance mobility. The fast-charging act is expected to be passed Bundestag/Federal Council in spring 2021. A volume of around 2 billion euros is earmarked for the development of the fast-charging infrastructure.

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Italy

MAJOR DEVELOPMENTS IN 2020

The effects of the Covid-19 pandemic on society and the global economy are unprecedented, the consequences for the automotive industry are significant and the recovery is still expected to be slow and complex. The reduction in economic activities, as well as frequent lock-downs, curfews and travel restrictions, including working from home, immediately generated a collapse in industrial demand and production in the first half of the year. This situation was difficult to recover in the second half of the year because the virus began circulating again in the fall. Nonetheless, the forecasts and targets for development objectives of electric mobility have not changed and continue indicating a massive introduction of electric vehicles that will be significantly felt from 2025.

New policies, legislation, incentives, funding, research, and taxation

In Italy, the “Budget” Law 2019[1] introduced a “bonus-malus” system for purchasing new vehicles. From 1 March 2019 to 31 December 2021:

- anyone who purchases (even with a lease) and registers a new passenger car in Italy with CO2 emissions below a given threshold value, will be provided with a bonus (in the form of a discount) depending on the amount of CO2 emissions per km, Table 1.

DIRECT INCENTIVES FOR PURCHASING NEW PASSENGER CARS

CO2 emissions [g/km]	Bonus with scrapping [EUR]	Bonus without scrapping [EUR]
00 - 20	6,000	4,000
21 - 70	2,500	1,500

Table 1: Eco-bonus (from 1 March 2019 to 31 July 2020)

Relating to the details on the conditions for eligibility, please refer directly to the sources

With the “Recovery” Law-Decree[2] and the “August” Law-Decree[3] establishing urgent measures on health, job and economy support, as well as social policies related to the epidemiological emergency due to COVID-19, funds for purchasing EVs were increased and the number of beneficiaries was extended. Due to these measures, the policy framework for electric mobility is now as in Table 2:

CO2 emissions [g/km]	Bonus with scrapping [EUR]	Bonus without scrapping [EUR]
00 - 20	10,000	6,000
21 - 60	6,500	3,500
61 - 90	3,750	2,000
91 - 110	3,500	1,750

Table 2: Eco-bonus (from 1 August 2020 to 31 December 2020)

Relating to the details on the conditions for eligibility, please directly refer to the sources

On the other hand,

- anyone who purchases (even with a lease) and registers a new passenger car in Italy, that exceeds the threshold value of 160 gCO2 per km, will be charged with a tax depending on the amount of CO2 emissions per km, as reported in Table 3.

TAXATION FOR PURCHASING POLLUTING CARS

CO2 emissions [g/km]	Tax [EUR]
161 - 175	1,100
176 - 200	1,600
201 - 250	2,000
> 250	2,500

Table 3: Eco-tax

New cars with CO2 emission values between 111 and 160 g/km are exempt from the incentive as well as from any taxation.

INDIRECT INCENTIVES ON EVS

Indirect incentives are mainly issued at a regional level. The reduction of the annual registration tax is the most used type of indirect incentive. Usually, electric vehicles are exempt from the annual registration tax for a time period of five years starting from the date of the first registration. After this initial five year period, they benefit from a 75% reduction of the value 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 the first registration. After this period the full conventional tax will be applied.

In many municipalities, electric vehicles have access to limited traffic zones and free parking in reserved areas. Some municipalities such as Florence, Milan and Rome, are gradually introducing restrictions to conventional vehicles.

INCENTIVES ON CHARGING POINTS

According to the "Balance" Law 2019[1], taxpayers are granted a tax deduction (to be distributed in 10 years) for costs incurred from 1 March 2019 to 31 December 2021 regarding the purchase and installation of EVs charging infrastructures. Initial costs for demanding additional power up to 7 kW are also included. This tax deduction is in the amount of 50 % of the costs on a total amount not exceeding 3,000 EUR. The charging infrastructures must have one or more not publicly accessible standard2 charging points.

Relating to the details on the conditions for eligibility, please directly refer to the sources.

Under the "Recovery" Law-Decree[2], taxpayers are granted a tax deduction (to be distributed in 5 years) for costs, incurred from 1 July 2020 to 31 December 2021, regarding the purchase and installation of EVs charging infrastructures. This tax deduction is granted when the purchase and installation of equipment is combined with renovation measures to increase building efficiency. Initial costs for additional power requirements up to 7 kW are also included. This tax deduction is 110 % of the costs on a total amount not exceeding 3,000 EUR. The charging infrastructures must have one or more not publicly accessible standard charging points.

Relating to the details on the conditions for eligibility, please directly refer to the sources.

HEVS, PHEVS, AND EVS ON THE ROAD

Despite the general reduction in sales (approximately -28 % compared to the previous year) due to the effects of the pandemic, the decrease in sales of petrol and diesel cars continues (approximately respectively -39 % and -40 % compared to the previous year) against the increase in the market share of hybrid, plug-in hybrid and battery electric cars (approximately respectively +102 %, +323 % and +204 % compared to the previous year).

Fleet Totals (as of December 31st 2020)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	1,000,000 ANCMA estimate	n.a.	n.a.	n.a.	50,000,000 ANCMA estimate
B Electric moped (<50 kmph)	n.a.	n.a.	n.a.	n.a.	1,300,000 ANCMA estimate
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle	n.a.	n.a.	n.a.	n.a.	6,800,000 ANCMA estimate
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	55,307 EAFO	n.a.*	44,212 EAFO	35 EAFO	39,545,232 ACI 01 Jan 2020
H Buses and Minibuses	586 EAFO	n.a.	0	13 EAFO	100,149 ACI 01/01/2020
I Light Commercial vehicles	6,315 EAFO	n.a.	98 EAFO	7	3,658,520 ENEA elaboration on ACI data as of 01 Jan 2020
J Medium and Heavy Weight Trucks	39 EAFO	n.a.	0	0	517,250 ENEA elaboration on ACI data as of 01 Jan 2020

* The total of HEVs and PHEVs as of January the 1st, 2020 amounts to 334,669 (Source: ENEA elaboration on ACI data as of 01/01/2020)

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3
I: UNECE categories N1
J: UNECE categories N2-N3

Total Sales 1st Jan 2020 to 31st Dec 2020

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	230,000 ANCMA estimate	n.a.	n.a.	n.a.	2,000,000 ANCMA estimate
B Electric moped (<50 kmph)	4,378 ANCMA estimate	n.a.	n.a.	n.a.	19,746 ANCMA
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle	6,385 ANCMA estimate	n.a.	n.a.	n.a.	218,626 ANCMA
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	32,485 ANFIA	221,893 ANFIA	27,407 ANFIA	2 ANFIA	1,381,496 UNRAE
H Buses and Minibuses	49 EAFO	n.a.	n.a.	n.a.	3,162 ANFIA
I Light Commercial vehicles	1,085 EAFO	n.a.	53 EAFO	n.a.	159,709 ANFIA
J Medium and Heavy Weight Trucks	11 EAFO	n.a.	n.a.	n.a.	20,303 ANFIA

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3
I: UNECE categories N1
J: UNECE categories N2-N3

CHARGING INFRASTRUCTURE OR EVSE

The main instrument to boost the deployment of a charging infrastructure for electric vehicles is the National Plan for Electric Charging Infrastructure (PNIRE)[4]. The first version of the Plan was issued in 2013, successively updated in 2014 and, more recently, in 2015. The last version came into force in 2016.

The PNIRE set targets for 2020 regarding the diffusion of the charging infrastructure in Italy, based on the assumption of an electric car market that, by 2020, would have an annual share of the total market of about 1 - 3%, (i.e. 18,000 - 54,000) electric cars registered in fleet of between 45,000 and 130,000 cars. The targets on the diffusion of the charging infrastructure have been defined considering a ratio of 1:10 between charging points and electric cars:

- normal power charging points (≤ 22kW): 4.500 - 13.000
- fast chargers (> 22kW): 2.000 - 6.000

The assumptions underlying the 2020 targets set by PNIRE, relating to the electric car market, have been met: in fact, registrations of electric cars (BEV plus HEV) accounted for about 4% of the total market and cars in circulation are about 100,000. The target regarding normal power charging points was also met since at the end of 2020 there were over 12,000 recharging points with power less than or equal to 22 kW in Italy. On the other hand, a different situation is presented by number of fast charging points, whose target at the end of 2020 has not yet been fully achieved. The implementation programme of the projects, submitted by the Regions and Local Authorities to the Ministry of Infrastructure and Transport is nearing completion: these projects, co-funded by the Ministry up to a maximum of 50% of the costs, are focused on public charging infrastructure , fuel distribution plants, private charging infrastructure (home / domestic charging, individual or condominiums) and private charging infrastructure publicly accessible (garages, parking spaces and such), in metropolitan and not metropolitan areas.An increase in recharging points is also expected thanks to the incentives programme implemented by the Government, described above.

Chargers as of 31st Dec 2020

Type of Public EVSE		Number of Charging Outlets	Number of Locations
AC Level 1 Chargers	AC charging ≤ 3.7 kW	12,150	n.a.
AC Level 2 Chargers	AC charging >3.7 kW, ≤ 22 kW		
AC Fast Chargers	AC charging 43 kW	1,231*	n.a.
DC Fast Chargers	DC charging ≤ 50 kW		
Superchargers	DC charging 120 kW		
Ultrafast-High power chargers	DC charging > 150 kW and ≤ 350 kW		
Inductive Chargers	EM charging	n.a.	n.a.

* Type 2 AC: 229, ChadeMo: 396, CCS: 524, Tesla SC: 311 (Source: EAFO). Please note that Type 2 AC charging points (229) are not counted in the total (1,231) because some of the DC chargers are also equipped with a Type 2 AC socket but the DC and AC charging points can't work at the same time.

EV DEMONSTRATION PROJECTS

In 2020, the main national research institutions continued their R&I activities and demonstration projects on topics relating to electro-mobility: vehicles, charging infrastructure, interaction with the electricity grid and use of renewable energy sources.

NATIONAL RESEARCH COUNCIL OF ITALY (CNR)

- Development of nano-structured, polymeric materials and components for the development of supercapacitors and batteries.
- Stress tests on innovative batteries in the automotive sector.
- Design, realisation and optimal management of smart DC micro-grids for electric and plug-in hybrid vehicles. The research activities are carried out through laboratory prototypes, which purse the efficient integration of stationary

energy storage systems, renewable energies and fast DC charging stations for sustainable electric mobility. Laboratory prototypes of smart DC micro-grids for full electric and plug-in hybrid vehicles are analysed in different operative conditions, obtained with proper settings and control of single power converters and using 1:1 scale battery packs. The proposed DC architectures present different advantages, mainly related to the real possibility to realize V2G operations and to store electric energy by means of energy storage buffers integrated within DC charging stations.

- Vehicle propulsion system - CNR patent (PCT / IB2018 / 051232)[5] which allows the creation of a hybrid vehicle engine with minimal impact on current motion transmission architectures, Figure 1. It provides for the interposition, between the engine and the transmission, of a planetary gear on one of whose axes there is an auxiliary power unit capable of storing and releasing energy. If the planetary gearing has orthogonal axes, the minimum impact on the existing transmission architecture could be obtained, for a more immediate technology transfer at low costs. This device, in comparison with other similar widely used systems (equipped with a planetary gear and two electric motors) differs in the presence of a single electric motor and in the purpose of the gear.

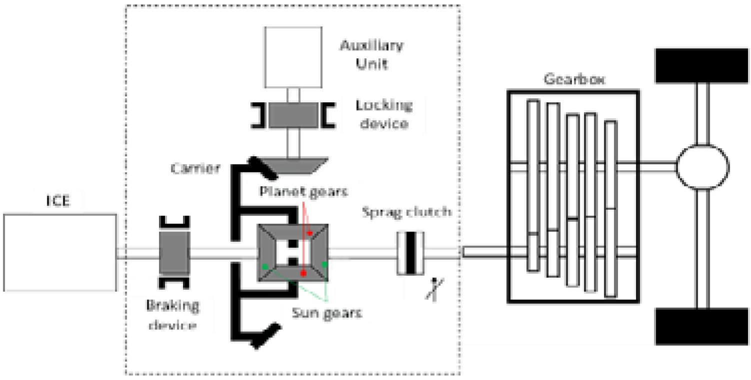

Figure 1: Diagram of the transmission system for a hybrid vehicle equipped with orthogonal axis gears (Image courtesy of CNR)

- Assessment and design of real-world driving cycles targeted to the calibration of vehicles with electrified powertrain. The study, presented in the THIESEL 2020 Conference[6] is the design of a series of real-world velocity profiles that can be used for the virtual platform during the design of such powertrain architectures.

- Development and energy optimisation of hybrid fuel cell / battery powertrains for the automotive sector. The electric motor can be powered by batteries, FC and supercapacitors: these elements, connected in series or parallel, supply energy on the basis of the energy strategy and the level of hybridisation to be carried out on the vehicle.

- Development of fuel cell power systems for marine applications both in inland waters and in the marine environment.

- Studies for the application of fuel cells in aeronautics, as an auxiliary generator powered by hydrogen obtained from kerosene reforming.

ITALIAN NATIONAL AGENCY ON NEW TECHNOLOGIES, ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT (ENEA)

Most of ENEA's activities are carried out under the National Electricity System Research Programme Agreement, funded by the Ministry of Economic Development:

- Looking at fast charging in Public Transport, ENEA is studying and testing the effects of Charging Architectures on batteries while increasing the level of battery stress: at the depot (slow charge during the night), at the terminal (slow charge during the night and fast charge at the terminal), and at the stop (slow charge during the night and fast/ultrafast charge at bus stops).

- Experimental investigation of the overcharge effects on commercial Li-Ion Cells, Figure 2. The tests were performed in a dedicated test field: monitoring was performed with a thermal infrared camera, calibrated thermocouples and a fast camera. A climatic chamber for abuse tests has also been used. A dedicated set-up has been built to monitor the pressure increase, the temperatures and to contain mechanical components in case of cell thermal runaway, Figure 3.

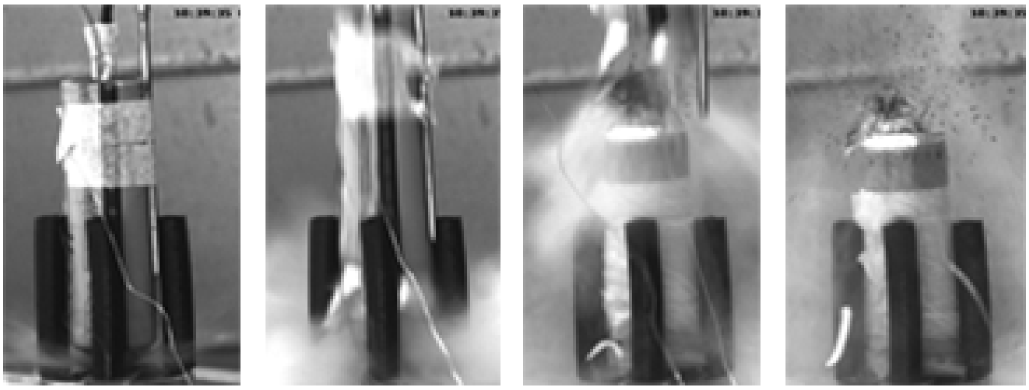

Figure 2: Venting of a battery cell subjected to overcharge (Source: ENEA)

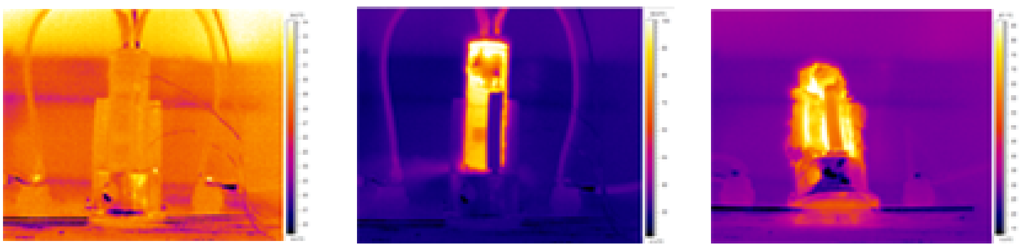

Figure 3: Thermo-graphic images of a battery cell during thermal runaway (Source: ENEA)

- Ultra-fast charging for buses with storage based on supercapacitors, on board the vehicle and inside the charging station.

- Fast charging for buses with a flywheel as storage system at ground inside the charging station and LTO battery on board the vehicle: flywheels have a much longer life than batteries, while LTO batteries have higher specific powers than conventional ones.

- Studies and tests on hybrid storage systems with batteries and supercapacitors proved that the useful life of batteries increases considerably over each type of vehicle driving cycle.

ENEA also joins numerous other national and international projects. Some examples are listed below:

- Funded by the Lombardy Region with the “Call Hub research and innovation”, the MoSoRe project (Infrastructures and services for Sustainable and Resilient Mobility) of the University of Brescia investigates the resilience of systems and infrastructures for mobility, proposing solutions related to road infrastructures, electric vehicle charging infrastructures and ICT infrastructures which allow the user to move safely and within the expected times, even in emergency situations.

- The industry powered, city-driven and user-centric project USER-CHI (Innovative solutions for USER centric CHarging Infrastructure) financed by the European Union’s Horizon 2020 Programme, will co-create and demonstrate smart solutions around 7 connecting nodes of the Mediterranean and Scandinavian-Mediterranean TEN-T corridors between February 2020 – January 2024 to boost a massive e-mobility market take-up in Europe.

- KIC EIT Urban Mobility: using cities as living labs to develop and demonstrate new technologies to transport people, freight and waste in smarter ways, the Knowledge and Innovation Community is aimed to foster integration and accelerate change in mobility to create more livable urban spaces. Co-funded by the European Institute of Innovation and Technology, a body of the European Union, the KIC has more than 85 partners (Industry, Research, University, Cities) from 16 European countries.

- ENEA contributes to the activities of the work-package 4 “Battery sensors, cooling, BMS, modules and packaging” of the EU-funded 3beLiEVe project[7]. This activity aimed to produce the next generation of Li-ion rechargeable batteries for electric vehicles in 2025 and beyond. This will be possible through the use of lithium nickel manganese oxide (LNMO), a cobalt-free cathode material that's a cost-effective alternative to current lithium-ion battery materials. In particular, ENEA is responsible for the integration of all sensors (internal and external) installed at the level of the single cell. In addition to the hardware/software integration with the Battery Management System, ENEA is responsible for the testing 'in real conditions' of the cell/sensors subset.

RESEARCH ON ENERGY SYSTEM (RSE)

RSE is currently working on a three-year project called "Scenarios and tools for electric mobility and its integration and interaction with the electric system”. The project includes many activities, both based on a “system” point-of-view and on a more “technological” view point. Mobility modelling activities have been launched, with the objective to create a multimodal traffic model for urban and extra-urban travels, to evaluate the impact of new local and national policies on mobility. The impact of new policies can be assessed further through an air quality model that has been progressively updated by RSE, by inserting more recent data and increasing the spatial resolution to 1x1 km. When considering environmental analyses, LCA (Life Cycle Assessment) studies comparing vehicles with different power supplies have been performed, confirming the benefits of EVs. Technical-economic assessments on the electrification of heavy-duty vehicles, boats for public transport on lakes and large stationary ships are on-going. With regards to technological aspects, the issue of EV integration into the grid and of flexibility offered during the charging process is particularly addressed. An optimisation model was created to schedule the charging process, considering the case study of a company fleet. The schedule allows both the charge of the vehicles and the provision of flexibility services to the grid, under specific rules allowed by Italian regulation. In order to test the algorithm, the electrification of RSE company cars is on-going and two bi-directional chargers for Vehicle-To-Grid (V2G) purposes were integrated and tested at RSE facilities. RSE is also active in supporting Institutions involved in e-mobility (Ministries, Regulatory Authority, Lombardy Region) or working groups (IEA, ACI, Motus-E, e-Mob).

In addition, in December 2019 the European Commission approved 3.2 billion EUR public support by seven Member States for a pan-European research and innovation project in all segments of the battery value chain[8]. Under the EU State aid rules, the project is qualified as an Important Project of Common European Interest (“IPCEI”). It was jointly notified to the European Commission by Belgium, Finland, France, Germany, Italy, Poland and Sweden: the seven Member States will provide in the coming years up to approximately 3.2 billion EUR in funding for this project, which is expected to unlock an additional 5 billion EUR in private investments. The project involves 17 direct participants, mostly industrial actors (including small and medium-sized enterprises) and research organisations which will receive up to approximately 3.2 billion EUR in funding. More specifically, 5 of these 17 direct participants are Italian enterprises and Italy has sought approval to grant up to approximately 570 million EUR. The project is part of the efforts toward the transition to climate neutrality, including through clean and low emission mobility. It is expected to bring significant opportunities for economic growth, job creation and technological development. It supports the development of highly innovative and sustainable technologies for lithium-ion batteries, involving R&I activities up to first industrial deployment across the whole battery value chain in line with environmental sustainability and circular economy principles.

OUTLOOK

On October 2020, the Italian Polytechnic Institute in Milano published the “Smart Mobility Report”[9] that, beside reporting a detailed analysis of technologies, regulations and current car market, presented forecast results from 3 market scenarios that can be summarized as follow:

- “base” scenario: this scenario foresees an adoption of electric vehicles that does not go beyond 3.5 million vehicles in 2030;
- “moderate” scenario: in this scenario, electric vehicles reach 5.5 million in 2030, over 14 % of the fleet total;
- “accelerated development” scenario: this scenario foresees that in 2030 the registrations of electric vehicles will amount to 65 %, reaching about 7 million (almost 20 % of the total).

A common factor between these three scenarios is that the real impact of electric vehicles will start giving its result around 2025.

It should be noted, the value foreseen by the moderate scenario in 2030 is close to that envisaged by the Integrated Energy and Climate National Plan[10], equal to 6 million electric vehicles.

With regard to public charging points for electric vehicles by 2030, forecasts show a minimum of 47,000 in the "base" scenario, to a maximum of 70,000 in the most developed scenario, passing by approximately 60,000 in the moderate scenario. With regard to private charging points for electric vehicles, the "base" scenario foresees a diffusion that does not go beyond 1.8 million units by 2030, while in the moderate scenario the private charging points exceed 3 million and, in the accelerated development scenario, private charging points exceed 3.9 million units. Similarly to what is shown in the forecasts on the market of electric cars, the spread of private charging points shows a very sustained growth between 2025 and 2030.

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The Netherlands

MAJOR DEVELOPMENTS IN 2020

The Dutch Government ambition is that by 2030, only zero emission passenger cars will be sold in the Netherlands. 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.

Despite the Covid19 pandemic, the number of full electric passenger cars increased in 2020. A purchase subsidy was introduced in 2020 for both new and used cars[1]. The budget for new cars was exhausted in one week. Almost 25% of new registrations were electric vehicles, with over 20% being BEVs. The pandemic did impact the sector tremendously; people worked from home and therefore charged less. Large investments were in the sector were also postponed.

The National Charging Infrastructure Agenda[2], installed as part of the National Climate Agreement, was fully implemented, resulting in an increase of the number of charging points installed per month.

Additional major milestones in the Netherlands includes: the announcement of zero emission zone (ZEZ) implementation for the 30-40 largest cities by 2025, 20 cities have already announced their plans for a ZEZ and more are expected to follow, and the 1,000th zero-emission public transport bus was delivered - making 1/5th of the total bus fleet for public transport zero-emission. The Netherlands are on track for its target to have 100% of public transport buses zero-emission by 2030.

Policy developments

The National Charging Infrastructure Agenda[3] 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 and that charging infrastructure will not be a barrier for electrification of other vehicle modes. By 2030, the fleet of electric passenger cars is projected to need 7,100 GWh of electricity or 1.7 million charging points, a huge task.

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. For planning purposes, the country is divided into 6 regions (5 geographic regions and the 4 largest cities combined) that each have a different focus, as can be seen in figure 1. In 2020 cooperation agreements were signed between the government, regions and grid operators; regional project offices were established. Working groups were set up to address the realisation process, open protocols and markets, smart charging, safety and cyber security, and logistics.

Figure 1: National Charging Infrastructure Agenda regions and focus

Cities can implement a zero emission zone for commercial vehicles from the 1st of January 2025. In October 2020, the national entry requirements for these zones were announced. From 2025, all new trucks and vans that want to enter a zero emission zone need to be emission free. Also as a result of Covid-19, a transitional arrangement applies for existing trucks and vans (until 2028 for vans and until 2030 for trucks). From 2030, all commercial vehicles entering these zones should drive emission free.

Access restriction for non-zero emission commercial vehicles is a new development, therefore the Transport Decarbonisation Alliance, C40 and Polis developed a guide[4] for countries, cities and companies to learn more about zero emission zones.

A National Strategic Approach to Batteries was announced, in which various ministries collaborate to address responsible use (such as raw materials and recycling issues) and smart exploitation of opportunities (such as economic chances for Dutch industry and using batteries as a grid buffer).

Financial and fiscal incentives

One of the drivers behind the increase of electric vehicles in the Netherlands is fiscal stimulation. The focus 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 2020.

Table 1: Fiscal incentives in the Netherlands 2020

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 CO2 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 CO2 emissions and amounts of registration tax.
Road tax	Zero emission cars are exempt from paying road tax. Plug-in hybrid cars < 51 gr CO2/km pay half the tariff (until 2025). 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 has to be paid on the private use of a company car. This is implemented by imposing a surcharge of 8% or 22% of the catalogue value on the taxable income. For zero emission cars with a purchase price < €45,000 this percentage is 8%. For the part > €45,000 and 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 CO2/km (no diesel engine) are on the list of deductible investments, as are the accompanying charging points.

Table 1: Fiscal incentives in the Netherlands 2020

In 2020, a national purchase subsidy was introduced: € 4,000 for a new car (2020 budget € 10 million) and € 2,000 for a used car (2020 budget €7.2 million). The subsidy scheme is valid until 2025 with a annually decreasing amount for new cars. The subsidy is applicable to BEVS with a range of at least 120 km, with a catalogue value between € 12,000 and € 45,000 and not for converted cars. The subsidy for new cars was exhausted in just one week and resulted in a sales spike.

The decrease in the energy tax for electricity for public chargers has been extended to 2022. It contributes to the willingness of companies to invest in public charging infrastructure.

Next to these national incentives, various municipalities and regions offer different grants and schemes for electric vehicles. Some examples:

- Rotterdam: subsidy for innovation in clean city logistics;
- Amsterdam: subsidy for electric commercial vehicles and taxis;
- Gelderland province: subsidy for electric vans.

Market developments

A tender for installing 8,000 charging points for the provinces of Brabant and Limburg by using data-driven roll-out was granted to Vattenfall. Using the SparkCity-model, placing is based on the expected need for charging points. Innovations like free choice of energy supplier and handsfree charging paying (without charge pass) will also be realised. Another large tender for the provinces of North-Holland, Flevoland and Utrecht contained a total of 20,000 charge points.

The province of Groningen put a fully electrically driven inspection ship into use, built at Royal Niestern Sander wharf in Delfzijl. It has 2 large electric motors, a battery package of 5,000 kg and many technical innovations on board.

Figure 2: Electric inspection ship (photo courtesy: Royal Niestern Sander BV)

An interesting innovation in inland shipping is the first container ship Alphenaar with swappable battery packs. It was developed for Heineken and will be deployed on a fixed route, which makes it possible to efficiently organise battery swapping. Electricity is stored in the battery packs at less demanding times, further helping the business case.

More than 20% of buses used for public transport are electric. The largest single fleet drives in the region IJssel-Vecht where 246 e-buses were taken into operation in one go. Already 23 of the 33 concessions in the Netherlands have emission free buses, both in and outside cities. This success is due to a mix of collaboration, clear goals (zero emission public transport by 2030) and knowledge exchanges.

There were several announcements of electrifying special use vehicles, like a concrete mixer (Kijlstra), a loader crane with trailer (ERA Contour & Vlot Logistics), a 10-12 ton rolling machine (BAM Infra) and a mobile crane (Spierings). Large construction machines are a bottleneck for further building projects, as a result of the nitrogen emissions. Electrification at building sites is an important step forward for local air quality and will further reduce noise and air pollution for people living in the vicinity.

Knowledge, innovation and research

The Electric Driving Monitor 2020[5] of the Royal Dutch Touring Club (ANWB) showed that 1 in 4 consumers are considering buying an electric car, an increase of 30% compared to 2019. Reasons for this positive change are the vehicle purchase subsidy, more vehicle choice, increased vehicle range and the fast charging infrastructure. The Dutch Association of EV drivers and Netherlands Enterprise Agency investigated the characteristics of EV drivers, their experiences with electric driving and their route to purchasing an EV. The study[6] identified 4 types of EV drivers: cost-conscious, environmentally conscious, pioneer and comfort-oriented.

The Ministry of Infrastructure and Water Management commissioned FIER to carry out qualitative and quantitative research on the bottlenecks experienced by drivers of electric vehicles. As a case study, the focus was placed on the corridor from the Netherlands to the South of France, the so-called 'E-route du Soleil'. The report[7] formulates recommendations on the availability of charging infrastructure, price transparency, European roaming and on the facilities at charging locations. The methodology used for this analysis is applicable to any TEN-T corridor in Europe.

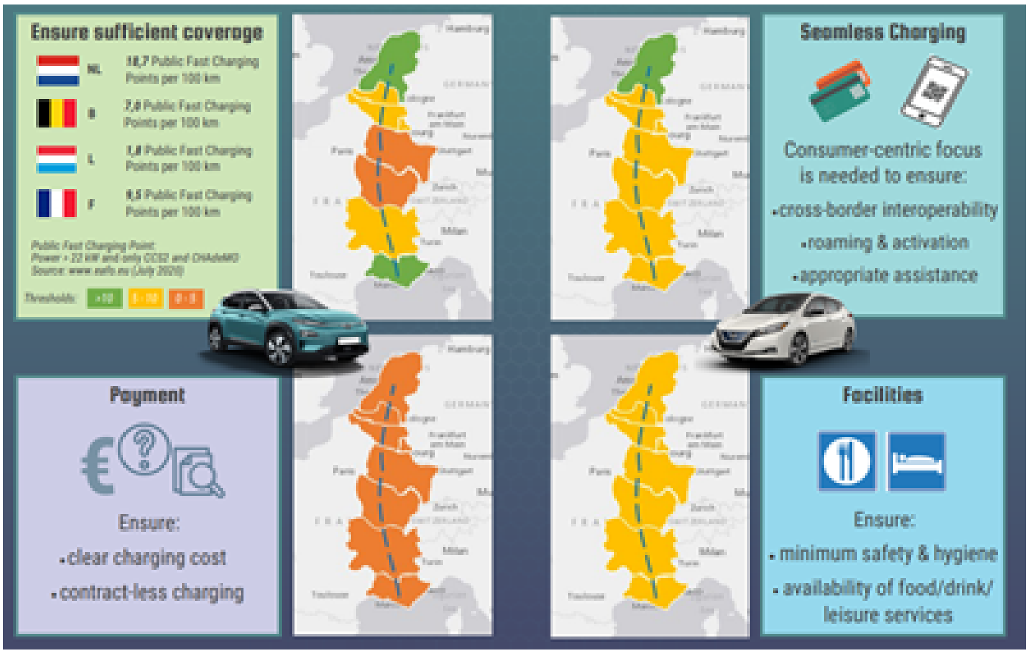


Figure 3: part of infographic E-route du Soleil

CE Delft executed a study[8] on various safety aspects of electric passenger cars, such as those relating to vehicles, fire, road safety and incident management. It showed that electric cars are just as safe as fuel cars. Electric cars do not lead to an increased fire hazard. Regarding charging infrastructure, especially the current technique of Mode 3 and Mode 4 charging (for regular and fast charging) is found to be very safe.

The Netherlands Enterprise Agency investigated, together with 23 housing Corporations, the possibilities for charging points at rental properties. Corporations can use the report[9] to form policy and statements of requirements for new construction projects, renovations and also to handle tenant requests.

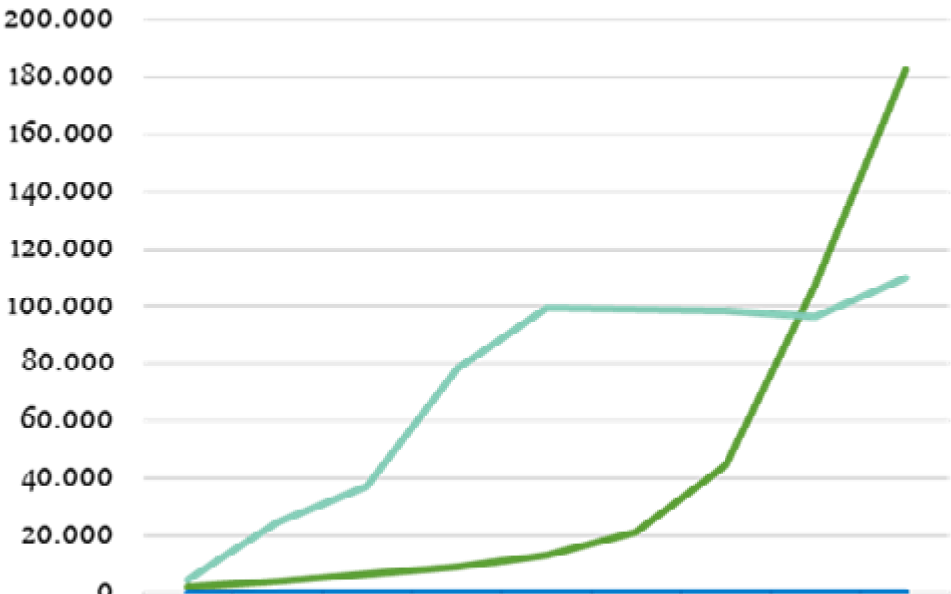
Smart charging can reduce the peak load of home charging electric cars by 40%, showed a pilot of Maxem, Enexis Grid Management, Enpuls and ElaadNL. 138 Households used an energy management system in which information on the available grid capacity was integrated and charging speeds were adjusted accordingly. 84% of the pilot participants said that they would keep on using smart charging in the future. Smart charging can also save tons of extra CO2 emission reductions (next to the CO2 reduction of electric driving itself), was found in a master thesis study. Several modelled scenarios showed a 10% increase in CO2 gains; applying vehicle2grid can even double that, growing with the renewables share in the electricity mix.

HEVS, PHEVS, AND EVS ON THE ROAD

The electric car fleet in the Netherlands is quickly becoming more fully electric; at the end of 2020 almost two thirds of plug-in cars consisted of BEVs. After a small dip in 2018, the number of PHEVs increased again too, as is shown in figure 4. At the end of 2020, there were 182,486 BEV passenger cars on the road (an increase of 70% compared to the end of 2019) and 109,754 PHEVs (an increase of 13%). The number of FCEVs more than doubled, from 156 at the end of 2019 to 390 at the end of 2020. There were 261,400 HEV passenger cars on the road at the end of December 2020, an increase of 24%% compared to the end of December 2019.

Over the year 2020, 24.6% of total new passenger car registrations were electric. Of these the majority was full electric (20.3%), the share of PHEVs in new registrations was 4.2%. Other vehicle types also steadily increase in numbers, as can be seen from table 2. Already more than 20% of the total fleet of buses used for public transport is electric.

The Netherlands has 730,000 users of shared car mobility and 64,312 shared cars (all fuels and all types of sharing). Of these, more than 5,000 or 8.2% were electric (BEV/PHEV) – a larger share than in the general fleet: in the total Dutch fleet of passenger cars electric vehicles (BEVs/FCEVs/PHEVs) accounted for 3.4%.



	2012	2013	2014	2015	2016	2017	2018	2019	2020
BEV	1.943	4.193	6.856	9.401	13.140	21.136	44.994	107.335	182.486
FCEV	5	6	8	26	33	42	55	215	390
PHEV	4.685	24.824	37.358	78.591	99.421	98.773	98.324	96.521	109.754

Figure 4: Development electric vehicles fleet in the Netherlands 2012-2020
Source: Dutch Road Authority, edited by RVO

Table 2: Dutch fleet totals, 31-12-2020
Source: Dutch Road Authority, edited by RVO

Fleet Totals as of December 31st 2020

Vehicle type	EVs	HEVs	PHEVs	FCVs	Total
A 2 and 3 Wheelers	81,722	62	0	0	2,088,835
B Passenger vehicles	182,486	261,400	109,754	390	9,247,369
C Buses and Minibuses	1,227	114	14	6	10,617
D Light Commercial vehicles	6,192	158	47	14	1,063,120
E Medium and Heavy Weight Trucks	148	21	31	8	173,256

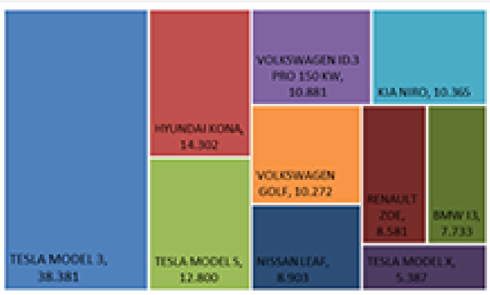
Table 3: Dutch registrations, 31-12-2020
Source: Dutch Road Authority, edited by RVO

Total Registrations During 2020[10]

Vehicle type	EVs	HEVs	PHEVs	FCVs	Total
A 2 and 3 Wheelers	22,855	0	0	0	105,280
B Passenger vehicles	72,945	47,255	15,396	147	358,641
C Buses and Minibuses	446	79	0	0	637
D Light Commercial vehicles	1,642	146	33	8	60,268
E Medium and Heavy Weight Trucks	41	5	0	2	10,516

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

Figure 5 shows the most popular car models in the Dutch BEV and PHEV fleet.



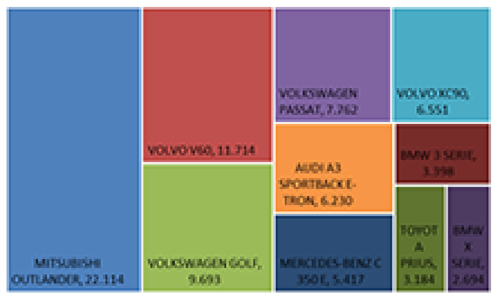


Figure 5: Top 10 of BEV (left) /PHEV (right) fleet in the Netherlands, 31-12-2020

Source: Dutch Road Authority, edited by RVO

CHARGING INFRASTRUCTURE OR EVSE

The Netherlands has a well-developed network of charging points, as is illustrated in figure 6, that shows the division of (semi)public charging points over the provinces.

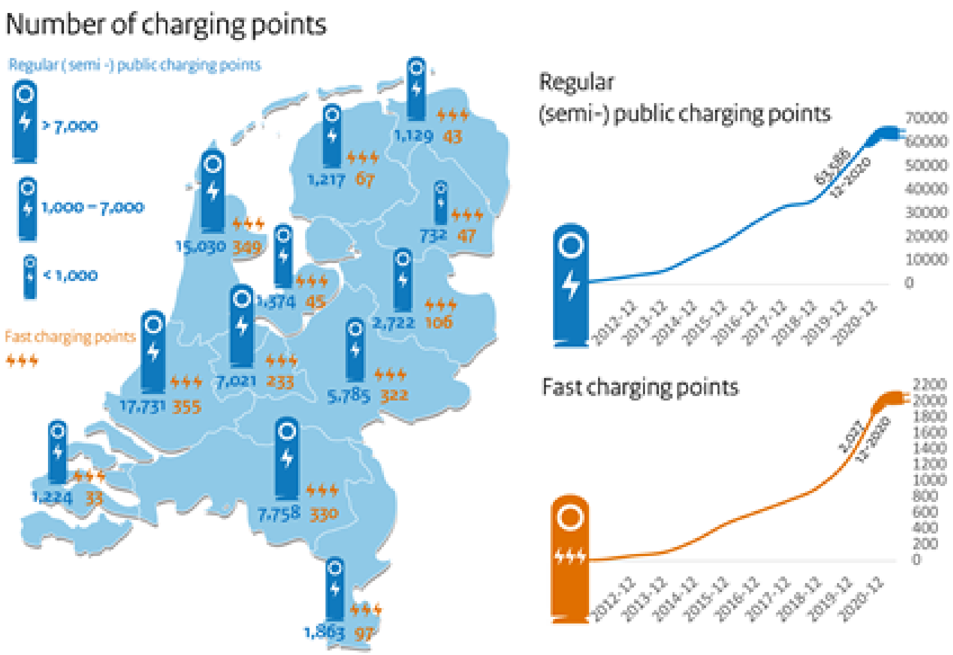


Figure 6: number and distribution of (semi)public charging points in the Netherlands
Source: Eco-Movement, edited by RVO

All charging is interoperable in the Netherlands, as has been the case since 2011. The Open Charge Point Protocol (OCPI), an independent roaming protocol for providers of charging infrastructure and services, was designed for that purpose. It provides information about location, real-time availability, CPO prices and real-time billing, as well as mobile access of chargers.

Compared to the end of 2019, the number of (semi) public charging points increased by 28% in 2020. Fast charging increased to 467 locations with 2,027 charging points. At the end of 2020, an estimated number of 169,000 private charging points were installed in the Netherlands.

Type of Public EVSE[11]	Number of Charging Points
AC Level 1 Chargers (≤ 3.7 kW)	2,057
AC Level 2 Chargers (>3.7 kW, ≤ 22 kW)	61,529
Fast Chargers (> 22 kW, ≤ 43.5 kW)	381
Superchargers (> 43.5 kW, ≤ 150 kW)	1,170
Ultra-Fast Chargers (>150 kW)	476
Inductive Chargers	n.a.

Table 4: number of charging points in the Netherlands
Source: Eco-Movement, edited by RVO

The Dutch government, knowledge institutes and companies together call for the use of open standards and protocols in charging infrastructure, as to stimulate innovation and global access – thus favoring EV uptake.

EV (DEMONSTRATION) PROJECTS

The first vehicle2grid charging plaza was opened in Lelystad. It consists of a covered parking place with 90 solar panels and 10 V2G-charging poles. Charging is done by electric shared cars and at night they supply the adjacent building with electricity from their batteries. It is part of an Experimental scheme for Smart Charging Plazas, financed by the Ministry of Infrastructure and Water Management.

In the MOOI subsidy scheme (mission-oriented research, development and innovation) several projects run around smart solutions for a reliable, affordable and equitable supply of electricity. One of them, ROBUST, aims for an integrated flexibility system, at regional level, that can facilitate more renewable energy and electric transport in cities. Flexibility is available for this from flex sources such as smart and bidirectional charging of EVs, stationary batteries, heat pumps and heat storage.

Figure 7: Project FLEX EV, Rotterdam Area (photo courtesy: DHL)

The demonstration scheme on Climate Technologies and Innovations in Transport (DKTI-transport) focuses specifically on entrepreneurs and partners in the transport sector who are willing 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.

Figure 7: Project FLEX EV, Rotterdam Area (photo courtesy: DHL)

A project example is FLEX EV by DHL, centred around flexible electric freight and maintenance logistics in the Rotterdam area. A large fleet of 34 electric vans (category N2, < 12 tons) and 2 electric trucks (category N3, > 12 tons) are operated. An important aspect is that a mix of various charging solutions are utilised.

OUTLOOK

It is unclear what the long-term impact of Covid-19 will be for the e-mobility sector. The economy in general will have to recover. The market for electric vehicles will continue to develop further, as more affordable cars are introduced into the market and more second-hand electric cars become available. The purchase subsidy for passenger cars is now set to last until the end of 2025. Before that, market developments will be evaluated to investigate whether more government support for electric cars will be needed, this will ensure that by 2030 all new sold cars will be zero emission. In 2021 a purchase subsidy for electric vans will be introduced, along with a subsidy scheme for non-road mobile machinery and extended support on 'learning by doing' for zero-emission trucks (via the DKTI-transport subsidy scheme).

The planned adjustment of the EU-Alternative Fuels Infrastructure Directive (AFID) is important to advance the electro-mobility developments in Europe, working on roaming across borders and price transparency for EV drivers. In the Netherlands, from 1st July 2021, CPOs will be obliged to publicly share information on the availability and ad hoc prices of (semi) public chargers, so dynamic information can be gathered.

Further work will be done to approach e-mobility in an integral way by taking into account the other subsectors of the energy transition, this will further improve the understanding of future electricity demand and supply.

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[8] https://www.agendalaadinfrastructuur.nl/organisatie/werkgroepen+nal/downloads_getfilem.aspx?id=1242998&forcedownload=true
[9] https://www.huurenergie.nl/wp-content/uploads/2020/09/huren-en-laden_eindrapport_v06mc-def.pdf
[10] New registrations, including 'young import' (?90 days after first registration)
[11] Including semi-public EVSEs

Norway

MAJOR DEVELOPMENTS IN 2020

The total number of BEVs in the passenger vehicle fleet reached 339,912 at the end of 2020, and the share of the total fleet reached 12.1%. The PHEV share of the total fleet reached 5.2% with 146,125 vehicles. Only 153 FCEVs were in the fleet at the end of 2020. The BEV market share of new vehicle sales reached 54.3% in 2020, while PHEVs accounting for another 20.4%, so ~75% of new vehicles sold new had a form of electric drivetrain. This was facilitated by the large number of new models with attractive characteristics that came on the market, and the continuation of favourable policies.

For Light Commercial Vehicles, the Battery Electric market share reached 8.5% in 2020, up from 5.6% in 2019. The fleet share reached 2 %. Battery Electric Heavy duty trucks continue to be a rarity, only 37 where in the fleet at the end of 2020. Battery Electric Buses are on the brink of a major breakthrough reaching a share of 2.9% of the total fleet, 453 in total. 403 of these are city buses and 50 are coaches.

New policies, legislation, incentives, funding, research, and taxation

The overall target for the vehicle policy is to support Norway's climate policy targets of reducing greenhouse gas emissions by 40% in 2030, compared with 1990[1]. This target subsequently led to the national vehicle targets in the National Transport Plan in 2017[2], of only selling zero-emission passenger vehicles, small light commercial vehicles and city buses from 2025, and 75% of coaches, all large light commercial vehicles and 50% of Trucks by 2030.

Norway has very attractive and comprehensive incentives for electric vehicles. BEVs and FCEVs are exempted 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 reduced annual tax, and several driver privileges with substantial economic value. The annual tax is levied as a tax on insurance with a fixed cost per day. ZEVs were exempted up to 2020, but from 2021 will ZEV owner pay 30% less than ICEV owners do. Table 1 provides an overview of the current legislation.

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 3,000 €. VW Golf: 6,000 €, larger vehicles even higher	To be continued unchanged at least until the end of 2021 , likely also the end of 2022.
VAT exemption	2001	Vehicles competing with BEVs are levied a VAT of 25% on sales price	To be continued unchanged until at leastthe end of 2021, likely also the end of 2022.
Reduced annual tax (formally a tax on vehicle insurance)	1996/ 2004	ZEVs were exempted until end of 2020. From 2021: BEVs and hydrogen vehicles 213 €, diesel/petrol: 297-307 € (2021-figures).	TBD, last change was for 2021.
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: 660 Euros, 4-11 years 398 Euros.	
Direct subsidies to users: Reduction of variable costs and help solving range challenges			
Reduced toll roads	1997	In Oslo users save 60%, 360-600 €/year. Some places savings exceed 1500 €	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 kms driven & market shares.	ENOVA** 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		Gasoline road use tax: 49,1 €C/litre Gasoline CO2-tax:12,6 €C/litre Diesel: 36,2 + 14,5 €C/litre respectively	Road use tax to be continued until it can be replaced by GPS road pricing

Table 1 Relative advantage of BEV incentives in Norway. Adapted from Figenbaum (2018) and updated.

* 10 NOK = 1 Euro
** ENOVA, a Government agency, supports the introduction of energy saving and climate gas reduction technologies in Norway. It supports charging infrastructure and infrastructure for alternative fuels.

Table 1: Relative advantage of BEV incentives in Norway. Adapted from Figenbaum (2018) and updated.

Incentives	Intro year	BEV buyers - relative advantage*	Future plans
User privileges: Reduction of time costs and providing users with relative advantages			
Access to bus lanes	2003/ 2005	Though some limitations, many 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.
Free or reduced parking fees	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.

The incentives and BEV specific policy are stable but a gradual revision of some of the user privileges are ongoing. The current user privileges include reduced parking charges, reduced ferry rates and full or partial toll road exemptions. The energy taxes are also much lower for BEVs, which further have access to bus lanes.

In 2017, parliament decided the full exemption for toll roads, parking charges and ferry rates are to be phased out, BEVs are now levied to 50 % of the rate that ICE vehicles pay. Several toll road companies have introduced increasing toll road charges (within the 50% limitation), for instance, in 2021 the city of Oslo will charge BEVs about 40% of the ICEV rate. Parking charges have also been introduced in many municipalities already. Access to bus lanes has been restricted to BEVs with at least one passenger, in addition to the driver, in the rush hours. In some areas surrounding Oslo this has been in place since 2015, but are still accessible other places. FCEVs have had the same incentives as BEVs, but have the added advantage of still being 100 % exempt from parking charges, toll roads and still have unrestricted access to bus lanes.

A 2020 law amendment has given people living in shared housing communities a right to install charging infrastructure, for their vehicle, in the parking space they have access to in the common parking facility[4]. This right is only denied due to special circumstances, for instance, if electrical capacity is not sufficiently available in the parking facility.

Norway is not part of the European Union but closely connected through the European Economic Area agreement (EEA). In December 2018 the Norwegian Parliament decided 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[3], and makes the Norwegian market more attractive for electric vehicle producers as the sales volumes now counts towards the EU CO2 target.

The VAT deduction for battery electric vehicles has no effect on LCVs used by enterprises as they can already deduct incoming VAT. The purchase taxes are also lower on diesel LCVs than diesel passenger cars, which also reduces the value of that incentive. LCVs benefit from the same local incentives as passenger cars. Enova, a Government Agency supporting the transition towards a low-emission society, provides a purchase incentive for Battery Electric Light Commercial Vehicles, ranging from 1,500-5,000 Euros/vehicle depending on the vehicle size and technical characteristics. Installation of accompanying charging infrastructure can also be supported. Enova has also provided support to battery electric and hydrogen HD

Trucks demonstration projects, and for publicly accessible fast charging and hydrogen infrastructure. A new programme will support the roll-out of battery electric and hydrogen HD trucks from February 2021. The programme will cover up to 40% of the extra cost of such vehicles over diesel equivalent version.

In the 2021, Climate Policy Bill[1], the Government proposes mandatory requirements for the purchase of zero emission vehicles (passenger cars and light commercial vehicles) to public fleets from 2022 and for city buses from 2025. The Parliament has not yet debated or voted on this proposal.

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 14 million Euros between 2017 and 2020. 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. A new research centre NTRANS, focusing on research on energy transitions started up in 2020.

HEVS, PHEVS, AND EVS ON THE ROAD

The total number of BEVs in the passenger vehicle fleet reached 339,912 in 2020. The BEV share of the fleet was 12.1 %. The PHEV share of the fleet reached 5.2%, and the number of registered PHEVs in the fleet was 146,125. Only 153 FCEVs were in the fleet at the end of 2020. The BEV fleet grew 34 % between 2019 to 2020.

The BEV fleet is brand diverse in Norway. The BEV fleet is split between, Nissan Leaf (ca. 65,000), Volkswagen E-Golf (ca. 48,000) and the BMW i3 (ca 28,000). There are more than 20,000 of three other models; Tesla Model S, Tesla Model 3 and Kia Soul, and more than 10,000 of Audi E-tron, Renault Zoe, Tesla Model X, Hyundai Ioniq, VW e-Up and Hyundai Kona.

The market for PHEVs was 50 % higher in 2020 than in 2019. The reasons for this market development could be a result of different reasons. A number of popular PHEVs came back to the market, with longer range in battery electric drive mode in 2020 and PHEV models were temporarily removed from the market in 2019, this was due to complications related to the introduction of the WLTP test.

In 2020, 75 % of newly sold vehicles had an electric drivetrain. The BEV market share of new vehicle sales reached 54.3% (76,735 units sold), while PHEVs accounted for another 20.4% (28,890 units sold). The best-selling BEV in 2020 was the Audi E-Tron, which also became the best-selling model overall regardless of propulsion system, with 9,277 sold, which was 6.5% of the total passenger vehicle market. The second and the third most sold vehicles were also BEVs, Tesla Model 3 with 7,770, and the VW ID.3 with 7,754. Several Chinese brands entered the Norwegian market during 2020.

The Chinese MG ZS EV was the 8th most sold vehicle in Norway with 3,720 sold.

FCEVs are very low in numbers, only 153 are registered in the fleet, and only 15 were newly registered in 2020. Following a number of key events, a major hydrogen refuelling operator going bankrupt in 2018, and an explosion in one of the remaining stations in June 2019, leading to a temporary closure of all remaining stations for the following 5 months, the FCEV market has been turbulent in Norway. This has likely been reflected in the low number of new vehicle sales.

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 13.7% in 2020. For large Light Commercial Vehicles, the market share reached 3.2%. The fleet shares reached 3.6% and 0.3 % respectively. In total, 9,749 are registered in the fleet of which 2,559 were sold new in 2020.

Battery Electric Heavy duty trucks continue to be a rarity, only 37 were in the fleet at the end of 2020. A new development was the registration of the first fuel cell electric truck in 2019, followed by another 3 in 2020. Battery electric buses are on the brink of a major breakthrough with a total of 453 in the fleet, of which 403 are city buses, 50 are coaches and 63 being Plug-in hybrids. In addition, 5 fuel cell buses are on the roads of Oslo. The explosion in the hydrogen station in June 2019 also temporarily stopped the usage of these buses, and delayed the introduction of the hydrogen truck, as the refuelling stations for these vehicles were also closed for a significant period.

At the end of 2020, 26 ferry services[1] used battery electric ferries (most in combination with other ferry types), and by 2022 Norway will have 70 battery-electric ferries in operation. Several hydrogen ferries and ships are under development.

Fleet Totals (as of December 31st 2020)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike		n.a.	n.a.	n.a.	
B Electric moped (<50 kmph)	937	n.a.	n.a.	n.a.	3,398
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle	274				195,590
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	339,912		146,125	153	2,810,814
H Buses and Minibuses	453		63	5	15,426
I Light Commercial vehicles	9,749		52	1	496,040
J Medium and Heavy Weight Trucks	37		2	4	70,186

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3 (Citybuses and coaches only)
I: UNECE categories N1
J: UNECE categories N2-N3

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3 (Citybuses and coaches only)
I: UNECE categories N1
J: UNECE categories N2-N3

Total Sales 1st Jan 2020 to 31st Dec 2020 (new vehicles)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike		n.a.	n.a.	n.a.	
B Electric moped (<50 kmph)	937	0	0	0	3,398
C Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle					
E Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
F Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
G Passenger vehicles	76,735	0	28,890	15	144,730
H Buses and Minibuses	250	0	0	0	1,403
I Light Commercial vehicles	2,559	0	32	0	29,997
J Medium and Heavy Weight Trucks	14	0	0	3	4622

CHARGING INFRASTRUCTURE OR EVSE

9 out of 10 current BEV owners can charge their vehicle at home in a private parking space in Norway[5]. According to a survey among EV owners, 69% use a dedicated wall box EVSE (Electric Vehicle Supply Equipment) for charging[6], whereas only 9 % of PHEV owners use this type of charging connection[7]. Based on these percentages, and the number of registered BEVs and PHEVs, the estimated installed number of wall box EVSE charge stations reached 247,000 by the end of 2020. These estimates are uncertain as there has been a steep increase from the 42% that said they used a wall box in the 2018 user survey[11,5], which would reduce the estimated number to 150,000.

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 50 kW fast chargers are equipped with both a CCS and a Chademo cable (and some also with AC 43 kW), but only one of these can be used at a time. A small number of these 50 kW fast chargers are single standard Chademo or CCS. The best estimate is therefore that there are 1,650 dual standard 50 kW CCS/Chademo fast chargers and 689 CCS Ultra fast chargers (≥150 kW) in Norway. The number of ultrafast chargers tripled during 2020. In addition are there 820 Tesla Superchargers (number of sockets/charging connectors, up to two plugs can be connected to one physical charger).

Table 5 shows the estimated numbers of different types of chargers.

Table 5 Chargers in use in Norway [8,9].

* these are mounted on the 50 kW DC fast chargers (Multi-standard chargers)
** a few of these have power levels between 50 and 150 kW.

Chargers as of 31st Dec 2020

Type of Public EVSE		Number of Charging Outlets	Number of Locations
AC Domestic Type Sockets (Schuko, 230V/10-16A rating)	AC charging ≤ 3.7 kW	4,556	n.a.
AC Level 2 Chargers, Type 2 Sockets	AC charging ≤3.7 kW, ≤ 22 kW	4,637	n.a.
AC Fast Chargers	AC charging 43 kW*	49	n.a.
DC Fast Chargers (CCS and Chademo)	DC charging 50 kW*	1,640	n.a.
Superchargers (Tesla)	DC charging 120-150 kW	820	n.a.
Ultrafast-High power chargers (CCS)	DC charging ≥ 150 kW and ≤ 350 kW	689	n.a.
Inductive Chargers	EM charging	0	n.a.

EV DEMONSTRATION PROJECTS

The BEV activities in Norway are mostly fully commercial. The government put in place incentives and support programmes that consumers and private companies respond to. Consumers find that BEVs are the best economic option[5] and private companies develop their businesses and introduce new business concepts and models within this framework. Therefore, there are few if any "demonstration projects" in Norway.

In the passenger vehicle market, the early majority adopter group has been achieved and Norway is now reaching the late majority group of adopters, having passed 50% market share in 2020. Deployment of city buses has also entered a roll-out phase and demonstration projects are no longer required. Demonstration and innovation projects are mainly within charging infrastructure deployment, and deployment of HD Trucks, coaches and large light commercial vehicles.

The bus operator Tide, has invested in 16 Chinese made battery electric coaches that will operate out of harbours with cruise traffic, and ports were "Hurtigruten", a national express coastal vessel operator, docks. The project, which has received 2.7 million Euros in public support from Enova[10], also includes the installation of 14 charging stations. The bus operator OsloBuss also took battery electric coaches into use in 2020. This development is interesting as Coaches have similar technology as long haul Trucks and similar needs for charging.

A project for the inductive charging of taxis is under development in Oslo. The inauguration was planned to be in 2020 but it has been delayed until 2021 due to Covid-19 related issues.

In Trondheim, the grocery distributor Asko has taken four hydrogen trucks into operation, in a demonstration and development project with several partners, one being Scania. They have installed a dedicated electrolyser for hydrogen production and their own refuelling station, the project also uses hydrogen-fuelled warehouse forklift trucks[11].

OUTLOOK

The BEV market in Norway will likely remain strong through 2021, and move further into the late majority adopters in the passenger vehicle segment. The major purchase incentives, i.e. the exemption from registration taxes and the VAT, remains in place after approval from the EFTA Surveillance Authority[12,13]. Purchasing a BEV makes economic sense to consumers and provides access to attractive and money saving driving-privileges. 2020 saw the introduction of many new generation attractive vehicles, a development that will continue into 2020.

A future consideration is if the increase in PHEV sales are additional to, or will replace some BEV sales. A further consideration is the impact of the new long range BEVs market on PHEV sales, in areas where PHEVs have been the only option to replacing long distance ICEVs, long range BEVs may attract PHEV buyers. BEVs are cheaper than PHEVs in all segments, yet many still buy PHEVs for their flexibility.

The aftermath of the hydrogen fuel station explosion in 2019, and the lack of hydrogen vehicle models will continue to lead to limited prospects for hydrogen passenger vehicles in 2021. Toyota is however launching the new Mirai FCEV with improved characteristics at a lower price, and there are efforts by Toyota and others to improve the hydrogen infrastructure for passenger vehicles.

In the light commercial vehicle segment, the market share for small LCVs should increase with the availability of many new models with longer range, some up to 200 km even in the winter, and fast charging up to 100 kW. The ENOVA incentive for zero-emission LCVs should also help boost the market. The large LCVs use less advanced technology or the same batteries as the small LCVs, leading to much poorer performance and shorter range, especially in the winter. The market prospects for large LCVs is therefore still limited.

The first produced battery electric trucks from large traditional OEMs were taken into operation in 2020 and more will come during 2021. This should lead to an increased interest in truck electrification. The battery electric city bus market is in mass roll out, and more buses will enter Norwegian cities as new tenders are awarded. The coach market in general is likely to be limited during 2021, due to the effects of Covid-19, so the battery electric coach market is uncertain, although there are buses available in the market

A big development has been the introduction of Chinese brands into the Norwegian vehicle market. Several brands entered the passenger vehicle, LCV and bus market in 2020, and at least one brand will enter the truck market with battery electric trucks in 2021. More Chinese brands and a wider selection of models will be introduced in the segments they already are present in.

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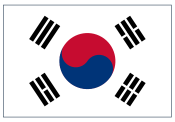
[13] EFTA Surveillance Authority (ESA) oversees the EU/EFTA trade agreement and is thus the equivalent of the EU Court.



Republic of Korea

MAJOR DEVELOPMENTS IN 2020

World's first hydrogen electric truck

In 2020, Hyundai Motor Company launched the world's first mass-produced hydrogen electric truck, the Exient FCEV. The Exient FCEV is a large cargo truck with a total weight of 34 tons, a 190 kW hydrogen fuel cell system consisting of two hydrogen fuel cells and a motor capable of producing up to 476 horsepower. Depending on the outside air temperature, refuelling for 8 to 20 minutes provides a range of 400 km. It is almost on par to the 12.7L diesel model which produces 540 horsepower and has 1000km of range. Hyundai Motor Company are also planning on releasing an FCEV model with overwhelmingly superior performance. It plans to introduce a large hydrogen electric truck for long-distance transport that can run over 1000 km on a single charge. Hyundai Motor Company exported 10 Exient FCEVs to Switzerland in 2020.

Hyundai Motor Company further produce hydrogen electric buses (Elec-City FCEV), which has a range of 430 km on a single charge The company recently signed a contract to supply city buses to local governments in Korea, part of this contract is set to supply hydrogen electric buses to be used for police transportation. Last month, the company further exported two Elec-City FCEVs to Saudi Arabia. In addition, it is developing hydrogen electric vehicles for garbage collection and road cleaning.

Hyundai Motor Company plans to do more than just sell hydrogen electric vehicles. The company's vision is to sell a hydrogen fuel cell systems in order to build a hydrogen economy. In 2030, 70 million hydrogen fuel cell systems will be made, of which 20 million will be sold to other companies. Fuel cell technology can be further applied to ships and trains, PAV (Personal Air Vehicle) and emergency power generation systems.[1]

Figure1: Hydrogen Electric Truck

New policies

In 2020, the Korean government planned to subsidise 99,950 electric vehicles; 65,000 passenger cars, 13,000 freight cars, 650 buses, 21,000 motorcycles, and 300 PHEVs (Plug-in Hybrid Electric Vehicles). The plan was to subsidise KRW 520 billion for passenger cars, KRW 70 billion for freight cars, KRW 70 billion for buses, KRW 24 billion for motorcycles, and KRW 1.5 billion for PHEVs. The total is KRW 820 billion. The amount of this subsidy is KRW 710 billion added to the original budget (KRW 710 billion).[2]

Incentives

In 2020, the Korean government set guidelines for subsidy measures, such as subsidy support standards, to stimulate the creation of an electric vehicle charging infrastructure network. A total of KRW 718,200 million was invested in the subsidy project, KRW 694,200 million was invested in the capital subsidy for local authorities and KRW 24,000 million was invested in the private body Korea Environment Corporation for the development of slow chargers.

In 2020, the Government stated the number of subsidies for the purchase of electric and hydrogen vehicles was 94,000 units, an increase of 57% from 60,000 units in 2019. However, the amount of support per unit decreased from KRW 9 million (miniature KRW 4.2 million) to KRW 8.2 million (miniature KRW 4 million). In addition, the subsidy system encourages the improvement of electric vehicle performance, focusing on range performance and the environment, and improves the subsidy calculation system to improve the efficiency of subsidy implementation.[3]

Funding

The Korean government is currently raising the rapid charging tariff rate of KRW 173.8/kWh to KRW 255.7/kWh from July 6. The effective period is until June 30, 2021. From July 2021 to June 2022, it will be reduced to a 25% discount on the basic usage charge and a 10% discount on power consumption, from July 2022 the discount will end. The increase in tariff rates are based on the Korean government and KEPCO (KEPCO), which operate about 90% of the nation's fast chargers, figures which both increased their charging rates by 47% from KRW 173.8/kWh to KRW 255.7/kWh. Most of the slow chargers, operated by private businesses, set the charging fee at KRW 200 per session, with some increasing by 2-3 times. According to the Korean government's 2016 explanation, once the discount is completely removed in 2022 and the usage fee returns to 313.1 per session, the rate for using a fast charger will rise to 44% of the cost of fuelling gasoline cars and 62% of diesel car refuelling.

Research

ELECTRIC VEHICLE PLATFORM 'E-GMP'

In 2020, the Hyundai Motor Group first unveiled the electric vehicle chassis, E-GMP (Figure 2). The introduction of E-GMP became the starting point for producing an innovative electric vehicle that supplemented the existing shortcomings in various aspects such as range, charging speeds, indoor space utilisation, design, and safety.

Figure 2: Electric vehicle platform'E-GMP'

The characteristic of E-GMP is that it is designed with an optimal structure for electric vehicles, unlike existing electric vehicles that use an internal combustion locomotive chassis. The space occupied by the engine, transmission, and fuel tank has been reduced, and the battery, motor, body, and chassis structures for electric vehicles have been equipped. Through this, Hyundai Motor Group is equipped with a technology that can run more than 500 km (domestic standard) on a single charge, and is equipped with the world's first 800 V charging system, enabling 80% charging within 18 minutes during rapid charging. E-GMP is equipped with new drive systems such as motors and reducers developed for next-generation electric vehicles, inverters for power conversion, and batteries. It has increased the maximum speed of the motor by 30-70% compared to the previous version, and even improved efficiency through weight reduction. E-GMP further considered a design for a two-way charging system. It is expected that the remaining power after driving can be transferred to the external power grid, to be used, or the vehicle can directly supply electricity to the electrical grid. Unlike the internal combustion engine platform, E-GMP made the floor flat. This better utilises space, meaning new indoor and outdoor designs can be expected. From the planning stage of the E-GMP, the Hyundai Motor Group has designed a platform that enables flexible product development across the boundaries of vehicle type and vehicle class. E-GMP can be applied to sedans and SUVs, high-performance and high-efficiency models, and can increase the electric vehicle choice in a short period.[4]

Taxation

According to Article 127 (Tax Base and Tax Rate) of the Local Tax Act, electric vehicles are classified as other passenger vehicles. They are therefore subject to KRW 20,000 taxation for business use and KRW 130,000 taxation for non-business use, including local education tax at 30%. As a benefit of electric vehicle tax, individual consumption tax is KRW 3 million, a 5% reduction limit of the vehicle price, education tax is KRW 900,000, 30% reduction of individual consumption tax, and acquisition tax is KRW 1.4 million (7% of the vehicle price) From 2020, there has been a change in the special rate system, Figure 3, for electric vehicles charging tariffs. Existing rates will be applied until June 2020, and the benefits will be gradually reduced until July 2022.[5]

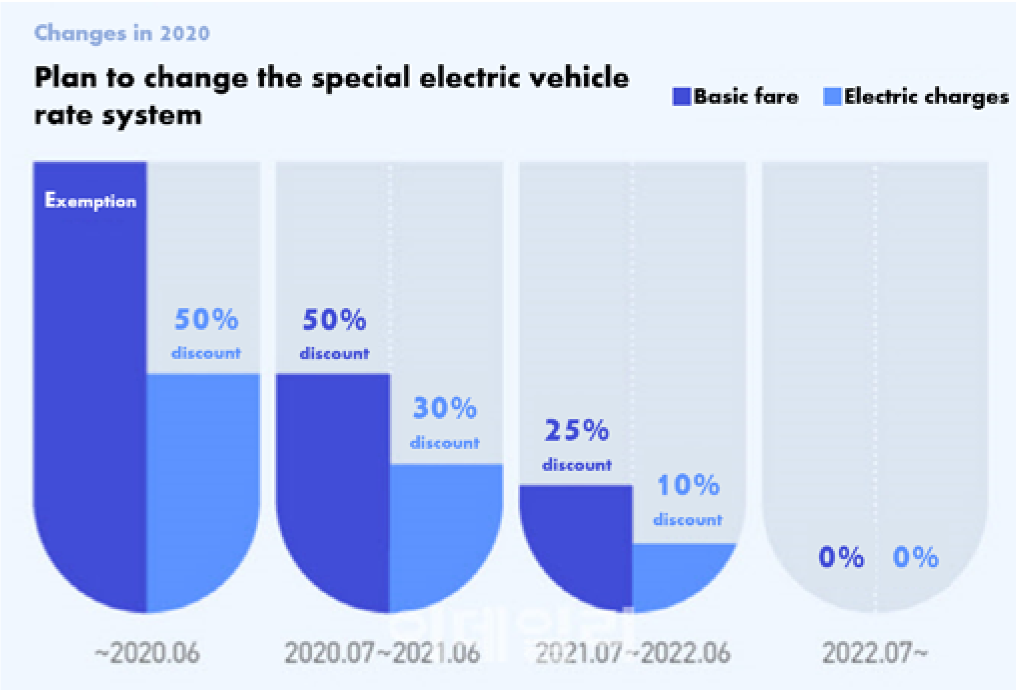


Figure 3: A plan to change the special rate system for electric vehicles

HEVS, PHEVS, AND EVS ON THE ROAD

In 2020, the domestic car industry sold about 1,67,000 units, an increase of about 4.8% from the previous year. Among them, the sales volume of eco-friendly vehicles was 165,000 units, which surged by 49.8% from 2019 (11,200 units). In hybrid cars, newly introduced SUVs such as Kia Sorento and Hyundai Tucson took market control, while small commercial vehicles such as Porter (Figure 4) and Bongo led the performance in electric cars. Hyundai Nexo, the only hydrogen fuel cell vehicle in the market, sold 5,786 units in 2020 alone. It increased by 38.0% from 2019 when it recorded 4,194 units. Nexo had 727 units in 2018 and 4,194 units in 2019, and its sales are increasing sharply every year until last year. In October 2020, it achieved 10,000 cumulative sales of hydrogen fuel cell vehicles as the world's first, single country, and single model.

Hybrid and plug-in hybrid sales surged 68.4% from 76,154 units in 2019 to 128,229 units in 2020. Grandeur, who was ranked as the 2020 best-selling car, took first place in the eco-friendly car market. The car with the highest growth rate is the K5. K5 hybrids sold 10,902 units last year and increased five-fold (422.4%) compared to 2,087 units in 2019. During the same period, the Sonata Hybrid sales volume was 9,209 units, a 20.1% increase compared to 2019. In addition, the K7 Hybrid decreased by 5.2%

compared to 2019, and the Niro Hybrid (including PHEV) decreased by 10.9%. Ioniq Hybrid, which is about to be discontinued for reorganization as an electric vehicle brand this year, fell 46.9%, showing the largest decline.

Last year, sales of electric vehicles were 31,016 units, up 4.0% from 29,817 units in 2019. Domestic car sales increased by 4.8%. The electric vehicle markets in 2020 was led by Porter and Bongo. Porter 2 Electric, which started full-fledged customer delivery in 2020, following its launch in December 2019, took the top spot in total electric vehicle sales with 9,037 units, and the Bongo 3 EV, which was released in February, has contributed to 5,357 units. Porter and Bongo (10,622 units) account for 46% of all electric vehicle sales. Second place is Hyundai Kona Electric. The Kona Electric sold 8,066 units, down 40.6% from 13,587 units in 2019. In addition, Renault Samsung SM3 Z.E. (857 units decreased by 2.1% from the previous year) and newly introduced Renault Joe (192 units), which remained at the level of last year ahead of discontinuance. Focussing on buses, electric buses increased from only 395 in July 2019 to 1,095 in 2020, an increase of 700.[6]

Figure 4: Hyundai Porter 2 Electric

Fleet Totals as of December 31st 2019

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	24,416	-	-	-	24,416
B Passenger vehicles	29,690	522,735	17,987	11,824	582,236
C Buses and Minibuses	1009	-	-	-	1009
D Light Commercial vehicles	-	-	-	-	-
E Medium and Heavy Weight Trucks	15,436	-	-	-	15,436

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

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	12,530	-	-	-	12,530
B Passenger vehicles	16,622	15,637	9,637	5,855	47,751
C Buses and Minibuses	700	-	-	-	700
D Light Commercial vehicles	1,412	-	-	-	1,412
E Medium and Heavy Weight Trucks	14,394	-	-	-	14,394

CHARGING INFRASTRUCTURE OR EVSE

The number of registered passenger electric vehicles in Korea increased by 19 times from 2015 (5,672) to the end of August 2020 (109,271). During the same period, the number of chargers increased from 1,994 units to 54,774 units, a significant increase of about 27 times.

The issue is that the number of personal chargers peaked at the end of 2017 at 59.7 per 100 EVs, and the number of public chargers per 100 electric vehicles has been in a stagnant state since the end of 2017. At the end of 2019, there were 22,140 personal charging units and 22,853 public use units. At the end of August 2020, there were 25,387 personal charging units and 54,774 units in total. As of the end of November 2020, 62,789 units.

In total, at the end of August 2020, there are 50.1 chargers per 100 EVs and 26.9 public destination chargers per 100 EVs. In Korea, charging is split between fast chargers and slow chargers (based on a personal slow charger). The quick charger takes 30 minutes from full discharge to 80% charge. It is mainly installed at locations such as highway rest areas and public institutions. Since chargers must supply high-capacity power, 50kW class is mainly installed. The usage fee is about KRW 2,700 per 100 km. The slow charger takes 4 to 5 hours from full discharge to full charge. It is mainly installed in houses or apartments. The battery capacity is mainly installed with a charger with a power capacity of about 6~7kW. At this rate electricity charges per 100 km is about KRW 1,100.[7]

Subsection

Type of Public EVSE	Number of Charging Points
AC Level 1 Chargers (≤ 3.7 kW)	
AC Level 2 Chargers (>3.7 kW, ≤ 22 kW)	62,789
Fast Chargers (> 22 kW, ≤ 43.5 kW)	
Superchargers (> 43.5 kW, ≤ 120 kW)	
Inductive Chargers	

EV DEMONSTRATION PROJECTS

The Korean government's ambition is for 10% of all vehicle sales to be electric and hydrogen vehicles within two years. Through this, the Government plans to make 2022 the first year of the popularisation of future cars. The Government plans to lower the price of electric vehicles by about KRW 1 million by 2025 through R&D of core parts. It also plans to start an enterprise for lease batteries.

By 2025, electric vehicles will reach price parity with internal combustion engine vehicles. In the future, more subsidies for eco-friendly vehicles from the government will be given to commercial sectors such as taxis, trucks, and buses, which have great environmental improvement potential. Electric taxis will pay KRW 2 million more than passenger cars, and the number of electric trucks supported will expand to KRW 25,000 from next year.

In the case of hydrogen trucks, a plan to introduce subsidies is also being considered. A subsidy cap is already introduced for passenger cars to promote price cuts. For electric vehicles, it was decided to extend tax support until the end of 2022, and to review whether to re-extend following 2022. The government has decided to impose relevant obligations on manufacturers and car rental companies to meet the demand for eco-friendly vehicles. Domestic manufacturers will complete a lineup of commercial vehicles such as 5~23t hydrogen trucks and hydrogen wide-area buses by 2024, and the government will smoothly promote parts, materials, development, and subsidies for demonstration according to the release schedule.

For electric vehicles, the goal is to achieve 10% of the global market share. To this end, the private sector plans to launch 20 models by 2024, including five new cars in 2021, and the government plans to support performance improvements such as range, battery efficiency, and charging speed. The related budget was KRW 385.6 billion by 2025.

Hydrogen vehicles will focus on countries that have built charging station infrastructures, such as Northern Europe and North America. In the case of hydrogen trucks, it is expected to export 64,000 units to North America and Europe by 2030 following the export of 1600 units to Switzerland.[8]

OUTLOOK

According to the automobile industry, market research firm SNE Research estimated the global electric vehicle sales volume of about 6,878,000 units in 2021. This is more than double the sales volume of 3.10 million units in 2020 (EV Volumes estimate). SNE Research predicts that the global electric vehicle market will grow by 21% on an annual average from 2021 to 2030, reaching 40 million units by 2030.

The Korean government announced that it will build more than 70 units of 350kW-class ultra-fast chargers, that can charge vehicles three times faster than chargers already installed from next year (Figure 5). This will be formed from a public-private partnership and will target major highway rest areas across the country. In addition to the independent slow charger, which has been mainly installed so far, the Korean government is planning to install various slow chargers such as outlet type and street light chargers.[9]

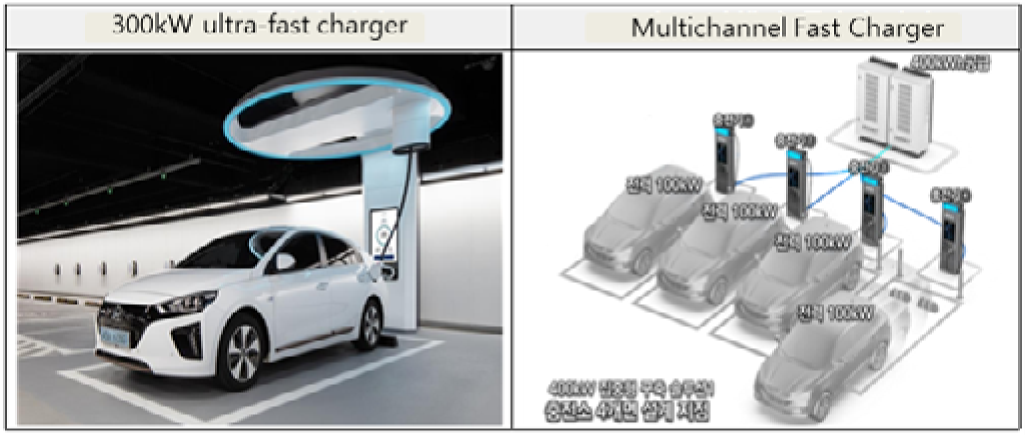


Figure 5

The Ministry of SMEs and Startups and the Jeju Special Self-Governing Province are preparing electric vehicle charging infrastructure and advanced electric vehicle performance and condition diagnosis services in the "Jeju Electric Vehicle Charging Service Special Zone". By incorporating an energy storage device (ESS), with a capacity of 50kW, into the existing 50kW fast charger, it realises 100kW rapid charging. The system will additionally provide a battery performance and condition diagnosis service to preemptively respond to the activation of used electric vehicle transactions.[10]

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Spain

MAJOR DEVELOPMENTS IN 2020

Relevant Strategies, Policies and Normative at National Level

DIRECTIVE 2014/94/EU AND SPANISH NATIONAL POLICY FRAMEWORK –MAN-

Directive 2014/94/EU of October 22nd 2014 establishes that each Member State shall adopt a national policy framework for the development of the market with regard to alternative fuels in the transport sector and the deployment of the relevant infrastructure and notify them to the European Commission before the November 18th 2016.

Directive 2014/94/EU was transposed into Spanish normative through Royal Decree 639/2016 of December 9th and the Spanish National policy framework (Marco de Acción Nacional-MAN-), consistent with the National Strategy to promote Energy Alternative Vehicles in Spain for the period 2014-2020 (VEA Strategy). This was approved by Minister Council and delivered on 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.

Recently (March 2021), in accordance with point 3 of Article 10 of the Directive, the Commission has delivered a report on the application of this Directive to the European Parliament and the Council, with effect from November 18th 2020". In the case of Spain, the checklist shows that almost all the requirements of Annex I from the Directive are covered and electricity is covered for all modes.

INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN –PNIEC- 2021-2030

In accordance with the Paris Agreement on Climate Change, in 2016 the European Commission presented its "Winter Package" - 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 the Climate for the period 2021-2030 to meet the minimum objectives of 23% GHG reductions – from 1990 level, 32% renewable energies introduction in primary energy and a 32.5%

improvement on energy efficiency.

The text of the Integrated National Energy and Climate Plan sent on March 31st 2020 to the European Commission coincides with the one currently included in the public consultation phase of the Strategic Environmental Study (SEA) and has already been sent to Brussels last January, as an updated draft. With this new communication to the European Commission, Spain complies with Regulation (EU) 2018/1999 of the European Parliament and of the Council of December 11th 2018 on the governance of the Energy Union and Climate Action (https://www.idae.es/informacion)-y-publicaciones/plan-nacion al-integrado-de-Energia-y-clima-pniec-2021-2030).

The document will be modified – and, where appropriate, will be sent again to Brussels – in those aspects that may be necessary after the completion of the environmental assessment process and the analysis of all the inquiries received. The public information phase should have concluded on March 25th but was delayed in the application of Royal Decree 463/2020, of March 14th, which declares a “State of alarm” due to the COVID-19 pandemic.

This Plan set the route to meet energy and climate goals by 2030, focusing on the objective of climate neutrality in the transport sector by 2050, with an intermediate objective of fully 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 to have 5 million electric vehicles (cars, vans, busses, and motorbikes) on road by 2030. A large number of these will be used in car-sharing platforms, which means around 16% of the current Spanish fleet will be in this category. This implies an accumulated energy savings of 3,524.2 kt for the period 2021-2030, representing a 25% share of the total energy savings expected for the transport sector (13.888 kt) in that period.

Also, in the context of increasing the contribution of renewable energies to electricity production, the switch to EV will directly affect the introduction of renewable energies in the transport sector. According to PNIEC`s objective, renewable energies will represent a 28% share in the transport sector, doubling the 14% EC objective by 2030. This will allow a reduction in the energy dependency of the country and improve energy supply and safety.

According to PNIEC, public incentives focused to promote electric vehicle acquisition amounts to 200 million EUR per year over the period 2021-2025, accounting for a total of 1,000 million EUR in the period. It is estimated that in 2025 a price parity will be reached for EVs compared to conventional vehicles, so from 2025 onwards, it will not be necessary to give any more public funding for EVs.

Nonetheless, this budget could be increased in the framework of the Next Generation Fund, announced by the European Commission, at the end of 2020.

CLIMATE CHANGE AND ENERGY TRANSITION LAW -PLCCTE-

On May 19th 2020, the Council of Ministers sent the first draft of the Climate Change and Energy Transition Law (PLCCTE) to the Parliament, which currently remains in parliamentary processing and has the aim for Spain to reach emission neutrality no later than 2050, in coherence with scientific criteria and the demands of citizenship.

Related to sustainable mobility, the set of Public Administrations will be able to implement measures that will make it possible for a fleet of cars and light commercial vehicles to reach carbon neutrality by 2050. To this end, in accordance with European regulations, they will adopt the necessary measures so that new passenger cars and light commercial vehicles gradually reduce their emissions, so that vehicles produce 0 gCO2 / km by no later than 2040. After consultation with the sector, measures will be put in place to facilitate the penetration of these vehicles, including support for R + D + i.

Likewise, the PLCCTE establishes that municipalities with more than 50,000 inhabitants and island territories will introduce, in urban planning, mitigation measures that allow the reduction of emissions derived from mobility. This includes the implementation of low-emission zones from no later than 2023; actions to facilitate travel on foot, by bicycle, or other active means of transport; and the improvement and promotion of the use of the public transport network. Shared electric mobility and the use of private electric means of transport should also be promoted.

The PLCCTE also makes the progressive installation of recharging points for electric vehicles in petrol service stations with the highest sales volume mandatory, which currently represent 10% of the network.

As a transposition of the Directive UE 2018/44, related to Energy Efficiency in Buildings, the Technical Building Code (CTE) will articulate the obligation of electric vehicle recharging infrastructure for parking in new or refurbished buildings, with the following requirements:

- Pre-installation for 100% of the new parking spaces in residential buildings and 20% in commercial and other buildings.
- One charging point for every 40 parking spaces, with a minimum of 1 point (and one charging point for 20 parking spaces in General State Administration buildings).
- Existing non-residential car parks are obliged to adapt to the previous requirements before January 1, 2023.

LAW OF SUSTAINABLE MOBILITY AND FINANCING OF TRANSPORT

The new Mobility Strategy and a Sustainable Mobility Law are currently in the process of integrating contributions from the public consultation. The final document is expected to be ready in the second or third quarter of 2021.

This new Law will be a regulation that links mobility to society and acts as a lever for economic growth, promoting environmental sustainability based on green taxation, digitisation, and planning. For this to be possible, a homogeneous and stable public transport financing plan is necessary as well as coordination between the different transport authorities of our country to create a coherent national mobility system.

Incentives Programs to promote EVs

MOVES I PROGRAM (INCENTIVE PROGRAM FOR EFFICIENT AND SUSTAINABLE MOBILITY I)

In February 2019, Plan MOVES was approved (Royal Decree 72/2019 / Royal Decree 32/2019), a new direct incentives program funded with 45 Million EUR and aimed to support projects and initiatives in the following lines of action:

1. Acquisition of alternative energy vehicles
2. Infrastructure deployment for EV charging
3. Public sharing e-bikes systems
4. Activities in the frame of Transport Plans for workplaces and activity centres.

MOVES Program (https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/plan-moves-ii/antecedentes-del-programa) is a national scale incentive program, which ran for proposals until the end of 2019, coordinated by IDAE and directly managed by the different Regional Governments, in collaboration with IDAE.

Provisional data shared with IDAE by Regional Administrations show that in the frame of MOVES I, there is a committed budget of 12 million EUR for applications for vehicles acquisition and also a 21.7 million EUR committed budget for applications for infrastructure recharging for EVs.

Also attending to provisional data on March 15th 2021, there were officially approved incentives for 1,970 applications for vehicles acquisition (1,898 of them EVs and the other 72 of Natural Gas and GLP trucks), accounting for a budget of 9.4 million EUR (applications could be for more than one vehicle).

Related to recharging points for EVs, incentives for 2,437 applications were officially approved, amounting to a total of 6,206 recharging points, accounting for a budget of around 11.9 million EUR.

This program is co-financed with the European Regional Development Fund (FEDER) within the POPE 2014-2020.

MOVES II PROGRAM (INCENTIVE PROGRAM FOR EFFICIENT AND SUSTAINABLE MOBILITY II)

To give continuity to MOVES I, the MOVES II Program (https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/plan-moves-ii) was approved by the Council of Ministers, at the proposal of the Ministry for the Ecological Transition and the Demographic Challenge, on June 16th through Royal Decree 569/2020.

MOVES II was initially given a budget of 100,000 million EUR, and on March 3rd 2021, was expanded with an additional budget of 19.83 million EUR applied to some regions (Madrid, Navarra, Comunidad Valenciana, Cataluña and Aragón). This exhausted their initial budget and ability to attend provisional applications.

MOVES II Program has a similar management format to MOVES I, meaning that is coordinated by IDAE and directly managed by the different Regional Governments, in collaboration with IDAE. Also, it is co-financed with FEDER funds, within the POPE 2014-2020.

Applications for incentives can be presented during a year, counted from the publication of the Regional Administrations calls, and can be applied to the 4 same lines of action than in MOVES I, with the addition of initiatives focused on adapting urban city centres to COVID-19 mobility scenery.

Provisional data shared with IDAE by Regional Administrations shows that in the frame of MOVES I, there is a committed budget of 30 million EUR in applications for vehicles acquisition and a 16.5 million EUR committed budget in applications for recharging infrastructure for EVs.

Also attending to provisional data, on March 15th 2021, there were requested incentives for 7,549 applications for vehicles acquisition (7,161 of them EVs and the other 388 of Natural Gas and GLP trucks), accounting for a budget of 45.6 million EUR (applications could represent more than one vehicle).

Related to recharging infrastructure for EVs, incentives for 4,158 applications were officially approved, amounting to a total of 7,309 recharging points, accounting for a budget of around 15.8 million EUR.

MOVES SINGULARES PROGRAM (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 bases of the MOVES Singular Projects Program (Ministerial Order TEC/752/2019). This program is aimed at both, public and private entities and it was provided with a budget of 15 million EUR and two types of projects:

1. Projects in urban settings: integrated management projects that contemplate changes in the mobility model and the configuration of the city, focusing 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: technological development projects and innovative experiences in electromobility that serves to promote the technological leap towards electric vehicles and encourages 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 their size.

This program, co-financed with FEDER funds (POCS 2014-2020), is directly managed by IDAE and establishes a requirement of a minimum investment of 100,000 EUR and a maximum incentive for each project of 3 million EUR.

This program, under the modality of competitive concurrence, ran for new applications from September 24th 2019 to November 25th 2019.

At the end of 2019, there were 130 requests, for a total of 160 million EUR, 86 of them were related to innovation in electromobility. In the end, due to the limited budget, only 25 projects could be incentivised: 13 of them related to electromobility initiatives (https://www.idae.es/evento/convocatoria-presentacion-de-resultados-del-programa-moves-proyectos-singulares-1).

Considering the high number of applications that couldn't be attended, National Government announced a new edition of this program for 2021.

HEVS, PHEVS, AND EVS ON THE ROAD

In 2020 there were 60,257 plug-in electric vehicles registered in Spain – BEVs and PHEVs – representing an increase of 76% compared to the previous year, (by the end of 2019 34,210 EVs were registered). This increase was sustained by the continuation of incentives programs to support EVs acquisition at a National scale (such as Plan MOVES II), and also by other initiatives and incentive programs launched at other different levels of the public administrations.

In the specific case of plug-in electric passenger cars (BEVs and PHEVs), there were 42,618 vehicles registered, representing a market penetration of 4.5 % during 2020. Considering both technologies, electric and conventional hybrid electric vehicles (HEVs) accounted for 182,227 vehicles, resulting in a 19.4 % market share.

The plug-in electric vehicles (BEVs and PHEVs) fleet in Spain at the end of 2020 accounted for 144,585, representing an increase of 63.7 % compared to the previous year 2019, which accounted for 88,329 EVs on the road.

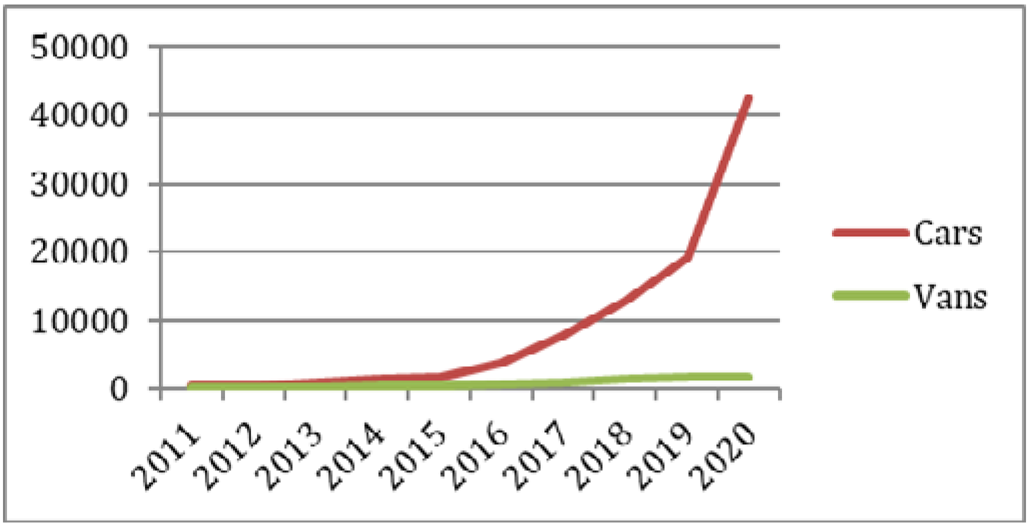

Figure 1: EVs market evolution (annual sales of cars –M1- and vans –N1-) in Spain

There was a large increase in the hybrid passenger car registrations from 2016 to 2020, with 139,609 registrations during 2020 alone, increasing from only 7,759 registrations during 2015. This shows that the impact of the Environmental car labelling, promoted by Spanish Traffic Authorities, and the different measures and initiatives implemented for air quality in regions and cities has had.

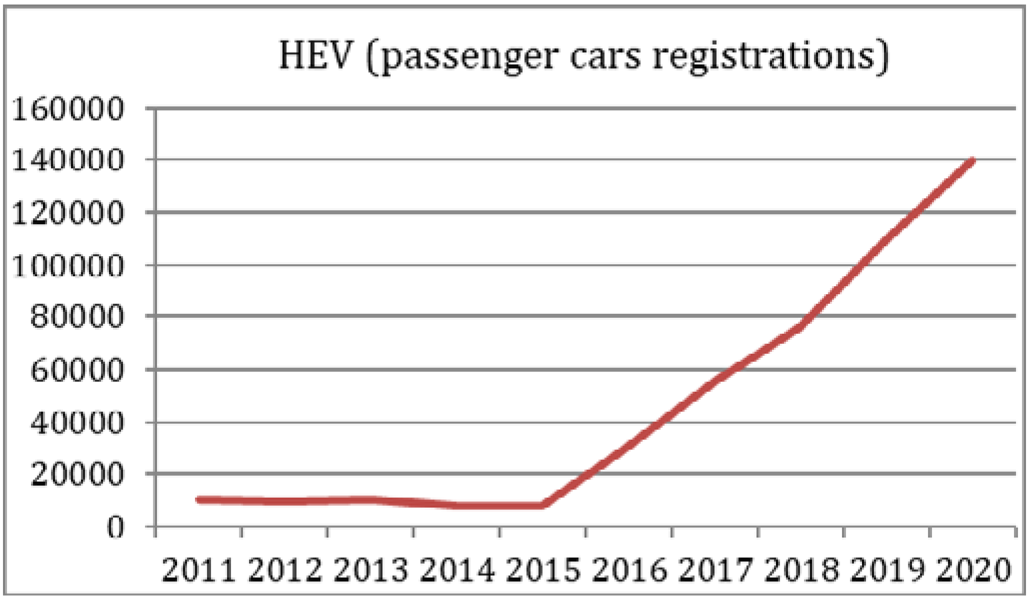

Figure 2: HEVs market evolution (annual sales of passenger cars –M1-) in Spain

Total sales during 2020

Vehicle Type (UNECE category)	BEVs	HEVs	PHEVs	FCVs	Total sales*
Bicycles (assisted pedaling)	180,000	0	0	0	1,140,000**
Mopeds (L1, L2)	8,055	0	0	0	24,347
Motorbikes (L3, L4, L5)	7,490	0	0	0	162,250
Quadricycles (L6, L7)	219	0	0	0	2,276
Passenger cars (M1)	18,624	139,609	23,994	7	939,090
Commercial vehicles (N1)	1,754	1,629	50	0	122,837
Buses (M2, M3)	51	292	7	0	2,268
Trucks (N2, N3)	9	41	4	0	31,378
Totals (without bicycles)	36,202	141,571	24,055	7	1,284,446

Table 1: Total sales of EVs and HEVs, per category (2020)

* Including both conventional and alternative technologies
**Estimated data at the end of 2020 (Source AMBE -Spanish Association of Bicycles and Brands-)

Source: IDAE, based on registrations of Spanish Traffic Authorities (DGT)

Table 2: Fleet totals of EVs and HEVs, per category (2020)

* Including both conventional and alternative technologies
**Estimated data at the end of 2020 (Source AMBE -Spanish Association of Bicycles and Brands-)

Source: IDAE, based on registrations of Spanish Traffic Authorities (DGT)

Fleet Totals during 2020

Vehicle Type (UNECE category)	BEVs	HEVs	PHEVs	FCVs	Total sales*
Bicycles (assisted pedaling)	630,000	0	0	0	30,000,000 approx.**
Mopeds (L1, L2)	20,565	0	0	0	1,891,765
Motorbikes (L3, L4, L5)	24,378	22	0	0	3,736,230
Quadricycles (L6, L7)	2,925	0	0	0	116,379
Passenger cars (M1)	43,470	480,169	44,256	8	24,717,840
Commercial vehicles (N1)	8,101	1,780	58	0	4,091,369
Buses (M2, M3)	628	1,221	77	0	63,398
Trucks (N2, N3)	106	292	21	0	940,331
Totals (without bicycles)	100,173	483,484	44,412	8	35,557,312

CHARGING INFRASTRUCTURE OR EVSE

Until now, official information on the number of charge points in Spain has not been available. However, National Government, through State Secretariat for Energy, has been working on a European project for the identification and placement of recharging points. According to estimations of the sector (Spanish Association of Car and Trucks Manufacturers –ANFAC- based on “Electromaps” data), at the end of 2020, there are 8,545 charging points available for public use (3,094 of them placed on roads and the other 5,451 in urban areas). These cover all the possible power ranges, meaning there are roughly 17 electric vehicles registered in Spain per charging point.

Considering that charging at home and workplace charging could cover around 85% of needs, the other 15-20% should be covered by public charging points, known as “opportunity charging

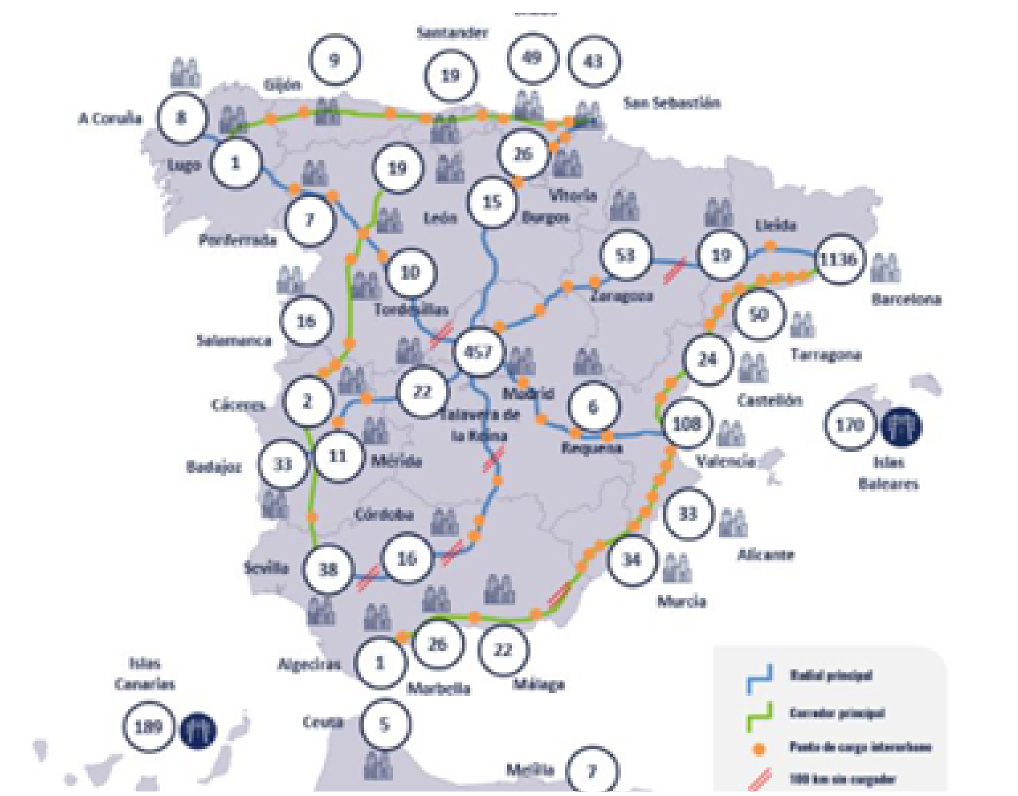

Figure 3: Recharging infrastructure deployed in the principal corridors, at the end of 2020 (Source: ANFAC)

At the end of 2020, public use charging points in Spain were classified in the following way:

Source: ANFAC, Recharging points in urban areas, classified per power, at the end of 2020

Power (kW)	P ≤ 22	22< P ≤50	50≤ P ≤150	150≤ P <250	P≥250
Charging points	5,028	167	242	0	14

Source: ANFAC, Recharging points in urban areas, classified per power, at the end of 2020

Power (kW)	P ≤ 22	22< P ≤50	50≤ P ≤150	150≤ P <250	P≥250
Charging points	2,722	119	228	1	24

Finally, as mentioned before, the Spanish Government is working on the transposition of Directive UE 2018/44, related to energy efficiency in buildings, through the update of the Technical Building Code. This will facilitate the installation of more public use recharging points by January 2023.

EV DEMONSTRATION PROJECTS

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 in progress. The project is 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 was a parallel project with other partners, although both projects share the same objectives.

The estimated cost of the project is 3,523,232 EUR with a UE maximum contribution of 1,761,616 EUR (up to 50%), for the deployment of 40 fast charging points in Spain – and 18 in Portugal – (> 40 kW) for electric vehicles in strategic areas of the Atlantic and Mediterranean corridors that pass through Spain and Portugal by the end of 2020.

Figure 4: CIRVE recharging points installed, at the end of 2020

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. The Action aims to deploy and operate a network of Normal, Fast and Ultra-Fast Charging Stations (up to 350 kW) for electric vehicles in Europe, providing linked coverage for long-distance travels and enabling cross-border trips towards Italy, Spain, and Romania to support these Member States to speed up their installation of electric vehicle infrastructure.

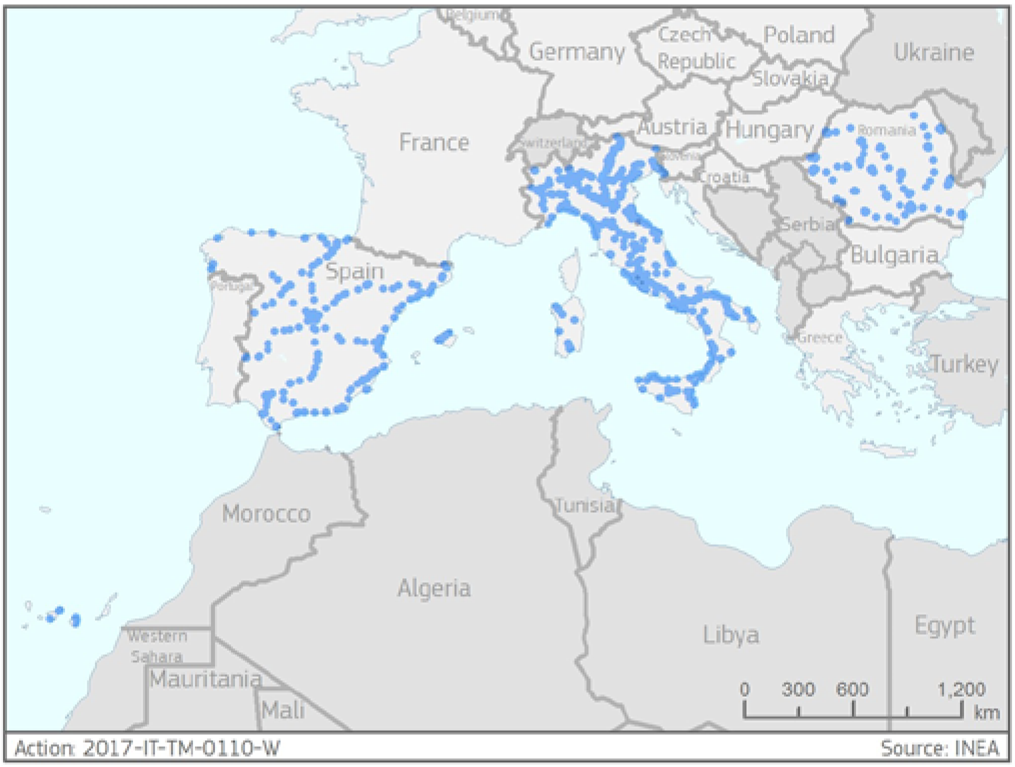

Figure 5: AMBRA recharging points programmed (Italy, Romania, Spain)

The Action intends to deploy 3,169 electric vehicle charging stations on 6 TEN-T Core Networks Corridors. The use of the charging points is expected to be possible either with ad-hoc payments or using any Mobility Service Provider as contract-based charging.

ULTRA-FAST CHARGING FOR ELECTRIC VEHICLES "UFC PROJECT"

Spain joins the initiatives for charging ultra-fast electric vehicles thanks to the UFC project, led by Repsol and Ibil, which have received recognition for their commitment to innovation in electric mobility, in the "EnerTIC Awards 2020". (https://enertic.org/v19/awards-2020).

The most innovative feature of the"Ultra-Fast Charge" project is the reduction of recharging times to between 5 and 10 minutes, a time similar to that of a conventional refuelling, thanks to the implementation of the most powerful recharging terminals in Europe.

The charging infrastructure, placed in Ugaldebieta town (Vizcaya), allows vehicles to be charged at powers of up to 400kW, which represents a great advance in Europe, where the available terminals do not exceed 350kW.

Figure 6: Ugaldebieta (Vasque Country, Spain) ultra-fast recharging infrastructure

Another of the most innovative aspects of this installation is that it allows the integration of distributed renewable generation and storage of energy, to optimise operating costs and the necessary power from the electrical network. This helps to stabilise the electrical system with the high penetration of renewables, or the discharge of that energy to the power grid.

Repsol and Ibil have jointly developed this project, involving strategic Spanish partners such as Ingeteam and Ormazabal in the process. The collaboration has resulted in a pioneering installation in which 100% of the technology and suppliers involved are national. This ultra-fast charging point allows Repsol to continue being a leader in mobility on the Iberian Peninsula and is a clear example of Repsol's commitment to innovation and the development of new products and services capable of meeting the needs of customers. Specifically, Ibil has been in charge of the conception, definition, and execution of the project, and now operates and maintains the infrastructure.

Regarding the electrical and electronic part, the inverters and recharging satellites have been developed by Ingeteam and the transformation centres have been supplied by Ormazabal.

This is the second ultra-fast charging point that Repsol and Ibil inaugurates, planning to have 4 stations in its national network.

https://www.ibil.es/wp-content/uploads/PROYECTOUFC_UltraFastCharge.pdf

Sweden

MAJOR DEVELOPMENTS IN 2020

In 2020, Sweden surpassed a 30% market share of new car sales, which is the highest market share in the EU, and currently hosts the largest electric bus fleet in the Nordics[1,2]. Over 3% of the passenger vehicle fleet, as well as the bus fleet, in Sweden, are plug-in electric vehicles. In 2018, Sweden adopted an ambitious climate law that stipulates net-zero greenhouse gas emissions by 2045. The law requires all policy areas, not only the environment, climate, transport, and energy, to contribute to achieving the target. 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 have been pointed out as key enablers to reach these goals.

In 2020, the Swedish Government launched two major initiatives in order to accelerate the electrification of the transport sector. First of all, the Electrification Strategy was launched that will contribute to a fast, smart and economically efficient electrification and comprises all user sectors, not just transport. The second initiative was The Government's Electrification Commission, which specifically aims to accelerate the electrification of the transport sector and comprises government and representatives of business, academia, local, and regional public authorities.

The Electric bus purchase rebate was redesigned in 2020 into a Climate rebate, which includes both other types of heavy-duty vehicles, such as trucks and electric working machines, as well as renewable fuels in addition to electricity and hydrogen. In 2020, the government decided to allocate 50 million EUR for 2021 and 55 million EUR for 2022 for regional electrification pilots of heavy-duty trucks with a focus on plug-in and fuel-cell electric trucks. The development of electric road systems (ERS) is also on-going, with the goal to deploy 2,000 kilometres of ERS on public roads by 2030.

New policies, legislation, incentives, funding, research, and taxation

In 2020, the government reinforced Sweden's major transport research and innovation partnership programme, the strategic vehicle research and innovation programme (FFI), with 10 million EUR between 2021 and 2022 to support the research and development of work machines in order to reduce greenhouse gas emissions and strengthen the Swedish automotive industry's competitiveness.

Since 2015, there has been a national investment-support scheme for the deployment of charging infrastructure in Sweden, Klimatklivet – The Climate leap. Klimatklivet grants up to 50 % of the investment cost. This has advanced the deployment of charging infrastructure, which by the end of 2020 comprised about 11,500 public charging points, however, certain areas and major public roads still lacked deployment of fast-charging stations. The government therefore appointed 15 million EUR for 2020-2022 to complete a nation-wide fast-charging infrastructure deployment and the first call, which applied a reversed auction approach, opened in the autumn of 2020.

In 2020, the government decided to merge the current home-charging support scheme, the PV solar support scheme and the stationary energy storage support scheme into a “green deduction” in the existing tax reduction scheme ROT (Repairs, conversion, extensions), which will enter into force by 2021.

HEVS, PHEVS, AND EVS ON THE ROAD

In 2020, PEVs constituted 32.2% of the new-car sales. The total stock of PEVs in Sweden was almost 187,400 vehicles (Swedish Transport Analysis, 2021[3]).

The most influential policy to promote plug-in electric vehicle sales in Sweden is the EU’s CO2 emission reduction targets for new vehicles[4]. In 2020, the phase-in of the 2021 target of 95 g CO2/km contributed to a significant market share increase and plug-in electric vehicles now comprise 3% of all passenger cars.

In 2020, there were three major national demand-side policies to promote the sales of plug-in electric vehicles in Sweden.

BONUS-MALUS SCHEME

The Swedish bonus-malus scheme was introduced in July 2018 and replaced a purchase rebate scheme. The bonus-malus scheme includes an element of decreasing the purchase cost of a vehicle, as well as the vehicle tax. In 2020, battery electric vehicles (BEVs) and fuel cell vehicles (FCV) were eligible for the maximum bonus, which is 6,000 EUR. For plug-in electric vehicles (PHEVs), the bonus decreases linear until 70 grams of carbon dioxide (CO2) based on the WLTP. The bonus-malus also include light-duty vans, which was not the case for the previous purchase rebate scheme.

The vehicle tax system was revised as the bonus-malus scheme was introduced. Previously, PEVs were tax-exempt in the first 5 years of ownership but since July 2018 the tax exemption has been reduced to last for 3 years.
In 2020, the government announced coming changes to the bonus-malus scheme and the proposed alternations includes changes to the bonus interval, from a maximum of 70 grams of carbon dioxide (CO2) to 60 grams, and increasing the bonus for BEVs and FCVs to 7,000 EUR.

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 EUR.

Given the PEV deployment among company cars, it now constitutes 75% of the total PEV ownership, this has probably been the most important incentive to promote the use of PEVs in Sweden.

In 2020, the government announced alternations to the entire fringe benefit system, where the benchmark shall be harmonised with the cost of a privately-owned car.

EV BUS/TRUCKS/WORK MACHINES REBATE

In 2016, the Government introduced a purchase subsidy specifically targeting electric buses. To begin with, only battery-electric and plug-in hybrid buses could be granted a rebate. However, in 2017, fuel cell buses using renewable hydrogen were also included in the scheme. In 2018, the EV bus scheme expanded to also allow private transport companies the purchase rebate. In 2019, the government decided to also include electric trucks and working machines. In 2020, 12 million EUR was allocated to the scheme and 2 million EUR was earmarked for trucks and working machines.

Fleet Totals as of December 31st 2020

Source: Swedish Transport Analysis, 2021; BIL Sweden, 2021[5]

Vehicle Type	EVs	HEVs [6]	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	1,970	0	0	0	413,157
B Passenger vehicles	55,734	122,290	130,461	28	4,944,067
C Buses and Minibuses	476	153 [7]		0	13,489
D Light Commercial vehicles	5,860	88	56	0	595,580
E Medium and Heavy Weight Trucks	29	0	24	0	84,333

Total Sales During 2020

Vehicle Type	EVs	HEVs	PHEVs	FCVs	TOTAL
A 2 and 3 Wheelers	4,654				15,134
B Passenger vehicles	28,097	66,134	47,806	5	292,024
C Buses and Minibuses	153				1,674
D Light Commercial vehicles	1,289	0			31,015
E Medium and Heavy Weight Trucks	18				4,960

n.a.: Not Available
A: UNECE categories L1-5
B: UNECE categories M1
C: UNECE categories M2-M3
D: UNECE categories N1
E: UNECE categories N2-N3

CHARGING INFRASTRUCTURE OR EVSE

The Swedish electricity market is completely deregulated, which enables almost anyone to become a charging point operator (CPO). This has created a vast ecosystem of charging infrastructure, which benefits from both private and public efforts to deploy EVSE.

KLIMATKLIVET – THE CLIMATE LEAP

In September 2015, the Swedish government launched the investment support scheme Klimatklivet, the Climate Leap[8]. As stated before, Klimatklivet is a general investment support scheme, not specifically aimed at charging infrastructure deployment, that grants up to 50 % of an investment cost. To date, over 29,600 charging points have been granted support. The majority (about 20,000 charging points) are non-public installations for company fleet vehicles or residents in multi-family dwellings. Klimatklivet has also granted support to charging stations for buses, trucks, aeroplanes, and boats.

HOME-CHARGING SUPPORT SCHEME

In 2017, the Swedish government decided on a home-charging support scheme. From February 1st, 2018, private households were subsidised 50 %, up to 1,000 EUR, for installing an EVSE at their home[9].

FAST-CHARGING STATIONS ALONG MAJOR ROUTES

To complete a nation-wide fast-charging network, the government appointed 15 million EUR for 2020-2022. The Swedish Transport Administration estimates that 70-80 additional locations for fast charging are necessary to fulfil a national wide network[10]. The first call opened in the autumn of 2020, where 21 identified locations along major public roads were subject to a reversed auction and 20 locations got tenders. In 2021, the second call comprised about 60 locations.

Type of Public EVSE	Number of Charging Points
AC Level 1 Chargers (≤ 3.7 kW)	3,547
AC Level 2 Chargers (>3.7 kW, ≤ 22 kW)	6,385
Fast Chargers (> 22 kW, ≤ 43.5 kW)	197
Superchargers (> 43.5 kW, ≤ 120 kW)	931
125-150 kW	328
350 kW	80
Inductive Chargers	0

EV DEMONSTRATION PROJECTS

The demonstration initiatives of plug-in electric vehicles have gone from testing the technology in passenger cars and buses to systems demonstrations of heavier vehicles and work machines as well as further improving the electric drivetrain in terms of energy efficiency and cost reduction. In addition to this, there's an increasing focus on behaviour and policy issues regarding the electrification of transport. Below are some examples of ongoing demonstration projects in Sweden.

REEL (REGIONAL ELECTRIFICATION)

The project REEL now brings together representatives of truck manufacturers, electricity network companies, energy companies, charging point operators, hauliers, buyers of goods transport, and member of the public to test and develop the electrification of regional transportation with heavy trucks in practice. Their first project is to understand the ease of transportation along 300 km in the regions Mälardalen and Västra Götaland. The project includes highlighting the following research topics:

- Where and how is it convenient to charge electrified trucks?
- What infrastructure is needed when many trucks are charging at the same time?
- How will smart charging affect transportation? Will it be more efficient to utilise the capacity at night when the infrastructure is less busy?
- Can an electrified freight transport system provide increased transport efficiency from an energy, environmental, resource, and economic perspective?
- How are logistics flows and scheduling optimised for drivers, vehicles, charging stations, and loading bays to minimise truck downtime?
- How are transparency and standardisation guaranteed to enable competition and economic sustainability in all parts of the system?
- How can public governance and support effectively promote the development of the transition?

Participating parties in the REEL project are Chalmers, Dagab, EVBox, Göteborg Energi, Scania, Vattenfall, DHL, and AB Volvo. The national authorities contribute funding, case expertise, system perspective, and synchronisation of R&I support and infrastructure measures. The Swedish Energy Agency and Vinnova finance with SEK 12.5 million (12.17 million EUR), while the project parties contribute with SEK 17.5 million (17 million EUR). The project is led by the collaboration platform CLOSER at Lindholmen Science Park. The project will run until the end of 2021.

ELECTROMOBILITY IN RURAL AREAS AND SMALL TOWNS – A SYNTHESIS

This project has produced a synthesis of the current knowledge of barriers and opportunities for electrified transport in smaller towns and rural areas in Sweden. Project partners are RISE, (Research Institute of Sweden) and VTI (Swedish National Road and Transport Research Institute).

By the end of 2019, roughly 2% of Sweden's nearly 5 million passenger cars were plug-in electric cars, most of these are registered in the bigger cities. For example, in the City of Stockholm, the share of plug-in cars was over 6%. Meanwhile, in the 131 (out of 290) municipalities that have less than 15,000 inhabitants, the share of plug-in cars was only 0.7%. In Sweden, there is a political focus on the electrification of rural transport and it has not been known why the share of plug-in cars in rural areas and smaller towns is so low and how it might change. Here are some of the preliminary conclusions from the studies that will end in autumn 2021:

- So far, available vehicle models have not been attractive enough. In areas with poor road quality and/or lots of snow in winter, four-wheel drive is important, and small cars are not very attractive.
- Subsidies are not optimal for rural and small-town residents. The most important

policy to facilitate the introduction of plug-in cars is the company car subsidy. Most company car owners reside in the major urban areas, meaning that this subsidy is directed towards urban consumers. When reviewed by the Swedish National Audit Office, it was found to disfavour rural residents economically.

- On top of this, transport-related climate policy is perceived as unreliable. The pattern of changing subsidies and definitions of what is "environmentally friendly" has led to a situation where it is difficult to know what car and what fuel to go for, both from an economic perspective and concerning climate impact reduction.

OUTLOOK

The development regarding the market share for plug-in electric passenger cars, city buses, and distribution trucks looks very positive in Sweden. One major driver for this development is the EU CO2 reduction requirements for new vehicles and where the Swedish policy framework has accomplished a high allocation compared to other EU markets. The future developments in Sweden depend on Swedish policy frameworks as well as other EU countries, which could influence the allocations of vehicles to Sweden. Major efforts are now being made to enable public fast charging for heavy vehicles. Continuous charging, so-called electric roads systems, are being explored more widely on public roads.

Swedish stakeholders participate in the two ICPEI (Important Projects of Common European Interest) projects on batteries. Ensuring the upscaling of a sustainable battery value chain is increasingly important.

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[6] Swedish Transport Analysis exclude mild hybrids from HEVs.

[7] Swedish Transport Analysis only show aggregated data for PHEV and HEV buses jointly

[8] https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2015517-om-stod-till-lokala_sfs-2015-517

[9] https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20171318-om-bidrag-till_sfs-2017-1318

[10] The Swedish Transport Administration, 2018. Infrastruktur för snabbladdning längs större vägar - ett regeringsuppdrag FULLTEXT01.pdf (diva-portal.org)

Switzerland

MAJOR DEVELOPMENTS IN 2020

In Switzerland, 2020 was largely governed by the dynamics of the COVID-19 pandemic and associated measures, as was the case worldwide. This resulted in the sharpest decline in overall mobility in decades and the lowest number of new car registrations since the oil crisis in the 1970s. However, on a positive note, the sales of vehicles with alternative drives, especially BEV and PHEV have reached a new all-time high.
The Swiss parliament passed the CO2 Act, which outlines the framework to reach net-zero by 2050 and for fulfilling the obligations associated with the Paris Agreement.

Impact of the coronavirus pandemic

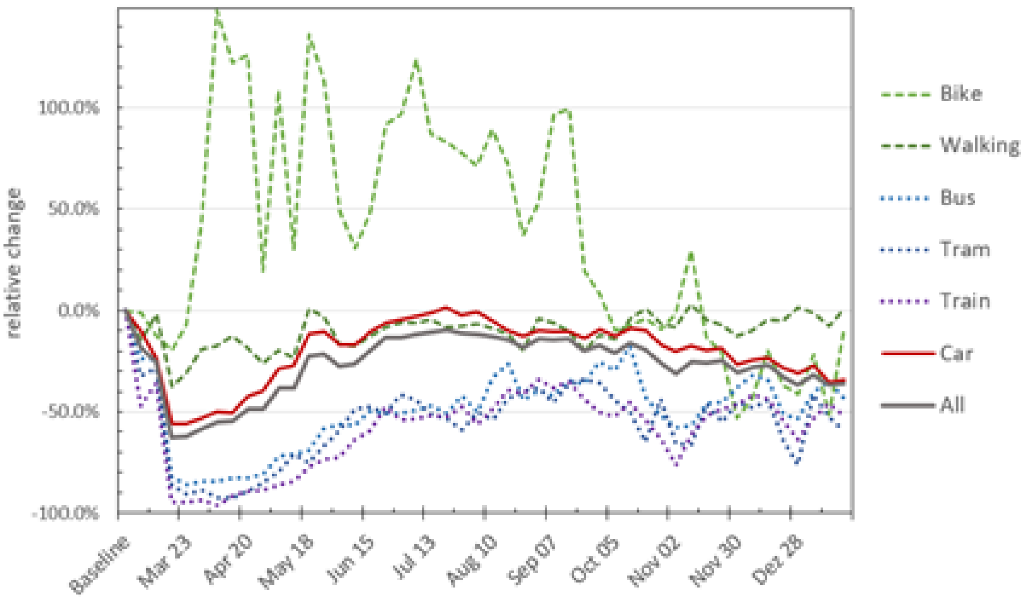

Figure 1: Impact of the pandemic and lock-down measures on mobility behaviour. (source: MOBIS:COVID, www.ivt.ethz.ch/en/research/mobis-covid19)

The spread of the coronavirus at the beginning of 2020 and the first lockdown in March and April resulted in a very dramatic decline in mobility. During the first weeks of the lockdown, the use of public transport decreased by up to 95% compared to the 2019 baseline. Almost one year later, the use of public transport is still down by around 50%. Unsurprisingly, private transport was less affected. The enormous increase in bicycle use can be explained by a general avoidance of public transport, the generally good and warm weather, and the lack of other leisure opportunities. In terms of energy consumption and infrastructure use, the severe impact on public transport is concerning. Other developments, notably the record sales of EVs and the increased popularity of bicycles give rise to hope. We continue to closely monitor mobility behaviour and its impact on energy consumption.

Electromobility roadmap 2022

Figure 2: Federal Councillor Simonetta Sommaruga speaks at the 10th Electromobility Congress and encourages the community to define more ambitious goals for the Electromobility Roadmap (image source: Mobility Academy of the Touring Club of Switzerland)

INITIAL POSITION:
At the end of 2018, representatives from the automotive, electricity, real estate, and vehicle fleet sectors, as well as from the federal government, cantons, cities, and municipalities signed the Electromobility Roadmap. They set a target to increase the proportion of electric vehicles in new passenger car registrations to 15% by 2022. They defined specific measures in the fields of “Vehicle market development”, “Charging infrastructure”, and “Incentives & framework conditions”.

CURRENT STATUS:
Of the 76 defined measures, 53 are being implemented, ten have already been completed, nine are being revised and the status of four has yet to be clarified. New measures are being set up continuously.

Thanks to the great commitment of all stakeholders, the goal set for 2022 has almost been achieved already: at the end of 2020, the share of plug-in vehicles was already 14.3%.

NEW OBJECTIVES:
In September 2020, Federal Councillor Sommaruga encouraged the Roadmap Community to discuss an extension of the roadmap until 2025 with new goals. Platform events and workshops were organised for this purpose where the more than 50 organisations and companies involved in the roadmap took part. All members should agree on new common goals for 2025 at a summit meeting scheduled for March 11th 2021.

New energy perspectives 2050+

The new energy perspectives 2050+ present scenarios on how Switzerland's Energy Strategy 2050 and the net-zero CO2 climate goals can be combined. In all scenarios, the transport sector needs to make the largest contribution to the reduction of greenhouse gases. A steep electrification path is foreseen for private cars with an EV share of new car sales of 28% in 2025, 60% in 2030 and 100% in 2040. Hydrogen and synthetic fuels will complement the electrification of heavy trucks and special vehicles.

New policies, legislation and incentives

TOTAL REVISION OF THE CO2 ACT

On September 25th 2020, the Swiss parliament passed the CO2 Act. Some of the most important measures concerning the transport sector are summarised as follows:

- Tightening of CO2 emission values for the average of new vehicles including heavyweight trucks, in line with the EU.
- Increase in the compensation obligation for fuel importers.
- Elimination of mineral oil tax reimbursements for public transport, after 2025 for urban transport and after 2030 for regional transport.
- New climate fund, to support among many other things charging infrastructure in multi-party buildings.

FURTHER INCENTIVES

Electric vehicles are exempt from the circulation tax in most cantons. In addition, some cantons grant purchase premiums for electric vehicles and some funding towards establishing charging infrastructure.
The administration is also working on the removal of obstacles and regulatory hurdles in the planning, installation and operation of charging stations.

HEVS, PHEVS, AND EVS ON THE ROAD

In 2020, only 236,817 new cars were registered (-24% compared to 2019). This is the lowest number of car sales since the oil crisis in the mid-1970s. However, the new record share of alternative drives of 28% is encouraging and corresponds to more than a doubling compared to the previous year (13%). The largest growth was recorded in plug-in hybrid vehicles (+239%), but sales of fully electric (+48%) and hybrid vehicles (+46%) also increased significantly. Given that Switzerland does not grant purchase premiums at a national level, the strongly increasing share of electric vehicles is particularly noteworthy. In the last months of 2020, more than one in three vehicles sold had an alternative drive. In addition to cars, lightweight vehicles, most notably electric bikes (+29%) and mopeds (fast e-bikes, +40%), also saw record sales in 2020.

Fleet Totals (as of January 31st 2021)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a.	n.a.	n.a.	n.a.	n. a.
B Electric moped (<50 kmph)	n.a.	n.a.	n.a.	n.a.	n.a.
C Auto-rickshaw	7109	0	0	0	7414
D Motorcycle	2774	47	0	0	674739
E Motorcycle with sidecar	0	0	0	0	2993
F Motorized tricycle	235	0	0	0	3950
G Passenger vehicles	52641	126175	30688	92	4752275
H Buses and Minibuses	62	359	0	2	11104
I Light Commercial vehicles	2512	177	1	0	409090
J Medium and Heavy Weight Trucks	125	29	1	20	77141

Total Sales 1st Jan 2020 to 31st Dec 2020

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	145738	0	0	0	145738
B Electric moped (<50 kmph)	26332	0	0	0	27354
C Auto-rickshaw	1062	0	0	0	1083
D Motorcycle	911				46232
E Motorcycle with sidecar	0	0	0	0	47
F Motorized tricycle	0	0	0	0	383
G Passenger vehicles	19599	32151	14367	42	236817
H Buses and Minibuses	29	198	0	0	823
I Light Commercial vehicles	772	117	0	0	28464
J Medium and Heavy Weight Trucks	32	0	0	18	3886

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3
I: UNECE categories N1
J: UNECE categories N2-N3

Quarterly updated information on new registrations of vehicles with alternative drives can also be found on the website of the Swiss Federal Office of Energy: www.bfe.admin.ch/bfe/en/home/supply/statistics-and-geodata/key-data-for-vehicles/key-data-relating-to-alternative-drives.html.

CHARGING INFRASTRUCTURE

Electric charging

As of 1 January 2021, there were 2,770 locations in Switzerland with 5,507 publicly accessible charging stations.

Chargers as of 31st Dec 2020

Type of Public EVSE		Number of Charging Outlets*	Number of Locations*
AC Level 1 Chargers	AC charging ≤ 3.7 kW	1125	51
AC Level 2 Chargers	AC charging >3.7 kW, ≤ 22 kW	1819	915
AC Fast Chargers	AC charging 43 kW	3441	948
DC Fast Chargers	DC charging ≤ 50 kW	99	21
Superchargers	DC charging 120 kW	628	191
Ultrafast-High power chargers	DC charging > 150 kW and ≤ 350 kW	609	68
Inductive Chargers	EM charging	0	0

* For some charging stations, only incomplete information is available and they are thus not categorised.

Real-time information on the availability and type of charging stations in Switzerland is available at www.ich-tanke-strom.ch. In addition, statistical and geo-information about Switzerland's charging infrastructure is available at https://www.uvek-gis.admin.ch/BFE/storymaps/MO_Kennzahlen_Elektromobilitaet/.

H2 Infrastructure

Switzerland boasts a highly innovative and integrated hydrogen network for mobility. Green hydrogen is locally produced from 100% renewable hydroelectricity. As of January 2021, hydrogen is available at 6 public filling stations in Switzerland.

Figure 3: Commercial hydrogen filling station in Switzerland (source: www.empa.ch).

EV DEMONSTRATION PROJECTS

Electric Busses

In 2020, a demonstration project was launched, dealing with the development and deployment of more efficient power electronics for heavy-duty applications. In the project, innovative inverters using SiC MOSFET technology are being developed. With this new technology, a reduction of transmission losses in the inverters by about 90% is expected. This translates into energy savings of about 20 kWh per day for a large electric bus. The inverters are integrated into a new and improved electric propulsion system for heavy-duty bus and truck applications, taking advantage of a more compact arrangement of the major components. In a first step, the new inverters are tested on a motor-generator test bench, with each unit being equipped with either a conventional or a new inverter. With these tests, a validation of the expected energy potential is performed. In a second step, prototypes of the propulsion system are tested in the field using electric buses that will be operated in the city of Baden.

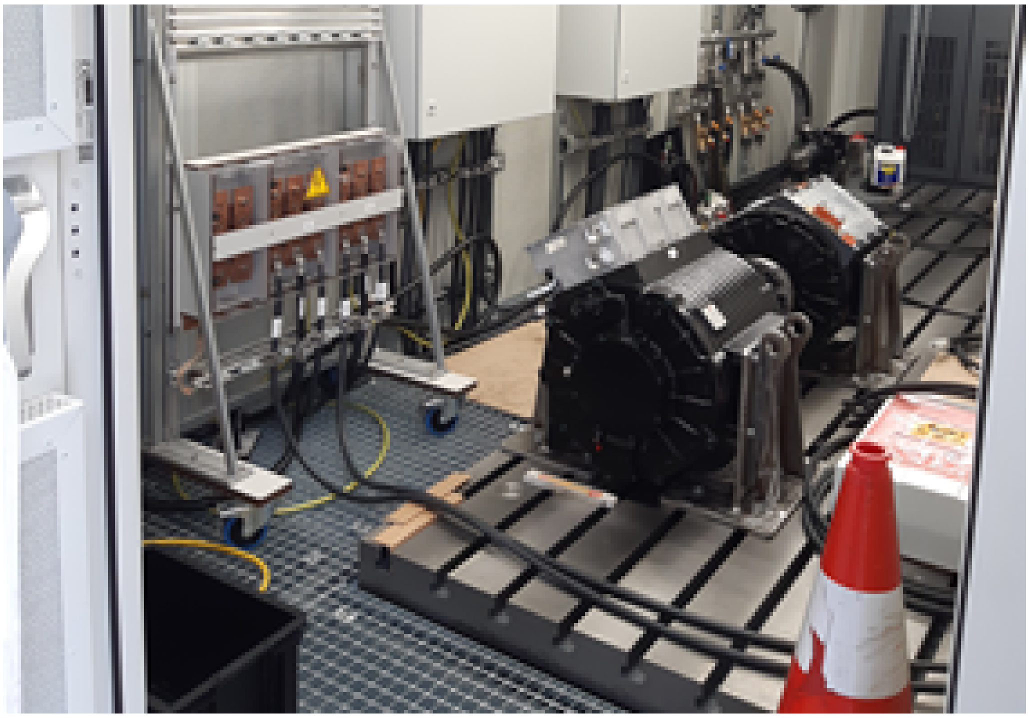

Figure 4: Motor-generator test bench together with conventional alternator and innovative SiC unit (on top first unit) (source: ABB Schweiz AG).

Electric Freight Vehicles

In 2020, an extension of the project involving the testing of Esoro AG's 34-t truck powered with a hydrogen fuel cell was undertaken. The vehicle was equipped with the newest-generation fuel cell stack and will undergo durability and performance tests for another full year. At the same time, a concept for a modular fuel cell propulsion system is being developed that can be industrially manufactured and universally implemented in electric trucks. The aim is to provide a turnkey solution to electric truck manufacturers that build entirely new and retrofit existing vehicles. The additional test campaign shall also generate more results on the technical, dynamic, and economic properties of fuel cell trucks. These efforts are part of the ongoing rollout of commercial fuel cell trucks marketed by Hyundai Hydrogen Mobility AG in Switzerland. Around 50 fuel cell trucks were in operation at the end of 2020. The goal is to increase this number to 1,600 vehicles by 2025.

Figure 5: More than 50 Hyundai fuel cell trucks are already in service in Switzerland (source: www.hyundai-hm.com).

Several campaigns by private companies are also noteworthy: DPD, one of the largest parcel and express transport providers in Switzerland, added a battery-electric Futuricum Logistics 18E truck with a range of up to 760 km to its fleet.[1] The Feldschlösschen brewery introduced 20 commercial electric 26 t trucks for the delivery of beverages. In cooperation with Holcim, a leading building materials manufacturer, Designwerk, developed the world's first fully-electric concrete truck mixer on 5 axes.[2]

Vehicle-to-X applications

In the last year, more experience has been gained in the vehicle-to-X (V2X) project in the Erlenmatt Ost area of Basel - a new district developed according to the targets of the 2,000 Watt Society. Among others, the area boasts a 580 kW photovoltaic (PV) system, a local district heating system, and two bidirectional-charging electric vehicles used for car-sharing (a Nissan Leaf and an e-NV200). Outside the peak PV hours, the area is a net energy consumer. Ideally, the cars are charged during the day and can be used in the evening for "peak shaving", helping to optimise the area's consumption. As part of a research project[3], studies are being conducted on how the mobility behaviour of the residents and the own consumption in the area can be optimised with an intelligent regulation and tariff system. Opportunities for new business models and system services should also be identified. While this is currently Switzerland's most comprehensive V2X project, the experience helped to initiate follow-up projects at a larger scale, most notably in the City of Yverdon in western Switzerland. Plans are in place to equip a commercial site with 200 businesses and over 1,500 workplaces with a local microgrid and charging stations for up to 250 of the 750 parking spaces. In the coming years, this infrastructure, together with the expected 300 to 400 electric vehicles, shall serve as a basis to investigate the technical challenges and commercial opportunities associated with large vehicle-to-grid systems.

Figure 6: The V2X project in the city of Basel inspired larger follow-up projects (source: www.novatlantis.ch).

OUTLOOK

Sales of electric vehicles remain strong and January and February 2021 confirm the trend of the preceding year.

Electromobility roadmap stakeholders are currently discussing more ambitious targets for 2025 with a 40% sales share of plug-in electric vehicles (BEV and PHEV). As for charging, 20,000 public stations are envisioned for 2025, together with a general incentive to facilitate charging at home.

In spring 2021, the report on “Enabling breakthrough of fossil-free drives in public road transport” in response to a parliamentary postulate will be published. It is in essence a roadmap for the transition from diesel buses to battery buses with opportunity charging and other charging strategies.

REFERENCES

[1] https://www.dpd.com/group/en/2020/06/11/dpd-switzerland-banks-on-electromobility-with-new-electric-truck

[2] https://www.futuricum.com/erste-vollelektrische-betonfahrmischer-an-holcim-ausgeliefert/#pll_switcher

[3] https://www.novatlantis.ch/fachveranstaltung-sektorkopplung

United States

MAJOR DEVELOPMENTS IN 2020

The United States (U.S.) population continues to rely on vehicles for personal transportation. However, because of the global COVID-19 pandemic, individuals drove less and the cumulative national vehicle miles travelled (VMT) for the year 2020 was 2,829.7 billion vehicle miles, which represents a decrease of 13.2% (430.2 billion vehicle miles) compared to the year 2019[1].

Sales of electric-drive vehicles in the U.S. in 2020 decreased ~9% from their 2019 value (~298,000 in 2020 compared to ~325,000 in 2019), the cumulative total reached 1.74 million plug-in electric vehicles (PEVs) since December 2010. During 2020, there were 44 PEV models sold, including both plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs); as well as 66 hybrid electric vehicle (HEV) models, for total sales of ~740,000 units.[2]

Industry and Market

MARKET DEVELOPMENTS

- Uber announced that “100 percent” of its rides will take place in electric vehicles by 2030 in the US, Canada, and Europe.[3]
- Proterra has opened a new battery production line co-located in its EV bus manufacturing facility in Los Angeles County. The new battery production line will manufacture Proterra’s battery packs with its next-generation cells.[4]
- Zoox Inc., the self-driving startup owned by Amazon.com Inc., unveiled a fully autonomous electric vehicle with no steering wheel that can drive for a day and a night on a single charge.[5]
- Walmart is targeting zero emissions in global operations by 2040. That includes completely electrifying its long-haul trucks and other vehicles by that year.[6]
- Exelon will electrify 30% of its vehicle fleet by 2025, increasing to 50% by 2030. This transition will be achieved through a combination of fully electric vehicles, vehicles with plug-in idle mitigation units and plug-in hybrids.[7]

BATTERY TECHNOLOGY

- Mercedes-Benz is investing over $1 Billion (USD) in global EV battery production.[8]
- Ford is investing €42M in its Valencia plant for new hybrid models and battery

assembly operations.[9]

- Stanford scientists identified new Li-B-S solid electrolyte materials that boost lithium-ion battery performance.[10]

- The battery supplier SK Innovation revealed that it is developing cells that will only need two quick 10-minute charges to cover more than 500 miles of range when installed in an EV.[11]

CHARGING INFRASTRUCTURE

- SAE International published a new J2954 wireless charging standard, paving the way for charging without the need for plugging in—widely considered to be a key enabler for accelerating the adoption of EVs and autonomous vehicles.[12]

- Electrify America expanded home charging offerings with the launch of Electrify Home, offering a simple and efficient purchase approach for existing and prospective EV owners.[13]

- General Motors Co. partnered with electric-vehicle charging operator EVgo Services to build nationwide fast-charging infrastructure as the automaker prepares a major push into battery-powered models.[14]

- Researchers at DOE's Oak Ridge National Laboratory (ORNL) demonstrated a 20kW bi-directional wireless charging system installed on a UPS medium-duty, plug-in hybrid electric delivery truck.[15]

Policy and Government

FEDERAL GOVERNMENT

- DOE announced $139 million in federal funding for 55 projects across the country that will support new and innovative advanced vehicle technologies including advancing lithium-ion batteries using silicon-based anodes.[16]

- DOE has announced more than $7 million in funding for a Michigan-based cybersecurity company, Dream Team (DTLLC), to develop infrastructure that protects the electric grid from cyber-attacks on EVs and EV charging systems. Once the electric roadway and vehicle-to-grid (V2G) technology has been developed, it will be tested at the American Center for Mobility (ACM).[17]

- DOE released the Energy Storage Grand Challenge Roadmap for a 44% reduction in manufactured cost for a 300-mile EV pack by 2030. A cost and performance target identified a $0.05/kWh levelised cost of storage for long-duration stationary applications, a 90% reduction from 2020 baseline costs by 2030. Achieving this cost target would facilitate commercial viability for storage across a wide range of uses including meeting load during periods of peak demand and grid preparation for fast charging of electric vehicles.[18]

STATE AND LOCAL GOVERNMENTS

- Governor Ron DeSantis (Governer of Floride) has signed the Essential State Infrastructure Bill into law, which expands EV charging stations to support growth in the use of electric vehicles in Florida. Specific state agencies will need to identify barriers and opportunities to advance EV adoption. The bill requires an interim report at the end of 2020 and a final report by July 1, 2021.[19]

- New York State's Department of Environmental Conservation (DEC) and the New York State Energy Research and Development Authority (NYSERDA) announced that over $24 million is available to replace diesel-powered transit buses with new all-electric buses. As part of the state's $128-million allocation from the federal Volkswagen Settlement, NYSERDA will invest $18.4 million to fund electric buses through the Truck Voucher Incentive Program, and the New York Power Authority (NYPA) will manage $6 million for associated charging infrastructure.[20]

- New York Governor Andrew M. Cuomo announced a package of major clean transportation initiatives, including a "Make Ready" order approved by the New York State Public Service Commission (PSC) to advance New York's commitment to accelerate its transition to cleaner mobility. The EV Make-Ready Program will be funded by investor-owned utilities in New York State. It creates a cost-sharing program that incentivises utilities and charging station developers to locate electric vehicle charging infrastructure in places that will provide a maximal benefit to consumers.[21]

- California approved a $437 million utility-based program that will add 38,000 new electric-car charging stations over five years. Approval from the California Public Utilities Commission gives Southern California Edison (SCE) the green light to start installing those stations, increasing charging infrastructure in the state that is by far the leader in electric-car adoption.[22]

LEGISLATION

- U.S. Rep. Ro Khanna introduced legislation to promote access to EVs around the country. A House companion bill, also sponsored by Rep. Khanna, aims to promote EV purchase and utilisation by government agencies.[23]

- U.S. Rep. Ocasio-Cortez introduced the bill to build a national network of high-speed chargers for electric cars under legislation. The bill — dubbed the EV Freedom Act — would establish a network of chargers along public highways within five years.[24]

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 2020. It also includes a price overview of the most popular-selling hybrid and electric vehicles. Figure 1 illustrates cumulative sales for HEVs, BEVs, and PHEVs over January – December 2020. It is observed that all three curves show a steady rise throughout the year, with the exception of the March-April timeframe when the Coronavirus lockdown was in effect in many cities.

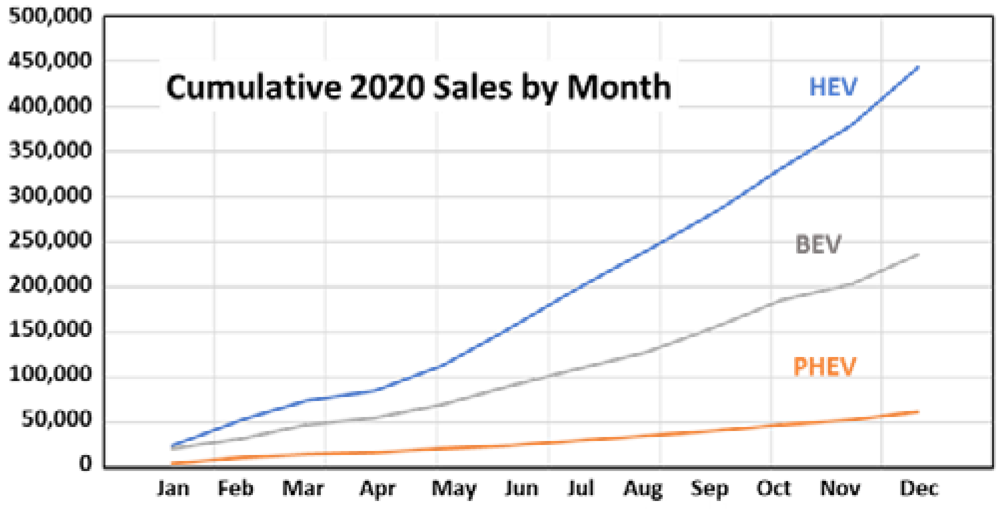

Figure 1: Cumulative sales of electrified vehicles in 2020, not including FCEVs. (Data source: Argonne National Laboratory)

Figure 2 shows the 2020 sales for the top 9 U.S. EV market leaders. It is observed that 2020 HEV sales increased 15% to 442,799 in 2020[25] from 384,447 in 2019. There were 33 different models sold across the top 6 manufacturers. The top-selling models include Toyota RAV4, Toyota Highlander, Toyota Camry, and Toyota Prius, which together accounted for 51% of the U.S. HEV market. The Toyota Prius lineup, once dominant in the market, is now 6% of the total market share (it was 12% in 2019), yet Toyota and Lexus together account for about 72% of the U.S. HEV market.

There were 32 different PHEV models sold across 13 manufacturers. The top five models include the Toyota Prius PHEV, Honda Clarity Plug-In, Chrysler Pacifica Plug-in, BMW 530e (5-Series Plug-in), and Mercedes GLC 350e; which together account for 50% of sales.

There were 18 different BEV models sold across 11 manufacturers. The top five models include Tesla Model 3, Tesla Model Y, Chevy Bolt, Tesla Model X, and Tesla Model S; which together account for 86% of sales.

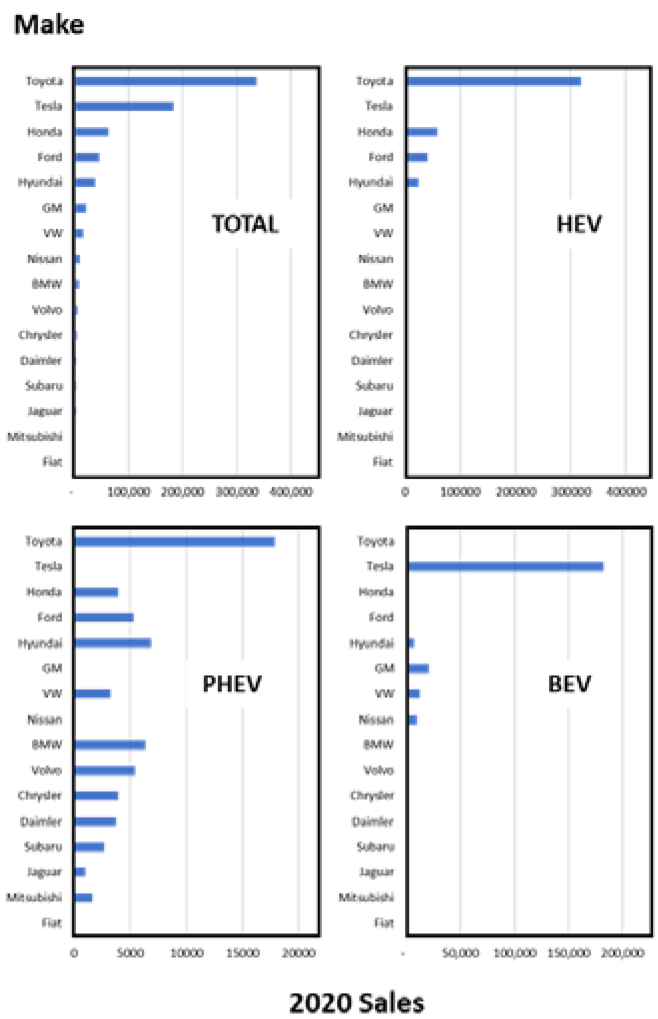

Figure 2: 2020 sales of electrified vehicles for market leaders. (Data source: Argonne National Laboratory)

Figure 3 shows the evolution of the U.S. HEV market (2005-2020) for prominent manufacturers. The corresponding information for the PHEV and BEV markets (2010-2020) appears in Figure 4 and Figure 5.

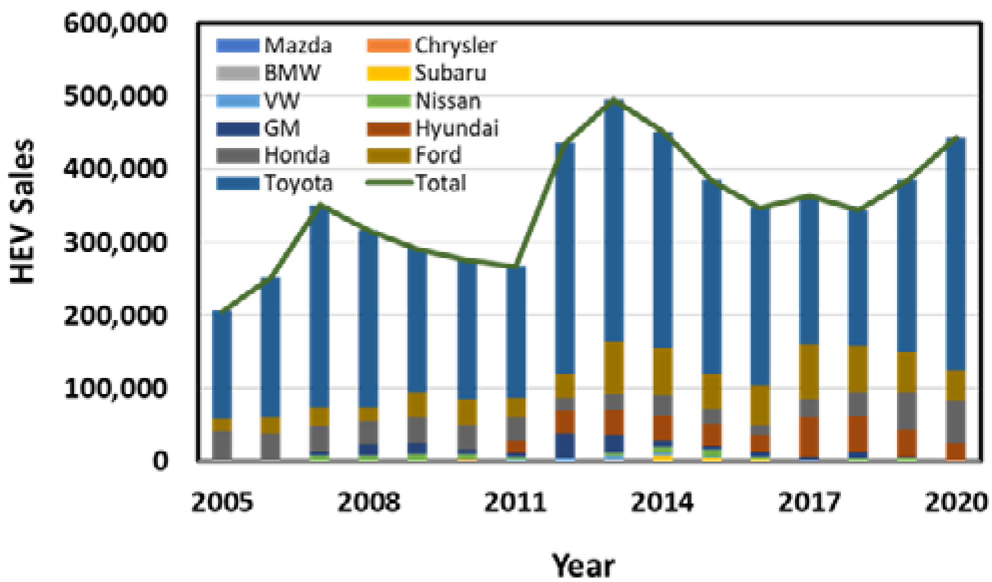

Figure 3: Evolution of the U.S. HEV market over time (2005-2020). (Data Source: Argonne National Laboratory)

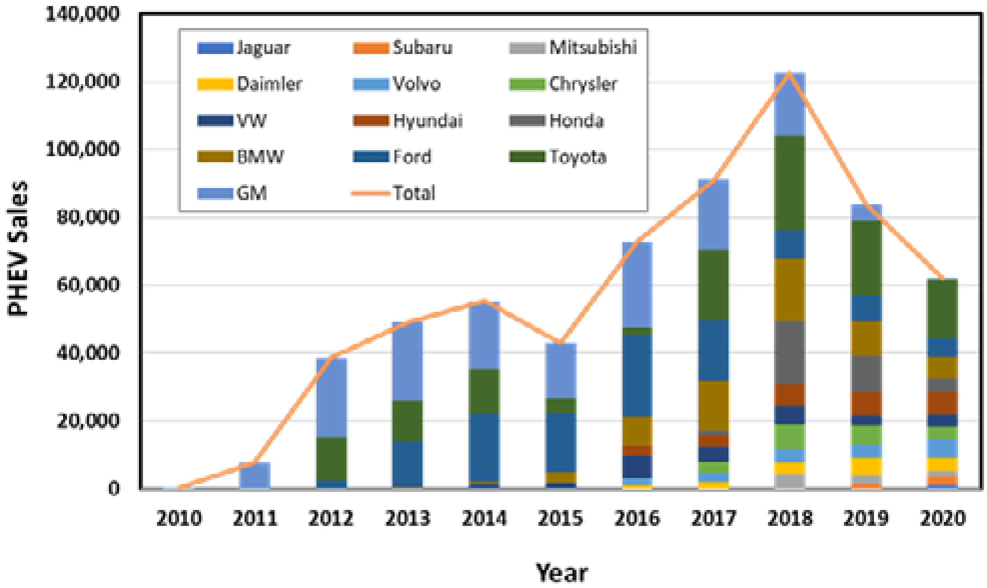

Figure 4: Evolution of the U.S. PHEV market over time (2010-2020). (Data Source: Argonne National Laboratory).

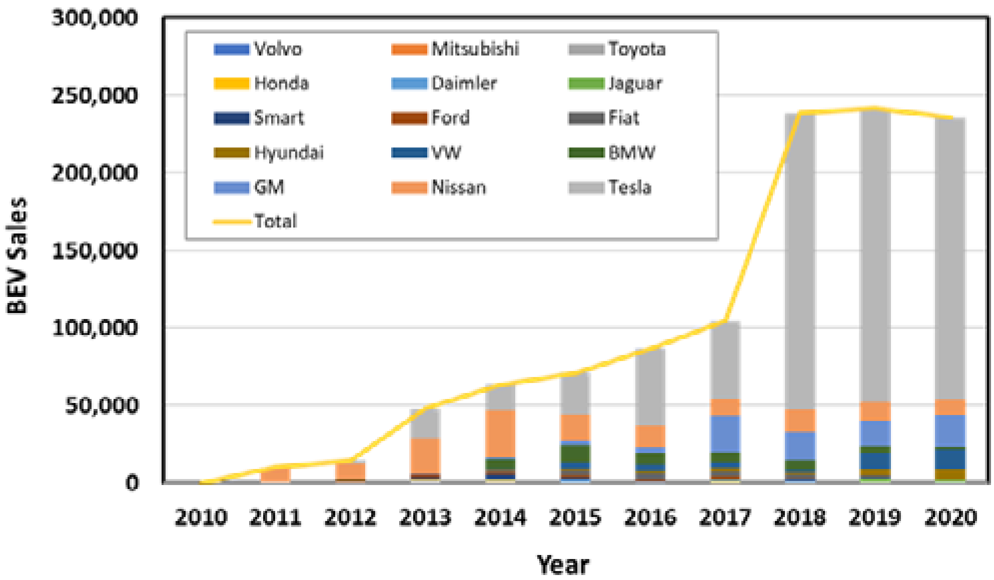

Figure 5: Evolution of the U.S. BEV market over time (2010-2020). (Data Source: Argonne National Laboratory).

In 2020, 33 plug-in hybrid electric vehicle (PHEV) models were available for sale in the United States across 13 manufacturers, and 18 battery electric vehicle (BEV) models across 15 manufacturers. In 2020, the total passenger electric vehicle (PEV) sales reached around 298,000 units, ~8% below the total sales in 2019. Five of the PEV models sold over 10,000 units in 2020, all BEVs. The highest-selling 2020 models included Tesla Model 3, Tesla Model Y, Chevy Bolt, Tesla Model X, Prius PHEV, Tesla Model S, Nissan LEAF, and Audi e-Tron (in decreasing sales order) together accounting for 78% of the combined PEV market. The 2020 sales data also demonstrates the dominance of Tesla's share of BEV sales; being responsible for 77% of BEV sales in 2020 compared to 58% in 2019.

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.

Fleet Totals on 31 December 2020

<table>
<tr><th>Vehicle Type</th><th>EVs</th><th>HEVs</th><th>PHEVs</th><th>FCVs</th><th>Total Fleet*</th></tr>
<tr><td>A Passenger Vehicles</td><td rowspan="2">1,115,335[27]</td><td rowspan="2">5,800,523[26]</td><td rowspan="2">626,195[26]</td><td rowspan="2">9,188[26]</td><td>11,000,000[27]</td></tr>
<tr><td>B Light trucks</td><td>138,000,000[27]</td></tr>
<tr><td>C Medium & Heavy Weight Trucks</td><td>n.a.</td><td>n.a.</td><td>n.a.</td><td>n.a.</td><td>13,234,000[27]</td></tr>
</table>

Total Sales during 2020

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total Fleet*
Electric Bicycles	278,000[28]	n.a.	n.a.	n.a.	n.a.
A Passenger Vehicles	156,099[26]	172,798[26]	36,055[26]	938[26]	5,304,000[26]
B Light trucks	79,779[26]	270,001[26]	25,992[26]	n.a.	11,609,000[26]
C Medium & Heavy Weight Trucks	n.a.	n.a.	n.a.	n.a.	755,000[27]
Totals (without bicycles)	**235,878**	**442,799**	**62,047**	**938**	**17,668,000**

Table 1: Distribution and sales of EVs, PHEVs and HEVs in 2020.

n.a.: Not Available
A: U.S Cars
B: US Class 1-2 Turcks (<10,000 lbs. GVWR)
C: U.S. Class 3-8 Trucks
*Including both conventional and alternative technologies

BEV	Untaxed, Unsubsidised Sales Price (USD)	BEV	Untaxed, Unsubsidised Sales Price (USD)
Audi e-tron	$69,100	Nissan Leaf	$31,670
BMW i3	$44,450	Polestar 2	$59,990
Chevrolet Bolt	$36,500	Porsche Taycan BEV	$79,900
Fiat 500E	$37,900	Tesla Model 3	$32,690
Ford Mustang Mach-E	$42,895	Tesla Model Y AWD	$44,690
Hyundai Kona	$37,390	Tesla Model S AWD	$74,490
Hyundai Ioniq	$33,245	Tesla Model X AWD	$84,690
Jaguar I-Pace	$69,850	Volkswagen ID.4	$39,995
Kira Niro EV	$39,090	Volvo XC40 Recharge	$53,990

Table 2: Market-Price Comparison of Available BEVs in the U.S.

Table 3: Market-Price Comparison of Available PHEVs in the U.S.

PHEV	Untaxed, Unsubsidised Sales Price (USD)	PHEV	Untaxed, Unsubsidised Sales Price (USD)
Audi A3 PHEV	$33,000	Lincoln Aviator	$51,100
BMW 330e	$41,250	Lincoln Corsair	$36,105
BMW 530e	$57,200	Mini Countryman SE	$29,900
BMW 740e	$95,900	Mitsubishi Outlander PHEV	$36,295
BMW i8	$88,000	Polestar1	$155,000
Cadillac CT6	$76,090	Porsche Cayenne SE	$81,100
Chevrolet Volt	$34,395	Porsche Panamera 4 E-Hybrid	$98,500
Chrysler Pacifica Hybrid	$39,995	Prius PHEV	$28,220
Ford Escape PHEV	$24,885	Range Rover Plug-in	$97,000
Ford Fusion Energi	$28,000	Range Rover Sport Plug-in	$83,000
Honda Clarity PHEV	$33,400	Subaru Crosstek	$35,345
Hyundai Ioniq	$26,700	Toyota RAV4 PHEV	$38,100
Hyundai Sonata PHEV	$27,750	Volvo S90 PHEV	$60,050
Kia Niro	$29,590	Volvo V60 PHEV	$67,300
Kia Optima	$35,390	Volvo XC60 PHEV	$53,500
Mercedes C350e	$43,400	Volvo XC90 PHEV	$63,450

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. This information is continuously collected by the U.S. DOE's Alternative Fuels Data Center (AFDC) and published on its website.[29]

From 2019 to 2020, the overall EV charging infrastructure availability in the U.S. grew rapidly. The total number of available stations grew from 25,061 to 42,750, or by 71%. This total increase reflects the respective 78% and 40% increases in the number of Level 2 and DC fast-charging stations, which more than offsets the 3% decrease in Level 1 charging stations. The average number of plugs at each station increased by 27% for Level 2 chargers and also by 27% for DC fast chargers from 2019 to 2020.

Table 4: Information on charging infrastructure in 2020, 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 26, 2021).

Number of Charging Stations

Chargers	2019	2020	Change
AC Level 1 Chargers	667 (1,492)	688 (1,376)	+3% (-8%)
AC Level 2 Chargers	20,857 (64,333)	37,113 (81,802)	+78% (+27%)
Fast Chargers	3,537 (13,576)	4,949 (17,312)	+40% (+27%)
Superchargers (incl. in Fast Chargers)	801 (7,638)	986 (9,726)	+23% (+27%)
Totals	**25,061 (79,401)**	**42,750 (100,490)**	**+71% (+27%)**

Table 5 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.

Table 5: List of the top 10 U.S. States with maximum number of EVSE plugs, grouped by charging level. (Data source: U.S. DOE AFDC, accessed March 26, 2021).

Number of Charging Stations

State	AC Level 1 Chargers	AC Level 2 Chargers	Fast Chargers	Superchargers (included in Fast Chargers)
California	170 (316)	11,575 (26,575)	1,381 (5,343)	203 (2,965)
New York	11 (15)	2,269 (5,139)	153 (633)	52 (452)
Florida	29 (39)	1,850 (4,080)	250 (901)	62 (602)
Texas	22 (32)	1,788 (3,853)	216 (733)	52 (459)
Georgia	10 (172)	1,250 (2,844)	167 (432)	20 (209)
Washington	18 (83)	1,322 (2,778)	181 (590)	29 (291)
Massachusetts	16 (18)	1,496 (3,101)	104 (330)	23 (206)
CO	6 (61)	1,168 (2,563)	148 (417)	24 (205)
MO	5 (5)	884 (1,790)	76 (184)	13 (103)
MD	9 (21)	861 (2,096)	170 (443)	22 (183)

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 6, the vast majority of those will be needed for Level 2 home charging.[30]

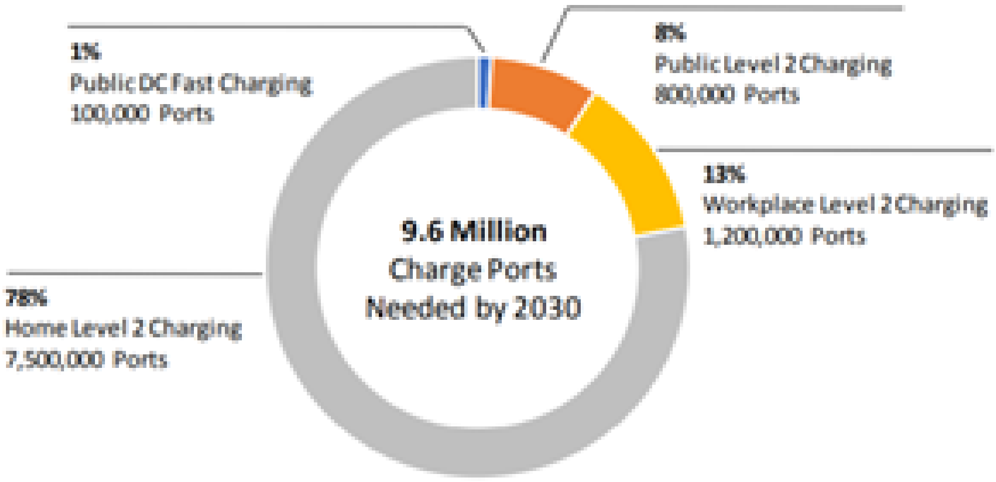

Figure 6: Projected EV charging infrastructure needs in 2030 (Source: EEI/IEI Forecast)

Volkswagen's subsidiary Electrify America has been investing in a 10-year, $2 billion, ZEV infrastructure, access, and education program (of which $800 million will be spent in California and $1.2 billion in the rest of the United States). This plan was set up from Volkswagen's emissions tests software settlement with U.S. federal regulators for diesel vehicles.[31] The plan's Cycle 1, completed in June 2019, included building its roadmap. In the current cycle (Cycle 2) it expects to install approximately 800 public charging stations (3,500 chargers) by December 2021. Subsequent cycles will establish ZEV Investment Plans from 2022 through 2026[32] as well as marketing efforts to raise consumer awareness of EVs.

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.[33] 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.[34]

Global sales of light-, medium-, and heavy-duty PEVs are estimated to continue growing according to 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.[35]

Electrification remains an integral feature of self-driving cars, as evidenced by ongoing test projects at Ford, GM, Uber, Waymo, and other auto industry members. As 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.

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Japan

NON -MEMBER COUNTRY

MAJOR DEVELOPMENTS IN 2020

Fuel efficiency standards

To promote energy conservation and CO2 emission reductions in passenger vehicles, the fuel efficiency standards were established with the target fiscal years being set at FY2010, FY2015 and FY2020. These standards are based on the Top Runner Programme[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 2030.

The scope of the target vehicles for the new fuel efficiency standards needs to include electric vehicles and plug-in hybrid vehicles, which are expected to be substantially popularised in the future. Target vehicles for the new fuel efficiency standards, therefore, include; passenger vehicles fuelled by gasoline, diesel, LPG, and vehicles with engines powered by electricity, that either has a carrying capacity of up to 9 passengers or 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, plug-in hybrid vehicles, gasoline, diesel, or LPG, are included in the calculation of corporate average fuel efficiency. When evaluating the energy consumption of electric drivetrain 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. Therefore, 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]

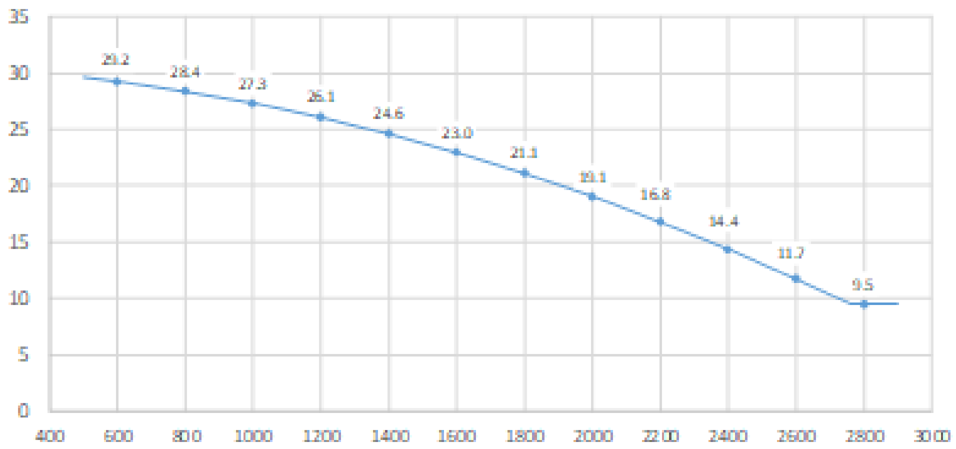
Fuel efficiency standard values (FE: km/L) are set as follows depending on the vehicle weight (M: kg).

M: Less than 2,759 kg
$FE = -2.47 \times 10^{-6} \times M2 - 8.52 \times 10^{-4} \times M + 30.65$

M: 2,759 kg or more
FE = 9.5

* FE value is rounded off to one decimal place.

The relational expression of fuel efficiency standard value and vehicle weight is shown below.



X Axis: Vehicle Weight (kg)
Y Axis: Fuel efficiency standard value (km/l)

For the current fuel efficiency standards, the corporate average fuel efficiency standard method (CAFE method) was adopted, in which an overall high energy conservation effect can be expected because 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) will improve 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 (3,823 USD as of February 9th 2021)
- PHEVs: up to 200,000 JPY (1,912 USD as of February 9th 2021)
- CDVs: up to 150,000 JPY (1,434 USD as of February 9th 2021)
- FCVs: up to 2,250,000 JPY (21,506 USD as of February 9th 2021)

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: partially exemption).
HEVs are partially exempt from paying “environmental performance excise”, “motor vehicle tonnage tax” and “automobile tax”.

HEVS, PHEVS, AND EVS ON THE ROAD

At the end of FY2019, cumulative EVs/PHVs/FCVs sales were over 9.4 million in Japan. In 2020, there were 1.35 million newly registered passenger EVs; 1.32 million were HEVs, 14,600 were EVs, 14,700 were PHEVs, and around 800 were FCVs.

Total stock as of March 31st 2020 (thousands)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a.	n.a.	n.a.	n.a.	n.a.
B Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
C Motorcycle	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
E Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
F Passenger vehicles	117.3	9145.2	136.2	3.7	9402.4
G Buses and Minibuses	1.4	19.6	0	0	21.0
H Light Commercial vehicles	n.a.	n.a.	n.a.	n.a.	n.a.
I Medium and Heavy Weight Trucks	n.a.	n.a.	n.a.	n.a.	n.a.

Total Sales 1st Jan 2020 to 31st Dec 2020 (thousands)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a.	n.a.	n.a.	n.a.	n.a.
B Auto-rickshaw	n.a.	n.a.	n.a.	n.a.	n.a.
C Motorcycle	n.a.	n.a.	n.a.	n.a.	n.a.
D Motorcycle with sidecar	n.a.	n.a.	n.a.	n.a.	n.a.
E Motorized tricycle	n.a.	n.a.	n.a.	n.a.	n.a.
F Passenger vehicles	14.6	1324.8	14.7	0.8	1354.9
G Buses and Minibuses	n.a.	n.a.	n.a.	n.a.	n.a.
H Light Commercial vehicles	n.a.	n.a.	n.a.	n.a.	n.a.
I Medium and Heavy Weight Trucks	n.a.	n.a.	n.a.	n.a.	n.a.

n.a.: Not Available
A: UNECE categories L1
B: UNECE categories L2
C: UNECE categories L3
D: UNECE categories L4
E: UNECE categories L5
F: UNECE categories M1
G: UNECE categories M2-M3
H: UNECE categories N1
I: UNECE categories N2-N3

CHARGING INFRASTRUCTURE OR EVSE

The Ministry of Economy, Trade and Industry (METI) provided support to charging infrastructure by a subsidy of “Promotion Project to Develop Charging Infrastructure for Next-generation Vehicles”. At the end of 2020, over 30,000 public charging stations, including over 7,900 quick chargers were installed in Japan.

Chargers as of 31st Dec 2020

Type of Public EVSE		Number of Charging Outlets	Number of Locations
AC Level 1 Chargers	AC charging ≤ 3.7 kW	21,916	19,385
AC Level 2 Chargers	AC charging >3.7 kW, ≤ 22 kW	7,939	7,500
AC Fast Chargers	AC charging 43 kW	-	-
DC Fast Chargers	DC charging ≤ 50 kW	-	-
Superchargers	DC charging 120 kW	-	-
Ultrafast-High power chargers	DC charging > 150 kW and ≤ 350 kW	-	-
Inductive Chargers	EM charging	-	-

EV DEMONSTRATION PROJECTS

In order to promote the electrification of heavy-duty vehicles, light trucks, and vans, it is necessary to promote automobile developments that are best suited for business use, improve the economic efficiency of operating electric vehicles, and develop the optimal levels of charge point infrastructure. For this reason, from FY2020, METI will provide financial incentives for the utilisation of energy management systems that improve economic efficiency and the development of optimal charging infrastructure, when multiple economic operators use electric vehicles for business in a region.

OUTLOOK

The Green Growth Strategy towards 2050 Carbon Neutrality states the following directions:

- By 2035, comprehensive measures will be taken to achieve 100% electrified vehicle sales in new passenger car sales.
- Over the next 10 years, we will strongly promote the introduction of electric vehicles and build a world-leading industrial supply chain and mobility society, including batteries. In this regard, special measures will be taken especially for the conversion of light motor vehicles and commercial vehicles, etc. to electric vehicles and fuel cell vehicles.
- Through these efforts to make energy carbon-neutral, we will pursue various options for carbon-neutralisation and aim for zero CO2 through the production, use, and disposal of automobiles in 2050.
- In order to reduce CO2 emissions and revitalise mobility at the same time, we will also work to solve issues related to mobility in local communities by changing the way cars are used. In addition, it will promote changes in user behaviour and accelerate the social implementation of new service infrastructure that responds to electrification.
- Batteries are also key to carbon-neutrality as the adjusting power required for the electrification of automobiles and the spread of renewable energy. We will work on policies such as research and development, demonstration, capital investment support, examination of institutional frameworks, and international cooperation for standardisation.

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[2] According to the GFEI’s working paper 20, 90% CO2 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 CO2 reduction target. The WtW approach would balance the effort at upstream and downstream

South Africa

NON -MEMBER COUNTRY

MAJOR DEVELOPMENTS IN 2020

New policies, legislation, incentives, funding, research, and taxation

The Ministry of Forestry and Fisheries and Environmental Affairs launched the Extended Producer Responsibility legislation in November 2020 which includes hybrid and electric vehicles batteries. Producer's responsibility for their product is extended to the post-consumer stage of a product's life cycle - Entire value chain responsibility.

The national uYilo Electric Mobility Programme in South Africa joined the Global Sustainable Mobility Partnership (www.gsmp.world). GSMP is network of independent, not-for-profit organisations with extensive, practical and real-world experience in implementing low and zero emission mobility with the objective to support cities, regions and countries to make the transition to zero-emission mobility and smart transportation.

HEVS, PHEVS, AND EVS ON THE ROAD

Fleet Totals (as of December 31st 2020)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a	n.a	n.a	n.a	
B Electric moped (<50 kmph)	n.a	n.a	n.a	n.a	
C Auto-rickshaw	n.a	n.a	n.a	n.a	
D Motorcycle	n.a	n.a	n.a	n.a	
E Motorcycle with sidecar	n.a	n.a	n.a	n.a	
F Motorized tricycle	n.a	n.a	n.a	n.a	
G Passenger vehicles	637	5011	653	0	6301
H Buses and Minibuses	n.a	n.a	n.a	n.a	

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3
I: UNECE categories N1
J: UNECE categories N2-N3

Fleet Totals (as of December 31st 2020)

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
I Light Commercial vehicles	n.a	n.a	n.a	n.a	
J Medium and Heavy Weight Trucks	n.a	n.a	n.a	n.a	

Total Sales 1st Jan 2020 to 31st Dec 2020

Vehicle Type	EVs	HEVs	PHEVs	FCVs	Total (including ICEVs)
A Electric bike	n.a	n.a	n.a	n.a	
B Electric moped (<50 kmph)	n.a	n.a	n.a	n.a	
C Auto-rickshaw	n.a	n.a	n.a	n.a	
D Motorcycle	n.a	n.a	n.a	n.a	
E Motorcycle with sidecar	n.a	n.a	n.a	n.a	
F Motorized tricycle	n.a	n.a	n.a	n.a	
G Passenger vehicles	92	153	79	0	324
H Buses and Minibuses	n.a	n.a	n.a	n.a	
I Light Commercial vehicles	n.a	n.a	n.a	n.a	
J Medium and Heavy Weight Trucks	n.a	n.a	n.a	n.a	

n.a.: Not Available
A: Pedelecs with power assist up to 25 km/h
B: UNECE categories L1 (Moped capable of driving up to 50 km/h with an engine less than 50cc)
C: UNECE categories L2
D: UNECE categories L3
E: UNECE categories L4
F: UNECE categories L5
G: UNECE categories M1
H: UNECE categories M2-M3
I: UNECE categories N1
J: UNECE categories N2-N3

CHARGING INFRASTRUCTURE OR EVSE

SOUTH AFRICAN BUREAU OF STANDARDS (SABS) RATIFIED STANDARDS
SANS 10142-1
Low Voltage Installations: An electric vehicle charging station is deemed to be a machine or an appliance.

SANS 62196-2 (Nat. amdt 2 2019)
National Foreword:
In South Africa, the allowed configuration for all A.C conductive charging on domestic, industrial, commercial and public access charging stations shall be of Type 2 socket only.

SANS 62196-3 (Nat. amdt 2 2019)
National Foreword:
In South Africa, the allowed configuration for all D.C. conductive charging on domestic,

industrial, commercial and public access charging station is Type AA and Type FF. Configuration Type AA is also known as CHAdeMO and configuration Type FF also known as a Combined Charging System 2

IEC 63110 to be the respective International Electrotechnical Commission (IEC) standard for the protocol for the management of electric vehicle charging and discharging. SABS will adopt the respective standard for South Africa through Technical committee 067/SC 07.

IEC 63119 to be the respective International Electrotechnical Commission (IEC) standard for information exchange for electric vehicle charging roaming services. SABS will adopt the respective standard for South Africa through Technical committee 067/SC 07.

Chargers as of 31st Dec 2020

Type of Public EVSE		Number of Charging Outlets	Number of Locations
AC Level 1 Chargers	AC charging ≤ 3.7 kW		
AC Level 2 Chargers	AC charging >3.7 kW, ≤ 22 kW		244
AC Fast Chargers	AC charging 43 kW		
DC Fast Chargers	DC charging ≤ 50 kW		85
Superchargers	DC charging 120 kW		
Ultrafast-High power chargers	DC charging > 150 kW and ≤ 350 kW		
Inductive Chargers	EM charging		

EV DEMONSTRATION PROJECTS

The national uYilo electric mobility programme launched in 2013, focussed on enabling electric mobility, has a supporting Smart Grid EcoSystem project for EV-Grid inter-operability. The facility includes:

- Localised Solar energy generation
- Storage through second-life EV batteries in stationary applications (Multi-manufacturer)
- Distribution through multiple charger network (AC charge points, DC fast chargers)
- Vehicle-to-Grid Ancillary Services from electric vehicles
- Energy Management System for load management on grid network
- IEC 61850 Smart Grid remote Communications

OUTLOOK

To address the significant contribution of transport to national GHG emissions of 10.8%, in 2018 government through the Department of Transport developed a Green Transport Strategy 2050, which aims to minimise the adverse impact of transport on the environment, while addressing current and future transport demands. This is underpinned by sustainable development principles. The strategy will promote green mobility to ensure that the transport sector supports the achievement of green economic growth targets and the protection of the environment. The road transport sector contributes approximately 91.2% of total transport GHG emissions. Strategic Pillar 8 includes the promotion of hybrid and electric vehicles.

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SECTION D

Contact Information

Executive Committee

CHAIR
Carol Burelle
Previously Natural Resources Canada
carol.burelle@canada.ca

SECRETARY
James Miller
james.miller@anl.gov

VICE-CHAIR / THE NETHERLANDS
Sonja Munnix
Netherlands Enterprise Agency
sonja.munnix@rvo.nl

VICE-CHAIR / REPUBLIC OF KOREA
Prof. Ocktaeck Lim
Ulsan University, Republic of Korea
otlim@ulsan.ac.kr

AUSTRIA
Andreas Dorda
BMVIT
andreas.dorda@bmvit.gv.at

Walter Mauritsch
Austrian Energy Agency
walter.mauritsch@energyagency.at

BELGIUM
Carlo Mol
VITO
carlo.mol@vito.be

Daan Six
VITO
daan.six@vito.be

CANADA
René-Pierre Allard
Natural Resources Canada
rene-pierre.allard@canada.ca

Carol Burelle
Natural Resources Canada
cburelle.hev-tcp-chair@outlook.com

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
Ariane Rozo
ADEME Service Transports et Mobilité
ariane.rozo@ademe.fr

Jérôme Poyet
ADEME Service Transports et Mobilité
jerome.poyet@ademe.fr

GERMANY

Matthias Laske
Federal Ministry for Economic Affairs and Energy
m.laske@fz-juelich.de

Stephen Schmid
DLR - German Aerospace Center
stephan.schmid@dlr.de

IRELAND

Graham Brennan
Sustainable Energy Authority of Ireland
graham.brennan@seai.ie

Declan Meally
Sustainable Energy Authority of Ireland
declan.meally@seai.ie

ITALY

Francesco Vellucci
ENEA Casaccia Research Centre DTE-PCU-STMA
francesco.vellucci@enea.it

NORWAY

Andreas Bratland
Department for Energy Research
abr@rcn.no

SPAIN

Isabel del Olmo
IDAE - Institute for the Diversification and Saving of Energy
isabel_delolmo@idae.es

Juan Larrazábal
IDAE - Institute for the Diversification and Saving of Energy
jlarrazabal@idae.es

SWEDEN

Peter Kasche
Swedish Energy Agency
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

UNITED KINGDOM

Tim Ward
Department for Transport
tim.ward@olev.gsi.gov.uk

UNITED STATES OF AMERICA

David Howell
US Department of Energy
david.howell@ee.doe.gov

Steven J. Boyd
U.S. Department of Energy
steven.boyd@ee.doe.gov

Task Operating Agents

TASK 01
Kate Palmer
Urban Foresight
kate.palmer@UrbanForesight.org

TASK 23
Hannes Neupert
EnergyBus e.V.
hannes.neupert@EnergyBus.org

Carlo Mol
VITO
carlo.mol@vito.be

TASK 26
Burak Ozpineci
Oak Ridge National Lab
burak@ornl.gov

TASK 30
Gerfried Jungmeier
Joanneum Research
gerfried.jungmeier@joanneum.at

TASK 32
Stephen Schmid
DLR - German Aerospace Center
stephan.schmid@dlr.de

TASK 33
Gerfried Jungmeier
Joanneum Research
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
otlim@ulsan.ac.kr

TASK 37
Steven J. Boyd
US Department of Energy
steven.boyd@ee.doe.gov

TASK 39
Carlo Mol
VITO
carlo.mol@vito.be

TASK 40
Stephen Schmid
DLR - German Aerospace Center
stephan.schmid@dlr.de

TASK 41
Özcan Deniz
DLR - German Aerospace Center
oezcan.deniz@dlr.de

TASK 42
Kate Palmer
Urban Foresight
kate.palmer@UrbanForesight.org

TASK 43
Cristina Corchero
Catalonia Institute for Energy Research (IREC)
ccorchero@irec.cat

TASK 44
Aymeric Rousseau
Argonne National Laboratory
arousseau@anl.gov

TASK 45
P.T. Jones
ORNL Center for Transportation Analysis
jonesp@ornl.gov

ieahev.org