IEA INTERNATIONAL ENERGY AGENCY
HYBRID & ELECTRIC VEHICLE TECHNOLOGY COLLABORATION PROGRAMME

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IA-HEV TASK 24: ECONOMIC IMPACT ASSESSMENT OF E-MOBILITY

THE ECONOMIC IMPACT OF E-MOBILITY IN AUSTRIA
TASK 24 COUNTRY REPORT

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CONTENT

Project Implementing Agreement on Hybrid and Electric Vehicles
Task 24 Economic Impact Assessment of E-mobility

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MANAGEMENT SUMMARY

In 2015 the one millionth electric vehicle took the road following an impressive market growth since the current electricifaction wave started around 2010. Global transition to a low-emission transport system will have to rely heavily on finding renewable energy sources to power our mobility needs. Clean power for transport is not only about setting emission ceilings and toughening our regulatory systems. Importantly for our economies, it also bears significant potential for value added and employment.

This report presents the results of two studies[1] on the economic potential of e-mobility in Austria. Both studies conducted a detailed component-level analysis for vehicles and infrastructure thereby taking into account the importance of the automotive sector in Austria as well as its very high export share of around 90%.

The results are clear: The Austrian industry's strength in e-mobility-related components leads to a significantly higher economic potential of e-mobility when compared to the conventional pathway. It is important to realise this potential and establish new e-

[1] BMWFW, IV, WKÖ (2011). *Elektromobilität – Chance für die österreichische Wirtschaft.* Fraunhofer Austria Research GmbH & TU Wien – Institut für Fahrzeugantriebe und Automobiltechnik
KLIEN (2016). *EMAPP – E-Mobility and the Austrian Production Potential.* Fraunhofer Austria Research GmbH, Austrian Mobile Power, Virtual Vehicle Research Centre

mobility value chains which also result in a changed industry structure. Both studies quantify effects:

- Direct e-mobility related gross value added effects in Austria amount to about €300 million in 2020 and €1.2 billion in 2030. Including indirect effects such as output and services in related industries from chemicals to banking the economic potential rises to €2.9 billion in 2030. Related to this is an employment potential of 3.800 full-time jobs in 2020 which can be expected to rise to 14.800 in 2030. Including related effects the authors expect 35.600 e-mobility-related full-time jobs in the automotive industry until 2030, in a best-case scenario employment potential could amount to 57.100 full-time jobs (Fraunhofer Austria & TU Wien, 2011).

- The 2016 update E-MAPP specifically focussed on production potential and concluded that the potential for Austrian vehicle production between 2015 and 2030 translates into a potential increase of €1.6 billion gross value added and around 17.000 jobs for the entire automotive production in Austria. For Austrian production technologies related to charging and H2 refuelling infrastructure gross value added potential adds up to €250 million and around 2.800 jobs in the period up to 2030. Value added and employment potential for e-mobility related components in Austria amounts to an increase in gross value added of about €200 million and around 2.700 jobs in the period from 2015 to 2030 (Fraunhofer Austria, AMP, VIF, 2016).

In terms of e-mobility patents Austria's automotive industry presented the results of an innovation analysis in a 2016 report[1]: the Austrian automotive sector registers around 348 patents per year. 50 patents specifically focus on E-Car research so based on its inhabitants Austria has the second highest e-mobility inventor concentration in Europe.

INTRODUCTION

Structural data[2]

Population:	~ 8.7 Million (1.1.2016)
Area:	83.879 km^2
Capital:	Vienna
Federal States:	9
Political Districts:	95
Municipalities:	2.354

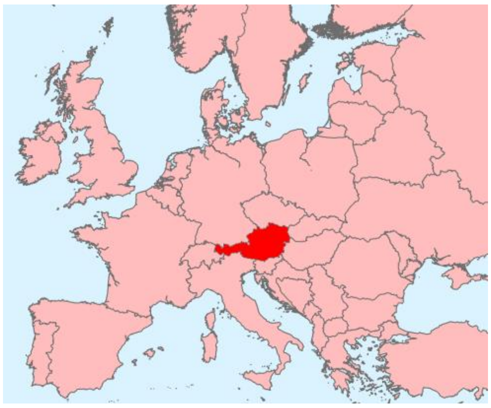

Figure 1: General country characteristics

This report is published as part of Task 24 (Economic Impact Assessment of E-Mobility) of the IEA Implementing Agreement for cooperation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). 8 countries (Austria, Belgium, Denmark, France, the region of Baden-Württemberg in Germany, the Netherlands, the United States of America and Switzerland) defined a common e-mobility value chain with the objective to gain insight into the economic impact of e-mobility within these countries.

E-Mobility value added in Austria covers important parts of the common value chain chosen as a shared model within Task 24. Electric cars (BEV, PHEV and FCEV) on the road reached around 10.500 by the end of October 2016, yet again a 61% increase on the whole year 2015 figures. With more than 700 companies in the Austrian automotive sector vehicle-related valued added, especially EV components, presents an important driving force. But there are also a number of companies engaged in charging infrastructure – ranging from charge point manufacturing to operations and related IT services. Even more varied is the still relatively nascent mobility services sector with the diversity being helped by the fact that the majority of Austrian companies are small and medium sized enterprises (SMEs).

SMEs in Austria[3]

99,7% of all companies
323.600 enterprises
1.898.500 employees

Table 1: Austrian company structure

Even though the understanding of e-mobility in Austria is deliberately broad – viz. "an intermodal mobility system of railway, e-commercial vehicles, e-busses, and e-passenger cars, e-scooters, and e-bicycles"[4] – this country report will mainly focus on passenger-car related and infrastructure value added. Whilst existing data sets clearly show the economic potential of e-mobility, it needs to be pointed out that no specific e-mobility industry data is available for Austria. As a result there is a need to resort to conventional available data sets for e.g. the relevant automotive, energy, ICT or machinery industries with the related implication of potentially over- or understating impacts. In addition, e-mobility (together with other trends like automated driving or digitalization) *transforms* industries and creates new alliances – a process which will be with us for a number of years to come.

Bearing these caveats in mind, the country report on Austria focuses on economic potential in terms of value added and employment potentials and mainly relies on three sources:

- A study conducted in 2011 by Fraunhofer Austria and Vienna Technical University entitled "Electromobility – Chance for the Austrian Economy",[5] which was published by the Austrian industry as well as the Economics Ministry BMWFW;

- A 2016 update of this study led by Fraunhofer Austria entitled "EMAPP – E-Mobility and the Austrian Production Potential" focussing in particular on production technologies, which was commissioned by the Austrian Transport Ministry bmvit;[6]

- For general trends and information on e-mobility in Austria: The annual "AustriaTech Monitoring report E-Mobility", which is commissioned by the Austrian Transport Ministry bmvit.[7]

The result of these first analyses shows a clear tendency, with the 2011 study quantifying the effect: until 2020 e-mobility in Austria has a gross valued added potential of about €300 million and until 2030 of €1.2 billion. Including indirect effects this potential increases to €2.9 billion gross valued added. Related to this is an employment potential of 3.800 full-time jobs in 2020 which can be expected to rise to 14.800 in 2030. Including related effects the authors expect 35.600 e-mobility-related full-time jobs in the automotive industry until 2030, in a best-case scenario employment potential could amount to 57.100 full-time jobs.

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Reading Guide

With every 9th job in Austria linked to the automotive industry and Austria having the 2nd highest E-Car inventor concentration in Europe, the development of alternative drive trains has become a key factor in ensuring competitiveness of the Austrian economy. The country report first describes general trends, policies and relevant e-mobility initiatives in Austria (Chapter 1), gives an overview of the relevant Austrian industry matched to the Task 24 value chain (Chapter 2) and concludes with reporting 2011 and 2016 results on e-mobility gross value added and employment potential (Chapter 3).

CHAPTER 1: E-MOBILITY IN AUSTRIA

DEVELOPMENT OF E-MOBILITY IN AUSTRIA

On 31 December 2015 around 4.7 million cars of class M1 were registered in Austria with 5.032 of these being BEV, 1.512 PHEV and 6 FCEV corresponding to 0.14% of the entire M1 population. Compared to the electric car population in 2014 this was an increase of 57%. Development of EV registrations since 2008 has been significant but the overall share of alternatively fuelled vehicles remains low as a percentage of the entire M1 stock. Whilst 2015 growth was not impressive compared to other markets, a new company tax scheme put in place by January 2016 immediately showed results with BEV registration growth rates of 139% (January), 221% (February), 133% (March), 238% (April) compared to 2015 numbers. New BEVs registered in the first four months of 2016 (1.330) nearly correspond to the entire number of new registrations in 2015.

ELECTRIC VEHICLE POPULATION

Vehicle Type, Fuel Type / Energy Source	2010	2011	2012	2013	2014	2015	2016 (Q3)
Cars M1	4.441.027	4.513.421	4.584.202	4.641.308	4.694.921	4.748.048	4.812.794
Petrol inc. Flex Fuel	2.445.506	1.997.066	2.001.295	2.003.699	2.011.104	2.019.139	2.038.589
Diesel	1.988.079	2.506.511	2.570.124	2.621.133	2.663.063	2.702.922	2.741.857
Battery-Electric (BEV)	353	989	1.389	2.070	3.386	5.032	8.142
Gas poweed Vehicles	n/a	2.670	3.109	3.651	4.262	4.775	4.978
Plug-In-Electric (PHEV)	n/a	n/a	n/a	408	776	1.512	2.391
Hydrogen (FCEV)	n/a	n/a	n/a	n/a	3	6	13
Electric Vehicle Population M1	**353**	**989**	**1.389**	**2.478**	**4.165**	**6.550**	**10.546**
Electric Vehicle - Change on Previous Year	**58,3%**	**180,2%**	**40,4%**	**78,4%**	**68,1%**	**57,3%**	**61,0%**
Share of EVs in M1 population	**0,01%**	**0,02%**	**0,03%**	**0,05%**	**0,09%**	**0,14%**	**0,22%**
Other battery electric vehicles of classes L, M, N	**3.217**	**4.024**	**5.120**	**5.594**	**6.067**	**6.532**	**7.845**
Motorbikes/Trikes/Quadricycles (class L)	3.034	3.772	4.565	4.835	5.116	5.324	6.243
Busses (class M2 und M3)	113	116	126	139	131	138	152
Duty Vehicles Class (< 3.5 t)	69	135	428	619	819	1.069	1.449
Duty Vehicles Class (> 3.5 t)	1	1	1	1	1	1	1

Table 2: Vehicle population M1, L, M, N – 2010-2016 (3. quarter), based on Statistik Austria

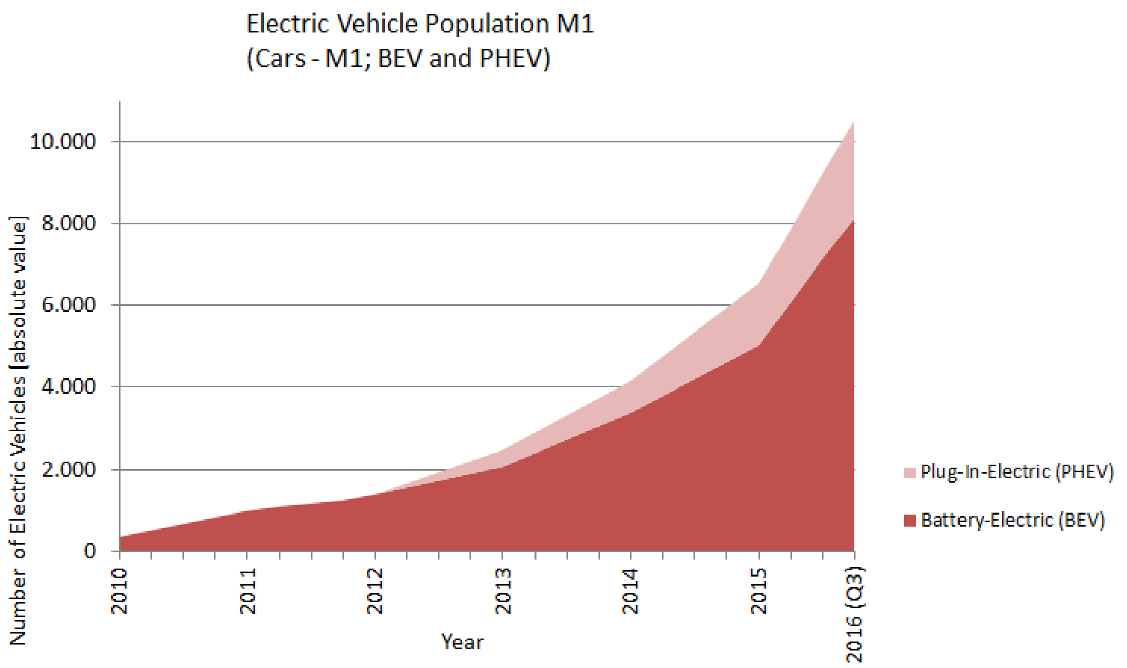

Figure 2: Electric vehicle population M1 – 2010-2016 (3. quarter) , based on Statistik Austria

ELECTRIC VEHICLE REGISTRATIONS

Vehicle Type, Fuel Type / Energy Source	2010	2011	2012	2013	2014	2015	2016 (Q3)
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Petrol inc. Flex Fuel	2.445.506	1.997.066	2.001.295	2.003.699	2.011.104	2.019.139	2.038.589
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Table 3: New vehicle registrations M1, L, M, N – 2010-2016 (3. quarter), based on Statistik Austria

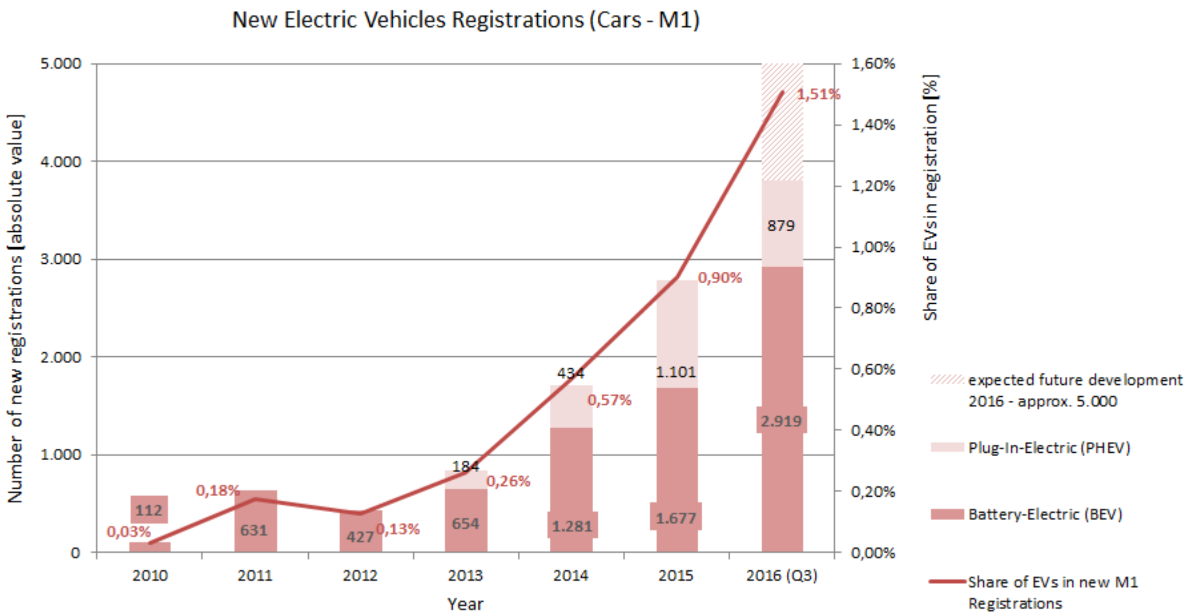


Figure 3: New electric vehicle registrations M1 – 2010-2016 (3. quarter), based on Statistik Austria

ELECTRIC VEHICLE REGISTRATIONS 2015 – BEV SALES BY MANUFACTURER

In 2015 most new BEV registrations were Teslas (492), corresponding to 30% of all newly registered BEVs in Austria. The US carmaker was followed by 2014's number one Renault (279). In third place of new BEV registrations 2015 came BMW (228). In general, the 2015 market was driven by new PHEV registrations with an increase of 153% on 2014.

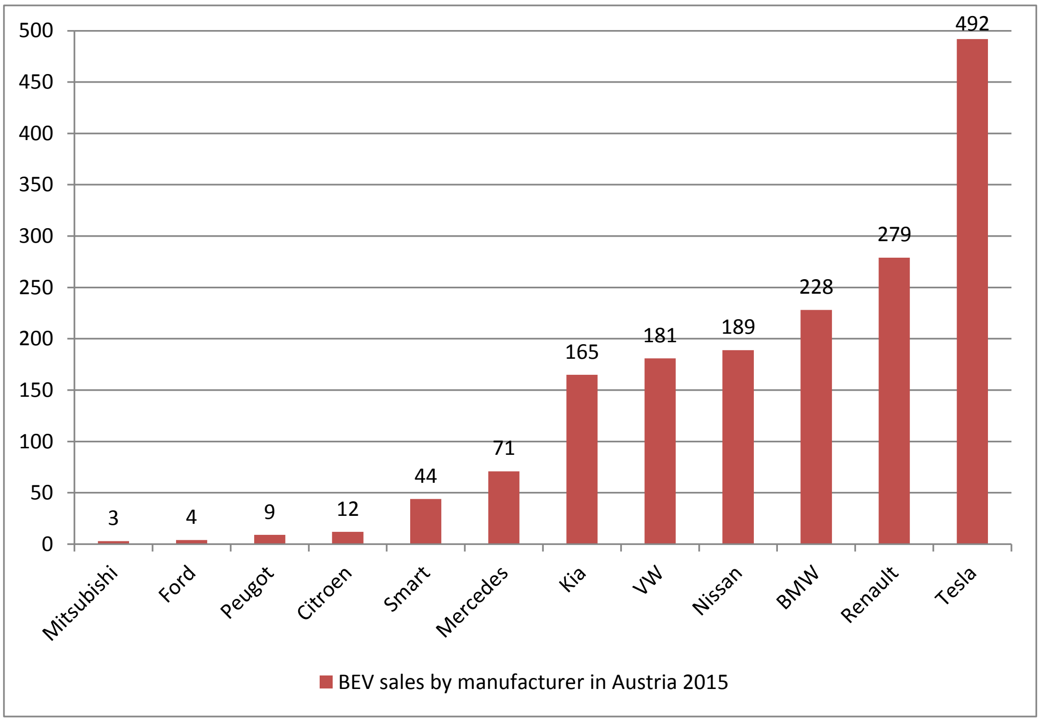


Figure 4: BEV sales by manufacturer 2015, based on Statistics Austria data

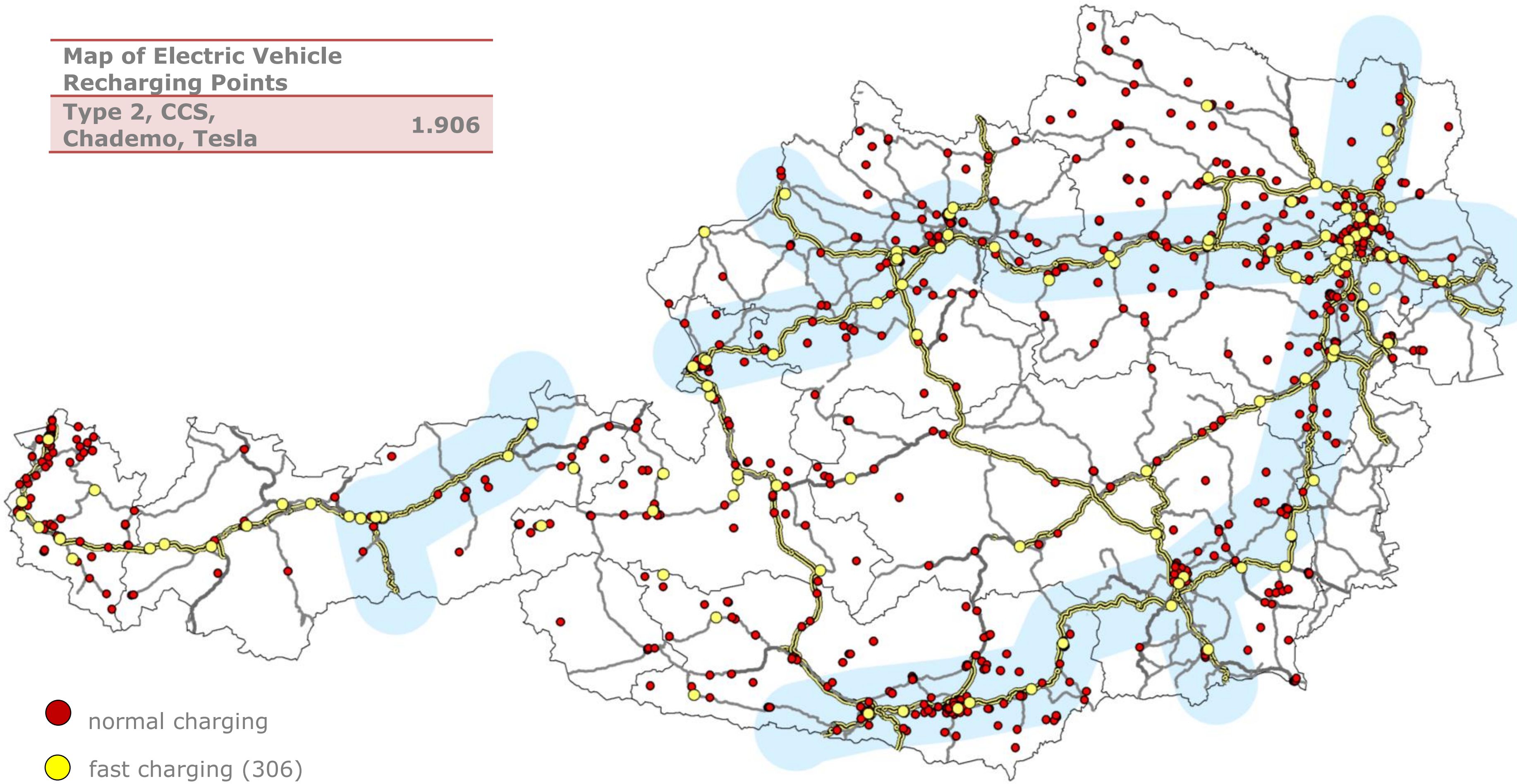
NUMBER OF EVSE

Figure 5 shows 1.906 recharging points (October 2016), which are relevant for reporting under EU Directive 2014/94 (Type 2, CCS, Chademo, Tesla) and is based on data from the Charging Infrastructure platform http://e-tankstellen-finder.com.

In October 2016 the platform E-Tankstellenfinder showed **306 fast charger locations** (> 22kW) in Austria with one charging station usually offering multiple charging points.

The currently ongoing implementation in Austria of EU Directive 2014/94 goes along with the creation of a register indicating the geographic location of refuelling and recharging points accessible to the public of alternative fuels.

Figure 5: Map of Electric Vehicle Recharging Points in Austria, 10/2016, based on http://e-tankstellen-finder.com, database map: basemap.at



STATUS OF ELECTRIC DRIVING ON INNOVATION ADOPTION CURVE

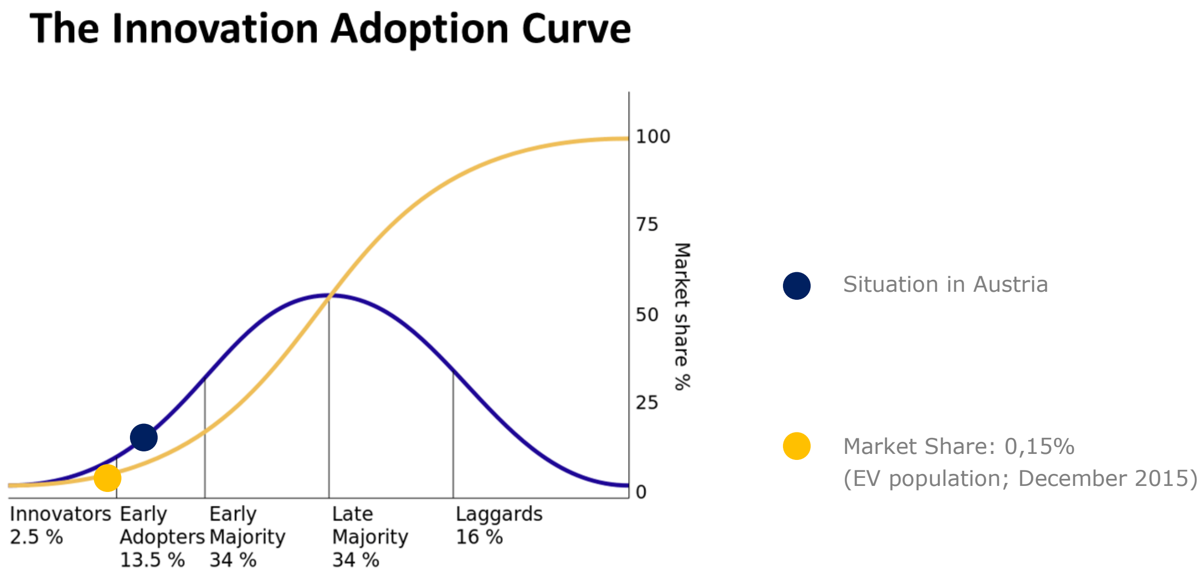


Figure 6: Electric driving innovation adoption curve Austria, position based on feedback collected from A3PS and Austrian Mobile Power

INNOVATION SYSTEM

The Austrian electric driving innovation system is broad ranging from basic and applied research over a variety of demonstration activities to a wide range of companies from the automotive, energy, ICT and mobility sectors engaged in product development.

Government funding activities match this variety. It is widely recognised that e-mobility presents the opportunity to substantially reduce GHG emissions and to create a sustainable transport system. Apart from Austria's very favourable starting position, featuring a share of more than 30% renewable energy on its final energy consumption (70% renewable energy in the electricity sector), there are a number of well-established R&D programs, initiatives and demonstration projects. An overview of the most important projects is given at the end of Chapter 2.

R&D spending in Austria has followed an upward trend with total R&D spending in 2015 amounting to over €10 billion. Public R&D spending especially for energy-related research has tripled since 2007 amounting to nearly €145 million in 2014.[8] Since 2002 the Austrian federal state has spent around €75 million on a mix of e-mobility-related funding ranging from research to direct vehicle support.[9] In addition, there are a number of e-mobility funding initiatives on the regional and municipal levels.

Summarising necessary RTD efforts, in 2015 the public-private partnership of automotive industry, research and Transport Ministry A3PS published a roadmap "Eco-Mobility 2025plus", representing Austria's expertise in the field of advanced vehicle technologies and energy carriers and providing a comprehensive perspective on future vehicle technology tends until 2025 and beyond.[10]

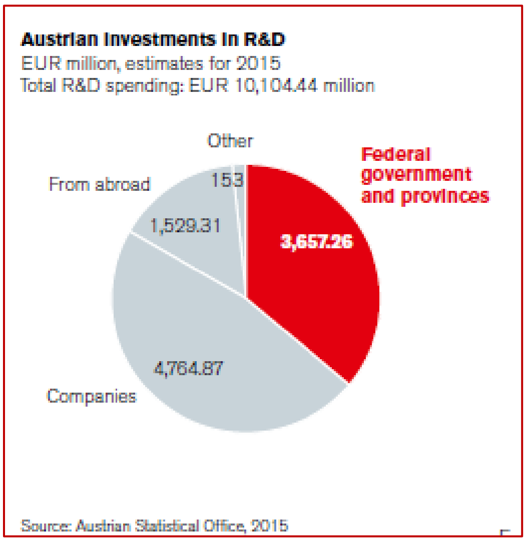


Figure 7: Austrian investments in R&D, taken from ABA[11] based on Statistik Austria

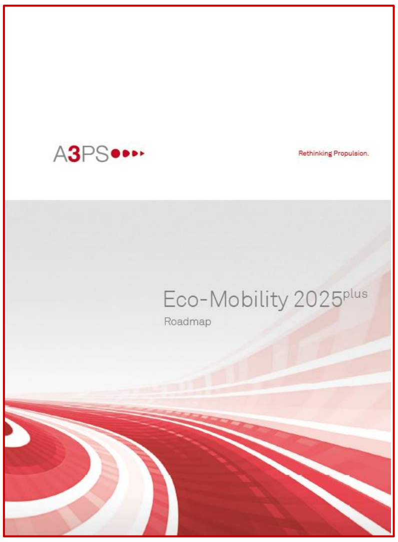


Figure 8: A3PS roadmap Eco-Mobility 2025^{plus}

Figure 9 summarises the eco-system of relevant funding, the governmental actors as well as e-mobility associations. The relevant industry is described in Chapter 2.

PATENTS

The Austrian Automotive Industry in May 2016 presented a patent analysis focusing specifically on E-Cars[12]. Over the past 5 years 253 inventors in Austria registered 233 E-Car patents – since 2006 the number of registered E-Car patents has doubled. Based on its inhabitants Austria has the second highest concentration of E-Car inventors in Europe (3.2 inventions per 100.000 inhabitants) and is only behind Germany (4.1).

Important companies include AVL List (45 patents, 58 inventors), Magna Steyr (16, 21), Magna Powertrain (13, 26), Siemens (9, 15), Fronius International (9, 14), Bosch (7, 4), Magna ECar (7, 13), Kapsch Trafficcom (7, 3) or KEBA AG (7, 2).

Observation period	Patent registrations	Annual average
2001-2005	32	6,4
2006-2010	101	20,2
2011-2015	233	46,6

Table 4: E-Car Patent Registrations in Austria, Source: Economica

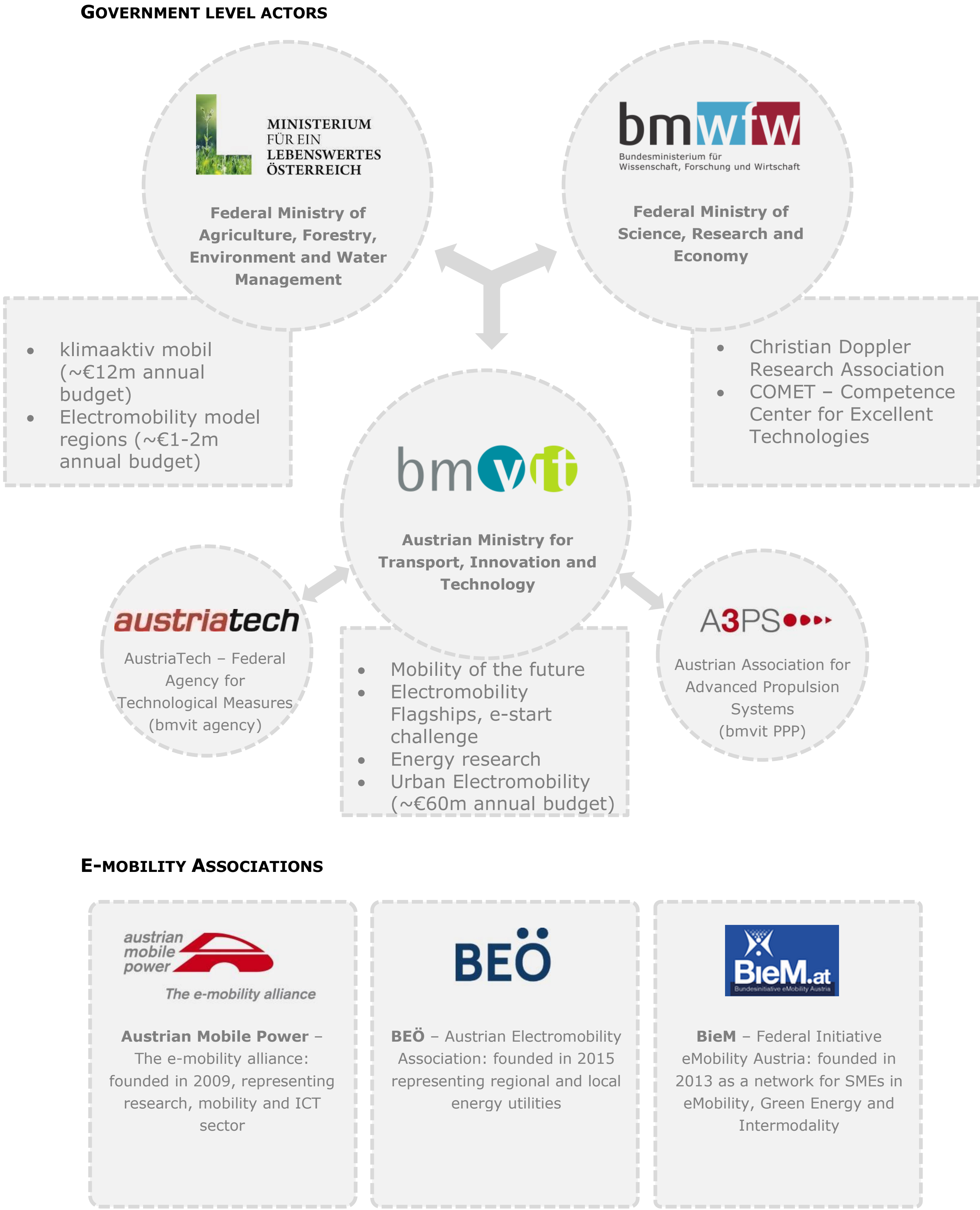


Figure 9: Government level e-mobility actors and national-level e-mobility associations

POLICY ON E-MOBILITY AND DESCRIPTION OF SPECIFIC MEASURES

Austria sets a wide-range of policies on the national, regional and local levels to promote e-mobility. The strategic framework is provided on the national level by the Electromobility Implementation Plan "Electromobility in and from Austria", which was jointly published by the Transport, Economics and Environment Ministries. Some of Austria's 9 federal states have regional e-mobility strategies and some of the larger cities have also integrated e-mobility in their local mobility planning.

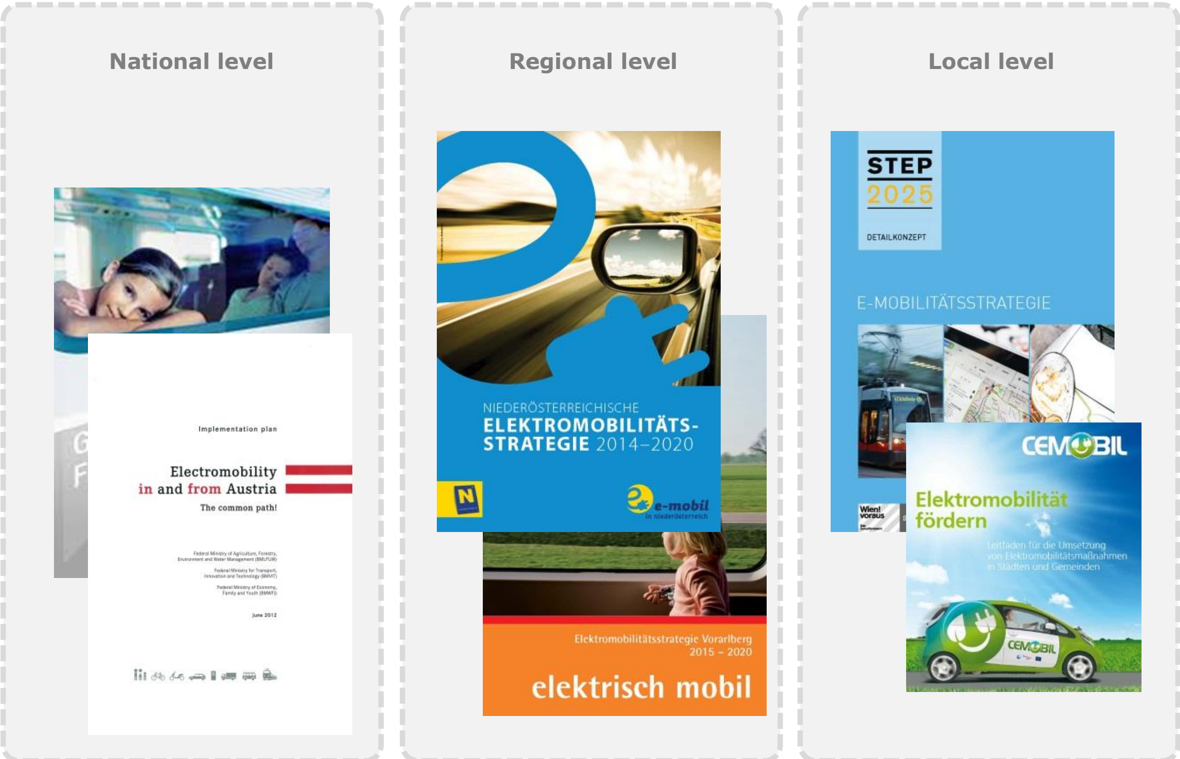


Figure 10: Examples of Austrian national, regional and local level e-mobility strategies

Figure 11 gives a broad overview of policy incentives in Austria. The most important changes in 2016 include:

- **On the national level:** 2016 saw the introduction of a new company car taxation scheme which excludes electric vehicles from private usage taxation. Vehicles with CO_2 emissions of 0 Gramm (BEVs and FCEVs) are completely exempted from this tax. Also, such vehicles are eligible for pre-tax deduction. In addition, the national procurement agency BBG has started a tender for EVs.
- **On the regional level:** With building codes in Austria being a matter of regional legislation several federal states plan adapting such that charging infrastructure can be easier installed. Also, in the context of implementing Directive 2014/94 in Austria, regions and national level together work on a unified permission system for the installation of charging infrastructure.
- **On the local level:** Municipalities' policy is quite varied with a number of cities having introduced e-mobility incentives. If the local level shows sufficient drive to step up incentives a new vehicle classification and labelling system will be introduced in 2016.

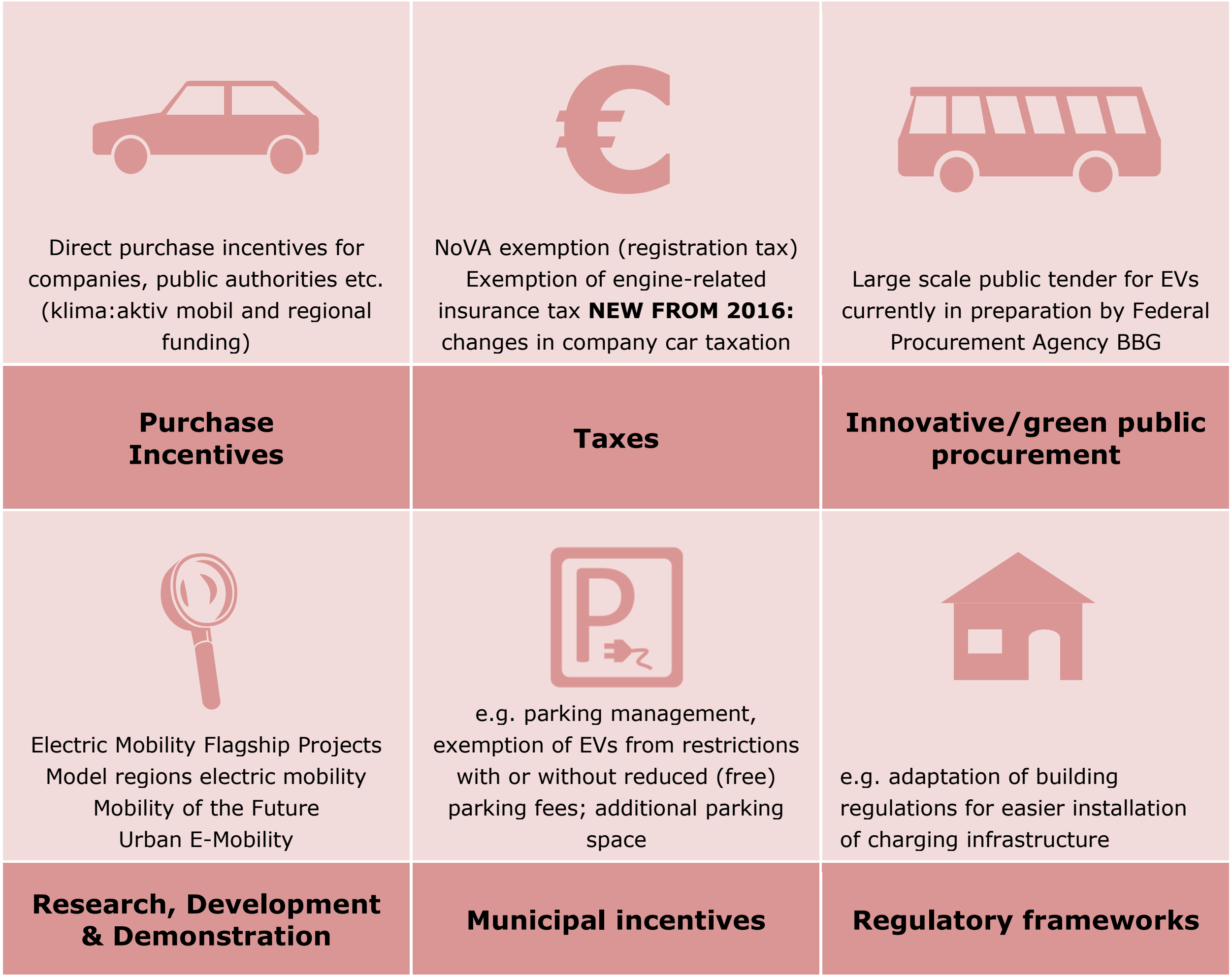


Figure 11: Overview of Austrian policy incentives for e-mobility

CHAPTER 2: INDUSTRY DESCRIPTION

Relevant industry sectors for e-mobility in Austria cover the four main categories of the common value chain defined as part of Task 24, viz. electric vehicles, charging infrastructure and energy as well as mobility services. Relevant industries are automotive, machinery industry, metal industry, electronics, electrical engineering, and ICT in addition to further relevant services. With no e-mobility-specific data being collected available studies extract conclusions from broader sector data (see Chapter 3). In general e-mobility is always treated as a system consisting of vehicles, infrastructure and services.

INDUSTRY DESCRIPTION FOR THE COMMON VALUE CHAIN

Chapter 2 gives a broad description of the Austrian industry covering the four main categories in the common value chain electric vehicles, charging infrastructure, energy and mobility services. Given the role of the energy sector in providing charging infrastructure the corresponding sectors are described in one section.

ELECTRIC VEHICLES

Focusing on value added most important for the economic potential of e-mobility in Austria is the automotive sector with more than 700 companies, up to 480.000 direct and related jobs, an annual turnover of €23 billion and, importantly for an innovative sector, an R&D rate of 12%.[13] In terms of industry structure the range of automotive services is very heterogeneous but there are only a few companies specialised on car and engine production thereby contributing about 60% of the entire industry turnover. Another 60% of companies contribute only 5% of turnover with the production of vehicle bodies and superstructures.[14]

Nearly 250.000 motor vehicles are assembled in Austria every year including passenger cars, motorcycles, trucks and tractors. 2.2 million engines and transmissions are manufactured in Austria each year and the automotive sector secures every 9th job in the country.[15] With an export rate of 90% and the highest share of researchers – about 14%[16] - the Austrian automotive sector offers particularly promising chances for e-mobility.

Key data – automotive sector (2014)[17], [18]	
Annual turnover	23 billion Euro
Market share Austria in global production	1.5% (13.3 billion Euro)
Market share Austria in global automotive electronics	0.3% (0.7 billion Euro)
Market share Austria in mechanical components	2.0% (12.6 billion Euro)
Employment (direct)	30.000
Employment related	450.000
R&D spending per employee	€19.650
Export share	90%

Table 5: Overview Austrian automotive sector, Fachverband Fahrzeugindustrie (2014, 2015)

The 2016 study E-MAPP focusing on production technologies identifies four value added areas, viz. electric engines, battery technology, fuel cells and power electronics with high innovation potential. Also, light weight design shows good value added potential for Austria though this cannot be specifically traced back to e-mobility. Austrian competence ranges from the component level such as battery production (in 2015 the Korean company Samsung took over the battery production from Austrian company Magna[19]; the Austrian company Kreisel, specialized on E-conversions and their high performance battery packs, announced the production of 40.000 batteries for vans and trucks in Asia[20]) to system integration. The Austrian industry is organized in a number of relevant networks (Table 6).

Austrian Automotive Clusters and networks	
AC Styria	220 members of the Styrian mobility industry including AT&S, AVL, EFKON, Infineon, Kapsch, MAGNA, NXP, Siemens, voestalpine
Upper Austrian Automobile Cluster	Austria's biggest automotive cluster with 250 companies covering the industry from Tier1 suppliers to SMEs including Continental, Fronius, MAN, BMW
A3PS – Austrian Association for Advanced Propulsion Systems	Public Private Partnership of the Austrian Transport Ministry and research as well as industry in the areas of advanced propulsion systems and energy carriers

Table 6: Overview Austrian Automotive Networks

With the Austrian automotive sector having the relatively highest share of researchers, Austrian research competence, specifically in the field of advanced power train and vehicle technologies as well as energy carriers, is also an important factor. Figure 12 gives an overview of some of the most active research institutions in the field:

Figure 12: Overview of Austrian research institutions in the automotive sector

Austrian strengths in Electric Vehicles

The 2011 Fraunhofer Austria and TU Wien study as well as its 2016 update on the Economic Potential of E-Mobility conducted a detailed analysis at component level which mapped both the competencies of Austrian companies as well as international competition and potential barriers to market entry. Table 7 summarises the results. The column "multi-use" signifies whether a particular component can be used in different vehicle concepts, which – given the strong Austrian position in the production of conventional vehicles – is important for a transition scenario.

Potential	Component	Multi-Use
high/ above average	Battery management	Yes
	Body – lightweight design, insulation	Yes
	Power electronics	Yes
	Charging station (see below)	-
neutral	Fuel cell	No
	Electric engine	Yes
	Transmission	Yes
	Combustion engine	Yes
low	Exhaust gas treatment	Yes
	Fuel tank	Yes
	Sound management	Yes
	Thermal management	Yes

Table 7: Component overview and component economic potential for Austria, Fraunhofer Austria and TU Wien (2011), Table adapted from original version based on update by Fraunhofer Austria et.al (2016)

The 2016 update E-MAPP, focusing on e-mobility-related production potential for Austria, mapped potential companies that cover critical parts of the value added chain. The mapping included 25 relevant companies for the production of electric engines, 10 relevant companies for fuel cells production technologies, 18 possible Austrian producers for battery technology, 65 Austrian companies in power electronics and 18 focusing on lightweight design – the overwhelming majority of the companies producing in Austria.

Even though this report focuses mainly on passenger vehicles, it is actually the E-Bike market which is very dynamic in Austria: Austria's biggest producer of bicycles KTM Fahrrad GmbH announced in the beginning of 2016 that E-Bikes account for half of KTM's annual revenue.[21] The above-mentioned company Kreisel announced the opening of a new battery production site for March 2017 with around 70 new jobs.[22]

CHARGING INFRASTRUCTURE & ENERGY

The charging infrastructure market in Austria includes charge point manufacturers as well as a number of services related to charge point operation. With charge point operations being very much driven by the Austrian energy sector these two sectors of the common value chain are described together for Austria.

For the full environmental potential of e-mobility to come to pass the electricity used for driving should come from renewable sources. Renewable energy accounts for 78.4% of Austrian energy production, 29.8% of gross inland energy consumption and 32.5% of gross final consumption of energy[23] placing Austria in a very favourable starting position for sustainable e-mobility. In addition to direct employment (see Table 8) the Austrian energy sector secures 1.5 jobs in other relevant sectors such as building.

Annual investments of energy industry	1.5 billion Euro
Employment (direct)	14.500
National value added	1.9 billion Euro (entire production effect: 2.9 billion Euro)

Table 8: Overview of Austria's energy industry, based on Oesterreichs Energie[24]

Important for future e-mobility in combination with the energy sector are developments in the area of smart grids. Industry and research are collaborating in the technology platform Smart Grids Austria (www.smartgrids.at) which is working on a transition from research and development to an Austrian lead market. Figure 13 gives an overview of Austrian Smart Grids activities.

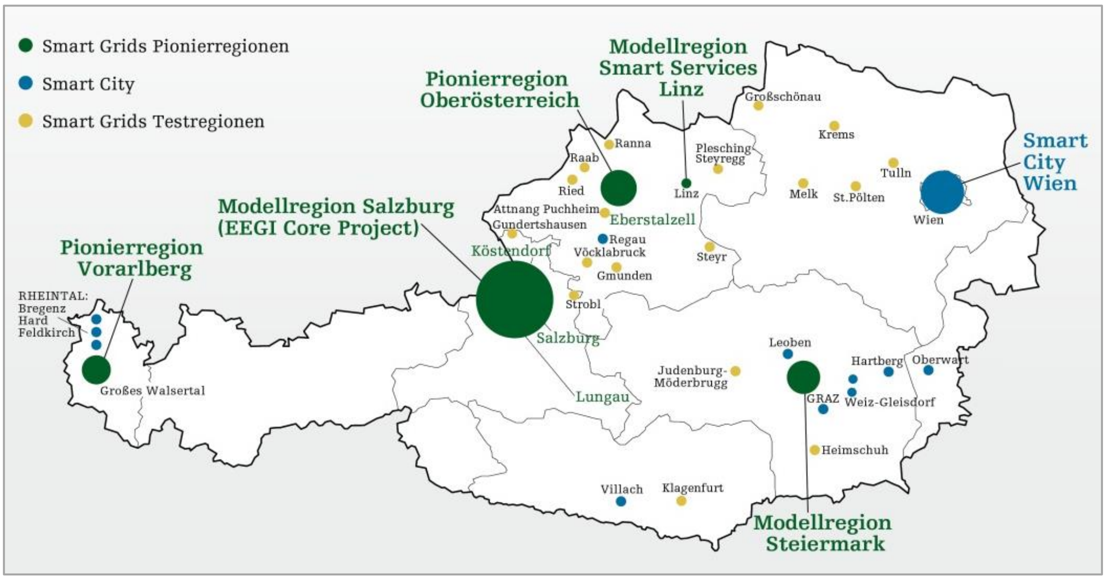


Figure 13: Overview of Austrian Smart Grids Test Regions, KLIEN & bmvit (2014)[25]

Due to e-mobility being a relatively young and dynamic market there are still no industry-specific data for charging infrastructure even though studies on the economic potential give some information on potential value added (Chapter 3). Relevant are both the ICT and electronics sectors with Table 9 summarising sector-level data.

	ICT / electronics (2014)	Electrical equipment (2014)
Turnover	4,9 billion Euro	11,7 billion Euro
Employment (direct)	21.351	45.170
Export data	~ 80%	

Table 9: Overview Austrian electronics and electrical equipment sectors, performance and structure statistics 2014 (Turnover & employment)[26], FEEI (2015 (export data))[27]

Austrian companies are active in charge point manufacturing, the operation of charge points as well as in the provision of services surrounding charge point operation and use. Nearly all of Austria's charge points are operated either by local or regional energy suppliers (many of which formed the e-mobility association BEÖ in 2015) or the company Smatrics, which is a joint-venture of energy company Verbund and Siemens. The potential for new participatory business models (similar to those already used in renewable energy) is shown by Austrian company ELLA, which builds charging infrastructure crowd-financed by citizen participation. E-Mobility services are supplied by a number of companies ranging from start-ups to large multinationals with e.g. NTT Data steering its international e-mobility business from Austria. Figure 14 gives an overview of Austrian companies involved in the charging infrastructure market.

With e-mobility also covering FCEV and the corresponding infrastructure it is important to note that Linde AG started series production of H2 infrastructure in Vienna in 2014.[28]

COMPANIES CHARGING INFRASTRUCTURE

Charge Point Manufacturers

Charge Point Operators

Charge Point Service Suppliers

Production / Operation of Hydrogen Stations

Figure 14: Overview of Austrian companies active in charging infrastructure for e-mobility

MOBILITY SERVICES

Mobility services are in many cases a nascent but highly dynamic sector with no specific industry data available. For Austria as for many markets "Mobility as a Service" is now used as a concept describing the use of a variety of mobility service such as public transport, car sharing, taxis or city bikes through a single interface which is offered by mobility operators. Customers receive information, book and pay services through mobility operators via (often also) mobile applications. Mobility services also include the freight sector.

"Mobility as a Service" would in the end allow new business models (offering e.g. different monthly mobility packages or pay-as-you-go services) and brings together a range of different industries from a variety of transport and payment services or the automotive sector itself (with e.g. BMW being an example of an OEM which redefines itself as a mobility operator including electric car-sharing, parking services, charging services etc.[29]).

Key for such a range of combined services are not just performing ICT systems which allow "transport roaming" (going well beyond current developments in the interoperability of charging infrastructure) but also a complete shift in the way mobility is organised as well as a corresponding adaptation of legal frameworks. In the end, planning paradigms will shift away from infrastructure-based planning to service thinking. E-mobility has already led to new co-operations and industry alliances bringing together automotive, energy and ICT services – "Mobility as a Service" (potentially in combination with a broader introduction of automated driving in the coming years) will demand an even greater openness to new forms of cooperation and new instruments to support these by public authorities. By supporting living lab research approaches by means of funding so-called "Urban Mobility Labs"[30] the Austrian Transport Ministry has taken this change into account.

E-Mobility in Austria is a starting point for a transition towards "Mobility as a Service" which in the end aims at increasing the efficiency of our transport systems. The Austrian e-mobility implementation plan 2012 emphasised the potential of e-mobility to induce changes in mobility behaviour.

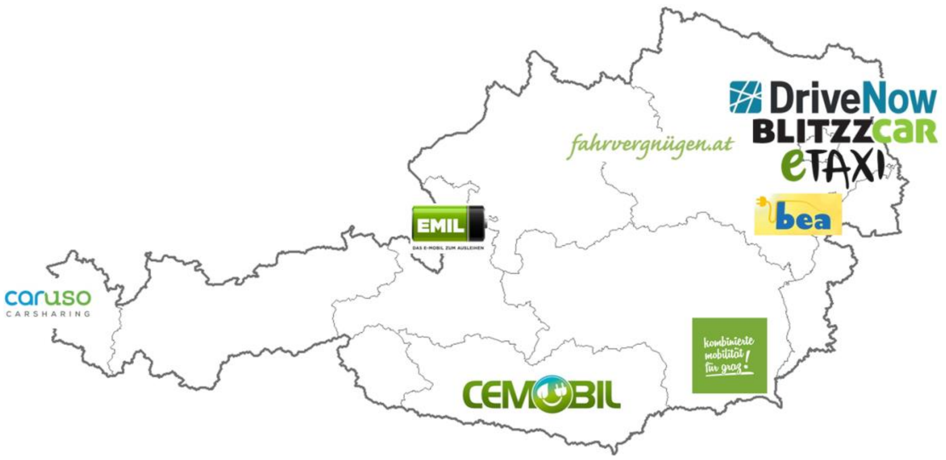


Figure 15 gives an overview of the larger E Car-Sharing and E-Taxi schemes in Austria which can only serve as an example for dynamic developments.

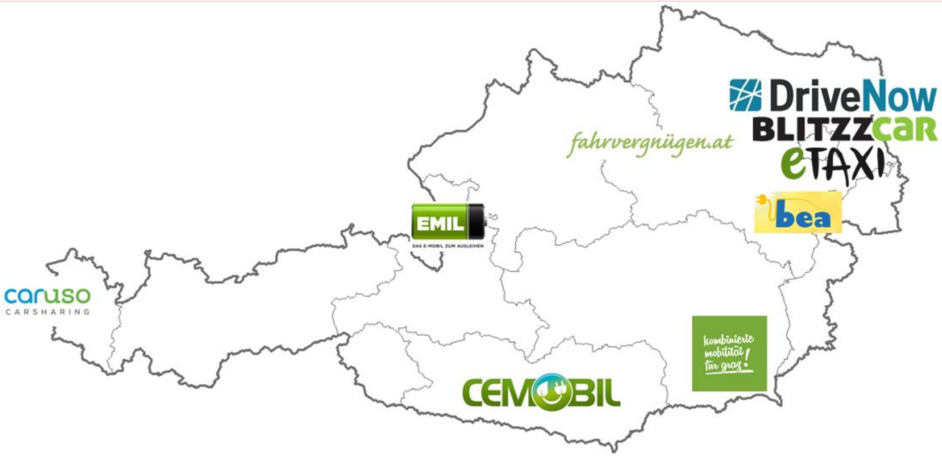


Figure 15: Overview of larger Austrian E-Taxi and E-Carsharing initiatives

Overview of the relevant e-mobility project landscape

With e-mobility still being a nascent industry, especially in services value added, many of the existing initiatives and also some companies were started as publicly funded projects. Table 10 gives an overview of the large-scale demonstration projects funded by the Austrian Transport Ministry over the past years, followed by a map of e-mobility model regions which are financed by the Austrian Environment Ministry (Figure 16).

Project	Content	Main companies involved
EMPORA I + II – E-Mobile Power Austria (2009 – 2014)	22 leading industrial and research companies collaborated on establishing an integrated e-mobility concept covering the entire value chain from vehicle to mobility services	Verbund (lead), A1, AIT, ATOS, AVL, EVN, infineon, Linz AG, Magna Steyr, Raiffeisen Leasing, REWE, Salzburg AG, Siemens, Wiener Linien & Wien Energie
E-LOG-Biofleet (2010 – 2014)	Development and integration of fuel cells with compressed hydrogen tanks for improving electric industrial trucks. Build-up of Europe's first indoor H2 refuelling station in a logistics warehouse.	HyCenta (lead), Linde, OMV, Fronius, Schenker, Joanneum Research
CMO – Clean Motion Offensive (2011 – 2014)	Development of cost-efficient components for the vehicle industry as well as charging infrastructure applications	AC Upper Austria (lead), FH Upper Austria, KEBA, Lagermax, Lightweight Energy Linz AG, smart e-mobility, Steyr Motors, TU Graz
eMORAIL (2010 – 2014)	Development of a concept for innovative, cost-efficient and green mobility solution for commuters	Austrian Railways ÖBB (lead), Denzel Mobility CarSharing, Sycube, Herry Consult, Hraz University, NTT Data
SMILE – Smart Mobility Info & Ticketing System (2012 – 2015)	Development of a Smart Mobility Platform combining information, booking and payment and integrating e-mobility	Wiener Stadtwerke, ÖBB (lead), Fluidtime, NTT Data, TU Wien
VECEPT – All Purpose Cost	Development and testing of a	AVL (lead), AIT, ecoplus,

Efficient Plug-In Electric (Hybridized) Vehicle (2012 – 2015)	PHEV serving as a volume model for the global market (planned market entry 2017)	Fluidtime, IEASTA, Infineon, Magna, Vienna University, Samaritans Vienna, Verbund, VIF
CROSSING BORDERS (2013 – 2016)	Creation of intelligent cross-border systems for e-mobility, building on EMPORA combining 13 companies from 4 countries	Verbund (lead), AIT, E.ON, Smatrics, Ecotech, Fluidtime, Ovos Media, Siemens, transport planning Käfer
EMILIA – Electric Mobility for Innovative Freight Logistics in Austria (started 2014)	15 Austrian companies collaborating on the technological optimisation of vehicles and logistics concepts	AIT (lead), AMP, AC Upper Austria, Bitter, DPD, ECONSULT, Gebrüder Weiss, Magna Steyr, Miba, REWE, Schachinger, Signon
eMPROVE – Innovative solutions for the industrialisation of electrified vehicles (started 2015)	Development of innovative solutions for the industrialisation of electrified vehicles with a focus on future mass production	IESTA (lead), AVL, Magna Steyr, AIT, Montanuniversity Leoben, Saubermacher, virtual vehicle, LKR Ranshofen, Zörkler Gears, ATT
KombiMo II – Graz (started 2015)	Introduction of E-Taxi and E-Car-Sharing Services in the City of Graz	Holding Graz (lead), Energie Graz, Chamber of Commerce Styria, e-mobility Graz, TU Graz, FH Joanneum, City of Grat
eTaxi Wien (started 2015)	Introduction of E-Taxi Services in the City of Vienna	Neue Urbane Mobilität (lead), Wien Energie, Chamber of Commerce Vienna, Taxi 31300, Taxi 40100, Metro Taxi,
SEAMLESS (started 2016)	Sustainable, Efficient Austrian Mobility with Low-Emission Shared Systems will test e-fleet concepts focusing on company car sharing	AIT (lead), Austrian Postal Services, Herry, tbw, Spectra, im-plan-tat, iC consulenten, ETA, T-Systems, ENIO, FRONIUS, Kalomiris, ecoplus, Greenride
LEEFF (started 2016)	Low Emission Electric Freight Fleets focuses on cost effective fleet management with the aim of significantly decreasing inner-city emissions caused by logistics services	i-LOG Integrated Logistics (lead), Council Sustainable Logistics (BOKU), Vienna University, Kreisel Electric, SATIAMO, Energie Ingenieure, SMATRICS, Schachinger, Greenway, SPAR, Quehenberger Logistics, FH Upper Austria, Consistix, Oberaigner Powertrain

Table 10: Large-scale Austrian e-mobility demonstration projects funded by Transport Ministry bmvit

Figure 16: Overview of Austrian E-mobility Model Regions funded by Environment Ministry BMLFUW

CHAPTER 3: ECONOMIC IMPACT INDICATORS

Electrification will lead to value added changes in a number of industries, mainly in the automotive sector but also in related industries such as energy or electronics. Quantifying these effects remains a challenge in the absence of industry-specific data but detailed analyses for Austria show a clear trend which confirms the economic potential of cleaning vehicles for Austria and beyond.

Chapter 3 describes the methodology used and results from the 2011 study on the Economic Potential of E-Mobility for Austria (BMWFW, IV, WKÖ. *Elektromobilität – Chance für die österreichische Wirtschaft*) carried out by Fraunhofer Austria and TU Wien as well as a 2016 update of this study (BMVIT. E-*MAPP – E-Mobility and the Austrian Production Potential*) conducted by Fraunhofer Austria, AMP and VIF. Economic impact is shown for (1) gross value added and (2) employment. Effects on exports were not specifically analyzed but with the automotive sector being the most important in terms of e-mobility potential the current export rate of about 90% clearly signifies that for a small open economy such as Austria exports are important. E-MAPP focuses specifically on production potential and draws conclusions based on more recent figures so Chapter 3 mainly reports E-MAPP results.

An important point, which is currently not quantified at all, concerns job quality. Certain components such as power electronics will become much more important for future automotive production with corresponding implications for skills. Future automotive jobs will probably require even higher levels of specialization and a shift away from traditional competencies so that any potential employment effect should always be analyzed in line with qualification needs and possible skills shortages.

METHODOLOGY

In order to quantify value added and employment potential of e-mobility both studies started from a portfolio of different vehicle segments including a variety of drive trains. Similarly, the authors used an infrastructure portfolio including slow, accelerated and fast EV charging as well as hydrogen refueling stations. Vehicle types used for the analysis included a conventional reference vehicle, a Plug-In-Hybrid Vehicle (PHEV), a Range Extender Vehicle (REX), a Battery Electric Vehicle (BEV) as well as a Fuel Cell Electric Vehicle (FCEV).

Both studies carried out a detailed component-level analysis which allowed the matching of necessary components for e-mobility with existing Austrian competencies as well as global market potential. Integrating the global market is necessary given the strong international economic integration specifically in the Austrian automotive sector.

The team used databases (e.g. MARKUS containing extensive information on 1.4 million companies in German, Austria and Luxemburg) in addition to desktop research and expert interviews to validate results. Figure 17 gives an overview of how e-mobility value added and employment potential were derived in the study (the methodology specifically for production is shown in Figure 21 below). Figure 18 shows how Austrian world market share was determined.

Due to the very detailed analysis at sub-component level it was possible to perform a detailed matching of potentials to value added classes and hence deduct employment potential. The results can be aggregated in different forms, e.g. Austrian NACE classes, vehicle components or vehicle concepts. E-MAPP focused specifically on production potential and combined unit number scenarios, expected world market share and production costs in order to determine potential production values for Austria. Specific production potential analyses were conducted for electric engine production, fuel cell production, lithium-ion battery production and power electronics production.

Figure 17: Method to quantify e-mobility value added and employment potential for Austria, Fraunhofer Austria et.al (2016), adapted by AustriaTech for Task 24 country report Austria

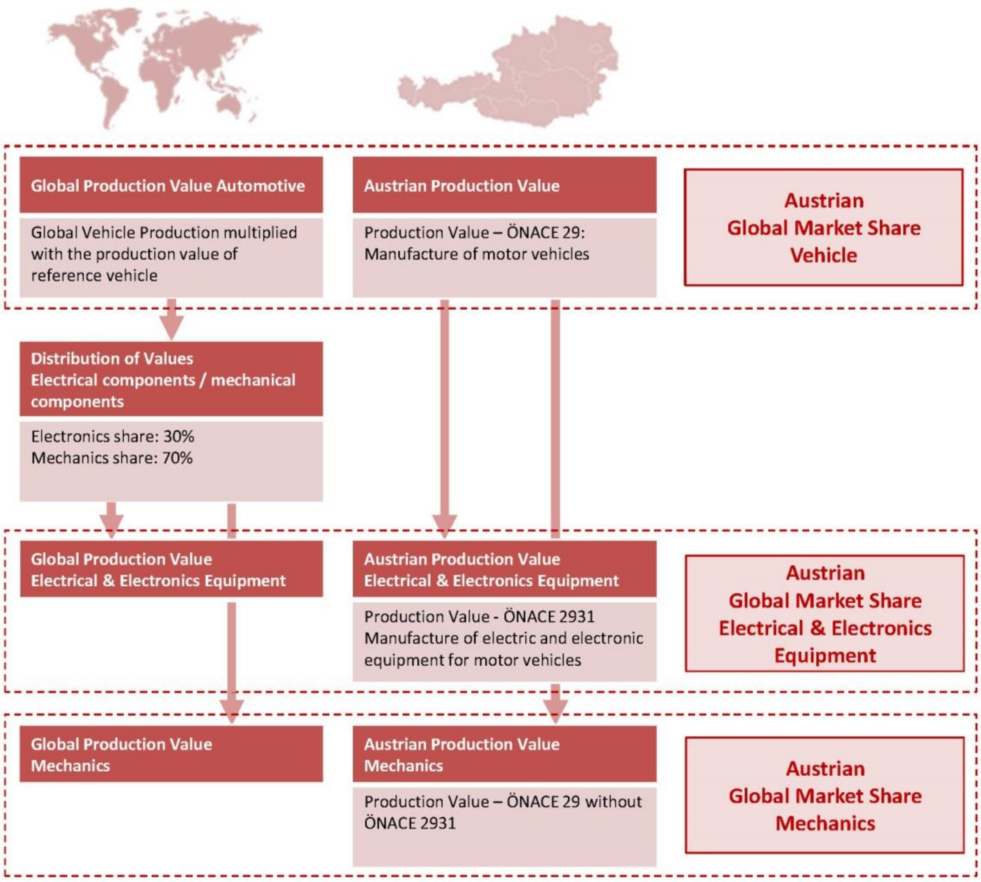


Figure 18: Method for determining starting values of Austrian global market share, Fraunhofer et.al (2016), adapted by AustriaTech for Task 24 country report Austria

Assumptions on global unit number scenarios for vehicles and infrastructure and production costs

In order to quantify value added and employment effects the team assumed scenarios for expected global vehicle and charging infrastructure production. Figure 19 shows the expected demand scenario assumed by E-MAPP for different vehicle types up to 2030. All scenarios are based on meta-analyses, the authors' analyses as well as expert interviews and allow quantifying value added and employment effects of e-mobility in Austria over the years up to 2030 taking into account technological, social and political factors.

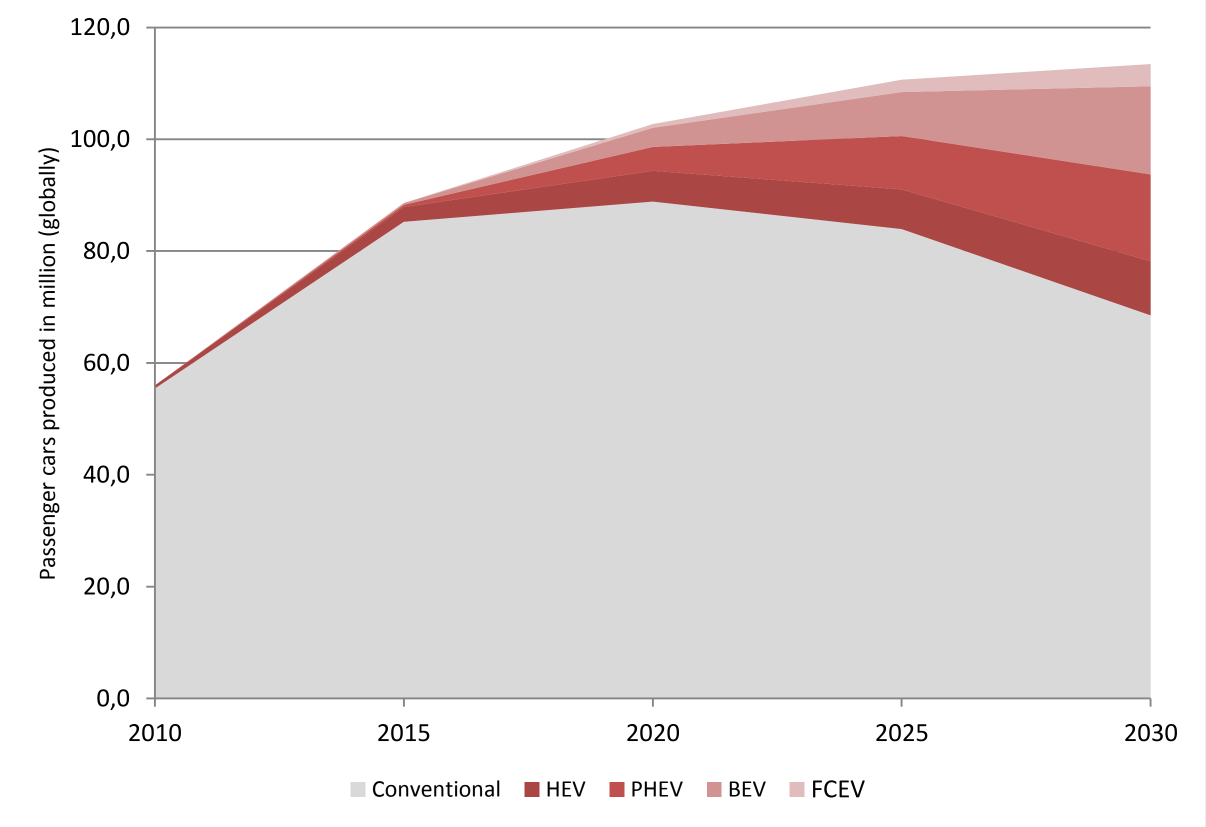


Figure 19: Global Unit Number Scenario for different drive concepts, Fraunhofer et.al (2016), adapted by AustriaTech for Task 24 country report Austria

Given 58.2 million cars which were produced globally in 2010 conventional drive train concepts (shown in grey) are expected by E-MAPP to dominate global vehicle production. From 2015 the authors assume that the share of e-mobility-related vehicle concepts will rise significantly, reaching about 40% of the annual vehicle production by 2030. In the period up to 2030 transition concepts like HEV and PHEV will dominate annual e-vehicle production.

The same method was applied by E-MAPP to the production of electric vehicle charging stations. Annual global production volumes are based on the following assumptions:

- **Slow charging (< 11kW):** until 2020 one slow charging station for every vehicle (BEV, PHEV) produced, after 2020 one slow charging station for every second vehicle produced.
- **Accelerated charging (11-22kW):** one charging device for 40 vehicles produced.

- **Fast charging (> 22kW DC and AC)** one charging device for 60 vehicles produced.
- **H2 station:** one station for 1.000 vehicles produced.

Figure 20 shows the global production of charging stations and H2 refueling stations expected by E-MAPP until 2030.

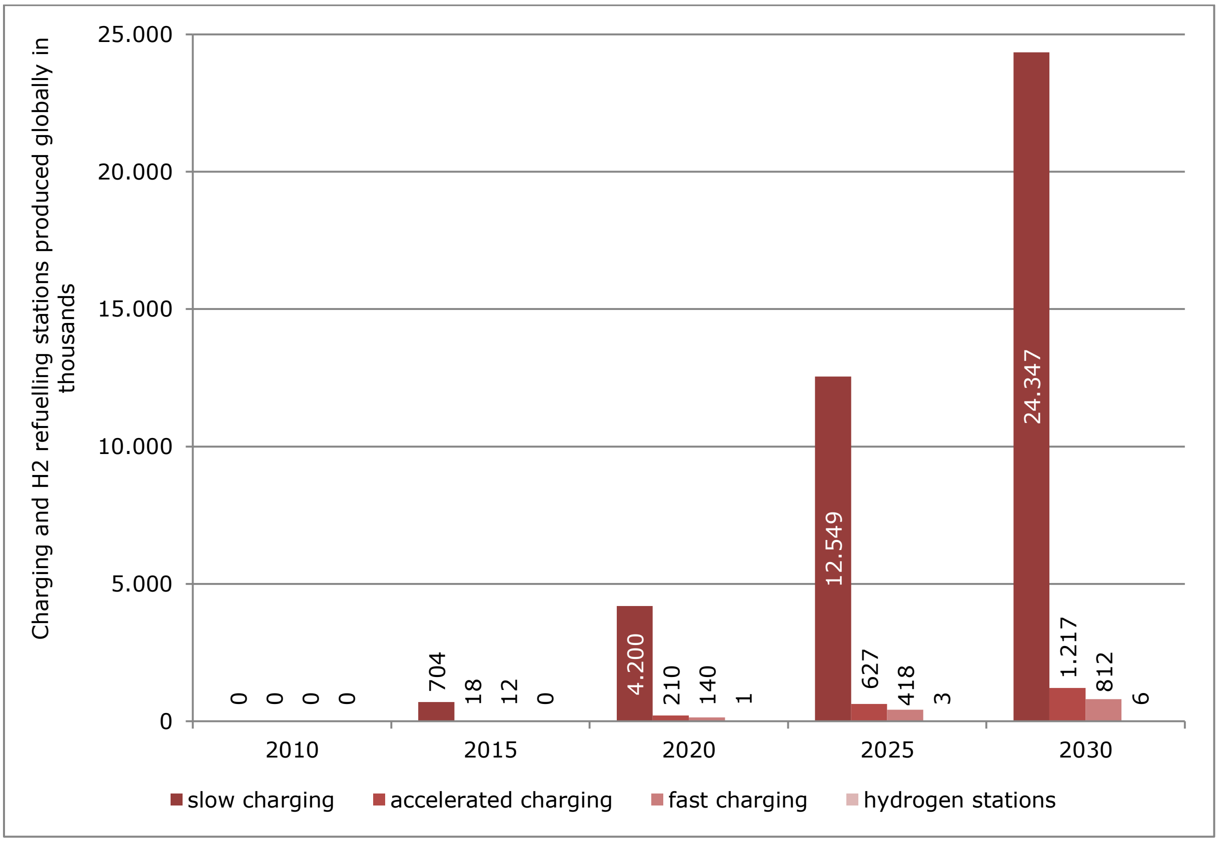


Figure 20: Global unit scenario for charging and H2 stations, Fraunhofer et.al (2016), adapted by AustriaTech for Task 24 country report Austria

In addition to scenarios regarding vehicles and infrastructure the 2011 study conducted by Fraunhofer Austria and TU Wien also looked at new business models including both new supply-side co-operations (e.g. OEM co-operations in battery technology, joint ventures to build-up charging infrastructure) as well as user-oriented business models (e.g. leasing of EVs, mobility on demand, V2G applications, fast charging, prepaid concepts). However, as already mentioned in Chapter 2, these services are very new and develop dynamically so it is at this point not possible to quantify effects on value added and employment.

Focusing specifically on production technology and based on a detailed component-level analysis of global production potential E-MAPP drew the following additional assumptions and results[31]:

- Production costs of FCEV and BEV will come down to the level of conventional vehicles which follows from expected cost reductions of new technologies such as fuel cell, hydrogen tank, lithium-ion batteries.
- E-mobility related components lead to value added in non-vehicle production NACE classes so the industry structure will change.

- Conventional components will continue to dominate total value added since they can be used both in conventional and in hybrid vehicles.
- Based on the global unit scenario described above, the authors assume specific production-related global value added and employment potential in 2030 will be double that of 2010.
- 76% of global value added and employment potential (both conventional and e-mobility related) is linked to global vehicle production.
- Charging infrastructure components are state-of-the-art and are used in a variety of non-transport applications so that production costs of components will not change significantly.
- In contrast, production costs for H2 refueling stations are expected to half by 2030.
- 1/3 value added is derived from the production of charging infrastructure components, 2/3 from the production of H2 stations.

E-MOBILITY VALUE ADDED AND EMPLOYMENT POTENTIAL IN AUSTRIA

Based on global unit number scenarios for the different types of reference vehicles and infrastructure, assumed cost regressions and Austrian world market shares both the 2011 and 2016 studies quantify e-mobility value added and employment potential in Austria in the period up to 2030. Both studies conclude that e-mobility related economic potential is significantly higher than that of the conventional reference vehicle.

Focusing on production technologies E-MAPP first analyzed global value added and employment potential based on global production units. Austrian potential is then derived taking into account Austrian world market share in the relevant NACE classes (see Figure 21). The authors include vehicle production, production of infrastructure components as well as the production of machinery and equipment to produce the four central elements of e-mobility (electric engine, fuel cell, lithium-ion battery, power electronics).

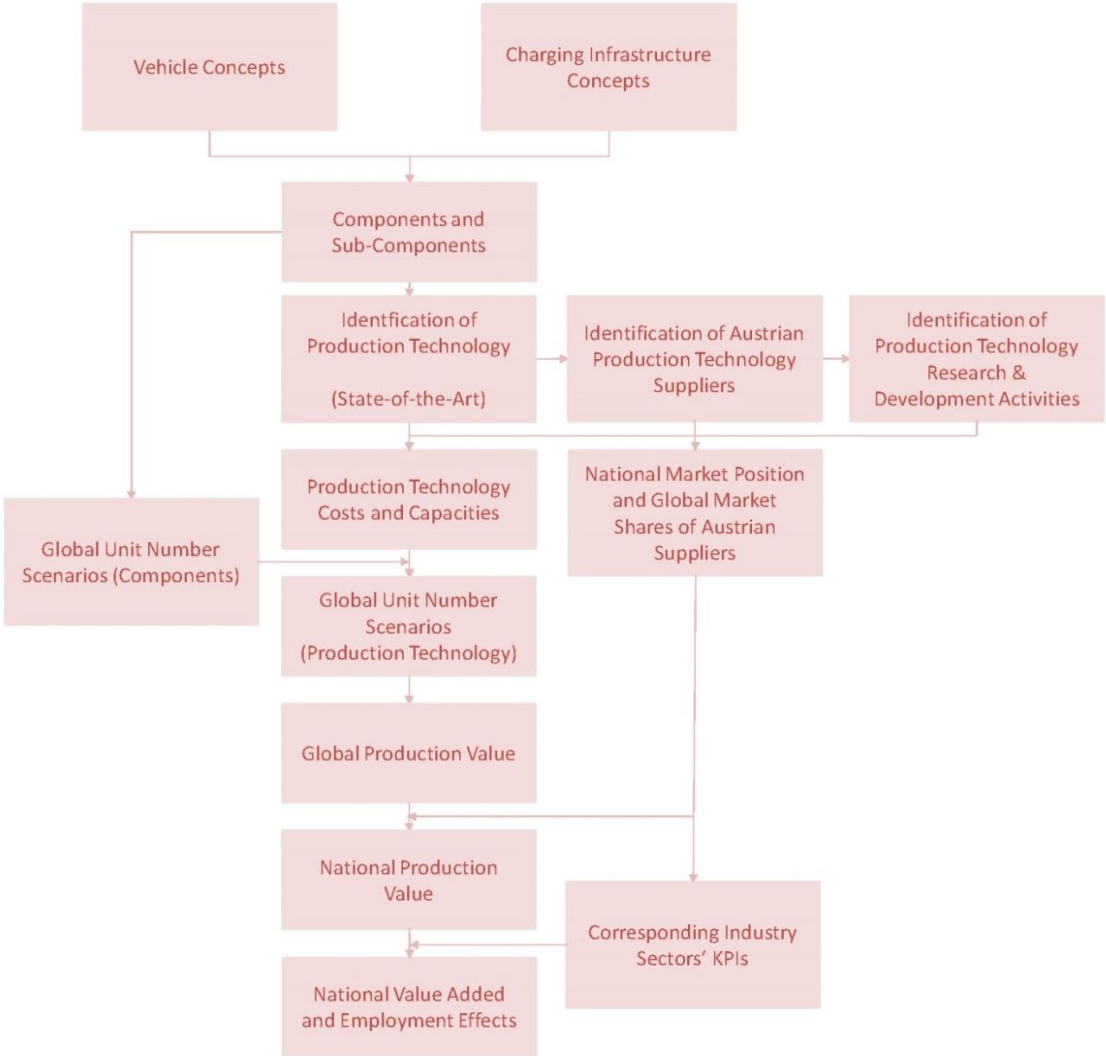


Figure 21: Method to quantify e-mobility value added and employment potential for Austrian production technologies, Fraunhofer Austria, AMP, VIF (2016), adapted by AustriaTech for Task 24 country report Austria

ASSUMPTIONS ON GLOBAL VALUE ADDED AND EMPLOYMENT EFFECTS

For vehicle production E-MAPP assumes that the entire *global* value added will increase from about €400 billion to about €650 billion. Correspondingly, global employment will rise from around 4.3 million to 7.2 million full-time jobs. Over the next 5 to 10 years this increase will mostly be due to effects in conventional vehicle production. However, components produced in conventional construction are also used in hybrid applications. Over the following years further increases in value added and employment can be almost completely traced back to e-mobility specific components which in the end will lead to a changed industry structure with an increasing dominance of e-mobility specific components.

Fast charging infrastructure production is assumed by E-MAPP to become significantly cheaper with a global rise in production from 140.000 units in 2020 to 800.000 units in 2030. For accelerated and slow charging significantly lower costs are assumed since these already today use standard electronics elements. Production costs for H2 refueling stations and hydrogen storage devices will also become significantly cheaper. E-MAPP assumes a cost reduction for one station from around €1.8 million in 2015 to €800.000 in 2030. Based on expected market development and cost reduction *global* value added for e-mobility-related infrastructure will rise to around €32 billion gross value added and 360.000 jobs in 2030, with 1/3 of this increase relating to the production of charging infrastructure and 2/3 to the production of H2 stations.

In terms of *global* value added and employment potential for e-mobility production technologies of the four central e-mobility-related components electric engine, fuel cell, lithium-ion battery and power electronics E-MAPP derives a value added increase of €27 billion and an additional 350.000 jobs in the period from 2015 to 2030.

AUSTRIAN ECONOMIC POTENTIAL

E-MAPP authors derived Austrian value added from the global potentials by assuming the following world market shares, which were drawn from available statistics by the Austrian Statistics Office, OECD and the World Bank, as a starting point:

- Electrical components of the vehicle: 0,38%
- Mechanical components of the vehicle: 1,75%
- Machinery and equipment: 0,77%

If specific company information was available, E-MAPP could attribute more specific values to some components resulting in a higher world market share in most cases. This applies to the production of power electronics components, the 12V electrical power supply battery, the electrical engine, the combustion engine and the conventional gear.

In general, the economic potential of total Austrian vehicle production amounts to an increase of around €1.6 billion and 17.000 jobs. This increase is relatively less than the corresponding global increase due to the relative current strength in Austria in the production of combustion engines whose world market share is expected to decline.

E-MAPP derives a rising gross value added of €250 million and 2.800 jobs for infrastructure components in 2030.

Value added and employment potential for e-mobility related components in Austria, according to E-MAPP, amounts to an increase in gross value added of about €200 million and around 2.700 jobs in the period from 2015 to 2030. Table 11 summarizes the effects derived by the E-MAPP authors.

	Value added potential 2015-2030	**Employment potential 2015-2030**
Total Austrian vehicle production	€1.6 billion	17.000
Production of e-mobility related components (electric engine, fuel cell, lithium-ion battery, power electronics)	€200 million	2.700
Production of e-mobility related infrastructure components (charging and H2 refueling stations)	€250 million	2.800

Table 11: Summary of E-MAPP results for Austrian e-mobility economic potential, based on Fraunhofer et.al (2016)

Figure 22 and Figure 23 summarize the e-mobility-related production effects for Austrian value added and employment in the period up to 2030 covering both vehicle and infrastructure production. In these figures E-MAPP authors show which potential can be derived from the production of e-mobility related components and which can be traced back to conventional components. The dashed line shows the value added and employment potential if the entire global production was limited to conventional vehicles.

E-MAPP analyses show that there is clear potential for e-mobility-related value added and employment both of which grow significantly more when compared to the conventional scenario shown by the dashed line. Hence, the Austrian economy can benefit more from global growth by investing in e-mobility which leads the authors to conclude that ignoring e-mobility would lead to risks for the Austrian automotive sector.

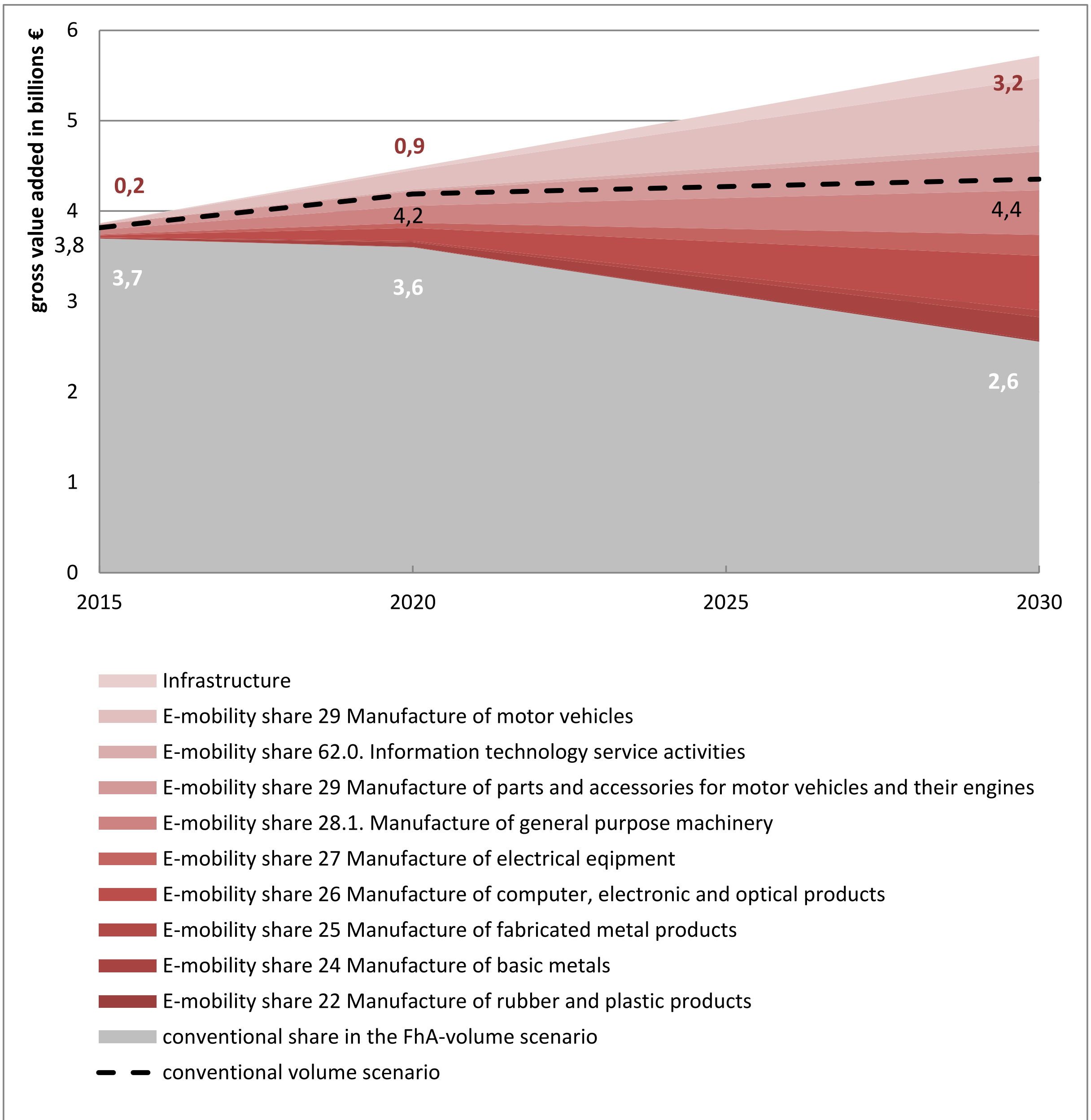


Figure 22: Austrian value added potential for e-mobility related production (NACE classes) and infrastructure including a conventional unit number scenario which assumes that the future market

is served by conventional models only, Fraunhofer et.al (2016), adapted by AustriaTech for country report Austria

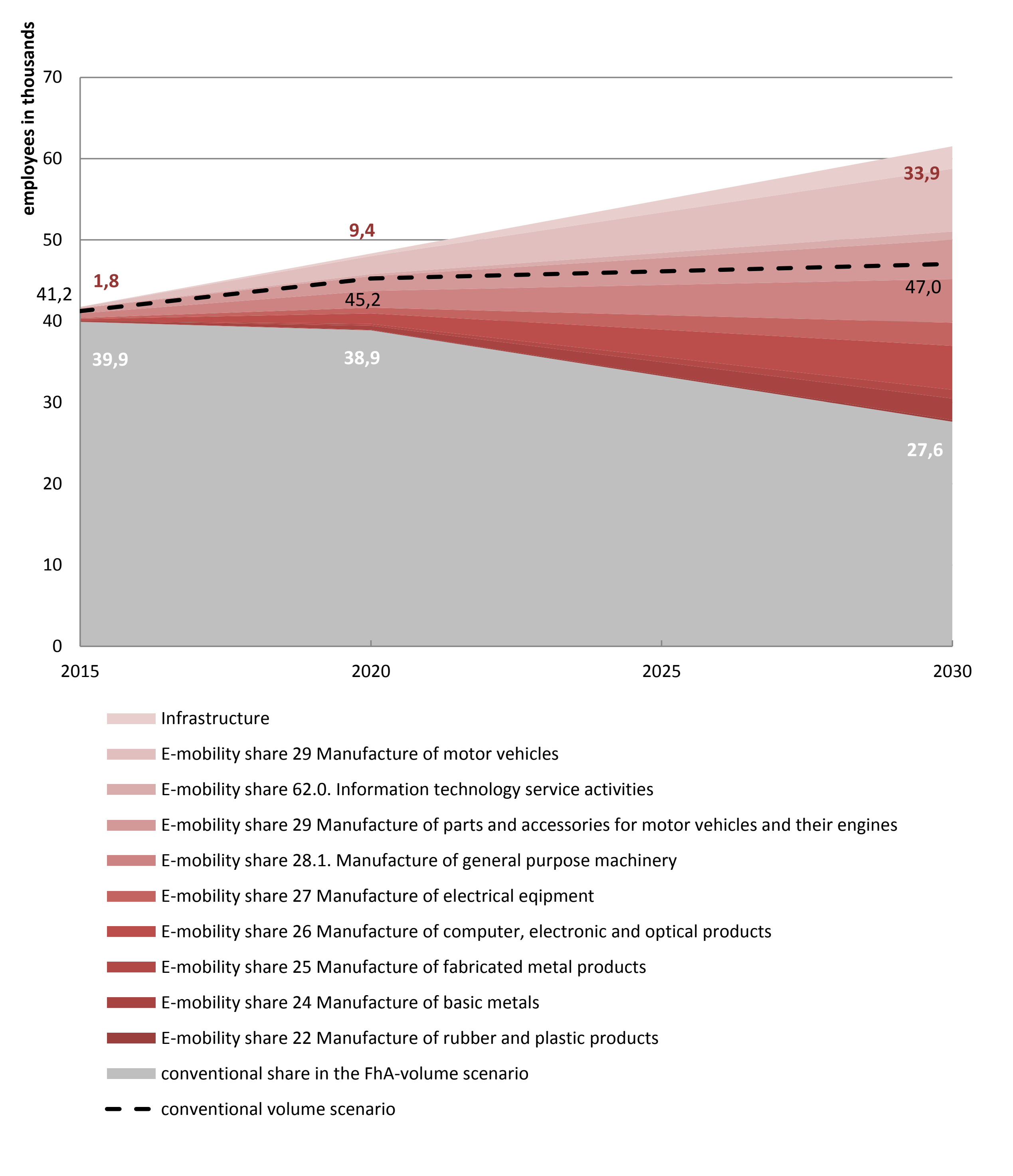


Figure 23: Austrian employment potential for e-mobility related production (NACE classes) and infrastructure including a conventional unit number scenario which assumes that the future market is served by conventional models only, Fraunhofer et.al (2016), adapted by AustriaTech for country report Austria

The 2011 study on E-Mobility economic potential in Austria went beyond production potential and attempted to quantify e-mobility related economic potential for vehicles and infrastructure in general on the basis of the same component-level analysis. Table 12 summarizes the results, which were however based on different global unit scenarios.

	Gross valued-added potential 2020	Gross valued-added potential 2030	Employment potential 2020	Employment potential 2030
Direct e-mobility related potential	€315 million	€1.23 billion	3.800	14.800
e-mobility related potential including indirect[2] effects		€2.9 billion		35.600
Best case scenario e-mobility related potential		€1.9 billion		23.800
Best case scenario e-mobility related potential including indirect effects		€4.7 billion		57.100

Table 12: Summary of E-Mobility Economic Potential analysed by Fraunhofer Austria and TU Vienna (2011)

[2] Such indirect effects include additional vehicle output, output by the chemical industry, metalworking industry, electric and electronics industry, vehicle trade, recycling, research and development services and other services in the transport, banking and insurance sectors

CONCLUSION

Austrian data on e-mobility economic potential clearly show significant value added and employment effects with major existing industry strengths, especially in the automotive as well as charging infrastructure segments of the common value chain used in Task 24 of the International Energy Agency Hybrid and Electric Vehicles Implementing Agreement.

Most available data and the studies presented in this report focus on the M1 vehicle segment but it can safely be stated that similar effects could be expected for duty vehicles and busses. The Austrian automotive industry is heavily focused on innovation and with a 14% share already shows a very high percentage of researchers.

When thinking about the transformation of our transport system it is important to remember that it is not only the electrification paradigm change which we are currently witnessing. In addition there are trends towards a mobility system which in the end will be increasingly based on clean power sources in addition to being automated, service-oriented, connected and shared. It is important to ensure both economic and environmental sustainability so being clear on e-mobility economic potential helps policy makers setting the right regulatory frameworks to manage transition from a fossil-fuel based to a low or even zero emission transport system.

Given this complexity the importance of training and qualification should not be underestimated. Also in a transition phase it will be important for industry to focus on multi-use components which can be used both in conventional, hybrid and electrified vehicle concepts.

Available studies for Austria show that ignoring or neglecting e-mobility as a game changer can in the medium term lead to value added and employment losses especially in the Austrian automotive industry.

END NOTES

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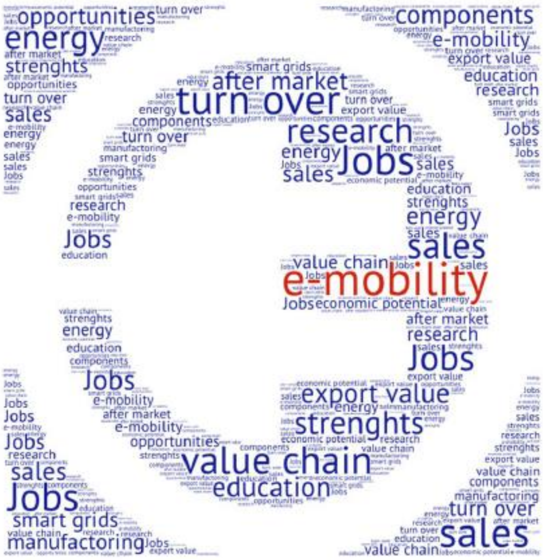
IEA HEV TCP - TASK 24 "ECONOMIC IMPACT ASSESSMENT OF E-MOBILITY"

THE ECONOMIC IMPACT OF E-MOBILITY IN BELGIUM

TASK 24 COUNTRY REPORT



Contact Person: Carlo Mol (VITO/EnergyVille)

Contents

Management Summary

The vehicle industry has always been an important industrial sector in Belgium. With a turnover of €25 billion, an export rate of 90% and 70,000 employees, it represents 10% of total Belgian exports and 10% of the industrial employment in Belgium today. Every year nearly 300,000 passenger cars and over 40,000 commercial vehicles, buses, coaches and bodies roll off the assembly lines. With these numbers, Belgium has one of the highest motor vehicle production figures per capita in the world. Besides the presence of OEMs, more than 300 automotive suppliers and some renowned research centres and universities are located in Belgium and create added value with activities ranging from research and design to production, testing and certification.

The vehicle industry is changing rapidly. Local vehicle assembly in particular has been under severe pressure in recent years due to several global trends. Even with a Belgian vehicle workforce renowned for its quality and efficiency, more and more vehicle assembly plants are closing and moving to low-cost countries. With the closure of the Ford Genk factory in 2014, 10,000 direct and indirect jobs in Belgium were lost. The government is proactively seeking solutions to recover these jobs and has developed action plans to mitigate the projected economic impacts of such factory closures. For future job creation, governments and industry have to make the right choices in a knowledge-intensive economy.

The vehicle industry in Belgium is transitioning to a clean and smart mobility industry. Within the automotive sector, the focus is no longer on making and selling ICE vehicles only. It is about offering a clean, comfortable and cost-efficient mobility service to the end customer. Electric vehicles can play an important role, especially when combined with the growth of renewable energy sources in the country's energy supply. The transport and energy sectors will become more and more interconnected, and this will create new economic opportunities for companies in this new e-mobility value chain (vehicles, charging infrastructure, ICT, mobility and energy services). Innovation can be an enabler for creating new jobs in this new e-mobility value chain.

The Flemish Government supported innovation in the field of electric mobility via the Flemish Living Lab Electric Vehicles programme (2011-2015). The Living Lab programme was an open innovation platform for testing new products and services related to e-mobility in real-life conditions. More than 70 local companies participated in this innovation platform, showing the interest and potential of e-mobility in Belgium.

But how can electric mobility strengthen the economic position of a country? To answer this question, Belgium and the Netherlands started up Task 24's "Economic impact assessment of e-mobility" and many other countries joined immediately, showing that countries invest in e-mobility not only for ecological purposes, but also for economic reasons.

Were we able to quantify the economic impact in jobs and turnover directly linked to electric mobility activities in Belgium? No.

Because of the limited resources within Task 24, we had to search for existing studies and information available today. This made it difficult because within Belgium, unlike in other countries, no dedicated studies on economic figures existed. However, based on a desk research supplemented with information from the Flemish Living Lab Electric Vehicles and sector federations like Agoria and ASBE, an overview of the main stakeholders active in e-mobility today was collected.

Were we able to detect a growth in e-mobility activities in Belgium ? Yes.

The Flemish Living Lab Electric Vehicles (2011-2015) was a good initiative to stimulate innovation and very valuable for companies to develop new knowledge, products and services. But it was also obvious that supporting innovation alone was not enough to achieve a major breakthrough in the roll-out of electric mobility. Even given the fact that Belgium is an ideal region to introduce electric mobility due to short geographical distances and an energy system capable of installing charging infrastructure combined with renewable energy, we didn't see a major breakthrough.

But since the beginning of 2016 the number of electric vehicles on the road in Belgium has grown significantly. Within the action plan "clean power for transport", new policy measures have been set up to stimulate the use of alternative fueled vehicles and related infrastructure.

More electric vehicles on the road means more services like sales, maintenance and after-service, but more and more charging infrastructure, energy and mobility-related services are also possible. An important trend to mention is that we not only see growth in electric passenger cars. The market share of electric passenger cars in Belgium was 1.82% in 2016 (source: http://www.eafo.eu/content/belgium). In addition, the interest in electrification of vehicles used for public transportation such as electric buses is growing fast. The fastest growing market within electric mobility is that of pedelecs, which are becoming more and more popular for younger people and for commuting, and which already had a market share of 23% in 2014.

For the economic impact on local OEMs and suppliers, we see that more and more companies are playing an important role in the electric mobility value chain. Renowned companies like Umicore, LMS-Siemens PLM Software, PEC, Leclanché and Punch Powertrain play an important role as suppliers in the e-mobility sector. But many more Belgium suppliers can be found in the country report in the annex. Local OEMs like Van Hool, VDL Bus Roeselare, Mol CY and E-trucks are also focusing more and more on the electrification of buses and heavy-duty vehicles. More details can be found in the country report in the annex.

For countries with a local passenger car manufacturing industry, individual investment decisions of OEMs significantly influence the whole system, not only in the countries where the OEMs are based, but also for the supply network in components and services in surrounding countries. For Belgium, Audi Brussels made a big announcement related to electric vehicles.

As of 2018, Audi Brussels will exclusively produce the first battery-electric SUV from Audi for the world market. This means Audi Brussels is becoming a key player for electric mobility within the entire Volkswagen Group. Audi Brussels will not only assemble the Audi e-tron, it will also have its own battery production site. Audi Brussels currently offers employment for 2,500 workers, and thanks to the new Audi e-tron project these jobs will be maintained after 2018. A qualification offensive will be foreseen to build up the needed knowledge and skills related to e.g. high voltage technology and aluminium Leichtbau. The site in Belgium will thus become a key plant for electric mobility within the Volkswagen Group. This will be an enabler for activities related to electric mobility at local suppliers, universities and research institutes.

Belgium is in a good position to play an important role in different parts of the e-mobility value chain. The Belgian e-mobility industry contains many innovative OEMs, suppliers and universities/research institutes to develop and/or produce new products and services in the different e-mobility value chains: electric vehicles (passenger cars, buses, light electric vehicles, and others), components such as batteries (and recycling, BMS, etc.), charging infrastructure, mobility and energy services.

List of figures

E-mobility in Belgium

Policy framework alternative fuels

Policy framework alternative fuels in Belgium

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

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

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

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

In that respect - and as stipulated by EU Directive 2014/94 regarding the deployment of alternative fuel infrastructure - Belgium has developed a national policy framework regarding alternative transport fuels/infrastructure (electricity, CNG/LNG, hydrogen).

The Regions of Belgium (i.e. Flemish Region, Walloon Region & Brussels-Capital Region) are competent for most aspects of the Directive (focus on infrastructure). The Federal Public Service of Economy and the Federal Public Service of Mobility & Transport (federal government of Belgium) are coordinating the national concertation and development of the Belgian policy framework. A mixed government steering group (Energy-Transport) was created in 2013. All concerned energy and transport departments (regional & federal) are represented in this group.

Policy framework alternative fuels in Flanders

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

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

IEA INTERNATIONAL ENERGY AGENCY HYBRID & ELECTRIC VEHICLE TECHNOLOGY COLLABORATION PROGRAMME

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

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

The most important actions want to stimulate the market by removing barriers like the high purchase cost, an appropriate public charging infrastructure and objective information on electric mobility.

All communication related to this action plan can be found on the following website: www.milieuvriendelijkevoertuigen.be.

Figure 1: Website www.milieuvriendelijkevoertuigen.be

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

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

- zero emission bonus for people buying an electric vehicle: max. 5.000€ and degressive in time (2016-2019)
- exemption from registration tax
- lowest rate of tax under the circulation tax (*)
- measures for an improved public charging infrastructure : more public charging points in 2020, an open and interoperable network (via "code-of-conducts"), a database for a centralized overview, new market model strategies like the role of market players like DSO's for a basic public charging infrastructure, new services to owners of electric vehicles without an own garage to ask for a charge point under certain conditions ("Station follows Car" concept), …
- multi-stakeholder working groups

(*) Starting from 2017, also electric vans will get some tax benefits to stimulate the greening of freight transport. New and existing electric vans will get an exemption to pay circulation tax.

End of 2016, different calls for projects have been launched to study or support some of the actions mentioned above.

Policy framework alternative fuels at city level

Public charging infrastructure
Not only federal and regional governments, but also cities can play an active role in stimulating electric mobility. Especially related to public charging infrastructure, cities can play a crucial enabling role since they are the owner of the public domain. Cities can set-up a supporting framework related to spatial planning, parking policy and enforcement, tendering public charging infrastructure, …

Low-emission zones in Flanders (LEZ)

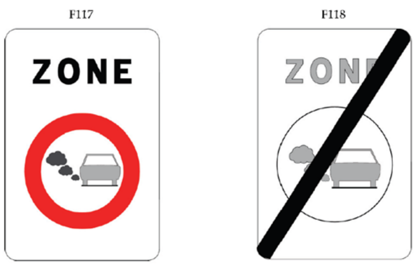


Figure 2: New road signs for low-emission zones in Flanders (Source : Flemish Government - Environment, Nature and Energy Department)

Cities can benefit a lot from electric mobility to solve local air quality problems. Therefore, first policy measures to keep polluting vehicles outside certain areas in cities can be seen. First city to introduce a low-emission zone will be Antwerp starting in February 2017.

Link to public transport and car/bike sharing schemes
Keeping polluting vehicles outside city centres can only be done efficiently, when there are sufficient alternatives for transportation to and within cities. Therefore, public transport plays an important role but also here we see a lot of interesting developments in electrifying the fleets (buses, metro, tram, train). Combining electric public transport with car and bike sharing schemes can not only solve local air quality problems but will also help in solving parking problems and traffic jams.

Policy framework alternative fuels in Brussels

The Brussels Capital Region is also developing an electric vehicle deployment plan.

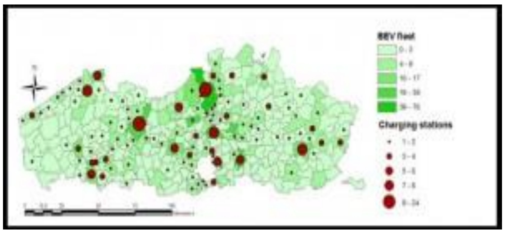


Figure 3: GIS-based optimal charging location analyzer (Source: VUB-MOBI)

Currently, EV infrastructure scenarios are developed based on VUB-MOBI's GIS-based optimal charging location analyzer.

PHEVs and BEVs on the Road

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

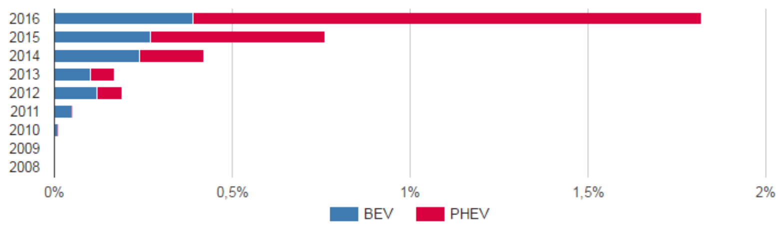


Figure 4: PEV (M1) market share in Belgium (Source: EAFO)

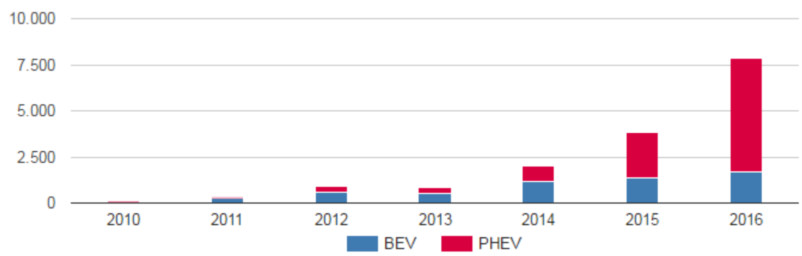


Figure 5: New registrations for PEV (M1) in Belgium (Source: EAFO)

(*) The statistics of 2016 in the figures above are made in December 2016

Most sold electric vehicles past 12 months are PHEV's with as top sellers Volvo XC90, BMW X5 40e and Porsche Cayenne. Within the BEV's the top sellers are Tesla Model S and Nissan Leaf.

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

Task24 Common Value Chain

Introduction

The Task24 participants described the e-mobility stakeholders in their respective countries, mapping the most important industry players in the different segments of the value chains. To facilitate this, common value chains were drawn up as part of Task24. These value chains were intentionally kept simple. We were uncertain of the format in which data would be available in existing studies that we used, so we abstained from using too much detail. Data collection and benchmarking would be easier this way too.

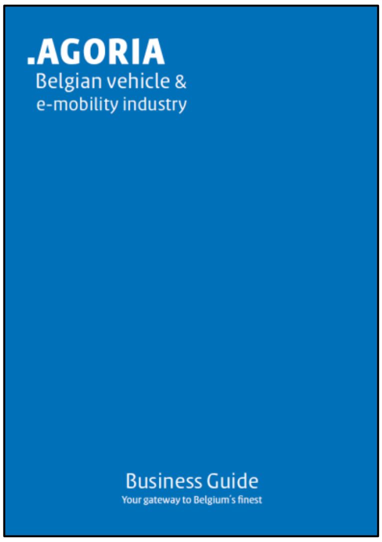
E-mobility is a multidisciplinary field, involving such aspects as mobility, energy, services and IT. E-mobility can also be an enabler of networked (multi-modal) and shared mobility services. Three common value chains were developed for electric vehicles, charging infrastructure and energy (see chapter 1.2 in main report).

It was decided that the value chains had to be described at least for passenger cars. Countries were free to describe other modalities (such as buses, trucks and two-wheelers) if they wished or if it proved useful to do so in their country.

Information Sources

Within the next chapters, we will summarize the information that was available for Belgium. Based on a desk research supplemented with information from the Flemish Living Lab Electric Vehicles and sector federations like Agoria, ASBE, i-cleantech, Smart Grids Flanders, … an overview of the main stakeholders active in e-mobility in Belgium was collected.

Please be aware that this description is not exhaustive. Because of the limited resources within Task 24, we had to search for existing studies and information available today. No economic indicators on jobs and turnover could be extracted. But the country report shows a non-exhaustive qualitative overview of companies active in Belgium on electric mobility.



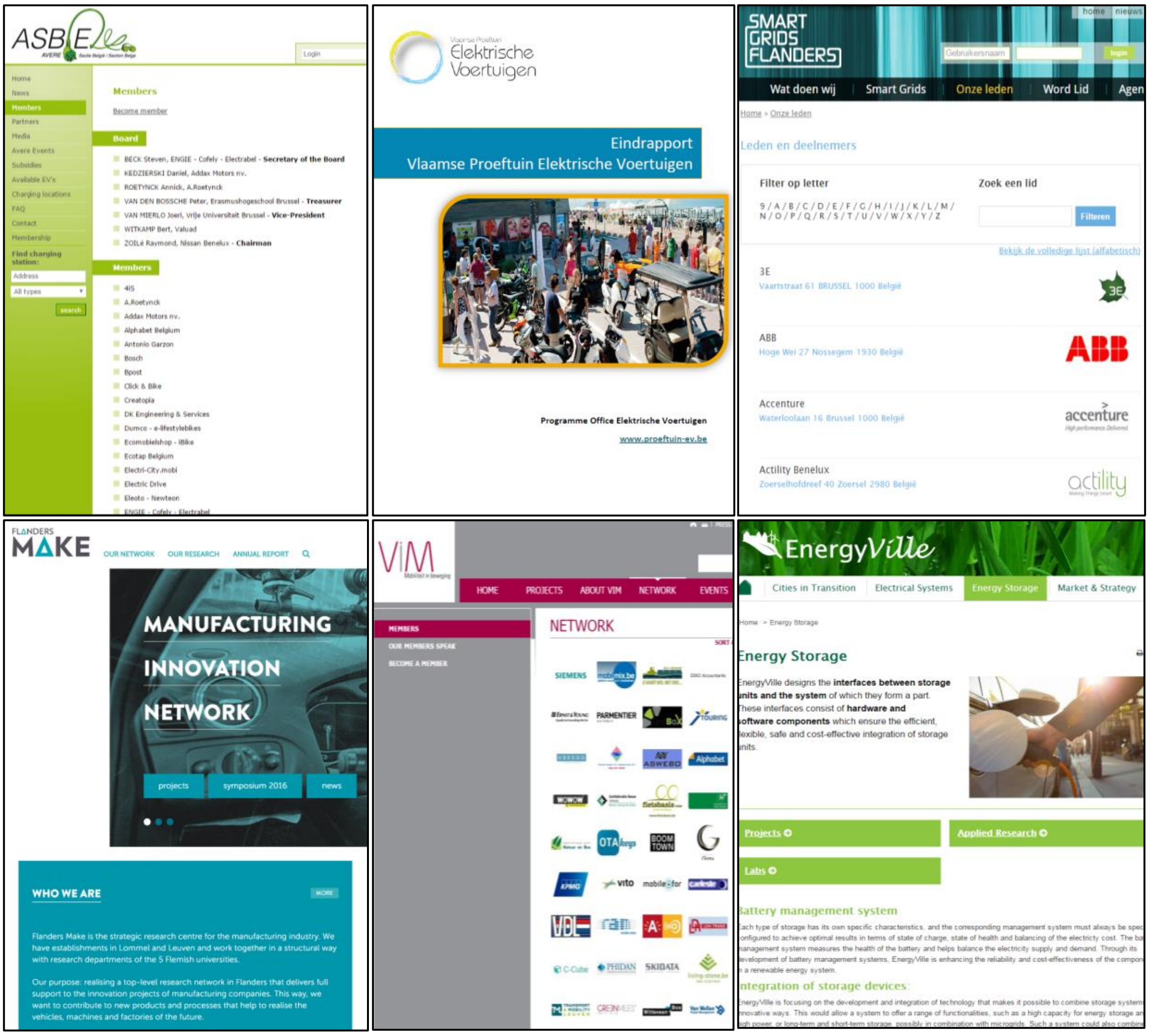


Figure 6: Information sources Task24 Country Report Belgium

Electric Vehicles

Passenger Cars

The vehicle industry has always been an important industrial sector in Belgium, but especially the car assembly is under severe pressure the past years. December 18th 2014 was a black day in our rich automotive history with the closure of the Ford Genk factory. The factory started its production in 1964 with the Ford Taunus 12M and produced in the nineties up to almost 500.000 cars per year.

Figure 7: Last car produced by Ford Genk factory in 2014 (Source: Belga)

In 2014, a Ford Galaxy was the last car that left the production line and almost 10.000 direct and indirect jobs have been lost. After the closure of Renault Vilvoorde and Opel Antwerp, this was another big loss of jobs in the automotive sector.

The government is proactively seeking solutions to recover these jobs and developed SALK, a regional strategic action plan, to mitigate the projected economic impacts of this factory closure. For future job creation, our industry has to make the right choices and has to be very efficient and innovative. Within the automotive sector, it is not only about making and selling vehicles anymore. It is about offering a clean, comfortable and cost-efficient mobility service to the end customer. Electric vehicles can play an important role, especially when we combine this with the growth of renewable energy sources in our energy supply. The transport and energy sector will get more and more interlinked and this creates new economic opportunities for companies in this new e-mobility value chain (vehicles, charging infrastructure, ICT, mobility and energy services). More information about companies active in these parts of the e-mobility value chain can be found in this chapter.

Today, Belgium still hosts 2 car assembly plants: Audi in Brussels and Volvo Cars in Ghent. Both OEMs are active in the field of electric mobility.

Volvo Cars is producing cars in Ghent since 1965. In 2014, Volvo Cars Ghent has built 264.000 cars (S60, XC60, V40 and V40 Cross Country) which was its second best result ever since the start in 1965. The number of jobs at Volvo Cars Ghent has been growing above 5.000 employees.

Figure 8: Electrification programme moving ahead at Volvo Cars (Source: Volvo Cars)

After successful testing of the pure electric Volvo C30 prototype, Volvo Cars is now moving ahead with its electrification programme. The existing Volvo V60 plug In Hybrid, which is currently built in Volvo's assembly plant in Gothenburg, will move to Volvo Car Ghent in 2016. After the phase out of this model, Volvo will further expand its hybrid programme, with estimates of 10% of the model range being hybrid or pure electric vehicles. Electrification is planned for both the compact and the large cars. The new models use the newly developed "Compact Modular Architecture (CMA)" platform which is electrification ready from the concept stage. This will allow the Ghent plant to produce plugin hybrids and pure electric models, as well as these new models.

Audi Brussels made a big announcement related to electric vehicles. Up to now it produces about 115.000 cars (Audi A1) per year and has 2.500 employees. But Audi is also preparing its international production network for the mobility of the future.

Figure 9: Audi e-tron quattro concept at Frankfurt Motor Show 2015 (Source: Audi)

Large series production of the first purely electric driven SUV from Audi will begin at the site in Brussels in 2018. The plant will also produce its own batteries. The company will transfer production of the Audi A1 from Belgium to Martorell in Spain. The site in Belgium will thus become a key plant for electric mobility at the Volkswagen Group. This will give a boost to the local e-mobility community and is a proof that our country has a good reputation when it comes to high-tech manufacturing and the knowledge-level of our employees (http://beautomotive.be/belgium-welcomes-audi-brussels-exclusive-production-electric-suv-model/).

Besides car assembly, Belgium has a lot of other activities in the passenger cars sector. Green Propulsion develops prototype electric vehicles. Toyota Motor Europe has its European headquarter, logistics centers, and technical R&D center in Belgium and the country has about 300 local automotive suppliers. Many of them are active in the electric vehicles value chain.

Having more and more electric passenger cars on the road, also means that extra jobs will be created in the sales, training and aftermarket divisions of the many OEMs/importers/distributors/leasing companies active in this segment. Sector federations like FEBIAC (http://www.febiac.be/) and Traxio (http://www.traxio.be/) can give an overview on the companies active in Belgium. Their members are not only active on passenger cars, but also on commercial vehicles and two-wheelers.

Buses

Busworld Europe Kortrijk 2015 (www.busworld.org) proved that the market of electric buses is in full expansion. Bus manufacturers Van Hool and VDL Bus Roeselare are very active in this field and have assembly plants in Belgium.

Van Hool, a Belgian independent manufacturer of buses, touring coaches and industrial vehicles, is very active in electric and fuel cell busses.

Figure 10: Electric bus inductively charged in city of Bruges (Source: www.benweyts.be)

Van Hool presented its inductively charged electric buses driving in the city of Bruges during Busworld 2015. This project was within the framework of the Flemish Living Lab Electric Vehicles.

Figure 11: EquiCity Geneva (Source: Van Hool)

With EquiCity, Van Hool developed an innovative concept for sustainable public transport in which hybrid, battery electric or fuel cell powertrain can be integrated.

Figure 12: Fuel cell bus used by public transport operator De Lijn (Source: Van Hool)

Van Hool is also coordinator from important European projects like "High VLO City" and "3Emotion", in which 21 Fuel Cell Buses will be introduced used in Rotterdam, London, Antwerp, Cherbourg and Rome.

VDL Bus Roeselare is also very active on the development and production of electric buses. They were selected by parent company VDL Bus & Coach to be the competence centre and production facility for all future electric city buses. The company is getting some big orders like 6 full electric buses for Cologne (Germany) and 43 full electric buses for Eindhoven (The Netherlands).

December 2016, 43 Citeas SLFA Electric buses were put in service within the Southeast-Brabant concession. The tender was issued by the Province of Noord-Brabant in the Netherlands with the objective of transitioning to entirely zero emission public transport in the period 2016-2025.

Figure 13: Citeas SLFA Electric bus (Source: VDL Bus Roeselare)

The VDL Citea SLFA Electric is an electric articulated bus with a length of 18.1 meters built in an updated, futuristic BRT (Bus Rapid Transit) design. The buses will be operated in high-frequency lines under the name 'Evolans'. Charging will be done at the bus stops via a quick charging system on the roof.

Freight logistics: electric vans and trucks

Within freight logistics we also see developments towards electric vehicles. For long-distance heavy-duty trucks this is not yet an economical viable option, but we see many smaller electric vehicles used for freight handling. The number of vehicles produced is maybe less than at within passenger transport today, but nevertheless this is a sector where we can expect an important growth (see IEA TCP-HEV Task 27, Electrification of transport logistic vehicles (eLogV)).

MOL CY is a developer and producer of industrial vehicles. The company was established in 1944 and is specialized in a broad range of vehicles: waste systems, trailers, port equipment, rail-road vehicles and special trucks. Some of these vehicles are offered as a 100% electric drive.

Figure 14: MINI G1 for refuse collection (Source: MOL CY)

This new vehicle features 100%-electric drive, both for the chassis and for the superstructure. The load container is equipped with a compactor mechanism and a container loading system to empty all containers complying with EN 840-1 and EN 840-2. The MINI G1 is based on a 100-% electric GOUPIL G5 chassis, with a GVW of 2 tonnes, allowing a load capacity of 500 kg. That makes this vehicle particularly appropriate for a quiet, environmentally friendly and at the same time very efficient refuse collection.

Figure 15: Electric tractor (Source: MOL CY)

Also vehicles used for freight handling in ports or inside logistic building are more and more electrically driven.

E-Trucks Europe develops full electric drivetrains for heavy-duty applications to integrate them in new or retrofitted trucks.

Figure 16 : Full-electric truck (Source: E-Trucks Europe)

Integrated in a mid-size truck up to 22 tons, this full electric vehicle has an autonomy range of about 250km and can cover the full speed range from 0 to 90km/h. This makes the E-Truck most suitable for urban application as there are garbage collection trucks, city delivery, transport of containers and so on. In case a larger action range or more on-board energy is required, the E-Truck can be equipped with a hydrogen driven range extender. The first prototype E-Truck is on the road since 2012. Several others were built for demonstration projects such as the EVTecLab platform within the Flemish Living Lab Electric Vehicles.

Electric vans like Nissan e-NV200 are also being used for freight delivery. As can be seen in the chapter on "mobility services" we see Belgian companies making a business on freight deliveries within cities with electric vehicles.

Light Electric Vehicles

Belgium is participating in two IEA-TCP-HEV tasks focusing on light electric vehicles:

- Task23: Light-Electric-Vehicle Parking and Charging Infrastructure
- Task32: Small Electric Vehicles

More information can be found on : http://www.ieahev.org/tasks/

Pedelecs

This sector is the biggest growing market within electric mobility. In 2014 a total of 436,549 new bicycles were sold in Belgium, up 30,000 (+7.5 percent) compared to the total of 2013. Pedelecs continue to increase its market share. A study at the Belgium's bike dealers concluded that e-bikes held a 23 percent of the bike market share in 2014. Electric bicycles are getting more and more popular also for younger people and especially for commuting.

In Belgium, we have a few manufacturers of pedelecs but most jobs and turnover is generated in the sales and after market services related to pedelecs. Also bike sharing schemes are interested in electric bicycles to complement their offer to the end customer.

Other Light Electric Vehicles

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

Figure 17: Green Urban Mobile (Source: Flanders' MAKE)

Suppliers

Belgium has a large group of suppliers to the automotive industry. Due to limited resources in Task24, we cannot list all suppliers here in detail. More than 300 suppliers are located in Belgium of which more and more are getting active in the e-mobility value chain. A lot of the innovations in the automotive sector are taking place on the suppliers side.

Some examples:

- Umicore supplies materials for the production of lithium batteries and runs the world's most state-of-the-art recycling facility for such batteries in Hoboken.
- Recently, the Swiss battery manufacturer Leclanché, through the acquisition of Malle-based Trineuron, chose to relocate its application development in Turnhout.
- Punch Powertrain is seeing a steady increase in its sales of hybrid powertrains to Chinese automotive manufacturers, with the prospect of doubling its turnover by 2020.
- Leuven-based PEC develops and supplies machines which allow Nissan to produce more efficient battery cells for the next generation Nissan Leaf.

For a more complete overview we recommend to check the information sources mentioned above and following websites:

- www.beautomotive.be is the homepage of the Belgian vehicle industry. The sector represents about 300 companies and 70.000 employees, or 10% of the Belgian export. Beautomotive.be brings together information on relevant companies, events, job opportunities and news items from the sector, covering the topics innovation, technology, talent, investments and internationalization.
- www.asbe.be is the Belgian section of the European AVERE network for manufacturers, suppliers, importers and distributors of Electrically propelled vehicles (battery, hybrid, fuel cell,...) and accessories. The purpose of the association is to promote the use of battery-electric, hybrid and fuel cell electric vehicles and supporting scientific and technological developments.

Charging infrastructure & Energy

Charging infrastructure

The rollout of charging infrastructure in Belgium was mostly depending on the initiatives from industry. Within the Flemish action plan for the clean-power for transport directive, a more prominent role has been given to the distribution grid operators (Eandis and Infrax) to set-up a framework to support the industry to install 5000 extra charging points (on 2500 locations) before 2020 in the public domain. Different brochures have been set-up to inform all stakeholders on the benefits of electric mobility and the procedures to install charging infrastructure at home, at work and in the semi-public and public domain.

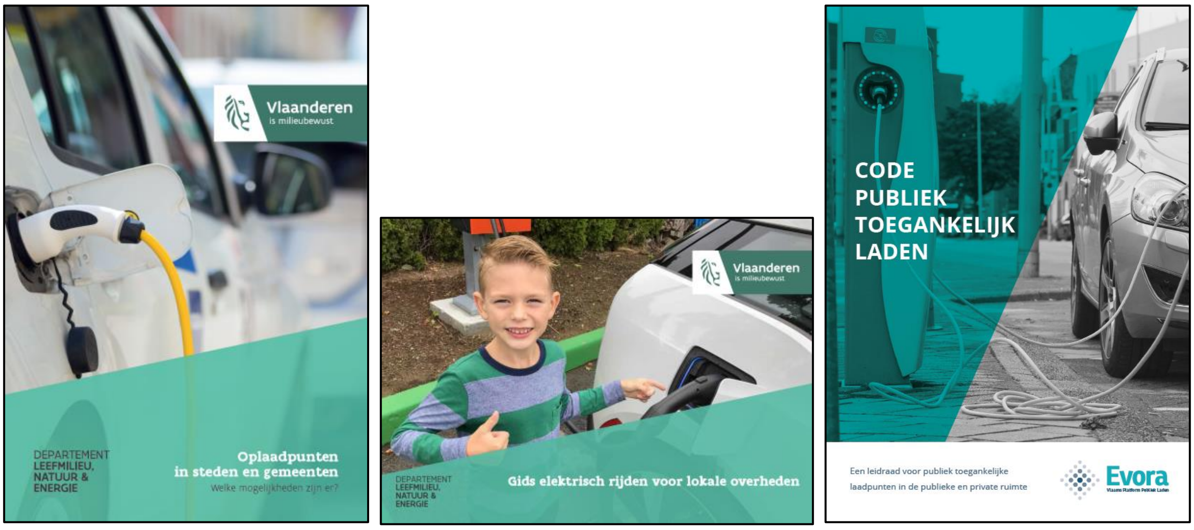


Figure 18: Brochures to inform stakeholders on e-mobility and charging infrastructure (Source: Flemish Government - Environment, Nature and Energy Department)

Getting an up-to-date overview on all charging points available in a country is not an easy task because this information is spread out over the different market players. If all market players should be connected to a central platform, it would be easy to get a real-time overview of the installed charging points. A database can be found on following website: http://milieuvriendelijkevoertuigen.be/.

Today, about 1.800 public accessible charging points are available in Belgium. Looking at the targets, a big growth in the number of charging points is expected in the public and semi-public domain. Initiatives in the public domain will be triggered mainly by cities and distribution grid operators. Initiatives in the semi-public domain will be initiated mainly by shops, restaurants, … and also by car manufacturers at their local dealers. For home charging, the car dealer or the home energy supplier play an important role to trigger the EV driver to make an investment in a wall-box at home.

How is the charging infrastructure market structured today ? From an economic point-of-view it is interesting to know how many companies are active as charging infrastructure operator or mobility service provider. And which type of companies take up which role ?

It is clear that this market is still under evolution. Many new local SME companies started up in the early years when the first electric vehicles were introduced on the Belgian market. They had to make a strategic choice on how to position themselves on the market and in the early years many companies tried to do almost everything themselves: from being charging point manufacturer (CPM) (hardware/software), to being charging point operator (CPO) up to being mobility service provider (MSP). Within a small market of electric vehicles the business model was very difficult and these companies tried to focus on a specific part of the charging infrastructure value chain. While the EV market was growing also new players came on the scene like energy retailers, CPO and MSP from neighboring countries or car manufacturers wanting to be the mobility service provider to the EV driver. Car manufacturers like Tesla even started to roll-out their own charging network.

In short, a market under evolution where consolidation between market players is expected and where "interoperability" will be crucial to get to a mature and economical sustainable business model in which the EV driver will get the expected quality and comfort level.

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

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

OpenChargePoint Belgium: a new sector organization of charge point operators active in Belgium has been set-up during 2015. The founding members (Allego, Blue Corner, Eneco Belgium, EV-Box Belux, EV Point and The New Motion) signed the "code-of-conduct" during an event at the Brussels Motor Show 2016. The organization is open for other charge point operators and aims to create an open, reliable and interoperable charging network in Belgium. This initiative supports the policy plans within the Flemish government related to the "clean power for transport" directive. On European level more sector organizations or "market places" like HUBJECT, e-clearing.net, e-Violin, GIREVE, … can be detected to enable "interoperability".

Not much economic market information (number of jobs, turnover, …) is available about the charging infrastructure market in Belgium. Following companies are or have been active on the Belgian charging infrastructure market (not exhaustive list): Arabel, BeCharged, eNovates / Blue Corner, EV-Point, Nissan, P2SE (Products Supplies and Services Europe), Power-Station, Powerdale, The New Motion, ThePluginCompany, Total Belgium, VitaeMobility, EV-BOX, Eneco, …

Energy

More and more companies, research institutes and governments are looking at electric mobility from energy point of view. What will be the impact of a massive introduction of electric mobility on our energy market ? What will be the impact on our electricity production, on our grid, … ?

Electric vehicles, when introduced in a smart way, can be an enabler for a higher introduction of renewable energy and at the same time for stabilizing the grid by using the flexibility that the batteries in the EVs can offer when they are connected to the grid.

What are the economic opportunities for companies aiming at products and services related to exploiting this energy flexibility on the energy market ? Companies working on topics like: smart charging, demand response, energy management systems behind the meter, ancillary services, batteries (incl. 2nd life batteries) and battery management systems, V2G, power electronics, ICT and control algorithms, … All these services can bring an added value in the overall business model / TCO of electric vehicles and charging infrastructure.

EnergyVille, an association of the Flemish research institutes KU Leuven, VITO and imec, is doing research in the field of sustainable energy and intelligent energy systems. It is also partner in the new Flemish Energy Cluster. EnergyVille is working intensively on the above mentioned energy services related to the link between electric mobility and the energy market. At its new head-quarter and lab-infrastructure in Genk, EnergyVille is setting up a low regulated zone for real life experiments in living labs. The Netherlands is setting up a broad "living lab smart charging" which can be connected to the EnergyVille living lab to intensify cross-border research on this topic.

Not enough time was left in Task24 to perform a more detailed study on the economic indicators of companies active in this market segment (jobs and turnover).

Mobility services

Electric vehicles can be an enabler for new and/or cleaner mobility services. Multi-modal transport and car and bike sharing schemes are getting more and more attention and electric vehicles fit very well in these mobility services. But it is obvious that the mobility world is going to change dramatically looking at new mobility concepts like Uber and the quick developments of autonomous vehicles. Autonomous vehicles and electric vehicles go hand-in-hand.

Networked and shared mobility

Mobility services will also be more and more "networked and shared". Networked meaning a combination of transport modes to get from A to B (walk, bike, train, tram, metro, bus, own car) and shared meaning not every transport mode used need to be owned by yourself (bike and car sharing, …).

The Olympus platform, developed in the Flemish Living Lab Electric Vehicles, aimed at such networked and shared mobility services. The company Olympus Mobility is continuing this work.

Olympus Mission:

- New mobility will be different in the future. More as a director, depending on the time and reason of the travel, people will decide how. All information about the travel options will be combined and available on the internet.
- Olympus focuses on networked mobility solutions and a seamless connection of private transport, public transport and shared vehicles. The Olympus mobile app and the Mobib access card play a central role in this.
- As a platform for multimodal mobility, Olympus helps all mobility actors to develop new markets and services:
    - Flexible multi-modal transport solutions can be offered to end-users in an easy way. E.g. a "cafetariaplan" including a predefined mobility budget or the ability of combining company cars and shared or public transport. An example of such a product in Belgium is Belfius E-fleet.
    - Olympus also wants to encourage the development of the electric vehicle market thanks to continued interoperability of charging infrastructure, an intelligent charging infrastructure and energy efficiency.

Examples of car sharing schemes in Belgium are Cambio and Zen Car and examples of bike sharing schemes are Blue-bike and Vélo.

Freight transport based on electric vehicles

Not only in passenger transport, but also for freight transport we noticed an increased interest in electric vehicles. New logistics concepts, where the diesel trucks deliver their goods in depots outside of the city centers and the last-mile delivery is done with smaller and more environment friendly vehicles, are getting more and more introduced in Belgium. Companies like CityDepot and Bubble Post are using cargo bikes and electric vans and trucks for these inner city deliveries.

Figure 19: Electric vans and trucks used for freight logistics (Source: CityDepot)

Figure 20: City deliveries with electric trikes (Source: Bubble Post)

Bubble Post invested in the development of urban trikes for city distribution. The electric tricycles (trikes) are capable of transporting up to 2m3 - 250kg. As they are legally bikes, they can deliver goods in city centers in the most efficient, flexible and sustainable way.

Research related to electric mobility in Belgium

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

It is obvious that within this new e-mobility value chain, innovation and knowledge plays a crucial role. Research institutes and universities play an important role in the generation of basic knowledge to support companies to develop and test new products and services, but also to set-up the right education material for training employees and students. The economic growth can be hampered by a lack of well-educated and trained employees.

Many research and demonstration projects related to electric mobility have been set up in Belgium together with research partners like e.g. Flanders' MAKE, VUB-MOBI and VITO/EnergyVille. These research institutes are well known for their e-mobility related research. The list of reference projects is too long to summarize in this country report, so we recommend taking a look at following websites :

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

Economic impact assessment of Danish e-mobility

COUNTRY REPORT TO IEA-HEV TASK 24 ABOUT THE DANISH ECONOMIC POTENTIAL FOR E-MOBILITY | FEBRUARY 2016

The publication Economic impact assessment of Danish e-mobility has been composed in relation to IEA-HEV Task 24 by The Danish EV Alliance and Cleantech Insight, and co-financed by the Danish Energy Technology Development and Demonstration Program (EUDP)

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1 Content

2 Introduction

Policy makers worldwide are implementing supportive measures to facilitate the introduction and implementation of electric transportation in their regions. While the reasons for implementation vary, electric mobility ("e-mobility") has an huge potential to stimulate economic growth in an environmentally friendly and socially beneficial way.

With the purpose of examining the economic growth potential in further details the International Energy Agency, IEA, launched Task 24 under their Hybrid & Electric Vehicle Implementing Agreement (IA-HEV) in the spring of 2014. IA-HEV is an international association of member countries and organisations enabling member parties 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. IA-HEV's primary work is conducted through Tasks.

Task 24 focuses on the economic impact of the introduction of e-mobility and benchmarks it against other participating countries. The participating countries in Task 24 are the Netherlands, Belgium, Germany, Switzerland, Denmark, Austria, France, and the USA.

2.1 The objective of the report

This country report for Denmark, covering the economic potential in the Danish value chain, is elaborated with the objective of supporting the work of Task 24 to benchmark the economic potential of e-mobility and set the benchmark of the e-mobility value chains of the participating countries.

Thus, primarily this country report comprises a description of the Danish e-mobility sector and secondly an economic value chain analysis of the sector. This knowledge makes it possible to describe areas with growth potential in the e-mobility value chain as the economic aspects of the value chain for e-mobility are thoroughly examined to be benchmarked against the other countries' e-mobility value chains.

The country report:

1. Describes the Danish value chain for e-mobility, including the sector players
2. Describes the Danish strengths in e-mobility

2.2 Method description and delimitation

This section describes choice of models and the methods of analysis used in connection with preparation of the Danish country report. In addition, the reasons for delimitation are explained, and the measures taken in connection with source critiques.

2.2.1 A common model for country reports

In Task 24 a common model for the country reports has been developed to form the basis for a trans-national benchmark. Given the fact that availability of information/knowledge varies widely in each country, the model should be regarded as a guideline for the content in the country reports.

The definition of the contents of the model for the country reports is as follows:

- Management Summary
- Introduction
    - Framework of Task 24 and IA-HEV
    - Some general country characteristics
- Chapter 1, E-mobility in country X
    - Development of e-mobility and status of innovation adaption curve
    - Number of electric vehicles
    - Number of EVSE (AC/DC, public/private, locations)
    - Description of policy and framework conditions for e-mobility
- Chapter 2, Industry description
    - Description of value chain
    - Mapping of the most important market players
    - Description of strengths and weaknesses
    - Description of projects and funding, if possible
- Chapter 3, Economic impact indicators, defined as
    - Turn-over related to e-mobility
    - Export volume related to e-mobility
    - Number of jobs related to e-mobility
    - Number of patents related to e-mobility
    - E-mobility's job-related impact on other sectors
- Conclusion

2014 is the base year of data collection but where accessible, data for 2015 can be included. This is a challenge for all countries in Task 24. It is difficult to collect detailed information about the capacity in each country, thus collection of qualitative data is also considered as a valid solution to this challenge.

2.2.2 The value chain

E-mobility is a broad area, and therefore, the steering group under Task 24 has delimited the value chain of the report to include only e-mobility for passenger vehicles, i.e. electric vehicles driven by the electric motor alone.

The value chain has been made on the basis of a considerable effort to assess the various means of defining the value chain for e-mobility. The group has among other things collected input from Roland Berger, Ernst&Young, McKinsey, Frost&Sullivan etc. Most of the value chains have been very complex and difficult to adapt across participating countries. However, the general opinion in the group has been that the value chain is a good basis for a description of the national e-mobility sectors even though not all countries have detailed information about all segments of the value chain. Particularly because this task is about collecting already available information, and, only if it can be done with little effort, collecting new data.

To reduce the complexity and to compare the value chain across countries, four categories have been defined:

- Electric vehicles
- Charging infrastructure
- Energy
- Mobility services

Each country can with this simple approach make its own outline of the value chain. The description of the Danish value chain can be found in the below relevant section of this report.

2.2.3 Collecting data for preparation of country report

As the focus of the task has been to collect already existing data, this project is based on secondary data such as reports, analyses, surveys etc. on the subject.

However, it has been difficult to collect data about key elements of some of the country reports, i.e. descriptions of the e-mobility sector and the economic indicators. Research of relevant reports or analyses concerning relevant results for our analysis was unsuccessful. Thus, it was decided to collect our own data, primary data, for this part of the project, to the extent it has been possible.

Assessment of players in the value chain

The e-mobility sector does not have its own sector code at for instance the central authority on Danish Statistics, thus it has not been possible to extract a list of data of enterprises in the sector in Denmark. The project has therefore been obliged to draw up this overview itself.

On the basis of the member base of Danish EV Alliance, dialogue with players in the sector, external available information (websites, new sources, annual reports, etc.), assessment of companies who have received subsidies from the Danish Energy Agency's pilot scheme for electric vehicles, and own experience, the project has compiled a list of players operating in the electric vehicle sector in Denmark. They may be 100 percent 'pure' electric vehicle players or they may have e-mobility as part of their business. The list is not exhaustive but is believed to give a valid bid on players in the industry.

Assessment of core strengths

To examine the Danish core strengths within e-mobility the project has been based on a previous assessment conducted by Invest in Denmark.

22 short-listed market players in the value chain (providers of infrastructure, car importers, research communities, component suppliers and consultants) were interviewed about among other their capabilities within the area of electric vehicles. Based on that assessment this project has followed up on the results of Invest in Denmark and "pressure tested" whether the results are still lasting. This has been conducted through a fairly comprehensive examination of more recent assessments and analyses on the Danish electric vehicle sector, and through dialogue with some of the players.

Assessment of funding and research in Denmark

In Denmark, the access to records of schemes and programmes subsidizing e-mobility, among other things, is good. One example is Energiforskning.dk and the website of the Danish Energy Authority.

In addition to desk research, the project has engaged in dialogue with the research and innovation communities in Denmark, and other relevant stakeholders, such as Insero E-mobility.

Assessment of projects

In this project, all e-mobility projects have been examined by looking into records of electric vehicle-projects in Denmark undertaken by the Danish Transport Authority in 2012. The records have been updated with the latest information about new projects.

Information about the projects has among other things been obtained from the Danish Transport Authority, Energiforskning.dk, The Danish Energy Authority, Insero E-mobility, "Årsrapporterne Energi", mv.

The total list of all 14 projects has been reviewed, with one of the reasons to form a general view of the breakdown in sectors and technologies in the value chain, and the size of subsidies allocated within the area of e-mobility.

Assessment of the economic indicators

It is our clear impression that the sector due to competitive considerations is concerned with ensuring confidentiality about data such as turn-over, etc. Thus, the project firstly examined whether reports or analyses with the relevant methodology approach were available. A few reports of an earlier date were indentified but their methodical approach could not be used. An inquiry made to Statistics Denmark regarding economic data of the e-mobility sector was without result.

Due to the size of the target group, the time and resources framework and the information requested, it was decided that a questionnaire study would be the most optimal method for collecting the economic data for this country report.

The questionnaire study was designed as simple as possible and undemanding for the operators in order to get the highest response rate as possible. Eight questions were formulated inspired by the Dutch participant in task 24, cf. questionnaire attached file.

The draft questionnaire study was circulated to selected players in the Danish sector for their comments on choice of design.

It was concluded that the players in the Danish sector in principle are not prepared to share information about their business with others. Thus, the option of anonymity was introduced in the questionnaire study in order to make it possible for companies to provide data that they usually would not share.

The questionnaire study was distributed electronically to 82 players in the electric vehicle sector. In connection with the assessment of the value chain and players in the e-mobility sector in Denmark the project has identified a total list of 181 players. But due to the time and resource factors, a small test sample group of the 181 was selected. The group is composed to represent the overall target group.

The participants were given one week to reply to the questionnaire. After a week, a reminder was sent and response time of one more week.

The results of the questionnaire study can be found in section 5.1.

2.3 Method critique

In relation to assessment of the Danish core strengths, it would be relevant to conduct new interviews of the 22 players from the survey of Invest Denmark about the Danish electric vehicle sector and broaden the group to include "Services and garage" and "Recycling". But this is has not been part of the commission of Task 24, and thus, not a priority area in this project.

In relation to the questionnaire study which purpose was to collect valid financial data from the sector, it is essential that the share of participants is as large as possible and that the participants are able to reply to the questions, i.e. are 'the right' participants. The response rate could possibly have been higher if more collecting methods had been available or if it would have been possible to reminding the participants by phone calls. However, this would have been beyond the time resources of this project.

2.4 Delimitation

The country report will only examine the national value chain of e-mobility, including the players of the sector, and assess only the Danish strengths in the area within e-mobility. The report does not comprise general background information about electric vehicles such as a description of the technology.

It's also important to underline that the report only reflects on general developments, research and market conditions in the e-mobility sector. There is no question of an in-depth analysis of the area and subject, thereto the time, resources and scope has not been.

The e-mobility market is progressing very fast at the moment and the individual player's strategies, plans etc. are currently changing. These conditions must be considered when reading this report.

2.5 About the parties of the report

Danish EV Alliance and Cleantech Insight were invited by the Danish Energy Authority to participate in the work of task 24 and after having sent an application to the EUDP programme in the autumn of 2014 the parties received subsidies under the EUDP programme to elaborate the Danish country report and to participate in the work of Task 24.

Danish EV Alliance
Danish EV Alliance (DEA) is a trade association for the e-mobility sector in Denmark and represents the whole value chain of e-mobility. DEA has approx. 50 members ranging from large industry groups to importers of electric vehicles, charging point operators, universities, and local authorities.

Cleantech Insight
Cleantech Insight is a Danish business consulting company, specialised in helping foreign companies with access to the Danish energy and cleantech market. Cleantech Insight support the companies with business development, go-to-market strategies, project development and fundraising. The founder of Cleantech Insight has a long experience within the e-mobility industry - both in Denmark and internationally.

Energy technology development and demonstration (EUDP)
The EUDP is a public programme and supports the development and demonstration of new energy technologies that creates growth and jobs, increases the security of supply, and contributes to the decarbonisation in Denmark before 2050. Furthermore, the EUDP funds Denmark's participation in international collaboration and knowledge sharing of energy technologies. The EUDP had subsidized the Danish participation in Task 24.

3 E-mobility in Denmark

3.1 Danish CO_2 reduction targets

As the rest of the world, Denmark is facing the challenge of reducing the CO_2 emissions in the transport sector that, contrary to other sectors such as industry or buildings, increases year after year.

One of the solutions to this challenge is a transition of the transport sector from fossil fuels to renewable energy, and the Danish Government long termed goal is to be completely independent on fossils fuels in 2050, including the transport sector. But furthermore, there are several other initiatives, which either instruct or recommend that Denmark reduces CO_2 emissions and phases out fossil fuels in the transport sector.

In addition to the Danish goal of independency of fossil fuels in 2050, Denmark is as a member of the EU subject to the common EU goal of reducing CO2 emissions by 30 percent as an EU average in 2030 in the non-ETS sector, i.e. in houses, agriculture, and in the transport sector. But Denmark is expected to receive a larger share of the average of 30 percent in 2030 when shares are allocated to the member states. If the agriculture cannot achieve its reduction, as it is a contestable sector, the transport sector has to provide much more than a 30 percent reduction[1].

Furthermore, during the COP21 climate summit in Paris the Danish Government approved the Electro-Mobility Declaration and Call to Action. By this declaration Denmark commits itself, together with Norway, Sweden, the USA, China, India, and Japan, to do their best to increase the stock of electric vehicles to a level according to the Paris goal of less than 2 degrees global rise of temperature.

It can according to the declaration be translated into the fact that the number of electric vehicles must represent 20 percent of the total global stock in 2030 which implies an annual new sale of 35 percent is electric vehicles at that time. To reach this goal in Denmark, there should be 480,000 electric vehicles on the Danish roads by the year 2030. This is equal to an average addition of 32,000 electric, hybrid, and hydrogen vehicles per year.

These ambitious figures for the phasing out of fossil fuel-based vehicles are indeed in line with the white paper[2], on transport published by the EU in 2011. The goal is to reduce the use of conventional vehicles in cities by 50 percent in 2030 and a complete phase out in 2050.

The political goals and ambitions as mentioned above will demand a number of political initiatives to support the transition that the transport sector is facing. The transport sector is in particular almost completely dependent on fossil fuels, primarily petrol and diesel, and the transport sector is the largest consumer of fossil fuels.

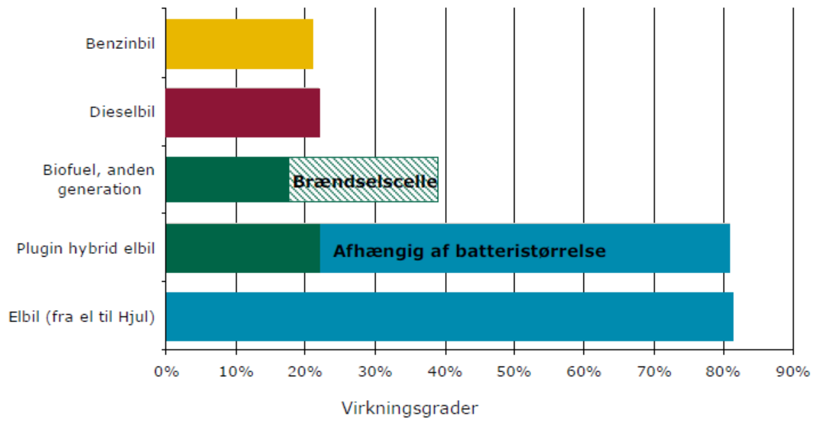
[1] Assessment of Danish EV Alliance

[2] http://ec.europa.eu/transport/themes/strategies/doc/2011_white_paper/white-paper-illustrated-brochure_en.pdf

Private passenger cars alone represent 10 percent of the total energy consumption, approx. 25 percent of the total oil consumption, and finally approx. 10 percent of the CO_2 emissions.

Electric vehicles have a huge potential for reducing the energy consumption as well as CO_2 emissions. The highest CO_2 reduction potential of the electric vehicles is in their high energy efficiency compared with conventional vehicles.

Figure 1 Energy efficiency by different energy sources in the transportation sector.



Source: Energinet.dk

3.2 World leading in wind power production

The large number of electric vehicles will be able to consume large amounts of renewable energy. Denmark has decided to base a substantial – and in future an increasing – share of its energy consumption on wind power. In 2015, Danish windmills generated what corresponds to 42.1 percent of the total electricity consumption in Denmark, and this is the highest figure ever, and the largest share for any country in the world

Phasing-in large amounts of wind power results in fluctuating energy production which gives a number of challenges compared with storage of energy and balancing of energy consumption and production. According to Energinet.dk Denmark can ensure optimal integration of the fluctuating electricity production from wind power by among other things to aim at intelligent, flexible charging of electric vehicles and a developed and implemented smart grid.

Through a strong interaction between electricity generation and the electric vehicles, and through smart grids, the electric vehicles can be charged at a low cost in hours with overcapacity in the grid and be discharged to the grid with a profit in hours of under capacity. In this way the electric vehicles can contribute to a cleaner and more sustainable transport sector, ensure an optimal use of the electricity production, and a sound business case for the owner.

Electric vehicles and smart grid offer a great potential in the future handling of these challenges and smart grid plays a substantial role in connection with the future integration of electric vehicles in the electricity system in Denmark.

3.3 Growth perspectives

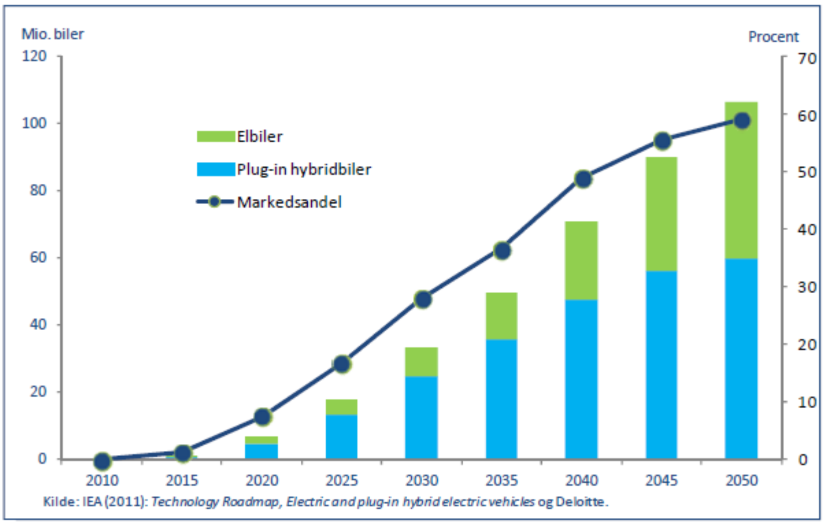
According to a Deloitte report from 2011 about electric vehicles and smart grid, the automotive industry is one of the largest and most globalized industries to be found. The market value (before tax and duties) of the European car manufacturing industry, in 2011 amounted to about DKK 2,000 billion (€ 268 billion) and globally, the industry amount to well over DKK 5,000 billion (€ 670 billion). In comparison, the Danish entire gross value added only amounts to about DKK 1,800 billion (€ 241 billion).[3]

As previously mentioned, the transportation sector is, in relation to the CO_2-reduction targets, one of the largest unsolved areas there is. Today, the sector is almost entirely based on the consumption of fossil fuels and the carbon emissions are on the rise. A switch to new, greener technologies is necessary, not just in Denmark or Europe, but globally, if the political climate ambitions are to be made, and in this picture, e-mobility plays an essential role.

3.3.1 EV market share is rising

IEA have forecasted rapid growth in the sale of electric vehicles and plug-in hybrids over the next couple of decades. In 2011, IEA forecasted that seven million electric and plug-in hybrid vehicles would be sold in 2020, and that the global market share in 2025 of electric and hybrid vehicles would reach 20 pct. rising to 50 pct. in the future.

Figure 2 IEA Blue Map Scenario for the global sale of plug-in hybrids and EVs from 2010-2050, yearly sale, Mio. cars from 2011.



Source: Elbiler og smart grid – perspektiverne for grøn vækst og beskæftigelse, 2011, Deloitte

Unfortunately, IEA has not updated this forecast for sale and marked share from 2011 since, however in the IEA Global Outlook 2013 for electric vehicles,

[3] Electric and plug-in hybrid road map, Blue Map scenario

the IEA expects the stock of EVs in 2020 to be of 20 million in the 15 countries that are a part of the Electric Vehicle Alliance group[4]. In 2012, during the making of the Global Outlook 2014, the 15 countries represented 90 pct. of the world population of EVs.

But the number of electric vehicles on the roads worldwide is not growing fast enough. The IEA Energy Technology Perspectives from 2015 concludes that the target of 20 million electric vehicles on the roads in 2020 will be hard to achieve without a much faster growth in electric vehicles on the roads. In order to make that happen, governments worldwide must implement supporting measures that ensure more electric vehicles on the roads.

One of the main conclusions in the aforementioned Deloitte report from 2011 is that the Danish production to the auto industry, in 2011 was equivalent to DKK 600 (€ 80.3) per car produced in Europe. However, the Deloitte report estimates that it is a realistic ambition to have an additional production of DKK 1.000 (€ 134) per electric vehicle.

Because of the enormous size of the global auto industry these projections of the marked share of electric vehicles holds significant business and employment potentials for Danish companies.

3.3.2 Battery prices are falling

Realising the potential production for electric vehicles is not going to happen on its own. It is important to be aware of the fact that the production costs for electric vehicles still for years to come will be higher than that of a comparable fossil fuelled car. Thus, the electric vehicle still is not at a price competitive level when compared to a fossil fuelled car.

The price movement of batteries for electric cars plays a crucial role for the competitiveness of electric cars. In a report, Carnegie Worldwide, a unit trust company, points out that the price of a battery for at Tesla amounts to 25 – 30 pct. of the total cost[5]. But prices on batteries are falling drastically. Based on historic data and projections of future battery prices, Stockholm Environment Institute has calculated an annual average price reduction of eight pct.[6], whilst Carnegie expects annual price reductions of up to 20 pct.[7]

Figure three hereunder shows a comparison by the Danish Energy Association of projections of battery cost prices from different sources. The figure shows that the projections of the cost of batteries have been too pessimistic, illustrated by the low 2014 prices from Nissan and Tesla, both lie under the projected battery cost range (grey area).

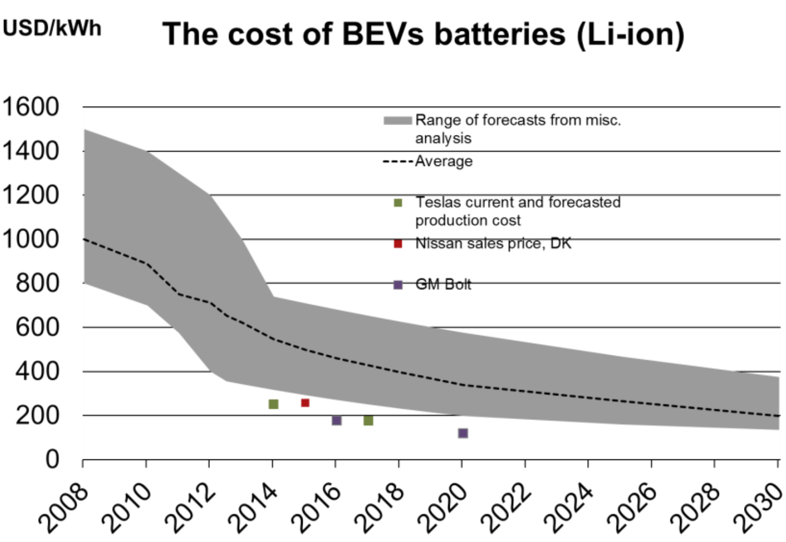
Until prices of electric vehicles achieve price-competitiveness with comparable fossil-fuelled cars, there is a pressing need to put in place swift-working, stabile and efficient means to get more electric vehicles on the roads, thus supporting a nascent industry which has got promising potentials for growth.

The battery price situation is somewhat parallel to the production of wind power. It has been a determining factor for the Danish wind power production success to have stable framework conditions, supporting a new and nascent industry, and this is also the need of the nascent Danish e-mobility industry. Different national governments, like Norway, Sweden, Germany, the Netherlands, USA and Japan have put in place significant incentive programs for

[4] The fifteen countries are: USA, UK, France, Spain, Portugal, Denmark, Netherlands, Sweden, Finland, Germany, Italy, China, India, Japan and South Africa.
[5] http://cww.dk/media/PDF/2015_12_Sol_og_batteriteknologi.pdf
[6] http://www.sei-international.org/publications?pid=2717
[7] See note 4

e-mobility. Denmark, on the contrary has the only country phased in registration tax on electric vehicles from 2016[8].

Figure 3 Battery price movement



Source: Danish Energy Association

3.4 Status of the Danish e-mobility market

The Danish population of electric vehicles reached 7,836 units by December 31st 2015, whilst sales in 2015 summed up to 4,524 units, almost threefold that of 2014, with 1,575 units sold.

Table 1 Overview of most popular EV models in Denmark in 2014 and 2015

Model	2014	2015
Nissan Leaf	587	224
Nissan e-NV200		476
Tesla S	460	2.737
VW E-UP!	219	79
Renault Zoe	145	330
BMW i3	62	492

Source: The Danish Car Importers Association

In 2015, EVs made up a two pct. share of the total number of cars sold which were 207,554. Tesla S was the most sold EV in 2015, and with 1,200 cars

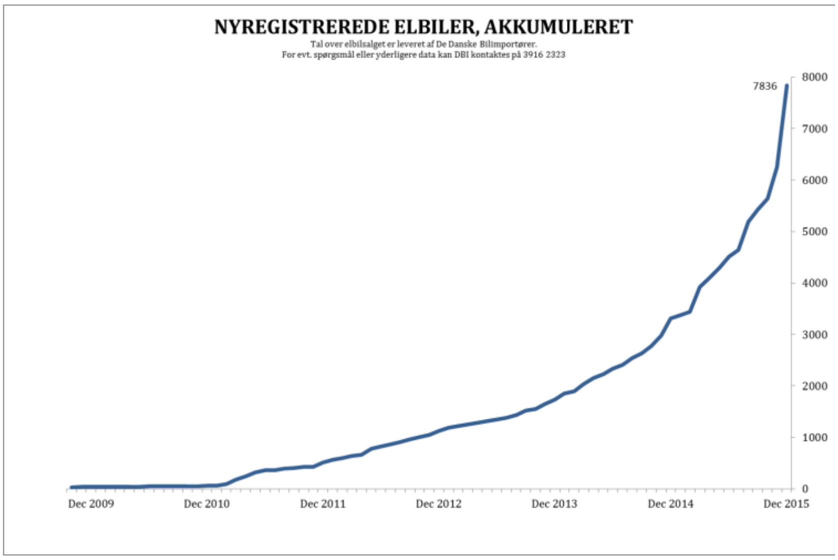
[8] Danish EV Alliance

sold in December alone, enough to secure first place of all sold cars in Denmark.

Looking into the future of expected EV sales, there is quite a gap in the numbers of the official Danish expectations. The number of EVs in 2020 is in the Danish Energy- and Climate projections 2015[9] by the Danish Energy Agency, set to be 6,000 units, rising to 10,000 in 2025 as a result of an improved economic situation. This projection was conducted before the massive sale of EVs that Denmark experienced in November and December 2015, just before registration tax for EVs was to be introduced by January 1st, 2016. The projections by the Energy Agency had considered the effects of the introduction of registration tax, however underestimated the effect. Thus, the projections of 6,000 EVs in Denmark in 2020 were already fulfilled January 1st, 2016, with a total of 7,836 EVs.

Contrasting the projections of the Energy Agency is the projections of the Danish Ministry of Taxation, done in relation to the introduction of registration tax. The ministry forecasted the sale of EVs in the period between 2016 and 2020, where registration tax on electric vehicles is phased in, to 24,000 units, thus tripling the current stock of vehicles, whilst adding taxes to the vehicles. Adding the existing vehicles, the ministry projects a total stock of approx. 32,000 EVs in 2020. If these projections are correct, EVs will make up 1.3 pct. of the total number of cars in Denmark, which in 2014 totalled 2.7 million cars and vans.

Figure 4 Development in stock of EVs in Denmark



Source: Danish EV Alliance

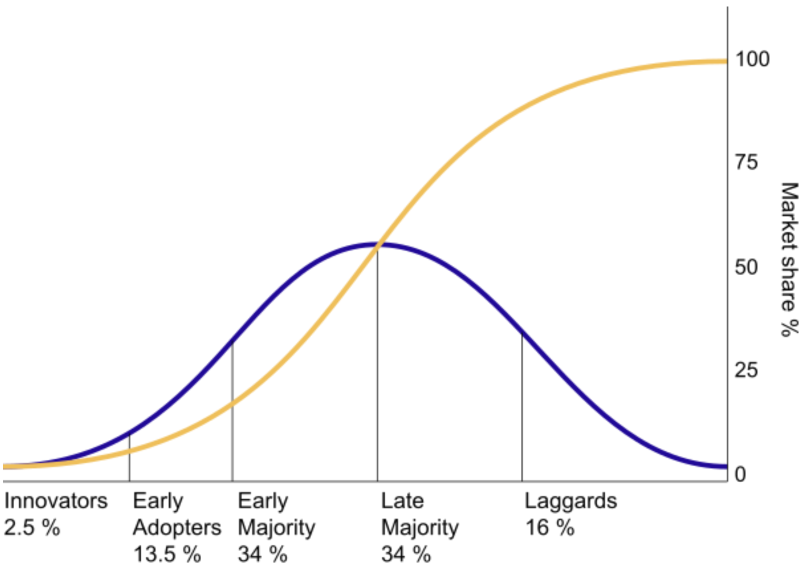
Within a three-year period, the Danish EV Alliance expects that public and private fleets, commuter cars and company cars, most efficiently can be converted to EVs. These segments have the advantage of not being too much

[9] http://www.ens.dk/sites/ens.dk/files/dokumenter/baggrundsnotat_d_-_transport.pdf

affected by the barriers that EVs normally are perceived to be affected by, like range anxiety and price. Generally speaking, these segments have the advantage of knowing the driving pattern in advance and that cars are bought through special discounted campaigns. Further, public and private fleets are expected to create visibility and neighbour effect, thus building bridges to a larger part of the private marked.

The Danish marked for electric vehicles are still at the first stage, 'Innovators', on Rogers's innovation adoption curve, as the sales share lays around two pct. of all cars. The Innovation adaptation curve is a theory that describes how, why and how fast new ideas and technologies are spread and adopted. The theory is based on the idea that a new technology must seek widespread acceptance to achieve critical mass and become self-sustaining.

Figure 5 Rogers Innovation Adoption Curve



Source: Wikipedia

The blue line above represents the different groups of consumers accepting the new technology whilst the yellow line shows the market share.

With a market share of two pct. for the Danish market, Denmark is still a long way away from having a self-sustaining market. According to Carnegie Worldwide, the law of Moore states that when a new technology reaches a market share of ten pct. the battle is in reality finished. The technology being replaced has in effect lost the battle and will be replaced on the mass market because of the great and increasing demand for the new technology[10]

A ten pct. market share of EVs in Denmark would require yearly sales of about 21,000 units. When this happens, EVs will, according to the law of Moore, have reached the crucial point in demand for EVs that should signify the beginning of the end for the fossil-fuelled car. When Denmark reaches this point is hard to say, however the Danish EV Alliance has it as an ambition,

[10] See note 4

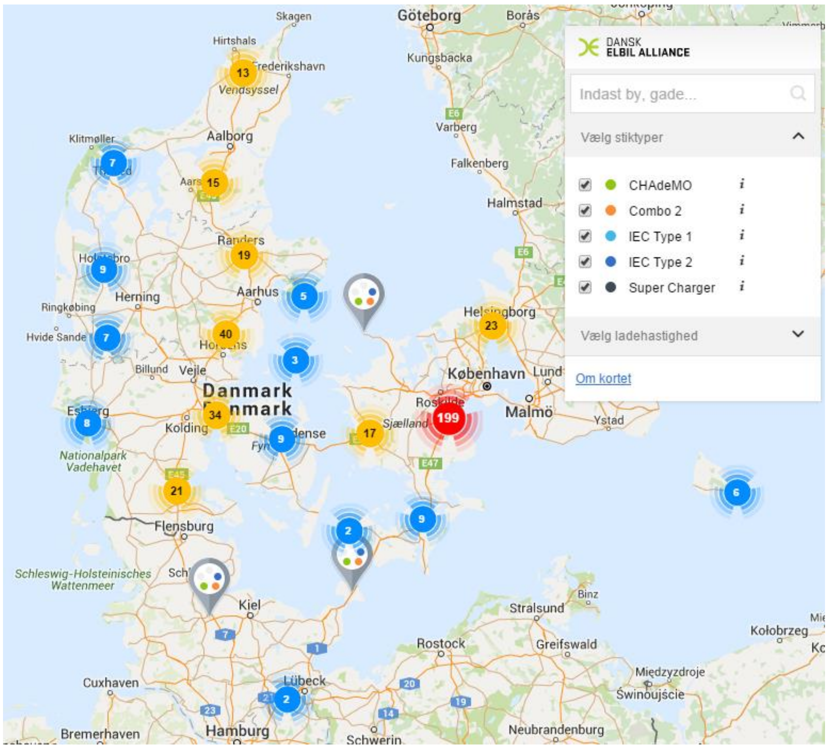
that the marked share of sales is ten pct. in 2020. However, if the current framework for EVs in Denmark, with the phasing-in of registration tax, is sustained, the Danish EV Alliance don't think this ambition is realistic.

3.5 Infrastructure

The Danish power grid has in different contexts been called smart grid version 1.0, because the integration of large amounts of renewable energy from i.e. wind power is far ahead.

As the first European country, Denmark had a nationwide charging infrastructure in 2012, including battery swapping stations and fast- and normal charging outlets. The charging network has since then been expanded to cover much better and fast charging along the highway network has been installed, allowing for fast charging along a large section of the Danish highway network. The total combined private and public investments in infrastructure are approx. DKK 2.5 billion (€ 330 million). Contrary to the success of the charging network, the battery swap technology turned out to be premature for the marked at the time of roll-out.

Figure 6 Map of charging stations in Denmark



Source: www.ladekortet.dk

In Denmark, there are four infrastructure operators; E.ON, CLEVER, CleanCharge and Tesla. In 2013, E.ON took over the charging points from the closed Betterplace while CLEVER, owned by the five energy utility companies SEAS-NVE, SE, NRGi, EnergiMidt and Energi Fyn, has been installing charging infrastructure since 2009.

In 2016, The Danish Road Directorate is expected to put new service stations with fast charging options along the highway network out to tender. Furthermore, it is also expected to put existing road side rest stops without charging infrastructure out for tender.

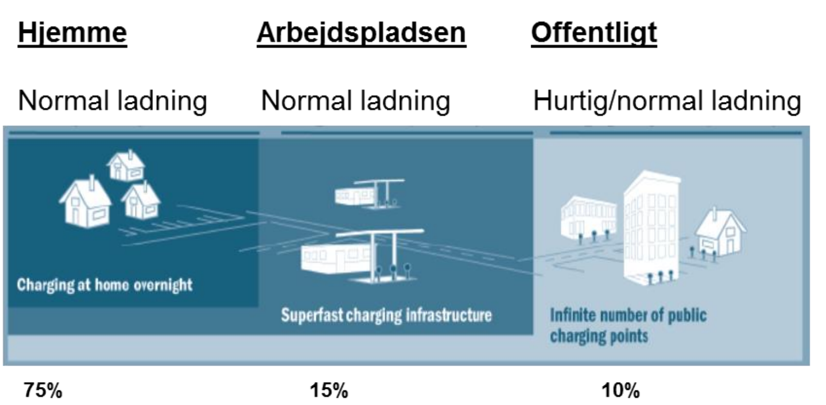
Table 2 Overview of charging outlets in Denmark per. 31.12 2015.

Plug type	Wattage	Outlets
IEC Type 1	3,7 kW	10
IEC Type 2	11, 22, 43 kW	1,391
CHAdeMO	50 kW	96
Combo 2	50 kW	108
Supercharger	125 kW	60

Source: Danish EV Alliance

In the international research project - Edison[11], which focused on developing optimal system solutions for the integration of EVs, it was concluded that if EVs gain a large market share, the average car will only seldom have the need for public charging on an everyday basis, however over time, all electric vehicles will need it. This means that there is a need for charging opportunities all over Denmark, however, there is only a need for a few outlets per charging point.

Figure 7 Expected distribution of charging of EV's (in Denmark)



Source: Roland Berger, DTU Transport and Cleantech Insight

[11] http://www.edison-net.dk/

Based on the Danish Ministry of Taxations projection of 32,000 EVs in Denmark in 2020, the number of charging points are expected to be 32,000 in 2020 (one per EV as home charging) plus 0.1 public charging point per EV, adding up to 3,200 charging points, half of which are expected to be fast chargers.

3.6 Danish framework and political conditions

In Denmark, there has previously been political support for the build-up of a national charging infrastructure for EVs in order to ensure a high penetration of EVs in Denmark. The national Energy Agreement in 2012 included a strategy for the promotion of energy efficient vehicles and hereunder a fund of DKK 40 million (€ 5.4 million) for direct support to infrastructure from 2013 - 2015.

Furthermore, another public funding scheme has supported the purchasing of electric vehicles by fleet owners directly by providing a monetary subsidiary. This has resulted in engaged and committed fleet owners, especially from the public sector, who has worked on boosting citizen EV awareness, and municipal engagement in projects about infrastructure among other. Over two thirds of the Danish municipalities have electric vehicles in their fleet, equivalent to 765 electric vehicles.

Unlike Germany and Spain, there has not from an official institution in Denmark been set a national goal or ambition for how many EVs should be on the road. However the Capital Region of Denmark, with 29 municipalities has formed a secretariat, Copenhagen Electric, that is to promote e-mobility by guiding the municipalities, hospitals, companies and citizens about the switch to electric vehicles and Copenhagen Electric have initiated a number of development activities and projects in conjunction with a long row of different partners.

Copenhagen Municipality has set an overarching goal of 85 pct. of all municipal cars and small vans must run on alternative fuels in 2015 (about 400 vehicles). The municipality has put a tender out for 300 charging outlets and the municipality is expected to reach a thousand on a longer term. In order to achieve the ambitious targets, the municipal has initiated a number of development- and demonstration projects, with the intention of easing up the implementation of EVs into the public institutions and to motivate citizens to also make the switch.

3.6.1 Danish framework conditions

EVs have until 2015 in Denmark been exempt from registration taxes, however a political agreement was passed in 2015 by the Danish parliament that over a five-year period phases in registration tax on EVs. The Danish registration tax system is extremely complex, thus in general terms; cars pay a registration tax of 105 pct. of the first DKK 80.500 (€ 10,785) that a car costs, and 150 pct. of the remaining price. From that amount, a number of deductions, such as energy efficiency (km/l) and safety gear (i.e. airbags) can reduce the registration tax a bit. EVs are phased in to this system on the same terms as fossil-fuelled cars, and will in 2016 pay a registration tax equivalent of 20 pct. of the total amount of registration tax. This percentage is increased to 40 pct. in 2017, 65 pct. in 2018, 90 pct. in 2019 and 100 pct. in 2020.

Introducing registration tax on EVs has in Denmark caused uncertainty about the framework conditions and the terms for investing in e-mobility for the stakeholders in Denmark, thus affecting the entire e-mobility industry and its continuous development in Denmark. An important element in the political agreement about registration tax on EVs is, however, that the political parties behind the agreement have engaged to continuous evaluate the impact on the Danish marked of introducing registration tax on EVs. This evaluation starts already in august 2016, and should result in alterations if there has been a negative impact.

Apart from registration tax on EVs, there are a couple of other important EV framework conditions.

<u>EV parking</u>

Municipalities can differentiate parking fees based on environmental performance up to DKK 5,000 (€ 670) a year.

<u>Exemption from electrification tax</u>

Charging operators and companies that use EVs as part of their business are exempt from paying the Danish electricity tax of DKK 0.87/kWh (€ 0.12/kWh). This is quite a significant amount, as the average price of one kWh is approx. DKK 2/kWh (€ 0.27/kWh).

EV owners can also be entitled to this exemption if they charge their EV at home through a subscription scheme with a charging point operator. The exemption from electrification tax applies only to the end of 2016.

<u>Green home renovation fund</u>

The government has set up a green home renovation fund from which citizens can get a tax rebate on up to DKK 12,000 (€ 1,610) for labour costs pr. person in the household above 18 years. This includes the installation of a home charger for EVs.

<u>Subsidiaries for energy saving initiatives</u>

The energy utility companies in Denmark are subject to secure energy savings at the consumer level. In their efforts to do this, they can provide subsidiaries to projects if the subsidiary is used to improve the energy efficiency. Included in this is the purchase of efficient vehicles, including EVs and in the future also including busses. The energy saving scheme is being renegotiated at the time of writing.

4 The Danish e-mobility industry

In the following section, the Danish e-mobility industry is described with a starting point in the value chain as it has been developed under the Task 24-project.

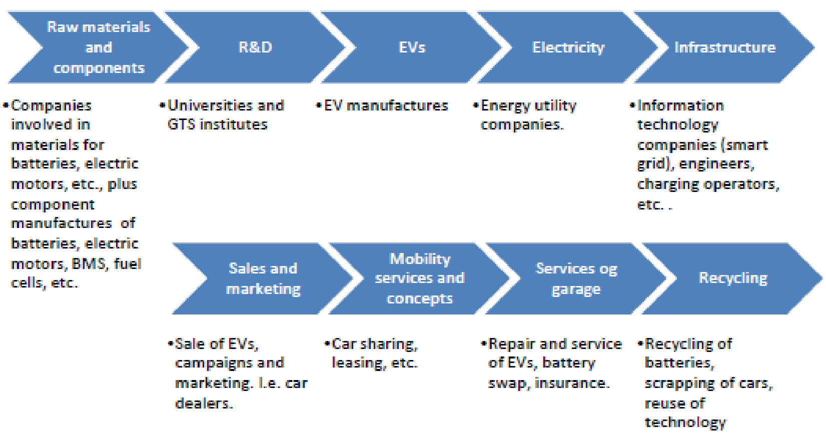
4.1 The e-mobility value chain

The Task 24 work group has gathered inspiration from a number of different sources in the efforts to develop a common value chain for e-mobility for this Task 24 project. After many discussions and drafts, a guiding version was decided upon, allowing each participating country to adapt the guiding version to ensure best fit with their specific market conditions. For the German market, it makes sense to elaborate the value chain for car production due to the large car manufacturing industry. This will not be the case for the Danish market.

The possibilities for a strong e-mobility sector in Denmark is supported by factors such as short geographical distances; a relatively large population density; that the population has a positive basic attitude to green energy, which the energy system also delivers; and the fact that a large part of the population live in a fashion that allows for the installation of equipment for home charging.

Figure 8 shows the value chain that has been applied to the Danish market.

Figure 8 Value chain for the Danish e-mobility sector



Source: Own preparation

The value chain for the Danish e-mobility industry is quite complex and the value chain is characterized by the fact that the industry is still in a development phase, thus experiencing a lack of i.e. technology standards. This means that more industry players will attempt to either form partnerships or attempt to define the standard by implementing technology.

Some of the key decisions to be made are: who will own the charging infrastructure?; should features related to intelligent charging and data collection be installed in the car or the charging post? Answers to questions like these will play an important role in defining which part of the value chain will become the strong and defining section.

Another tendency observed is the increasing integration of the value chain. The Chinese battery manufacturer BYD chose to launch its own electric vehicle and own electric bus rather than just to sell batteries to OEMs. Another tendency on the rise is a closer cooperation between the traditional OEMs and battery manufactures, energy utility companies or with industry players involved in charging infrastructure. Component suppliers for i.e. charging points will likewise draw benefits from integrating with the access to the infrastructure.

In the early stages of the product and market phase of e-mobility, the development in Denmark happened within the infrastructure in particular. Now, there is a shift in focus to services related to the usage of the EV. Thus, positions of strength will be centred on the access to infrastructure and the user. This will bring more focus on smart phone apps and services which assist and support the EV user. This is supported by BMW, Volvo and Tesla among others, who are focusing on EV commodities in the form of apps, remote control, autonomous driving etc.

4.2 Industry players in the Danish value chain

A mapping of industry players has identified 181 e-mobility industry players who are or have been involved in e-mobility in Denmark. Among the key and central players are the charging point operators CLEVER and E.ON and component/hardware manufactures ABB, Siemens and Schneider, are all engaged in activities related to infrastructure for EVs and E-busses. Another key player is Lithium Balance who has gained a strong international position in the BMS industry. Denmark does not have any car OEMs, but have importers of the respective car brands with EVs in their portfolio. Finally, Denmark has some internationally acclaimed Universities and GTS-institutes within the R&D section of the value chain such as among others Danish Technical University (DTU), Aalborg University (AAU) and Danish Technological Institute (TI).

Below are presented a number of areas in which Denmark holds a position of strength.

4.3 EVs

There is a need for new technological competences in the battery and electric motor technologies as a consequence of the EV market break through. It is expected that the traditional car manufactures in particular will have this need, because 35 pct. of the drive train of the traditional car is to be replaced by electric drive trains. Further, the battery industry and suppliers to the car manufacturing industry, so-called Tier 1 suppliers, will pay a lot of attention to the aforementioned technologies.

4.3.1 The battery

Despite the insecurity about the precise size of the battery market, it has been projected to become very significant in the future[12]. The battery is essential for the success of the EV and continuous R&D is required to further develop the battery, to lower the cost and increase the quality.

Denmark has participated in R&D activities in relation to batteries for many years and still has world leading research programs underway in related areas. Danish battery research is characterized by smaller groups of a high degree of niche knowledge at an international level.

Denmark has a:

- unique experience in production of synthesis
- unique knowledge of how to optimally use the battery and the cost of using/bringing it to its maximum. Denmark has one of the strongest research centres for testing of in-use-batteries (charging, discharge, electric current and communication) in the form of Powerlab and Syslab.
- unique knowledge about battery degradation
- leading testing and demonstration facilities in relation to controlling the battery.

Furthermore, the world-leading company within catalysis and surfaces, Haldor Topsøe, is Danish. Haldor Topsøe is participating in a project that seeks to develop the next generation battery. This project also includes Lithium Balance, Technical University of Denmark and Stanford University.

4.3.2 The electric motor

Electronic control systems have gained increased dissemination over the last years within the established OEMs and their suppliers. Applications of these systems are particularly interesting because they are anticipated to set the standard for the continuous technology development in the area. The Danish company Danfoss, a world-leading supplier of technologies for several industries including power electronics, expects a 20 pct. growth potential within power electronics.

Power electronics is a field in which Danish companies are very strongly represented on an international level in both the production (primarily Danfoss and Grundfos) but also within R&D (especially Aalborg University). Aalborg University has one of the leading research environments within power electronics and the same goes for a couple of north German institutes like the university of Kiel and the institute for silicon technology in Itzehoe.

Thus, it is fair to characterize Denmark and northern Germany as a world leading knowledge centre for power electronics. This is perceived by the industry as a decisive position of strength, a position Denmark also has achieved from a business perspective. This success is the result of user focused development cooperation between the industry and knowledge institutions and due to the education of students with the right competences.

4.3.3 Materials

The industry has become aware of the value of new materials. Among others BMW focuses on lightweight construction in the form of intelligent use of alu-

[12] Roland Berger, Boston Consulting Group, Bosch, among others.

minium and modern magnesium alloys[13]. It is about producing competitive and secure general electric vehicles (both on the battery side and in relation to collision). It is also about new and light materials, that can provide a lower weight. It is expected that the technological developments will be achieved through cooperation between international companies and universities.

In research and development, Denmark, particularly through Aalborg University, is today very strong positioned internationally. The university form part of influential research councils and has leading experts within the area.

4.4 Infrastructure

The Danish potential related to infrastructure it closely connected to the pioneering role that Denmark has had when it comes to integrating large amounts of renewable energy into the grid. EVs represent a part of the future solution. Danish experiences and solutions will provide first mover advantages and has resulted in the creation of knowledge environment that can support the expansion to other countries. This is already observable when looking at the two Danish charge point operators E.ON and CLEVER who both are expanding their networks into Sweden, Norway and Germany.

Denmark will have the prototype of a smart grid which will mean that the Danish industry can play a part in developing commercial solutions that will be in demand in Europe in five to ten years' time.

On the test and demo side Denmark has first class skills and test facilities and there has been running/is running large demo projects such as Edison, EcoGrid and Parker, all looking at the coupling and communication between the power grid and the electric car. DTU, which is one of Europe's strongest research centres on electric power and energy systems, is also involved in these projects.

Denmark is of ABB declared a world leader with respect to future intelligent energy and smart grid[14], and Nissan has chosen Denmark for its new prestige project. This is achieved in collaboration with DTU, which is one of the first in the world to deliver the solution that Nissan and other stakeholders are demanding.

In addition, Denmark is involved in defining European standards for smart grid and EVs. This will mean that Danish companies will be given the opportunity to contribute to defining e-mobility standards and first movers can thus be setting the framework for future technologies, policies, compatibility etc.

4.4.1 Charging points

The market for charging points is still at a project stage in many countries and the charge point manufactures are looking for markets for testing of real-live business cases, that contain more than few units.

It is a problem if the charge point does not function properly. The Danish testing platform NEVIC (at DTU) tests and certifies charging points in accordance with industry standards. They ensure that the EV owners can charge their EVs trouble-free country wide. NEVIC is an independent institution, conducting commercially viable tests as far as this project are aware, the only of its kind in Europe.

[13] BMW, "Dit benchmark"
[14] ABB, Copenhagen Climate Solutions Conference in October 2015.

As mentioned before the Danish government has supported the build-up of charging infrastructure from 2013 – 2015 and Danish energy utility companies see charging points as a strategic too for geographical expansion, for building new customer relations and for selling electricity. The total combined private and public investments in infrastructure are approx. DKK 2.5 billion (€ 330 million).

4.4.2 IT

There is a need for easy and cheap measuring, billing and clearing mechanisms between system operators, energy companies and EV fleet owners. This gives rise to the demand for new solutions. With Denmark at the forefront of smart grid and with energy companies and mobility service providers looking for new solutions, it makes Denmark the ideal country for development, testing and demonstration activities.

4.4.3 Apps and telematics

Smartphone apps and other EV-related services are expected to be at the center of attention on a short timeframe. The OEMs focuses on telematics because it is an area outside their normal competences and because it is seen as an add-on which they expect to grow significantly and therefore means an opportunity for profit.

Denmark has experiences from the development of cell phones and is capable of producing exclusive consumer electronics with user experience, design and safety as key parameters. Denmark has experts within user centered product development and user driven design. World class research with a much bigger volume are found in other countries, however in terms of making innovative products application-oriented, ensuring the user the best experience, Denmark ranks among the best in the world[15].

Due to that fact, Volvo chose to place their digital development unit in Copenhagen. Volvo has big ambition with human machine interface which is one of the areas in which they expect to see significant growth and where they want to provide the best solutions to the market. Basing their development unit in Copenhagen is a step towards achieving that goal.

Furthermore, the Danish consumers are known for being early adopters. Studies have showed how Danish consumers accept new products twice as fast as i.e. consumers in England or south and central Europe[16]. A significant portion of Danish consumers are also willing to pay for new technologies and thus the acceptance and market development is expected to happen faster in Denmark.

4.5 Mobility services and concepts

The changes that follow from the growing e-mobility industry will create new opportunities for innovative companies if their products cover several of the e-mobility value chain sections. A market concept could be that users buy personal mobility rather than a particular vehicle. In such a concept, the user has access to an EV for daily trips while for longer trips, a PHEV or diesel car that offers greater range, is provided.

[15] Aalborg University
[16] "The International Take-off of New Products", Gerard Tellis

The German DriveNow concept has through their Danish partner, Arriva, implemented a car sharing scheme in Copenhagen. They have put 400 BMW i3 EVs on the streets of Copenhagen, and this is a unique situation. Thus, Denmark is at the forefront in terms of market build up and are in reality past demonstration projects to actual implementation of full-scale projects. This contributes with many crucial experiences for the Danish e-mobility industry players.

Based on the value chain for e-mobility, the Danish competences have been summarized in the table below. As the table illustrates, the Danish competences does not fall in relation to raw materials as Denmark does not have any raw materials to extract.

The development of e-mobility opens up for interesting new business opportunities as the exposition above show, highlighting the most interesting and promising opportunities.

Table 3 E-mobility competences in Denmark

Section in value chain		R&D	Test & demo	Marked build-up
Components	Battery	x	x	
	Electric motor	x		
	Materials	x		
Infrastructure	Charging points	x	x	x
	IT	x	x	
	Apps and tele-matics	x	x	
Mobility services and concepts	Services and concepts		x	x

4.6 Funding and research activities in Denmark

Danish research and testing and demonstration facilities are important for the continues support of the current and the future positions of strength within Danish e-mobility.

In 2015, several governmental funds were in place for e-mobility in Denmark. The Danish Energy Agency had in total DKK 50 million (€ 6.7 million) for e-mobility funding activities from 2008 – 2015 and the Danish Transport and Construction Agency had DKK 200 million (€ 26.8 million) for funding activities related to green transportation from 2009 – 2015. In addition, DKK 40 million (€ 5.4 million) was set aside to provide direct subsidiaries to the purchase of EVs and the installation of charging points from 2013 – 2015.

Additionally, the national climate fund provided an additional DKK 27 million (€ 3.6 million) to provide direct subsidiaries to e-busses, public procurement of green vehicles, etc. However, this fund has been significantly reduced, with only enough funds to provide funding in 2016.

In addition following programmes exist in Denmark:

- Energy Technology Development and Demonstration Program (EUDP, DKK 400 million (€ 53.6 million in 2015))
- Innovation Fund Denmark (budget 1.6 billion in 2015 (€ 210 million))
- ForskEL-programme (DKK 130 million yearly (€ 17.4 million))
- ELFORSK (DKK 25 million yearly (€ 3.4 million))
- The Market Development Fund (DKK 135 million yearly (€ 17,3 million))
- Insero Horsens (unknown budget)

Generally speaking, Denmark is quite successful in getting funds from the EU funding schemes. Today, Denmark is a hub for the development of electrical technology and according to the EU, 22 pct. of the European smart grid R&D, test&demo and implementation projects takes place in Denmark[17]. That is tenfold as much as expected when related to the Danish GDP.

The cooperation between the Danish knowledge hubs and the well-established parts of the industry regarding product and technology development is in itself valuable. On top of this, higher education degrees play a vital role in delivering qualified employees to the industry.

There are five research and development institutions and GTS in Denmark that are directly engaged in e-mobility. They are Danish Technical University, Aalborg University, University of southern Denmark, Aarhus University and Danish Technological Institute.

Further, there are several excellent e-mobility testing facilities in Denmark that span from laboratory testing to full-scale testing.

- NEVIC is a test platform for new EVs and charge points. NEVIC tests and certifies charge points to European standards and make sure that EV owners can safely and trouble-free charge their cars. Open for commercial tests.
- Syslab can test EVs in a closed smart grid system with alternating sources of renewables from initial testing and up.
- PowerLabDK is a unique testing facility for development and testing of new technologies for the future power grid, and is one of the largest in the world. It allows for full-scale EV testing. The strength of the center is the opportunity to conduct large-scale laboratory testing to full-scale testing of a complex grid on the island of Bornholm. Here 28.000 consumers are involved in combination with 33 pct. wind power production. Thus, the centre can conduct tests that integrate controlled laboratory experiments with a real-live system. The centre is open for commercial and non-commercial projects.
- The battery laboratory of the Danish Technological Institute offers standardized and specific testing of batteries and their specialists work in close cooperation with chemical and engine technical laboratories, allowing the testing of the characteristics of the battery pack,

[17] #Smart Energi nr. 1, 2014, af Energinet.dk og Danske Energi

the internal chemical composition and integration with other technical components. It also has a "rolling laboratory".

Some educational programs have specific courses focused on e-mobility like mechanics, rescue workers, fire-fighters and police. In addition, the following places can be mentioned:

- AutoTeknisk Center in Viborg, part of the Mercantec school. Currently the only place where mechanics can undergo further training in relation to safety and diagnostics on hybrid and EVs
- Tradium Technical school (mechanics)
- Technical School Centre (TEC) in Hvidovre
- Syddansk Erhvervsskole in Odense and Vejle supported by the Danish Energy Agency via the EV test programme

4.7 Projects

From the previously mentioned financing programs and funds, 144 projects have received funding in the period from 2008 to 2015 (+ 3 projects finishing in 2017). Some are still ongoing while others have ended.

In total, DKK 174 million (€ 23.3 million) have been used for R&D, testing and demonstration of technologies. Within R&D, funding has primarily been applied to development of batteries for electric vehicles (new materials and BMS) and the electric motor. For the testing and demonstration, the main area of focus has been infrastructure for electric vehicles, like intelligent charging and charging operations, which is most relevant in a smart grid perspective and the systematic approach that is to integrate the electric vehicle into the energy system.

Furthermore, Denmark has gained numerous experiences from real live testing of electric vehicles and different mobility concepts. User involvement projects have been completed and some are still ongoing. Approx. DKK 110 million (€ 14.7 million), or 63 pct. of all funding has been given to electric vehicle projects.

The projects in table 4 below are divided along the sector and technology development areas of the e-mobility value chain.

The projects were/are managed by:

- 63 companies
- 23 public institutions, mainly municipalities
- 11 organizations
- 15 R&D or GTS institutes

Table 4 E-mobility projects in Denmark

Section of the value chain	Technology area			
		R&D	Test & demo	Trials/Market build up
Components	Battery	7	1	2
	Electric motors	3		
	Materials	1		
EVs	EVs	3	1	58
Infrastructure	Charging points		5	6
	IT		8	
	Apps/telematics			
Mobility services and concepts	Services and concepts			25

In the above table appears only 120 projects, since it has not been possible to obtain information for all 144.

5 Economic impact indicators

5.1 Economic indicators

The core element of this project is to describe the value chain of the Danish e-mobility industry, map out the industry players and to describe the economic performance of the value chain.

The Task 24 steering group has, as previously mentioned developed a model for the value chain of e-mobility, and three key indicators for the economic performance of the value chain has been selected. Those are total revenue, export and the number of employees related to e-mobility.

During the project process, it became clear that it was difficult to get hold of this data for the Danish industry, and this seems to be the same for the other countries that have participated in Task 24. This type of data is sensitive information that most of the industry players are not interested in sharing with others. It has not been possible through this project to enter into close dialogue with the industry players one on one to gain insights into their data. Furthermore, it can be difficult for some of the industry players like component manufactures to know to which industry they are supplying their products, if they produce components that are not exclusively for the e-mobility market. Finally, the central authority on Danish statistics, Statistics Denmark, does not have a specific e-mobility industry code, that allows the collection of this type of key indicators for the Danish industry.

The result of these challenges in gathering the key economic indicators was to compile a short survey to be distributed to a specific selected group of 82 industry players from the Danish e-mobility market. The players were selected to be representative of the overall group of 181 industry players.

Despite the possibility for anonymity and reminders to the group to provide answers, the response was low. Only 15 responders answered all eight questions while nine responders partially responded. Thus, the project received 24 full or partial responses from the selected group of 82 industry players.

That brings the response rate to a mere 18 pct. for the responders who answered all questions and a rate of 30 pct. if the partially responders are incorporated. This low response rate is unfortunately too low to be considered as a valid source of data from which statistical conclusions can be made. A rule of thumb states that a response rate below 50 pct. is questionable when looking at a small reference group. In reality, however, a big effort is often required in order to reach a response rate of 50 – 70 pct.

Even though the survey is not considered to be statistically representative, the survey still holds insights to be brought forward, and to be investigated in further detail in another context.

By looking at the results of the survey, 14 industry players answered the question about revenue related to e-mobility, and they have an accumulated yearly revenue of DKK 144.466 million (€ 19.3 million). They represent six of the nine value chain sections. 18 industry players from seven of the nine value chain sections have responded to the question about employees related to e-mobility, and they employ 183.5 employees accumulated. In terms of export related to e-mobility, the survey results are unfortunately too limited to comment on this.

Based on the results above, it is unfortunately not possible to estimate key economic indicators for the entire Danish industry due to the low response rate, and due to the large span in answers. For the revenue figures, the answers range from no revenue and up to DKK 100 million (€ 13.4 million). This large span results in uncertainty about the validity of results if a calculation of the average revenue across all industry players were conducted. The range of answers related to employees span from none to 100 and this brings the same uncertainty as mentioned earlier. Another source of uncertainty is related to the validity of the responses in the survey, as it is the industry players themselves that have provided the answers and it is not possible for the project to verify the answers.

Thus, based on the limited responses in the survey and due to the high uncertainty if the results were used to make an average calculation across all industry players, the project can only conclude, that the Danish sector at least had an accumulated revenue related to e-mobility of DKK 144.466 million (€ 19.3 million) and employed 183.5 persons.

The project have had to realize that Denmark, like the other participating countries have struggled with uncovering the key economic indicators. At the time of writing, only two countries have uncovered the key economic indicators, but they have had to hire consultants to ensure impartiality. Both countries have also had the benefit that the national statistical agencies of both countries have been able to collect data specifically for the e-mobility industry. Both these options have not been possible for the Danish project.

5.2 Patents and innovation

The number of patents that a country has claimed can indicate to what extend the Danish industry players are able to convert research activities to commercially viable innovation solutions.

In terms of the e-mobility industry, it is difficult to map out the exact number of patents due to the complexity, size and intertwinement of the industry with the energy industry, smart grid industry, car manufacturer industry, etc. However, at study conducted by the Danish consulting company Damvad[18] has mapped the total number of patent applications with a Danish origin that are related to i.e. electricity in the transportation sector. This study shows that there has been 118 patent applications from 2003 – 2012, a relatively low number in relation to the global number of patents of 21,551. The largest Danish player in this field is DTU with 43 patent applications out of the 118 Danish applications.

The Dutch working group has, in a study conducted for the Task 24 project, conducted a search in The European Patent Bureau and The World Intellectual Property Office (WIPO) on behalf of all the participating countries in Task 24. The search for patents was divided in eight sub-categories:

[18] "Analyse af Erhvervsmæssige potentialer ved grøn omstilling af transportsektoren", 19. juni 2014, udarbejdet for Energistyrelsen af Damvad.

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

In their study the Dutch group found a total of 137 Danish patent applications over the period from 2005 – 2013, of which a large percentage was related to the fuel cell sub-category with 119 patent applications. The Dutch study has collected information up until first half of 2013, due to the fact that patents have a secrecy period of 18 months and after that some processing time to be included in the statistics. This Dutch study was executed in June 2015.

The total number of global patent applications within the specified time period is 39,064 applications with Japan, Germany and the US as the top three in seven of the eight sub-categories. The Danish number of patent applications sums up to only 0.35 pct. of the global patent applications, however in the fuel cell sub-category, Denmark are among the top ten countries.

The Danish study from Damvad and the Dutch study have focused on different, however somewhat overlapping, time periods and with different constraints, however when you compare the figures from the two studies, the trend is the same. Denmark scores low on in an international comparison on the number of patent applications.

One of the key findings in a study by Deloitte from September 2011 for the Danish EV Alliance was that Denmark at the time had established a number of positions of strength within the e-mobility industry and smart grid that gave Denmark a good starting point for benefitting from this in terms of business and employment opportunities.

These positions of strength were additional to the number of Danish companies who already were well-established as suppliers to the automotive industry. The Danish automotive supplier industry had at the time of the study employed a workforce of 8,000 – 9,000 people, and the total revenue was around DKK 9 bn (€ 1.21 billion). In 2011, the industry produced products with high growth potentials, also in the future, like speaker systems and bodywork. This seems not to have altered much since 2011 and the established industry continues to be a solid foundation for future growth in new areas of manufacturing. The highlighted areas of new expertise related to e-mobility in this report supplement rather than replace the existing industry.

5.3 Job creation

There is no doubt that the implementation of a smart grid into the power grid and the gradual electrification of the automotive industry have a significant potential for the Danish economy in terms of export and occupation. But it is connected to significant uncertainty to estimate the exact potential, the time frame and the policy framework conditions for the realization. So far, it has been difficult to forecast the development of the e-mobility industry and how quick the development is taking place.

Deloitte estimated in 2011, based on a number of premises that electric vehicles and smart grid implementation could lead to a potential for 10,000 new jobs on a medium long timeframe (2020-2025) and about 20,000 new jobs on a long time frame (2030-2040). It is expected that many of the new jobs will be in the knowledge intensive areas. In comparison, the total occupancy of the wind turbine industry in Denmark in 2011 comprised of about 25,000 people, including suppliers.

Unfortunately, it has not been possible through the project to uncover the current level of employment in Denmark within the e-mobility industry. Thus, the 2011 estimates from Deloitte must be used as the plausible potential size of the future employment potential, but in practice it could be higher or lower.

6 Conclusion

Denmark has established a number of positions of strength within smart grid technology and e-mobility which means that Denmark has a good basis for benefitting from the opportunities that the e-mobility industry can offer.

The possibilities of a powerful e-mobility sector in Denmark is also strengthened by factors such as; short geographical distances and relatively high population density, that the population has a positive basic attitude to green energy, which the energy system also provides and that a relatively large proportion of the population lives in such a way that it is relatively simple to install equipment for home charging.

It is estimated that the commercial Danish positions of strength within e-mobility are related to:

- Components
- Infrastructure
- Mobility services

1) In relation to the production of EVs, components and equipment, the analysis shows that Danish companies have established positions of strength within areas like power electronics, BMS, apps and telematics.

2) In terms of smart grid, the assessment is that Denmark has a head start due to the high share of wind power integration and decentralized combined heat and power production. Denmark has thus already a smart grid version 1.0 in place. Combined with a nationwide charging infrastructure for EVs since 2012 and four charge point operators in free competition, it gives valuable experiences of integrating the EVs into the energy system and in terms of the marked build-up and testing.

In terms of research and development activities, Denmark is also on the forefront on the smart grid area. The Danish Universities are international knowledge hubs for the development of advanced electro technical systems and according to the EU, 22 pct. of the European smart grid R&D, test&demo and implementation projects takes place in Denmark. Several international concerns like Siemens, IBM and ABB have placed developmental resources in Denmark with reference to the front-runner position and the Danish energy sector is also a proactive driver, e.g. in relation to expanding smart meters.

3) In terms of mobility services and concepts, Denmark is also part of the leading pack of countries. This is supported by the vast and long experience with real-live tests and demonstrations of EVs and other mobility concepts. At least 83 of national EV projects and about 63 pct. of the public funding has been given to market trial projects with EV's and mobility concepts. This provides a solid basis for the development of new business models and services.

Denmark is in an international perspective in a position in which we can play a key role on niche e-mobility areas in the development of the future EVs. But this development presuppose an attractive home market where e-mobility products and solutions can be tested and innovated. The development of the future Danish e-mobility industry is hard to predict in a situation where the phasing in of registration tax on EVs can affect the e-mobility industry negatively.

Finally, it is also important to mention that the report merely has provided general considerations on the development and research, and market conditions within the e-mobility industry. It's the project clear opinion that the area and the subject can bear a more detailed analysis.

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France Report

Introduction

France profile	
Population [in million]	66.6a
Size [in km2]	551,500a
Gross domestic product (in trillion EUR)	2.02a
Passenger vehicle sales (in thousand)	~1,765b
Passenger vehicle stock (in million)	~32.2c
New passenger car CO2 emissions (in g/km)	115b
Passenger new vehicle market share	
Battery electric vehicles	0.6%b
Plug-in hybrid electric vehicles	0.1%b

a (Central Intelligence Agency, 2015)
b (ICCT, n.d.)
c (Ministry of Ecology, Sustainable Development and Energy, 2014)

With a GDP of roughly €2 trillion, France is the second-largest economy in Europe. France is the EU's second most populous country, but has a low population density (~121/km2) compared to Germany (~227/km2), the UK (~263/km2), and the Netherlands (~408/km2). The country is home to a number of vehicle manufacturers, including Renault, Peugeot, and Citroën, as well as manufacturing plants of foreign brands. The domestic manufacturer Bolloré, a small car maker exclusively focusing on EVs, claimed a 11 percent share of French new EV registrations in 2014 (Mock (ed.), 2015).

France is Europe's third-largest new car market and accounted for 14 percent of Europe's new car registrations in 2014. With average CO2 emissions of 115 g/km and an average vehicle mass of 1,303 kg, France has one of the most efficient and lightest new car fleets in Europe. Domestic manufacturers made up almost half of the French new car market in 2014 and more than 60 percent of the new electric car market.

Chapter 1: E-mobility in France

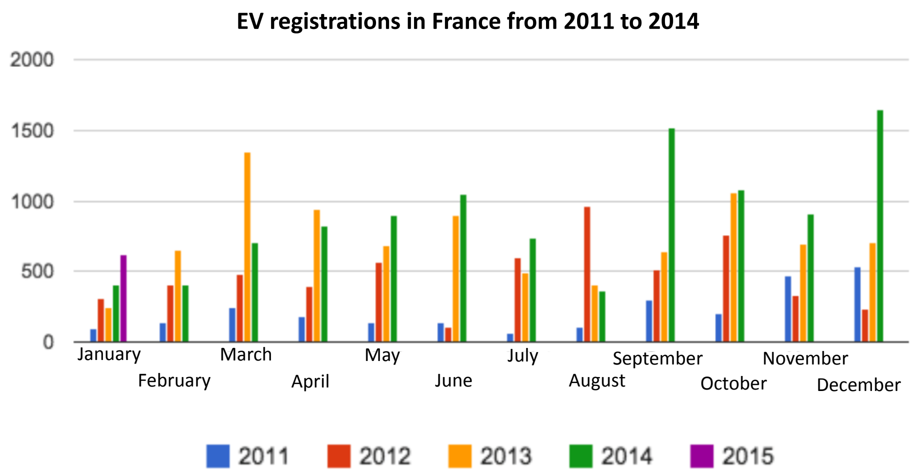
EV market ended 2014 on a 7.8% increase compared to 2013. It reached 15,045 registrations, 70% from private cars. Indeed, the passenger car segment has widened the gap with the light commercial vehicle segment. He crossed a new milestone in 2014 by reaching 10,560 registered units: 20.3% more than in 2013. Meanwhile, the light commercial vehicle segment decreased 13.3% with 4485 new units in 2014.

The most successful passenger car in France is the Renault ZOE with 5,970 registrations (+ 8.3%) followed by 1,604 Nissan LEAF (+ 11.5%) and 1,170 Bolloré Bluecar (77.8 %). Unlike 2013, the market has diversified and expanded with new models like the Kia Soul EV, Volkswagen e-up! and e-course or even more recently, the Mercedes B-Class Electric. Most manufacturers now offer an EV, which covers much of the travel needs in France (IEA International Energy Agency Hybrid & Electric Vehicle Implementing Agreement).

Image 1: Renault ZOE

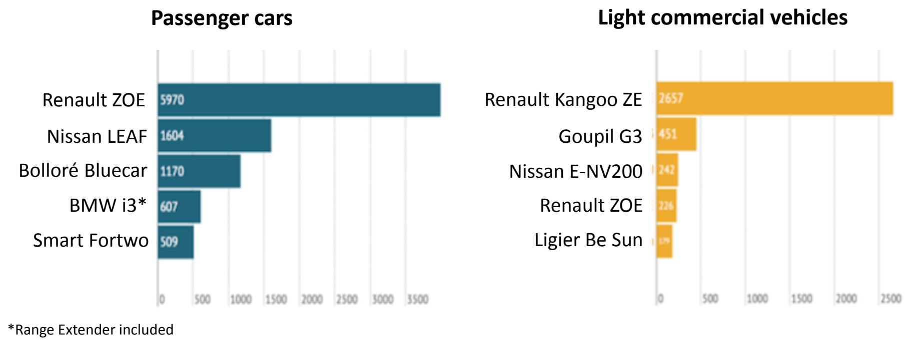
Image courtesy of www.renault.fr

Graph 1: Evolution of EV sales month by month



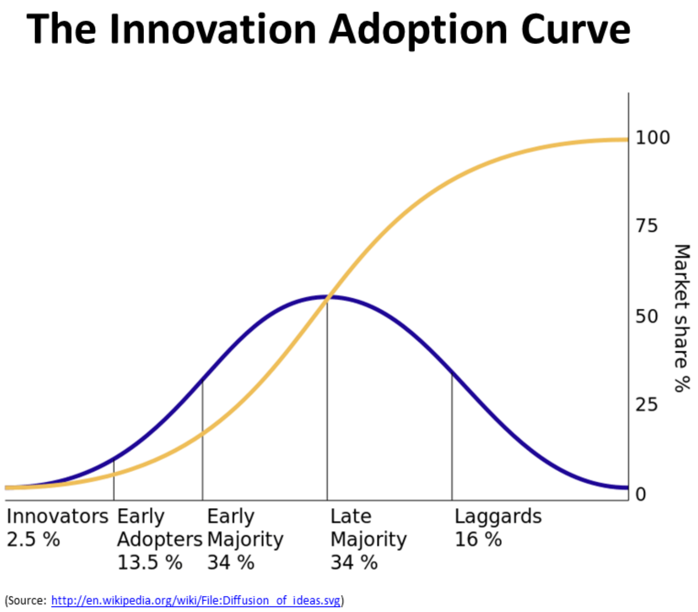
Graph courtesy of www.automobile-propre.com

Graph 2: EV sales by models



Graph courtesy of www.avere-france.fr

Status of electric driving on innovation adoption curve



Electric vehicles represent 0.59% of the 1.7 million registrations in France. Electric driving can be qualified as being still in the Innovators phase on the innovation adoption curve.

Number of electric vehicles

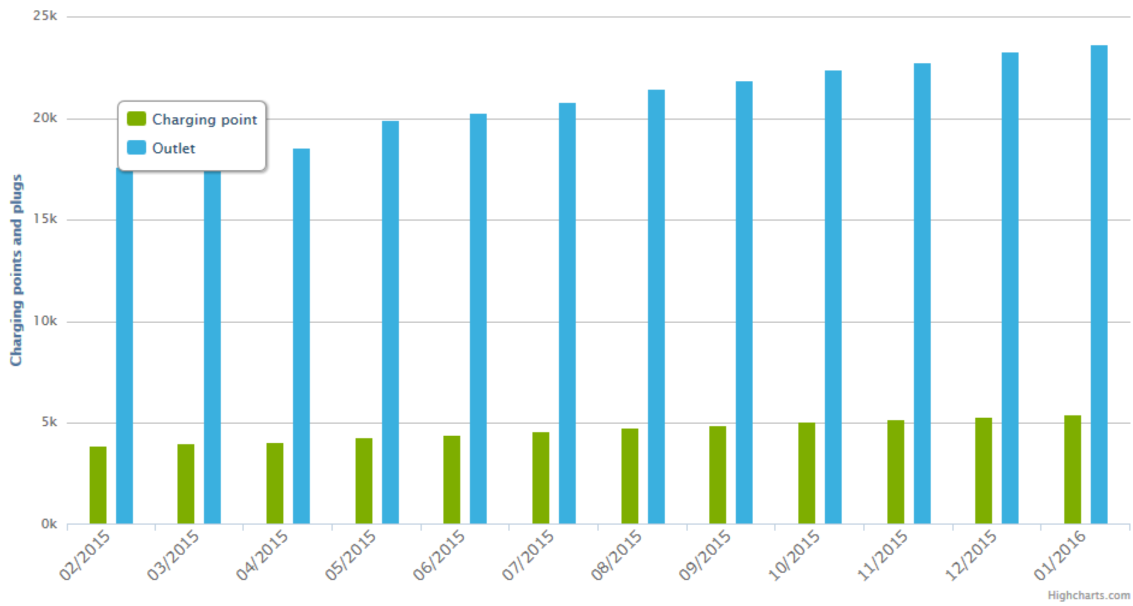
Fleet Totals as of December 31, 2014	
Vehicle Type	EVs
Passenger vehicles	26’691

Total Sales during 2014	
Vehicle Type	EVs
Bicycles	70’000
Motorbikes	372
Quadricycles	60
Passenger vehicles	10’560
Multipurpose	n.a.
Buses	43
Trucks	0
Industrial vehicles	4’437
Totals with bicycles	85’472
Totals without bicycles	15’472
n.a. = not available	

Number of EVSE

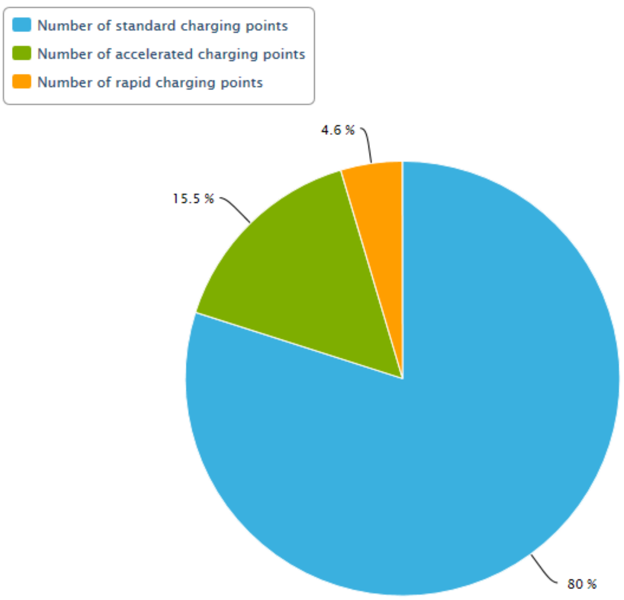
There is considerable uncertainty about charging point availability in France. According to the government's registry, roughly 1,200 charging points were available in October 2015 (Etalab, 2015). However, the effort to gather data on EVSE is still recent and not every charging points have yet been register on this database. The Energy Transition for Green Growth documentation claims that 10,000 public charging points were available in mid-2015 (Ministry of Ecology, Sustainable Development and Energy, 2015). According to the user-based registry Chargemap.com, the number of charging points is much higher, with roughly 23,600 registered plugs for 5,424 charging points (Chargemap.com).

Number of charging points and plugs in the last 12 months



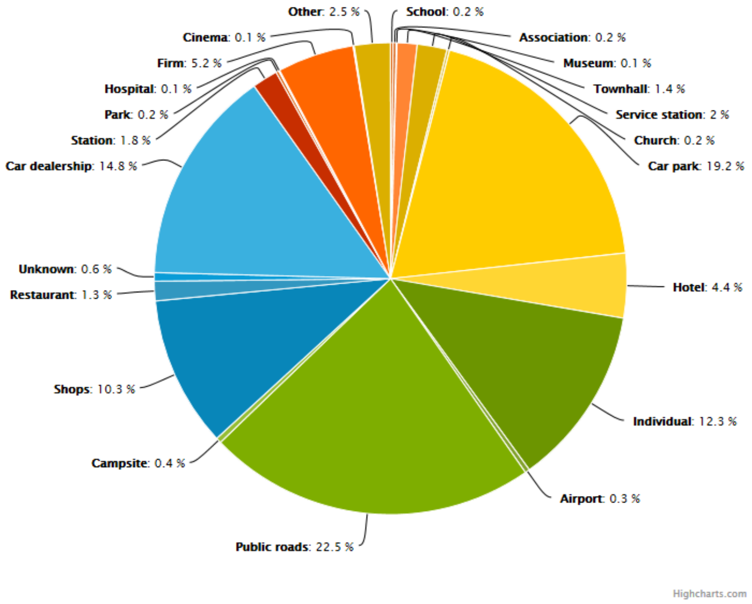
Distibution of plugs according to charge speed

This graph shows the distribution between fast charge and standard charge points. Fast charge points allow to charge 80% of an electric car's battery in less than an hour.



Distribution of charge points per location type.

This graph shows the distribution of charge points for each location listed on ChargeMap. The "other" category features charge points for which we do not have this information yet.



Policy on e-mobility and description of specific measures

Specific plan for developing EV market:

In 2014, the French Government has led a strategy aimed at fostering a domestic electric vehicle market through the automotive industry support plan. In the plan, the French government makes special efforts to achieve the goal of developing EV and PHEV market.

To strengthen efforts in the development of a charging infrastructure, EV Infrastructure deployment plans are now integrated into one of the 34 plans announced by French President Hollande in his 10-year industrial policy to increase French competitiveness. These plans aim to unite economic and industrial stakeholders around a common goal and improve the effectiveness of the tools implemented by the government.

Law on energy transition:

In 2014, France’s government has also unveiled a bill to reduce the country's dependency on nuclear energy and fossil fuels over the next four decades. The legislation, proposed by Environment Minister Ségolène Royal, aims to cut France’s energy consumption in half by 2050 in comparison with 2012. The ambitious bill also seeks to reduce the use of fossil fuels in the country by 30 percent in the next 15 years. Among the bill’s 80 articles are plans to boost EV and PHEV markets. Among the many measures, the so-called “energy transition” law aims at encouraging the use of electric cars.

For instance, the bill plans for the installation of 7 million EV charging points by 2030 (including public and private charging spots) and a conversion premium for the purchase of an electric vehicle in case of disposal of an old diesel vehicle. With the new bonus system, and under certain resource conditions, the amount may reach 10,000 euros. Furthermore, at the time of renewal of state car fleets and public institutions, the bill shows an objective of 50% of the public vehicle fleet to be "clean".

Evolution of the bonus-malus system:

In France, cars are taxed (malus) or credited (bonus) if their carbon emissions are above or below certain targets. Those targets evolve each year.

Table 3 Bonus-Malus system for 2014

BONUS-MALUS SYSTEM FOR 2014	
CO2 emissions (g/km)	BONUS-MALUS
20 and less (EV)	-6300 €
21–50	-4000 €
51–110	-3300 €
111-130	0 €
131–135	150 €
136–140	250 €
141–145	500 €
146–150	900
151–155	1600
156–175	2200
176–180	3000
181–185	3600
186–190	4000
191–200	6500
201 and more	8000

Conversion premium:

France is implementing a new initiative to financially compensate car owners who trade in a diesel vehicle, aged 13 years or more, for a fully electric vehicle or a plug-in hybrid. The campaign comes from the Ministry of Ecology, Sustainable Development and Energy, and seeks to target older cars, which are responsible for a disproportionate percentage of greenhouse gas emissions.

The bonus, or what the French government is calling the "conversion premium," is available to any individual in the nation who trades in an old clunker for a vehicle that runs on clean energy. The dollar amount depends on the type of vehicle purchased, and ranges up to €10,000 ($11,321.47 at today's exchange rate) if a fully electric vehicle is selected, or up to €6,500 ($7,358.37) for a plug-in hybrid. If the old car is replaced with a vehicle that meets Euro 6 specifications and emits less than 110 gCO2/km, there's an additional €500 ($565.64) incentive for non-taxable households. This incentive plan is the brainchild of former presidential candidate Ségolène Royal, who is now head of Ministry of Ecology, Sustainable Development and Energy.

Tax credit:

At the end of 2014, the French government decided to create a tax credit on the income. 30% of expenditure for purchasing and installing a charging system for electric vehicle is eligible for the credit. This initiative aims at easing installation of individual charging point, in particular in buildings and condominiums.

Technical guide for the development of charging infrastructure:

In 2014, the government updated the national technical guide for the development of charging infrastructure for Plug-in vehicles. The new recommendations aim at simplifying access to charging spots and facilitating their use. Specifically, the document provides updated information on charging spots standardization. It encourages the registration of each charging spot on a national website and gives recommendations about interoperability which should allow the subscriber to a charging operator using the network of another operator.

Image X.3: DC combo2, AC, and DC CHAdeMO plugs at a charging station

Image courtesy of www.moteurnature.com

Installation of specific panels for EV charging stations:

Specific panels to facilitate location and access to charging stations have been developed and installed. The road signs now include new signs to indicate the presence, proximity or direction of an electric vehicle charging station.

Charging infrastructure deployment:

As part of the "Investment for the Futur" Program, ADEME supports electromobility through a fund dedicated to local authorities willing to deploy charging infrastructure for Plug-in vehicles. This fund has already financed fifteen projects representing more than 5,000 charging points. It was renewed July 17, 2014 and will end December 31, 2015.

In addition to this incentive for local authorities, the French government encourages also private operators to build and maintain EV charging points by offering a tax exemption for the use of public space. The goal is to provide adequate infrastructure on the entire territory and not just in cities. The law passed in July 2014 offers tax exemption for any operators which builds, maintains or operates public EVs charging infrastructure as long as the charging points are located in at least two regions. French regulators hope to support development of charging infrastructure without putting the financial burden on local authorities.

The law on energy transition plans for the installation of 7 million EV charging points by 2030 (including public and private charging spots). Charging infrastructure is supported with €50 million in funding through the national Investment for the Future program. Large-scale charging infrastructure deployment projects in areas with more than 200,000 inhabitants are supported by the ADEME-managed call for charging infrastructure deployment projects.

In addition to this public initiative, the French government has launched a call aiming at designating national operators to install and manage EV charging infrastructure. Selected companies will pay reduced taxes when building charging stations. The tax exemption concerns rent for occupying public domain. Through this private initiative with public support, the goal is to accelerate the development of a national network of EV charging points in complement to the local authorities' deployment projects. This mandate will apply to recharging points which are 'national' in scale, and will not prevent local initiatives. To profit from this initiative, companies must be operational in at least two regions in France.

As one of the selected company, Groupe Bolloré, the French conglomerate that operates electric car-sharing services in Paris, Bordeaux, Lyon and Indianapolis, has become one of the national operators to develop and manage a charging network across France. Bolloré plans to invest 150 million euros ($172 million) to install 16,000 Level 2 chargers over the next four years. Subscribers will be able to reserve time slots at chargers, and the network will also offer wi-fi and carpooling services.

At the end of 2014, the Company Nationale du Rhône (CNR) announced his intention to also submit its project to create a corridor of 23 fast charging stations along the Rhone axis. These stations will be fed by renewable electricity from CNR hydroelectric plants. (IEA International Energy Agency Hybrid & Electric Vehicle Implementing Agreement)

Image courtesy of Bolloré

Electric vehicle manufacturers

Most car manufacturers offer all electric cars. The main manufacturers producing them in France are Daimler, Mia, Renault and PSA.

Daimler

Daimler produces the Smart Fortwo on its site in Hambach. Production of the electric version of the Smart Fortwo began in 2012, and the site employs 1 600 staff. In 2013 the site achieved turnover of 135 M€, up 24% on the previous year.

Mia Electric

Mia Electric's French base is in Cérizay, in Deux-Sèvres, and the manufacturer employs 200 workers at the site. For a long time, Mia was associated with the Heuliez Group, whose many difficulties finally led to judicial liquidation of the company in April, 2013. Only three of its activities survive - Mia Electric cars, JDM licence-free cars, and EADS helicopter cabins.

Mia Electric has remained very fragile since the liquidation of Heuliez, despite receiving significant support from the Poitou-Charentes region, which owns 12% of the capital. The company was taken over by the Focus Asia consortium in June, 2013, but recurring cash-flow problems and disappointing results finally took over (200 cars registered in 2013 rather than the 800 expected by shareholders). Judicial liquidation was declared in March, 2014, and the production line was sold in July, 2015.

Renault

France's second largest car manufacturer has developed a number of concept cars and electric vehicle models: Fluence, Zoe, Twizzy, and the Kangoo ZE van for the commercial vehicle segment. Only the Kangoo and the Zoé are actually produced in France, at the Maubeuge and Flins sites respectively. The Maubeuge site, which manufactures commercial vehicles only, has been producing the Kangoo ZE since September, 2011, while the Flins factory has been assembling the Zoe since 2012.

At the end of 2013, the group signed a contract with Bolloré (or rather with its subsidiary Blue Solutions) whereby the two companies would jointly market car sharing solutions, jointly manufacture the Bluecar, and design and produce a 3-seater vehicle based on a Bolloré 20 kWh battery. The Bluecar, which has been built in Italy so far, is produced – partially at least – at the Renault plant in Dieppe since June, 2014, and Renault could also provide some of the components.

PSA

The PSA group only makes two electric vehicles, the Peugeot Ion and the Citroên C-zero, both of which are built in Japan by Mitsubishi. This market segment does not appear to be one of the group's priorities.

Battery manufacturers

Blue Solutions

Blue Solutions is a Bolloré Group subsidiary that develops the Lithium-Metal-Polymer (LMP) batteries used by the Bluecar. Blue Solutions began manufacturing batteries in 2001, and the French factory in Ergué Gabéric was built in 2009. At the end of 2013, in addition to signing the partnership agreement with Renault, Blue Solutions also went public.

Saft

The Saft group specialises in making high-tech batteries for industry. The group's main markets are in the aerospace, energy, and transport (air, rail and road) sectors. The group achieved turnover of 598m M€ in 2012 and 624 M€ in 2013, of which the transport sector accounted for 22%. The group has three production sites in France, in Bordeaux, Poitiers and Nersac (near Angoulême). Batteries for the automobile market are primarily manufactured at the Nersac site, which was acquired from Johnson Controls in early 2013.

Dow Kokam France and Forsee Power

The Dow Kokam group entered the French battery production sector in early 2010 when it acquired Société des Vehicles Electriques, a wholly owned subsidiary of the Dassault group, which specialises in systems integration. The company's French production site is in Lognes, in Seine et Marne. In December, 2013, the company was taken over by Forsee Power, a battery design specialist resulting from the 2011 merger between Uniross Industrie, Ersé and Energy One. The takeover was carried out through the Electranova Capital investment fund, which invested in Forsee Power at the start of 2013. In 2013, Forsee Power Industry achieved turnover of 3.9 M€, and employed 21 people.

E4V

Energy for vehicles (E4V) is a French manufacturer of Lithium-ion batteries. The main applications for these products are electric and hybrid vehicles, boats, trains, industrial vehicles and stationary precast concrete pumps. The company's production site is in Le Mans. In 2012, it achieved turnover of 3.3 M€ and had 7 employees.

Car share scheme management

Bolloré

In 2007, the Bolloré group started collaborating with Italian manufacturer Pininfarina on the development of an electric car. This led to the formation, in 2010, of a joint company, following which, in 2011, Pininfarina sold its share of the company back to Bolloré for 10 M€. The Bluecar which initially was made in Pininfarina's Italian factory, which was rented by Bolloré is now produced in to Renault's Dieppe site.

The Bluecar is primarily designed for the car share market and has been used by the Autolib' scheme in Paris since 2012. When the scheme was first launched, it had 313 pick-up stations and a fleet of 1,000 vehicles. In July 2015, there was 3,305 vehicles and 975 stations, and, at the end of March 2015, the scheme had 78648 members.

Bluecars are also used by car sharing schemes in Lyon (Bluely) and Bordeaux (Bluecub), since October 2013 and January 2014 respectively. It cost 20 M€ to set up the scheme in Lyon, which offers 250 vehicles and 100 charging stations. The Bordeaux scheme, which also cost 20 M€, comprises 90 cars and 40 stations.

Bolloré is also targeting the international market with its car sharing systems, and in June 2013 it won a contract with Indianapolis in the United States worth 46.5 M€. The scheme is intended to serve a city with a population of 1.7 million, and comprises 500 vehicles and 200 pick-up stations. Bolloré also plans to export its car sharing system to London, where it would require an investment of 120 M€ and would initially offer around 100 vehicles.

Electric vehicles for car sharing schemes and company car fleets

Car sharing schemes have proved to be a significant market for electric vehicles. The Autolib' scheme, for example, which was launched in Paris in 2011, purchased 399 cars, or 15% of all new electric vehicle registrations that year. In 2012, Bluecar accounted for 27% of newly registered electric vehicles, with 1,543 registrations.

Using the estimated average price of electric vehicles, the value of the car share market in 2011 would be around 10 M€ (including sales margins), and 38 M€ in 2012.

Peugeot was awarded the second lot in the first public group purchase order coordinated by La Poste (the French Post Office). Between 2010 and 2013, a total of 2,256 new Peugeot Ions were registered, accounting for 13% of all new electric vehicles registered at this time. The estimated value of the market for the four year period is 56.5 M€.

Chapter 3: Economic Impact Indicators

Methodology

This report comprises an evaluation of the electric vehicle market. Only privately owned vehicles have been included.

The value of expenditure (investment) on private electric vehicles has been broken down as follows:

- Value of the vehicles at factory prices when manufactured in France or at customs prices if imported (i.e. value of production and imports);
- Value of distribution margins

For each of these components, the evaluation includes both the level of business (value of the market in millions of Euros) and the directly related jobs.

The value of the production and the market is estimated for the vehicles as finished products i.e. no reference is made to upstream activities. This means therefore that the evaluations include neither the value of intermediate consumption nor that of specific components, such as batteries for example due to a lack of reliable data.

The same principle was used to evaluate jobs: only direct jobs are included in the calculations, indirect and spin-off jobs therefore being excluded.

2- Estimate of the domestic market in unit

The value of the domestic market is estimated using a method quantity * price. The quantity corresponds to the registrations (in units) of electric vehicles in France.

Registrations are estimated from data from the annual publication of ADEME "Market development, environmental and technical features - new passenger cars sold in France."

Registrations of electric vehicles per model in units

Model			2010	2011	2012	2013	2014	2015
B.M.W.	SERIE I	I3			10	68	193	279
BOLLORE	BLUECAR			399	1543	658	1170	1191
BYD	E6							2
CITROEN	C-ZERO	ELECTRIC	27	645	1335	80	154	397
FORD	FOCUS	ELECTRIC				4	8	1
KIA	SOUL	EV					63	485
LUMENEO	NEOMA					3		
MERCEDES	CLASSE B	ELECTRIC					15	93
MIA				249	384	201	9	
MINI			50					
MITSUBISHI	I-MIEV		8	42	24	38		54
NISSAN	LEAF			83	524	1438	1600	2222
NISSAN	NV200	ELECTRIC					12	76
PEUGEOT	ION	ELECTRIC	30	639	1409	178	163	725
RENAULT	FLUENCE		13	396	295	18	5	1
RENAULT	ZOE				48	5511	5970	10407
SMART	FORTWO	ELECTRIC	34	52	66	478	509	336
TESLA	MODEL S					17	328	708
TESLA	ROADSTER		11	9	10	1		
THINK	CITY		11	110				
VOLKSWAGEN	GOLF				15		89	125
VOLKSWAGEN	UP					64	265	166
VOLVO	C30E			6				
OTHERS						22	8	

Sales of electric vehicles in units

	2010	2011	2012	2013	2014	2015
Yearly registrations of EV in number of unit	184	2 630	5 663	8 779	10 561	17 268

4- Estimate of the domestic production in unit

Production of electric vehicles in France is relatively recent. Most models offered on the domestic market are indeed produced abroad:

- The Peugeot and Citroën vehicles are made in Japan in collaboration with Mitsubishi,
- The Bluecar is produced in the Turin plant of Pininfarina; as part of the agreement between Renault and Bolloré ; production will be repatriated at Flins from 2015;
- The Nissan Leaf is imported from the United Kingdom and Japan since 2013.

The only models of electric vehicles produced in France since 2012 are the Renault Zoe (Flins site), the Mia Electric (Cerizay), and the Smart Fortwo in Alsace.

The production volume is determined using the CCFA (French Automobile Manufacturers Committee) data or data provided by the manufacturers. Where production value is not available for a given model it is estimated that the production is at least equal to the internal market.

Details on composition of the domestic production of electric vehicles in units for 2015

Model			Domestic production in unit
B.M.W.	SERIE I	I3	-
BOLLORE	BLUECAR		
BYD	E6		-
CITROEN	C-ZERO	ELECTRIC	-
FORD	FOCUS	ELECTRIC	-
KIA	SOUL	EV	-
MERCEDES	CLASSE B	ELECTRIC	-
MITSUBISHI	I-MIEV		-
NISSAN	LEAF		-
NISSAN	NV200	ELECTRIC	-
PEUGEOT	ION	ELECTRIC	-
RENAULT	FLUENCE		-
RENAULT	ZOE		18 656
SMART	FORTWO	ELECTRIC	2 013
TESLA	MODEL S		-
VOLKSWAGEN	GOLF		-
VOLKSWAGEN	UP		-
		TOTAL	**20 669**

Domestic production of electric vehicles in units from 2010 to 2015

The same data sources and methodology were used for year 2010 to 2014.

	2010	2011	2012	2013	2014	2015
Domestic production of EV in number of unit	34	301	498	10 655	13 236	20 669

5- Estimate of foreign trade in unit

There is no public data on foreign trade of electric vehicles with enough details. All estimates are presented from the following equilibrium relationship:

Domestic market + exports = production + imports

Details on composition of the foreign trade of electric vehicles in units for 2015

Model			Domestic production in unit	Domestic market in unit	Imports in unit	Exports in unit
B.M.W.	SERIE I	I3	-	279	279	-
BOLLORE	BLUECAR			1 191	1 191	-
BYD	E6		-	2	2	-
CITROEN	C-ZERO	ELECTRIC	-	397	397	-
FORD	FOCUS	ELECTRIC	-	1	1	-
KIA	SOUL	EV	-	485	485	-
MERCEDES	CLASSE B	ELECTRIC	-	93	93	-
MITSUBISHI	I-MIEV		-	54	54	-
NISSAN	LEAF		-	2 222	2 222	-
NISSAN	NV200	ELECTRIC	-	76	76	-
PEUGEOT	ION	ELECTRIC	-	725	725	-
RENAULT	FLUENCE		-	1	1	-
RENAULT	ZOE		18 656	10 407	-	8 249
SMART	FORTWO	ELECTRIC	2 013	336	-	1 677
TESLA	MODEL S		-	708	708	-
VOLKSWAGEN	GOLF		-	125	125	-
VOLKSWAGEN	UP		-	166	166	-
		TOTAL	**20 669**	**17 268**	**6 525**	**9 926**

Foreign trade of electric vehicles in units from 2010 to 2015

The same data sources and methodology were used for year 2010 to 2014.

	2010	2011	2012	2013	2014	2015
Domestic production of EV in number of unit	34	301	498	10 655	13 236	20 669
Domestic market of EV in number of unit	187	2 630	5 663	8 779	10 561	17 508
Imports of EV in number of unit	150	2 329	5 165	2 586	4 072	6 525
Exports of EV in number of unit	-	-	-	4 462	6 748	9 926

7- Estimate of the domestic market in Euro value

Average purchase price per model for the year 2015:

Model			Average purchase price in €
B.M.W.	SERIE I	I3	38 865
BOLLORE	BLUECAR		18 217
BYD	E6		25 000
CITROEN	C-ZERO	ELECTRIC	26 900
FORD	FOCUS	ELECTRIC	32 900
KIA	SOUL	EV	36 117
MERCEDES	CLASSE B	ELECTRIC	44 012
MITSUBISHI	I-MIEV		23 658
NISSAN	LEAF		29 872
NISSAN	NV200	ELECTRIC	33 980
PEUGEOT	ION	ELECTRIC	26 900
RENAULT	FLUENCE		26 600
RENAULT	ZOE		23 257
SMART	FORTWO	ELECTRIC	25 156
TESLA	MODEL S		87 987
VOLKSWAGEN	GOLF		37 590
VOLKSWAGEN	UP		23 260
		TOTAL	**32 957**

Prices previously obtained are used for estimating the value of the domestic market. The estimated domestic market includes distribution margins, which must be reprocessed to obtain a "manufacturers / importers' price market” (assuming that margins are the same for vehicles imported or locally produced). These margins are estimated from data of INSEE annual survey of automotive companies.

From 2006 to 2015, the margin was stable at around 11% -12%.

Domestic market in € value for the year 2015:

Model			Domestic market in unit	Average purchase price in €	Average purchase price w/o VAT in €	Average manufacturers / importers price in €	Distribution margins in €	Domestic market in €
B.M.W.	SERIE I	I3	279	38 865	32 496	28 988	978 614	8 087 720
BOLLORE	BLUECAR		1 191	18 217	15 232	13 588	1 958 111	16 182 731
BYD	E6		2	25 000	20 903	18 647	4 513	37 294
CITROEN	C-ZERO	ELECTRIC	397	26 900	22 492	20 064	963 810	7 965 371
FORD	FOCUS	ELECTRIC	1	32 900	27 508	24 539	2 969	24 539
KIA	SOUL	EV	485	36 117	30 198	26 939	1 580 891	13 065 217
MERCEDES	CLASSE B	ELECTRIC	93	44 012	36 799	32 827	369 405	3 052 933
MITSUBISHI	I-MIEV		54	23 658	19 781	17 646	115 298	952 873
NISSAN	LEAF		2 222	29 872	24 977	22 281	5 990 415	49 507 565
NISSAN	NV200	ELECTRIC	76	33 980	28 411	25 345	233 070	1 926 195
PEUGEOT	ION	ELECTRIC	725	26 900	22 492	20 064	1 760 106	14 546 332
RENAULT	FLUENCE		1	26 600	22 241	19 840	2 401	19 840
RENAULT	ZOE		10 407	23 257	19 446	17 347	21 843 782	180 527 121
SMART	FORTWO	ELECTRIC	336	25 156	21 033	18 763	762 833	6 304 405
TESLA	MODEL S		708	87 987	73 568	65 627	5 622 123	46 463 827
VOLKSWAGEN	GOLF		125	37 590	31 430	28 037	424 064	3 504 657
VOLKSWAGEN	UP		166	23 260	19 448	17 349	348 471	2 879 924
		TOTAL	**17 268**	**32 957**	**27 556**	**24 582**	**42 960 873**	**355 048 541**

For the period 2010-2015, starting from a price level for each model on the market in 2015, as detailed above, previous price series are reconstructed by changing the 2015 prices using the index of consumer prices for new car from INSEE.

The same data sources and methodology were used for year 2010 to 2014.

Domestic market in € value from volumes and prices per model from 2010 to 2015:

Model			2010						2011					
			Domestic market in unit	Average purchase price in €	Average purchase price w/o VAT in €	Average manufacturers / importers price in €	Distribution margins in €	Domestic market in €	Domestic market in unit	Average purchase price in €	Average purchase price w/o VAT in €	Average manufacturers / importers price in €	Distribution margins in €	Domestic market in €
B.M.W.	SERIE I	I3	-	35 025	29 285	26 124	-	-	-	35 881	30 001	26 763	-	-
BOLLORE	BLUECAR		-	16 417	13 727	12 245	-	-	399	16 819	14 063	12 545	605 650	5 005 371
BYD	E6		-	22 530	18 838	16 804	-	-	-	23 081	19 298	17 215	-	-
CITROEN	C-ZERO		27	24 242	20 269	18 081	59 072	488 197	645	24 835	20 765	18 524	1 445 681	11 947 776
FORD	FOCUS		-	29 649	24 790	22 114	-	-	-	30 374	25 396	22 655	-	-
KIA	SOUL	EV	-	32 549	27 215	24 277	-	-	-	33 344	27 880	24 870	-	-
LUMENEO	NEOMA		-		-	-	-	-	-		-	-	-	-
MERCEDES	CLASSE B		-	39 664	33 164	29 584	-	-	-	40 633	33 974	30 307	-	-
MIA			-	18 526	15 490	13 818	-	-	249	18 979	15 869	14 156	426 502	3 524 811
MINI			50	27 550	23 035	20 549	124 320	1 027 436	-		-	-	-	-
MITSUBISHI	I-MIEV		8	21 321	17 827	15 903	15 394	127 222	42	21 842	18 263	16 291	82 792	684 234
NISSAN	LEAF		-	26 921	22 509	20 080	-	-	83	27 579	23 059	20 570	206 588	1 707 339
NISSAN	NV200		-	30 623	25 605	22 841	-	-	-	31 371	26 230	23 399	-	-
PEUGEOT	ION		30	24 242	20 269	18 081	65 635	542 442	639	24 835	20 765	18 524	1 432 233	11 836 634
RENAULT	FLUENCE		13	23 972	20 043	17 880	28 125	232 440	396	24 558	20 533	18 317	877 681	7 253 563
RENAULT	ZOE		-	20 959	17 524	15 633	-	-	-	21 472	17 953	16 015	-	-
SMART	FORTWO		34	22 671	18 956	16 910	69 566	574 927	52	23 225	19 419	17 323	108 995	900 787
TESLA	MODEL S		-	79 294	66 299	59 143	-	-	-	81 233	67 921	60 589	-	-
TESLA	ROADSTER		11		-	-	-	-	9	-	-	-	-	-
THINK	CITY		11	27 550	23 035	20 549	27 350	226 036	110	28 223	23 598	21 051	280 185	2 315 576
VOLKSWAGEN	GOLF		-	33 876	28 324	25 267	-	-	-	34 704	29 017	25 885	-	-
VOLKSWAGEN	UP		-	20 962	17 527	15 635	-	-	-	21 474	17 955	16 017	-	-
VOLVO	C30E		-	27 550	23 035	20 549	-	-	6	28 223	23 598	21 051	15 283	126 304
OTHERS			-	27 550	22 033	19 655	-	-	-	28 223	21 546	19 220	-	-
			184	**28 862**	**22 033**	**19 655**	**389 463**	**3 218 700**	**2 630**	**28 223**	**21 546**	**19 220**	**5 481 590**	**45 302 397**

Model			2012						2013					
			Domestic market in unit	Average purchase price in €	Average purchase price w/o VAT in €	Average manufacturers / importers price in €	Distribution margins in €	Domestic market in €	Domestic market in unit	Average purchase price in €	Average purchase price w/o VAT in €	Average manufacturers / importers price in €	Distribution margins in €	Domestic market in €
B.M.W.	SERIE I	I3	10	36 826	30 791	27 467	33 236	274 674	68	37 622	31 457	28 061	230 887	1 908 157
BOLLORE	BLUECAR		1 543	17 261	14 432	12 874	2 403 701	19 865 298	658	17 635	14 745	13 153	1 047 249	8 654 950
BYD	E6		-	23 688	19 806	17 668	-	-	-	24 201	20 235	18 051	-	-
CITROEN	C-ZERO		1 335	25 489	21 312	19 011	3 071 020	25 380 330	80	26 040	21 773	19 422	188 009	1 553 797
FORD	FOCUS		-	31 174	26 065	23 252	-	-	4	31 848	26 629	23 754	11 497	95 018
KIA	SOUL	EV	-	34 222	28 614	25 525	-	-	-	34 962	29 232	26 077	-	-
LUMENEO	NEOMA		-				-	-	3	35 908	30 023	26 783	9 722	80 348
MERCEDES	CLASSE B		-	41 703	34 869	31 105	-	-	-	42 605	35 623	31 778	-	-
MIA			384	19 479	16 287	14 529	675 066	5 579 061	201	19 900	16 639	14 843	360 992	2 983 406
MINI			-				-	-	-				-	-
MITSUBISHI	I-MIEV		24	22 417	18 743	16 720	48 555	401 284	38	22 902	19 149	17 082	78 543	649 113
NISSAN	LEAF		524	28 305	23 666	21 112	1 338 576	11 062 611	1 438	28 917	24 178	21 568	3 752 846	31 015 253
NISSAN	NV200		-	32 197	26 921	24 015	-	-	-	32 893	27 503	24 534	-	-
PEUGEOT	ION		1 409	25 489	21 312	19 011	3 241 249	26 787 180	178	26 040	21 773	19 422	418 321	3 457 197
RENAULT	FLUENCE		295	25 204	21 074	18 799	671 027	5 545 679	18	25 749	21 529	19 205	41 829	345 697
RENAULT	ZOE		48	22 037	18 426	16 437	95 465	788 964	5 511	22 513	18 824	16 792	11 197 275	92 539 466
SMART	FORTWO		66	23 836	19 930	17 779	141 980	1 173 385	478	24 352	20 361	18 163	1 050 536	8 682 119
TESLA	MODEL S		-	83 371	69 708	62 184	-	-	17	85 174	71 216	63 529	130 679	1 079 989
TESLA	ROADSTER		10	-	-	-	-	-	1	120 000	100 334	89 504	10 830	89 504
THINK	CITY		-	28 966	24 219	21 605	-	-	-				-	-
VOLKSWAGEN	GOLF		15	35 618	29 781	26 566	48 218	398 496	-	36 388	30 425	27 141	-	-
VOLKSWAGEN	UP		-	22 040	18 428	16 439	-	-	64	22 516	18 826	16 794	130 053	1 074 817
VOLVO	C30E		-	28 966	24 219	21 605	-	-	-				-	-
OTHERS			-	28 966	24 219	21 605	-	-	22	35 908	30 024	26 783	71 296	589 224
			5 663	**28 966**	**24 219**	**21 605**	**11 768 092**	**97 256 962**	**8 779**	**35 908**	**30 024**	**26 783**	**18 730 565**	**154 798 055**

Model			2014						2015					
			Domestic market in unit	Average purchase price in €	Average purchase price w/o VAT in €	Average manufacturers / importers price in €	Distribution margins in €	Domestic market in €	Domestic market in unit	Average purchase price in €	Average purchase price w/o VAT in €	Average manufacturers / importers price in €	Distribution margins in €	Domestic market in €
B.M.W.	SERIE I	I3	193	38 430	32 132	28 664	669 385	5 532 111	279	38 865	32 496	28 988	978 614	8 087 720
BOLLORE	BLUECAR		1 170	18 013	15 061	13 435	1 902 044	15 719 369	1 191	18 217	15 232	13 588	1 958 111	16 182 731
BYD	E6		-	24 720	20 669	18 438	-	-	2	25 000	20 903	18 647	4 513	37 294
CITROEN	C-ZERO		154	26 599	22 240	19 839	369 687	3 055 267	397	26 900	22 492	20 064	963 810	7 965 371
FORD	FOCUS		8	32 532	27 201	24 265	23 488	194 117	1	32 900	27 508	24 539	2 969	24 539
KIA	SOUL	EV	63	35 712	29 860	26 637	203 050	1 678 100	485	36 117	30 198	26 939	1 580 891	13 065 217
LUMENEO	NEOMA		-				-	-	-				-	-
MERCEDES	CLASSE B		15	43 519	36 387	32 460	58 914	486 893	93	44 012	36 799	32 827	369 405	3 052 933
MIA			9		-	-	-	-	-		-	-	-	-
MINI			-				-	-	-				-	-
MITSUBISHI	I-MIEV		-	23 393	19 559	17 448	-	-	54	23 658	19 781	17 646	115 298	952 873
NISSAN	LEAF		1 600	29 537	24 696	22 031	4 265 156	35 249 225	2 222	29 872	24 977	22 281	5 990 415	49 507 565
NISSAN	NV200		12	33 599	28 093	25 060	36 388	300 726	76	33 980	28 411	25 345	233 070	1 926 195
PEUGEOT	ION		163	26 599	22 240	19 839	391 292	3 233 822	725	26 900	22 492	20 064	1 760 106	14 546 332
RENAULT	FLUENCE		5	26 302	21 992	19 618	11 869	98 089	1	26 600	22 241	19 840	2 401	19 840
RENAULT	ZOE		5 970	22 997	19 228	17 153	12 390 650	102 402 067	10 407	23 257	19 446	17 347	21 843 782	180 527 121
SMART	FORTWO		509	24 874	20 798	18 553	1 142 647	9 443 362	336	25 156	21 033	18 763	762 833	6 304 405
TESLA	MODEL S		328	87 002	72 744	64 892	2 575 441	21 284 639	708	87 987	73 568	65 627	5 622 123	46 463 827
TESLA	ROADSTER		-		-	-	-	-	-		-	-	-	-
THINK	CITY		-				-	-	-				-	-
VOLKSWAGEN	GOLF		89	37 169	31 078	27 723	298 552	2 467 369	125	37 590	31 430	28 037	424 064	3 504 657
VOLKSWAGEN	UP		265	22 999	19 230	17 154	550 052	4 545 881	166	23 260	19 448	17 349	348 471	2 879 924
VOLVO	C30E		-				-	-	-				-	-
OTHERS			8	32 588	24 379	21 748	21 052	173 983	-	32 957	24 655	21 994	-	-
			10 561	**32 588**	**24 379**	**21 748**	**24 909 668**	**205 865 021**	**17 268**	**32 957**	**24 655**	**21 994**	**42 960 873**	**355 048 541**

Domestic market in € value from 2010 to 2015:

	2010	2011	2012	2013	2014	2015
Average purchase price in €	28 862	28 223	28 966	35 908	32 588	32 957
Average purchase price w/o VAT in €	22 033	21 546	24 219	30 024	24 379	24 655
Average manufacturers / importers price in €	19 655	19 220	21 605	26 783	21 748	21 994
Domestic market of EV in number of unit	184	2 630	5 663	8 779	10 561	17 268
Distribution margins in €	389 463	5 481 590	11 768 092	18 730 565	24 909 668	42 960 873
Domestic market of EV in €	3 218 700	45 302 397	97 256 962	154 798 055	205 865 021	355 048 541

8- Estimate of the domestic production in Euro value

The value of domestic production is assessed from the estimate of the domestic production in unit and the average price collected from the decomposition of sales and prices in France.

Domestic production of electric vehicles in Euro value for 2015

Model			Domestic production in unit	Average purchase price in €	Average purchase price w/o VAT in €	Average manufacturers price in €	Domestic production in €
RENAULT	ZOE		18 656	23 257	19 446	17 347	323 620 060
SMART	FORTWO	ELECTRIC	2 013	25 156	21 033	18 763	37 770 138
		TOTAL	**20 669**	**24 207**	**20 240**	**36 110**	**361 390 197**

The same data sources and methodology were used for year 2010 to 2014.

Domestic production of electric vehicles in Euro value from 2010 to 2015

	2010	2011	2012	2013	2014	2015
Domestic production in M€	2	43	98	155	205	361

9- Estimate of foreign trade in Euro value

There is no public data on foreign trade of electric vehicles with enough details. All estimates are presented from the following equilibrium relationship:

Domestic market + exports = production + imports

Foreign trade of electric vehicles in Euro value for 2015

Model			Domestic production in unit	Domestic market in unit	Imports in unit	Exports in unit	Average manufacturers / importers price in €	Domestic production in €	Domestic market in €	Imports in €	Exports in €
B.M.W.	SERIE I	I3	-	279	279	-	28 988	-	8 087 720	8 087 720	-
BOLLORE	BLUECAR			1 191	1 191	-	13 588	-	16 182 731	16 182 731	-
BYD	E6		-	2	2	-	18 647	-	37 294	37 294	-
CITROEN	C-ZERO	ELECTRIC	-	397	397	-	20 064	-	7 965 371	7 965 371	-
FORD	FOCUS	ELECTRIC	-	1	1	-	24 539	-	24 539	24 539	-
KIA	SOUL	EV	-	485	485	-	26 939	-	13 065 217	13 065 217	-
MERCEDES	CLASSE B	ELECTRIC	-	93	93	-	32 827	-	3 052 933	3 052 933	-
MITSUBISHI	I-MIEV		-	54	54	-	17 646	-	952 873	952 873	-
NISSAN	LEAF		-	2 222	2 222	-	22 281	-	49 507 565	49 507 565	-
NISSAN	NV200	ELECTRIC	-	76	76	-	25 345	-	1 926 195	1 926 195	-
PEUGEOT	ION	ELECTRIC	-	725	725	-	20 064	-	14 546 332	14 546 332	-
RENAULT	FLUENCE		-	1	1	-	19 840	-	19 840	19 840	-
RENAULT	ZOE		18 656	10 407	-	8 249	17 347	323 620 060	180 527 121	-	143 092 939
SMART	FORTWO	ELECTRIC	2 013	336	-	1 677	18 763	37 770 138	6 304 405	-	31 465 733
TESLA	MODEL S		-	708	708	-	65 627	-	46 463 827	46 463 827	-
VOLKSWAGEN	GOLF		-	125	125	-	28 037	-	3 504 657	3 504 657	-
VOLKSWAGEN	UP		-	166	166	-	17 349	-	2 879 924	2 879 924	-
		TOTAL	**20 669**	**17 268**	**6 525**	**9 926**	**24 582**	**361 390 197**	**355 048 541**	**168 217 016**	**174 558 672**

Foreign trade of electric vehicles in Euro value from 2010 to 2015

	2010	2011	2012	2013	2014	2015
	In M€	In M€	In M€	In M€	In M€	In M€
Domestic market	3	45	97	155	206	355
Imports	1	39	90	51	94	168
Domestic production	2	43	98	155	205	361
Exports	-	37	91	51	93	174

10- Full Time Employees (FTE) related to domestic production

FTE related to manufacturing of electric vehicles

For the production of electric passenger cars, FTE are estimated using the ratio of production / employment collected from INSEE data for the Automotive manufacturing sector for the years 2006 to 2013 and linearly interpolated for 2014 and 2015.

	2010	2011	2012	2013	2014	2015
Production in M€	58 300	60 900	55 300	52 700	50 200	47 800
FTE	133 800	126 600	123 100	118 300	113 700	109 200
FTE / M€	2,30	2,08	2,23	2,24	2,26	2,28

	2010	2011	2012	2013	2014	2015
Domestic production in M€	2	43	98	155	205	361
FTE / M€	2,30	2,08	2,23	2,24	2,26	2,28
FTE	5	89	218	348	464	825

FTE related to distribution of electric vehicles

For distribution, FTE are estimated using the ratio of production / employment collected from INSEE data for the "car trading business" sector for the years 2006 to 2013 and linearly interpolated for 2014 and 2015.

	2010	2011	2012	2013	2014	2015
Distribution in M€	10 244 000	10 649 000	10 164 000	9 701 000	9 259 000	8 837 000
FTE	146 107 000	142 536 000	136 186 000	130 119 000	124 322 000	118 784 000
FTE / M€	14,26	13,38	13,40	13,41	13,43	13,44

	2010	2011	2012	2013	2014	2015
Distribution in M€	0,4	5	12	19	25	43
FTE / M€	14,26	13,38	13,40	13,41	13,43	13,44
FTE	6	73	158	251	334	577

FTE related to maintenance of electric vehicles

	2010	2011	2012	2013	2014	2015
Annual maintenance cost for an EV in €	729	734	711	721	728	733
EV stock	3 725	6 355	12 016	20 797	31 364	42 595
Maintenance in M€	2,72	4,66	8,54	14,99	22,83	31,22
FTE/M€	5,68	5,65	5,85	5,56	5,52	5,52
FTE	15	26	50	83	126	172

IA-HEV Task 24: Economic Impact Assessment of E-mobility

THE ECONOMIC IMPACT OF E-MOBILITY IN GERMANY

Task 24 country report

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THE ECONOMIC IMPACT OF E-MOBILITY IN GERMANY

CONTENT

1. Management Summary

The automotive industry is the largest industry sector in Germany, accounting for 404 billion Euro in 2015, providing 792,500 jobs. Currently 41 OEM sites are located in Germany. German OEMs provide one third of global automotive R&D expenditure, with R&D investments amounting to 19.7 billion Euro in 2014. The German automobile industry counts 100,000 employees in R&D.

Germany's policies in support of e-mobility entered a new phase in 2016. Whereas former policies mainly focused on RTD funding and demonstration projects, nowadays in addition the maket ramp-up is addressed. New regulations, tax excemptions and a buyer's premium constitute a supportive environment for e-mobility. The registration of new vehicles shows a growing share of electric vehicles (still on low level) from 1.4% until June 2016 to 2.4% in October 2016.

Task 24 – Economic Impact Assessment of E-Mobility investigates the economic position of individual countries and aims at getting a better understanding of the value chain for e-mobility. The country report for Germany focuses on the automotive cluster in Baden-Württemberg, where in-depth studies on the impact of e-mobility on employment are available.[1,2] Baden-Württemberg is home of the most important automotive cluster in Europe.

The studies conducted a detailed analysis based on all relevant components of vehicles and a realistic scenario of the global market development for electric vehicles. The most recent study furthermore investigated the capability of the existing value chain to unlock the theoretical market potential. Whereas the potential calculated from market growth and shares indicates up to 24,000 additional jobs in Baden-Württemberg in 2025 compared to 2013, the realistic picture accounts for 18,000 additional jobs in the same period.

The report elaborated by Wirtschaftsförderung Region Stuttgart in cooperation with Innovationhouse Deutschland covers the vehicle production and its corresponding value chain only. An overall assessment of the economic impact needs to take into account after sales services and new business opportunities related to e-mobility as well. As electric vehicles are less complex than combustion engine cars, services in workshops tend to be lower in future, resulting in a decrease of employment, whereas services around e-mobility and charging infrastructure provide new job opportunities. Whether this will result in overall employment growth or loss goes beyond the scope of this report.

Fig. 1: OEMs and suppliers in Germany (source: GTAI 2015)[3]

Whether a specific country or region will be able to develop in such a direction, depends on singular events as well. The decision of an OEM for a new production site significantly influences the whole value chain. As an example the Porsche production of the "Mission E" will start in Stuttgart Zuffenhausen. 1,200 additional jobs will be offered by Porsche from the year 2020 in a new plant, 200 more in its development departments. Further impact is expected in employment along the value chain. The future development of Germany's automotive sector mainly depends on appropriate investment decisions at the right moment. It will be crucial for the German economy as a whole not to miss the wright moment to turn (combustion) vehicle production to the next stage of mobility industries.

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[1] Structure Study BW^e Mobil 2011 – Baden-Württemberg on the way to electromobility, e-mobil BW GmbH
[2] Strukturstudie BW^e Mobil 2015 – Elektromobilität in Baden-Württemberg, e-mobil BW GmbH
[3] Industry Overview: The Automotive Industry in Germany (Issue 2016/2017), Germany Trade & Invest

2. Introduction

2.1 Framework of Task 24 and IA-HEV

In 1993 the IEA founded the Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). Its objectives are the collaboration on pre-competitive research as well as the compilation and dissemination of information. The Executive Committee (ExCo), which consists of one delegate per member country, governs the work of IA-HEV. Different working parties are treating specific topics. The reports of these Tasks are a major part of the deliverables of the IA-HEV.

This report is one of the deliverables of Task 24 – Economic Impact Assessment of E-Mobility. The ExCo approved this Task in November 2013 and work started in May 2014. The final report is expected to be delivered by end of 2016. Task 24 sets its focus on the economic impact of this emerging market. It looks at how e-mobility can strengthen the economic position of a country and what growth is expected in this sector. It aims at getting a better view on the value chain for e-mobility in general and specifically on the economic potential of the local industry.

Task 24 participants are Austria, Belgium, Denmark, France, the region of Baden-Württemberg in Germany, the Netherlands, the United States of America and Switzerland. Every participant produces a country report on the economic perspective in its specific country. These results will then be analysed and summarized in a final benchmark report. The present report is the country report for Germany.

2.2 General characteristics of the German market

Economic Structure of Germany

Germany Trade and Invest, the economic development agency of the Federal Republic of Germany, characterizes the German economy as follows[4]:

- Germany's economic policies enhance a broad and competitive industrial environment with a strong focus on innovative future technologies. Many small and medium sized enterprises utilize this potential, making them leaders in their respective markets. Across industries large and small, German products are worldwide export hits.
- Germany is the largest market in Europe. It constitutes 21 percent of Europe's GDP (EU-28) and is home to 16 percent of the total European Union (EU) population. The German economy is both highly industrialized and diversified – with equal focus placed on services and production.
- The German economy finds itself in a solid upswing. The German government forecasts significant growth of 1,8% in GDP for 2015 and 2016.
- Global player: The German exporting industry presents itself stronger than ever. It is an important pillar of German economy. Germany is the world’s third-largest exporter after China and the United States. The export figures in 2014 were on a similar high level as record setting year of 2013. German-produced goods from the chemical, automotive, and machinery & equipment industries are in particularly high demand worldwide.
- Key driver of the German economy is the manufacturing industry. Almost 10 percent of Europe's manufacturing companies are German. They generate 30 percent of the EU's gross value added in manufacturing alone. In fact, they represent more than one fifth of all of Germany's value added – one of the highest shares in Europe. Increasingly more foreign companies are placing their faith in Germany as an essential location for production sites and are benefiting from the country's excellent business framework and superior productivity rates.
- Economic backbone of the German economy are small and medium-sized enterprises. Exports are driven by Germany’s backbone of highly innovative small and medium-sized enterprises (SMEs). These constitute 99.6 percent of all companies that employ 62 percent of all employees in Germany. Many of these SMEs are world market leaders in their respective niche segments. Together with internationally leading companies - such as Bayer, BASF, Daimler, Volkswagen, and Siemens to name but a few - they make up Germany’s manufacturing industrial base.
- The close relationships are reflected in the significance of the EU as a foreign trade partner. Nearly 60% of all German exports remain within the EU. Around three quarters of all foreign direct investments in Germany – and more than half of all German direct investments overseas – originate from or are made in EU countries.

[4] Germany Trade and Invest (GTAI), www.gtai.de

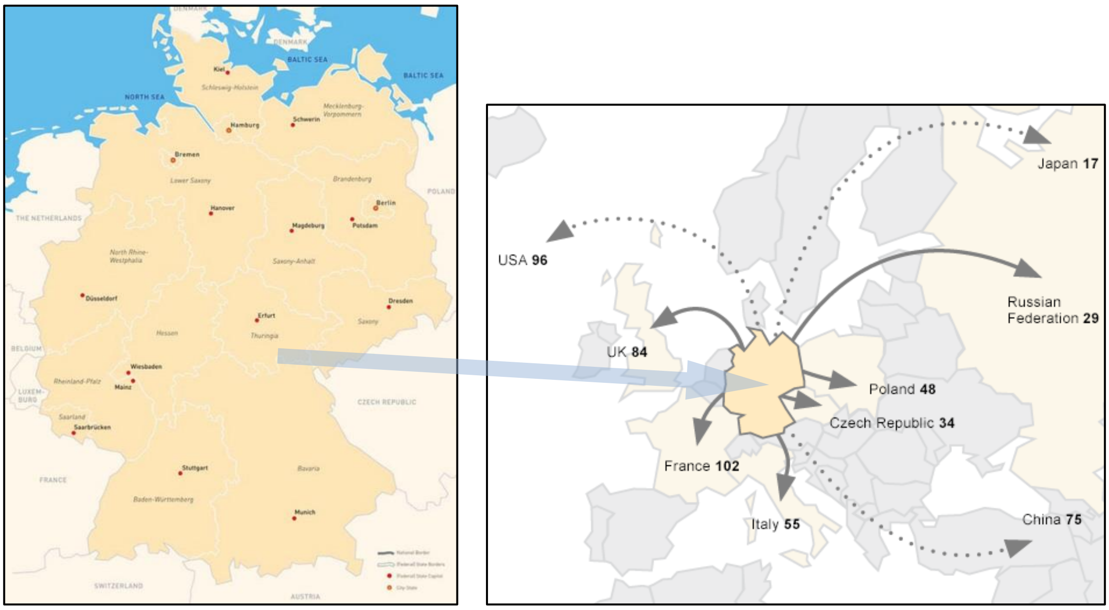

Fig. 1: Germany within the European Union and German exports 2014 in EUR bn (GTAI, Federal Statistical Office 2015)

Economic Activity (2015)	
GDP	EUR 3,032.8 billion
GDP per Capita	EUR 37,130
GDP by Sector	Services 53.1%, Industry 30.5%, Trade 15.8%, Agriculture 0.6%
GDP growth	1.7%
Inflation Rate	0.3%
Export of goods	EUR 1,196 billion
Imports of Goods	EUR 946 billion
Economic Structure (2015)	
Number of companies	3.63 million
Percentage SMEs (2014)	99.3%
Turnover companies (2013)	EUR 6,085.0 billion
Turnover SMEs (2012)	EUR 2,149 billion
Labour force	43.0 million
Unemployment Rate	4.3%

Fig. 2: Economic figures of Germany (www.destatis.de)

The automotive industry in Germany

Among all industry sectors the automotive sector is the most crucial for the German economy[5]:

- The automotive industry is the largest industry sector in Germany. In 2015 the automotive sector listed a turnover of EUR 404 billion, around 20 percent of total German industry revenue. Germany is Europe's number one automotive market, accounting for over 30 percent of all passenger cars manufactured (5.7 million) and almost 20 percent of all new car registrations (3.21 million).
- Germany is home to 43 automobile assembly and engine production plants with a capacity of over one third of total automobile production in Europe.
- One in every five cars worldwide carries a German brand.
- In 2014, automotive industry R&D expenditure reached EUR 19.7 billion, equivalent to 35% of Germany's total R&D expenditure. The German automotive sector spends EUR 9.4 billion on external R&D.
- 21 of the world's top 100 automotive suppliers are German companies.
- Around 77 percent of cars produced in Germany in 2014 were ultimately destined for international markets – a new record
- R&D personnel within the German automobile industry reached a level of just over 100,000 in 2015. Around 792,500 are employed in the industry as a whole.

[5] GTAI Industry Overview (Issue 2016/2017), VDA 2015, ACEA 2015, PWC 2013

The automotive industry in Baden-Württemberg

This country report will focus mainly on the state of Baden-Württemberg with its outstanding automotive industry which is also a reason why Baden-Württemberg became one of the four showcase regions for electromobility in Germany.

In Baden-Württemberg headquarters of the two renowned automotive manufacturers Daimler AG and Porsche AG and a high number of major suppliers are located, for example Bosch, ZF Group, MAHLE, Getrag, KSPG, Eberspächer, Continental, SEW Eurodrive, Wittenstein, Dürr, Festo, Freudenberg, Mann+Hummel. In addition, the Audi AG is present with a major production and development location. The headquarter of car2go, Germany's second largest car sharing provider, is also located here.

In 2014 Baden-Württemberg's companies had a market share of 6 % of worldwide sales in the automotive industry. In 2013 nearly 212,000 people were employed in more than 300 companies involved in vehicle manufacturing in Baden-Württemberg, having an annual industry turnover of approximately EUR 88 billion. Altogether more than 400,000 employees contribute directly or indirectly to the automotive value creation chain, when including the parts of the chemical industry, the rubber and plastics processing industry and metal products manufacturing industry, which also contribute to the automotive industry.[6]

Best practice: The Stuttgart Region – One of the most comprehensive automotive clusters in Europe[7]

The Stuttgart Region, core region of Baden-Württemberg, is an excellent example for an outstanding regional German automotive cluster. It is even one of the most comprehensive automotive clusters in Europe with 190,000 employees in car manufacturing and mobility industries. Car manufacturers (OEM) and suppliers dominate the economic structure and employment in the Stuttgart Region. The automotive industry plays a key role in the economy of the Stuttgart Region, accounting for a sixth of all local jobs. With respect to geographic concentration, density of companies and specialisation, Stuttgart Region is the leading automotive region in Germany. Besides Daimler AG and Porsche AG approximately 400 suppliers are located in the region, with companies of different sizes ranging from small and medium-sized enterprises (SMEs) to global players like Bosch in the field of electronics, from small automotive-design offices to Bertrandt AG, a leading engineering company. In contrast to other automotive regions, many of the suppliers still are independent companies, which are not part of any corporate group. Robert Bosch GmbH, Mahle GmbH, Behr GmbH & Co. KG[8], Eberspächer GmbH & Co. KG and Mann+Hummel GmbH all headquartered in the Stuttgart Region, and are listed in the group of "Top-100-Automotive-Suppliers 2010". In 2014, the automotive industry produced with 12.4% of all employees in the German automotive industry a turnover of EUR 53 billion (14.3% of national turnover in the sector), of which EUR 42.5 billion (17.9% of Germany) are exports.

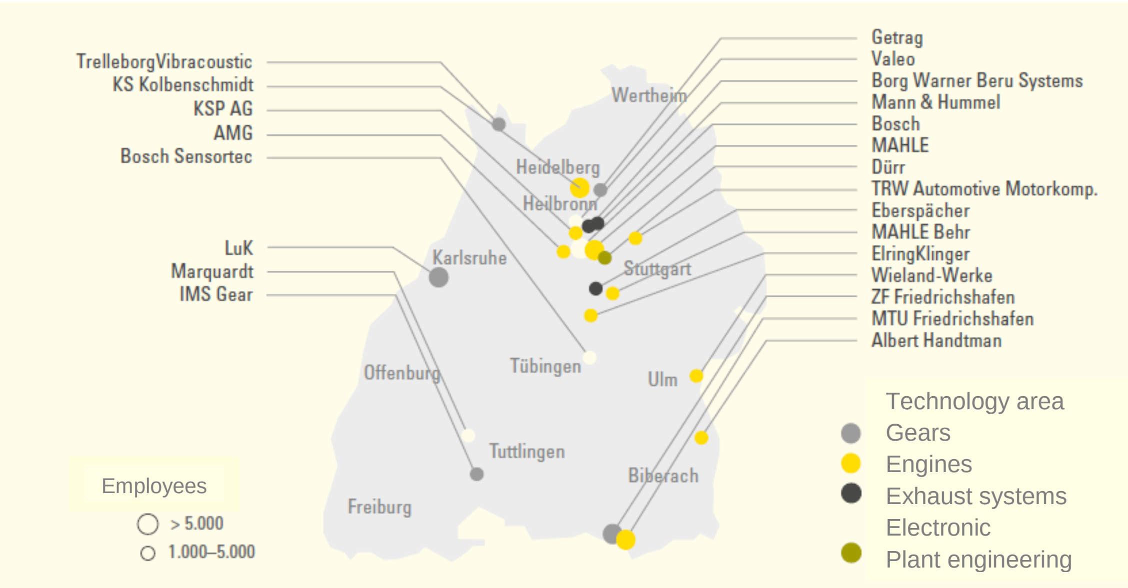

Fig. 3: Map of important automotive suppliers in Baden-Württemberg (Strukturstudie BW^e Mobil 2015)

[6] Structure Study BW^e Mobil 2011 – Baden-Württemberg on the way to electromobility, updated with figures from Strukturstudie BW^e Mobil 2015 – Elektromobilität in Baden-Württemberg, e-mobil BW GmbH
[7] Electromobility in Europe 2015
[8] Since 2013 Mahle holds 51% shares of Behr, which has been renamed to Mahle Behr GmbH & Co. KG

3. Electromobility in Germany

3.1 Development of electromobility

Due to the importance of the German automotive sector, German policy supports the automotive industry in the serious transformation process from combustion to electric vehicles. The goal in this process of change is, to strengthen the German automotive industry along their entire value chain in international competition. This includes the establishment of new business areas for suppliers and related industries.

During the economic crisis in 2007/2008 Germany decided to establish a national support scheme for electromobility. Based on the traditional strengths of the national carmakers, this smart specialization strategy aims at closing the gap to leading electromobility nations and placing German automotive industry on top of the global development. Germany should not only become a lead market for electromobility but a lead provider of electric vehicles and sustainable mobility solutions.

In the National Electromobility Development Plan of Germany the goal has been set to bring one million electric vehicles onto German roads by the year 2020, including BEV, PHEW, REV. By the year 2030 the goal is six million electric vehicles on German roads. This is part of Germany‘s advanced climate protection strategy, which forecasts a reduction of greenhouse emissions by 80 percent, compared to 1990, by the year 2050.[7]

3.2 Policy on electromobility and incentives

National level – Germany

The German “Nationale Plattform Elektromobilität” (NPE) was established in 2009 by the Federal government as a think tank and policy advisory group for the implementation of the National Electromobility Plan. It brings together representatives of industry, the research and political communities, the trade unions and civil society in Germany. Its members have agreed on a systemic, market-driven approach characterized by a readiness to deploy a variety of different technologies in order to achieve the goal of making Germany the world’s leading supplier and market for electromobility by 2020. The NPE produced a general roadmap for its systemic approach during the market ramp-up phase, which has been published in September 2013.[7]

In the summer of 2009 the German Federal Government published the “German Federal Government’s National Electromobility Development Plan”, which structured Germany’s funding activities. The goal of the National Development Plan for Electromobility is to advance research and development, market preparation for and introduction of battery powered vehicles in Germany.

Germany’s National Development Plan for Electromobility is based on a strong and broad foundation. The BDEW (Federal Association of the Energy and Water Sectors), VDA (German Automobile Industry Association) and ZVEI (German Electrical and Electronic Manufacturers’ Association) national industry associations acknowledged their responsibilities in 2009.

In 2009 a half a billion Euro programme for research, technology development and innovation (RTDI) has been launched (Economic Stimulus Package II), including Information and Communication Technology (ICT) for electromobility (IKT II) and eight pilot regions of electromobility schemes. The promotion of this programme electromobility has come to an end in 2011.

As a next step, four showcase regions were selected in April 2012 in a national competition and have been supported with an overall Federal funding of 180 Mio Euro over 3 years to demonstrate everyday usability of electric vehicles and prepare for the market roll-out of electromobility solutions (including the LivingLab BW^e mobil in Baden-Württemberg). The showcase regions are offering potential users and the general public in Germany the opportunity to gain first-hand experience of the system electromobility.

Further subsidies of 1 billion euros have been earmarked by four federal ministries for electromobility from 2012 to 2017. These are:

- The Ministry of Education and Research (BMBF): EUR 226,817,339
- The Ministry for Economic Affairs and Energy (BMWi): EUR 255,437,954
- The Ministry for Transport and Digital Infrastructure (BMVI): EUR 386.905.518
- The Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB): EUR 121,113,642

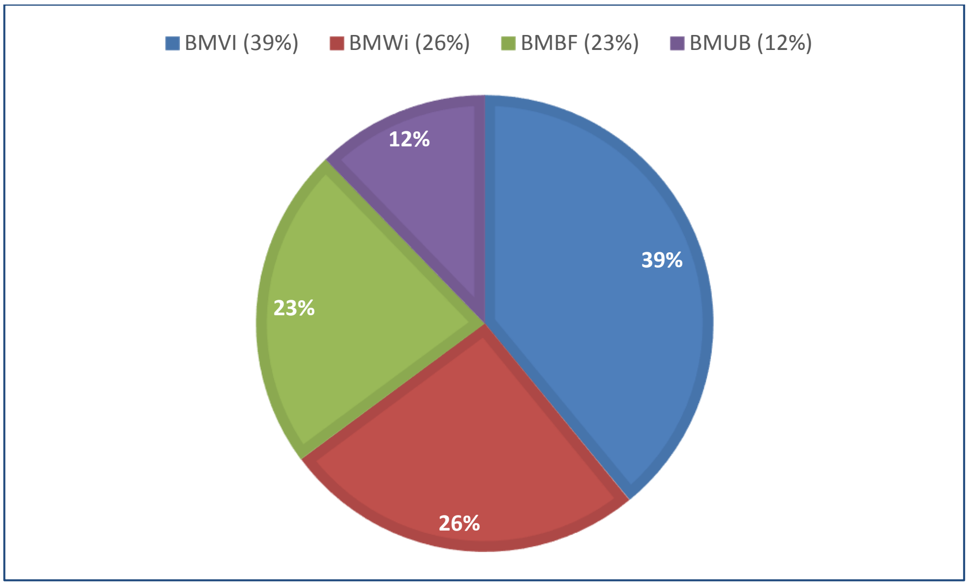

Fig. 4: E-Mobility - Funding per National Ministry

Comparing the allocation of the national funding to the federal states, it turns out that Baden-Württemberg due to its automotive competence (and therefore electromobility relevance) is receiving the largest share.

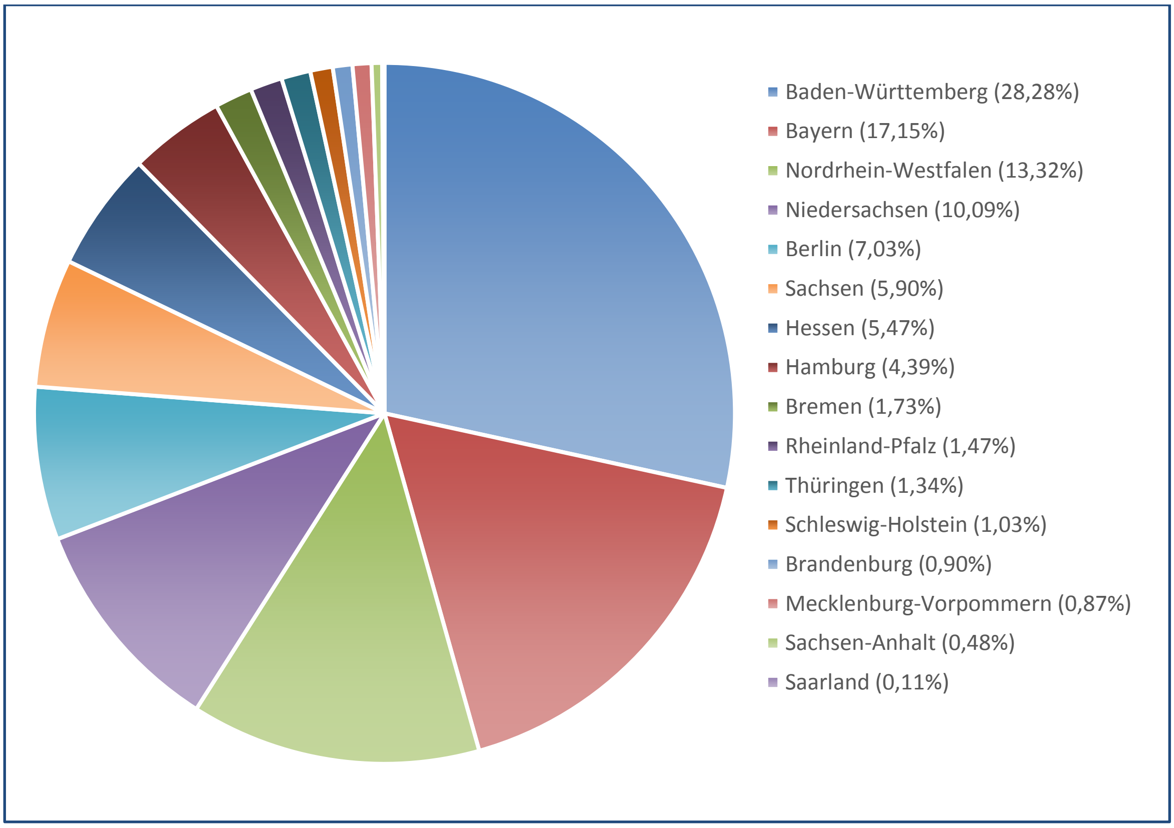

Fig. 5: Electromobility - Funding per federal state 2012 - 2017

The introduction of the **first Electromobility Act of 2015** authorized municipalities to privilege electric vehicles to a considerable extent. This includes free parking, the use of bus lanes and exceptions to noise and emission protection zones, for example for delivery traffic. Another possibility is to promote not only public infrastructure, but also the installation of private infrastructure, for example wall boxes in single and multi-family houses. A suitable package of state and local measures could significantly increase the market penetration of electric vehicles in Germany in the coming years.[9] In 2012 the Federal Government has launched the initiative to acquire more than 10% environmentally friendly vehicles when buying new vehicles for its own fleets.

Important steps were taken in 2016, where national policies turned from the main focus on RTD funding to additional market uptake incentives. A buyer's premium came into force in June 2016. The total volume of the program of EUR 1.2 billion is financed equally by national funding and the OEMs. The purchase of a full electric vehicle is supported with EUR 4,000, buyers of plugin hybrid vehicles receive EUR 3,000. (Luxury) vehicles costing more than EUR 60,000 will not be supported. In addition, owners of electric vehicles benefit from a road tax exemption (no road tax need to be paid for 10 years).

State level – Baden-Württemberg

Funding is available in most German States that extends beyond the Federal programs. In its first electromobility initiative, the state of Baden-Württemberg provided a total of EUR 28.5 million for the years 2010 to 2014, to which the founding of e-mobil BW as a state agency can also be attributed. In principle, the state agency functions as an umbrella organization to coordinate the activities in the electromobility sector in Baden-Württemberg. Since 2012 the second state initiative on electromobility is running with a total volume of EUR 50.25 million. Main activities were the funding of R&D (EUR 30 million) and vehicle procurement (EUR 11.75 million).

The greatest volume of research funds for electromobility is made available from the Federal Ministry for Research and Education (BMBF). Thus, for example, in the „Association Southwest for Electrochemistry for Electromobility" alone, the Baden-Württemberg participants were funded with EUR 14 million. [10]

Future prospects

As a prerequisite for the large-scale introduction of electric vehicles in the years to come, appropriate political, regulatory, technical and infrastructural frameworks have to be created. For example, open European standards, which will also serve as ambitious global benchmarks, are necessary to ensure interoperability, safety and acceptance. In the framework of the National Development Plan for Electromobility the Federal Government will contribute to this process until 2020.

3.3 Number of electric vehicles[11]

In the National Electromobility Development Plan a market preparatory phase (2010 - 2014), which is completed by now, and a market ramp-up phase (2015 - 2017), which has begun, were distinguished. The plan is implemented by the National Platform Electromobility (NPE, see chapter 3.2 on policy and incentives).

At the end of the market preparation phase the results can be summarized as follows: German industry is on its way to become an international lead provider. At the end of 2015, 29 electric vehicle models from German manufacturers were on the market who will be expanding their product range steadily in the coming years. The cooperation of leading industries and science along the value chain of electric mobility is well established. The focus on the promotion of research and development, standardization and education and qualification has proven itself by international standards.

[9] Strukturstudie BW^e Mobil 2015 – Elektromobilität in Baden-Württemberg, e-mobil BW GmbH
[10] Structure Study BW^e Mobil 2011 – Baden-Württemberg on the way to electromobility, e-mobil BW GmbH E-Mobil BW
[11] NPE 2015, Strukturstudie BW^e Mobil 2015, VDA 2015

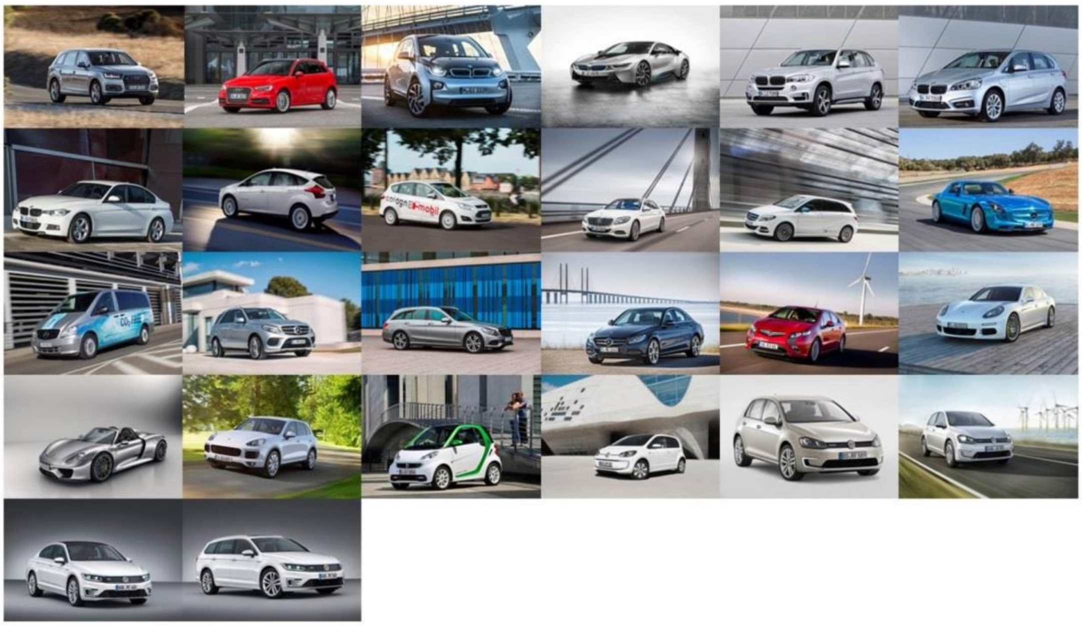

Fig. 6: By the end of 2015 the German manufacturers have launched 29 electric vehicles (VDA 2015)

In 2015 approx. 3.20 million of passenger vehicles were newly registered, from a total population of 45 million vehicles. In the area of "new registrations of electric vehicle" (BEV, PHEV, REEV) the number of newly registered passenger vehicles in Germany increased to 45,993 vehicles. In the area of "new registrations of electric vehicles" the state of Baden-Württemberg is ranked fourth among the 16 federal states.

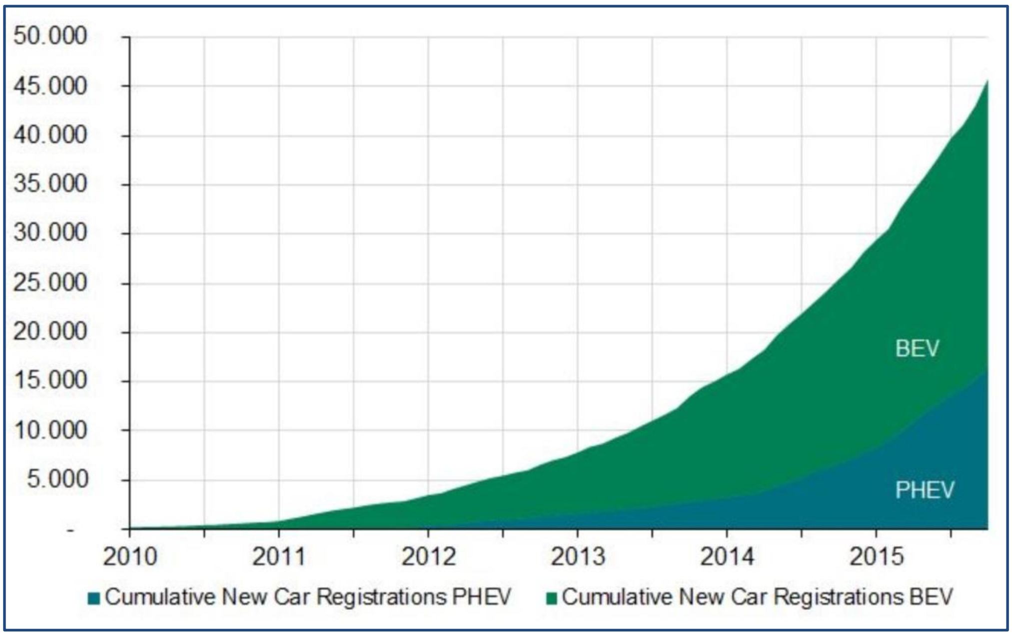

Fig. 7: Cumulative New Car Registrations (VDA 2015)

Future prospects

The actual challenge is to implement the potential of German industry in higher market shares and thus achieve the position as lead provider. Electric vehicles have to compete with other drive concepts particularly in terms of price and range. To this end, it still requires pre-competitive research and development at a high level. To continue the innovation processes, the NPE has identified a total project volume of research and development amounting to around 2.2 billion euros by the end of the market ramp-up phase in 2017.[12]

[12] NPE 2015

3.4 Development of the charging infrastructure

AC Charging

In the middle of 2016 in total 6,517 charging points at 2,800 public charging stations, mostly AC type 2, for the approx. 60,000 electric vehicles were established. However, the growth rates of the vehicle numbers are higher than for the charging infrastructure. If the vehicle population increases by the end of 2016 to more than 70,000 vehicles, the ratio will become one publicly accessible charging point per ten electric vehicles.

Fast charging

In the middle of 2016 in total 230 publicly accessible fast charging points with Combo 2 connectors were installed. The construction of fast charging infrastructure is supported by European, federal and state subsidies. The construction of approximately 1,400 additional DC fast charging stations is planned until end of 2017. For the period 2017-2020 about 5,700 more fast charging points will be needed, which would lead to a significant reduction in the perceived undersupply and range anxiety.

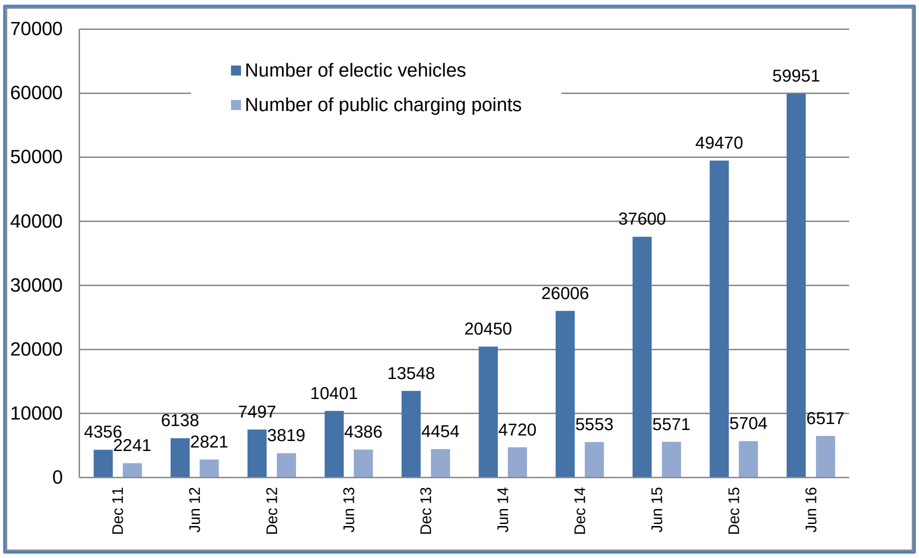

Fig. 8: Comparison of the market ramp-up of electric vehicles and publicly accessible charging infrastructure (KBA / VBA, BDEW 2016)

The operation of publicly available charging stations is still generally in deficit and the ramp-up of electric vehicles is significantly stronger than the further construction of publicly accessible charging infrastructure. The further expansion of publicly accessible AC charging infrastructure has slowed down since 2012 due to the lack of cost efficiency because of low utilization. The majority of recent electric vehicle users charge their vehicle at home or at their workplace. Charging at home or at the parking space during the night or during working hours is convenient. Nevertheless, a publicly accessible charging infrastructure for some users groups is necessary.

In contrast to the AC “standard charging infrastructure” the ramp-up of the DC fast charging infrastructure shows currently a significantly higher dynamics.

Future prospects

The future aim is to extend the public AC charging infrastructure development primarily for drivers without a fixed own parking space and for carsharing fleets in inner cities. An extension of additional 10,000 AC charging points is regarded as appropriate by the NPE to keep the financing requirements to a minimum. The three biggest German cities Berlin, Hamburg and Munich have recognized this need and provide approx. EUR 14 million for the further expansion of public charging infrastructure. The state of Baden-Württemberg supports the existing public charging infrastructure with subsidies until mid of 2018.

The facilitation and standardization of charging has recently taken a further step forward. The Federal Council approved the charging infrastructure legislation of the Federal Ministry of Economics and Technology (BMWi). The regulation sets minimum standards for the construction and operation of public charging points for electric vehicles as well as clear and binding rules on charging connector standards.

The Federal Ministry of Transport and Digital Infrastructure (BMVI) will launch a funding scheme for charging infrastructure end of 2016 / early 2017 with a volume of EUR 300 million (200 million for 5,000 DC fast charging stations, 100 million for 10,000 AC charging stations). In addition, the installation of DC charging stations at 400 service areas along the German motorways already is ongoing (58 Tank&Rast service areas already installed end of October 2016).

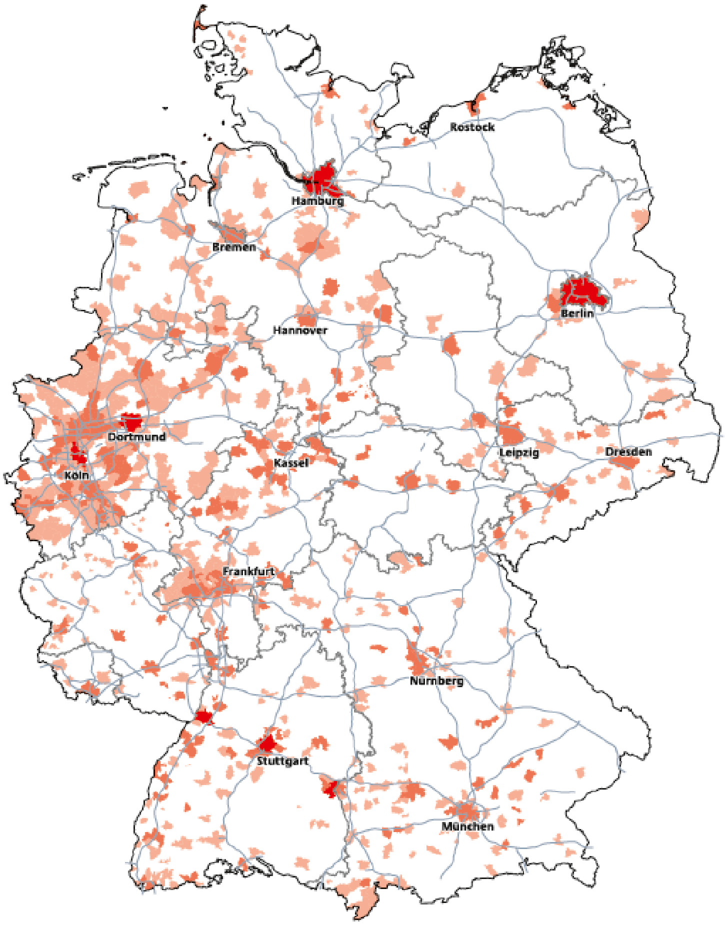

Fig. 9: Distribution of charging infrastucture in Germany (BDEW June 2016)

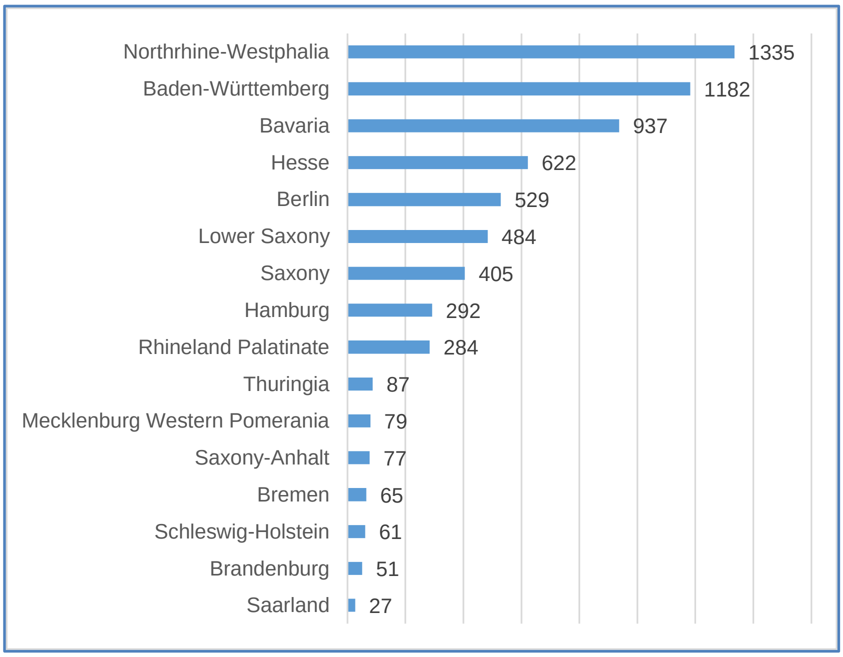

Fig. 10: Charging points in the Federal States in Germany by June 2016 (source: BDEW)

3.5 The innovation system on electromobility

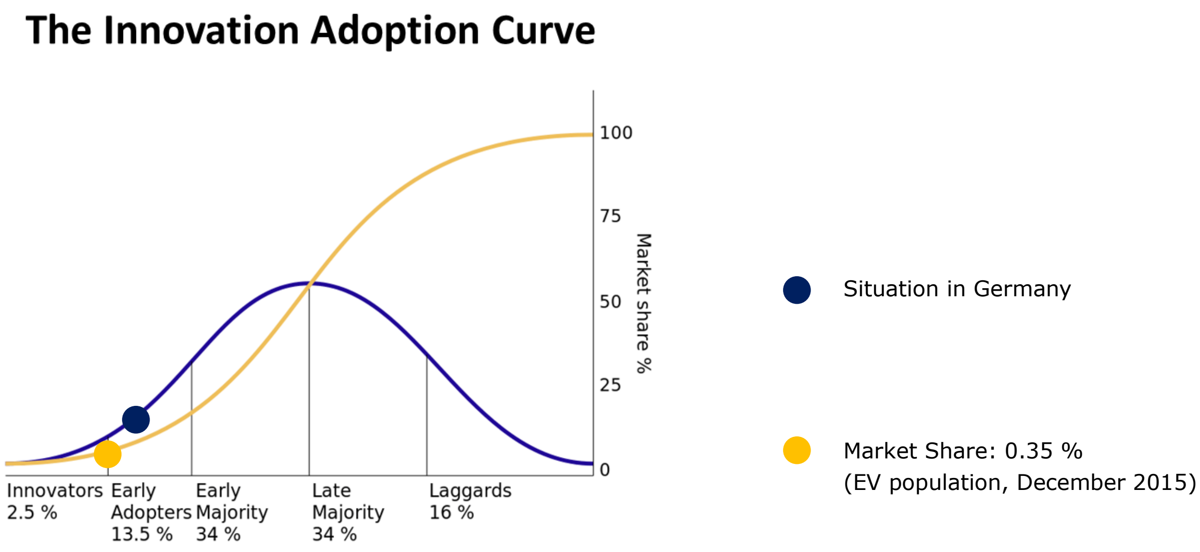

Figure 1: Electric driving innovation adoption curve

By the end of 2015 electric vehicles accounted for 0.35 % of the vehicle stock of 45.1 Mio vehicles in Germany only. Newly registered cars in 2015 had a share of 1.44 % of EVs. The same figures were reported in the first half of 2016, whereas the share grew during summer steadily to 2.35 % in October 2016. This might be a first impact of the recently launched buyer's premium.

The innovation system for electromobility In Germany includes all types of actors: universities, research institutes and companies all along the value chain and covers all types of projects: from basic research to large scale demonstration. Contrary to other technological areas (except energy technology) public actors like municipalities and public transport providers belong to the electromobility innovation system as well. They take an active role in experimenting with new mobility solutions in real life testing and feed their experiences back to research again.

Twenty years ago, innovation in Baden-Württemberg has been seen as a path dependent development with the risk to run into a dead end. Aware of this situation, innovation policy started to focus on smart specialization and cluster management addressed cross disciplinary approaches. Instruments proven to strengthen the regional innovation system therefore easily could adapted to the requirements of electromobility. Establishing a state agency for electromobility and fuel cell technology – e-mobil BW GmbH – triggered new cooperation projects instantly and facilitated the successful acquisition of national and European funding for RTD.(compare 3.2).

Cooperation in the electromobility cluster goes beyond collaboration in projects. Companies, municipalities, research institutes and universities build a community which prepares the State of Baden-Württemberg for the structural change in automotive industries.

4. Industry description of Germany

4.1 Electric vehicles industry

National level – Germany[13]

The NPE sees Germany already on its way to become a lead provider in electromobility, while it admits other countries a considerable advance in the competition for the lead market. German vehicle production still has a small output of electric vehicles. However, in recent years the opportunities for a high share in global electric vehicle production have improved considerably for German OEMs. With respect to the electric vehicle production target figures for 2019 (5-year horizon) Germany was in second place worldwide in a benchmark published early 2014. For 2017, Germany is expected to reach place 4 in EV production. The study states, Germany and China have continued to catch up with the leaders.[14]

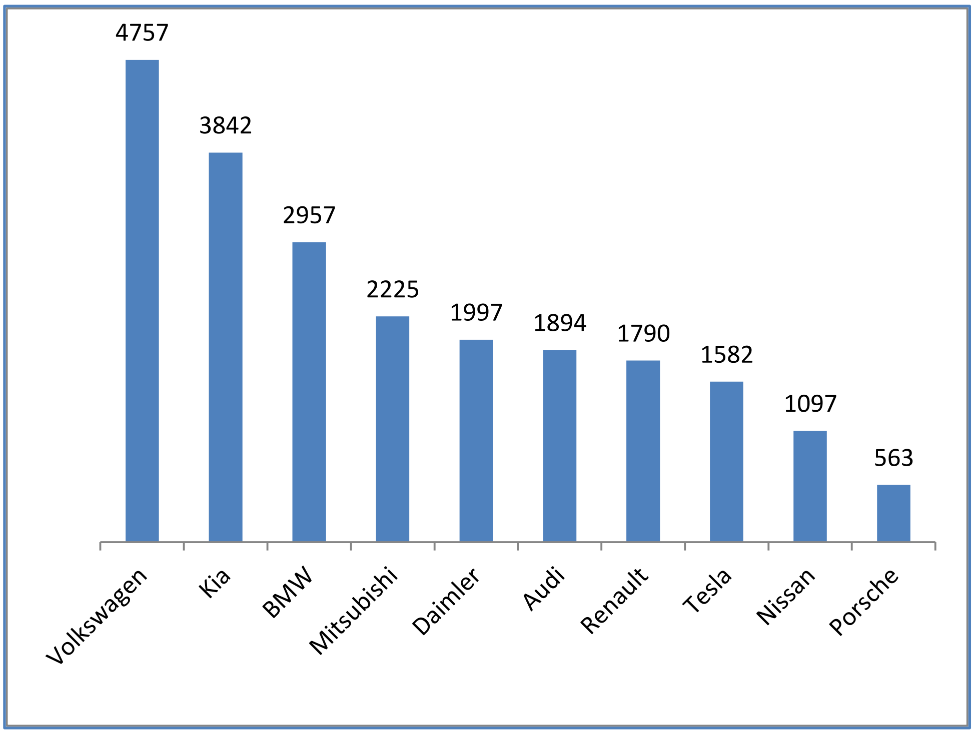

Fig. 10: Manufacturer ranking of in Germany newly registered electric cars in 2015, BEV and PHEV only (KBA 2016)

Although the figures of electric vehicle registrations do not yet correspond to the expectations of the government to bring one million electric vehicles onto the road by 2020, the technological progress, especially preparing for mass production, is very positive according to experts interviewed in the “Strukturstudie BW^e Mobil 2015 – Elektromobilität in Baden-Württemberg”.

The development of Bosch’s e-mobility business can be seen as an example of recent developments: While the first plug-in series vehicle with Bosch technology had come on the market in 2010, Bosch has already realized 30 production projects in the field of electric mobility by the end of 2014.

The capacity and efficiency increase of electric vehicle batteries will remain the key focus of research in the coming years. For the development and production location Germany it will therefore be of central importance to establish in parallel to an increase in the efficiency of internal combustion engines more competences in the field of battery technology and cell research.

State level – Baden-Württemberg

The main added value segments in the field of electric vehicles are ancillaries and the thermal management as well as the core components of the electrified powertrain, the electric motor, the power electronics and the traction battery. Baden-Württemberg with its specific expertise in particular has good opportunities of becoming a lead provider in the following segments[9]:

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[13] Strukturstudie BW^e Mobil 2015 – Elektromobilität in Baden-Württemberg, expert interviews
[14] E-Mobility Index Q3 2015, Roland Berger – Automotive Competence Center & Forschungsgesellschaft Kraftfahrwesen mbH Aachen September 2015

• plant engineering in the fields of battery, power electronics and electric machine
• development and production of active materials for battery cells
• assembly of battery modules and systems and vehicle integration of the system
• manufacture of power electronic components
• manufacturing, assembly and quality assurance of electrical machines
• production of auxiliary equipment and components for thermal management solutions

In these areas there are a number of promising research projects and initiatives in Baden-Württemberg:

- project initiative Competence E/Karlsruhe
- production of battery cells / plant engineering: project elab
- battery cell / active materials: project LULI – STROM AUS LUFT UND LITHIUM
- alternative storage technologies: project PowerCaps
- drive train / E-machine manufacturing: project e-generation
- battery module installation / plant engineering: project AutoSpEM
- battery system installation / plant engineering: project ProBat
- power electronics and auxilliary aggregates: project InnoROBE
- power electronics / Chargers: project BIPoLplus
- E-machine production / plant: project Epromo
- thermal management: project GaTE

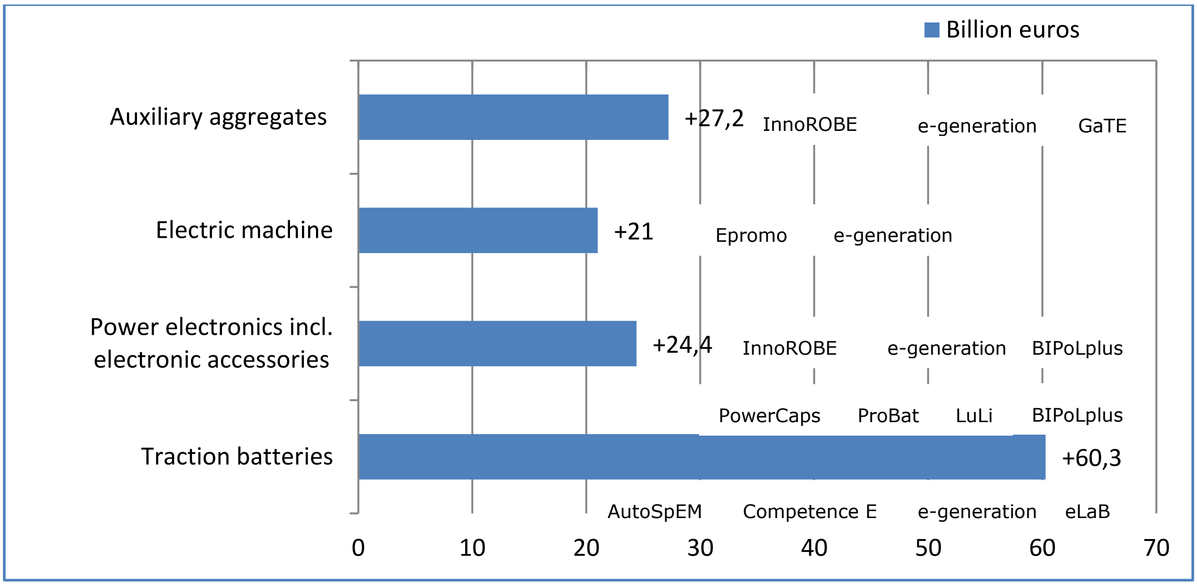

Fig. 11: Change of the global market volume in 2025 compared to 2013 in billion euros in the main value segments and projects in Baden-Württemberg related to these segments (Strukturstudie BW^e Mobil 2015 – Elektromobilität in Baden-Württemberg)

The Structure Study BW^e Mobil 2011 – Baden-Württemberg on the way to electromobility investigated the effects on the whole electric mobility value chain in detail.[10]

Total vehicle
In the area of full electric and hybrid electric vehicles, the companies headquartered in Baden-Württemberg are actively working on full vehicle concepts.

- **Daimler AG's** activities extend over the entire product portfolio. Hybrid, fuel cell and full electric concepts are being developed for passenger vehicles (Mercedes A-Class, B-Class, and S-Class, Smart fortwo electric drive), as well as for commercial vehicles (Vito E-CELL), buses (Citaro BlueTec Hybrid) and trucks (Fuso Canter E-Cell). Daimler AG, among others, is also active in several fleet tests and announced its first full electric bus for 2018.
- With the models Panamera, Cayenne, and 918 Spyder, **Porsche AG** has developed multiple hybrid vehicles. The 918 Spyder has been on the market in limited quantities until mid of 2015. With the decision to start the production of its Mission E in 2020 in a new plant in Stuttgart with 1,400 additional employees, Porsche set a milestone for e-mobility in front of his headquarter.
- **Audi AG** is developing hybrid and battery-electric vehicles under the e-tron label, and is expanding its Neckarsulm electromobility competence center. For example, the models A6 and A8 hybrid and the sports

car R8 e-tron will be manufactured at the Neckarsulm location. Additional vehicles, such as the A1 and A2 e-tron should follow. Moreover, the Volkswagen Group will focus its fuel cell research at the location of the premium Audi plant in Neckarsulm for the entire group.
- **Small and medium-sized business** also develop complete vehicles. Examples are ID-Bike GmbH in Stuttgart with the development of the ELMOTO E-bike, and the company X-Tronic in Magstadt, which is currently working on a new model of the Schwalbe (Swallow), the so-called E-Schwalbe.

Battery technology
Baden-Württemberg is in a good starting position, particularly in the area of research and development. The research location Ulm, has developed into a center for battery research with the Center for Solar Energy and Hydrogen Research (**ZSW**), the University of Ulm and the Helmholtz Institute for Electrochemical Energy Storage. The ZSW activities range from materials research and the development of manufacture methods to life cycle and safety tests for components and systems. ZSW can draw upon over 20 years of experience in lithium-ion batteries and fuel cells for mobile and stationary applications. At the ZSW, the new research and development lab „**eLaB**" was opened in the fall of 2011. The eLab should strengthen the establishment of a regional battery industry and close the gaps in the value-creation chain. Building on these efforts with funding from the Federal Ministry for Education and Research (BMBF) and the state of Baden-Württemberg, a pilot production facility for lithium-ion batteries will be established in Ulm. In addition to collaboration in the innovation alliance „Lithium Ion Battery LIB 2015", the ZSW is also participating in the „Elektrochemie Kompetenz-VerbundSüd" program with other research institutes from Baden-Württemberg, such as the Karlsruhe Institute of Technology (KIT), the University of Ulm, the Max Planck Institute for Solid Body Research and the German Aerospace Center (DLR) in Stuttgart. In the „Kompetenznetzwerk Lithium-Ionen-Batterie (KLiB)" program coordinated by the ZSW, currently 29 companies and research institutes have come together from along the entire value creation chain for lithium-ion batteries.

Amongst companies active in the area of battery technology could be mentioned:
- **Dürr AG** is involved in the development of production facilities for all aspects of the vehicle battery and battery charging stations. Dürr AG treats cell manufacturing as an additional topic area and sees synergies in the coating of electrodes.
- **ads-tec GmbH** specializes in automation technology for battery installation systems, produces its own modular high-performance energy storage device and offers customer-specific battery designs.
- Together with other companies, such as **ZF Friedrichshafen** and **Continental**, **ads-tec** develops components and manufacturing processes for lithium-ion batteries and commercial vehicles as part of the „Future goes Electric" project (FUEL), funded by the Federal Ministry for Education and Research.
- The technology for manufacturing rechargeable batteries and battery systems is the focus of **Leclanché S.A.,** with the business unit Leclanché Lithium and its production location in Willstätt. This is where Leclanché pursues industrial manufacturing of largeformat, high-capacitive lithium-Bi cells (up to 20 Ah), as well as electrode coating, separator production and quality management.
- Another company, **Varta Microbattery GmbH in Ellwangen**, is involved in research and development in the area of lithium batteries.
- **ElringKlinger AG**, headquartered in Dettingen/Erms, is pursuing further development of its competencies in the area of battery technology.
- System solutions for manufacturing lithium-ion batteries are offered by **Harro Höfliger Verpackungs-maschinen** GmbH.
- For development of manufacturing technologies for battery production, **Manz Automation AG** must be cited. As part of the innovation alliance „Production Research for High-Performance Lithium-Ion Batteries", Manz Automation AG, together with other partners, wants to research manufacturing technologies and apply their research to the requirements of large-scale production.
- The Stuttgart based plant engineering firm, **M+W Group**, has developed a concept for the planning and construction of lithium-ion battery factories with modular bundling of the production processes. In 2010, the first order was placed for the construction of a lithium-ion factory in Finland.
- Another joint venture, the German **ACCUmotive GmbH & Co. KG**, headquartered in Nabern, has been formed between Daimler AG und Evonik Industries. Its location for the production of lithium-ion batteries is in Kamenz (Sachsen).

However, the actual production of the cell will remain the domain of large enterprises, due to the huge investment costs and this preferably will take place in other federal states. As an example, **Daimler AG** recently announced the plan to expand its battery production in **Kamenz, Saxony**. The plan is to invest EUR 500 million in the construction of a second battery factory at Deutsche Accumotive, which will triple the production and logistic space of the Kamenz site. In the new factory lithium-ion batteries will be produced for electric and hybrid vehicles for Mercedes-Benz and smart.

Electrification of the drivetrain

In addition to the battery as a central component of electric vehicles, a high level of significance is ascribed to the electric machine, the power electronics and transmission technology. In Baden-Württemberg not only the global players, but also many small and medium-sized companies, have become active in the field of electromobility.

Electric Machines

In addition to **Daimler AG**, **Robert Bosch GmbH** is also active in almost all areas associated with electrification of the drivetrain. Moreover, Bosch and Daimler AG have founded the joint venture, **EM-motive GmbH**, for the manufacturing and sales of electric motors.

Further, **SEW-EURODRIVE GmbH & Co. KG** in Bruchsal is involved with propulsion system issues. In early 2011, together with Brose Fahrzeugteile GmbH & Co. KG, the firm founded the company **Brose-SEW Elektromobilitäts GmbH & Co. KG**, that markets propulsion and charging systems for electric and hybrid vehicles. There is also a collaboration between Aradex AG in Lorch and ate GmbH in Leutkirch, which together develop and market the **VECTOPOWER** electric propulsion system. Other companies are active in the area of propulsion technology, such as **Schopf**, **AMK automotive GmbH**, and **Ricardo Deutschland**.

In the area of research on alternative propulsion concepts, the **KIT** and the **University of Stuttgart,** the **DLR** with the **Institute of Vehicle Concepts**, as well as the **universities of Esslingen, Ulm,** and **Karlsruhe**, must be cited.

Power electronics

Companies from the power electronics sector include the large enterprises such as **Bosch, Daimler AG** and **Porsche AG** for example, as well as the **AMK Group** headquartered in Kirchheim/ Teck, **Lauer & Weiss GmbH** from Fellbach and **Bertrand AG**, headquartered in Ehningen. A cooperation of industry and research/teaching that is unique in Germany is the Robert Bosch Center for Power Electronics that was opened in June 2011.

Transmission

Transmission technology, in particular, offers new fields of application in the area of parallel hybrid or power-split hybrid vehicles. Baden-Württemberg companies are working on innovative solutions in this area including, for example **ZF Friedrichshafen AG**, the third-largest supplier to the automotive industry in Germany. ZF is active in the area of hybrid vehicles and electric vehicles. **LuK**, as a Schaeffler Group company, is also active in the areas of development, manufacturing, and sale of transmissions, as is the **Getrag Corporate Group** in Untergruppenbach.

Lightweight Construction

Lightweight vehicle construction is a key technology for energy saving and low-emission vehicles. In Baden-Württemberg there are many recognized research institutes and a number of companies that are active in this field, particularly with regard to weight reduction in vehicle manufacturing and also in the area of electromobility. Lightweight construction plays a central role in reducing the energy requirements of vehicles and thus reducing the necessary battery capacity, through its weight-reduction possibilities, particularly for electric propulsion concepts. The three OEMs headquartered in Baden-Württemberg (Daimler, Porsche, and Audi) are further strengthening their activity in this field.

Fuel Cell Technology

In the area of fuel cell technology, Baden-Württemberg is extremely well positioned both nationally and internationally, in terms of its industry and research landscape. In addition to a number of research institutes, such as the Center for Solar Energy and Hydrogen Research (ZSW) at Ulm, the Max Plank Institute for Solid State Research in Stuttgart and the Fraunhofer ICT in Karlsruhe. universities and technical schools, numerous companies are working in the field of hydrogen technology and fuel cell technology. As a subsidiary of Daimler AG, NuCellSys GmbH is one of the leading companies in the area of development and manufacturing of fuel cell systems for vehicle applications.

4.2 Charging infrastructure and energy suppliers

Baden-Württemberg

The roll-out of public and public available charging infrastructure is one of the greatest challenges at the moment. Providing a comprehensive charging infrastructure without short term expectations of return-on-investment needs public-private endeavour. Therefore, the upcoming national funding scheme provided by BMVI (see above) will be crucial for the short term development of the electromobility in Germany.

The Structure Study BW^e Mobil 2011 took a closer look at companies active in the charging infrastructure sector[10]:
In the charging technology sector the Bosch subsidiary, **Bosch Software Innovations**, develops software and backbone solutions for the operation and roaming of charging stations.

The companies **Conductix-Wampfler, SEW-Eurodrive, Lapp Kabel, Heldele, Swarco und Kellner Telecom**, are involved in innovative projects for electric vehicles.

In terms of energy supply and the establishment of charging stations, **EnBW AG** is extremely active as the largest energy supplier in Baden-Württemberg. Together with Daimler AG, Bosch, SAP and other companies, EnBW, in the recently concluded MeRegioMobil project, has been investigating the optimal networking of power grid and electric vehicles via modern information and communication technology (IuK). The company is also active in the H2 Mobility project, which involves the establishment of a hydrogen infrastructure, the iZEUS (intelligent Zero Emission Urban System) project funded by IKT for Electromobility II, the German/ French fleet test CROME and in the IKONE project. CROME focuses on cross-border operability with France and fast charging.

MVV Energie AG, as a regional provider with a Germany-wide network of utilities, is involved in infrastructure projects such as „Model City Mannheim" and „Future Fleet" together with SAP AG. Moreover, other energy suppliers and smaller providers of infrastructure solutions are active in Baden-Württemberg.

The **FKFS of the University of Stuttgart**, **KIT,** the **Fraunhofer IAO**, the **Fraunhofer ICT** and the **ZSW** are active in the area of research. In 2011 the research charging station, ELITE, was placed in service by the FKFS. In addition, research is also underway in the area of inductive charging. Among other activities, KIT is involved in the MeRegio and Smart Home projects focusing on the topics of grid integration of electric vehicles. The Fraunhofer IAO installed a total of 30 AC charging stations and DC fast charging station for research purposes in the parking facility of the institute center.

Best practice: ALIS project, Stuttgart[7]

Under the lead of EnBW AG the project ALIS (Aufbau Ladeinfrastruktur Stuttgart und Region), funded by the State of Baden-Württemberg, has installed 500 AC charging points with a connected load of 22 kW each in the Stuttgart Region in 2012 and 2013[15]. This will not only expand the essential infrastructural basis for electrical mobility, but will also enable the development of sustainable business models and the analysis of user response and behaviour. Through this project, Stuttgart became the first city in Germany with a comprehensive charging infrastructure in order to guarantee access to this infrastructure for drivers of electric vehicles from all over Germany and many European countries. The charging stations are connected via a common backend to European and national platforms allowing "e-roaming" for incoming and outgoing electric drivers. The city council of Stuttgart decided on a three years exemption of parking charges for electric vehicles (Battery Electric Vehicles and Plugin Hybrid Vehicles) in all public parking areas. Through the integration of the car2go system with e-vehicles, the Federally and State funded LivingLab BW^e mobil aims at finding out about barriers and problems when setting up a public charging infrastructure for electric vehicles. The 500 charging points mentioned may be used by the 500 Smart electric drive of car2go as well, and at the same time make electromobility more usable for private persons.

Best practice: inFlott project, Stuttgart[7]

Once charging infrastructure is installed, connected and in use, charge management becomes important to avoid local peak loads. Electric supply and demand need to be managed in smart grids. Thus, the project inFlott coordinated by the utility company EnBW AG and funded by the Federal Ministry for Economic Affairs and Energy (BMWi) aims to implement and verify smart charging solutions. An integrated fleet and charging management has been developed, demonstrated and tested.[16] As a first spot to implement the system, a car park in Stuttgart has been selected which is operated by a company owned by the state of Baden-Württemberg. The charging of

[15] For details see http://www.livinglab-bwe.de/projekt/alis/ (in German only)
[16] For details see http://www.livinglab-bwe.de/projekt/inflott/ (in German only)

electric vehicles parked in this garage is managed by a server which decides when to charge which vehicle according to its requirements (“to be charged with x kWh at time y”), and is thus planning the electricity consumption of the overall system. Similar solutions are already installed in other semi-public parking areas, e.g. company car parks.[17] Based on experiences collected through these projects, future solutions for urban quarters will be developed and implemented.

Today, in Stuttgart more than 570 AC charging points of the energy supplier EnBW and approximately 20 DC fast charging points of private investors are accessible. Roaming agreements between the providers allow all electric vehicle drivers to access the charging infrastructure free of discrimination.

4.3 Mobility services

Electromobility still is reaching special user groups only. Even offers open to everybody such as electric car sharing or pedelec rentals, addressing different needs of citizens, are not accessed by large groups of consumers. In order to overcome the threshold to acceptance of these systems, appropriate mobility services aim to integrate such services into concepts of intermodality and everyday use cases.

Use case: Moovel[18]

Moovel is a mobility app for citizens developed and provided by Moovel GmbH which is a subsidiary of Daimler Financial Services AG. Moovel unites a variety of mobility providers in one app including car-sharing, taxis, bus and train connections and bicycle rental, and calculates optimal routings based on trip duration and costs for various options. The trips could be booked via the app after registration.

Use case: Polygo[19]

A consortium of 22 partners ranging from public transport providers, carsharing providers, bike and pedelec rental schemes, municipal undertakings, a bank and technology providers[20] developed and implemented an integrated mobility services platform. Based on a general applicable identifier, electromobility services, car sharing, pedelec rental, public transport and other services could be booked with one multifunctional service card only, which is named PolygoCard. The electronic card is rolled out to more than 150.000 public transport users. The core use case will be intermodal traffic. The card offers an e-ticketing function for all holders of annual tickets for the public transport provision, and seamless access to and special benefits for the solutions offered by all cooperation partners, e.g. DB Rent with its Flinkster carsharing (including electric vehicles) and its call-a-bike rental, car2go with its 500 Smart electric drive, and the municipal e-bike stations of the Netz-E-2-R community managed by NAMOREG (Nachhaltig Mobile Region Stuttgart) and operated by nextbike. This smart card based solution serves a double function as an information and a booking platform not only for electrical mobility, but also for public transport and diverse additional services, for instance for leisure time. It is a primary goal of the implementation to connect other projects and facilitate easier access by the public. Additional features will be added, such as the use of PolygoCard as library card for the Stuttgart city and district libraries.

Use case: car2go electric

Since 2012 Stuttgart hosts one of largest full electric carsharing fleets. More than 500 Smart electric drive are offered in the free floating car2go carsharing scheme. In order to make it happen, the city of Stuttgart decided free parking for all electric vehicles in the city area and the State of Baden-Württemberg invested in the most comprehensive charging infrastructure in a German city.

[17] For details see http://www.livinglab-bwe.de/meldungenarchiv/inflott-startet-pilotbetrieb/ (in German only)
[18] www.moovel.com
[19] www.mypolygo.de
[20] The complete list can be found at http://www.stuttgart-services.de/projektpartner.html

5. Economic Impact in Germany (the case of Baden-Württemberg)

In the structure study published by e-mobil BW GmbH - State Agency for Electromobility and Fuel Cell Technology in 2011 and updated in 2015, the potential market volumes of different vehicle components and the impact on employment regarding conventional components and components for electrified drivetrains were investigated for the state of Baden-Württemberg. The studies were carried out by the Fraunhofer Institute for Industrial Engineering (IAO)[21].

5.1 Methodology

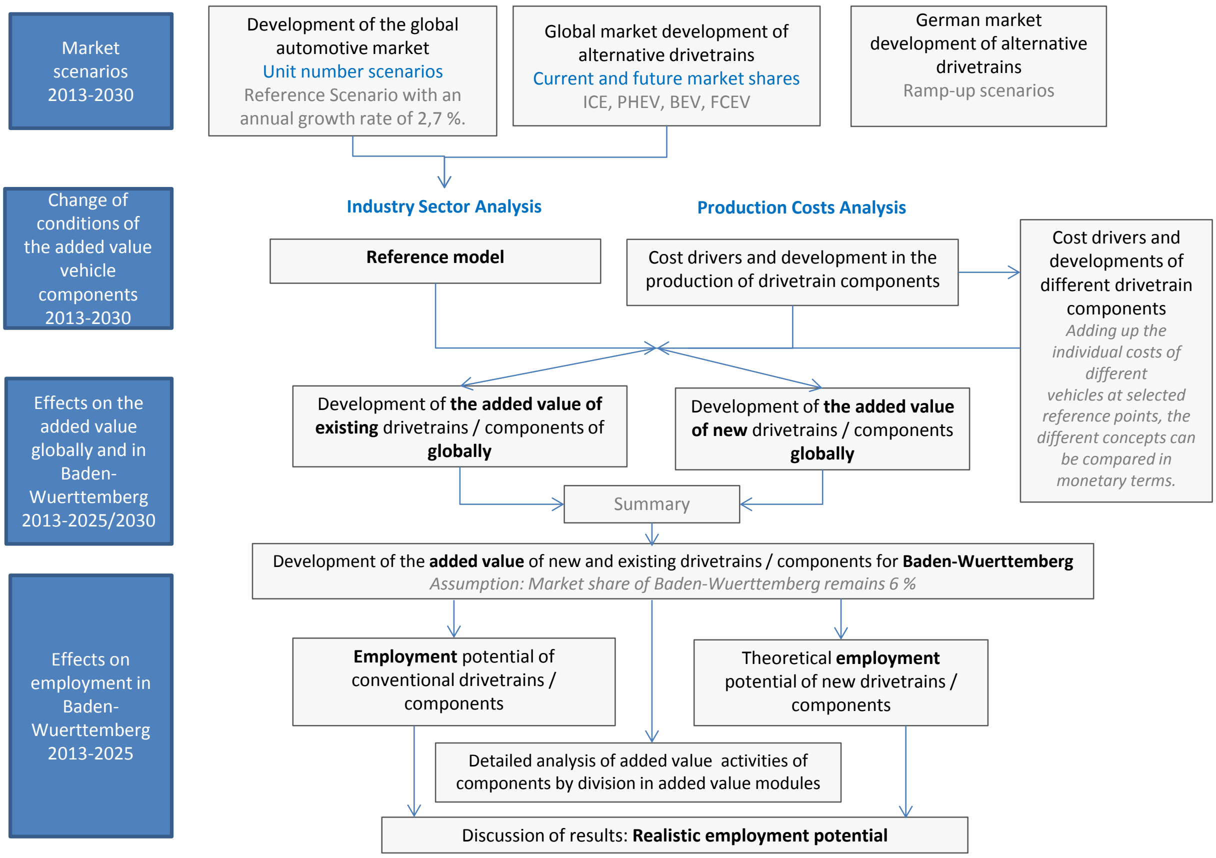

Fig. 12: Method to quantify the potential market volume of e-mobility and employment effects in Baden-Württemberg[21] (adapted).

Reference model: To quantify the impact of the technological change through electric mobility on the added value and to analyze the impact on the employment structure in Baden-Wurttemberg, a comprehensive reference model was developed and used in the study of 2015. It considers the different drivetrain concepts, starting from the classic combustion engine-powered vehicles through various hybrid vehicles, to battery-electric vehicles and fuel cell vehicles.

In addition to the predecessor study of 2011, the classical component-based added value review has been complemented by a processual dimension. For each vehicle concept the corresponding components and the processes of service provisions were investigated and separated into manageable process units. This allows to generate added value statements relating to key processes in the manufacturing of electric vehicle specific components as well as to take into account the associated value added segment of mechanical engineering. The assessments of the market prices and potential cost reductions of individual components and related manufacturing processes are based on a meta-analysis of already published studies. The results were validated by expert interviews and updated for the period between the last publication (2011) and the present one (2014-2015).

[21] Structure Study BW[e] Mobil 2011 – Baden-Württemberg on the way to electromobility and Strukturstudie BW[e] Mobil 2015 – Elektromobilität in Baden-Württemberg.

Effects on the added value: The aspects, examined in the previous steps, will be used and interrelated for the determination of the potential added value changes. Based on the drivetrain concepts defined in the reference model the parameters of the market scenarios (global market development, distribution of drive types) and the component- and process-oriented cost resp. market assessment over time are significant input variables of the analysis.

Effects on the employment: Based on the identified potential for added value in the time period considered, employment effects for the region of Baden-Württemberg are derived. The resulting values are referred to as a “theoretical potential”. Subsequently, the theoretical potential in terms of their real achievement is discussed. Based on this discussion the actually “realistic potential” is estimated. For this, so-called value-added modules and in these modules component-specific value-added activities were investigated and discussed.

5.2 Potential market volume of Baden-Württemberg – Effects on the added value

Assumptions

The reference market scenario assumes for the period from 2013 to 2030 an annual market growth in the automotive sector by 2.7%. The drive train distribution in 2025 consists of 72.6% ICE (including optimized combustors), 9.6% HEV, 9,6 % PHEV and REEVs and 7.7% BEV. In 2030 it consists of 55.5% ICE (including optimized combustors), 14.4% HEV, 14.1% PHEV and REEV and 15 % BEV. The below stated added value potentials represent the difference between the global market volume of the reference year 2013 and 2025 or 2030 respectively.

Global development

Based on these assumptions, a growth in the global market volume of +216.78 billion euros (2025) resp. +341.25 billion Euro (2030) in the considered components compared to the reference year 2013 can be expected, of which +47.49 billion euros (2025) or +52.49 billion euros (2030) can be attributed to the conventional components of the engine (including fuel system), the exhaust system and the gearbox.

Due to the increased efficiency in the drive train as well as the electrification of auxilliary components significant changes in the field of efficiency technologies and the auxiliary units are expected. This results in both areas in a total potential of +57.93 billion euros (2025) resp. +82.37 billion euros (2030), which accounts for around a quarter of the total increase in each year. Approximately half of the total increase is attributed to purely electrified components in 2025 (power electronics including charger, electric motor, battery system, fuel cell system). The total increase in these components is +111.36 billion euros in 2025.

For the year 2030, the proportion of these components increases to the overall growth potential +206.21 billion euros. At this time, approximately 60% of the resulting added value potential is expected to be based on these new components.

Development in Baden-Württemberg

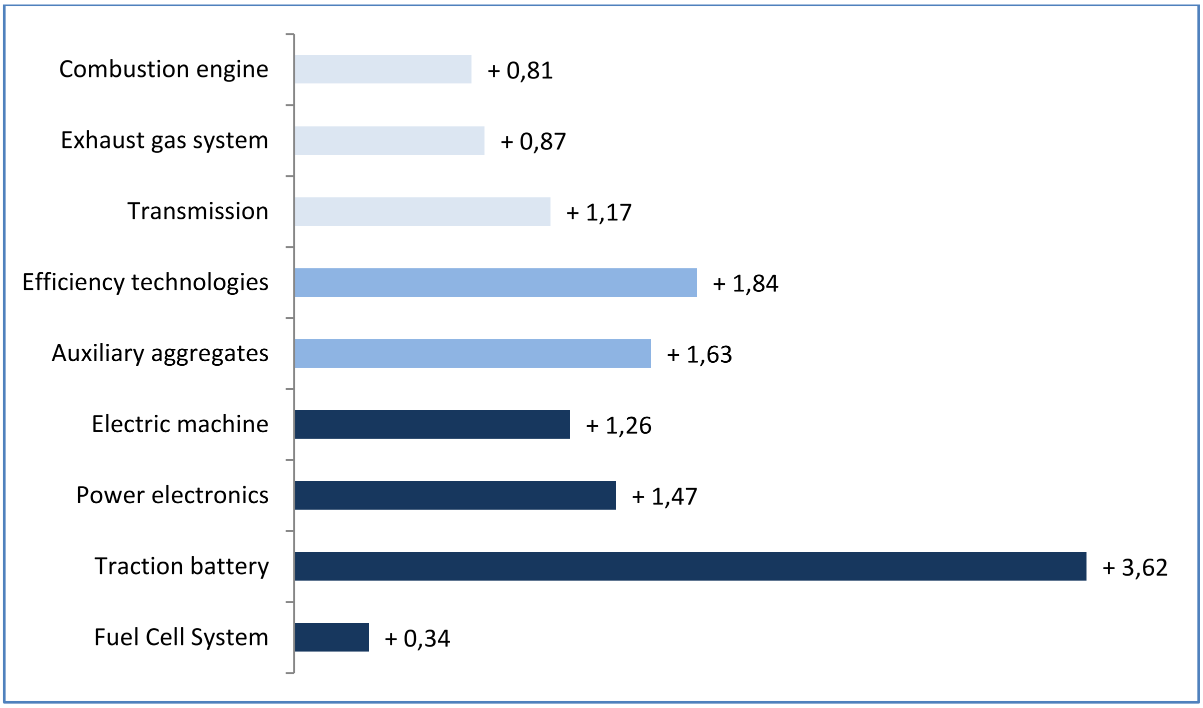

Fig. 13: Theoretical change of the market volume for production in Baden-Württemberg in 2025 compared to 2013 in billion Euro (Strukturstudie BW[e] Mobil 2015 – Elektromobilität in Baden-Württemberg)

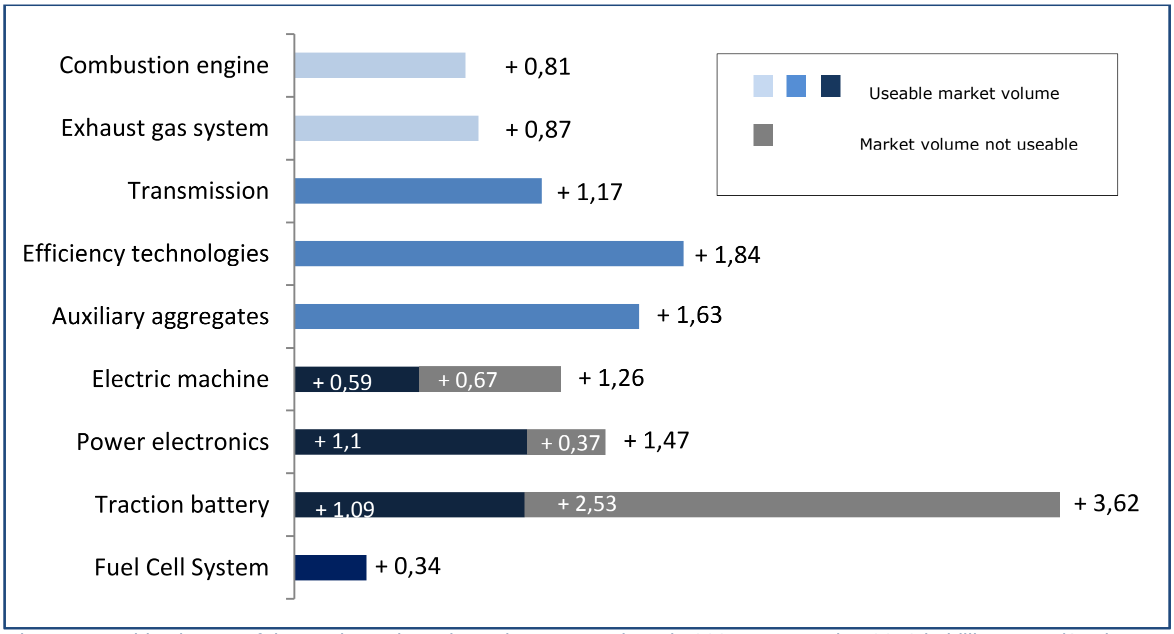

Fig. 14: Useable change of the market volume in Baden-Württemberg in 2025 compared to 2013 in billion Euro (Strukturstudie BW[e] Mobil 2015 – Elektromobilität in Baden-Württemberg)

5.3 Employment effects in Baden-Württemberg

Based on the identified potentials for added value in the time period considered, employment effects for the region of Baden-Württemberg are derived. The analysis here refers to the changes between 2013 and 2025. In order to unite significant portions of the value in the state of Baden-Württemberg, the companies located here must succeed in achieving a leading position in global competition not only in the field of research and development, but also in the production of significant electrified powertrain components and efficiency technologies. Achieving a sufficiently high vertical integration in the field of new drive train components and the associated solutions is an essential prerequisite for the creation of jobs. Further value contributions can also be generated by the development, production, design and installation of production facilities by companies of Baden-Wurttemberg.

Determination of the effects on employment

Assuming that Baden-Württemberg's automotive industry will keep its market share of approximately 6 percent of worldwide sales in 2025, the resulting employment effects are as follows.

The focus of the consideration is on the components of the drivetrain. Calculation of job effects was made using turnover per employee. The value assumed for this is EUR 415.000 in 2013. Due to the productivity growth rate of 2.8% per annum in recent years, the reference value increases to EUR 504.000 (turnover / employee) for calculating the effects on employment in 2025.

Theoretical potential – new drive trains and components electric machine

By implementing the electrical machine in the various drive concepts a significant increase in turnover can be expected for the year 2025. Assuming an unchanged market share for Baden-Württemberg a theoretical increase of EUR 1.26 billion in 2025 is the result. The theoretical employment potential increases to +2500 compared with 2013.

Power electronics

In the field of power electronics (including charger) a significant theoretical increase in turnover can also be expected. For Baden-Württemberg there is an increase of EUR 1.47 billion in 2025, which corresponds to a theoretical increase in employment of +2910 compared with 2013.

Traction battery / Battery system

In the coming years the battery system as a key component of electrified vehicle concepts has an enormous growth potential. The theoretical change in the market volume for Baden-Württemberg amounted to a total of EUR 3.62 billion in 2025. The detailed determination of the resulting employment potential results in +5400 employees compared to 2013.

Fuel Cell

Taking into account the assumed market distribution in the field of the production of fuel cell systems for future vehicle generations results in a theoretical change in the market volume of EUR 0.34 billion in 2025, representing an increase of +675 employees compared to 2013.

Summary

Altogether, the components of the electrified powertrain provide for a theoretical potential of +11.485 employees for 2025 compared to 2013. Along with the potential of the "conventional" value segments a total employment potential of +24.015 employees compared to the reference year 2013 results for the year 2025.

Realistic potential – new drive trains and components

Baden-Württemberg is considered as today's technology leader for combustion engines. Therefore, it needs to be discussed whether the theoretical job potential of the „new" components shown in the analysis can be realized in the future. In addition, the developments within the fields of conventional components also have to be considered. Relocation of research and production sites of companies located or stagnation of major markets (EU) are further challenges in the coming years.

Electric machine

The market will require much more electrical machines. However, a large-scale series production of electrical machines does not exist in Baden-Württemberg today. This leads to the assumption that the majority of these components, under some circumstances, will not be manufactured in Baden-Württemberg. The joint venture between the Baden-Württemberg companies, Bosch and Daimler (EM-motive), started the production of electric motors for the automotive sector in Hildesheim (Lower Saxony).

The very high share of material costs in the total production costs of the electrical machine can be regarded as a limiting factor in terms of the actually realistic added value in the country. Assuming that in 2025 a limited number of companies in Baden-Württemberg deals with the production of traction motors and its components a reduction of the theoretical market potential in these segments from 6% to 2% is assumed. In the assembly and testing, however, the achievement of the theoretical share remains at 6%. With over 50% of all German machine tool and precision tool manufacturers, Baden-Württemberg has optimal prerequisites to support innovative concepts and production technology companies in the automotive industry in the future. Highly trained professionals and a good networking between businesses and universities are identified as additional benefits in Baden-Württemberg.

Based on these assumptions, a reduction of the theoretical market share (6%) of all observed value segments to 2.8% is seen to be the currently realistic reference value. This results in a realistic market potential of EUR 588 million in 2025, representing an employment potential of +1170 employees.

Power electronics

The power electronics are a key component in the electrified drive concept. However, the production of individual components such as power modules, film capacitor or control electronics require deep expert knowledge and experience in the semiconductor industry and in the high voltage range. Due to the great importance of the assembly operations in the production process, fine-tuned process techniques and extensive quality assurance processes play an important role. Based on the existing activities in the power electronics manufacturing in Baden-Württemberg there is a moderate adjustment of the expected market share in 2025 from the theoretical reference value of 6% to 4.5%. Based on this assumption, a realistic change in the market volume of EUR 1.1 billion and thus an employment potential of +2180 employees are probable.

Traction battery / Battery system

The traction battery provides by far the biggest theoretical market potential for Baden-Württemberg within the area of the new drivetrain components. However, the state of Baden-Württemberg does not yet have a large-scale cell manufacturing facility in the traction battery sector.

With the construction of a pilot production facility for lithium-ion batteries in Ulm the foundation has been laid for profound research for economic solutions in the field of battery production. This institution is a central point of contact and dialogue opportunity for the participating companies and research institutions in Germany with a focus on the cell format of the prismatic cell. In addition to the facility in Ulm another research and production facility in Karlsruhe for the production of large-format lithium-ion cells with a focus on the geometry of the pouch cell could be put in operation.

From a manufacturing standpoint the main challenges currently are transferring newly developed production methods, materials, components and parts of the plant into industrial manufacturing of near-series batteries for electric vehicles. It is also necessary to develop quality assurance standards and methods, to design pure and drying room concepts for the mass production of battery cells and to continue working on coating methods and intelligent handling and automation solutions.

The machinery and equipment manufacturing and installation of the batteries and the integration of the system in the vehicle offer very good opportunities for increased value creation. Moreover, the production of components of the battery modules provides also important potential for value creation. These include, for example, control and electronic components, sensors, solutions for temperature control or structural and chassis components.

Assuming that by 2025 a cell production in the state of Baden-Württemberg cannot be settled, the theoretical market potential for the traction battery is reduced by about 70%, corresponding to a decrease from 6% to 1.8% equivalent.

The share of added value of the traction battery in the electric vehicle is particularly high[22]. Due to the economic importance of the German automotive industry, it is of great importance that Germany improves its competences in battery technology and research, for example in cooperation with foreign producers. The production of battery modules and systems is well represented in Germany with potential for further development. However, there is a lack of technological expertise and manufacturing facilities for battery cells.

Summary

In the study a distinction was made between a theoretical potential and a realistic potential for the new drivetrains and related components. Assuming a constant market share of 6%, a strong increase in employment of a total of +11.485 employees compared to 2013 would result until 2025. After discussion, however, only an increase in employment of +5645 employees is considered realistic.

When also including conventional components, ancillaries and efficiency technologies the study shows a result of a realistic employment growth of in total +18.175 employees for the year 2025 compared to 2013 for the value segments considered (compared to a theoretical employment growth of +24.015 employees).

In spite of these estimates, a projection beyond the years 2030 and 2040 makes it clear that the essential value creation of the future automotive industry lies in the traction battery. For companies in Baden-Württemberg, the question arises as to the areas where increased value creation and job potential can be tapped. Stronger alignment in the area of cell manufacturing or a concentration on cooling, packaging and system concepts, and thus on manufacturing and integration of complete systems, represent possible alternatives.[10]

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[22] Begleit- und Wirkungsforschung Schaufenster Elektromobilität (BuW), Ergebnispapier Nr. 17

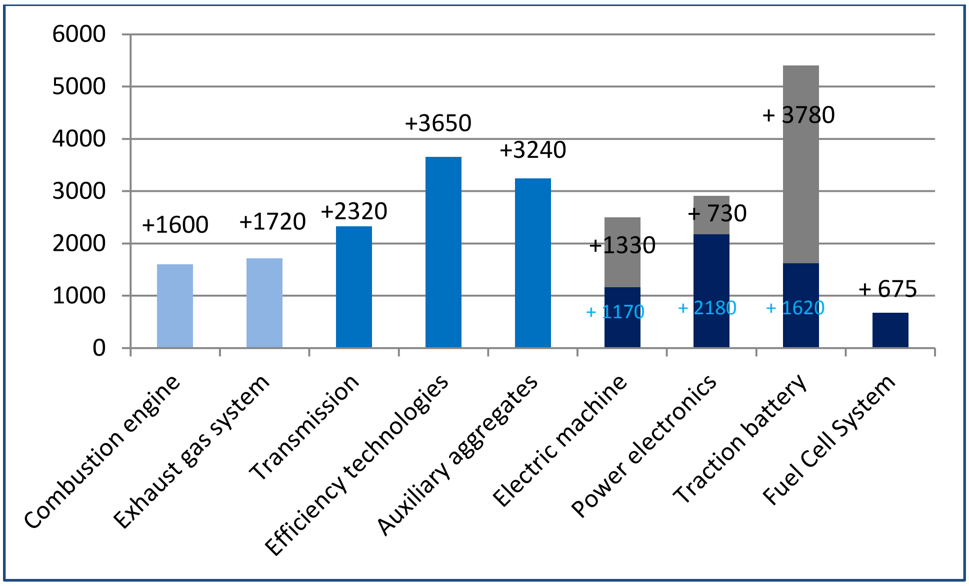

Fig. 15: Employment potential automotive production in Baden-Württemberg in 2025 (Strukturstudie BWe Mobil 2015 – Elektromobilität in Baden-Württemberg)

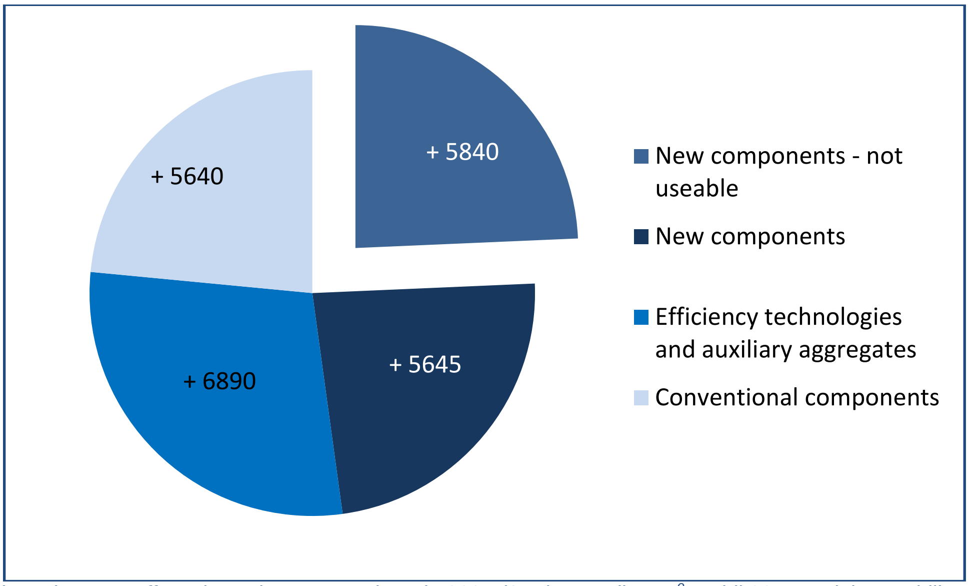

Fig. 16: Total employment effects in Baden-Württemberg in 2025 (Strukturstudie BWe Mobil 2015 – Elektromobilität in Baden-Württemberg)

Best practice: Porsche AG – Mission E production in Stuttgart

The first full electric Porsche will be produced in Stuttgart from 2020. This will result in more than 1,400 new jobs in and around Stuttgart. The company will be investing around EUR 700 million in a new plant at its headquarter in Stuttgart-Zuffenhausen. 1,200 additional employees will produce the car, and additional jobs will be created in the IT and development departments. The production of the Mission E will make use of Industry 4.0 approaches allowing highly flexible and adaptable processes.

6. Conclusions

The analysis of the economic impact of electromobility faces several challenges for the investigators. Firstly, assumptions for the overall market development of electromobility differ significantly between scenarios which are more conservative and more progressive. Secondly, the definition of the underlying value chain influences strongly the outcome as it could include after sales markets and value added services along charging infrastructure as well. Thirdly, the development of international competitiveness of globally operating companies is difficult to estimate influencing income and jobs generated by exports. Nevertheless, our research shows the potential for midterm gain of jobs and income generated by electromobility outbalances the loss of jobs in traditional automotive sectors in Baden-Württemberg. Comparison with other studies show similar trends, but absolute values are not directly comparable.

The automotive industry in Germany, which has a crucial role, is at the beginning of a serious transformation process, which it cannot escape. As long as the transition to electric mobility is delayed by the fact that plug-in hybrids are preferred by German OEMs and full product portfolio of fully electrically driven vehicles is not developed, Germany runs in danger of losing its role as a possible international lead provider. Currently the "window of opportunity" to be at the head of the competition for the future electromobility market is still open to German OEMs and their suppliers (which trigger strong innovation impulses).[22] In such early phases of a new market, local development significantly depends on individual decisions of OEMs influencing the whole value chain.

National policies need to be defined and implemented carefully, as their impact strongly is related to the position of a technology along the innovation adoption curve (higher impact of RTD funding in early phases, buyer’s premium may speed-up from early adopters to early majority). Therefore priority for ongoing and future public support in Germany should focus on improving the framework for users of electric vehicles, but should not support the development of vehicle and drivetrain technologies any more. Further progress of the latter will be increasingly driven by competition in the growing market. Tax incentives or subsidies for electric and hybrid vehicles are able to speed-up the market penetration, but need to be handled carefully in order to avoid market disturbances.

Crucial for the success of electromobility will be an appropriate barrier-free and seamless charging infrastructure. At present, no noteworthy return on invest exists for charging station, nor any proven business model. A systematic development of a fast charging network will be essential for long distance use of electric vehicles. On top of the “charging agenda”, however, stands the comprehensive e-roaming between all charging suppliers in public and semi-public areas, offering access for charging with a single registration point for users at their preferred energy provider only.[7]

German municipalities should make use of their opportunities to favor electromobility on a regulative basis, and orientate themselves at successfully proven foreign examples. Ideally, the policy should put together a suitable coordinated package of non-monetary and monetary incentives to promote electric mobility. In particular they should promote the installation of a public and customer-friendly accessible charging infrastructure - in cooperation with the industry.

Memo / Notes

IA-HEV Task 24: Economic Impact Assessment of E-mobility

The economic impact of E-mobility in the Netherlands

Task 24 country report

Date 15 March 2016

Colophon

Project	Implementing Agreement on Hybrid and Electric Vehicles Task 24 Economic Impact Assessment of E-mobility

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Contents

Management Summary

Task 24 of the IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) concerns assessment of the economic impact of E-mobility. Eight countries (Austria, Belgium, Denmark, France, the region of Baden-Württemberg in Germany, the Netherlands, the United States of America and Switzerland) are trying to gain insight in the economic impact that E-mobility can have on a country. The present document is the Dutch report on this topic, the Dutch country report.

The Netherlands has seen a steady growth in both the number of electric vehicles and the charging infrastructure. In 2015, 9.7% of new vehicle registrations were for electric vehicles, while about 1% of the total passenger car fleet was electric.

The position of the Netherlands as a frontrunner in e-mobility has helped an active e-mobility sector to develop here. Companies have been able to develop crucial knowledge and experience in the home market. As a result, Dutch organisations are active in almost all segments of the value chains for vehicles, charging infrastructure and energy. The present report describes the main industry and market players.

Most business activity takes place in the subsections of:

- New (custom-made) vehicles (boats, buses, trucks, scooters and LEVs);
- Charging infrastructure;
- Drivetrain technology, range extenders, EMS (components);
- Smart grids and metering;
- Mobility services (such as leasing).

The strengths of Dutch businesses also lay in these sectors. Dutch companies export products and services, particularly in the fields of charging infrastructure and the related smart grids and metering. The manufacturing of electric vehicles (not passenger cars but most other modalities) is also on the rise.

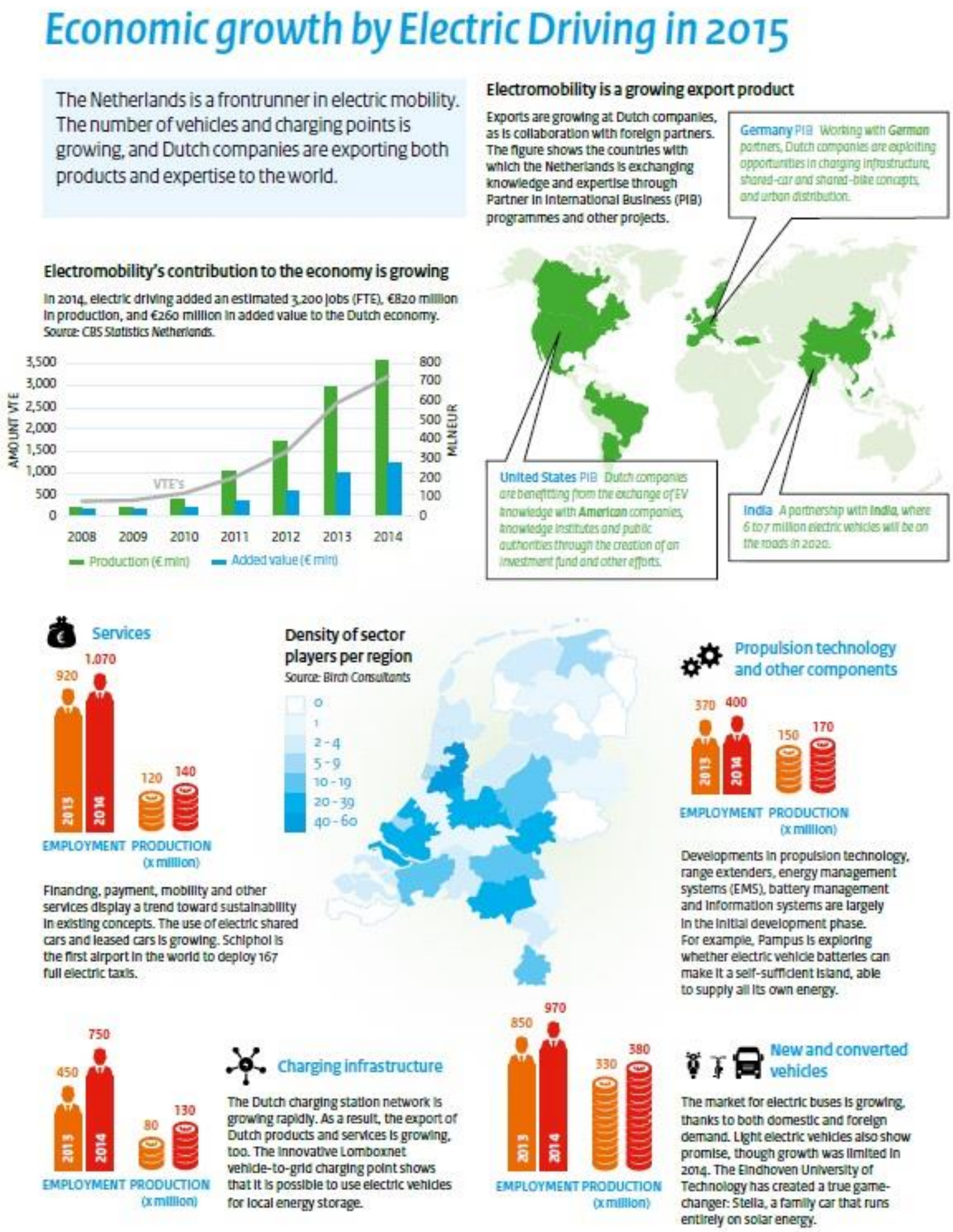
Dutch e-mobility companies have been surveyed to collect data on the economic impact of e-mobility in the Netherlands. CBS Statistics Netherlands calculated the results and were able to add to the data with the aid of their national database and a list of companies active in e-mobility.

Direct employment in e-mobility has increased almost tenfold since 2008, from 350 FTEs in 2008 to 3,200 FTEs in 2014. Although growth has slowed a little during the past year, the number of jobs in this field still increased by 25% compared with 2013.

A breakdown of these data into market clusters shows that employment is highest in the services sector (financing, payment, mobility and other services) and in the manufacture and retrofitting of vehicles. The market segment comprising the manufacture and retrofitting of (custom-made) vehicles contributes the most to production and added value, whereas the charging infrastructure and smart grids segment shows the fastest growth in these indicators.

The quantitative data collected on exports were not sufficient to allow hard conclusions to be drawn, but they do indicate a rise in the number of Dutch companies exporting their knowledge and experience in the field of e-mobility.

The following infographic was prepared to summarise the conclusions of a report on the economic potential of e-mobility in the Netherlands that was published towards the end of 2015[1]. It shows the main trends in some economic indicators for the e-mobility sector as a whole and for the subsections Services, Charging Infrastructure, Propulsion technology and other components and New and converted vehicles.



[1] 'Cashing in on Electromobility's Economic Potential, the state of affairs in mid-2015': (Verzilvering Verdienpotentieel Elektrisch Vervoer, stand van zaken medio 2015) http://www.rvo.nl/sites/default/files/2015/12/Rapport%20Verdienpotentieel%20Elektrisch%20Vervoer%20medio%202015.pdf (report in Dutch).

Introduction

Implementing Agreement on Hybrid and Electric Vehicles and Task 24

The IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) was set up in 1993 as a basis for collaboration on pre-competitive research and the production and dissemination of information. The work of the IA-HEV is governed by the Executive Committee (ExCo), which consists of one delegate per member country. The work is performed through a variety of Tasks that are focused on specific topics.

This report is one of the deliverables of Task 24: *Economic Impact Assessment of E-Mobility*. The Task was approved in November 2013 and work on it started in May 2014. The aim is to deliver the final report by mid-2016.

The objective of the Task is to gain a better impression of the electric mobility value chain in general and, more specifically, a clearer understanding of the economic potential of the local e-mobility sector in each participating country. In this way, Task 24 yields insight into the economic impact that e-mobility can have for a country.

In the project, key economic indicators were identified that each participant tried to describe for their country. Common value chains for the manufacturing of cars, charging infrastructure, energy and mobility services were developed as part of the work. To facilitate data collection and benchmarking, these value chains were kept simple and focused on passenger cars.

Every participant will produce a country report on the economic perspective in their own country. These results will then be analysed and summarised in a final benchmark report. Task 24 participants are Austria, Belgium, Denmark, France, the region of Baden-Württemberg in Germany, the Netherlands, the United States of America and Switzerland.

The present report is the country report on the economic impact of e-mobility in the Netherlands.

The Netherlands

Data on the Netherlands	(Oct 2015)
Population	16,958,611
Surface Area	33,800 km^2
Inhabitants per km^2	502
Capital	Amsterdam
Provinces	12
Municipalities	390

(Source: www.hollandtradeandinvest.com)

Figure 1: Country specifications for the Netherlands

The Netherlands is a small country situated in the delta of some of Europe's main rivers. It has a healthy, growing economy with a strong services sector and excellent industries such as life sciences, electronics, agri-food, chemicals, water technology and engineering. It offers local and foreign businesses an environment that is conducive to international trade, efficient export, innovation and collaboration with some of the world's best companies and research institutes. (Source: www.hollandtradeandinvest.com).

It is also ideal as an initial market and testing ground for electric vehicles. The Netherlands is flat, densely populated and largely metropolitan, with consumers who are not averse to trying something new. It has a good electricity infrastructure, but no strong ICE-vehicle brand names.

The Netherlands encourages the electrification of transport because this contributes to climatic objectives, the transition to cleaner energy and improvement of the quality of life in the cities. The development of an e-mobility sector also strengthens the economic position of the Netherlands and contributes to green growth.

In order to monitor the extent to which these economic opportunities are achieved, the Netherlands Enterprise Agency (RVO.nl) compiles an annual report on the economic perspective of e-mobility in the Netherlands based on market surveys, interviews with stakeholders, desk research and an analysis of the innovation system. The most recent report was written by RebelGroup and EVConsult and published by Netherlands Enterprise Agency in December 2015[2]. Along with its Annexes, it is the main source for the present report. Other sources include international brochures on e-mobility in the Netherlands, monitoring data and market information.

Reading guide

This report starts with a brief introduction on the framework in which this project was carried out and also contains general information on the Netherlands and the reasons for investing in e-mobility. Chapter 1 gives data on the development of e-mobility, while Chapter 2 describes the sector as a whole, with special reference to the value chains developed as part of the work of Task 24. Chapter 3 examines the economic impact of e-mobility in the Netherlands with the aid of a set of indicators.

[2] 'Cashing in on Electromobility's Economic Potential, the state of affairs in mid-2015': Verzilvering Verdienpotentieel Elektrisch Vervoer, stand van zaken medio 2015: http://www.rvo.nl/sites/default/files/2015/12/Rapport%20Verdienpotentieel%20Elektrisch%20Vervoer%20medio%202015.pdf (report in Dutch).

1 E-mobility in the Netherlands

1.1 Development of e-mobility in the Netherlands

The number of electric vehicles in the Netherlands, and the number of charging points for these vehicles, are growing steadily.

1.1.1 Vehicle registrations

Registrations of electric passenger cars doubled in 2015. A total of 87,531 electric passenger cars were registered in the Netherlands at the end of 2015. Of these, almost 11% were Battery Electric Vehicles (BEVs), the majority consisting of Plug-in Hybrid Vehicles (PHEVs). This represents an increase of 37% in BEVs and 112% in PHEVs compared with the end of 2014.

See Table 1 and Figure 2 for an overview.

Number as of	31-12-2013	31-12-2014	31-12-2015
Passenger car (BEV)	4,161	6,825	**9,368**
Passenger car (E-REV, PHEV)#	24,512	36,937	**78,163**
Commercial car < 3.5 tons	669	1,258	**1,460**
Commercial car > 3. 5 tons	39	46	**50**
Bus*	73	80	**94**
Trike/quadricycle	632	769	**872**
Motorbike	125	196	**268**
Total excluding mopeds (scooters)	**30,211**	**46,111**	**90,275**
Moped (helmet required, max 45 km)	3,130	3,441	**3,610**
Moped (no helmet required, max 25 km)	19,772	23,850	**28,459**
Microcars	141	172	**219**
Total including mopeds (scooters)	**53,254**	**73,574**	**122,563**

#:excluding full hybrid vehicles; *:including trolley buses and some hybrid buses

Table 1: Number of registered electric vehicles
(Source: Dutch Road Authority, edited by RVO.nl)

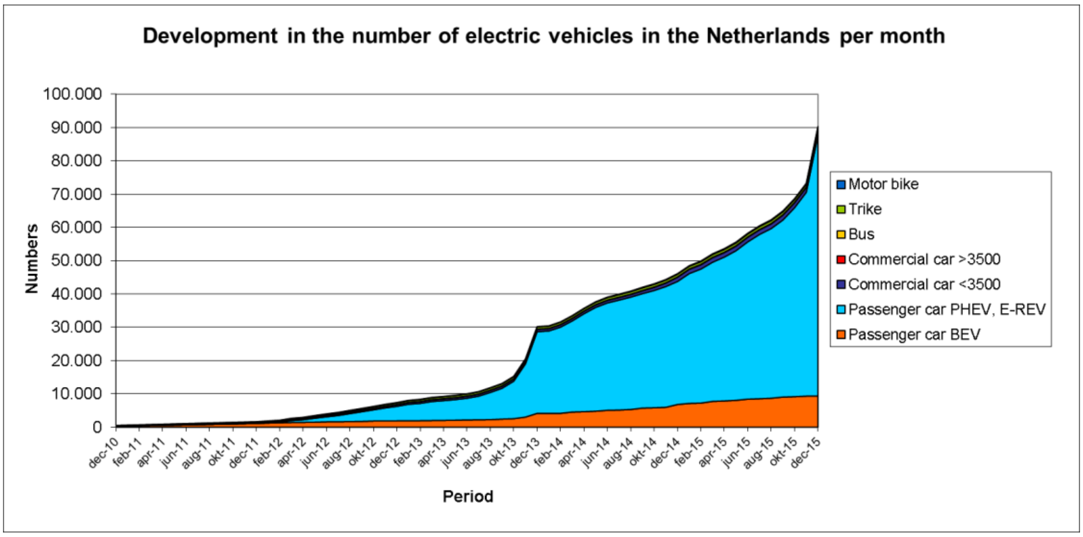


Figure 2: Developments in registration of electric vehicles (excluding mopeds) in the period 2010-2015 (Source: Dutch Road Authority, edited by RVO.nl)

The effect of upcoming changes in fiscal incentives at the end of 2013 and 2015 is clearly visible in Figure 2. An overview of Dutch policy and incentives in the field of e-mobility is given in section 1.3.

Market share developments are shown in Table 2.

Registrations in period	2013	2014	2015
Total registrations	419,388 (100%)	390,402 (100%)	**449,350 (100%)**
Total EV registrations	22,415 (5.3%)	15,089 (3.9%)	**43,769 (9.7%)**
- Of which BEV	2,251 (0.5%)	2,664 (0.7%)	**2,543 (0.6%)**
- Of which E-REV, PHEV	20,164 (4.8%)	12,425 (3.2%)	**41,226 (9.2%)**

Table 2: Market share of BEVs/PHEVs compared with total registrations (Source: all registrations: BOVAG/RAI via www.bovag.nl, BEV/ PHEV: Dutch Road Authority, edited by RVO.nl)

There were 9.7% new registrations for BEVs or PHEVs in 2015, compared with 3.9% in 2014 and 5.3% in 2013. About 1% of the total passenger car fleet was electric (BEV and PHEV) by the end of 2015.

The most popular models in the Dutch fleet for PHEV and BEV are shown below.

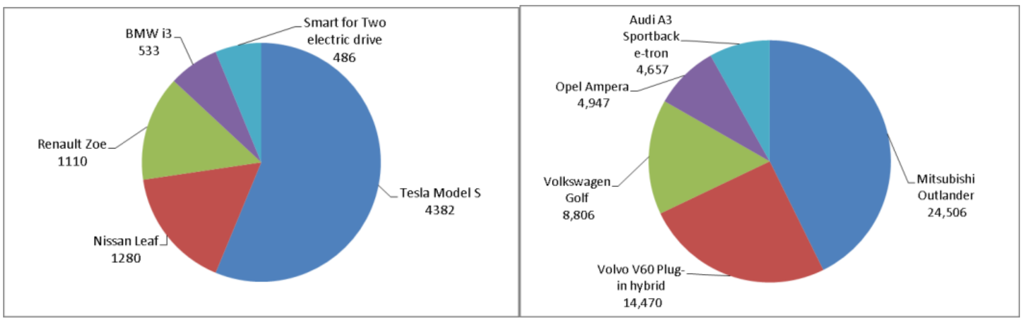


Figure 3: Top 5 registrations in BEV fleet (left) and PHEV fleet (right), 31-12-2015 (Source: Dutch Road Authority, edited by RVO.nl)

1.1.2 *Charging infrastructure*

The Netherlands has made national agreements on interoperability, in line with European standards. Many charging systems in use in the Netherlands have been interoperable since the beginning of 2011.

There were over 7,300 public charging points and more than 10,300 semi-public charging points in the Netherlands at the end of 2015. The number of fast chargers increased by 80%, from 254 at the end of 2014 to 465 at the end of 2015. This includes 7 Tesla Supercharger stations with 51 chargers in total. Next to these publicly accessible charging points, an estimated minimum of 55,000 private charging points were in operation.

This brought the ratio of public charging points to electric passenger vehicles to 0.8 by the end of 2015.

Number installed by Charging point category	31-12-2013	31-12-2014	31-12-2015
Regular public (24/7 publicly accessible)	3,521	5,421	7,395
Regular semi-public (limited public accessibility)	2,249	6,439	10,391
Public and semi-public fast charging points	106	254	465
Private charging points			
Estimate based on research in 2012 and extrapolations for subsequent years	18,000	28,000	55,000

Table 3: charging infrastructure development[3]

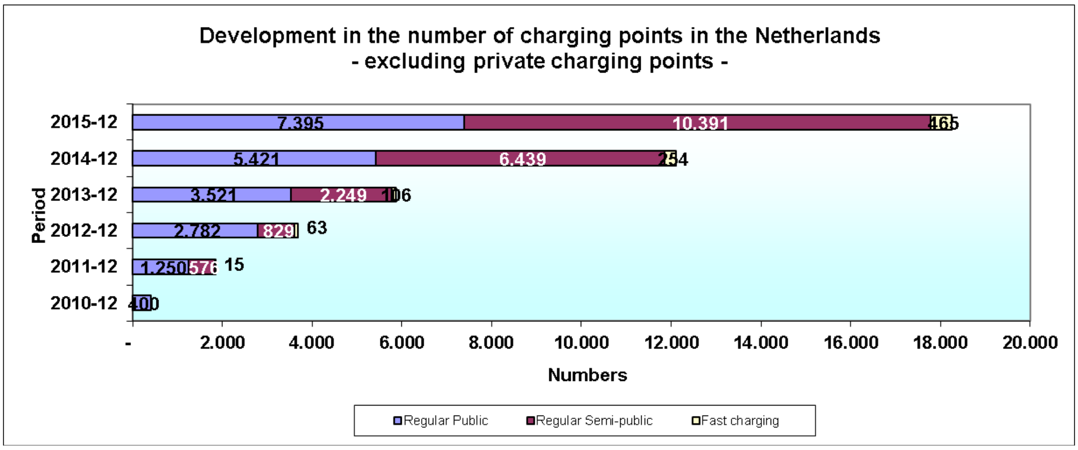


Figure 4: charging infrastructure development[4]

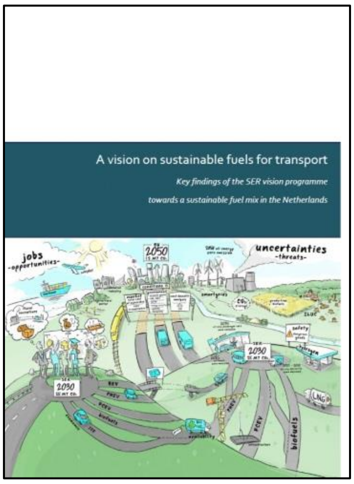
[3 & 3] Based on data from Stichting e-laad, EV-Box B.V, NUON and Essent, The New Motion (data up to 31-10-2012) and Oplaadpalen.nl (starting with data as of 30-11-2012). Up to 28-02-2014 it is assumed that charging points from e-laad, Nuon and Essent are public and the others semi-public. As of 31-03-2014 Oplaadpalen.nl states whether charging points are public or semi-public.

1.1.3 Policy on e-mobility and incentives

1.1.3.1 National Energy Agreement for Sustainable Growth

Over 40 parties representing public authorities and market operators in the Netherlands have signed the National Energy Agreement for Sustainable Growth, reflecting the willingness of many parties to work on making Dutch society and economy sustainable. The agreement contains a separate chapter on mobility, the most important target being to reduce CO_2 emissions in the mobility sector by 17% by 2030 and by 60% by 2050.

1.1.3.2 Vision on sustainable fuels for transport



A vision on sustainable fuels has been drafted to complete the mobility agenda in the National Energy Agreement. This vision document states that all newly sold vehicles need to be capable of driving emission-free by 2035.

The Formula E-team (a public-private partnership between companies, research centres and governments), has drafted interim goals based on this vision. The aim is to create a nationwide network of charging points in the short term. Three vehicle-related ambitions have been identified: 1) EVs should be made more attractive to the consumer market, 2) PHEV drivers should be encouraged to drive as many ‘e-kilometres’ as possible, and 3) 50% of newly registered cars should have an e-drivetrain by 2025. Thirty per cent of these, that is 15% of all new registrations, should be BEVs.

1.1.3.3 Green Deal on public charging infrastructure

Large Dutch cities such as Amsterdam, Rotterdam, The Hague and Utrecht are organising tenders for the installation and operation of public charging infrastructure. Since most public charging stations are still not commercially viable, public authorities and the business community have used shared financing to create new charging stations. The national government is helping to remove financial barriers in the form of a Green Deal.

The Dutch government uses Green Deals to help local authorities, citizens, companies and organisations to implement environmental initiatives. Several Green Deals on e-mobility have been signed in recent years, including one in June 2015 on public charging infrastructure. The national government has made € 5.7 million available for this project, which aims to expand the public charging network in the Netherlands. Additional financing will come from local governments and private enterprises.

The National Knowledge Platform for Charging Infrastructure was also set up as part of this Green Deal. The aim here is to bring down the cost of the public charging infrastructure through research and innovation projects.

1.1.3.4 Financial and fiscal incentives

One of the main drivers behind the increase of the number of electric vehicles is fiscal incentives. These measures have focused more strongly on stimulating zero-emission vehicles since 1 January 2015, and even more strongly since 1 January 2016. Major changes in the Dutch taxation system as applied to cars are expected in the period 2017-2020, and fiscal incentives for PHEVs will gradually be reduced until these vehicles are taxed in the same way as conventional cars.

Table 4 gives an overview of incentives in place in 2016.

Policy measure	Details
Registration tax	Zero emission cars are exempt from registration tax. The registration tax for other cars is progressive, with 5 bands depending on the level of CO_2 emission. Plug-in hybrid cars are in level 1 (1-79 gr CO_2/km) and pay € 6 registration tax per gr CO_2/km. The rate for level 2 (80-106 gr CO_2/km) is € 69 per gr CO_2/km, and the rate for the highest level (174 gr CO_2/km or more) is € 476 per gr CO_2/km.
Road tax	Zero emission cars are exempt from road tax. Plug-in hybrid cars (< 51 gr CO_2/km) pay 50% of the road tax due on a regular car.
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 done by imposing a surcharge of 4-25% of the catalogue value on the user's taxable income. For zero emission cars this percentage is 4%. For most plug-in hybrids (< 51 gr CO_2/km), the percentage is 15%. The next level (51 – 106 gr CO_2/km) attracts a 21% surcharge, while a 25% surcharge is imposed for all higher emission levels.
Tax deductible investments	The Netherlands has a system of facilitating investments in clean technology by making such investments partially deductible for the purposes of corporate and income taxes. Zero-emission cars and plug-in hybrid cars without a diesel engine are regarded as tax-deductible investments, as are the accompanying charging points.

Table 4: Fiscal incentives for E-mobility in the Netherlands

In addition to these national instruments, there are various regional subsidies for electric vehicles (passenger vehicles, commercial vehicles, trucks and/or scooters) and/or the installation of charging points for them.

1.1.4 Innovation system for electric driving in the Netherlands

Innovation occurs within the context of a wider system, the "innovation eco-system". The successful advance of an innovation from early development to mass market introduction is determined by the structure of the overall innovation system and how it works.

The graph presented in Figure 5 shows the innovation diffusion curve proposed by Prof. Everett Rogers (in blue) together with the curve representing the rise in the innovation's market share (in yellow).

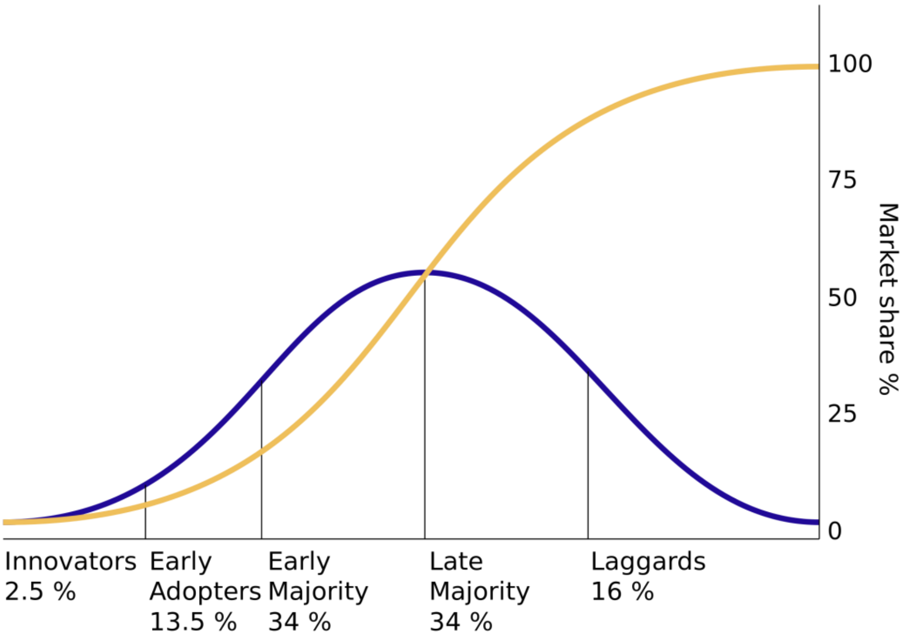


Figure 5: Innovation diffusion (or adoption) curve and Market share curve

Analysis of the seven main interacting functions in an innovation system (entrepreneurial activities, knowledge development, knowledge diffusion, guidance, market formation, resource mobilisation and creation of legitimacy) makes it possible to understand why it is difficult to get the market to accept some innovations, and what can be done to change this situation. Such an innovation analysis was performed by Birch Consultants[5], and was included as an appendix to the report "Cashing in on Electromobility's Economic Potential" (see reference 2 on page 7 of the present report).

Until the first commercial applications, an innovation system is in the developmental phase. This is followed by the "take-off" phase, which lasts until the period of fast market growth known as the acceleration phase. E-mobility in the Netherlands (and in many other countries) is at the end of the "take-off" phase, which corresponds to the end of the early adopters phase of the innovation diffusion model illustrated in Figure 5.

Innovations can advance to the acceleration phase when there is sufficient creation and diffusion of knowledge and entrepreneurs are active, when resources become available for scale-up, when governments guide market development by formulating a clear vision for the field and effective policies for implementing this vision, and the innovation is not opposed by the market.

[5] Birch Consultants (2015). Innovatiesysteemanalyse Elektrisch Vervoer (Bijlage 3 bij Rapport Verzilvering Verdienpotentieel): http://www.rvo.nl/sites/default/files/2015/12/Bijlage%20III%20bij%20Rapport%20Verzilvering%20Verdienpotentieel%20EV%2C%20Innovatiesysteemanalyse%20Birch.pdf (report in Dutch)

The analysis by Birch Consultants shows that knowledge creation and diffusion in the Dutch electric vehicle sector are adequate. Private investments are starting up in some sectors, giving entrepreneurs the opportunity to scale up. In the short term, however, there still is insecurity about the direction the market is likely to take and some market players are still unduly dependent on government policy. Legitimacy in the existing market is an area of concern.

2 Industry description

The Netherlands has invested a great deal in the electrification of transport in recent years. Dutch companies gained valuable experience by leading the way in the development and scaling up of e-mobility, thus creating a home test market and promoting further growth of the sector. This chapter describes the e-mobility sector in the Netherlands. It focuses on passenger cars, but when other vehicles make a substantial contribution to the sector, the organisations active in their development and use are also mentioned.

2.1 Value chains

E-mobility is a multidisciplinary field, involving such aspects as mobility, energy, services and IT. This is reflected in the common value chains developed by the participants in Task 24, the main features of which are shown in Figures 6 – 8.

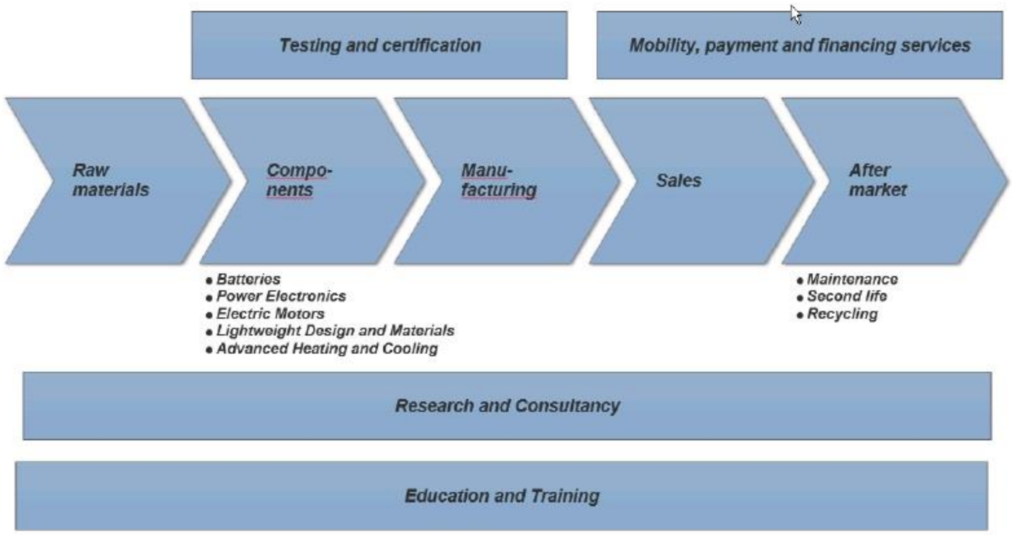


Figure 6: Vehicles value chain

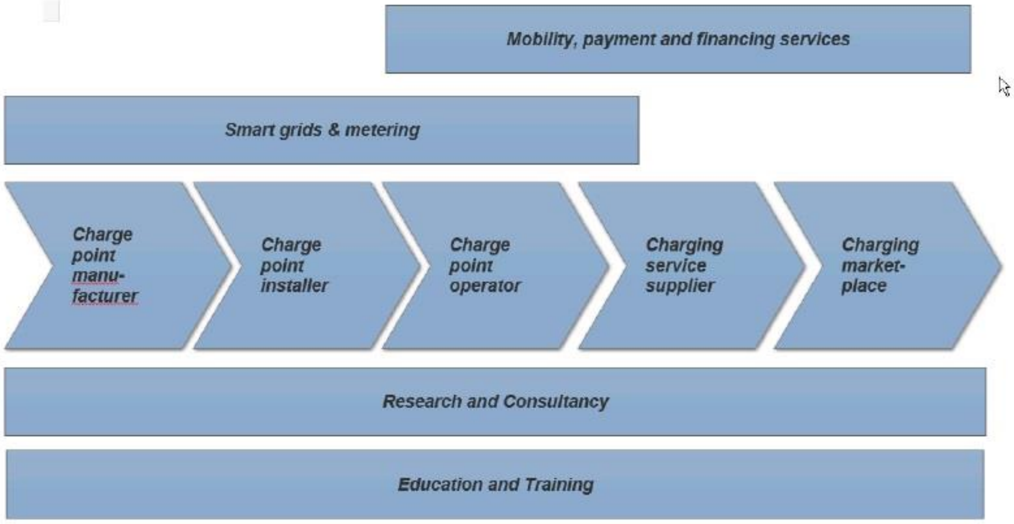


Figure 7: Infrastructure value chain

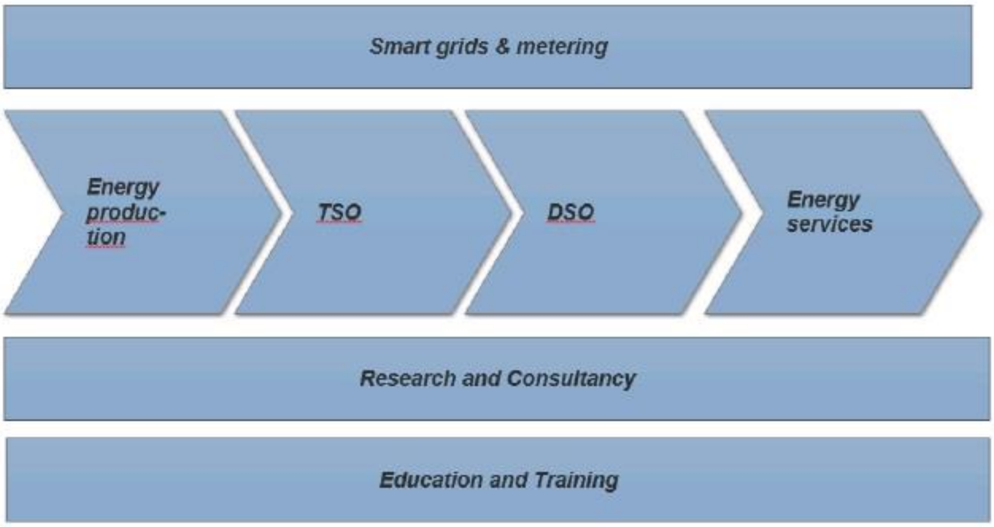


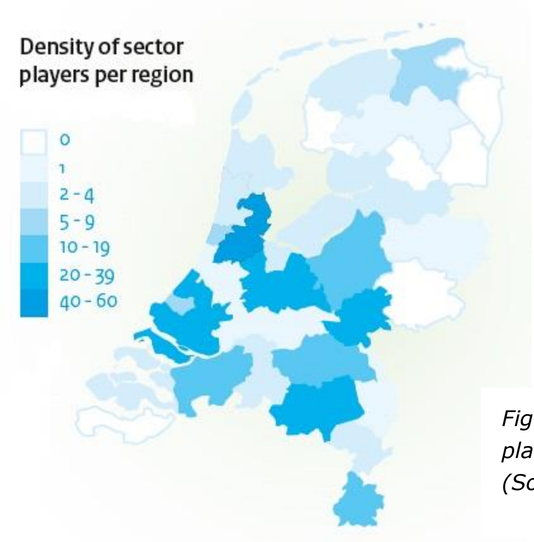
Figure 8: Energy value chain

The value chain for services in the Netherlands is not shown separately in this report, since its various elements are too closely interwoven with those of the other value chains to allow independent presentation.

2.2 Industry players in general

The above-mentioned report by Birch Consultants (see reference 4 on page 13) gives an overview of the most important parties involved in e-mobility in the Netherlands. Birch Consultants studied more than 280 projects that were partly financed by national or regional governments in the course of 7 years, with a total of over 550 national participants and 280 foreign participants. The organisations in question are active in almost all parts of the value chains.

About 300 SMEs and almost 100 large companies were active in the Dutch e-mobility sector in recent years, alongside a number of research or knowledge centres and various levels of government.



Consideration of the geographical location of the parties involved shows that they have become increasingly concentrated over time around the cities of Amsterdam, Rotterdam, Utrecht and Eindhoven. Figure 9 shows the situation in mid-2015.

Figure 9: Regional distribution of E-mobility players in the Netherlands (Source: Birch Consultants)

It is also interesting to see how the Dutch e-mobility network has evolved. The density of e-mobility players and the links between them have increased strongly in recent years, as shown in Figure 10.

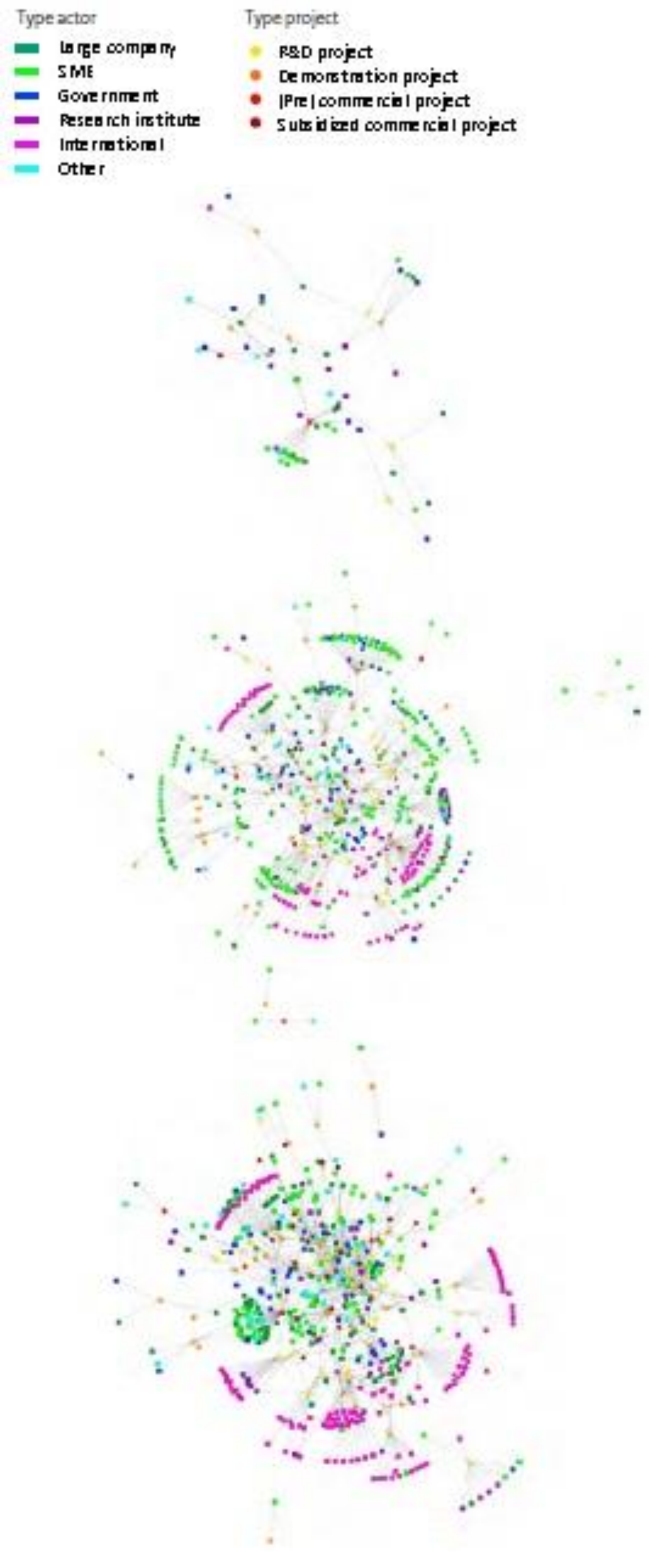


Figure 10: Development of Dutch e-mobility network, 2008 – 2011 – 2014 (top to bottom)

2.3 Industry players in different segments of the Dutch e-mobility value chains

This section gives a brief description of the various players in the Netherlands in the different segments of the value chains shown in Figures 6, 7 and 8. Most of the information presented here was taken from the Birch Consultants report and the report on the Economic potential of e-mobility published in 2015 (see references 2 and 5 above).

In view of the fairly condensed nature of this report, there is only room to mention key players here. A full list of E-mobility companies active in the Netherlands, with a breakdown by market cluster, is given in Annex 1.

2.3.1 Vehicles value chain

2.3.1.1 Raw materials

Not many players are active in the production of raw materials for e-mobility in the Netherlands. Most of the raw materials for vehicles and charging poles are imported from abroad.

2.3.1.2 Components

Several companies active in the Netherlands manufacture components and drivetrain technologies for use in the e-mobility field. Most of these are SMEs and many are members of the sectoral association AutomotiveNL. Of the almost 300 SME companies in the database studied, an estimated 80-120 supply the electric vehicles industry with power electronics, electric motors, lightweight design and materials and advanced heating and cooling systems; most of these products are exported. However, e-mobility is estimated to comprise only about 10-20% of the activities of the majority of these companies, although a few (such as e-Traction, which produces wheel hub motors) are completely dedicated to work in the field of electric vehicles.

One big player in this segment is NXP, which produces chips for vehicles (though not only for electric vehicles). Some companies are active in battery management and information systems, partly through R&D projects.

2.3.1.3 Manufacturing

Some companies are still active in converting conventional passenger cars to electric cars but this has mostly been a bridging niche.

Tesla Motors has a distribution centre and an assembly plant for the European market in the Netherlands. Other manufacturers of electric passenger cars are located in the Netherlands, but with sales offices rather than manufacturing sites.

A number of large and smaller companies are involved in manufacturing and assembling custom-made e-trucks (such as DAF, GINAF, Volvo and Hytruck) and e-buses (VDL and Ebusco). Ebusco assembles only 100% electric buses, the rest also produce conventional vehicles. Special electric vehicles are produced by dedicated companies such as 2getthere and Electrocar. The US company Zero Motorcycles has a Dutch production facility for electric motor bikes and there are several successful dedicated producers of electric scooters and bicycles.

2.3.1.4 Sales

Electric vehicles, like conventional vehicles, are largely sold by car importers and car dealers. There are hardly any players that are dedicated to the sale of electric vehicles.

2.3.1.5 After-sales market

Electric vehicles require less maintenance than conventional vehicles, and this work is usually done by service centres that service conventional as well as electric vehicles. The second-hand market for electric cars is still underdeveloped, as is the recycling of such vehicles. However, the Dutch car recycling giant ARN also deals with electric cars. An interesting project in which ARN participates with energy company Alliander and several research institutes is the deployment of used car batteries for energy storage on the small island of Pampus off Amsterdam.

2.3.1.6 Testing and certification

Important testing and inspection/certification centres for electric vehicles are the Dutch Organisation for Applied Scientific Research TNO, TASS, TÜV (Best), the Dutch Road Authority (RDW) and KEMA.

2.3.1.7 Mobility, payment and financing services

Many companies are active in this field in the Netherlands. Most of them are SMEs, such as the electric car leasing company MisterGreen. The majority are 100% dedicated to e-mobility, presenting themselves as a one-stop shop for e-driving.

The number of electric cars used for car-sharing is growing, as is the number of companies involved. A big player in this field is Car2Go in Amsterdam. Electric taxis are also being more widely used, for example at Schiphol airport, where BBF Schipholtaxi and the BIOS group use Tesla cars as taxis (the former had 96 in their fleet in 2015, and the latter 71 in the same year).

2.3.1.8 Research and consultancy

Universities of Technology and Universities of Applied Sciences work together in the field of innovative e-mobility research in D-Incert, the Dutch Innovation Centre for Electric Road Transport. Student teams help companies that are active in this field to develop innovative electric vehicles and race the prototypes all over the world.

Research organisations and consulting firms such as TNO, CE Delft, ECN, DHV, Ecorys and Movares not only work in the field of e-mobility but also have special electric vehicle departments.
The Netherlands also has some dedicated e-mobility consulting firms such as APPM, EV Consult, FIER Automotive, Het Energiebureau and Overmorgen. All of these organisations are active in all E-mobility value chains.

2.3.2 Charging infrastructure value chain

2.3.2.1 Charge point manufacture

Many Dutch companies are active in the production of charging points. The main ones are EV box, Alfen, ABB, Ecotap, Heliox, Cohere and Fastned. ABB and Fastned specialise in fast chargers. With the exception of ABB most of these companies are SMEs and totally dedicated to e-mobility. They are expanding their business abroad, to Belgium, Germany and other European countries but also further afield. For example, EV Box and Cohere are active in the United States.

Inductive or wireless charging is an emerging technology. Proov is active in this field and cooperates in national projects (for example in Utrecht) and international ones (for example in London).

2.3.2.2 Charge point installation

The companies named as manufacturers in 2.2.2.1 also install the charging points they produce. Large construction and installation companies such as Cofely, Heijmans and Joulz (part of energy company Eneco) install charging infrastructure as well, although this is a relatively small business activity for them.

2.3.2.3 Charge point operation

Many charge point manufacturers and installers also operate charging points. Most fast chargers are operated by private companies such as Fastned and Tesla. Semi-public charging stations may be run by companies from outside the E-mobility sector such as Ikea. Public charging points in many cities are tendered to a specific operator. In other municipalities, organisations such as Allego are active in rolling out charging points. The public charging points that were installed in the past by Elaad are now operated by EVnetNL.

2.3.2.4 Charging service suppliers

These are also known as mobility service providers. A major player in this field in the Netherlands is The New Motion, which is also active in other countries such as Germany and India. Other companies that are active in this field include Essent, TravelCard and GreenFlux.

2.3.2.5 Smart grids and metering

There is a great deal of development in the field of smart grids, including several pilot projects. A number of distribution system operators (DSOs) such as Stedin are active in this field. Stedin is part of the consortium that set up the first V2G charging pole in Utrecht, officially opened in June 2015. Twenty bi-directional poles were installed in Utrecht in March 2016, and the aim is to increase the total number here to 200.

The Dutch province of Noord-Brabant has installed 100 innovative public charging points for electric cars in the province’s five largest cities. DSO Enexis and other market players developed a charging point for the pilot project in Noord-Brabant that smart-charges electric cars and is 50 per cent cheaper than existing stations.

2.3.2.6 Mobility, payment and financing services

Interoperability has been a unique feature of the Dutch e-mobility landscape. The parties involved agreed right from the start to be interoperable, and have been quite successful in achieving this. Dutch companies active in payment and financing services export their knowledge and experience abroad.

2.3.3 Energy value chain

2.3.3.1 Energy production

Most of the large Dutch electricity producers such as Essent/RWE, Eneco and Nuon are active in e-mobility.

2.3.3.2 Transmission System Operator (TSO)

The Dutch TSO is TenneT.

2.3.3.3 Distribution System Operator (DSO)

Several DSOs, such as Alliander, Enexis and Stedin, are active in electric vehicle projects. They link up public and semi-public charging infrastructure.

ElaadNL and EVnetNL have emerged from the DSO foundation e-laad (E-charge), which established a network of around 3,000 public charging stations for electric cars across the Netherlands between 2009 and the beginning of 2014. ElaadNL is the knowledge and innovation centre for charging infrastructure in the Netherlands, providing coordination for the links of public charging stations to the electricity grid on behalf of the network managers involved. Managing the existing charging stations is not one of ElaadNL’s functions. This is done by EVnetNL in consultation with the relevant municipalities. See section 2.3.2.3 (Charge point operation) for further details.

2.3.3.4 Energy services

These were already described in previous sections dealing with the vehicles and infrastructure value chains.

2.4 Dutch strengths in e-mobility

D-Incert and Ecorys carried out a study in 2012, in an attempt to gain a clearer picture of the economic potential of the e-mobility sector in the Netherlands. They identified 15 innovation tracks or product/market combinations (PMCs) on the basis of their analysis. The Formula E-Team characterised 12 of these, which are shown in Figure 11, as economically promising.

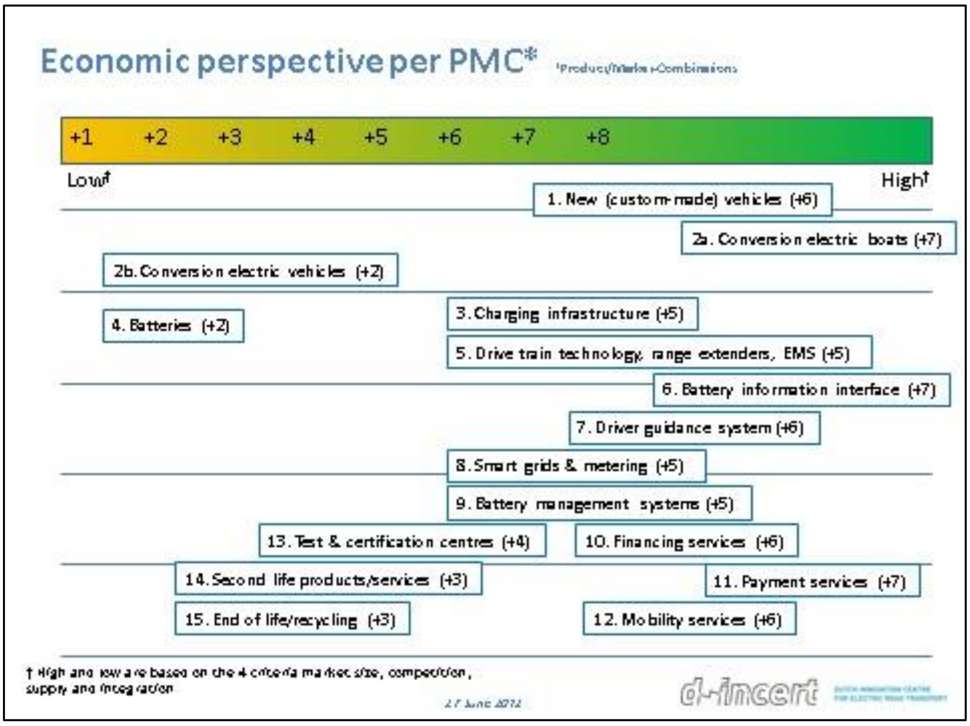


Figure 11: Economic perspective of Dutch e-mobility sector in 2012
(Source: D-Incert)

The Netherlands Enterprise Agency has produced an annual review of the economic perspectives of the e-mobility sector since 2013. In 2014 and again in 2015, their report showed that most business activity took place in the following segments:

- New (custom-made) vehicles (boats, buses, trucks, scooters and LEVs);
- Charging infrastructure;
- Drivetrain technology, range extenders, energy management systems (EMS) and components;
- Smart grids and metering;
- Mobility services (such as leasing).

The strengths of Dutch businesses also lay in these sectors. Especially in the field of charging infrastructure and the related smart grids & metering, Dutch companies export products and services. The manufacture of electric vehicles (not passenger cars but most other modalities) is also on the rise.

3 Economic impact indicators

As the economic perspectives of e-mobility form an important argument for the Dutch government's involvement in the promotion of electric driving, research has been performed to determine the employment and other economic indicators related to this sector.

3.1 E-mobility employment, production and added value

The Netherlands Enterprise Agency has worked together with a number of industry associations and CBS Statistics Netherlands (the Dutch national statistics office) to calculate the number of jobs related to the e-mobility sector in the Netherlands.

A questionnaire was developed, inquiring about the number of jobs, production/turnover volume, export volume and investments – for e-mobility and for the overall business activity of the companies surveyed (to determine how much of their business is devoted to E-mobility) – in 2014 and previous years. The questionnaire was distributed to members of two industry associations, to well-known companies in the field of electric vehicles and was also posted on social media. The members of the industry associations were gently urged by a prominent, respected figure from the sector to complete and return the questionnaire. Trust is very important in this connection, as companies are hesitant to provide the economic information requested if they fear that their competitors will discover sensitive details of their business operations in this way. Individual company results were not published.
CBS Statistics Netherlands calculated a number of indicators on the basis of the replies to the questionnaire, and also provided a breakdown by sub-segment. They supplemented the data collected with the aid of a list of companies active in e-mobility and their own national database with economic data on Dutch companies. The proportion of business activity devoted to E-mobility as derived from the average answers to the questionnaire was applied to similar segments or companies of a similar size.

The available data did not give any indication of how the growth of jobs in the e-mobility sector influences employment levels in the rest of the automotive sector (the impact on 'business as usual').

Figure 12 shows the growth of the electric vehicle sector in the Netherlands between 2008 and 2014, in terms of direct employment (in FTEs), production volume and gross added value.

Figure 12: e-mobility economic indicators
(Source: CBS Statistics Netherlands)

Direct employment in e-mobility has increased nearly tenfold since 2008, from 350 FTEs in 2008 to 3,200 FTEs in 2014. Although growth slowed down a little during the last year, the number of jobs still increased by 25% compared with 2013.

In early 2015, research company CE Delft used various scenarios to estimate the number of jobs in electromobility in 2020, arriving at figures somewhere between 5,400 and 18,850 with a mean prediction of around 10,000 jobs in 2020.

A breakdown of the data collected into market clusters shows that employment is highest in the services sector (financing, payment, mobility and other services) and in the manufacture and retrofitting of vehicles. The highest percentage increase in jobs in 2014 was found in the charging infrastructure and smart grids segments. Production and added value follow the same trend.

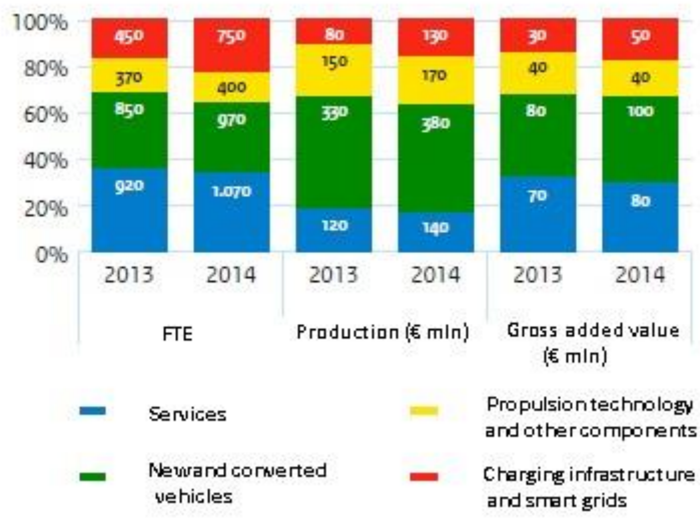


Figure 13: Breakdown of economic indicators by market segment
(Source: CBS Statistics Netherlands)

The manufacturing and retrofitting segment made the largest contribution to production and added value, whereas the indicators for charging infrastructure and smart grids shows the fastest growth.

Figure 14 compares employment and production in the four above-mentioned market segments in the Netherlands.

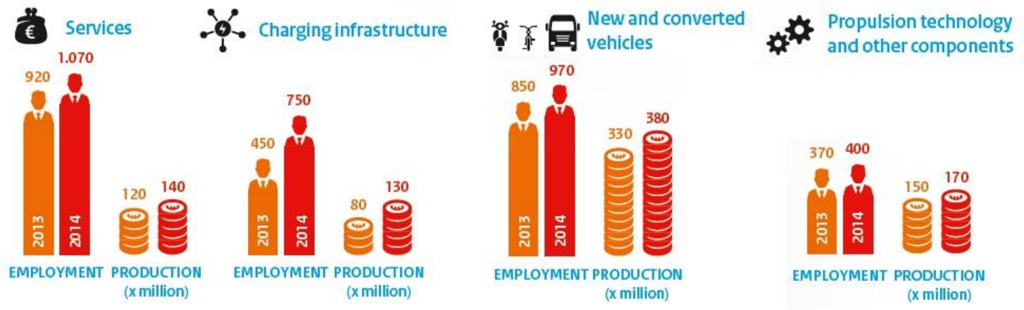


Figure 14: Comparison of economic indicators for the various market segments (Source: CBS Statistics Netherlands)

3.2 Exports

Unfortunately, the questionnaires did not yield enough hard data on export volumes to make it possible to draw any quantitative conclusions in this field.

Some encouraging qualitative trends can however be distinguished. The Netherlands has been a frontrunner in e-mobility in recent years. Relatively high sales of electric vehicles have contributed to the rapid growth of Dutch EV (electric vehicle) companies, enabling them to develop high-end products and gain expertise in this new market. Dutch companies such as The New Motion, Cohere, Viricity, EVConsult, EVBox, ABB, E-traction, NXP, Ebusco and VDL are active in a variety of countries, including the United States of America, India, China, Singapore, Bhutan, Germany, Malaysia, the United Kingdom and Belgium.

The Partners in International Business (PIB) programmes[6] set up by the Dutch government appear to be effective in converting initial exposure into long-term revenue. International missions, conferences and trade fairs are showing considerable interest in electric driving in the Netherlands.

[6] www.rvo.nl/pib

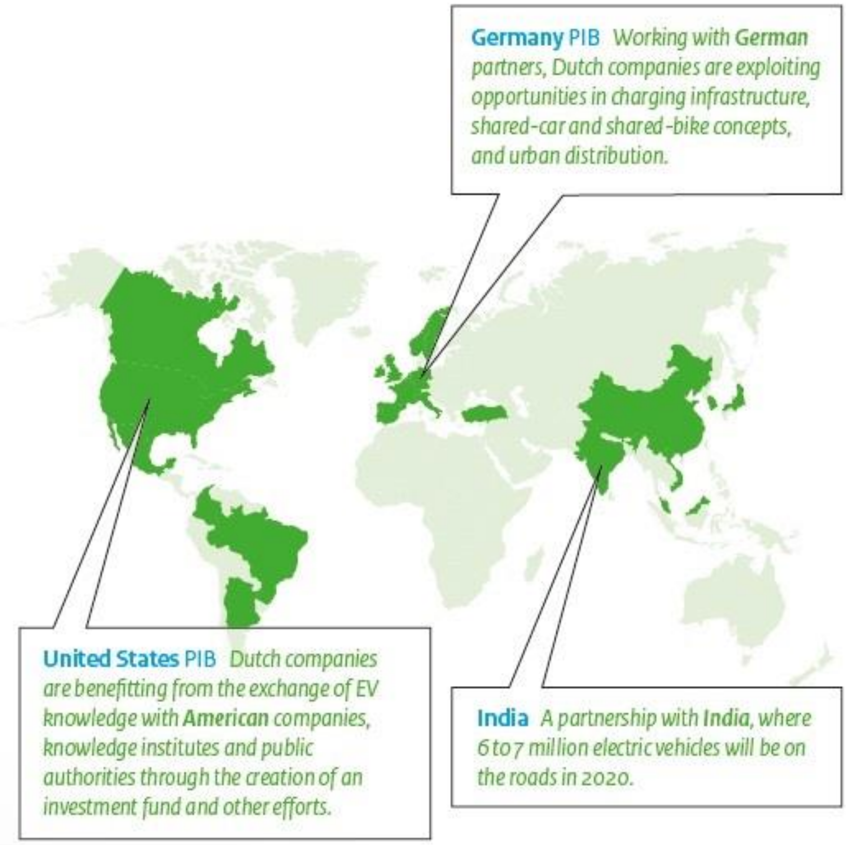


Figure 15: Inward and outward bound missions on EV and PIB components (Source: RVO.nl)

Dutch companies and research institutes also participate in various European programmes.

3.3 Education

A successful EV sector needs many specialists who are trained in various aspects of electric transport. Company R&D can also benefit from cooperation with students. Studies have been carried out to identify educational trends in the field of e-mobility.

Interest in electro-mobility is growing in Dutch educational establishments, especially universities of applied sciences and in university research departments. Electric driving and sustainable mobility are however not yet structurally embedded in vocational training programmes.

Collaboration between universities and industry is on the rise. A particularly striking phenomenon in this connection is the existence of nearly 20 Dutch student racing teams driving electric vehicles, which have achieved considerable success on an international scale. They have worked together with Dutch companies to design highly innovative electric cars and motor bikes (even a boat) and use them to compete in student races.

Figure 16: Examples of innovative e-vehicles designed by Dutch student teams

3.4 Patents

An overview of patent applications is an indicator of the status of R&D and innovation in a country, and hence of that country's economic potential. A survey performed in June 2015 by the patents department of the Netherlands Enterprise Agency inventoried international patent applications filed at the European Patent Bureau or the World Intellectual Property Office (WIPO) from 2008 to the present for inventions in the field of e-mobility, which was divided for the purposes of the survey into eight subsections: drivetrain technology, battery information systems, battery management, batteries, fuel cells, charging infrastructure, navigation and smart grids.

The results of this survey for the period 2008 – 2012 are shown in Figure 17. It should be noted that the details of patent applications remain confidential for a period of 18 months, and a certain processing time is needed before statistics can be derived from the available data. As a result, the June 2015 survey fails to give the complete picture for 2013.

Figure 17 shows that there were a particularly large number of patent applications in the field of navigation in 2008 and 2009. It should be noted that this technology is used for conventional vehicles as well as for electric vehicles. The number of patent applications has fallen in recent years.

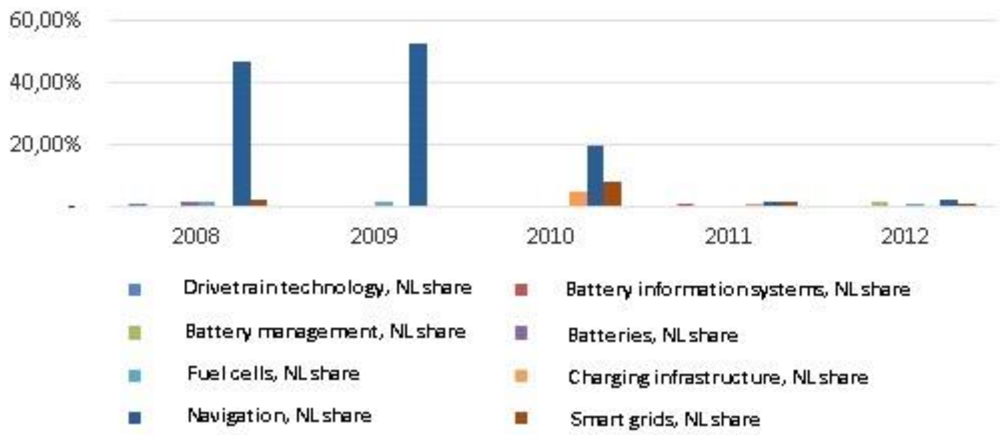


Figure 17: Dutch patent applications in various segments of the e-mobility field, as a percentage of the patent applications from all countries
(Source: Patents department of the Netherlands Enterprise Agency)

Annex I List of companies active in the various Dutch market clusters

Drivetrain technology and components, battery management and information systems	Financing, payment, mobility and other services
MI-Partners BV Eindhoven	DCB Energy BV
Sioux Embedded Systems BV Eindhoven	IMC Organisatie Personeel Subsidie
Progression-Industry Eindhoven	Dutch Traffic Consult
Brabant Alucast International BV Oss	EVConsult
Benteler Engineering Services Helmond	NL Mobility
GKN Service Benelux BV Halfweg	AON
Advanced Electromagnetics BV Sprang-Capelle	Duyndam
Brace Automotive Eindhoven	INND
Buvo Castings BV Helmond	Renova
CCM Centre for Concepts in Mechatronics Nuenen	Tendris
Centurion Akku Nederlandse Accumulatoren Produktie B.V. Roermond	Alphabet Nederland B.V.
DTI – Drivetrain Innovations B.V. Eindhoven	Amega Groep
Gear Chain Industrial BV Eindhoven	Athlon
Green Motion Technologies B.V.	Autolease Centrale B.V.
Altran B.V. Eindhoven	Autolease Lam
Bakker Magnetics BV Son	DirectLease B.V.
Componenta BV Weert	Electric Motorcycles Nederland
Chroma ATE Europe BV Ede	Europcar Autoverhuur
Neds PEM fuel cells Arnhem	Gebouwenzorg
Honeywell BV Amsterdam Zuidoost	J&T Autolease
Denso Europe BV Weesp	Mango Mobility B.V.
Euro Support Advanced Materials B.V. Uden	MPI
Benteler	RTC
Emobiletron	Rüttchen Autowereld
Prodrive Technologies	sQoot tweewieler lease
Star engines	Strix Lease Services BV
Storm Eindhoven	Terberg Leasing
Tegema	Van Mossel Groep
Power Motive BV Etten-Leur	WeMobile
TTI INC. Eindhoven	Zoem elektrisch deelvervoer
Veds	ANWB
Betronic BV	ASML
Sycada.Green	Boudesteijn
Midtronics BV Houten	Business Lease
Cleantron BV Nieuw Vennep	CGI
GP Batteries Europe BV Asten	Combipakt Nijmegen
V Tron	HNR EVC
ARN	Post NL
	Seats Network
	Stichting Limburg Elektrisch
	UPS
	VCCR
	VNA Lease
	TNO Automotive Helmond
	Delft Tyre Helmond
	TASS International Helmond
	Moditech
	RDW

Charging infrastructure and smart grids	New and converted (custom-made) vehicles
Van Leeuwen Oplaad	Elektrisch Varen
Alfen BV	EV NL
Allego	´Lightweight Structures B.V. Delft
BAM Infratechniek	RAVO BV Alkmaar
Bosch	Daf Trucks N.V. Eindhoven
Chargepoint / Reewoud Energietechniek	Modesi Eindhoven
Cofely	NPSP Composieten BV Haarlem
Ecotap	Segula Technologies Nederland BV Eindhoven
EV Laadkwartier	Bluekens
EV-Box	Detroit Electric
Fastned	Green Team Twente
FlexiCharge.nl	Plastisol
GreenFlux	PON
Lastmilesolutions	Ten Cate
MisterGreen Electric Lease	Toyota
Mourik E&I BV	Volvo Cars
The Good Movement b.v.	Zero bikes amsterdam
The New Motion	Nissan NL
Delta Electronics Hoofddorp	QWIC
Emmergy Helmond	Renault Nederland N.V.
Heliox B.V. Best	Metazet
ABB BV Rijswijk	DUVEDEC Europe BV Helmond
Allego	BMW Group NL
ECO Movement	BYD Europe
Elaad	Emco Benelux BV
Nuon	M-Products
Plug me in project	Spijkstaal Elektro BV Spijkenisse
Reewoud	Trikke Europe
The plugin company	Zerobikes
Laadmedia	e-Traction Europe BV Apeldoorn
Eneco Zakelijk	E-Trucks Europe Westerhoven
essent new energy	Ginaf
East Coast Electric	2Getthere
Pura Vida Renewable Energy	ESFA
Peec Power BV s-Gravendeel	GreenMo - Noveco BV
Energie Nederland	Accenda
Enexis	Hytruck
Netbeheer Nederland	Allmotive BV
Stedin	B-style & Flexitrans BV
	EMOSS bv Oosterhout
	Frisian Motors BV
	Elektrisch Varen
	EV NL

Other	
JJAdvies	Machiel van Dalen
Energy Engineers	Misteli
Ecomobiel	Movares
Hogeschool Rotterdam Automotive Engineering Rotterdam	NMU
Hogeschool van Arnhem en Nijmegen	PBL
Schone Lucht Rally	Platform toekomstbestendige mobiliteit
Steketee Design Eindhoven	Policy Research
Strukton Embedded Solutions Son	Rai Vereniging
H&S speed equipment vof Sevenum	Rally Masters
Technische Universiteit Eindhoven	Rebel Group
Hogeschool Arnhem Nijmegen - HTS Autotechiek Arnhem	RHDHV
E-Mobility Consulting Breda	Roelof Reinieman
Provincie Noord-Brabant 's Hertogenbosch	Samson
Automotive NL	Sub Zero Race
B M I	Syntens
Bayings	Universiteit Twente
BEN ECO	Vereniging Doet
Bovag	VORM Net
Careo	AFPT Sprang-Capelle
Elektromobilitaet	Allianz Nederland
Emma Communicatie	Dutch-INCERT
Emodz	E-Mobility
Energie Ambassadeurs	Poet Farmer
Everts	Roodworks BV communicatie-advies
Feweb	Zero emissie busvervoer
Fier	Aad de Wit Verhuizingen
Gemeente Uithoorn	APPM
Heiwegen	AW Projects
Het Energiebureau	ECN
Hiepractief	Eurocarbon BV Sittard
ICT Office	Emove Adventure
InMotion	HAW
IVDM	Mac
KPVV	

ECONOMIC IMPACT ASSESSMENT OF E-MOBILITY IN SWITZERLAND

IA-HEV, Task 24
Country report

On behalf of

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE

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The Swiss Federal Office of Energy (SFOE) has mandated e’mobile to collaborate with the IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) including Task 24.

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Management Summary

Task 24 – Economic Impact Assessment of E-Mobility of IEA's Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV) looks at how e-mobility can strengthen the economic position of a country and what growth is expected in this sector. It aims at getting a better view of the value chain for e-mobility in general and specifically on the economic potential of the local industry. The present report is the country report for Switzerland.

Every eighth job in Switzerland depends on the automotive sector. More than 300 companies are producing for the international automotive industry. Their export shares are high and in terms of export volume almost as important as the Swiss watch industry. German car manufacturers are their most important clients.

Switzerland has an ongoing tradition of more than 100 years in electric mobility. Although the country does not have a relevant automobile production any more, it still produces special electric vehicles for tourist resorts, industrial use, postal and communal services.

In 1995, the Swiss Federal Office of Energy launched its «Large-scale fleet test with lightweight electric vehicles» in Mendrisio in canton Ticino and in several Swiss partner towns. Since the end of this project in 2001 there are no more federal subsidies for purchasing electric cars. Despite this fact, the market for BEVs, EREVs and PHEVs has steadily grown since the introduction of the new generation of electric vehicles in 2011. As by 30 September 2015 10,264 plug-in cars were registered in Switzerland and 6,366 were BEVs.

There is no comprehensive information available specifically on the characteristics of the e-mobility sector in Switzerland. However, a survey of the automotive industry by swissCAR in 2013 gives some valuable information.

7% of the companies participating in the swissCAR survey indicated that products for the electric mobility belong to the most lucrative segments of their business. Typically, companies in the automotive sector are developing lightweight and innovative components first for electric cars. Subsequently, their clients may use them for conventional cars as well. The authors of the present report expect this share to grow, as e-mobility is gaining in importance for the global automotive industry.

A desktop research done by e'mobile has identified 174 companies and organisations actively working in the field of e-mobility early in 2016. By far most of the companies are manufacturing electric vehicles or components including batteries. This is confirmed by the analysis of patent requests filed by Swiss companies at the European Patent Bureau from 2005 to 2013. Most of the patents concerned batteries.

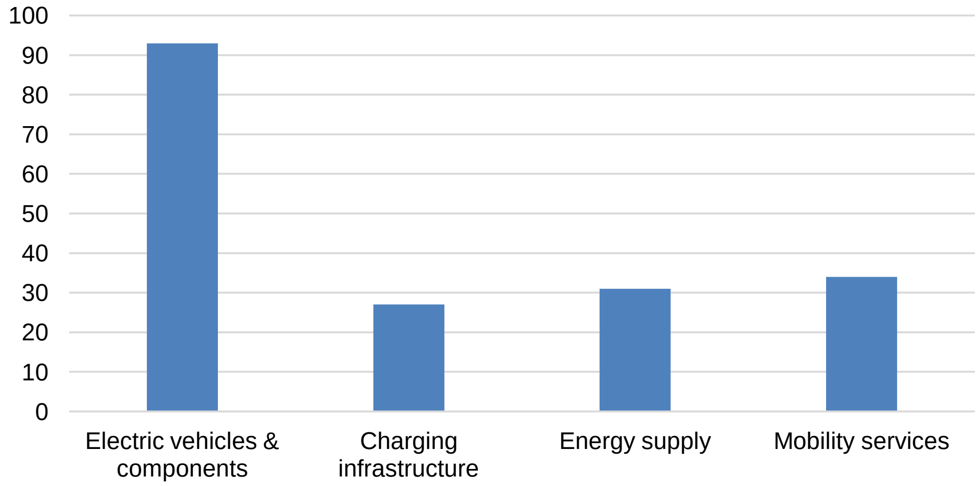

Figure 1: Companies and organisations in the e-mobility sector (Source: e'mobile)

1 Introduction

1.1 Implementing Agreement Hybrid and Electric Vehicles (IA-HEV) and Task 24

In 1993 the IEA founded the Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). Its objectives are the collaboration on pre-competitive research as well as the compilation and dissemination of information. The Executive Committee (ExCo), which consists of one delegate per member country, governs the work of IA-HEV. Different working parties are treating specific topics. The reports of these Tasks are a major part of the deliverables of the IA-HEV.

This report is one of the deliverables of Task 24 – Economic Impact Assessment of E-Mobility. The ExCo approved this Task in November 2013 and work started in May 2014. The final report is expected to be delivered by mid 2016. Task 24 sets its focus on the economic impact of this emerging market. It looks at how e-mobility can strengthen the economic position of a country and what growth is expected in this sector. It aims at getting a better view on the value chain for e-mobility in general and specifically on the economic potential of the local industry.

Task 24 participants are Austria, Belgium, Denmark, France, the region of Baden-Württemberg in Germany, the Netherlands, the United States of America and Switzerland. Every participant produces a country report on the economic perspective in its specific country. These results will then be analysed and summarized in a final benchmark report. The present report is the country report for Switzerland.

1.2 Country profile

Switzerland is situated in the centre of continental Europe, where Rhine and Rhone, two of Europe's biggest rivers, originate. Its topography is characterised by the Alps (60%), the fertile Central Plateau (30%) and the hilly Jura mountains (10%). Most major towns and industrial zones are located on the Central Plateau where two thirds of the country's inhabitants live. In urban areas such as Zurich, Basel, Geneva and Lausanne, the population density exceeds the level of 5,000 inhabitants per km^2.

Population (30.09.2015)	8,306,200
Surface Area	41,285 km^2
Inhabitants per km^2	201
Capital	Berne
Cantons	26
Foundation (confederation)	1848
Companies: Share of Small and Medium Enterprises (SME)	99.6%
Share of companies with in house R&D (2012)	48%

Figure 2: Data on Switzerland (Sources: Weltkarte.com, Swiss Federal Office of Statistics, Federal Dep. of Foreign Affairs)

75% of the Swiss population are German speaking and they are living in the eastern, northern and central parts of Switzerland. 20% is French-speaking, living in the western part of the country. Canton Ticino (TI) in the southern part of Switzerland is Italian speaking like the southernmost valleys of Canton Grisons (GR), where Rhaeto-Romansh and German are the predominant languages.

99.6% of Switzerland's firms are small (up to 49 employees) or medium sized (50 to 249 employees).[1] Over 80% are micro enterprises (up to 9 employees) and they employ every fourth working person. Small and medium enterprises (SME) are important Swiss innovators. They largely contribute to the diversification of the Swiss economy as well as to its stability.

1.3 Machine, electrical engineering and metals industry

Switzerland has one of the most competitive economies in the world thanks to its highly developed service sector. Nevertheless, it is the machine, electrical engineering and metals industry (MEM) that is the largest industrial employer in Switzerland. With a total workforce of 330,000 employees, MEM firms generate about 18% of Switzerland's gross domestic product[2]. It is also the country's second largest exporter after the chemical and pharmaceutical industry (32.2% of total Swiss exports). In 2012, it exported goods valued at CHF 64.6 billion (app. USD 65 billion)[3], and a significant share stemed from the automotive industry. The Swiss MEM industry also employs over 500,000 persons abroad.

Today, Swiss MEM firms are some of the most competitives in the world. They are mainly manufacturers for machine tools and machines for the textile and printing industries. In absolute figures, Switzerland is the 10th largest exporter of machinery in the world.

There are more than 2,500 companies working in this industry and most are either small- or medium-sized firms. The major big players are ABB, Alstom, Bobst, Liebherr, Georg Fischer, Rieter and Schindler. The automotive industry is an important customer for serval of them. ABB for instance is a major player in the emerging market of charging infrastructure.

1.4 Chemical and pharmaceutical industry

The chemical and the pharmaceutical industries are Switzerland's export leaders contributing roughly up to 40% of total exports. They currently employ around 65,000 people in Switzerland and over 355,000 internationally.

A few chemical and pharmaceutical firms, such as Novartis, Roche, Merck, Serono, Syngenta, Firmenich and Givaudan, dominate the industry. However, nearly half of all employees work in small- or medium-sized companies. In all, there are around 1,000 companies actively working in this sector. As for MEM firms, the automotive industry is an important customer for several of the chemical firms such as the EMS Group.

1.5 Electricity sector

In Switzerland, there are over 800 electric utility providers[4]. Most of these companies are active above all as power suppliers. 80% are owned and operated by communes and cantons. This is now about to change with the liberation of the energy market which encourages some of these companies to use electric mobility for promotion purposes. Only a few large electric utility providers exclusively focus on the electricity transmission.

Generating electricity in Switzerland is largely free of CO_2 emissions: approximately 56% are hydropower, 38% nuclear, 4% alternative power such as solar and wind, and 2% thermal power

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[1] www.seco.admin.ch/themen/05116/05118/index.html?lang=en

[2] www.eda.admin.ch/aboutswitzerland/de/home/wirtschaft/taetigkeitsgebiete.html

[3] Exchange rate by March 2016: CHF 1.00 = USD 0.99

[4] www.strom.ch

including waste incinerators. The Swiss population has decided to gradually shut down their nuclear power plants. The Energy Strategy 2050 of the Swiss Federal Office of Energy shows how renewable energies may replace nuclear power.[5] The industry considers this a big challenge. This may be the reason why some companies are holding back their investments in e-mobility, which opens new business opportunities for electricity suppliers.

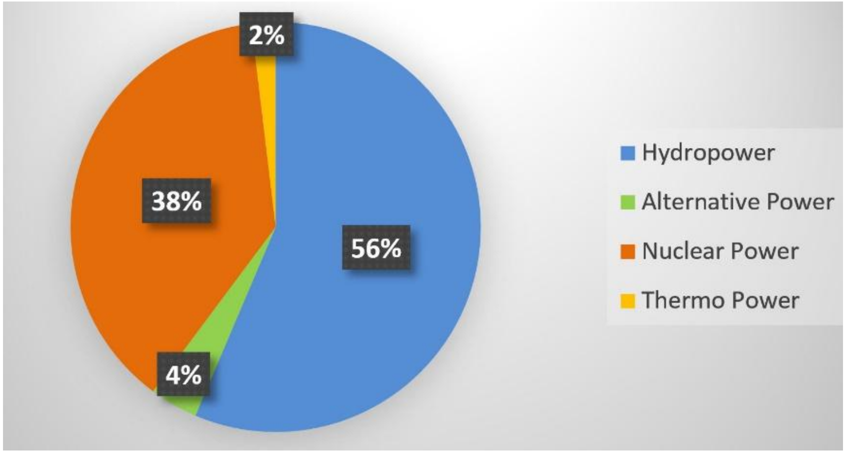

Figure 3:
Swiss mix of power production 2014
(Source: www.strom.ch)

1.6 Characteristics of the Swiss transport sector

The mobility market in Switzerland is constantly growing. In 2015 the overall distance individually travelled was an estimated 95 billion kilometres additionally to the 17.6 billion kilometres covered by public transport. In September 2015 4.5 million passenger cars, 717,500 other motor vehicles (buses, trucks, industrial vehicles) and 710,000 motorbikes and quadricycles were registered[6].

There were 537 cars per 1,000 inhabitants and CHF 12 billion worth of fuel sold. 38% of the energy is used by transport, which makes this the most important energy consumer in Switzerland. It is responsible for almost one third of Swiss CO_2 emissions. This is more than any other sector. It is unchallenged that transport and mobility will play a decisive role on the way to a sustainable society.

Although federal policy acknowledges the potential of electric mobility for reducing overall CO_2 emissions, incentives generally account for all cars with low CO_2 emissions.

In 2014, the automobile sector had an estimated turnover of CHF 90 billion. It accounted for 20,745 firms and organisations with a total of 218,600 employees.

The Swiss market in general is well-heeled and the average Swiss population is well educated, open to innovation and it shows a high awareness for environmental issues including climate change. Therefore, it is not surprising that clean technologies have increasingly come into focus of the industrial sector and that there is an ongoing interest in electric vehicles even without subsidies for electric cars. Nevertheless, 4x4 vehicles enjoyed a share of over 40% of the car sales in 2015[7], which is the highest 4x4 proportion in Europe. This also reflects the general wealth as well as the mountainous terrain in Switzerland.

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[5] www.bfe.admin.ch/themen/00526/00527/index.html?lang=en&dossier_id=05024

[6] Swiss Roadtraffic Association, Vademecum 2016

[7] www.auto-schweiz.ch

1.7 History of the automotive sector

Switzerland has a long tradition with all sorts of electric vehicles. In the early 20th century, the electric car manufacturer Tribelhorn Ltd. near Zurich started its production[8]. Out of this grew a new industry mainly managed by SMEs who manufactured electric vehicles for tourist resorts, industrial use, postal and communal services.

From 1985 to 1993 the «Tour de Sol» solar race promoted solar electric vehicles. In 1995 the Swiss Federal Office of Energy launched its «Large-scale fleet test with lightweight electric vehicles» in Mendrisio in canton Ticino and in several Swiss partner towns. Both projects encouraged young Swiss engineers to work on electric drive trains. At the same time, teams of technical universities have started to develop solar and electric vehicles. They successfully participated in international electric car races. Several of the young engineers involved in one of these projects have started their own business. They are now selling their products to renowned car manufacturers throughout the world.

Switzerland does not have relevant car manufacturers any more. Nevertheless, its automotive sector is as important as the watch industry in terms of export volume. In 2014 more than 300 companies with 24,000 employees and a total turnover of an estimated CHF 9 billion supplied all kinds of components to the international car industry in general and to German car manufacturers in particular[9].

2 E-mobility in Switzerland

2.1 Development of e-mobility

Since the market introduction of the new generation of BEVs, EREVs and PHEVs in 2011, electric car sales have steadily increased (see figure 4)[10]. They have roughly doubled every year since 2013.

In Switzerland 3,265 BEVs have been newly registered in 2015. This is a plus of 95%. Almost every second BEV was a Tesla Model S that is the most expensive BEV on the Swiss market. Renault ZOE and BMW i3 were running second and third respectively.

EREVs have proven to be less successful. This is mainly due to the fact that Chevrolet withdrew from the Swiss market at the end of 2014 thus reducing the offer to just two models. The growth in 2015 reflects the progress of the BMW i3 sales, where its range extender model was more popular than the BEV version.

PHEVs have seen an impressive growth of more than 200% in 2015. In this category 2,331 cars were sold last year. This reflects the market introduction of an interesting choice of new models. Again, it was the most expensive model of PHEVs that sold best in 2015: The Audi e-tron (688 vehicles) was ahead of the VW Golf GTE (626 vehicles) and the Mitsubishi Outlander PHEV (340 vehicles). This compares to conventional models, where the VW Golf was the most popular model in Switzerland over all.

[8] Johann Albert Tribelhorn und seine Erben: EFAG, NEFAG, Pioniergeschichte des elektrischen Automobils, Schweizer Pioniere der Wirtschaft und Technik, Verkehrshaus der Schweiz, Luzern

[9] Swiss Roadtraffic Association, Vademecum 2016

[10] Markt der Eco-Mobile, Aktualitäten und Trends 2016, EnergieSchweiz, Bern 2016

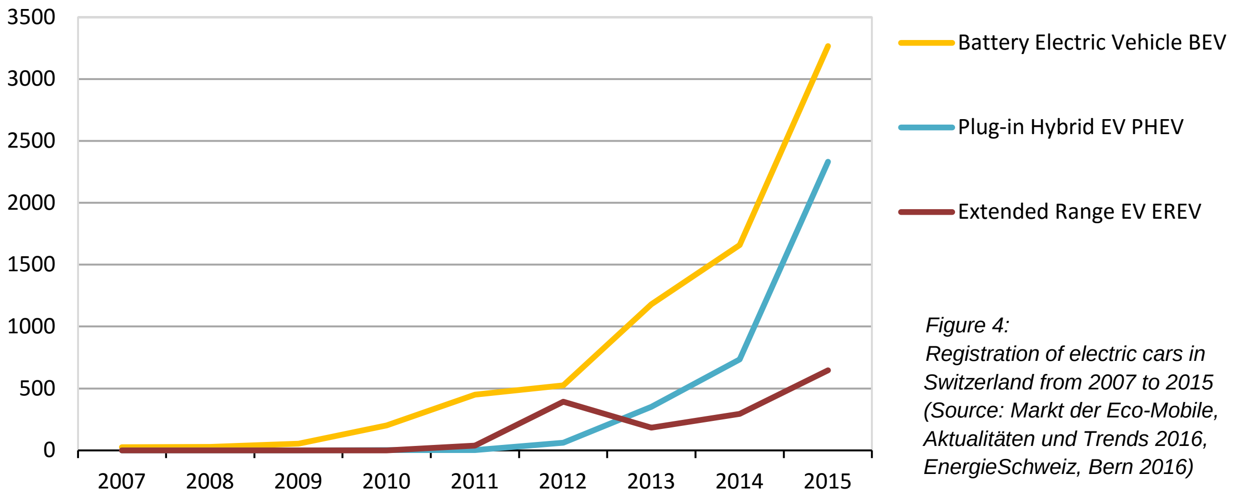

Figure 4:
Registration of electric cars in Switzerland from 2007 to 2015 (Source: Markt der Eco-Mobile, Aktualitäten und Trends 2016, EnergieSchweiz, Bern 2016)

As per 30 September 2015 10,264 electric cars were registered in Switzerland and 6,366 were BEVs. This figure almost doubled compared to the previous year, when the Swiss EV fleet counted 5,435 cars.

Sales of small electric vehicles and electric scooters have remained stable at about 2,000 units a year for a few years now. Sales of electric trucks and light utility vehicles show no significant development.

E-bikes and pedelecs have been very successful in Switzerland for several years now. Almost 66,000 units were sold in 2015[11]. This success is largely due to the fact that a couple of very innovative Swiss manufacturers are pushing the market development. The market volume amounts to an estimated CHF 0.3 billion.

2.2 Status of e-mobility on the innovation adoption curve

In 2015 e-bikes and pedelecs have reached a market share of over 20%. They are well established players in the early adopter's market. All the other segments remain in the innovators stage with shares of just below 2% for all EVs and 1% for BEVs.

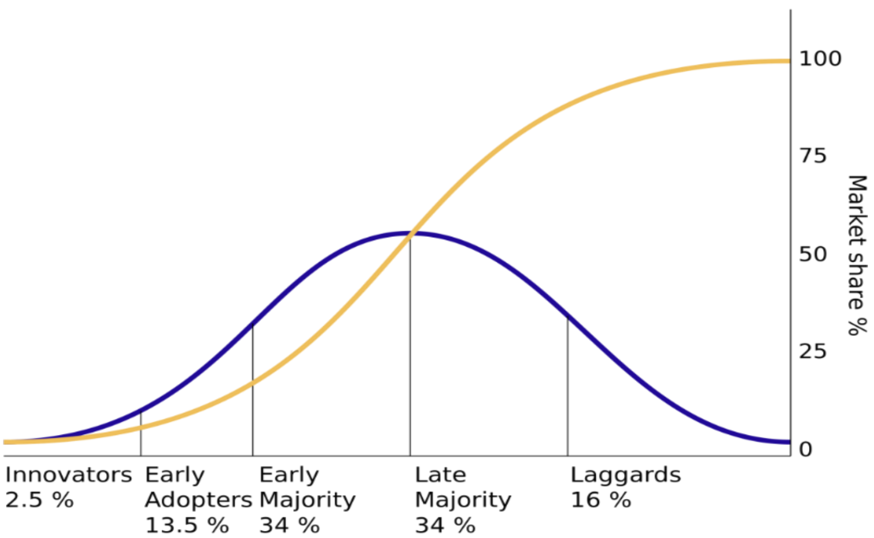

Figure 5:
Innovation adoption (diffusion) curve by Rogers (in blue) and development of market share of the innovation (in yellow).

[11] www.velosuisse.ch (10.03.2016)

Fuel cell electric vehicles (FCEV) have entered the Swiss market in late 2015 when Hyundai sold at least one ix35 to a commercial user. As there are only a few industrial hydrogen filling stations, car manufacturers are reluctant to introduce their FCEVs into the Swiss market yet. Switzerland has no promotional programme for FCEVs at the moment.

2.3 Charging infrastructure

By the end of 2015 close to 1,400 public charging stations with 3,200 charging points were registered in the Swiss national database[12]. There were 1,260 Level 1 and 2 AC-stations with 1-3 EVSEs each and 120 fast charging stations (CHAdeMO, CSS, Tesla Superchargers and 43 kW AC) with 1-3 EVSEs each.

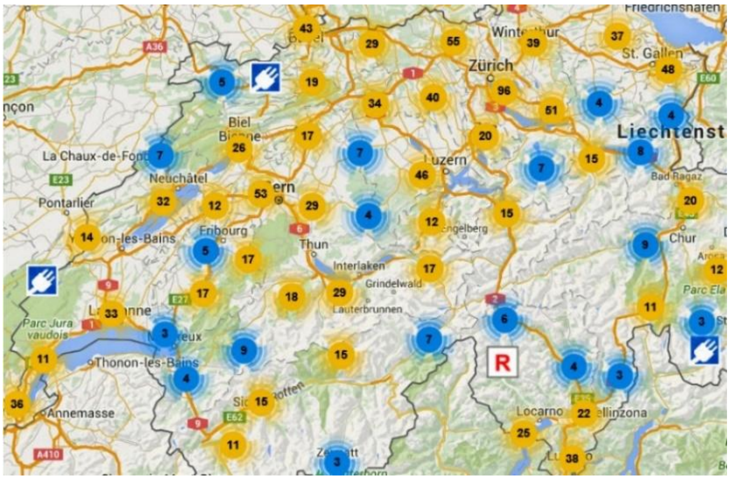

Figure 6:
Public charging stations in Switzerland (Source: www.e-mobile.ch)

In 2015 several commercial operators of public fast charging stations have introduced different access and payment systems. This trend will continue in the near future, as public charging is getting more and more sophisticated. New technical standards increasingly include the option to reserve particular charging points and to see the free/busy status by apps in real time.

The Swiss project KORELATION monitored the use of 199 electric cars during 18 months (2013/2014)[13]. The results confirm that about 90% of charging is done either at home or at work. Swiss electric car drivers use public charging stations – preferably fast charging – especially when driving longer distances.

Figure 7:
The project KORELATION monitored the use of 199 electric cars and analysed aspects of costs, reach and charging infrastructure in the daily use of these vehicles. (Project by e'mobile, supported by SwissEnergy of SFOE)

[12] www.LEMnet.org

[13] KORELATION, Praxiserfahrungen mit Elektroautos: Kosten – Reichweite – Ladestationen, Schlussbericht vom 26. Januar 2015; e'mobile

It is almost exclusively the private sector that is installing the charging infrastructure. Most EV owners have a private charging point (HCD) usually with 220V/16 A at home. Furthermore, hotels, restaurants, shopping centers and garages increasingly offer private charging points to their customers. e'mobile assumes that the total number of private and public charging points accounts for 13,000 units at least.

2.4 Policy on e-mobility and description of specific measures

The electric mobility has a great potential to contribute to solutions of environmental, societal and economic challenges. In May 2015 the Swiss Federal Council acknowledged this fact by approving the master plan for e-mobility[14]. This report assumes that e-MIV (electric motorized individual transport) will play an important role in the future.

The federal policy aims at the promotion of renewable energies in order to improve sustainability. E-mobility is set to play an essential part in reducing fossil fuel consumption by traffic. In the context of the New Energy Policy 2050 (NEP) the Swiss Federal Office of Energy identifies corresponding measures. It mentions contributions for research and development as well as pilot, demonstration and flagship projects but also information and consulting programs.

The Swiss government does not consider to establish an action plan dedicated to e-mobility only and there are no plans to introduce subsidies for electric vehicles. However, electric vehicles enjoy the following incentives at a national level:

- They are exempt from the vehicle import tax of 4%.
- There is no tax on electricity as «fuel» for electric vehicles (approx. USD 0.8/litre for gasoline and diesel).
- The Swiss Federal Office of Energy continues to support research projects as well as activities promoting electric and other energy efficient vehicles.

The road tax is part of the legislation of the 26 Swiss cantons. The calculation method of this tax varies from one canton to the other[15]. For conventional medium-sized cars, the tax amounts to a few hundred CHF per year. In the last few years several cantons have started to charge this tax based on CO_2 emissions and thus supporting indirectly the market introduction of EVs. Several cantons have exempted BEVs altogether or are charging an administrative fee only, which usually is less than CHF 100. Recently, a couple of cantons have cancelled their incentives for clean cars including electric vehicles.

A few towns are supporting the market introduction of EVs with their own promotional programme. Sometimes this includes subsidies of up to CHF 5,000[16].

Some utility companies in Switzerland offer support with the installation of charging points for electric vehicles of individuals and companies. Electric utility providers are installing and financing most of the public charging stations.

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[14] www.e-mobile.ch/pdf/2016/Bericht_Motion_12.3652.pdf

[15] www.bfe.admin.ch/energieetikette/00886/02038/index.html?lang=de&dossier_id=02083

[16] https://co2tieferlegen.ch/de-ch/foerdergelder

3 Industry description

3.1 Automotive industry

In 2013 the Swiss Center for Automotive Research (swissCAR) of the ETH Zurich published a report on the Swiss automobile industry[17]. The analysis of the automotive sector included a questionnaire sent to 315 companies with clients of the international automotive industry and with relevance to this sector. Specific questions were raised on research and development and some points addressed the importance of the electric drive train.

Six professional associations and another six intersectoral associations represent the business interests of the automotive sector in Switzerland. More than 30% of the companies participating in the swissCAR survey were members of Swissmem, the association of the MEM industry sector, which is the most important organisation for these firms. But 20% have stated that they are not a member of any of these associations.

30% of the companies were vehicle manufactures, almost 50% were suppliers of components and the remaining 20% delivered goods for production. 36% were producing goods for electric and 48% for hybrid electric vehicles. Some of their products were used for both categories as well as for conventional cars.

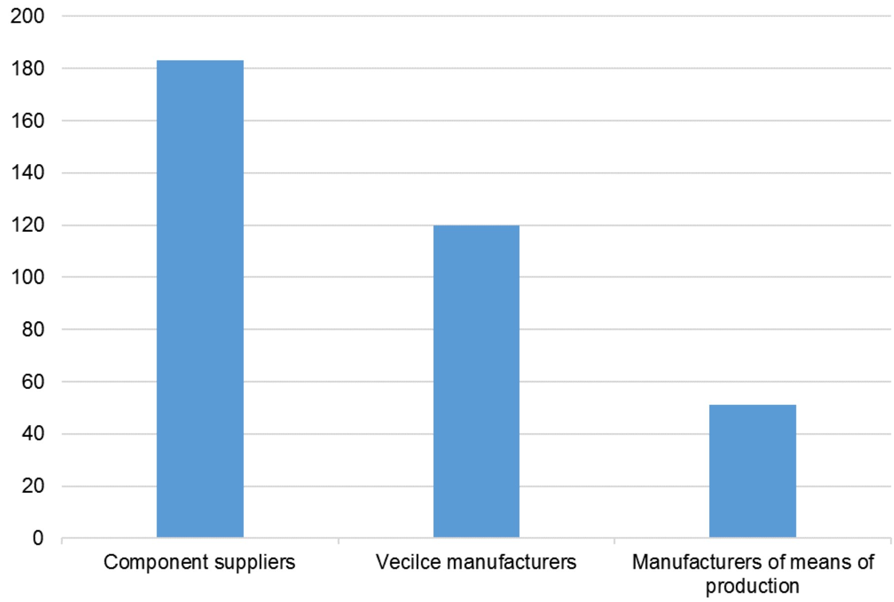

Figure 8: Relevant companies of the Swiss automotive sector 2013 by area of activity (more than one mentioning possible, source: swissCAR, 2013)

The automotive sector of Switzerland strongly depends on exports and particularly to Germany. More than 60% of the participating companies were exporting the majority of their products. Less than 10% were selling all their products in Switzerland only. Therefore, the euro exchange rates above all are a crucial business factor for development.

Electronic car components are a fast growing market. Companies like Brusa Elektronik are specialized in this field. Nevertheless, more than half of the firms answering the questionnaire mentioned, that they are not active at all in this domain. This came rather as a surprise as the researchers considered activities in the sector of electronic components to be an indicator for innovation and progressive business strategy. The report thus concluded that the automotive industry in Switzerland is more conservative than expected.

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[17] Schulze, Anja et al., Automobilindustrie Schweiz, Branchenanalyse 2013, ETH Zürich 2013

3.2 Electric vehicles industry

Only 7% of the companies participating in the swissCAR survey indicated that products for the electric mobility belong to the most lucrative segment of their business. Interviews with some of these companies have shown that this share might grow as the EV market is gaining in importance worldwide.

Nevertheless, electric cars and their components already play a significant role for some companies. The MEM company Georg Fischer e.g. produces the aluminum battery box for the VW eGolf and Audi A3[18]. In 2014 the company's annual turnover amounted to CHF 3.8 billion, whereof about one third stemmed from the automotive sector. Components for electric cars were contributing only 1%. On the other hand, already 5 to 10% of the company's investment costs contributed to the EV sector.

Companies in the automotive sector are typically developing lightweight and innovative components first for electric cars. Their clients subsequently use them for conventional cars as well. This often makes it more difficult to define the scope of the EV industry.

Not included in the survey of swissCAR were companies producing e-bikes, pedelecs and e-scooters. A few small companies with less than 100 and often even less than 10 employees are manufacturing communal vehicles tailored to the specific local demand in car free tourist resorts like Zermatt or Saas Fee. Most of these companies are reluctant to export their products. The swissCAR survey includes only those companies that are linked to the automotive industry.

Similarly, companies manufacturing e-scooters are largely producing for the Swiss market only. Kyburz Switzerland is the most important exception exporting its three-wheeler scooter to countries as far away as New Zealand. This medium sized company is about to enter the car market with its eRod launched at the Geneva International Motor Show 2016.

About a dozen, mainly small firms are manufacturing e-bicycles and pedelecs mostly for the home market. Their annual turnover is estimated at CHF 0.3 billion. In this sector Biketec is by far the most relevant company in Switzerland. After 20 years in business this company with about 200 employees is well established. It produces 400 e-bikes a day and exports about 75% mainly to Germany and the Netherlands. Recently Biketec has set its eyes on markets outside of the EU, namely South Korea.

[18] www.srf.ch/sendungen/trend (05.12.2015)

3.3 Charging infrastructure

The swissCAR survey dedicated a chapter to manufacturers of charging infrastructure. They identified 16 companies being relevant to this market in 2013:

Company	Manufacturer of charging infrastructure	Service provider
ABB	x	
Alpiq E-Mobility		x
Amperio		x
Demelectric	x	
DISA	x	
EKZ		x
EVTEC	x	
Green Motion	x	
Groupe E		x
IEM	x	
m-way		x
Protoscar	x	
QvR	x	
Schneider Electric Schweiz	x	
Siemens Schweiz	x	
The Mobility House Schweiz		x

Table 1:
Relevant companies in the field of charging infrastructure (Source: swissCAR)

The head offices of 12 companies are located in Switzerland and mostly in the Zurich area. 50% of them have been founded after the year 2000.

They are mainly service providers and hardware importers. Only a few are manufacturing charging stations in Switzerland. They are either small with less than 100 employees or big with more than 1000 employees. In either case, no more than 10 persons are working on the charging infrastructure. The survey estimates the total number of employees in this sector to about 60 persons in 2013.

In 2012 the survey participants produced 5,600 charging stations and exported 1,800 mainly to Germany, France and Austria. Although the exports would have grown by now, their share on the world market remains small. Nonetheless, they cooperate closely with car manufacturers and importers.

3.4 Energy suppliers

A few years ago several electric utility companies have set up their own division working for the EV market. The Swiss Electric Utilities Association (VSE/AES) founded a commission to discuss relevant questions about charging electric vehicles and its impact on the grid. Meanwhile this commission has published recommendations to the association’s members but it is no longer active.

By now most of the utilities have reduced their activities in the EV sector and they have integrated it into their daily business. Less than ten of them are keeping their promotional activity on electrical mobility going. The most active ones are Alpiq InTec and Groupe E:

- Alpiq InTec, one of the biggest electric utilities, founded Alpiq E-Mobility in 2012[19]. This subsidiary has nine employees and offers comprehensive infrastructure solutions as well as planning, installation and maintenance of charging stations for electric vehicles.
- Groupe E has launched its MOVE programme in 2013[20]. This electric utility is based in Fribourg and Neuchâtel and has introduced the public charging network MOVE. Groupe E cooperates with other power supply companies throughout Switzerland thus offering a nationwide charging network. By March 2016 the MOVE network accounted for 112 charging stations in 20 cantons that are accessible for all standard electric vehicles.

3.5 Mobility services

The following professional organisations are major players regarding e-mobility in Switzerland:

- E'mobile (www.e-mobile.ch): e'mobile was founded in 1980 and was run as an independent association up to the end of 2015. It is now a professional association and part of Electrosuisse, the leading professional association for electrical, energy and information technology in Switzerland. E'mobile is the technologically and brand-neutral institution for efficient vehicles, such as electric, hybrid and natural gas / biogas cars in Switzerland. It operates as a hub to foster closer cooperation between the automotive sector, infrastructure providers, energy suppliers and government agencies. The professional association offers brand and product-neutral information and counseling, carries out promotion initiatives such as exhibitions and information events and arranges test drives.
- The Mobility Academy (www.mobilityacademy.ch) in Bern is a subsidiary of the Swiss Touring Club TCS, one of the three major automobile clubs in Switzerland. The Mobility Academy positions itself as a think-tank for future mobility. In 2011 it initiated the «Swiss Forum for Electric Mobility» and it is hosting the Forum's secretariat. The forum's mission is to accompany the market introduction of electric vehicles in Switzerland. It provides and disseminates knowledge on e-mobility to stakeholders of industries, public administrations and academia. Its most prominent activity is a yearly conference on e-mobility.
- Swiss eMobility (www.swiss-emobility.ch), founded in September 2012, is an association supporting the political and institutional basis for the development of e-mobility in Switzerland. Among other activities, the association organises the Swiss eDay and it coordinates the EVite network of charging stations. They cooperate closely with The Mobility Academy of TCS, which is hosting the organisation's offices.
- Fondazione VEL was founded in view of the «Large-scale fleet test with lightweight electric vehicles» in Mendrisio in canton Ticino. The foundation secured finances for the association AssoVEL which was responsible for running the VEL project from 1996 to 2001 as well as the following projects VEL2, VEL3 and VEL4. In the beginning the VEL-project was working with electric vehicles only. The project included hybrid electric vehicles as well when Toyota's Prius became available on the Swiss market. As from 2001 onwards other energy efficient and low emission vehicles were included in the promotional programme as well. Infovel in Mendrisio was an information and competence centre for sustainable mobility and had an impact far beyond the canton Ticino. It was operative during 20 years and closed in October 2015. ENERTI SA, unifying nine major electricity utilities in Ticino, has taken over mainly technical activities of infovel and one of its employees.

[19] www.alpiq-intec.ch/en/about-alpiq-intec/subsidiaries/alpiq-e-mobility/alpiq-e-mobility.jsp

[20] www.move-net.ch/de/move-kunde-angebot

The mobility service sector also includes a couple of innovative companies with a focus on electric vehicles:

- Umwelt Arena (www.umweltarena.ch) near Zurich hosts 45 permanent and interactive exhibitions on sustainability, renewable energy and nature. One section looks at sustainable mobility. In cooperation with car importers, they regularly offer test-drives of electric vehicles. Their exhibition includes different types of charging stations and visitors can charge their vehicles during their stay.
- M-way (www.m-way.ch): Migros, the biggest retailer in Switzerland, founded M-way in 2010. This subsidiary was to set the focus on establishing a network of charging infrastructure and to sell electric cars, electric scooters and electric bicycles. Meanwhile there are 29 shops, which are offering above all electric bicycles and all kinds of accessories, electric kickboards, electric scooters and a choice of home charging stations for electric cars as well.

Insurances and leasing companies start to develop special offers for electric vehicles. There is no information available on their turnover or number of employees working on these projects.

3.5 Universities

Several of the Swiss universities are actively contributing to the development of electric vehicles and e-mobility respectively. Most relevant are the following universities and federal research institutes:

- Bern University of Applied Science (www.ti.bfh.ch) is the only Swiss university with a division for automotive engineering. They are looking at all technical aspects of e-mobility. Recently they founded their own formula students e-racing team.
- ZHAW (www.zhaw.ch) is one of the leading universities of applied sciences in Switzerland. It is oriented towards topics relevant to society. One of their curent projects is developing busines cases for e-mobility in touristic areas.
- HES-SO Valais/Wallis (www.hevs.ch) is specialised in the smart grid technology including e-mobility.
- Ecole polytechnique fédérale de Lausanne EPFL (www.epfl.ch) is a global research player. Several of their departments look at various aspects of e-mobility. Their research involves engineering work as well as areas of energy supply and human behaviour. On their campus they are running an autonomous electric vehicle.
- ETH Zurich is one of the world's leading universities of technology and natural sciences. Several of its engineering departments are looking at improvements of the electric drive train. Its Institute for Dynamic Systems and Control (www.idsc.ethz.ch) has gained several awards for innovative hybrid electric drive trains. Their Formula student's team has won several races and broken world records with their electric racing cars. Like EPFL they closely cooperate with the international automotive industry.
- University of Zurich with its Swiss Center for Automotive Research swissCAR (www.swiss-car.ch) is looking at economic aspects in particular. Their technology and innovation management group among others seeks to understand how firms organise and operate to efficiently develop new technologies and technology based products. This includes products related to e-mobility.
- Paul Scherrer Institute (www.psi.ch) and the Swiss Federal Laboratories for Materials Science and Technology (www.empa.ch) have a special interest in the fuel cell technology.

4 Economic Impact on the Swiss Market

4.1 Sources of information

There is no comprehensive information on the economics of the e-mobility sector available in Switzerland. The swissCAR report is the only recent research that includes this field. Although its focus was on the industry's structures, it provides some valuable information on the economic impact.

Other sources of information such as annual reports or official statistics may give information on the turnover and the number of employees. For several reasons the interpretation of these data is complex particularly in regard of e-mobility:

- Multinational firms are producing in several countries and e-mobility contributes only a small percentage of their annual turnover. In their official reports, they hardly ever publish their e-mobility proportion, neither for a single country nor for the whole group.
- Component suppliers are generally very discrete and particularly on activities concerning their innovations. Usually components for electric cars are among their most innovative products.
- In Switzerland's e-mobility sector the companies are predominantly small or even micro-sized with less than 10 employees. They rarely publish their annual reports, information on turnover or the number of employees. It is therefore difficult to find reliable and comprehensive data on their business.
- Micro-companies and particularly in the e-mobility sector are quite often start-ups. Not all of them can establish themselves on the market. On the other hand, successful companies may grow rapidly. Either way this will result in significant fluctuations in turnover and numbers of employees.

Some indications on the e-mobility market can be drawn from the analysis of patents filed at the European Patent Bureau or the World Intellectual Property Office, market indications on the automotive sector and by desktop research. These results are summarised in the following chapters.

4.2 European patents

The overview of requested patents is an indicator for developments in R&D and innovation of a country, thus also indicating its economic potential. The patent department of the Netherlands Enterprise Agency performed a patent query involving international patent requests filed at the European Patent Bureau or the World Intellectual Property Office (WIPO). These data were made available to Task 24 partners. The sector of e-mobility was divided into eight subsections: drive train technology, battery information systems, battery management, batteries, fuel cells, charging infrastructure, navigation and smart grids.

This query was done in June 2015 and it covers the years 2005 to 2013. The year 2013 is not fully covered though, as patents have a secrecy period of 18 months and after that, some processing time has to be added.

By far the largest number of patents filed by Swiss companies belongs to the battery categories followed by fuel cells (see figure below). Most of the patents were registered in the years 2010 to 2012 (approximately 60 per year). Michelin (87), ABB Group (45) and Belenos Clean Power Holding AG (30) requested the largest number of patents. As Michelin and ABB are multinational companies, these patents will influence not only the Swiss automotive components market. Belenos Clean Power Holding was the most active purely Swiss owned company in this query. Meanwhile, they have set a focus on small and particularly powerful batteries for cars as well as other applications.

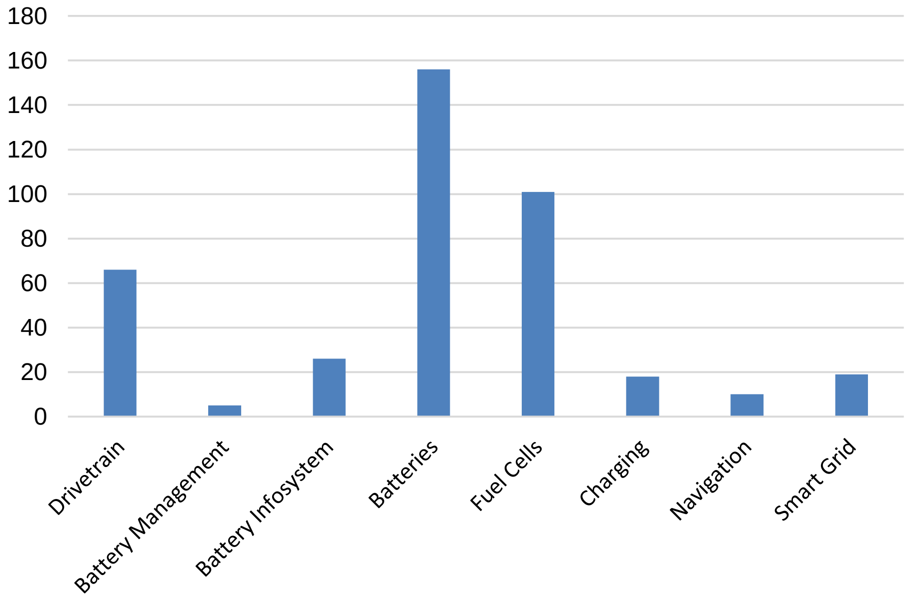

Figure 9:
Patents filed by Swiss companies at the Patent Bureau or the World Intellectual Property Office (WIPO) from 2005 to 2013 (Source: patent department of the Netherlands Enterprise Agency)

Considering the very high percentage of small enterprises in Switzerland and the costs involved in patenting innovations, it comes as no surprise, that most of these companies filed only few patent requests.

4.3 Economic impact of the automobile sector

According to the Swiss road traffic association FRS the automobile sector[21] had achieved an estimated turnover of CHF 90 billion in 2014. It accounted for 20,745 firms and organisations with a total of 218,600 employees. This includes component suppliers of the automotive industry with an estimated turnover of CHF 9 billion, 300 companies and 24,000 employees. One out of eight Swiss employees worked directly or indirectly for the automotive sector.

In the same year, electric cars accounted for a market share of about 1%. Therefore, the overall impact on the Swiss economy is an estimated turnover of CHF 0.8 billion at the most. However, this figure does not comprise the component suppliers, manufacturers of charging infrastructure and sales of electricity for the 11,000 plug-in cars registered in Switzerland at the end of 2015.

E-mobility most likely will continue to stimulate economic growth in the Swiss component supplier sector but other players are expecting a reduced turnover due to the introduction of electric vehicles in the mass market. For instance, Swiss owners of car repair shops expect a negative economic impact due to reduced maintenance work on electric vehicles.

Empiric data of one of the major fleet managers in Switzerland support this thesis: Mobility Solutions SA, a subsidiary of the Swiss Post, operates ten Renault Kangoo Z.E. vehicles as well as identical models running on petrol. They have compared overall costs for both versions during seven years. According to their analysis, service costs of the electric model are approximately 30% lower[22].

[21] Verband des Strassenverkehrs, Vademecum 2016

[22] Markt der Eco-Mobile, Aktualitäten und Trends 2016, p 12, Bern, 2016, EnergieSchweiz, 805.001

4.4 Results of desktop research

E'mobile has identified 174 companies and organisations being active in the e-mobility sector in winter 2015 / 2016 as shown in figure 10. Information on these firms was collected mainly through desktop research and personal contacts.

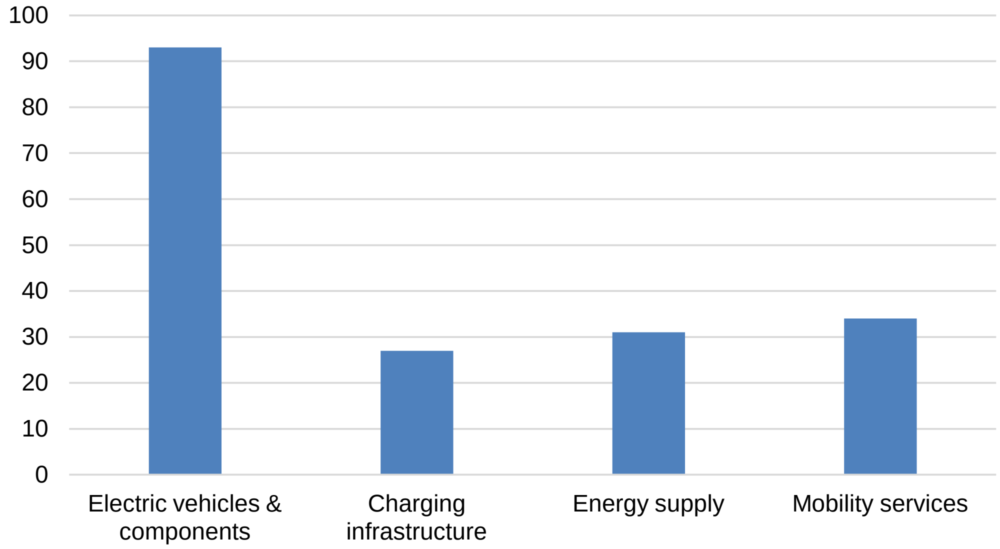

Figure 10: Companies and organisations of the e-mobility sector (Source: e'mobile)

By far most of the companies (93) are manufacturing electric vehicles or components including batteries. This confirms the results of the mentioned patent analysis above. 26 companies are manufacturing electric two-wheelers, communal vehicles or heavy-duty vehicles. This reflects the success of e-bikes and the long tradition of electric communal vehicles.

25 of these companies and organisations exclusively work on e-mobility: 19 companies manufacture vehicles and components and three each produce hardware and software for charging infrastructure and services for e-mobility. Only five manufacture components exclusively for electric cars.

The only medium sized companies fully dedicated to e-mobility are Brusa with about 120 employees and Biketec with 200 employees, the biggest companies exclusively working on e-mobility and e-bikes respectively. Eight firms are small with less than 100 employees and 15 firms have a maximum of 10 employees.

Altogether, firms fully dedicated to e-mobility have created an estimated 600 direct jobs. Most of the other companies rather sustain jobs in the automotive sector than create new ones by launching e-mobility projects. This could change in the near future as German OEMs are gaining market shares with their electric cars.

Concerning the turnover of companies and organizations in the e-mobility sector very little information is available through desktop research. A rough estimation amounts to a few hundred million Swiss francs. For more precise and reliable data an appropriate follow-up survey is required.

5 Conclusion

Switzerland is characterised by a very high share of small and medium (up to 249 employees) sized enterprises (SME). 99.6% of all companies are SMEs. The machine, electrical engineering and metals industry (MEM) together with the chemical and pharmaceutical industry are the leading Swiss exporters. Companies of the international automotive industry are important customers for Swiss enterprises of both sectors.

In 2013 the Swiss Center for Automotive Research swissCAR of the ETH Zurich has published a report on the Swiss automobile industry. The analysis of the automotive sector included a questionnaire sent to 315 companies with clients of the international automotive industry and with relevance to this sector. Some points addressed the importance of the electric mobility.

Only 7% of the companies participating in the swissCAR survey indicated that products for the electric mobility belong to the most lucrative segment of their business. Interviews with some of these companies have shown that they expect this share to grow as the electric vehicles market is gaining in importance worldwide.

The swissCAR survey dedicated a chapter to manufacturers of charging infrastructure. In 2013 they identified 16 companies being relevant to this market. They are mainly service providers and only a few are manufacturing charging stations in Switzerland. The survey estimates the total number of employees in this sector to about 60 persons in 2013. In 2012 the survey participants produced 5,600 charging stations and exported 1,800 of those mainly to Germany, France and Austria.

Since the market introduction of the new generation of BEVs, EREVs and PHEVs in 2011, EV sales have steadily increased. In Switzerland 3,265 BEVs have been newly registered in 2015. This is a plus of 95%. Almost every second BEV was a Tesla Model S. This is the most expensive BEV on the Swiss market. As per 30 September 2015 10,264 plug-in cars were registered and 6,366 were BEVs. This figure almost doubled compared to the previous year, when the Swiss EV fleet counted 5,435 cars (3,741 BEV).

This market development is even more impressive as there have been no federal subsidies for buying an EV during this period. Only a few communes support the market introduction of EVs by granting subsidies of up to CHF 5,000 (app. USD 5,000).

Switzerland has no major car manufacturer. Nevertheless, in terms of export volume its automotive sector is as important as the watch industry. In 2014 the automotive industry counted for more than 300 companies with 24,000 employees and an estimated turnover of CHF 9 billion (approx. USD 9 billion). About 50% of them supply all sorts of components as revealed by the swissCAR survey. The findings for Switzerland of the international patent query by the Netherlands Enterprise Agency confirm the importance of batteries in particular. By far the largest number of patents filed by Swiss companies belongs to the battery categories followed by fuel cells.

A desktop research performed by e'mobile in 2015/2016 has identified 174 companies and organisations. These companies are active above all in the electric vehicle production including batteries and other components. They were followed by mobility services, electricity suppliers and charging infrastructure providers. It is difficult to find reliable information on the turnover of these companies and organisations and to estimate their economic impact. However, it seems that the Swiss e-mobility industry is rather sustaining jobs than creating new ones.

Finally, it has to be stressed that at present there is no comprehensive data available specifically on the economic impact of e-mobility in Switzerland. This Task 24 report revealed the importance to pursue research in this respect.

MARCH 15, 2016

ECONOMIC IMPACT OF E-MOBILITY IN THE UNITED STATES:

PRELIMINARY ESTIMATES OF GROSS ECONOMIC IMPACT OF PLUG-IN ELECTRIC VEHICLES

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Acronyms and Definitions

AEO	Annual Energy Outlook
AFDC	Alternative Fuels Data Center
BEV	Battery Electric Vehicle
CV	Conventional Vehicle
DOE	Department of Energy
DCFC	Direct Current Fast Charge
EVSE	Electric Vehicle Supply Equipment
HEV	Hybrid Electric Vehicle
I-O	Input-Output
Li Ion	Lithium Ion
LDV	Light-Duty Vehicle
MSRP	Manufacturer's Suggested Retail Price
NiMH	Nickel Metal Hydride
OEM	Original Equipment Manufacturer
PEV	Plugin Electric Vehicle
PHEV	Plugin Hybrid Electric Vehicle
RIMS	Regional Input-output Modeling System
Value added	In national accounts, the contribution of capital and labor to raising the value of a product; corresponds to incomes received by owners of these factors of production.
ZEV	Zero Emission Vehicle

Abstract

This report summarizes economic impacts associated with select aspects of e-mobility in the United States. It uses input-output analysis to estimate impacts from the production of plugin electric vehicles (PEVs) and the electricity used to power them, from the construction of manufacturing capacity to produce PEVs and their batteries, and from the installation and operation of off-board electric vehicle supply equipment (EVSE). Economic impacts include estimates of employment, earnings (roughly equivalent to income) and economic output in the industries that are directly engaged in the production of batteries, motor vehicles and EVSE as well as in the supporting industries that comprise their supply chains. Supply chain impacts are augmented by estimates of induced impacts as dollars are re-spent elsewhere in the economy. Estimates are reported for two scenarios: one of minimal PEV penetration built off the reference case in the *2015 Annual Energy Outlook* (AEO Scenario) and one based on the targets of those U.S. states committed to introducing significant numbers of zero emission vehicles (ZEV Scenario). In the AEO Scenario, PEV penetration remains on the order of 1% of light-duty vehicle (LDV) sales through 2030; in the ZEV Scenario LDV penetration rises to 1.5% of sales in 2020, 5% in 2025 and 6.5% in 2030.

Results show that PEV deployment adds 110,000 jobs by 2030 in the AEO Scenario. In the ZEV Scenario, with its far greater PEV market penetration, employment associated with PEV deployment quickly surpasses that number, reaching 180,000 jobs in 2020, over 450,000 jobs in 2025 and over 600,000 jobs in 2030. For the battery industry alone the ZEV Scenario yields significant increases in employment, with gains of approximately 40,000 jobs in 2025 and 57,000 jobs in 2030. This contrasts with roughly flat job growth under the AEO Scenario.

Management Summary

This report presents the results of a high-level analysis of gross economic impacts associated with select aspects of e-mobility in the United States. It includes impacts from the production of plugin electric vehicles (PEVs) and the electricity used to power them, from the construction of incremental manufacturing capacity to produce PEVs and their batteries, and from the installation and operation of off-board electric vehicle supply equipment (EVSE) to recharge PEVs. Economic impacts include estimates of gross employment, income, and economic output in the industries that are directly engaged in the production of batteries, motor vehicles and EVSE as well as in the many supporting industries that comprise their respective supply chains. Estimates of these "supply chain" impacts are augmented by estimates of induced impacts as dollars attributable to transactions along each of these supply chains are re-spent elsewhere in the economy.

Estimates are reported for two scenarios. A scenario of minimal PEV penetration was built off the assumptions and results of the reference case in the U.S. Department of Energy/Energy Information Administration *2015 Annual Energy Outlook* (USDOE/EIA 2015). As a counterpoint to this modest scenario, an alternative with more rapid PEV uptake (and associated economic impacts) was developed from the targets of the 10 U.S. states that have committed to introducing significant numbers of zero emission vehicles (ZEVs).[1] Known respectively as the AEO and ZEV Scenarios, these scenarios bracket a range of potential market uptake. In the AEO Scenario, PEV penetration remains on the order of 1% of total light-duty vehicle (LDV) sales through 2030. By contrast, in the ZEV Scenario LDV penetration rises to 1.5% of sales in 2020, 5% in 2025 and 6.5% in 2030.

Methodology

Input-output (I-O) analysis was used to investigate impacts associated with PEVs. Costs associated with the vehicles themselves, residential and public EVSE and electricity were estimated by major component and allocated to appropriate sectors in RIMS II (Regional Input-output Modeling System), the I-O model used for the analysis.[2] Results included annual supply chain and induced impacts on U.S. employment, earnings income, and economic output associated with PEV deployment under the two scenarios from 2015 through 2030 (See Section 3 for specific definitions of these terms).

Results

Economic impacts associated with the two scenarios are shown in Figures S1 through S6. Results include annual impacts from PEV manufacturing and sales, EVSE sales and installation, electricity consumption by all PEVs estimated to be on the road in the year of interest, and the construction of battery and vehicle manufacturing facilities (as needed). As shown in Figure S1, PEV deployment adds 110,000 jobs by 2030 in the AEO Scenario. In the ZEV Scenario, with its far greater PEV market

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[1] For additional information on the ZEV mandate see http://www.zevfacts.com/zev-mandate.html.

[2] RIMS II, developed by the Regional Product Division within the Bureau of Economic Analysis of the U.S. Department of Commerce, contains 406 economic sectors based on the 2002 U.S. Benchmark Input-Output Table and 2008 regional data (for additional information about RIMS II multipliers and assumptions, see www.bea.gov/regional/rims/).

penetration, employment associated with PEV deployment quickly surpasses that number, reaching 180,000 jobs in 2020, over 450,000 jobs in 2025 and over 600,000 jobs in 2030 (Figure S2).

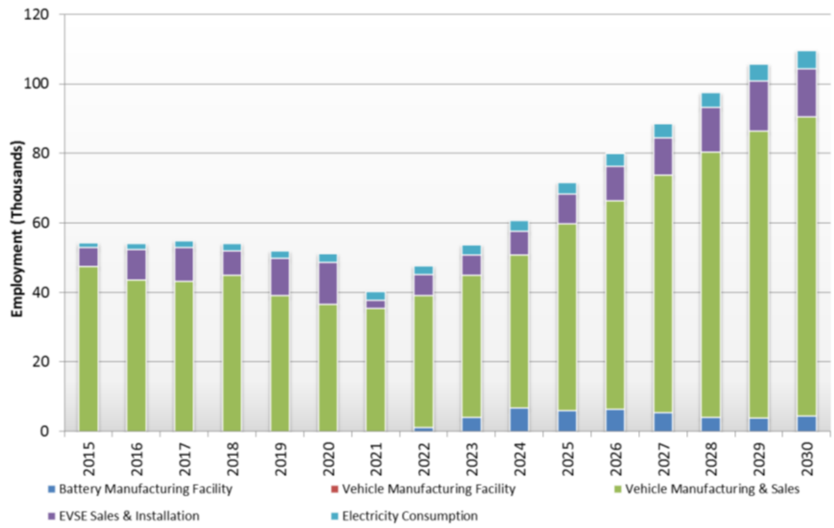


Figure S1. Job Gains Associated with PEV Deployment, AEO Scenario

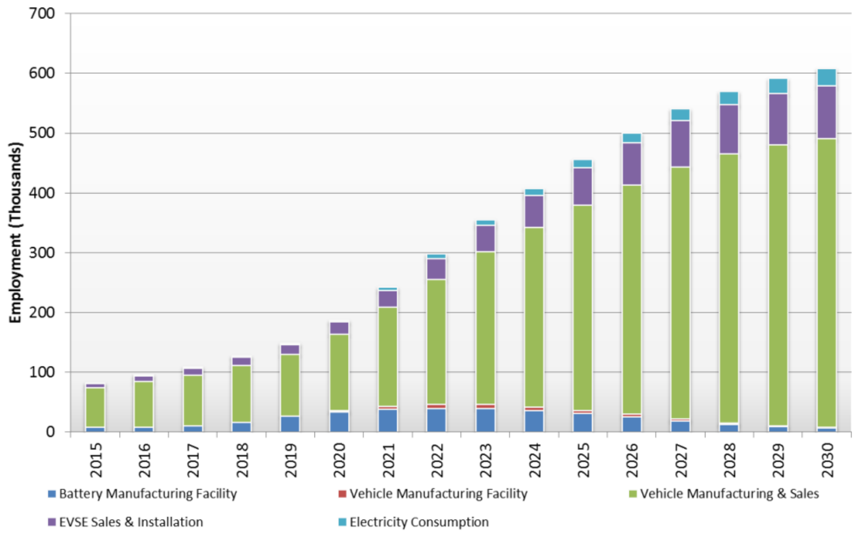


Figure S2. Job Gains Associated with PEV Deployment, ZEV Scenario

PEV impacts on earnings (income) and economic output (Figures S3 through S6) follow general trends similar to impacts on employment. Again, the ZEV Scenario produces much greater impacts, a reflection of its more rapid and sustained growth in PEV sales over the time frame of interest. Results for the AEO Scenario, in addition to being considerably less than for the ZEV Scenario, show an initial decrease from 2014 values through about 2021 before they begin to slowly increase. Again, PEV manufacturing and sales account for the bulk of the impacts under both the AEO and ZEV Scenarios.

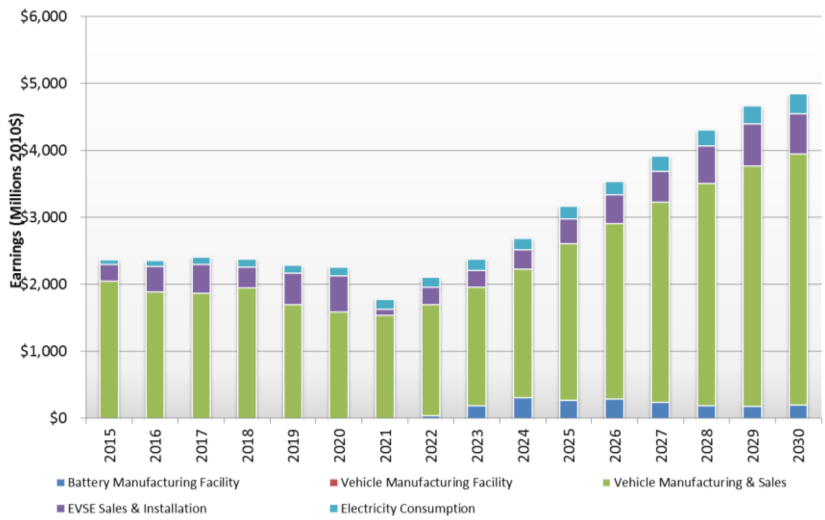


Figure S3. Increased Income (Earnings) Associated with PEV Deployment, AEO Scenario

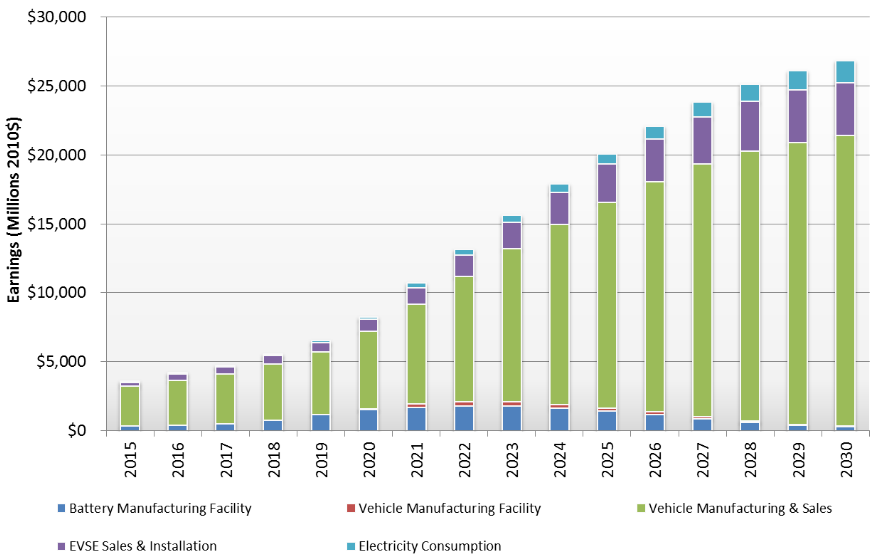


Figure S4. Increased Income (Earnings) Associated with PEV Deployment, ZEV Scenario

Unlike Figures S1-S4 which show impacts associated with specific types of PEV-related expenditures (i.e., vehicles, EVSE, electricity consumption, and battery and vehicle manufacturing), Figures S5 and S6 show impacts broken down by whether they occur along the supply chains of those PEV-related expenditures or are induced by the re-spending of those dollars elsewhere in the economy.

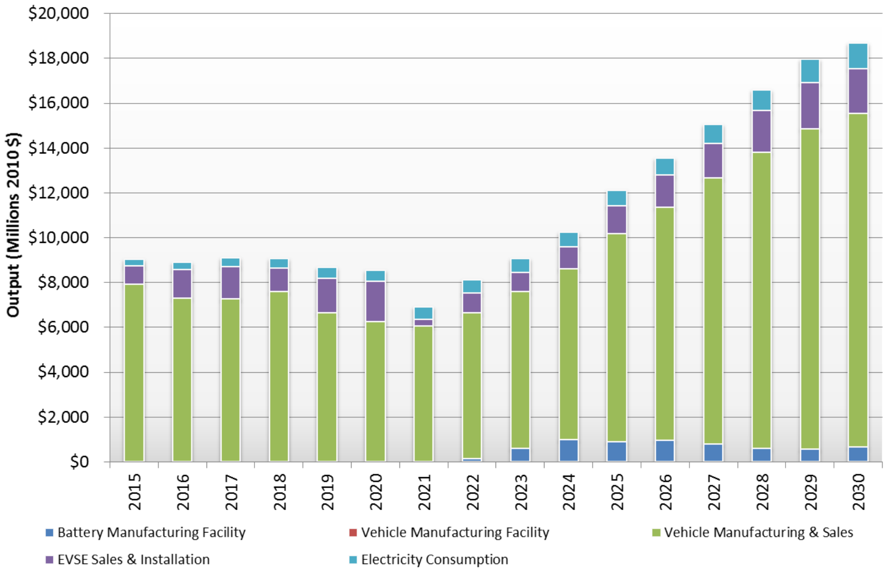


Figure S5. Increased Economic Output Associated with PEV Deployment, AEO Scenario

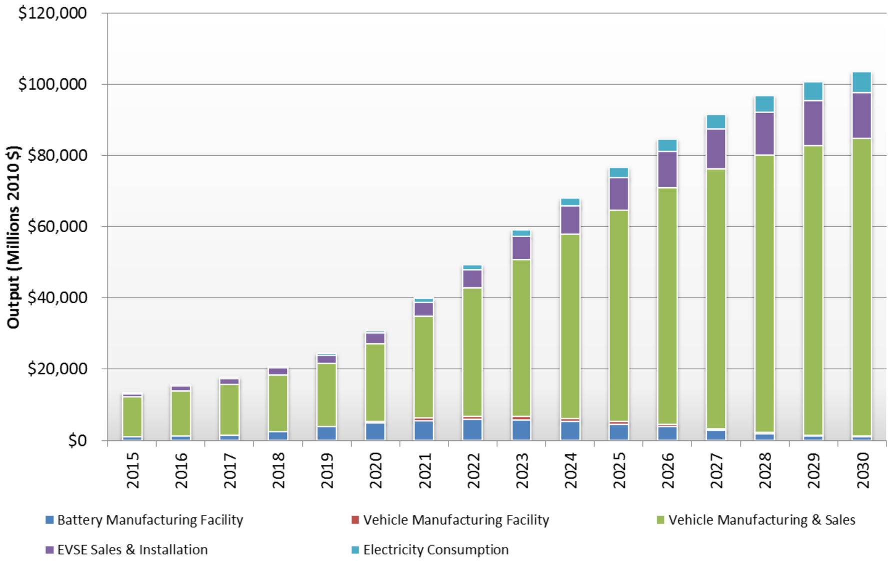


Figure S6. Increased Economic Output Associated with PEV Deployment, ZEV Scenario

Because I-O analysis uses a bottom-up approach to summarize expenditures across a range of industrial sectors, results can be examined for specific sectors or groups of sectors. For this analysis, the battery industry was examined in more detail. Figure S7 shows jobs created within the battery industrial sector under the two scenarios.[3] Consistent with the total results shown above, the ZEV Scenario yields significant increases in battery industry employment, with gains of approximately 40,000 jobs in 2025 and 57,000 jobs in 2030. This contrasts with roughly flat job growth under the AEO Scenario. Note that estimates of nearly 13,000 jobs in 2015 include direct and indirect employment throughout the supply chain (i.e., for all materials, sub-assemblies, separators, etc., some of which are imported) as well as induced jobs.

This analysis assumes forecast demand for PEVs, batteries, and EVSE will be met by domestic suppliers. Since most PEV assembly is assumed to occur in the United States, battery production also is expected to be in the U.S., generally in close proximity to PEV assembly in order to reduce transport costs. As a result, future job growth in the battery sector is likely to be primarily domestic. At present, Tesla is the main U.S. PEV manufacturer heavily dependent on imported batteries, a situation projected to end once Tesla's new battery production facility is fully operational. In this analysis, all batteries are assumed to be produced domestically.

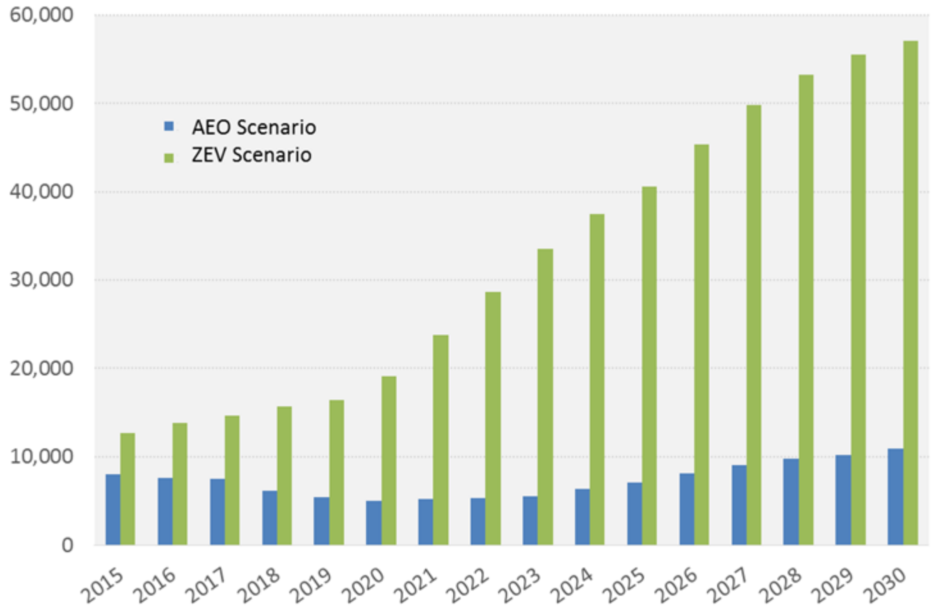


Figure S7. Employment in the Battery Industry from PEV Deployment under Two Scenarios

[3] Jobs associated with construction of the manufacturing facility to produce these batteries are not included in Figure S7. For the ZEV Scenario such jobs peak at approximately 39,300 in 2022; for the AEO Scenario a much smaller peak (4,400 jobs) occurs in 2030.

1.0 Introduction

At present, e-mobility in the U.S. is confined primarily to passenger travel via battery-electric and plug-in hybrid electric vehicles (i.e., BEVs and PHEVs, collectively known as PEVs). While connected and autonomous vehicles, smart phone-enabled mobility apps, electric two-wheelers, fuel cell-electric vehicles and various forms of web-based mobility services may become major players in e-mobility, the current e-mobility space is largely limited to light-duty PEVs and thus this document focuses exclusively on them. We explore recent trends in the numbers of such vehicles on U.S. roads, investment in vehicle and battery production, and the impact of future growth on the U.S. economy in terms of gross employment, earnings (or income) and economic output under two future scenarios. Impacts are estimated from projected vehicle sales, attributed sales of electricity and private infrastructure to support those vehicles, expenditures for vehicle and infrastructure production facilities and for public charging infrastructure. Future analyses will extend those estimates to additional types of expenses as well as net effects in the 2020 and 2030 timeframe.

As shown in Figure 1, PEV sales in the U.S. market have risen substantially in the past five years, growing from less than a thousand units in 2010 to 118,882 in 2014 (Miller 2015). While nickel metal-hydride (NiMH) batteries support the bulk of these vehicles, an increasing share of vehicles (hybrid electric vehicles, or HEVs, as well as all PEVs) are equipped with lithium ion (Li-Ion) batteries. It is estimated that 2.65 gWh of Li-ion batteries were installed in e-drive vehicles sold in the U.S. in 2014.

While manufacturers have brought an increasing number of PEV models to market in the past five years, six models dominate (Figure 2). The Nissan Leaf, Chevy Volt, Tesla Model S, Toyota Prius PHEV, Ford Fusion Energi and Ford C-Max Energi accounted for over 83% of new PEV sales in calendar year 2014 (Zhou 2015).

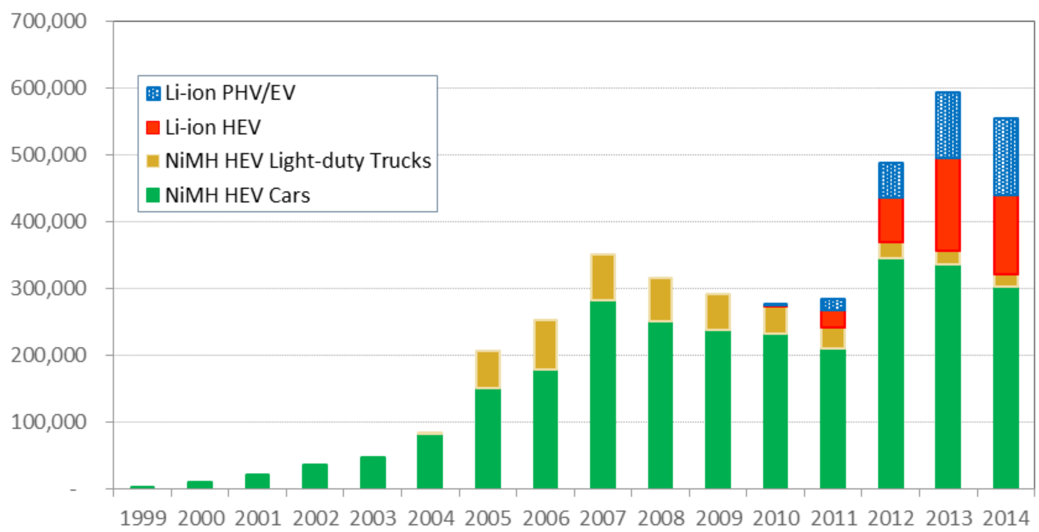


Figure 1. PEV and HEV Sales in the U.S. Market by Battery Technology, 1999–2014 (Source: Miller 2015)

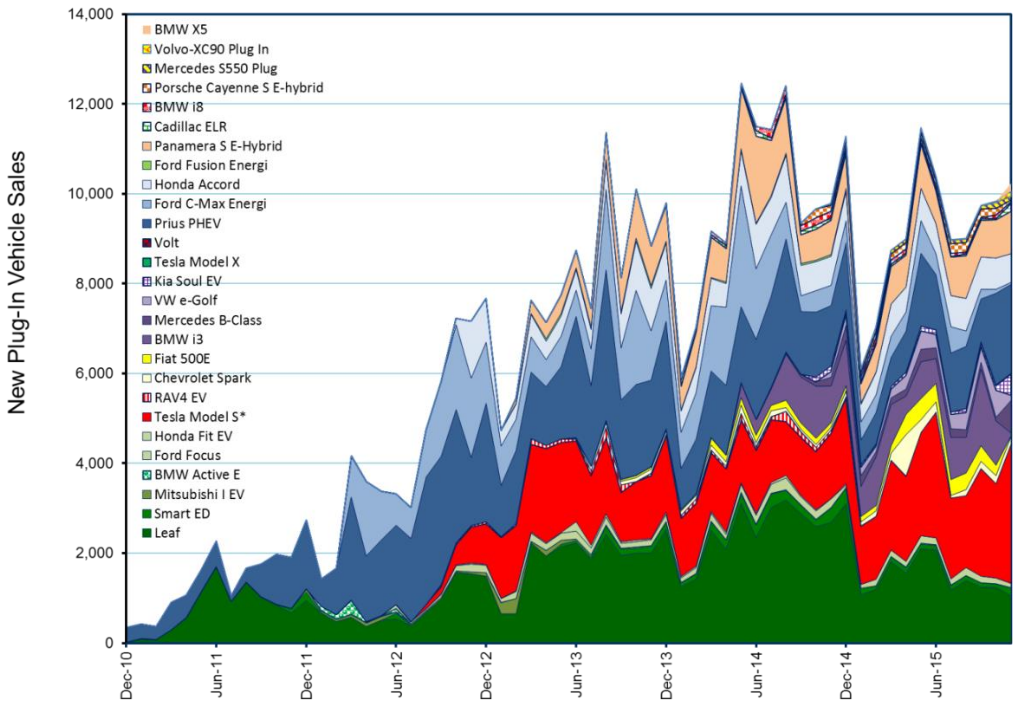


Figure 2. PEV Sales in the U.S. by Make and Model, Calendar Years 2010–2015 (Source: Zhou 2015)

As with all vehicles, PEV sales tend to be seasonal, peaking during the summer and plunging with the temperature. For much of 2015, PEV sales have been relatively flat as falling gasoline price has spurred sales of less efficient vehicles, particularly light-duty trucks. Thus, while PEV sales continue to rise as a percentage of *car* sales, cars have declined as a percentage of *light-duty vehicle* (LDV) sales (Figure 3, Zhou and Santini 2015).

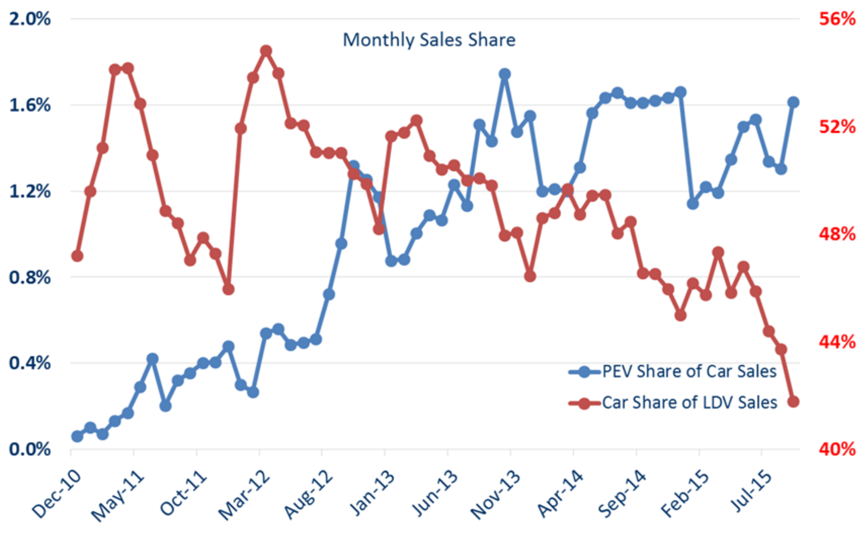
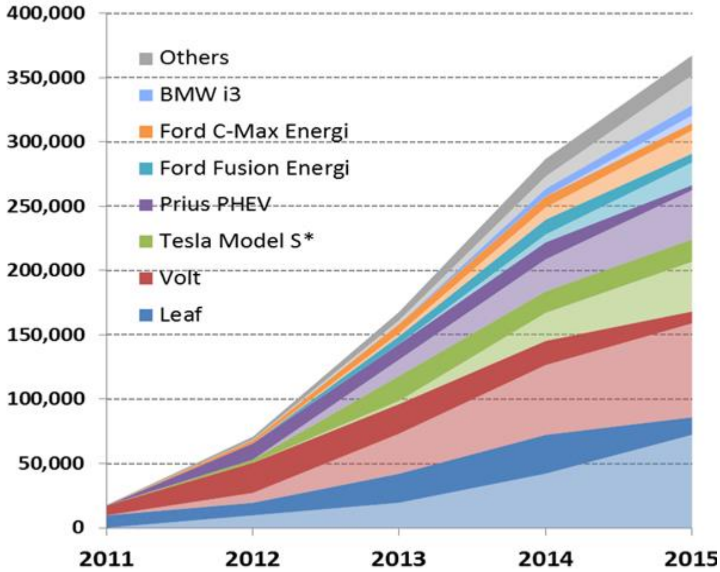


Figure 3. Sales Shares of PEVs and Cars, 2010–2015 (Source: Zhou and Santini 2015)

Cumulative PEV sales totaled 287,261 units at the end of 2014, and are on track to exceed 400,000 by the end of 2015 (Figure 4, Zhou 2015).[4]



Source: Zhou 2015.

Figure 4. Cumulative PEV Sales, 2010–Mid 2015

[4] Discrepancies in sales estimates among various sources occur due to differences in metrics (model year versus calendar year data), reporting policies (e.g., Tesla does not report sales to any official organization), and definitions (e.g., whether neighborhood EVs, cargo vehicles, and/or two-wheeled vehicles are included).

2.0 Expenditures Associated with PEVs

2.1 Plug-in Electric Vehicle Manufacturing and Sales

Calculated as a function of sales and Manufacturers' Suggested Retail Price (MSRP) by make and model, revenue from sales of plug-in electric vehicles is estimated at $4.63 billion in 2014 (Table 1). Although rebates and other dealer incentives may have reduced this amount, no data are available to confirm the amount of such a reduction.[5] Thus, the full MSRP is used for these calculations.

Table 1. Estimated PEV Sales, Retail Price and Revenue in the US, 2011–2014

	PEV Sales, Jan-Dec of Calendar Year	*Sales-Weighted Average Manufacturer Suggested Retail Price (MSRP)*	*Estimated PEV Sales Revenue (million $)*
2011	17,763	$36,165	$ 642.4
2012	53,169	$36,699	$1,951.3
2013	97,096	$41,151	$3,995.6
2014	118,882	$38,930	$4,628.1

Figure 5 shows the breakdown in estimated PEV sales revenue by make and model in calendar year 2014. Because of its relatively high retail price, Tesla accounts for a disproportionate share of the total.

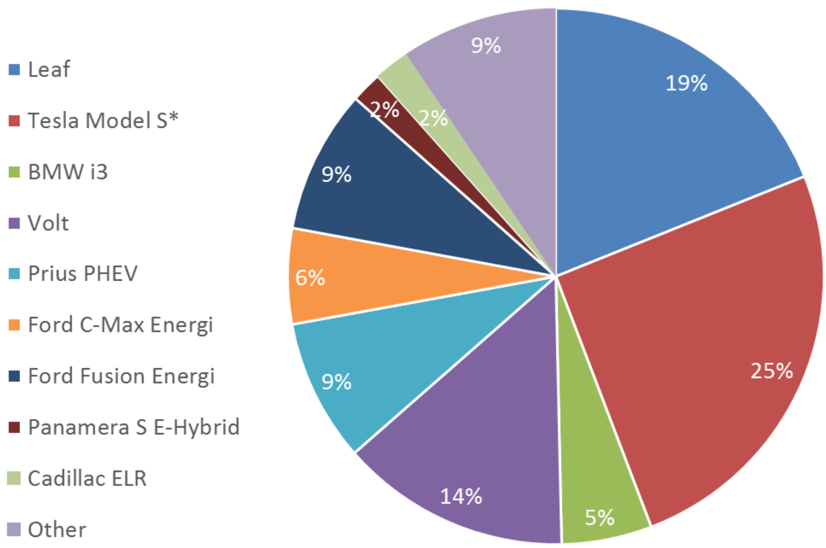


Figure 5. Estimated PEV Sales Revenue by Make/Model, 2014

As mentioned above, out-of-pocket expenditures for PEVs are often reduced by various purchase incentives. A federal tax credit of up to $7,500 is available for PEVs purchased in or after 2010. Since the amount of the credit varies with the capacity of the battery used to power the vehicle, BEVs

[5] Limited data for Chevy Volt, Nissan Leaf and Toyota Prius PEV sales suggest that transaction prices may be 91-98% of MSRP for these models (https://www.truecar.com/#/).

qualify for the full credit while PHEVs qualify for 33–71% of the credit (for estimates of the credit amount by make and model (see https://www.fueleconomy.gov/feg/taxevb.shtml). A number of states also provide tax credits or rebates and various exemptions or reductions in fees (Figure 6). Federal and state incentives are additive. In addition, several states also provide non-monetary incentives like access to high-occupancy vehicle lanes and preferential parking.

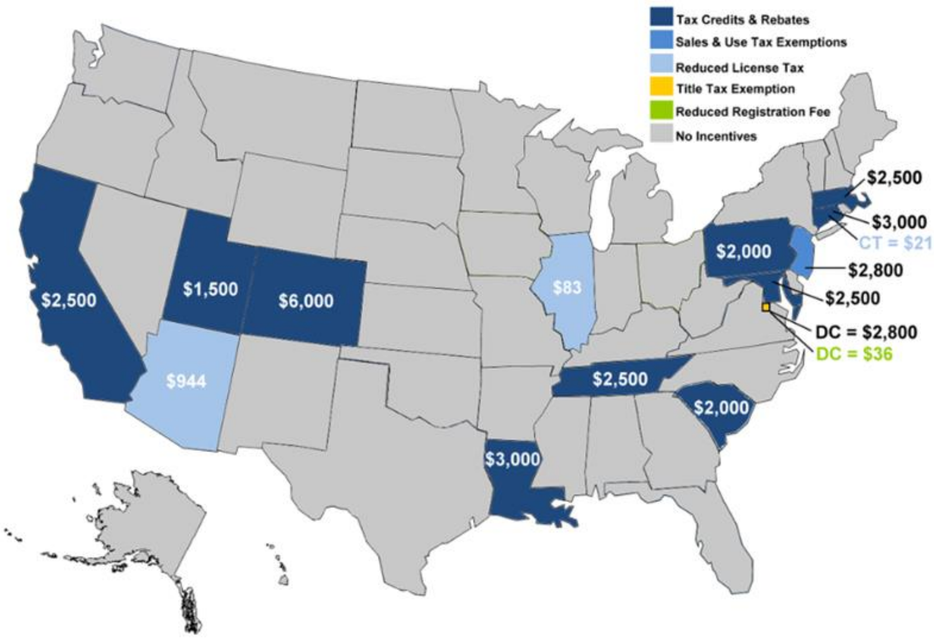


Figure 6. Value of State PEV Incentives as of July 2015 (Source: USDOE 2015)

2.2 Charging Infrastructure

Consisting of Level I, II and III Electric Vehicle Supply Equipment (EVSE), the U.S. charging infrastructure includes private residential and workplace units, public units at various sites, and a network of direct current fast chargers (DCFCs) including "superchargers" available to Tesla owners. PEVs sold in the U.S. market typically come equipped with an on-board charger, a cable/plug for charging from conventional household current (120 V/15–20 amp dedicated service), and associated safety equipment.

Figure 7 illustrates a hierarchy of expected use of charging infrastructure. While most PEVs are charged at residences (often overnight), an increasing number of workplace and commercial units are being deployed to augment residential EVSE. According to the U.S. DOE's Alternative Fuels Data Center (AFDC) approximately 11,700 public charging locations with nearly 30,000 charging outlets were in operation in the U.S. in 2015 (USDOE/AFDC 2015) and another 130 locations with over 400 outlets were in various stages of development.

Figure 7. The Charging Pyramid, Anticipated Use of PEV Charging Resources (Source: Santini *et al* 2014)

2.2.1 Level I–Level III EVSE

Level I charging can be accomplished using a standard 120V 20 amp circuit (12–16 amp continuous power, preferably in a dedicated circuit) and can provide 40 miles of electric range in 6–10 hours (Table 2). Level II chargers, operating at 240 V in a dedicated circuit can reduce this to 4 hours (or less), depending on the power of the EVSE and the voltage and current of the supply. For BEVs Level II residential charging is likely to be preferred.

Level III or DCFC units can replenish 50% or more of battery capacity in 20 minutes or less (Table 2). According to the AFDC there are approximately 1,470 public DCFC charging locations with over 3,100 charging outlets in operation in the U.S. (USDOE/AFDC 2015). Some 245 of these locations (with over 1570 charging outlets) are part of Tesla's 120kW supercharger network. As of January 2016, nearly 12,000 public "stations" with over 30,000 outlets were available for PEV charging in the U.S. As shown in Figure 8, the vast majority of these locations are in California.

Table 2. Required Electric Supply, Charging Time and Range Addition by Charging Level

Charging Level	*Vehicle Range Added per Charging Time and Power*	*Supply*
AC Level I	4 mi/hour @ 1.4kW 6 mi/hour @ 1.9kW	120VAC/20A *(12-16A continuous)*
AC Level II	10 mi/hour @ 3.4kW 20 mi/hour @ 6.6kW 60 mi/hour @ 19.2 kW	208/240VAC/20-100A *(16-80A continuous)*
DC Fast Charging (Level III)	24 mi/20minutes @24kW 50 mi/20minutes @50kW 90 mi/20minutes @90kW	208/480VAC 3-phase *(input current proportional to output power; ~20A-400A AC)*

Source: Smith and Castellano 2015.

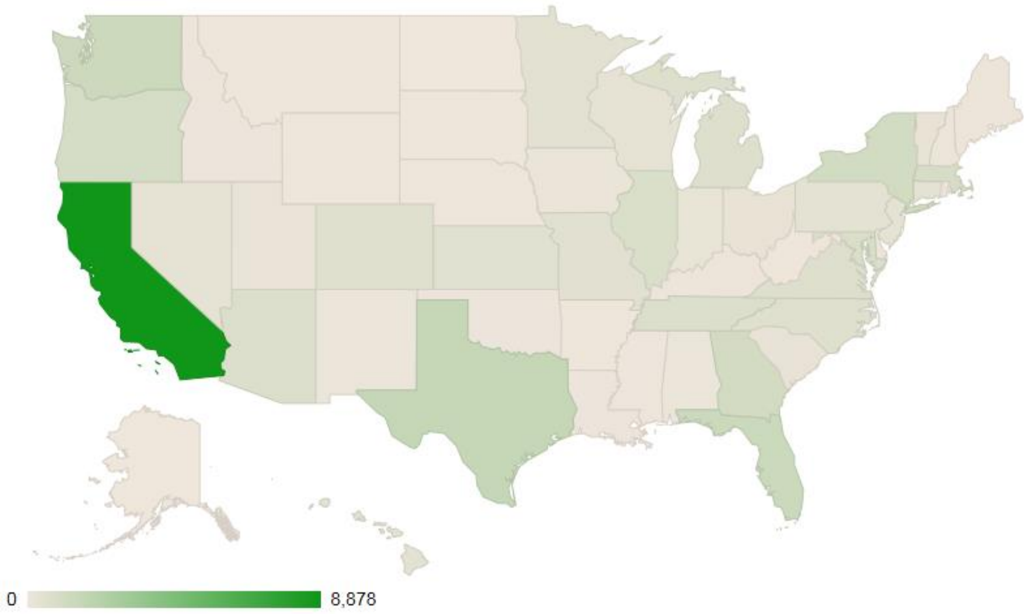


Figure 8. Public Electric Charging Stations by State, January 2016 (Source: USDOE/AFDC 2016)

2.2.2 EVSE Manufacturing and Sales

There is a wide range in EVSE cost (Table 3). Level I units can range from a simple plug-in cord set, to wall- mounted units with a keypad for access control, to hardwired pedestal units with access control and cable management. Single-port Level II units span a comparable cost range depending on included features. Level III or (DCFC) units can range from approximately $10,000 for low power (25–50 kW) units with low charging amperage, a single port, and no display or networking components to $40,000 for high power (50kW+) units with high charging amperage enabling multiple vehicles to charge at once, advanced access control, an advanced display, and software enabling energy consumption monitoring, data analysis and networking.

Table 3. Unit Costs of EVSE by Charging Level

Charging Level (single port)	*EVSE Unit Cost Range*
Level I	$300–$1,500
Level II	$400–$6,500
DCFC	$10,000–$40,000

Source: Smith and Castellano 2015.

As with PEV purchases, a number of incentives are available for the purchase and installation of EVSE. In December 2015, the Alternative Fuel Infrastructure Tax Credit (which originally expired on December 31, 2013) was extended retroactively through December 31, 2016. The credit applies to fueling equipment for natural gas, liquefied petroleum gas (propane), liquefied hydrogen, electricity, E85, or diesel fuel blends containing a minimum of 20% biodiesel installed between January 1, 2015 and December 31, 2016. The tax credit (30% of the cost, not to exceed $30,000) excludes permitting and inspection fees, but permits infrastructure developers of multiple sites to use the credit toward each location. Consumers who purchase qualified residential fueling equipment prior to December 31, 2016 may receive a tax credit of up to $1,000 (USDOE and USEPA undated). State incentives include various rebates, tax credits and exemptions, as well as grants and loans (Figure 9).

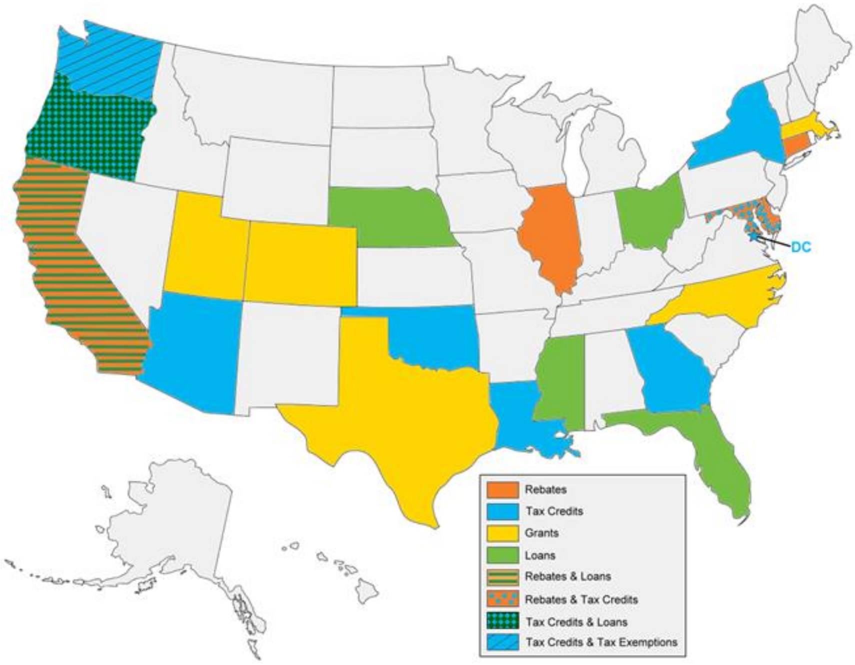


Figure 9. State EVSE Incentives as of July 22, 2015 (Source: Davis 2015)

2.2.4 EVSE Installation

EVSE installation costs depend on the characteristics of the site and anticipated demand. For Level I installations with an available dedicated circuit of sufficient amperage on the electrical panel, no additional equipment or installation may be required. Level I sites that require an additional circuit or a service upgrade may be considerably more expensive. Data from USDOE-supported deployment projects suggest the following ranges for EVSE installation costs (INL undated):

– Level II residential: $300–8,000
– Level II workplace: $2,220
– Level II public: $600–12,660
– Level III (DCFC): $8,500–50,000

2.3 Electricity

Electricity consumption by PEVs is virtually negligible at present. However, once PEVs comprise a larger share of the vehicle fleet, electricity will become a component of total PEV expenditures. Because the vast majority of current and future vehicles are expected to be charged at home, the average unit cost of electricity for PEV charging is likely to approximate that for residential electricity. According to Navigant estimates, electricity purchases for PEV charging in 2014 accounted for approximately $110 million in revenue in the U.S. market (Navigant 2015).

2.4 Vehicle and Battery Production Facility Development and Expansion

In recent months a number of companies have announced their intent to invest in PEV and/or Li-ion battery production in the U.S. (Table 4). Added to prior investment estimates, investment in total U.S. PEV and Li-ion battery production is now on the order of $15 billion (Table 4). According to the managing director at Shanghai-based Gao Feng Advisory Co. China is investing a comparable sum (i.e., $15 billion by 2020) on EV development (Bloomberg 2015).

Table 4. Select Investments in PEV and Li-Ion Battery Production in the US

Investor	Facility Type	Reported Investment	Date/ Timeframe	Comment
GM	All	$1,820,000,000	Since 2009	Michigan only. Includes HEVs.
Faraday Future	Auto production	$1,000,000,000	2015	
State of Nevada	Auto production	$335,000,000	2015	Tax incentives/infrastructure in support of Faraday Future facility.
Nissan	Auto/battery production	$1,700,000,000	2015	Smyrna, Tennessee.
Tesla	Battery production	$5,000,000,000	2015	Batteries for autos and homes.
State of Nevada	Battery production	$1,300,000,000	2014	Incentives in support of Tesla investment
DOE	All	$2,400,000,000	2015	Grants/loans to various companies. May be some double counting.
Ford	Auto production	$4,500,000,000	2015	Probably includes investments in Europe.
Tesla	Auto production	$42,000,000	2010	Purchase of former NUMMI site in CA. Excludes upgrades and equipment.

2.5 EVSE Production Facility Development and Expansion

Navigant has estimated total EVSE sales of nearly 134,000 units in the U.S. market in 2014, and over 304,000 units cumulatively (Navigant 2015). As shown in Figure 10, over 72% of these units are at residential locations (as compared with ~62% of EVSEs at residential locations worldwide). Navigant also reports nearly $200 million in revenue from EVSE sales in the U.S. in 2014 (Navigant 2015). EVSE production facility development and expansion expenditures are not modeled in this analysis.

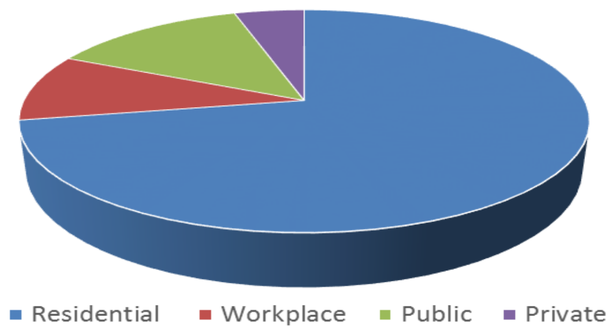


Figure 10. EVSE Unit Sales in the U.S. Market by Location (Source: Based on Navigant 2015)

3.0 Economic Impact Approach

Sales of PEVs and their utilization impact the U.S. economy in several ways. Sales send revenue not only to original equipment manufacturers (OEMs) like GM, Nissan, Ford, Toyota and Tesla, but also up several supply chains including:

- Vehicle, parts and service retailers (generally automotive dealers)
- Suppliers of OEM and replacement parts
- Developers/manufacturers of EVSE and related off-board charging components
- Installers of charging infrastructure
- Electricity providers

Economic impacts associated with these supply chains are often referred to as "supply chain" effects or "direct and indirect" effects. Supply chains are complex (comprising transactions among many economic sectors), geographically diverse (involving off-shore and on-shore suppliers) and fluid (changing over time). Given the size of the economy and the number of participants in PEV supply chains, estimating the magnitude of supply chain impacts is daunting, constrained by incomplete and/or disparate data, and virtually impossible to verify. Input-output (I-O) modeling is the generally accepted method for quantifying the magnitude of expenditures anticipated in response to a particular set of circumstances and capturing a web of transactions along multiple supply chains. I-O modeling also accounts for ripple or induced effects from the re-spending of dollars (for vacations, restaurant meals, etc.) by supply-chain workers elsewhere in the economy.

3.1 Methodology

This assessment of economic impacts attributable to PEVs is based on input-output methodology. Economic impacts were estimated using the Type I and Type II, final-demand multipliers developed by the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) for the Regional Input-output Modeling System (RIMS II). RIMS II contains 406 economic sectors based on the 2002 U.S. Benchmark Input-Output Table and 2008 regional data. RIMS II is based on a set of national input-output (I-O) accounts that reflect the goods and services produced by each industry and the use of those goods and services by industries and final users. The national region utilized for this analysis comprises the 48 contiguous states and Washington D.C. For a complete discussion of the methodology used to create the RIMS II multipliers and additional information on the RIMS II model, see https://www.bea.gov/regional/rims/.

Several key concepts underlie the analysis and results. They are:

- Gross employment. Measured in jobs, gross employment is employment associated with expenditures for modeled activities. It includes both full-time and part-time employment.

- Gross earnings. These consist of wages, salaries, and proprietors' income. Together they represent the income of a business. In this report, the term earnings is used interchangeably with pretax income.
- Gross economic output. This economic concept represents the total value of sales by producing enterprises including the value of intermediate goods used in production. Gross domestic product is different from gross economic output because it does not include the value of the intermediate goods used in production (Bess and Ambargis 2011).

Two distinct types of economic impacts are estimated in this analysis, including:

- Industry supply chain impacts. These are impacts directly associated with expenditures on PEVs and their use. They include all steps in the manufacture, distribution and sale of the PEV and EVSE, installation of the EVSE, and operation of the PEV. Expenditures also include the upstream purchases made by those industries, such as for input materials. In this analysis, industry supply chain impacts are equivalent to what are often referred to as direct and indirect impacts.
- Induced impacts. These impacts are induced by supply chain impacts. They account for the additional expenditures (on housing, meals, entertainment, etc.) by individuals and households who earn income due to supply chain impacts and then re-spend it elsewhere in the economy.

Several important assumptions aid in understanding RIMS II and the results of this analysis:

- Fixed purchase patterns. I-O models assume that industries do not change the relative mix of inputs used to produce output. They also assume that industries must double their inputs to double their output.
- Industry homogeneity. I-O models assume that all businesses in an industry use the same production process.
- No supply constraints. I-O models are often referred to as "fixed price" models because they assume no price adjustment in response to supply constraints. In other words, businesses can use as many inputs as needed without facing higher prices.
- No regional feedback. RIMS II is a single region I-O model. It ignores any feedback that may exist among regions.
- No time dimension. The length of time that it takes for the total impact of an initial change in economic activity to be completely realized is unclear because time is not explicitly included in I-O models. The actual adjustment period varies and is dependent on the initial change in economic activity and the industry structure.

This analysis considers gross economic impacts associated with the production and use of PEVs, the construction of infrastructure to produce and operate those vehicles, and associated electricity use. Gross economic impact analysis takes into account only those economic impacts associated with the project or activity being modeled. It does not include losses occurring in other economic sectors which may be displaced by the new economic activity. In other words, this analysis does not compare gains in one sector against potential losses in other economic sectors due to shifts in vehicle technology (from internal combustion engine vehicles operating on gasoline purchased at local refueling stations to PEVs operating on electricity obtained from local utilities using third party-supplied EVSE). While important and meaningful that level of analysis is beyond the scope of this initial effort.

3.2 Scenarios

For this analysis, two scenarios were defined to examine a range of potential PEV market success. A conservative or "business as usual" scenario was taken from the Reference Case of the U.S. Energy Information Administration's *Annual Energy Outlook* (AEO). That scenario (called our AEO Scenario) assumes minimal penetration of PEVs in auto and light truck markets. Note that in the AEO Scenario, 2014 and 2015 PEV sales and market share estimates are forecasts, not reported values (which may not agree with values reported elsewhere). By contrast, a more optimistic scenario was built around the mandate for zero emission vehicles (ZEVs) adopted by 10 states, primarily in the Western and Northeastern U.S., and using reported PEV sales for 2014 and 2015.[6] The latter scenario, called our ZEV Scenario, essentially nationalizes the ZEV goals by assuming that PEVs sold in ZEV states will comprise 70% of all PEVs sold throughout the U.S. Thus, total sales of PEVs in the U.S. will be 1.43 * ZEV sales in each year. Table 5 lists key parameters of the two scenarios.

Table 5. PEV Sales and Cost Assumptions and EVSE Costs, AEO and ZEV Scenarios

	PEV Sales (000)		*PEV MSRP*	*Residential EVSE*		*Public EVSE*			
Year	AEO	ZEV	(2010$)	Unit Cost*	Installation Cost*	AEO (000)	ZEV (000)	Unit Cost*	Installation Cost*
2015	116	116	34,461	685	750	5	5	18,350	11,250
2020	76	265	29,544	685	750	17	22	18,350	11,250
2025	123	788	26,747	685	750	8	69	18,350	11,250
2030	198	1,110	26,747	685	750	14	95	18,350	11,250

*Average, all levels, all locations, in 2010$.

Figure 11 illustrates the market penetration assumptions in the AEO and ZEV Scenarios. Note that these market penetrations apply to all light-duty vehicles (LDVs). Thus, for example, while PEVs in the ZEV Scenario capture 10% of the overall LDV market in 2030, their penetration is 15% of the automotive market and 5% of the light-truck market.

[6] These include California, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island and Vermont. For additional information on the ZEV mandate, see http://www.zevfacts.com/zev-mandate.html (Alliance of Automobile Manufacturers 2015). Note that zero emission vehicles include fuel cell electric vehicles (FCEVs) as well as PEVs. For this analysis, we assume that FCEVs account for a minimal share of the total.

Figures 12 and 13 illustrate the consequences of these market penetration assumptions. Since total LDV sales and PEV retail price[7] are assumed to be the same in both scenarios, the *value* of PEV sales (measured on the right axes of both figures) is solely due to market penetration.

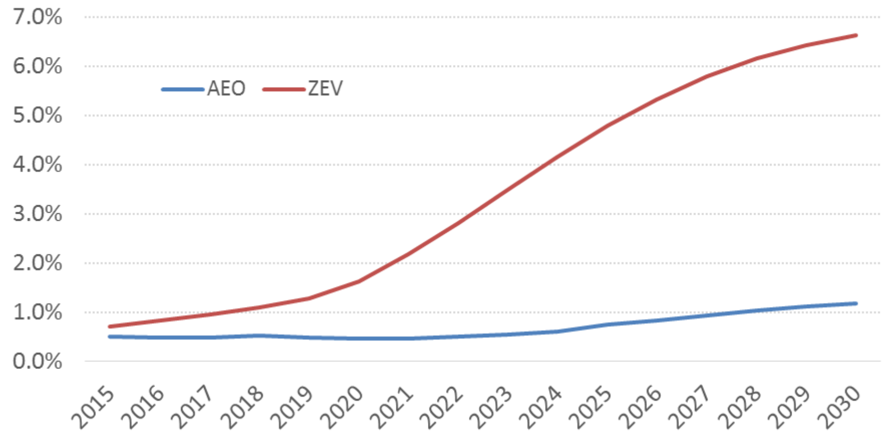


Figure 11. PEV Market Shares, 2015–2030, under AEO and ZEV Scenarios

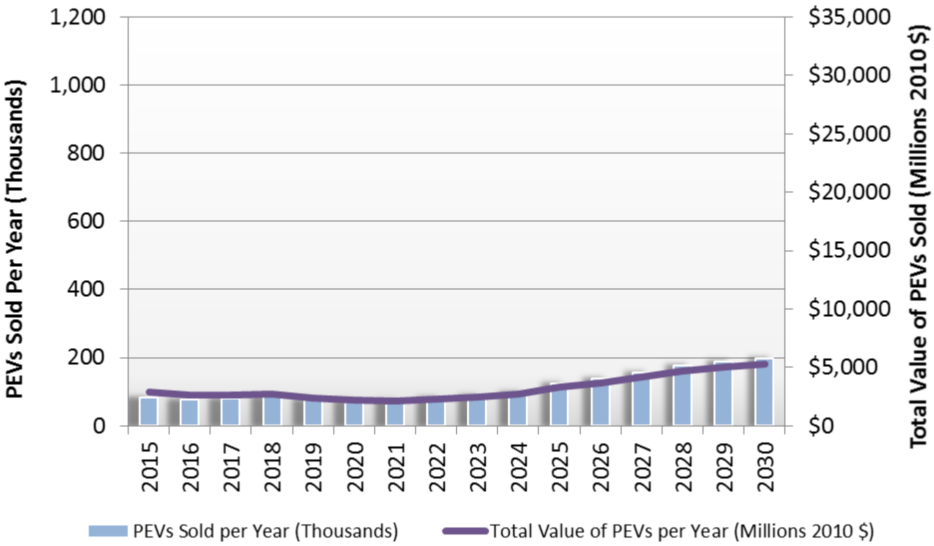


Figure 12. Quantity and Value of PEVs Sold Per Year, AEO Scenario

[7] It may be argued that with fewer sales, producers are less likely to achieve scale economies in the AEO case. Hence, PEV retail prices could be considerably higher. Thus, AEO estimates can be considered conservative.

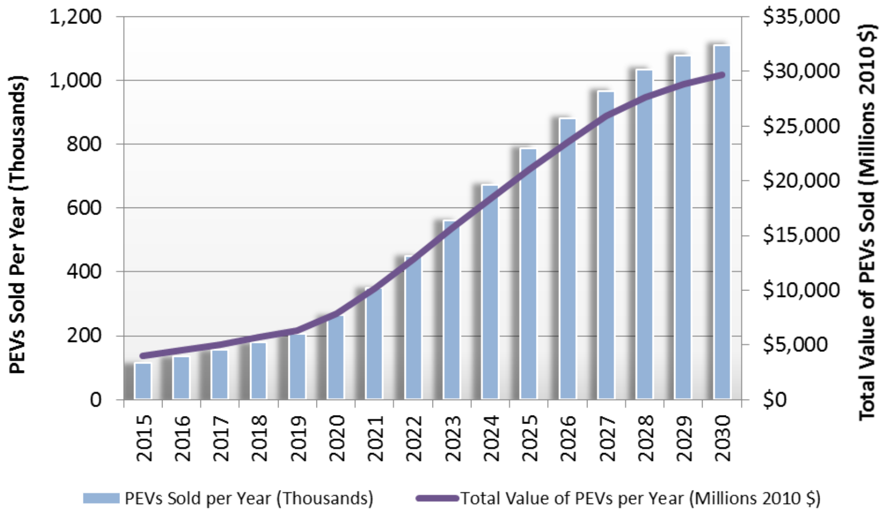


Figure 13. Quantity and Value of PEVs Sold Per Year, ZEV Scenario

While the two scenarios differ in market penetration assumptions, they share the same macroeconomic assumptions. Most importantly, these include energy price; total light-duty vehicle (LDV) sales; auto and light-truck shares of LDV sales; and PEV efficiency, utilization and price. Other assumptions common to both scenarios include:

- PEV sales in all years are split evenly (i.e., 50% each) between BEVs and PHEVs.
- Each PHEV requires the purchase and installation of Level I EVSE at the location where the vehicle is domiciled (i.e., either a residential or fleet location). This additional expense is incurred at the time of PEV purchase.
- Each BEV requires the purchase and installation of Level II residential EVSE at the location where the vehicle is domiciled (i.e., either a residential or fleet location). This additional expense is incurred at the time of PEV purchase.
- Investment in production facilities for vehicles and/or batteries is driven by the volume of PEVs assumed to be sold in the scenario, not investment announcements (which may include anticipated exports, HEVs, non-vehicular battery production, etc. as well as anticipated PEV sales that are much higher than assumed in our scenarios).
- All production facilities require a 2-3 year construction period.
- Vehicle assembly capacity will be added based on a reference 100,000 unit-facility at a total cost of $300 million (including design and engineering, equipment, installation and construction).
- Battery pack production will be added based on a reference 100,000 unit-facility at a total cost of $1.9 billion (including design and engineering, equipment, installation and construction).
- EVSE production facility development and expansion are not included in this analysis.
- Electricity price will remain constant at $0.12 per kWh.
- PEV utilization, efficiency and charging patterns reflect the assumptions of the AEO Scenario.

– Density of public charging infrastructure (or the number of PEVs per public EVSE) will be the same in both scenarios.

– All components and materials for battery and vehicle assembly plants modeled will be manufactured and supplied by firms located in the US.

Because both scenarios assume the same cost of and requirements for private EVSE and the same density for public EVSE, expenditures on EVSE also are a function of PEV market penetration. This can be seen in Figures 14 and 15 (which plot numbers of private and public EVSE) and Figures 16 and 17 (which show expenditures on EVSE) for each scenario. Although the AEO scenario has much lower total expenditures for EVSE, the ratio of public EVSE expenditures to private EVSE expenditures increases with time as more of the costlier public units are added.

Note that several other incentives and rebates are available to PEV purchasers. As was shown in Figure 9, several states provide various forms of purchase and use incentives. In addition to those, a federal tax credit of up to $7,500 is available to PEV purchasers filing annual tax returns. However, tax credits and exemptions typically do not reduce purchase expenditures. Rather, they provide reimbursement to the purchaser for amounts already paid to dealers (and ultimately to original equipment manufacturers or OEMs). Thus, incentives transfer additional dollars from government to PEV purchasers who in turn may save or re-spend them on a range of things including not only tax liabilities, but also discretionary items like vacations and entertainment. The economic impact of tax incentives is a complex issue outside the scope of this analysis.

As sales of PEVs increase, it may be necessary to expand the manufacturing capability of PEV battery and vehicle assembly plants. In this analysis, sufficient capacity is assumed to be added in anticipation of future demand and estimated impacts from the construction and operation of those facilities are included in our results. By contrast, electric generation capacity is assumed sufficient to handle the incremental demand of PEVs at all times under both scenarios. Thus, generation capacity is not modeled in this analysis. However, because the ZEV Scenario assumes that 70% of all PEVs will be sold in ZEV states, we recognize that capacity shortages could occur at some times in some locales. Options for resolving potential shortages include capacity expansion, demand management, additional storage (including vehicle-to-grid options) or various other policy or technology options. The identification and analysis of these options is beyond the scope of this analysis.

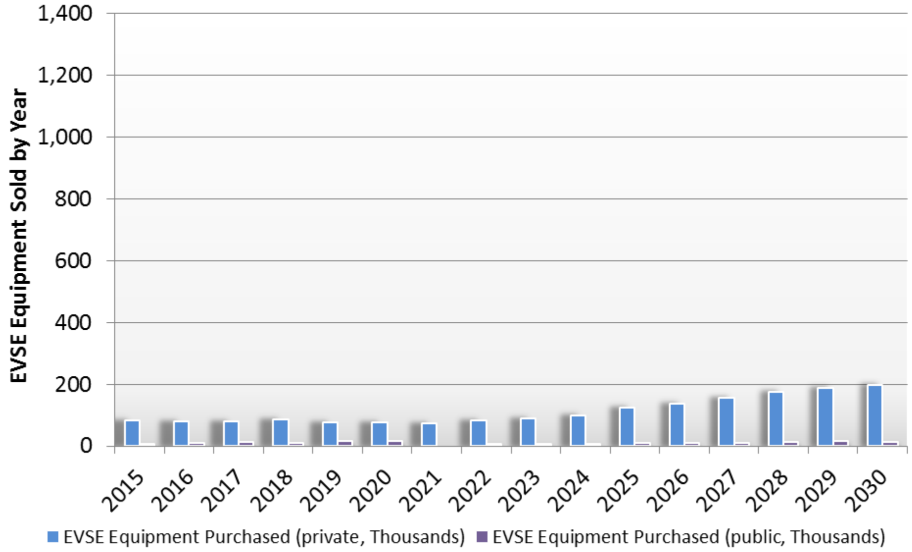


Figure 14. Private and Public EVSE Units Sold by Year, AEO Scenario

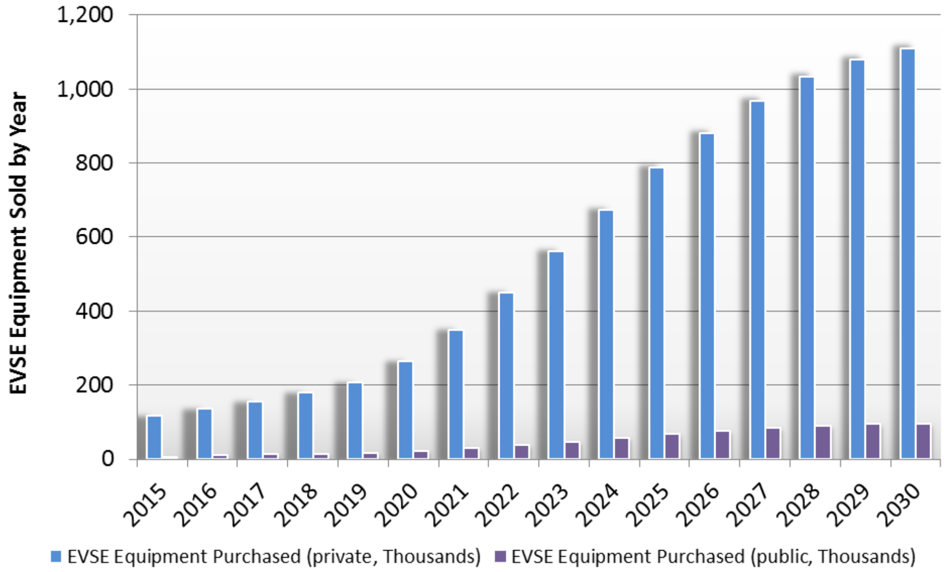


Figure 15. Private and Public EVSE Units Sold by Year, ZEV Scenario

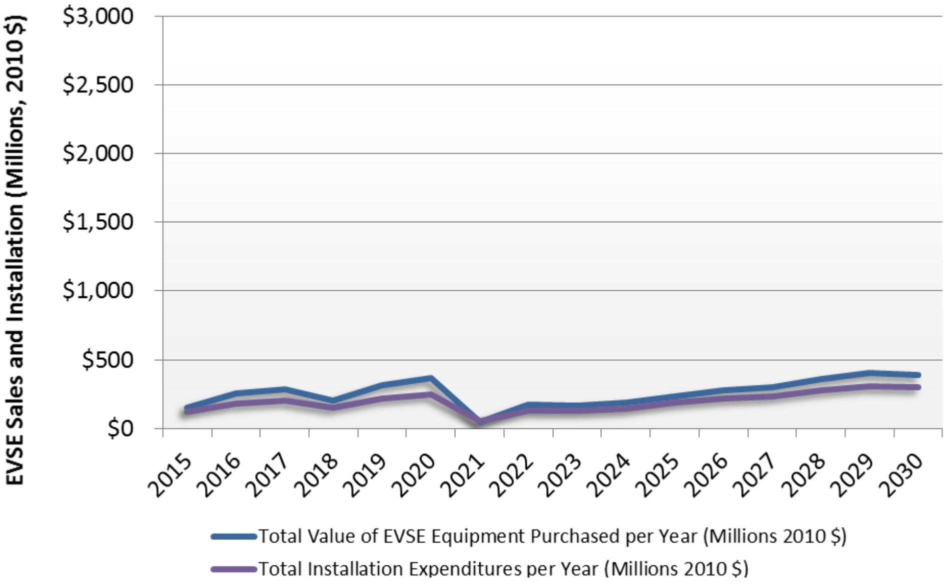


Figure 16. Annual Expenditures on EVSE, AEO Scenario

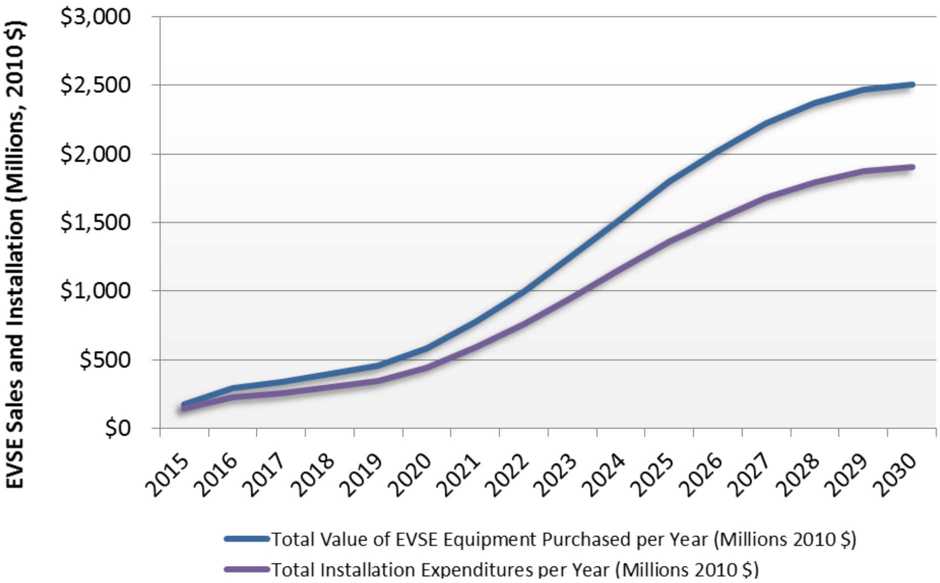


Figure 17. Annual Expenditures on EVSE, ZEV Scenario

Electricity demand and expenditures for electricity to charge PEVs are shown in Figures 18 and 19. Again, note that the demand curve is quite similar to PEV sales because the two scenarios share the same assumptions with respect to PEV efficiency (i.e., miles per kWh), range, utilization (i.e., miles per vehicle), and charging characteristics (e.g., duration, length, level, location).

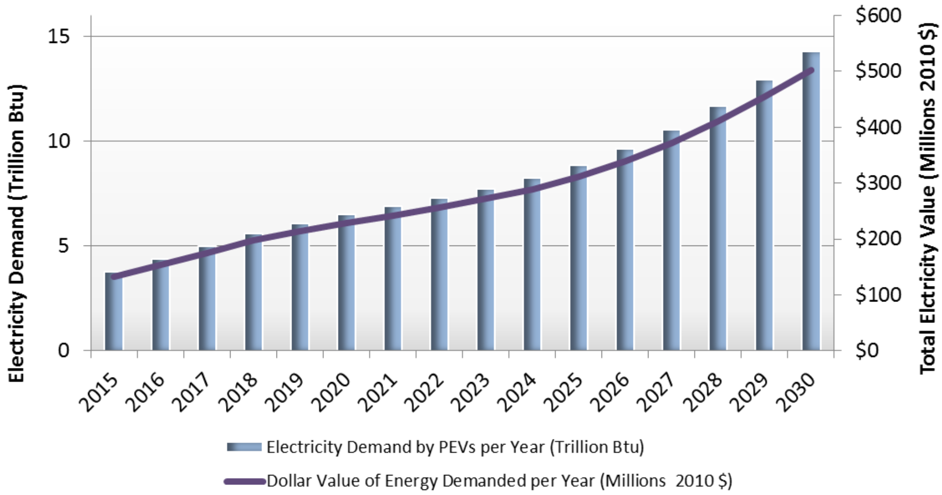


Figure 18. PEV Electricity Demand, AEO Scenario

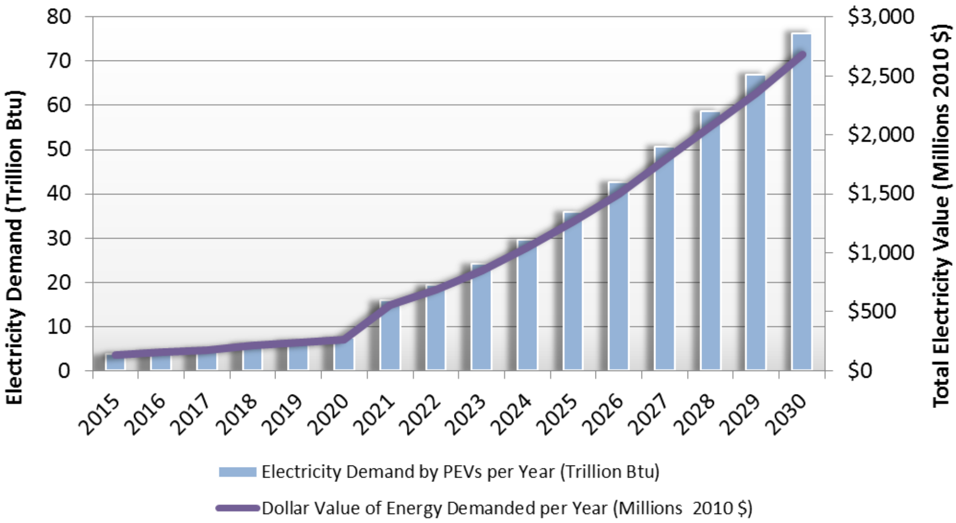


Figure 19. PEV Electricity Demand, ZEV Scenario

4.0 Economic Impact Results

4.1 Employment

Figures 20 and 21 show overall employment impacts for the two scenarios. The ZEV Scenario clearly has greater impact due to the much greater number of PEVs sold in that scenario. Not only does the AEO Scenario produce less employment in each year but growth in employment slows in the middle years of the scenario. This pattern reflects a drop in both PEVs and EVSE additions because of a combination of relatively weak PEV sales and the assumption that the ratio of public EVSE per PEV will decline over time. Nevertheless, the AEO Scenario yields employment estimates of 40,000–60,000 jobs per year from 2016 through 2024. Beyond 2024 employment grows steadily in the AEO Scenario, rising to over 70,000 jobs in 2025 and reaching 110,000 jobs in 2030.

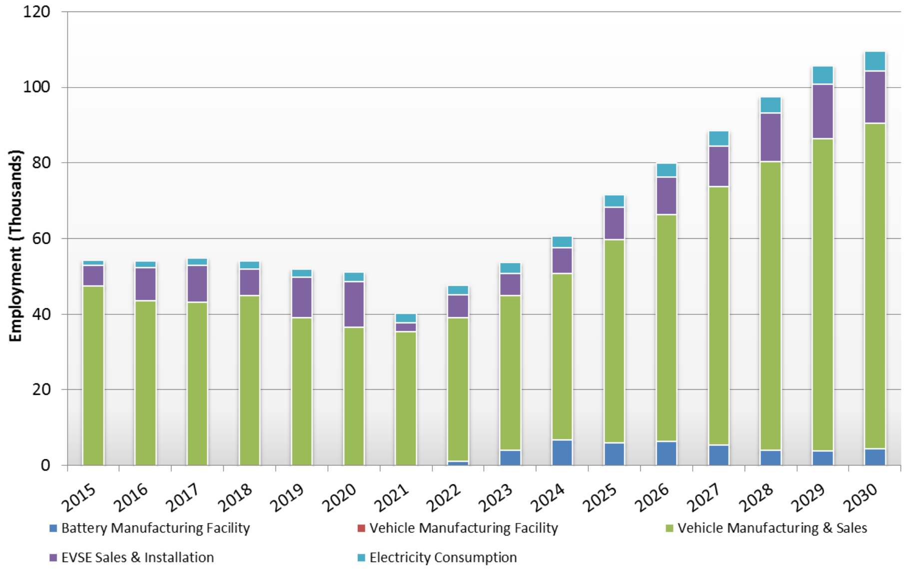


Figure 20. Supply Chain and Induced Employment by Source, AEO Scenario

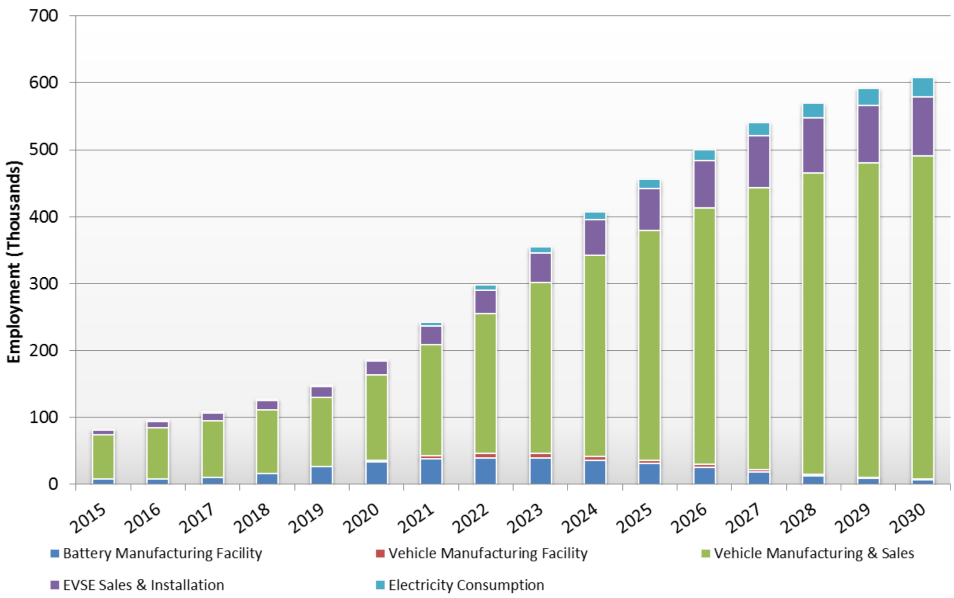


Figure 21. Supply Chain and Induced Employment by Source, ZEV Scenario

The ZEV Scenario produces more dramatic growth in employment, rising from approximately 187,000 in 2020 to 456,000 in 2025 and 608,000 in 2030. Vehicle manufacturing and sales account for the bulk of employment gains in both scenarios, followed by EVSE sales and installation, expansion of battery manufacturing capacity and electricity consumption. Because existing vehicle manufacturing has considerable excess capacity both domestically and overseas, neither scenario requires much in the way of expanding PEV production capacity. As shown in Figure 21, no expansion in PEV manufacturing capacity occurs in the AEO Scenario while a small capacity expansion (and attendant employment) occurs in the middle years of the ZEV Scenario. Note that these estimates ignore the potential for export demand to require additional production capacity both for batteries and vehicles. In 2015 Tesla exported nearly half of the 50,580 BEVs it produced in the US, amounting to some $1.7 billion in export value.

4.2 Gross Earnings and Economic Output

Figures 22–25 show breakdowns of gross earnings (supply chain plus induced) and economic output attributable to the two PEV scenarios. Both measures reflect the patterns described above for employment impacts. For the AEO Scenario both earnings and output struggle initially and do not begin growing until 2022. By the mid-2020s both measures are growing steadily in the AEO Scenario. By contrast, the ZEV Scenario experiences more robust growth in both measures.

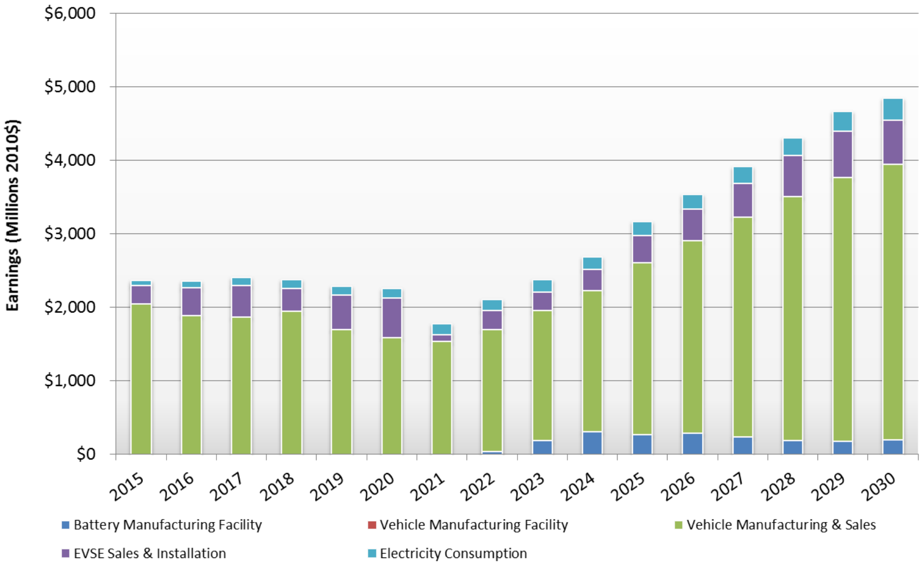


Figure 22. Supply Chain and Induced Earnings (Income) by Source, AEO Scenario

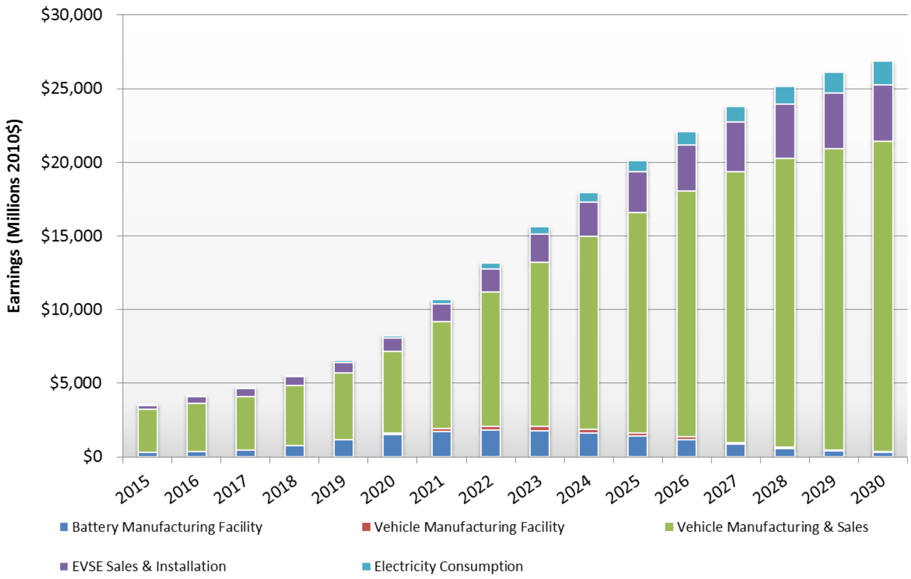


Figure 23. Supply Chain and Induced Earnings (Income) by Source, ZEV Scenario

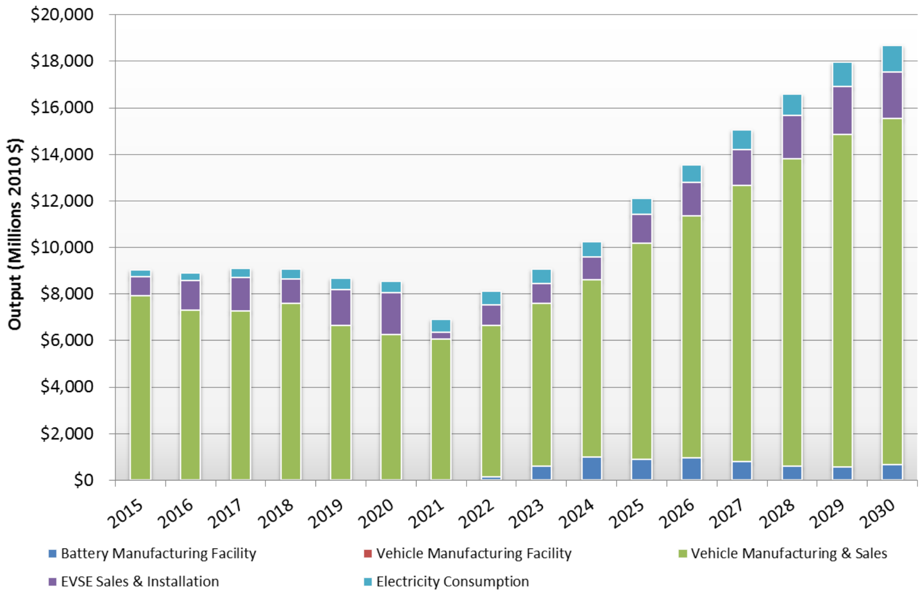


Figure 24. Supply Chain and Induced Gross Economic Output by Source, AEO Scenario

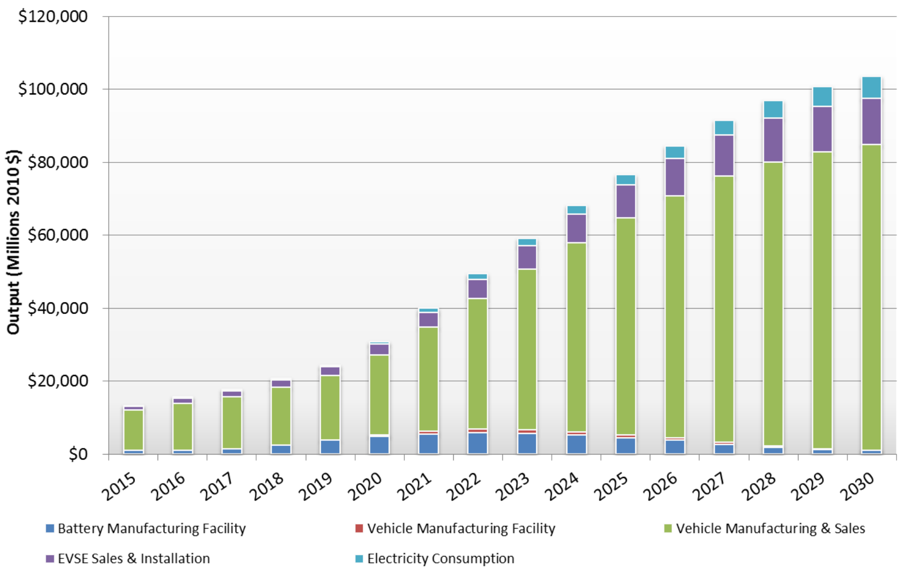


Figure 25. Supply Chain and Induced Gross Economic Output by Source, ZEV Scenario

4.3 Sector-Specific Results: Batteries

Because I-O analysis uses a bottom-up approach to summarize expenditures across a range of industrial sectors, results can be examined for specific sectors or groups of sectors. For this analysis, the battery industry was examined in more detail. As shown in Figure 26, jobs (both supply chain and induced) associated with supplying batteries for PEVs follow the same general pattern as total employment, earnings and output.[8] Again, employment in the AEO Scenario initially drops due to declining PEV sales before slowly rising in the mid-2020s. By contrast, the ZEV Scenario shows a steady increase in battery-industry employment, reaching approximately 40,000 jobs in 2025 and 57,000 jobs in 2030.

Note our estimate of nearly 13,000 jobs in 2015 includes both direct and indirect employment throughout the supply chain (i.e., for all materials, sub-assemblies, separators, etc., some of which are imported) as well as induced jobs.

Note also that this analysis assumes forecast demand for PEVs, batteries, and EVSE will be met by domestic suppliers. Since most PEV assembly is assumed to occur in the United States, battery production also is expected to be in the U.S., generally in close proximity to PEV assembly in order to reduce transport costs. As a result, future job growth in the battery sector is likely to be primarily domestic. At present, Tesla is the main U.S. PEV manufacturer heavily dependent on imported batteries, a situation projected to end once Tesla's new battery production facility is fully operational. In this analysis, all batteries are assumed to be produced domestically.

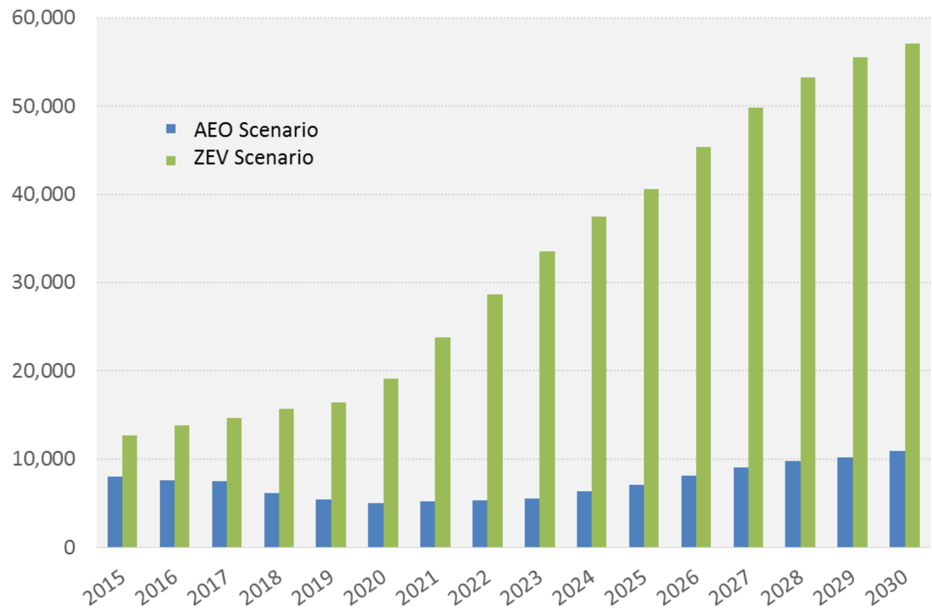


Figure 26. Battery-Related Employment from PEV Manufacturing

[8] While additional employment is associated with expanding battery-manufacturing capacity in the ZEV Scenario (but not in the AEO Scenario, see Figures 20 and 21) these are not included in Figure 26.

5.0 Conclusions and Next Steps

PEVs and the infrastructure to produce and operate them can have a significant impact on the U.S. economy in the coming years. If states that have agreed to a Zero Emission Vehicle mandate achieve their targets, approximately 9.3 million PEVs are likely to be on U.S. roads in 2030 (as compared with 1.7 million under EIA's AEO Scenario). These vehicles are likely to contribute to over 600,000 jobs, $17 billion in gross earnings to their supply chain (plus another $10 billion in the form of induced earnings as workers consume other goods and services) and $104 billion to U.S. economic output. If market penetration exceeds these targets and/or adoption exceeds our assumptions for non-ZEV states these estimates could grow.

As stated above, this analysis is an initial effort which can and will be improved. It estimates economic impacts associated with only one aspect of e-mobility, namely plug-in electric vehicles (PEVs). Many other e-mobility technologies and services are in the process of being developed and introduced. If even a handful of them achieve market success, the mobility landscape is likely to change dramatically in the years ahead. As penetration metrics become available the economic impacts of these new entrants can be examined. This is a logical next step for this analysis.

In addition to examining additional e-mobility options, this analysis would benefit from the following types of follow-on study:

1. An explicit examination of uncertainty. Many of the estimates and assumptions discussed above are highly uncertain. This is to be expected given that the technology is new to the market, infrastructure is in the process of being deployed, consumer behavior is not well understood, and costs vis a vis conventional vehicles remain high. At this point, few would argue that PEVs are in the "early adopter" phase of their introduction to the U.S. market.
2. An investigation of new versus displaced demand. Some of the expenditures identified in this analysis may displace expenditures for conventional vehicles. In the absence of a breakdown between replacement and additional vehicles, we have assumed that ALL expenditures are associated with additional or new demand. This assumption should be re-examined in future analyses.
3. Analyses of import and export effects. While this analysis estimates economic impacts resulting from decisions to adopt e-mobility by people who reside in the United States, it is less definite about the extent to which these impacts affect the United States economy. Depending on exports and imports, impacts on the U.S. economy may be greater or less than the totals reported here. Assumptions about exports and imports in the present report are important candidates for refinement.

Finally, this report should be viewed as documentation of a high-level analysis performed as a first step in a continuing effort to understand the economic impacts of e-mobility. Estimates of jobs, income, and economic output were developed using existing publicly available information and tools and broadly accepted goals. This analysis does not attempt to answer the question of whether those goals will or will not be met. Nor does it tackle issues of displacement of employment in industries which may see declines as a result of increased e-mobility. Continued research and analysis is needed to refine the estimates provided here, investigate additional aspects of e-mobility, better understand supply chain implications, and identify hurdles to continued deployment of e-mobility technologies and services.

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