



# Full electric and plug-in hybrid electric vehicles from the power system perspective

Subtask 5, Report n:o 1

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International Energy Agency Demand-Side Management Programme

**Task XVII: Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages**

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## **EXECUTIVE SUMMARY - Full electric and plug-in hybrid electric vehicles from the power system perspective**

### **TASK XVII: INTEGRATION OF DEMAND SIDE MANAGEMENT, DISTRIBUTED GENERATION, RENEWABLE ENERGY SOURCES AND ENERGY STORAGES**

**Task extension: The effects of the penetration of emerging DER technologies to different stakeholders and to the whole electricity system**

**Background** Energy policies are promoting distributed energy resources such as energy efficiency, distributed generation (DG), energy storage devices, and renewable energy resources (RES), increasing the number of DG installations and especially variable output (only partly controllable) sources like wind power, solar, small hydro and combined heat and power.

Intermittent generation like wind can cause problems in grids, in physical balances and in adequacy of power.

Thus, there are two goals for integrating distributed energy resources locally and globally: network management point of view and energy market objectives.

Solutions to decrease the problems caused by the variable output of intermittent resources are to add energy storages into the system, create more flexibility on the supply side to mitigate supply intermittency and load variation, and to increase flexibility in electricity consumption. Combining the different characteristics of these resources is essential in increasing the value of distributed energy resources in the bulk power system and in the energy market.

This Task is focusing on the aspects of this integration.

**Objectives** The main objective of this Task is to study how to achieve a better integration of flexible demand (Demand Response, Demand Side Management) with Distributed Generation, energy storages and Smart Grids. This would lead to an increase of the value of Demand Response, Demand Side Management and Distributed Generation and a decrease of

problems caused by intermittent distributed generation (mainly based on renewable energy sources) in the physical electricity systems and at the electricity market.

## Approach

The first phase in the Task was to carry out a scope study collecting information from the existing IEA Agreements, participating countries with the help of country experts and from organized workshops and other sources (research programs, field experience etc), analyzing the information on the basis of the above mentioned objectives and synthesizing the information to define the more detailed needs for the further work. The main output of the first step was a state-of-the art report.

The second phase (Task extension) is dealing with the effects of the penetration of emerging DER technologies to different stakeholders and to the whole electricity system.

The main subtasks of the second phase are (in addition to Subtasks 1 – 4 of the phase one):

**Subtask 5:** Assessment of technologies and their penetration in participating countries

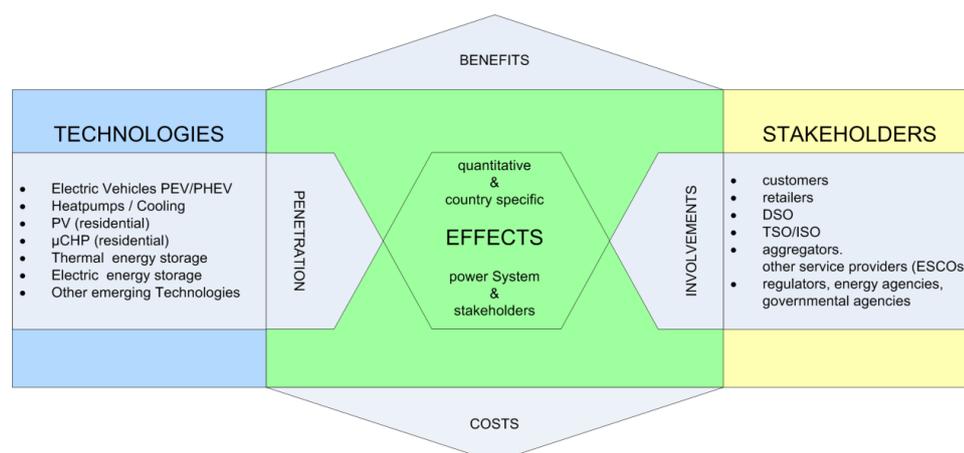
**Subtask 6:** Pilots and case studies

**Subtask 7:** Stakeholders involved in the penetration and effects on the stakeholders

**Subtask 8:** Assessment of the quantitative effects on the power systems and stakeholders

**Subtask 9:** Conclusions and recommendations

The figure below describes the concept of this extension.



## Results

The report briefly reviews current electric vehicle technology, presents some future prospects, and presents some possible consequences to the power system, and ways in which the harmful effects could be minimized.

In addition the present situation and some prospects of EV in the participating countries, Finland, France, Austria, Netherlands and Spain are presented. We can make the following observations:

### **Incentives**

In Finland currently there are tax reductions for the registration tax and annual vehicle taxes. In France the government provides a direct 5,000 euro subsidy for the purchase of the electric vehicle (max 20 % of the purchase price). In Austria EV's are exempt from the registration tax, and there are direct subsidies (up to 5000 euro) in three of the nine provinces. In Spain some regional governments grant direct subsidies for the purchase of EV. In the Netherlands incentives include total exemption of the registration fee and road taxes, which result in savings of approximately 5,300 € for private car owners over four years (ACEA 2010). There are also parking spaces dedicated to EV.

In general, the incentives vary even inside the country and can change rapidly.

### **Future scenarios**

It is very difficult to forecast the pace of growth in the number of electric vehicles. The scenarios prepared in different countries involve different assumptions, and thus are not directly comparable. If we neglect this problem and take the medium or target scenario from each country and avoid the low and high scenarios (if different scenarios have been presented), we end up with the results in table below. Unfortunately, in some cases the figures refer to FEV and in some cases also PHEV is included.

*Table: medium or target scenarios of EV penetration in different countries.*

	number of EV		per 1000 people	
	2020	2025	2020	2025
Finland	79,000		15	
France	2,000,000	4,500,000	31	69
Spain	1,000,000		22	
NL	200,000	1,000,000	12	59

### **Impacts on the electricity grid**

Results from all countries were not available and the parameters used in charging studies vary from case to case. Generally the findings seem to indicate that the effect of charging intelligence is considerable. In Finland and NL a significant portion of the vehicle fleet can consist of full electric vehicles without causing problems to the local grid, if smart charging has been implemented. In other countries, such as Italy, the distribution grid has been dimensioned differently, with very small power allocated to each connection point. In France, 7.5 million EV's and PHEV's (portions not defined) would not cause significant peaks in the transmission grid, if smart charging has been implemented.

If smart charging is insufficient to alleviate the load caused by charging, problems can be alleviated by encouraging local generation (such as  $\mu$ -CHP's) to supply part of the charging power, and finally by expanding grid capacity.

International Energy Agency Demand-Side  
Management Programme

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Management, Distributed Generation,  
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## List of abbreviations

AMM	Advanced metering management
AMR	Automatic Meter Reading
AS	Ancillary Services
BM	Balancing Mechanism
BRP	Balancing Responsible Party
CENELEC	European Committee for Electrotechnical Standardization
CHP	Combined Heat and Power
CSP	Concentrated Solar Power
DER	Distributed Energy Resources
DG	Distributed Generation
DR	Demand Response
DS	Distributed Storage
DSB	Demand-Side Bidding
DSI	Demand-Side Integration
DSM	Demand-Side Management
DSO	Distribution System Operator
EN	European Standard (developed by European Committee for Standardization)
ENTSO-E	European Network of Transmission System Operators for Electricity
ETSO	European Transmission System Operators
EV	Electric vehicle
FEV	Full Electric Vehicle
HAN	Home Automation Network
HEMS	Home Energy Management System
HEV	Hybrid Electric Vehicle
HV	High-voltage
ICE	Internal combustion engine
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEV	International Electrotechnical Vocabulary
LV	Low-voltage
NTA	Netherlands technical agreement
PCC	Point of Common Coupling
PHEV	Plug-in Hybrid Electric Vehicle
PV	Photovoltaic (power generation)
RES	Renewable Energy Source
RCD	Residual Current Device
RTP	Real-time Pricing
STATCOM	Static Synchronous Compensator

TBA	To be announced
ToU	Time of Use
TSO	Transmission System Operator
UML	Unified Modeling Language
UPFC	Unified Power Flow Controller
V2G	Vehicle to Grid
VDE	Verband der Elektrotechnik, Elektronik und Informationstechnik
VPP	Virtual Power Plant
VTT	Technical Research Centre of Finland
μCHP	Micro Combined Heat and Power

# 1. Introduction

Electric vehicles (EVs) are different from regular hybrid electric vehicles; they use electricity from an external source to propel part or all of their mileage. The usual source for the electricity is the power grid, although PV panels can also be used to directly charge the vehicle batteries. Plug-in hybrid electric vehicles (PHEV) can generate electricity using an on-board generator which is driven by internal combustion engine.

EVs in this report cover both full electric vehicles (FEV) and plug-in hybrid electric vehicles (PHEV). EVs have potential to contribute to more efficient operation of power systems through intelligent timing of their charging and discharging. This possibility frames the main perspective of the report. The report is background material for the Task XVII of IEA Demand Side Management Programme – Integration of Demand Side Management, Energy Efficiency, Distributed Generation and Renewable Energy Sources. EVs can potentially decrease the integration costs of distributed generation and variable power sources by creating flexibility in the power system. On the other hand EVs compete with other possible sources of demand response.

In this report we concentrate on light-duty vehicles, which usually have seven seats or less. They include sedans, mini-vans, personal pick-up trucks, etc. FEV buses are also operational in some cities but are currently limited to niche applications because of their limited range. Buses may benefit from very short-term energy storage during their frequent stops. Supercapacitors may be used in hybrid electric buses to store braking energy and to improve acceleration. Of course, trolley buses which draw power from overhead lines have been running for decades but the subject of this report is EV which use batteries to store energy.

Second chapter of the report reviews the current status of EV technologies. Third chapter summarizes IEA and some other scenarios for the uptake of EVs. Fourth chapter explains the effects of charging EV on the power system, and fifth chapter briefly explains what system services EV could provide. Last chapter provides a summary of findings. Appendices tell about the current situation, policy and future prospects of EV in the participating countries.

## 2. Electric vehicle technology

### 2.1 Overview

The main differences between EVs and conventional internal combustion vehicles are in the powertrain. Figure 1 shows the main components of a FEV powertrain and related electrical components. Some EV components, like battery packs and battery management systems, are not yet produced in high numbers for automotive purposes and require further R&D. Other components are being mass produced for similar purposes as they will be used in EVs, including motors, chargers, and converters. While these can be already acquired at a reasonable cost, they could also benefit from optimisation to EV use.

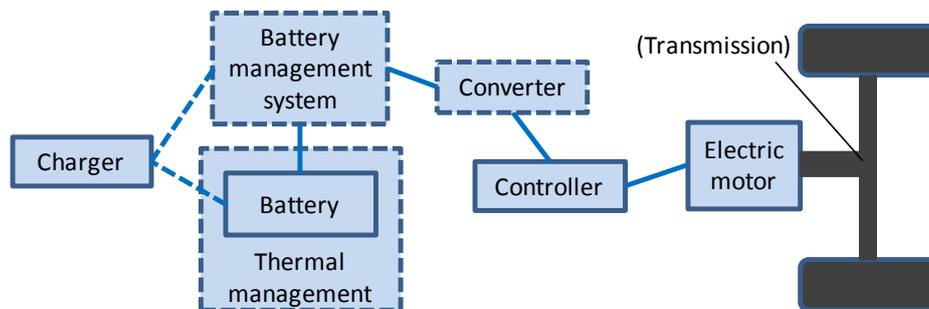


Figure 1. Main components in the energy train of a full electric vehicle.

The critical part of EV technology is the battery and the management systems around it. Battery types which can be considered for EV include lead-acid batteries, nickel metal hydride batteries and lithium-ion batteries. Of these only lithium-ion batteries come close to providing enough energy density and driving range for intercity travel, although they cannot compete with fuel vehicles. Significant amount of research is on-going to improve currently commercial battery chemistries as well as to find new chemistries (e.g. de Guibert 2009). For example, lithium-ion batteries with lithium-iron phosphate cathode are seen as a promising battery type for EV because of its durability and high power density. Other cathode types include cobalt dioxide, nickel-cobalt-manganese, nickel-cobalt-aluminum and manganese oxide spinel. Anode types include carbon, which suffers from poor safety and lifetime, and lithium titanate, which suffers from lower energy density.

The main issues related to the EV batteries are cost, weight, cycle life (number of charge-discharge cycles the battery can tolerate), calendar life, charging and discharging power, safety, and performance in low and high temperatures. In cold conditions the

battery pack requires heating and also car interior requires heating, which reduce the available mileage considerably.

The most serious drawback with lithium-ion batteries is their high cost. There are also estimates that by 2020 the cost of lithium-ion batteries can decrease by 65 % from the current 1000–1200 USD per kilowatt-hour of capacity if manufacturing volumes increase (Dingner et al 2010). Element Energy Ltd (2012) predict a 50 % cost reduction from 2011 to 2020. Figure 2 presents future estimates of the battery cost. We can see that the estimates differ significantly. Of course, it is very difficult to predict the development of manufacturer mark-ups. We should also note that the usable capacity is only about 80 % of the total battery capacity. The cost figures are normally given for the total capacity. The cost per capacity also to some extent depends on the battery size, with larger batteries being cheaper.

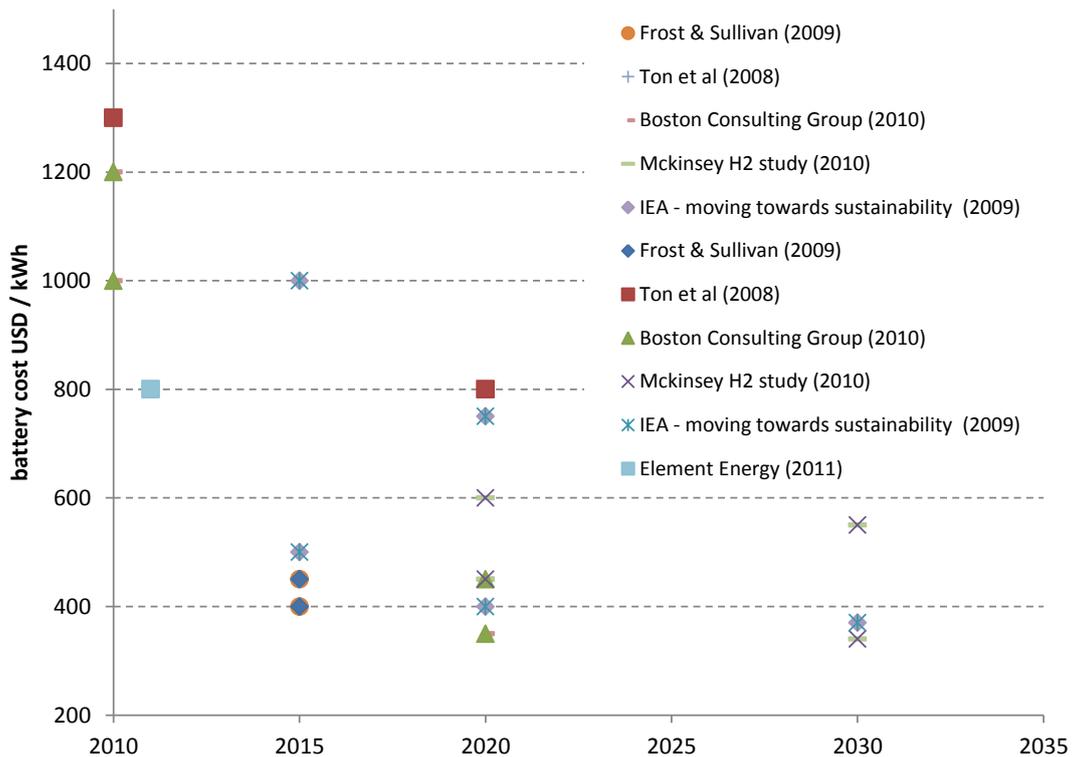


Figure 2: Some future estimates of the cost of the Lithium-ion battery pack for EV. The abscissa shows the cost per kWh of battery capacity.

Competitiveness of EVs is highly dependent on the EV cost, but also on other things. These include incentives, availability of charging stations, public image of EV's, performance, fuel cost, etc. Figure 3 shows one example of the break-even fuel cost

depending on the residual value of EV batteries with one set of assumptions. The residual value stems from the fact that the batteries can have a second life in other uses after their capacity has diminished. We see that without incentives FEV's are far from being economically competitive. For PHEVs the break-even cost is likely to be earlier.

In the driving mode, controller draws current from the batteries or sends a signal to the optional battery management system (BMS) according to the pedal position and motor status. If BMS exists, then it distributes the required current draw between the cells in order to maintain similar state of charge between the battery cells and prolong the battery life. PHEVs require more complicated control strategies since they have to optimise between electricity and fuel use (e.g. Rousseau et al 2007).

If the EV has an AC motor, inverter is required to convert DC from the battery to AC before the controller. This adds to the costs and complexity, but AC motors can be more efficient than their DC counterparts. Current goes through the controller to the motor, which turns the drive train. In-wheel motors can be used to bypass the whole transmission with the drawback of heavier wheels. A charger without BMS tries to optimise the charging process and terminates the charging once the batteries are full enough. If BMS exists, then charger communicates with the BMS to optimise the charging profile according to the information BMS has gathered about the individual cells.

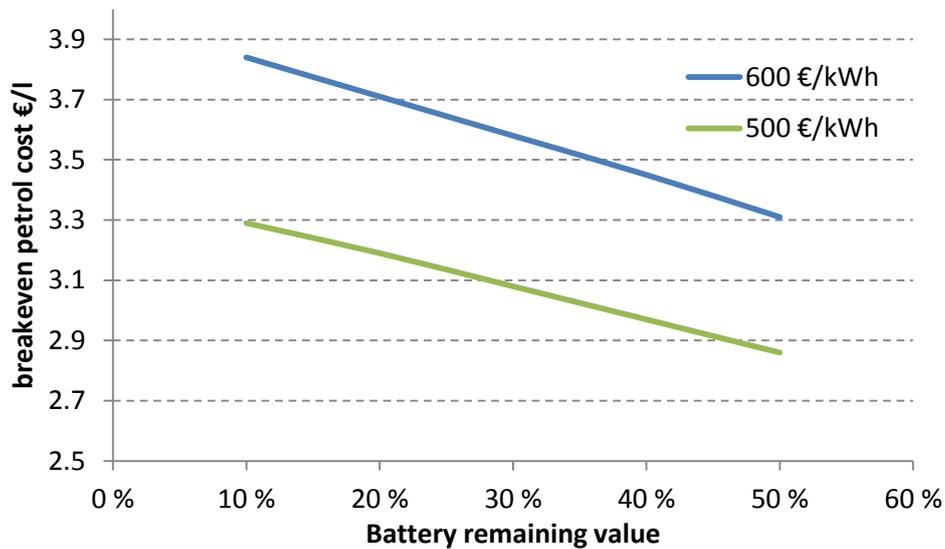


Figure 3. Example of break-even fuel cost for internal combustion engine vehicle compared to FEV when the battery residual value varies. Two curves are shown with different battery initial prices. Annual driving of 20 000 km is assumed for both vehicle types. In this analysis the lifetime of the vehicles was 10 years, interest rate 10 %, cost of electricity 0.14 €/kWh, fuel consumption 5 l/100 km, electricity consumption 200 Wh/km and the capacity of EV battery pack was 35 kWh. The assumption was that the price of FEV excluding the battery is the same as that of fuel vehicle (Archer 2011). Also maintenance, insurance, etc. were assumed to cost the same.

There are at least three different PHEV concepts. A series hybrid is connected to the wheels only through the electrical system. It therefore has a generator producing electricity from the fuel. A separate motor uses electricity either from the battery or from the generator to turn the wheels. A parallel hybrid has an engine and a motor separately connected to the drive train. In a pure parallel hybrid fuel cannot be used to charge the batteries. A power-split hybrid means that there is a connection from the engine to the wheels through a generator as well as through the drive train. A power-split device controls where power is drawn from and makes it possible to charge the batteries with the engine/generator.

## 2.2 Charging electric vehicles

Modern EV normally employs a lithium-ion battery as energy storage. They need to be frequently charged, which can pose a problem for the electrical network as well as electric installations at consumer premises. On the other hand, good access to charging point is essential to make EV a feasible alternative to fuel vehicles. Four major categories of charging are distinguished here according to the location: home, workplace, public parking, and fast-charging stations.

Most EV's can be readily plugged into standard LV single-phase or three-phase socket (charging modes 1 and 2 of IEC 62196). In apartment houses and many commercial and industrial buildings the possibility to install such outdoor sockets is dependent on the availability of suitable parking lots and the possibility to install necessary wirings and charging posts. Attention should be paid on these issues in new buildings. In colder climates these can already be available for car preheating purposes. Unfortunately, the experience in Finland is that these are generally insufficient for EV charging because of overheating of the CEE 7/4 Schuko sockets during the long charging period. The problem is aggravated in summer. When installing wirings in new parking lots, it is recommendable to use electrical conduits so that the conductors can be updated for EV charging.

Work-place charging could potentially be of major importance especially for PHEV's, since it could halve the required battery size for the daily commute. Most FEV owners would likely have a large enough battery for a round-trip to work in any case and work-place charging opportunity would not be as valuable to all of them.

Public parking includes parking lots of retail establishments, roadside parking and park-and-ride areas, which provide commuters with the possibility to combine private driving with public transportation in city centres. Public parking areas do not usually have wirings available. It is an open question what portion of the public parking spaces would require a charging opportunity in order to serve a certain penetration of EV's or whether such installations could be profitable. Many EV owners might not use public charging at all, if it costs more than home charging. Note that slow charging at home does not necessarily involve any installation costs.

Naturally, charging capacity at any location is restricted locally by the size of the conductors from the circuit breaker panel as well as fuses. In addition, the supply contract with the DSO as well as the capacity of the feeder line can restrict the available power especially if other high capacity appliances need to be used simultaneously. Reinforcing the distribution network may be needed if penetration of FEV increases. It has been estimated that this is especially the case in Japan, USA and South Korea, where the network architecture is different from for example northern Europe. In these countries the MV network is rather extensive and one distribution transformer supplies just a few consumers. The DSO would quite soon need to upgrade some distribution transformers if home charging of EV becomes popular.

In addition to battery swapping, fast charging is the only way to enable long distance trips for FEV. An adequately extensive network of fast-charging stations will considerably increase consumers' interest towards FEV. Most consumers cannot

afford a secondary fuel vehicle for longer trips. However, driving habits vary between countries and in some countries consumers may be satisfied with shorter range, perhaps combined with renting a PHEV or fuel car for longer trips.

Fast-charging can only take place at dedicated charging stations, which are connected to the MV network (a single fast-charging point can also be connected to LV network). Some Li-ion battery chemistries can be detrimentally affected by frequent fast charging. For example Nissan reports that if fast charging is the primary way that the owner recharges (their Leaf model), then the gradual capacity loss is about 10 percent more than with slow charging (Hybridcars 2010). Tests have also been performed with an alternative lithium-iron phosphate and lithium titanate battery construction which could allow ultra-fast charging in just 5 min without noticeable performance degrade after 20,000 charge-discharge cycles (Zaghib et al. 2011). However, this construction has not yet been tested in the large scale. Of course, fast charging produces plenty of heat, so the battery must be actively cooled but the same applies for discharging during driving.

Another possible categorization of charging is according to the charging speed. A rough categorization is presented in Table 1. The standard IEC 61851-1, which deals with safety requirements of the charging systems, specifies a more detailed list of charging levels, including voltages and maximum currents. The standard also lists four “charging modes”, which specify the type of current, protection and signaling. The charging modes mentioned in IEC 61851-1 are

- Mode 1: The battery is charged from a normal household socket with protective earth or standard 3-phase socket. The charging current must not exceed 16 A.
- Mode 2: Also charging from mains using standard sockets, such as IEC 60309. The charging cable must include a residual current circuit breaker. The charging current must not exceed 32 A.
- Mode 3: A dedicated charging station is required. Control and signal pins are used, which improve safety and enable communication between the vehicle and the charging station. For example, it is not possible to start the vehicle while charging. This mode also enables higher charging currents than modes 1 or 2. Protective devices in the charging cable are not needed.
- Mode 4: fast charging using an off-board charger.

Table 1: Categorization of EV charging speeds. The charging time is based on a typical 25 kWh battery.

Charging speed	Typical charging time	Typical charging power	Implementations
Slow	10 h	3 kW	SAE J1772 IEC 62196
Medium	3 h	10 kW	IEC 62196
Fast	15–30 min	50–100 kW	CHAdeMO IEC 62196-3 (TBA)
Ultra-fast	6 min	250 kW	still experimental

The electrical connection between the vehicle and charger can be DC, AC single phase or AC 3-phase. It is not practical to install a large and expensive AC-DC converter into the vehicle. Therefore fast charging is best implemented as DC charging (mode 4). As shown in Figure 4, the charging components which can be carried onboard the vehicle may vary.

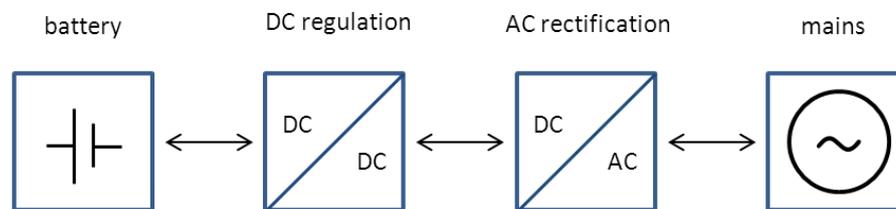


Figure 4: Different stages of power conditioning may be either included onboard the vehicle or at the charging station.

The most prominent standard concerning the electrical connectors used in charging is IEC 62196-2, which was published in October 2011. The connectors listed are

- Type 1: single phase plug reflecting the plug specifications in standard SAE J1772/2009;
- Type 2: single and three phase plug reflecting the plug specifications in VDE-AR-E 2623-2-2 “Mennekes plug”;
- Type 3: single and three phase plug with shutters reflecting the EV Plug Alliance proposal.

The original attempt in EU was to adopt a single standard type of plug for recharging EV. At the moment types 2 and 3 remain as rival designs. The type 3 plug has different

dimensions than type 2 and is equipped with shutters, which are required by law in some European countries. Shutters may provide some additional protection e.g. for children but may be problematic in cold climates due to accumulation of ice. Indeed standardization of charging connectors is complicated due to different electrical installation rules in different countries. Whether the two types will both prevail in Europe will be seen in the near future. Type 2 plug is now used in Germany, whereas French and Italian manufacturers advocate the type 3 plug.

We should note that IEC 62196-2 does not contain a proposal for DC charging (mode 4). This is scheduled for the next part of the standard series, IEC 62196-3 (IEC 2012). Other widespread plug types include CEEplus and Chademo. CEEplus is compatible with standard IEC 309 industrial plugs and connectors. CEEplus plugs suit standard IEC 309 sockets and standard plugs may be plugged into CEEplus sockets. It is able to deliver 16 A current (3-phase).

Battery swapping has been proposed as an alternative to fast charging. In this scheme the EV is driven to a swapping station, battery of the EV is removed, and a fully charge one is installed, and the used battery is sent for recharging (on-site if possible). However, the problems in this set-up may be insurmountable. First of all, all car manufacturers should adopt one, or at worst, a few universal battery designs. The electrical interface should be identical in all battery packs, as well as the mechanical dimensions and attachment. Battery packs have cooling systems with connections to other parts of the vehicle; this interface should also be standardized. Because the size of the battery pack is quite large, it has implications to the whole chassis design. This would limit manufacturers' freedom to design cars, possibly leading to loss of innovation. Furthermore, more battery packs would be needed than in fast-charging scheme. To exaggerate, there should be two battery packs for each EV: one inside the vehicle and one being charged and stored at a swapping station.

Lastly, the battery swapping station would still need the same MV grid connection as fast-charging station for charging the used batteries. From the grid point of view the swapping station could be easier to integrate compared to fast-charging station because there is some flexibility in the charging time of the batteries.

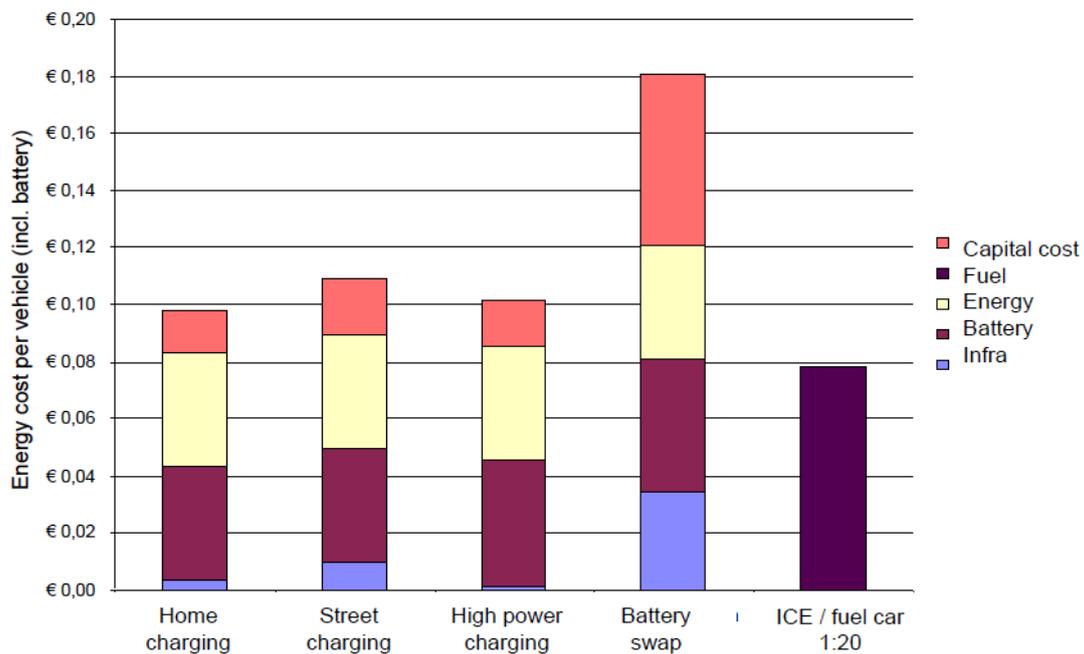


Figure 5: Cost of different charge infrastructure systems per vehicle-kilometer. Cost of modifying the electrical grid was not included in the numbers. Source TNO.

Despite the problems, an EU funded project Easybat has been launched. The project attempts to specify the mechanical, thermal and electrical interfaces of the switchable battery pack (Easybat 2012). A company Better Place has erected the first battery swapping stations in Denmark and Israel. They are compatible with a specific EV model by Renault.

### 3. Scenarios for electric vehicle uptake

IEA Transport, Energy and CO<sub>2</sub> – Moving Toward Sustainability (IEA 2009a) presents several scenarios for EV uptake in the next decades. Here three scenarios are presented: Baseline, BLUE Map and BLUE EV/Shifts. The baseline scenario assumes continuation of current trends without any breakthrough of EVs. BLUE Map scenario forces a decrease in transport related CO<sub>2</sub> emissions and assumes that EVs will be the largest type of personal vehicles globally by 2050. BLUE EV/Shifts assumes even larger share for EVs and a decrease in the use of personal transportation. (see **Virhe. Viitteen lähde ei löytnyt.**)

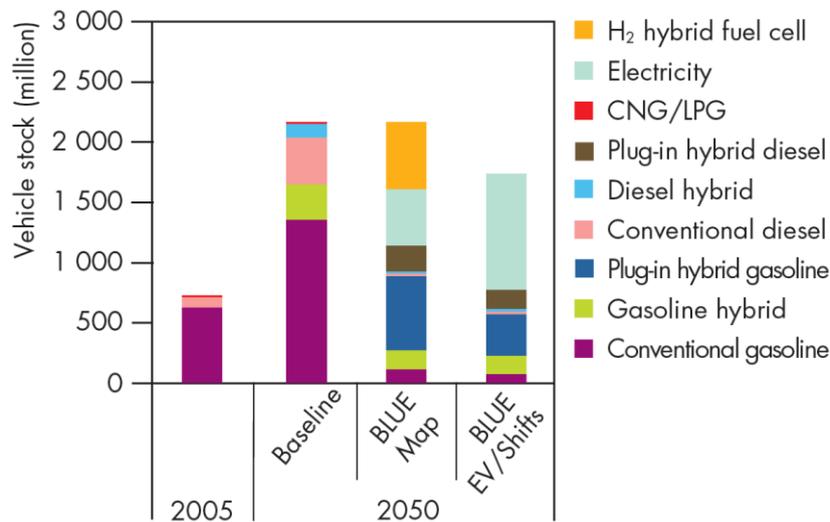


Figure 6. Share of different vehicle types in 2050 according to IEA 2009.

Figure 7 shows the estimated sales of different vehicle types in the BLUE Map scenario from 2000 to 2050. EVs start to gain considerable market share by 2025–2030 and dominate the markets by 2035–2040. It should be noted that the fuel cell vehicles in the chart are likely to be fuel cell hybrids, which also have batteries recharged from the grid.

The IEA World Energy Outlook 2009 (IEA 2009b) also contains estimates about EV market shares. In the ‘450’ scenario it was assumed that climate warming will be restricted to 2°C. In this scenario the share of EVs from personal vehicle says is 16% in 2020 and 28% in 2030. In comparison the reference scenario has no EVs by 2030.

In contrast to IEA scenarios, the two Shell 2008 Blueprint scenarios include one with EV penetration of one third by 2050 and one with only marginal penetration. Roland

Berger Strategy Consultants (2010) has estimated in their most optimistic scenario that the share of EVs will be around 3% of new vehicles by 2015 (1.2 million) in the major markets and 8.8 million vehicles by 2020 (estimated number of new vehicles was 50.2 million in 2015). Deutsche Bank (2008) sees that estimates concerning the EV penetrations even in the near-term are highly uncertain.

In addition to these global estimates, national scenarios have been made in several countries. High scenarios can be found in UK (BERR 2008, highest up to 20 million EVs in 2030, when the current vehicle fleet is around 28 million), in Sweden (Energimyndigheten 2009, up to 3.3 million EVs in 2030 with current vehicle fleet of about 4.3 million), in Switzerland (Alpiq 2009, around 15% in 2020), and in Finland (20% by 2030). The same sources usually have much lower penetration scenarios as well – it is clear that the range of estimates is high and reflects the high uncertainty whether EVs will manage to gain market share over conventional internal combustion vehicles.

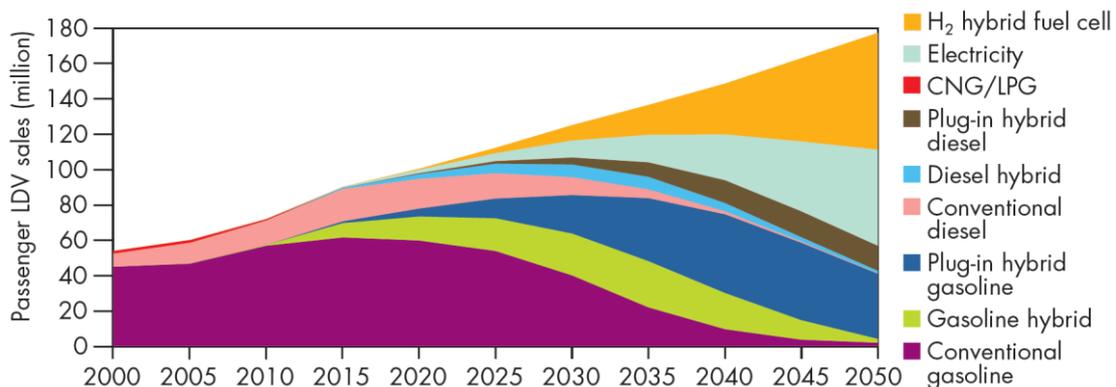


Figure 7. Sales of different vehicle types in the BLUE Map scenario (IEA 2009).

IEA 2009c has collected together several national estimates and calculate that the aggregated range of sales by 2020 is 4–10 million vehicles depending on the assumptions about growth rates for those estimates that were not for 2020. The upper range is higher than the estimate in IEA 2009a, which has sales of around 7.5 million EVs by 2020.

Subsidies play a central role in EV uptake. Governments must consider the effects on environment, effects on economy, and fiscal effects. Currently in many countries transportation fuels are heavily taxed, and the taxes are an important source of income for governments. This is especially the case in EU. If a large portion of vehicles consumed electricity instead of liquid fuels, the tax income would decrease. Most likely other taxes would then be imposed on EV or electricity to compensate for the loss. On

the other hand, decrease of imports, enabled by decrease in consumption of gasoline and diesel, would benefit developed countries. The exact effects on tax revenue depend on the electricity generation mix, taxation of electricity generation and consumption, and availability of domestic fuels.

## 4. Effects of charging electric vehicles

This chapter covers different aspects of electricity consumption of EVs. Timing of charging, total consumption and charging location are the important aspects. Timing is affected by the available periods for charging, charging strategies, and expectations of vehicle users about the status of the battery. Expectations are affected by the vehicle type (PHEV/FEV) and the size of battery pack, since a large battery pack does not necessarily need to be always full at the time of the next departure.

Typical average consumption of battery electricity for EVs is between 0.17–0.25 kWh/km depending on the vehicle mass, drag and driving conditions. In winter conditions electric heating of the car interior consumes a considerable amount of power if there no separate fuel heater. Of course, FEVs consume more grid electricity than what the batteries can output to the power train, since there are losses in charging and inside the batteries.

EVs will increase the total consumption of electricity. However, per capita consumption of electricity, vehicle ownership, and average daily driving distances all have a large variation from country to country. Therefore, the increase in electricity consumption due to high penetration of EVs would also exhibit large variation. With an average daily driving distance of 50 km, per capita electricity consumption of 9.1 MWh/person/year (OECD average in 2007), 0.5 vehicles per capita (approximate for conventional vehicles per capita in OECD), and an average grid electricity consumption of 0.2 kWh/km would yield a 20% increase in the electricity consumption.

Possible charging periods are those when the vehicle could be plugged to the grid and these depend on the factors reviewed in the previous chapter. When EVs are plugged to the grid, the charging strategy (in case of slow and medium charging) then schedules the charging. The most straightforward strategy is to start charging right away at highest available charging capacity until the battery is full. Considering home charging, with high EV penetration this is likely to create a new peak in consumption at the system level and in distribution grids in residential areas. If, as it is probably likely, most EV charging will take place at homes when people come from work or from running errands in the afternoon, the new peak will be in the late afternoon/early evening.

Figure 8 shows when personal vehicle users depart or arrive at home and work. The figure is based on data from the National Travel Survey of Finland (WSP LP Consultants 2006), but the original data has been processed.

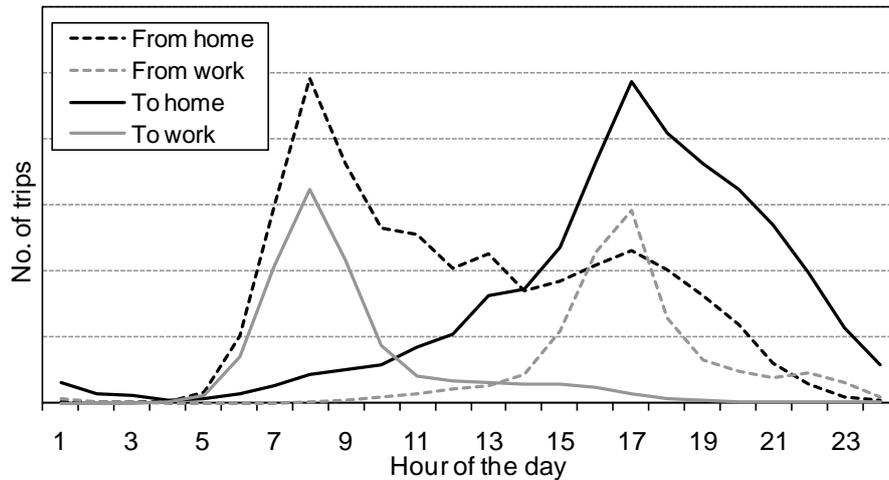


Figure 8. Number of departures and arrivals from home and work for personal vehicles in the Finnish NTS data

#### 4.1 Smart charging or grid-to-vehicle

Smart charging of EV refers to modulation of the charging power according to power system needs. It is also called controlled charging or grid-to-vehicle (G2V). In other words, not only the end-user needs are considered but the charging schedule is decided according to a multi-objective optimization where both the end-user's and power system needs are considered. For example, charging may be delayed when prices on intra-day power market are high, or the load at the local substation is high.

From the power system perspective the perfect strategy would include information about the cost of electricity during the possible hours of charging as well as values for the different balancing and ancillary services that the EVs might be providing. In a perfect situation, it would be known beforehand when the vehicle is going to be used next time and how much electricity the batteries would need at that time. There would also be information about the discounted cost of battery degradation as a function of charging level and charging depth. With such perfect information, the benefits of EVs to the power system could be of same magnitude as the costs of charging. However, in reality some drivers wish to prepare for uncertainties, such as an unexpected need to use the vehicle in the middle of night. For many future EV users, immediate charging could thus hold considerable value.

In the real world, an acceptable smart charging strategy is required. For most users the best option for slow charging might be to have prescheduled departure times for the vehicle with an override option to start charging immediately. Even this will not be easy

enough for some portion of the users and they are likely to prefer immediate charging no matter the cost.

## 4.2 Vehicle-to-Grid

Vehicle-to-Grid (V2G) means that the batteries of an EV, which is connected to an appropriate charging station, could also be discharged to the grid, when the system benefits are high enough. This is opposed to Grid-to-Vehicle (G2V), i.e. smart charging, where power flow is unidirectional, although its magnitude can be modulated. From the consumer point of view this could be profitable when the cost difference between charging and discharging is high enough to cover the round-trip efficiency loss and any degradation that the battery will experience due to extra cycling. Round-trip efficiency of Li-ion batteries in automotive use is 80–90% depending on the characteristics of the duty cycle (Valøen and Shoesmith 2007, Gibson & Kelly 2010). Battery degradation depends especially on the battery type, as well as depth-of-discharge and on the charge/discharge currents. A very high or very low state of charge (SOC) degrades battery more than operating around 20–80% SOC level. High charge currents are usually more degrading than low currents. However, lithium titanate and certain lithium-iron-phosphate constructions can tolerate high currents well.

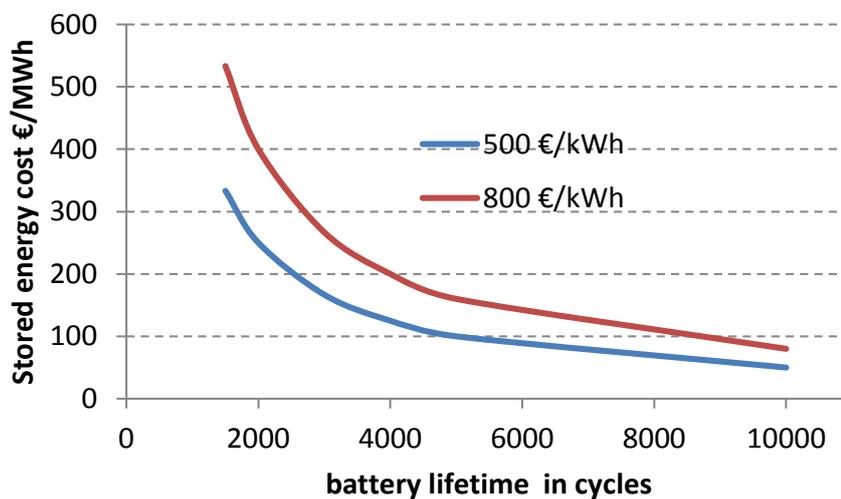


Figure 9: An estimation of the cost of stored energy in batteries emerging from battery degradation, shown as function of battery lifetime (charge-discharge cycles) and battery purchase cost. The picture does not take into account the energy losses in the charge-discharge cycle, which can reach 20 %.

A normal charger would not be able to feed power into the grid; hence additional equipment has to be installed either in the vehicle or at the charging point. For EVs with

3-phase AC motors this could be less expensive because they already have the required inverter. V2G discharging can be treated on power markets the same way as any storage-type DR load.

### 4.3 Examples of effects of EV charging

While conditions will vary considerably from country to country, an example of EV behaviour is shown here to demonstrate the possible effects of EVs in the Finnish power system. Finnish data from the National Travel Survey was analysed in order to extract possible charging periods. It was assumed that almost all EVs could charge while at home and a small share also at work. No other charging opportunities were considered. Figure 6 shows the share of vehicles plugged-in during a typical week. It is notable that at all times large share of vehicles could be plugged-in. Figure 7 shows how much electricity EVs arriving to the grid had spent after their previous charging opportunity. In other words, this is the amount of electricity that has to be charged into the batteries before they leave again. Figure 8 presents the effects of immediate charging. In this example EVs increase the annual electricity consumption by 3.5%. The number of vehicles was 500,000 FEV's and 500,000 PHEV's. Figure 9 is the same as Figure 8, but with smart charging EVs, which are also capable of V2G i.e. discharging when electricity prices are very high.

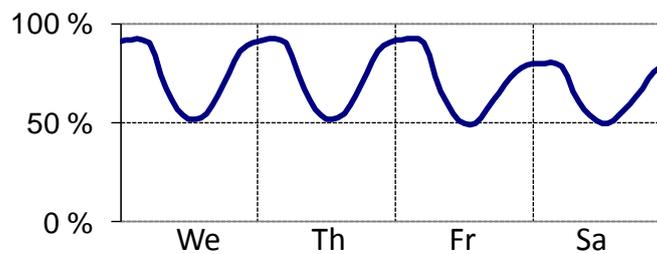


Figure 6. Share of EVs plugged in during four days

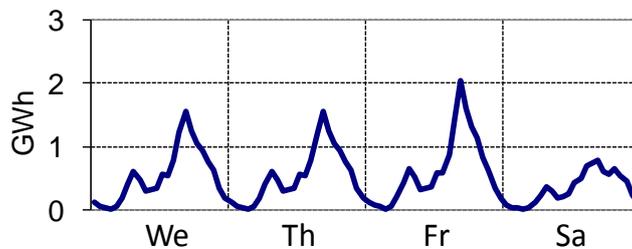


Figure 7. Charging room in the batteries arriving to the grid

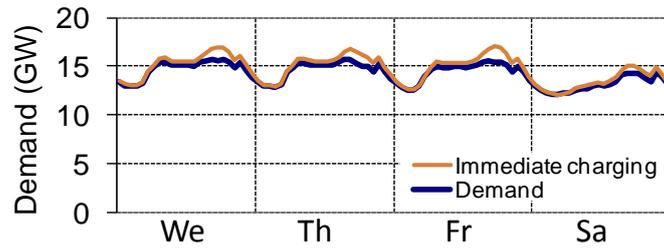


Figure 8. Total demand resulting from immediate charging of EVs on top of other demand in Finland. 500,000 FEV's and 500,000 PHEV's were included in the simulation.

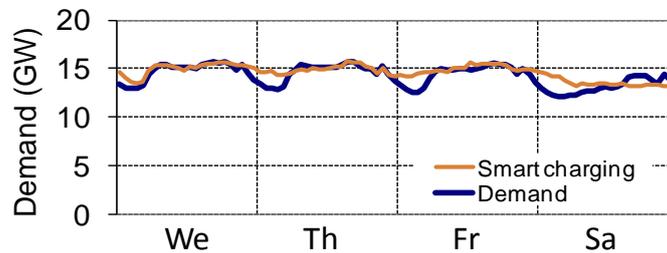


Figure 9. Total demand resulting from smart charging of EVs on top of other demand in Finland. 500,000 FEV's and 500,000 PHEV's were included in the simulation. In this simulation V2G capability was assumed.

An important aspect to EV charging is that of distribution networks. In many areas distribution grids are already overburdened. In these cases additional load from EVs can force costly network upgrades. Some examples are shown in the appendices. On the other hand smart charging EVs could be used to prevent this from happening and V2G might even help to postpone distribution grid enforcements. Naturally this would require additional information to control the charging on top of the market signals and vehicle user settings. In many cases the distribution network load is the highest, when power market prices are low, and vice versa. The services which can be provided by EV smart charging or V2G are discussed in the next chapter.

## **5. Services which can be offered by smart charging and V2G**

Smart charging and V2G can provide the same types of services to the power system as DR and DG in general. In the present situation an aggregator company is needed, which takes care of contracting and selling the power output provided by EV. The role of the aggregator is discussed in more detail in Subtask 7 report.

Charging (or discharging in case of V2G) reprofiling, which the the DR provided by EV, can easily be sold on the day-ahead and intra-day power markets. Naturally this requires that proper forecasts of EV charging in normal situation (in absence of control signals) and forecasts of charging responses to control signals are available and that control signals can be sent to EV chargers or HEMS reliably and quickly.

Smart charging EV's could not only charge (or discharge) according to the organized day-ahead and intra-day power markets, but also offer ancillary services to the TSO. Ancillary services are support services, whose purpose is not directly to provide power for consumer but to ensure the reliability and security of the grid. They include operating reserves, which maintain the frequency of the grid within acceptable margins, reactive power support and black start capability services.

Balancing market is considered to lie in the grey area between electricity markets and ancillary services (Nyeng 2010). EV with smart charging in principle can take part in balancing markets but the rules for participating vary from country to country.

Reserves are used to correct small deviations in frequency that occur throughout time and to provide backup power when large power plants or transmission lines unexpectedly trip off from the grid. There is a considerable lack of consistency in the terminology concerning reserves. Different terms such as primary reserve, secondary reserve, tertiary reserve, frequency-controlled operating reserve, frequency-controlled disturbance reserve, fast disturbance reserve, spinning reserve, etc. are used. Different words are used to mean the same thing and the same English words can mean different things in different countries. ETSO (predecessor or ENTSO-E) has suggested harmonization of the terms (ETSO 2007). Different types of reserves differ in terms of how often they are used, how fast they should respond and whether they are locally or centrally controlled.

Reserves can be in some cases profitably provided by smart charging, depending on e.g. the country in question. Pricing of reserves varies from country to another depending on

e.g. electricity generation portfolios. For example, Anderson et al. (2010) estimate that a modest EV (10 kWh battery and 3.5 kW charging power) could benefit 50 € per month by providing primary reserve on the German market. In Sweden the corresponding reserve type is called frequency-controlled normal reserve, and the benefit could be 20 € per month. These numbers are significantly higher than the profits for different types of flexible loads estimated in the EU-DEEP project, and also do not include costs such as communication between the EV and an aggregator. According to Rezania and Prügler (2012), in Austria the most profitable application would be providing downward regulation (load increase) on the secondary control energy market (UCTE secondary reserve).

The value of V2G on the other hand is dependent on possible sources of income versus the costs from efficiency losses, battery degradation, and additional capital expenditure. Currently no sound business case can be presented: the costs far exceed the possible income generated. Battery lifetime and cost as well as charger cost should be reduced significantly before V2G becomes profitable. Also, if different kinds of demand side management and smart charging EVs will be increasingly available in the future, the possible revenues will diminish. Another trend in the opposite direction (increasing the need of short-term balancing) is that of increasing penetration of variable and partially predictable production such as wind and solar power.

## 6. Status and perspectives of EV in participating countries

The appendices in this report discuss the present situation of EV in Finland, France, Austria, Spain and the Netherlands. We can make the following observations.

### 6.1 Incentives

In Finland currently there are tax reductions for the registration tax and annual vehicle taxes. In France the government provides a direct 5,000 euro subsidy for the purchase of the electric vehicle (max 20 % of the purchase price). In Austria EV's are exempt from the registration tax, and there are direct subsidies (up to 5000 euro) in three of the nine provinces. In Spain some regional governments grant direct subsidies for the purchase of EV. In the Netherlands incentives include total exemption of the registration fee and road taxes, which result in savings of approximately 5,300 € for private car owners over four years (ACEA 2010). There are also parking spaces dedicated to EV.

In general, the incentives vary even inside the country and can change rapidly.

### 6.2 Future scenarios

It is very difficult to forecast the pace of growth in the number of electric vehicles. The scenarios prepared in different countries involve different assumptions, and thus are not directly comparable. If we neglect this problem and take the medium or target scenario from each country and avoid the low and high scenarios (if different scenarios have been presented), we end up with the results in Table 2. Unfortunately, in some cases the figures refer to FEV and in some cases also PHEV is included.

*Table 2: medium or target scenarios of EV penetration in different countries.*

	<i>number of EV</i>		<i>per 1000 people</i>	
	2020	2025	2020	2025
Finland	79,000		15	
France	2,000,000	4,500,000	31	69
Spain	1,000,000		22	
NL	200,000	1,000,000	12	59

### **6.3 Impacts on the electricity grid**

Results from all countries were not available and the parameters used in charging studies vary from case to case. Generally the findings seem to indicate that the effect of charging intelligence is considerable. In Finland and NL a significant portion of the vehicle fleet can consist of full electric vehicles without causing problems to the local grid, if smart charging has been implemented. In other countries, such as Italy, the distribution grid has been dimensioned differently, with very small power allocated to each connection point. In France, 7.5 million EV's and PHEV's (portions not defined) would not cause significant peaks in the transmission grid, if smart charging were implemented. In Finland one million EV's and PHEV's (equal shares) would cause only small increase in the total power demand if smart charging were implemented.

If smart charging is insufficient to alleviate the load caused by charging, problems can be alleviated by encouraging local generation (such as  $\mu$ -CHP's) to supply part of the charging power, and finally by expanding grid capacity.

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## Appendix 1

## Present situation of EV in Finland

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Jussi Tuunanen

In the following sections, the country specific issues about the plug-in vehicles from Finland will be provided. First, as a background, some statistical information about the vehicle fleet from Finland is provided.

In Finland, there is in total about 3 million passenger cars, of which about 80 % are gasoline fuelled, and rest 20 % are diesel engine cars. There were changes in taxation system of the cars in 2008, which increased the popularity of the diesel cars. The annual amount of the registrations of the new passenger cars from the year 1988 is presented in the Figure A-1. The variation in the total amount of the sold cars is mostly due to the development of the whole economy.

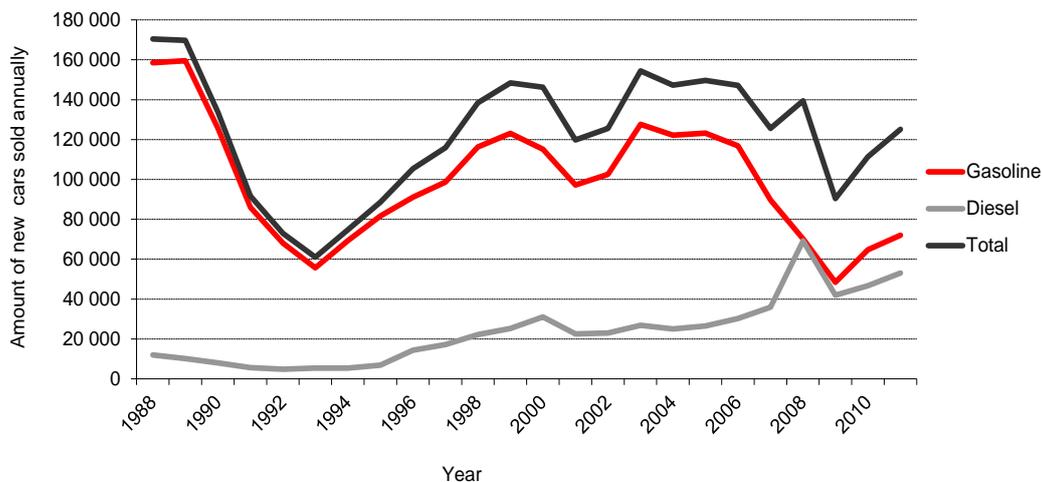


Figure A-1. Annual registrations of the new passenger cars in Finland.

Renovation rate of the car fleet is quite slow in Finland, which affects obviously the penetration of the new technologies. This is further illustrated in the Figure A-2, where the share of the cars in the fleet from the original amount as the function of the car age is presented. It can be seen that for instance over 50 % of the 19-year-old cars are still in the fleet.

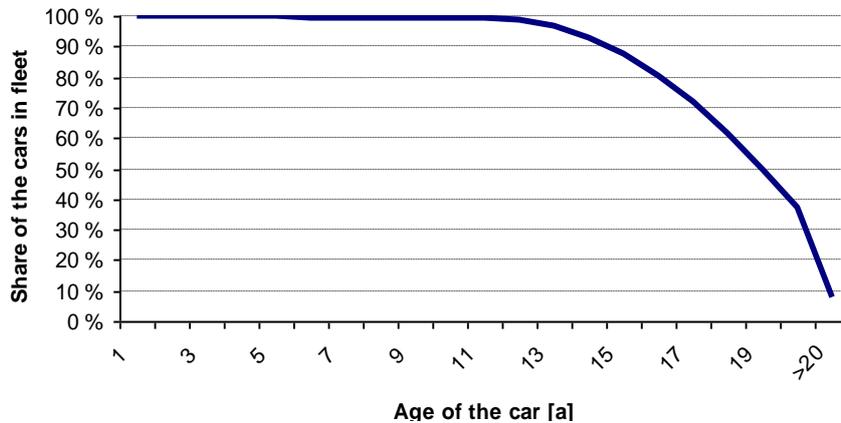


Figure A-2. Percentage of the cars in fleet as the function of the age of the car (based on the information in Mäkelä et al. 2008)

## A1.1 Technologies and their penetration

In Finland there are only a few plug-in vehicles in fleet at the present. In December 2011 there were a total of 56 electric vehicles. From January to May 2012 20 new electric vehicles were registered. Only a few of these EV's belong to private citizens. Actually the number of EV in Finland has *decreased* during the last ten years.

In the national statistics, cars are divided based on the fuel they use to gasoline cars, diesel cars, and others. These statistics from the previous years is illustrated in the Table A-1. Share of the group *other* has increased, but it is still minor, compared to conventional gasoline and diesel cars. This group mostly consists of flex-fuel vehicles which consumer E85 fuel blend but includes also electric vehicles.

Table A-1. Registrations of *new* cars annually in Finland.

Year	Gasoline	%	Diesel	%	Others	%	Total
2005	123 020	83	25 139	17	2	0,00	148 161
2006	116 128	80	29 512	20	60	0,04	145 700
2007	89 789	71	35 782	28	36	0,03	125 608
2008	70 239	50	69 247	50	49	0,04	139 535
2009	48 456	54	41 904	46	75	0,08	90 568
2010	64 750	58	46 709	42	408	0,40	111 867
2011	72 509	57	53 098	42	853	0,7	126 010
2012 (1-3)	28 256	59	18 957	40	590	1,2	47 803

## A1.2 Penetration scenarios

In year 2009, Ministry of Employment and Economy put up working group to find out the meaning of the electric vehicles for Finland. This included such issues as the studies for the penetration of the electric vehicles, as well as considerations of the business potential in the field of the electric vehicles. In the vision of the working group, 25 % of all new cars in the year 2020 are plug-in vehicles, and 40 % of those (i.e. 10 % of all new cars) are fully electric vehicles. Furthermore, the total annual revenue in the field of the manufacturing the electric vehicles and related products (components, software, power electronics etc.) in Finland is estimated to be two milliard Euros in year 2020 (Ministry of Economic and Employment 2009). However, a penetration vision of the electric vehicles seems to be quite optimistic. The outcomes of the working group are based on the research results of the background report (Biomeri 2009). In this report, there is also shown three different scenarios for the penetration of the electric vehicles in Finland for the years 2020 and 2030, as illustrated in Table A-2.

Table A-2. Penetration scenarios of the electric vehicles in Finland (Biomeri 2009).

	year	Proportion of new cars		Cumulative amount of the sold cars		Proportion of annually driven distance	
		PHEV	EV	PHEV	EV	PHEV	EV
<b>Basic scenario</b>	2020	10 %	3 %	66 000	13 000	3 %	0,6 %
	2030	50 %	20 %	480 000	160 000	19 %	7 %
<b>Rapid scenario</b>	2020	40 %	6 %	190 000	26 000	8 %	1 %
	2030	60 %	40 %	960 000	450 000	38 %	19 %
<b>Slow scenario</b>	2020	5 %	2 %	38 000	12 000	2 %	0,5 %
	2030	20 %	10 %	207 000	92 000	8 %	4 %

### A1.3 Policies

Currently there is a purchase tax and an annual tax for the passenger vehicles in Finland, which both depend on the CO<sub>2</sub>-emissions of the vehicle. Purchase tax was previously between 12.2–48.8 % of the purchase value of the vehicle; minimum tax is achieved by the CO<sub>2</sub>-emissions of 60 g/km or less, while maximum tax is for vehicles with the

emissions of 360 g/km or more. Since the beginning of April 2012, the minimum tax was lowered to 5 %, the rate which now applies to EV.

Similarly, annual tax varies between 43.07 €/a (0 gCO<sub>2</sub>/km) to 260 €/a (emission level 223 gCO<sub>2</sub>/km or higher). If the only power source of the vehicle is electricity, its taxes are based on the emission level of 0 gCO<sub>2</sub>/km. In addition to annual tax, there is an annual fuel-tax for the vehicles, which use other fuels than gasoline. This is mainly because gasoline fuel has higher taxation (cent/l) than other fuels. Tax is based on the weight of the car and energy sources, as illustrated in Table A-3.

*Table A-3. Fuel tax of the passenger vehicles from 1.1.2013*

<i>Energy source</i>	<i>Tax (cents/day/100 kg)</i>
Diesel	5.5
Electricity	1.5
Electricity and gasoline	0.5
Electricity and diesel	4.9
Methane	3.1

## **A1.4 Charging studies**

In chapter 5 of the report, there was illustrated a study concerning the impacts of the EV charging from the national power system viewpoint. Similar studies have been done also from the viewpoint of the medium voltage distribution network. Results of these studies, similarly as in the nation level studies, reveal that the peak demand would increase, if the charging of the vehicles is uncontrolled, and, again, by employing smart charging, increase in peak demand can be avoided. The results of these studies are illustrated in the Figure A-3, where the changes in the peak load of a medium voltage feeder in the densely populated area is presented with different charging strategies of the electric vehicles. Relevant input data of the calculations is presented in the figure also.

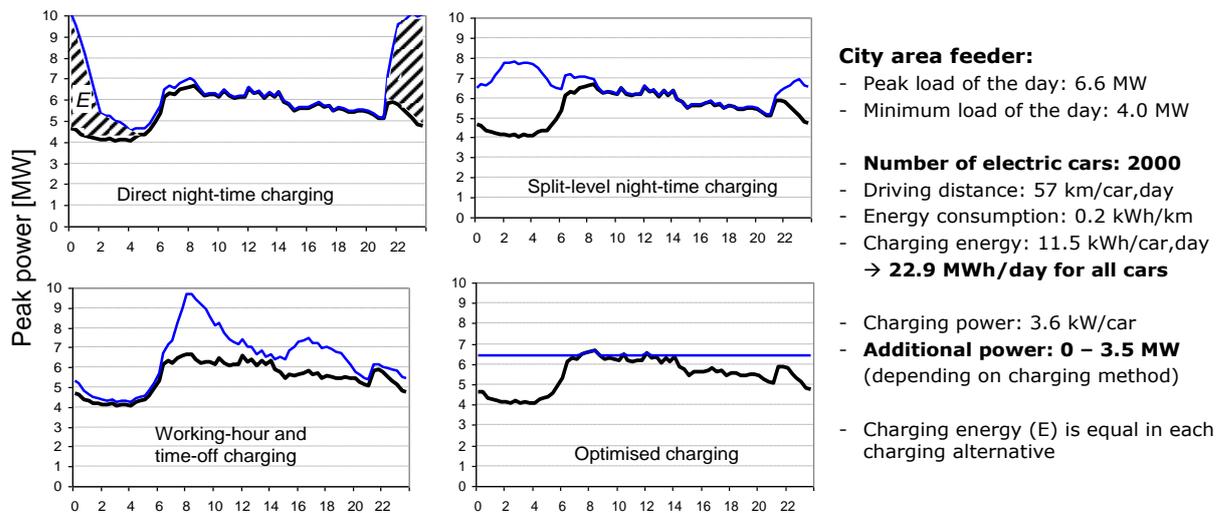
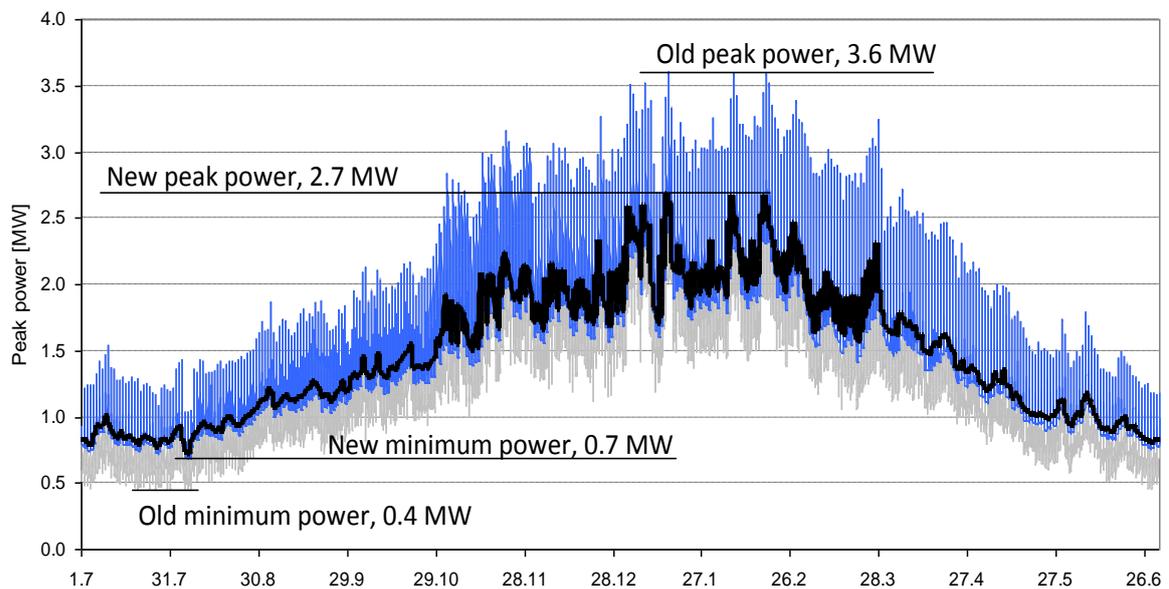


Figure A-3. Peak load of a city area medium voltage feeder with (blue line) and without electric vehicles in four different charging strategies (Lassila et al. 2009).

Furthermore, similar analyses have been done for the assumption that vehicles can also discharge their batteries to grid. This would result to situation where peak demand of the grid can be even decreased from the current situation. In Figure A-4 it is illustrated how the load of a medium voltage feeder would change, if there were a certain amount of electric vehicles with V2G possibility. If the charging and discharging could be done by optimal strategy from the viewpoint of the distribution network, taking also into account the driving habits of the people, the minimum power would increase and peak power would decrease. This would increase also the peak operating time of the network.



*Figure A-4.* One-year load curve with electric cars but without energy storages (the topmost curve) and in the situation where electric cars and energy storages are included (in the middle). The bottom curve illustrates the minimum powers without cars and storages. (Lassila et al. 2010).

In addition, there have been analyses concerning the profitability of the V2G function. In Figure A-5, there is illustrated the price of the battery storage (cnt/kWh) as function of the lifetime (number of the cycles) of the battery. Battery capacity is 30 kWh, and 3 different prices (10, 15, 20 k€) for battery package are assumed. At present, lifetimes of the batteries are assumed 2000-4000 cycles, thus, using them as a storage would not be profitable with the current prices (of batteries and electricity) and lifetimes. However, if lifetimes of the batteries increase and prices decrease, the service would be economically profitable.

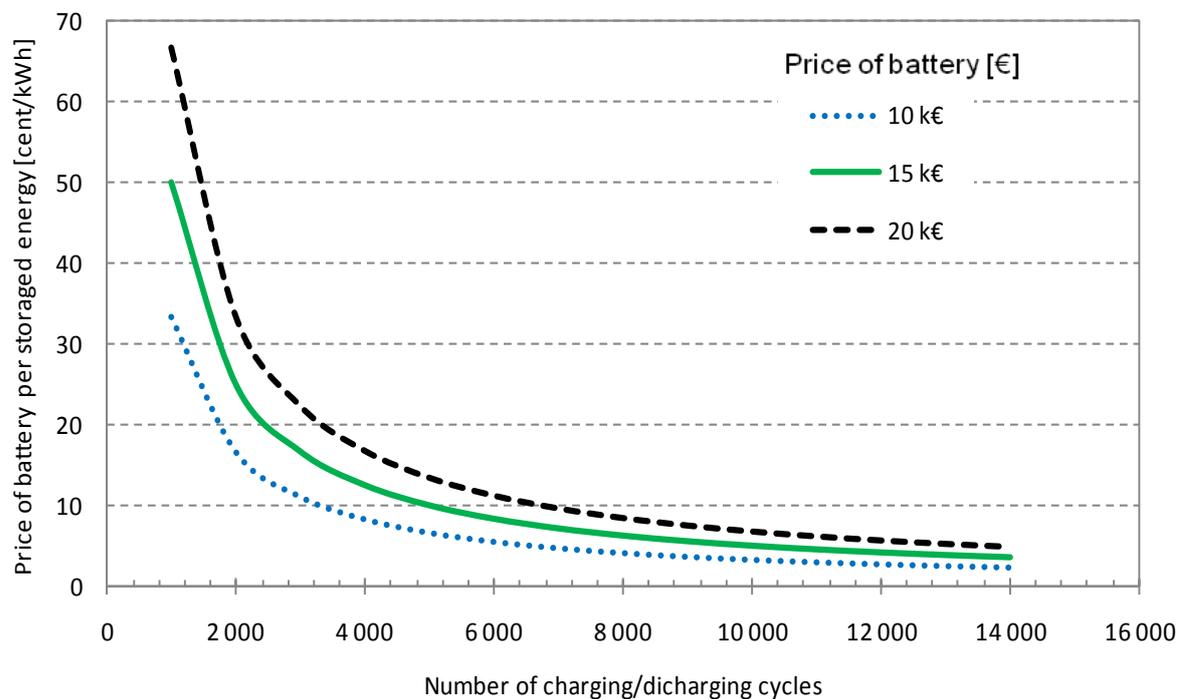


Figure A-5. The cost of 30 kWh battery used as an energy storage as the function of the battery lifetime.

Furthermore, there have been studies about the interface between the plug-in vehicles and power system, including the physical electrical interface and ICT-interface, as well as electricity market models for the billing. The possible principles of these are illustrated in Figure A-6 and Figure A-7.

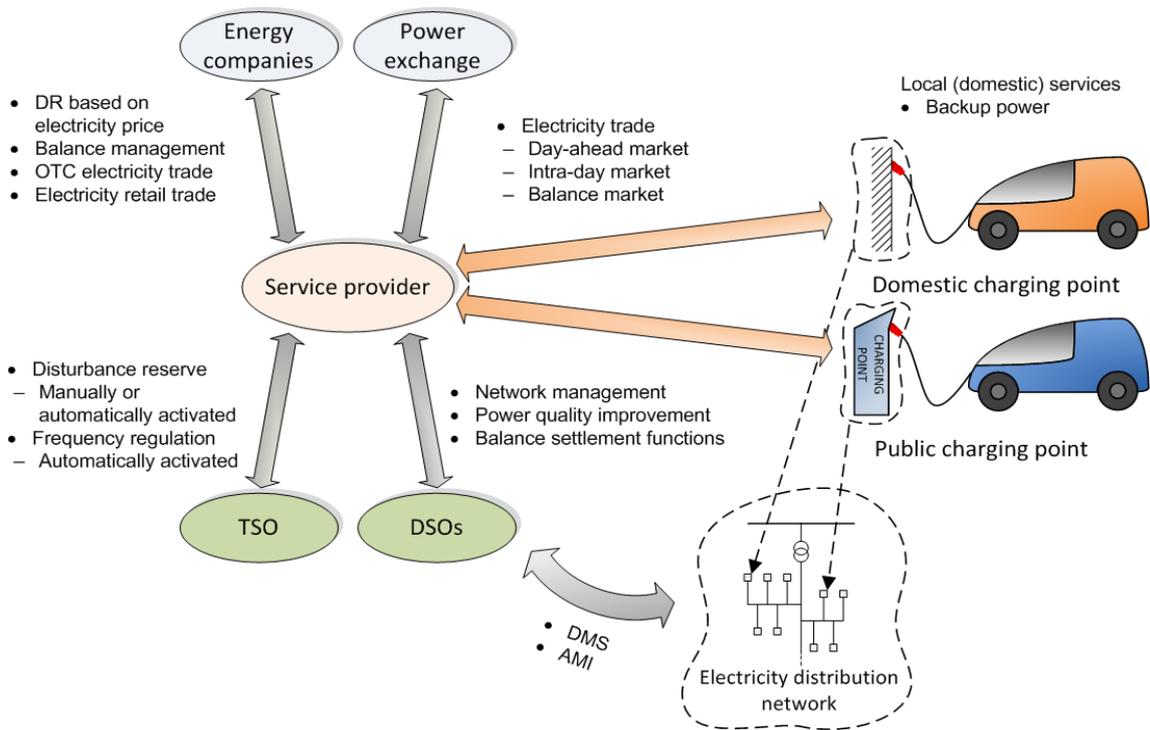


Figure A-6. Interface between plug-in vehicles and power system (Rautiainen 2010).

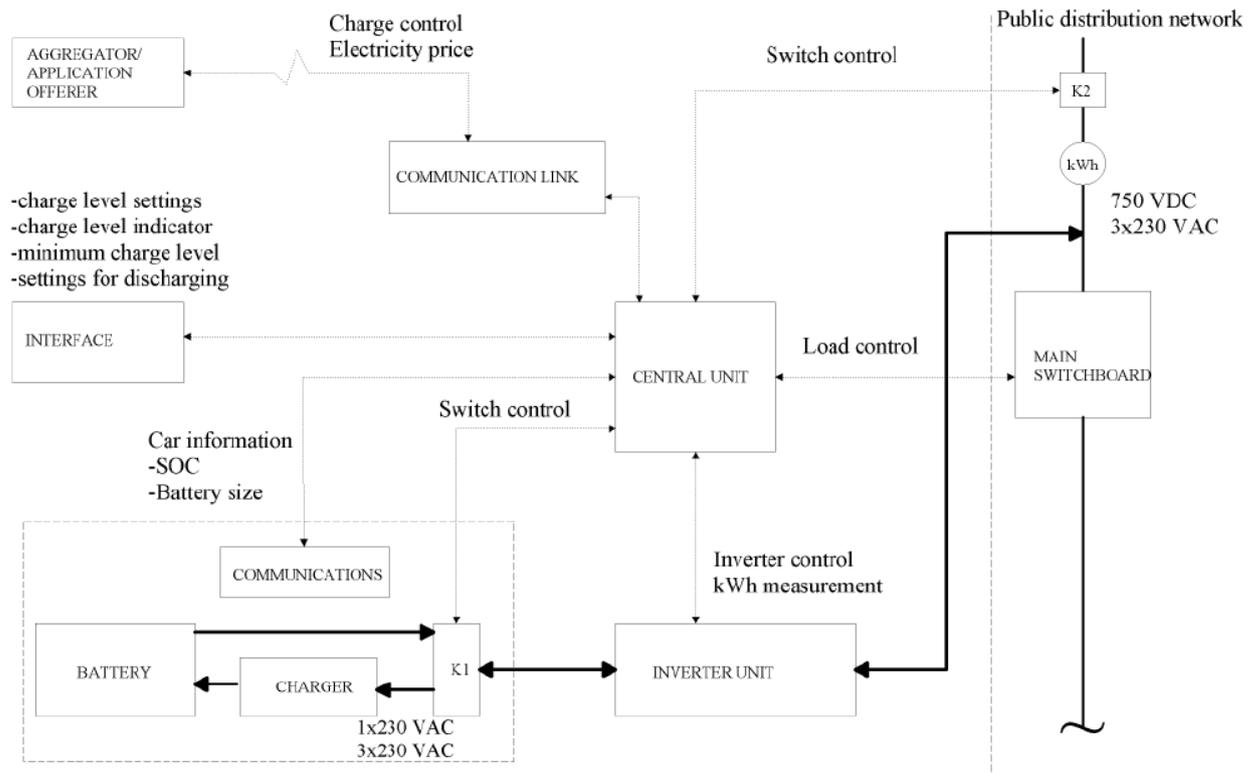


Figure A-7. Charging system with an option to charge or discharge the battery pack (Makkonen et al. 2010)

The research work illustrated in this section is currently ongoing, mostly in the “Smart Grids and Electricity Markets” research program.

## A1.5 Data of vehicle travel

Finnish National Travel Survey, which has been discussed in Section 5, have been utilised in the studies concerning the daily vehicle travel and charging needs. Some statistical information about the travel of the vehicles and people in Finland is provided also here, mostly based on previously mentioned study.

The average daily travelling distance of a Finn is 42 km, of which 32 km is by a passenger car. The amount of the daily domestic trips is three, and average time spend on travelling is 1 hour and 10 minutes per day.

Average kilometres driven by a passenger car per year is 18 000 km/a. Typically, distances of single trips are quite short, although the share of the long trips is more dominating, when comparing them to total driven distance. This is illustrated further in Figure A-8, where the cumulative share of the amount and distance of the passenger car

trips in Finland as the function of the trip distance is shown. Blue line in the figure shows the share of the trips below certain distance from the total amount of the trips. It can be seen, for instance, that 90 % of all the journeys of passenger cars are below 50 km. Furthermore, pink line in the figure presents the share of the trips from the total distance driven by cars. Based on that, it can be seen that about half of the total distance driven by the passenger cars consists of trips below 50 km. This information can be utilised, for instance, to analyse the potentiality and profitability of the plug-in vehicles in Finland.

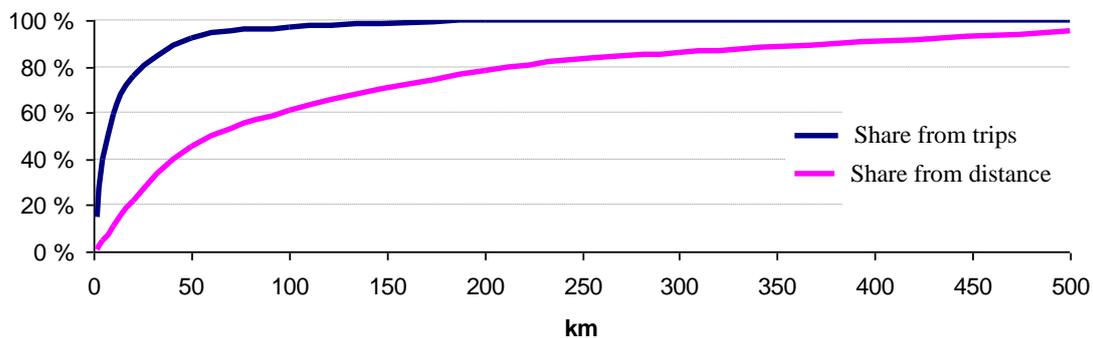


Figure A-8. The cumulative share of passenger car trips as a function of trip distance. Share from the total amount of trips in blue line and share from the total distance of the trips as pink line.

## A1.6 Research and demonstration projects

Following research projects, related to this topic, are ongoing or have been finished lately:

- ENETE – Promoting Energy Efficiency by Energy Companies
  - Project was carried out during 2008-2010, and was finished in August 2010
  - Research institutes: Aalto-University (TKK), Lappeenranta University of Technology, University of Eastern Finland, and VTT
  - Financed by TEKES (Finnish funding agency for technology and innovations) and private companies
  - Major tasks of the project were:
    - Demand control and management
    - Energy monitoring services to the electrical customers
    - Assessment of the spatial impact of the energy saving measures
    - Energy conservation impacts on health
    - Energy saving and energy business

- There have been analyzed, for instance, the impacts of the plug-in vehicles in the energy efficiency objectives, demand side management potential and technology, and impacts of the energy efficiency actions on the electricity distribution
- List of the publications will be in the final report (some of them listed in the references section)
- Final report and publications will be available in end of the 2010
- INCA – interactive customer gateway for electricity distribution management, electricity markets, and services for energy efficiency
  - Project was carried out during 2008-2010, and was finished in August 2010
  - Research institutes: Tampere University of Technology, Lappeenranta University of Technology, and VTT
  - Financed by TEKES (Finnish funding agency for technology and innovations) and private companies
  - Major tasks of the project were:
    - The overall concept; functions, exploiting processes and business models
    - Determination and demonstration of functions and technological solutions of network interface
    - Functions of advanced automatic meter reading (AMR)
    - Network connection of distributed generation as a part of interactive customer interface
    - Network interface of plug-in hybrid cars and effects on network infrastructure and electricity market
    - Technological solutions and business models for market and price oriented demand response
    - Effects of interactive customer interface on overall system-wide energy efficiency and survey of possibilities to develop energy efficiency services
    - Exploiting data of interactive customer interface in enhancing customer load modelling for network calculations, in network asset management and in active distribution management
  - Analysis within this topic have included, for instance, studies of the impacts of the plug-in vehicles for electricity distribution network, charging infrastructure and considerations of the electricity market models for the electric vehicles
  - List of the publications will be in the final report (some of them listed in the references section)

- Final report and publications will be available in end of the 2010
- SGEM – Smart Grids and Energy Markets
  - Five years research program (2009-2014), first funding period 9/2009-2/2011
  - Financed by TEKES (Finnish funding agency for technology and innovations) and private companies
  - All the major research institutes and private companies related to the field of the electricity distribution take part on the research program
  - Research themes include visions for smart grids towards 2035, active resources (demand response, EVs, DG), management and operation of the grid, and development of the electricity markets
  - Some of the publications listed in the reference section
  - For more information, see <http://www.cleen.fi/research/index.php/SGEM>

In addition to research activities, there is a growing industry in the field of electric vehicles. Valmet Automotive Inc. is manufacturing Think City electric vehicle (product of the Norwegian Think As) and will start manufacturing the Fisker Karma plug-in hybrid. Further, it has designed in co-operation with other Finnish expert groups an electric concept vehicle EVA. In addition to car manufacturing, there is battery manufacturing, as Eurobean Batteries Ltd. has lithium-ion battery manufacturing plant in Varkaus, Finland. Furthermore, there have been smaller scale activities in development of electric vehicles, such as electric racecar ERA and some electric conversion from the conventional combustion engine cars, such as e-Corolla and VW Passat conversions.

Furthermore, manufacturing industry in the field of the work machines has been traditionally strong in Finland. Currently there are many study projects for hybridization of these work machines, such as forklifts and cranes, as well as forestry and mine machinery.

## References of the Finnish national report

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Lassila J., Kaipia T., Haakana J, Partanen J., Järventausta P., Rautiainen A., Marttila M. 2010. *Electric cars – challenge or opportunity for the electricity distribution infrastructure?* Proceedings of the European conference on Smart Grids and mobility, June 2009, Germany

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charging and discharging in automotive applications*. SPEEDAM 2010

## Appendix 2 Present situation of EV in France

Raphael Marguet

### A2.1 Challenges

One of the main goals of the deployment of the electric vehicle is to replace in the transport sector the use of fossil fuel by the use of electricity produced from low-carbon energy sources. Indeed the transport sector is responsible of 69% of the French oil demand and 33.5% of the French CO<sub>2</sub> emissions<sup>1</sup> (CO<sub>2</sub> emissions represented 74% of the GHG in 2008<sup>2</sup>).

In the specific French context, and because of the importance of nuclear power in the electricity generation, 89% of the electricity produced in France is low-carbon energy (nuclear, water power, wind power)<sup>3</sup>. Therefore the electric vehicle can potentially have very low CO<sub>2</sub> emissions level, provided that vehicle recharge strategies are well mastered. The ADEME<sup>4</sup> (environment and energy control agency, a public organization) produced a figure (below) in its monthly publication<sup>5</sup> showing the major difference of CO<sub>2</sub> emissions levels of cars for different types of propulsion and energy.

The figure below shows the importance of the energy mix of a country.

The French government has commissioned the French senator L.Negre to produce a Green book (green paper) on the theme “Charging facilities for non-carbon vehicles”<sup>6</sup>. Much information reproduced in this report has been found in this green book.

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<sup>1</sup> Chiffres clés Energie et Climat 2010 – ADEME (p.48 & A7 p.14)

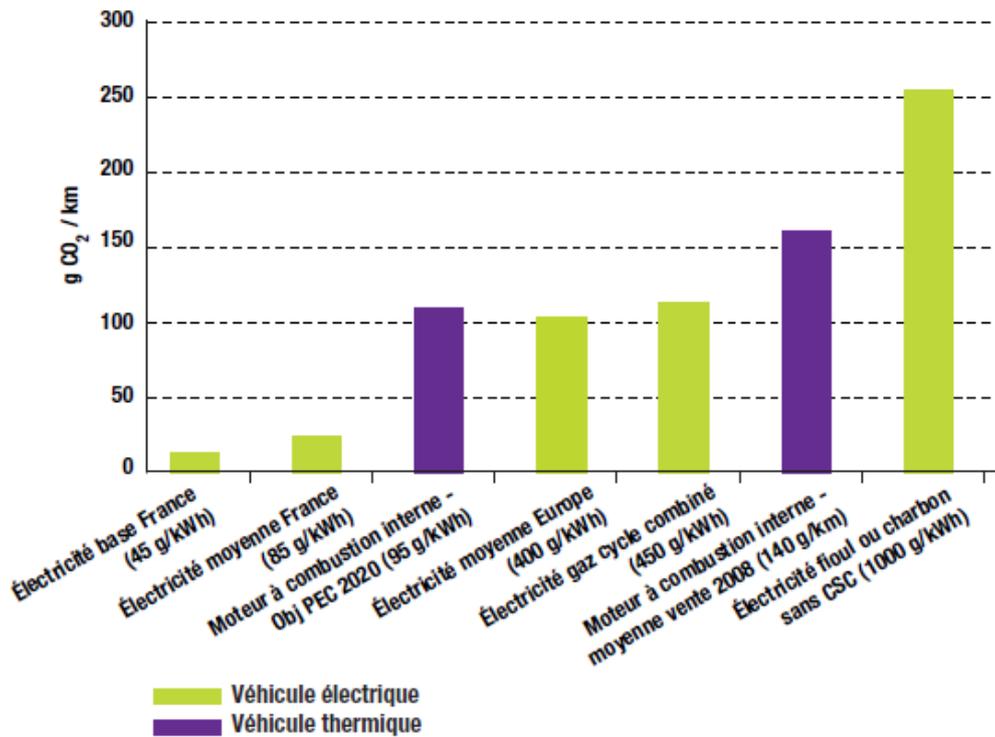
<sup>2</sup> Energy Policies of IEA Countries – France 2009 – IEA (p.33)

<sup>3</sup> Bilan Energétique de la France pour 2010 – MEDDTL (Department of Ecology, Sustainable Development, Transport and Housing)

<sup>4</sup> Agence De l’Environnement et de la Maîtrise de l’Energie

<sup>5</sup> “Ademe & vous” n°21, 21/07/2009

<sup>6</sup> Livre Vert sur les infrastructures de recharge ouvertes au public pour les véhicules « décarbonés » – L.Negre – [www.developpement-durable.gouv.fr](http://www.developpement-durable.gouv.fr)



Source : ADEME

Figure A-9 – CO<sub>2</sub> emission levels of cars from well to wheel for different types of propulsion and energy mixes<sup>7</sup>

## A2.2 The current technological and commercial offer in France

We currently have in France a small commercial and technological offer of electric vehicles (EV), hybrid electric vehicles (HEV) and plug-in hybrid electric vehicle (PHEV). This offer concerns different type of vehicles, batteries, and charging facilities.

### A2.2.1 HEVs, PHEVs, EVs and Batteries

- HEVs, PHEVs and EVs

Even if a few HEVs have already been put up for sale on the French market, the commercialization of EVs and PHEVs will mainly start in 2011. About 15 new EV/PHEV will be on the market until 2013.

- Available HEV and PHEV technologies:

<sup>7</sup> <http://www.smartgrids-cre.fr/index.php?rubrique=dossiers&srub=vehicules&page=6>

HEV are classified in mild-hybrid or full-hybrid technology. The first category is made of vehicle using electricity as backup energy (for startup, strong acceleration...) mainly to reduce the fuel consumption while the second category can use alone either the electric or fuel engine or a combination of both.

PHEVs possess a rechargeable battery but also a fuel engine. They can use either the electric or fuel engine or a combination of both. Their battery power can vary between 5 or 7 kWh.

- Available EV technologies:

EVs are 100% electric vehicles and do not have a fuel engine. Their battery power is usually between 7 and 35 kWh.

The following table shows the current and future (up to 2013) commercial offer of electric vehicles in France.

Caractéristiques des principaux modèles de VE/VHR devant être lancés d'ici 2013 (non exhaustif)										
Techno.	Marque	Modèle	Type	Date	Autonomie	Batterie	Vitesse maximale	Recharge admise <sup>8</sup>		
								CN	CA <sup>9</sup>	CR
VE	Renault	Kangoo ZE	Utilitaire léger	Mi 2011	160 km	Li Ion	135 km/h	X	X	X
		Fluence ZE	Berline familiale	Mi 2011	160 km	Li Ion	135 km/h	X	X	X
		Zoé	Berline compacte	Mi 2012	160km	Li Ion	130km/h	X	X	X
		Twizy	Quadricycle	Mi 2011	100 km	Li-ion	75 km/h	X		
	Nissan	Leaf	Berline	Mi 2011	160 km	Li Ion	140 Km/h	X		X
	Peugeot Citroën	Peugeot Ion	Véhicule urbain	S2 2010	150 km	Li Ion	130 km/h	X		X
		Peugeot Partner Elec. Venturi	Utilitaire léger	S2 2010	120 km	Ni Cl Na	110 km/h	X		
		Citroën C-zero	Véhicule urbain	S2 2010	130 km	Li Ion	130 km/h	X		X
		Citroën Berlingo Elec. Venturi	Utilitaire léger	S2 2010	120 km	Ni Cl Na	110 km/h	X		
	Heuliez	Mia	Véhicule urbain	Mi 2011	90 km	Li Pho Fe	110 km/h	X		
	Bolloré	Bluecar	Véhicule urbain	Mi 2011	150 à 250 km	LMP	130 km/h	X		
	Volvo	C30	Berline	S2 2010	150 km	Li Ion	130 km/h	X		
	Volkswagen	Blue-e-motion	Véhicule urbain	2013	130 km	Li Ion	135 km/h	X		X
Daimler	Smart fortwo	Véhicule urbain	2009	135 km	Li Ion	100 km/h	X			
VHR	Peugeot	3008 / 5008	Monospace	Demo 2012	20 km en électrique	Li Ion	200 km/h	X		
	Opel	Ampera	Berline	Prod. 2011	60 km en électrique pur	Li Ion	161 km/h	X		

Figure A-10:– French commercial offer up to 2013 of EVs and PHEVs<sup>8</sup>

- Batteries

The battery technologies are currently dominated by the Lithium-Ion technology which enabled the launch of EVs because of its high performances.

The development of battery technologies and their industry must overcome three major challenges:

- Technical and economic performances
- Security regarding toxic gas emission and flammability risks
- Recycling and/or second life

The evolution of battery technologies will play an important role in the successful launch of EVs and PHEVs and in their competitiveness against classic thermal engine vehicle.

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<sup>8</sup> Livre Vert sur les infrastructures de recharge ouvertes au public pour les véhicules « décarbonés » – L.Negre – [www.developpement-durable.gouv.fr](http://www.developpement-durable.gouv.fr)

### **A2.2.2 Charging facilities**

Charging facilities are to be installed to provide the charging of the EV fleet in coherence with the economic, electric network and energy production constraints.

Charging schemes will have to avoid:

- creation or amplification of national peak power consumption (which often involves expensive and highly GHG emitting means of production)
- creation of local peak power consumption which is likely to bring local grid congestion

### **A2.2.3 Technical characteristics of present and future facilities**

At the present time very few EV charging facilities exist. For example Paris has 175 charging stations, installed during the last ten years, for a total of 294 plugs. A very small number compared to the vehicle fleet in Paris.

The current charging facilities are composed of a terminal with 2, 3 or 4 plugs for the charge of electric vehicles (two wheels, car or small truck), delivering a 16 amps current<sup>9</sup>.

Recommendations for the development and construction of new charging facilities have been made (see Green book) concerning the types of charging schemes and the plugs.

- Charging schemes
  - Slow/Normal charging:  $P \approx 3 \text{ kVA}$  (16 A single-phased)
  - Accelerated charging:  $P \approx 22 \text{ kVA}$  (32 A three-phase)
  - Fast charging:  $P \approx 43 \text{ kVA}$  (64 A three-phase)

Depending of the charging schemes the charging time varies from 30 minutes to 8 hours. But not every vehicle can handle all three charging schemes.

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<sup>9</sup> Plugs and Charging Facilities for Electric Vehicles – DBT – document reference: TEQCO082.C

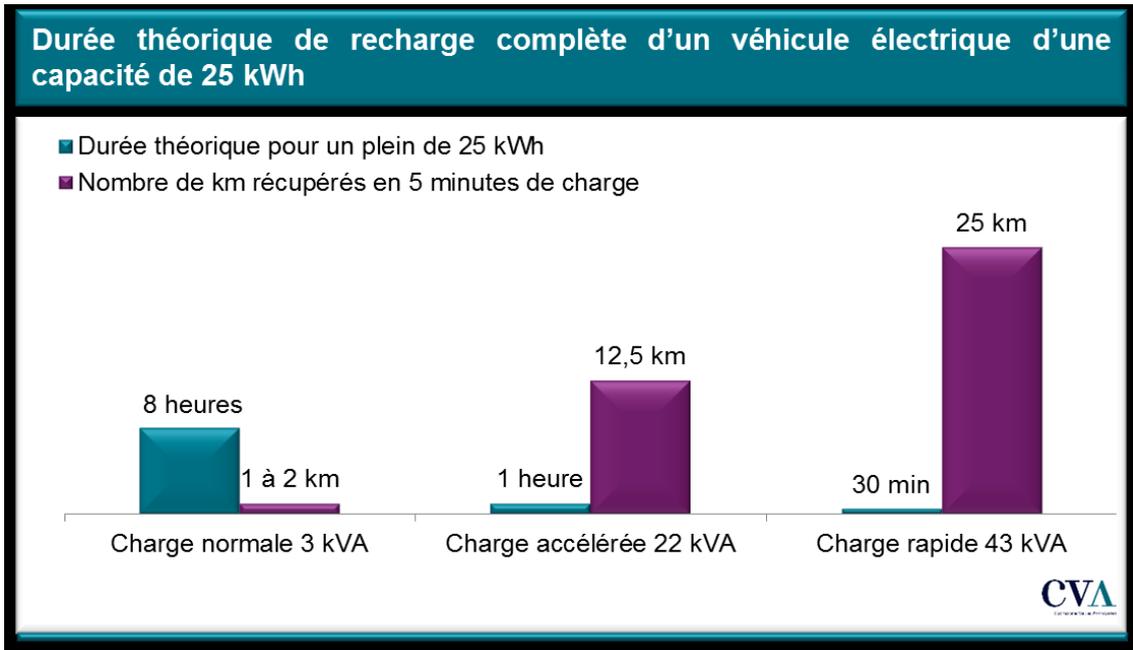


Figure A-11: Charging time and kilometers available after 5 minutes of charge depending of the charging scheme<sup>10</sup>

The charging facilities must be compatible with the greatest number of plugging technologies. Therefore recommendations have been made for the French charging facility stock. They are regrouped in the following table:

	Charging scheme	Plugs		Cables			
		E/F	62196-2 type3	nomad	attached	alternating current	continued current
Terminals	Slow/Normal (3kVA)	X	X	X		X	
	Accelerated (3-22kVA)	X	X	X		X	
	Fast (43kVA)		X		X	X	X

Table A-4 – Characteristics of the terminals recommended for the French charging facilities

<sup>10</sup> Livre Vert sur les infrastructures de recharge ouvertes au public pour les véhicules « décarbonés » – L.Negre – [www.developpement-durable.gouv.fr](http://www.developpement-durable.gouv.fr)

One can note the following:

- The users should have their own cable so that the terminals will be independent of the vehicle-side plugs (except for the fast charging terminals)
- Two types of terminal plugs are allowed by the French regulations allowing the charging of old (E/F) and new generation (62196-2 type3) EVs.

Other charging schemes are being studied but seem unconventional:

- coupling of the charging facility and the vehicle docking in an automated system
- ultra-fast recharge (5 minutes)
- wireless recharge using electromagnetic induction

#### **A2.2.4 Recommendations for facilities usage and configurations**

These recommendations are found in the green paper produced by L.Negre. They tackle the usage of the proposed charging schemes and the configuration of the charging facilities.

- Charging schemes
  - The majority of the recharge (90-95% of the charging energy) must be carried out by slow/normal charging during long-period parking. This type of recharge is well suited for the following charging facilities: private/public night parking, long parking during the day such as company/enterprise parking.
  - The accelerated charging scheme will mainly be developed for reassurance purpose and launching of the EV market. This recharge must be used according to the electric network constraints (local demand, local power available, number of vehicles using this charging scheme at the same time). This type of recharge is well suited for public charging facilities used for an occasional recharge or in short-period parking places (shopping precinct...).
  - The fast charging scheme must only be used for unplanned and very occasional recharge needs or for specific needs such as taxis for example.

### **A2.3 Deployment perspectives**

The French government will play an important role in the deployment of EVs since it will have to guide and lead the way, for the industry first, but also for the general public. Below is given the government's roadmap and the most probable deployment scenarios considered.

#### **A2.3.1 The French government involvements**

The following information comes from the government's press pack "*Launch of the national plan for the deployment of EV and PHEV*"<sup>11</sup> released on the 1<sup>st</sup> of October 2009.

### **An economic model undergoing transformation**

In 2030 the economic model of the car sector will be very different from today's economic model: firstly, combustion vehicles will probably be forbidden to travel in city centers (noise and GHG pollutions), secondly, the property aspect between the users and their vehicles will become less and less important as renting and vehicle-sharing will develop. Anyway, three major factors will make these transformations unavoidable:

- The energetic crisis (oil dependency...)
- The environmental crisis (GHG emissions...)
- The current economic model's crisis (based on fast renewal of vehicles by their owners which is impossible today because of the economic crisis and tomorrow because of the increasing environmental problems)

For all these reasons, the guidelines for the deployment of EVs (and PHEVs) are now written down in a "national plan" (see above) which proposes 14 concrete actions split into the following themes:

- Create a competitive team (research and industry) for the development of EVs
- Anticipate and accompany the future vehicle uses
- Anticipate the environmental challenges

As a beginning the government took two concrete measures:

1. A public order, made together with enterprises, city community organizations and state representatives, for 100 000 EVs until 2015
2. A 5 000 € bonus for the order of a vehicle emitting less than 60 gCO<sub>2</sub>/km

### **A2.3.2 Probable Scenarios**

The ADEME has written in February 2011 the *Guidelines for charging facilities for EVs and PHEVs*<sup>12</sup>.

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<sup>11</sup> Lancement du plan national pour le développement des véhicules électriques et hybrides rechargeables – Ministère du Développement Durable – Dossier de presse – 01/10/2009

Four challenges and three key parameters for the deployment of EVs are pointed out:

- Challenges:
  - Include the vehicle industry in the development of new transport solutions
  - Take profit of a favorable energetic (low-carbonated electric energy production in France) and industrial context
  - Create a public service of electricity supply for EVs
  - Take into account the constraints of the electrical network
- Key parameters:
  - Choice of the standards of the different components of the system  
Charging facilities – Electric vehicles
  - Long term viability of the chosen economic and business models
  - Adequacy between the offer (products, charging facilities, services) and the users' needs

Keeping in mind these ideas, the guidelines of the ADEME proposes visions at horizon 2020 and at horizon 2050.

- Horizon 2020
  - Scenario 1 – *No restriction on combustion vehicle circulation*
    - Strong public investment in charging facilities located in companies parking and private parking
    - Incentive to EVs purchases
  - Scenario 2 = Scenario 1 plus :
    - Public investment in public parking
    - Public investment in targeted street parking or public transport access.
  - Scenario 3 – *Restriction on combustion vehicle circulation*
    - Scenario 2 plus city centers prohibited to combustion vehicle
- Horizon 2050

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<sup>12</sup> Feuille de route Infrastructures de recharges pour véhicules électriques et hybrides rechargeables

Four scenarios for the horizon 2050 are given in the guidelines report. Those scenarios are ranged from the less interactive to the most interactive with the electric grid. The details of the scenarios are not very important as they just serve for working out the different problematic that will show up. However it is interesting to see the range of time on which the deployment of EVs is based: at least 10 years for the premises, 40 years for a mature state of development.

Through the press-pack “*Launch of the national plan for the development of EVs and PHEVs*” and the report gathering the conclusions of the study (“*Groupe de Travail sur les Infrastructures de recharge pour les véhicules électriques ou hybrides rechargeables*”) the French government sight of the EVs market is the following:

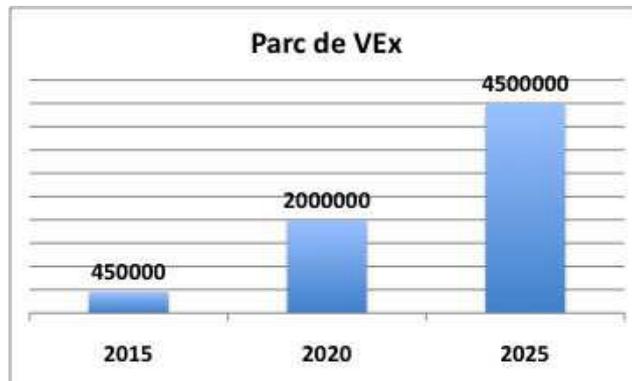


Figure A-12: – Estimation of the number of EVs/PHEVs in the national fleet of vehicles

To be in adequacy with the estimated number of EVs the French government announces the following number of terminals which need to be installed:

Number of terminals	2015	2020	2025
Private or company terminals	900 000	4 000 000	9 000 000
Public space terminals - normal charging	60 000	340 000	750 000
Public space terminals - fast charging	15 000	60 000	150 000
<b>TOTAL</b>	<b>975 000</b>	<b>4 400 000</b>	<b>9 900 000</b>

The study also gives the expected environmental results for 2020:

- fossil fuel import decrease of 4 MToe
- GHG decrease of 17.5 millions of tonne of CO<sub>2</sub>e
-

## **A2.4 Connection and grid management**

### **A2.4.1 Impact on the electric network**

The main impact on the network will be in terms of power, not in terms of energy. Indeed, using the perspectives for 2020 (see Deployment perspectives above) which is of 2 million of EVs/PHEVs, the increase of energy consumption due to the usage of EVs would be of 4 to 5 TWh according to the CRE<sup>13</sup>. This represents only 0.6% of the current French consumption.

However in terms of power, considering that only half of the vehicles (1 million) are using a slow/normal charging scheme (3 kVA) at the same time (during the night for example), it represents an electric power of 3 GW, approximately 2.5% of the current capacity of the French network.

Thereof it is necessary to define:

- a deployment strategy of the charging facilities taking into account the user's needs as well as the network constraints
- Intelligent charging strategies in favor of slow/normal charging scheme in long-period parking charging facilities but furthermore charging strategies which take into account the state of the network (load, capacity...)

The optimization of the charging facilities and the set up of intelligent charging scheme, relying on smart grid technologies, are necessary to achieve a good insertion of EVs on the network and to avoid:

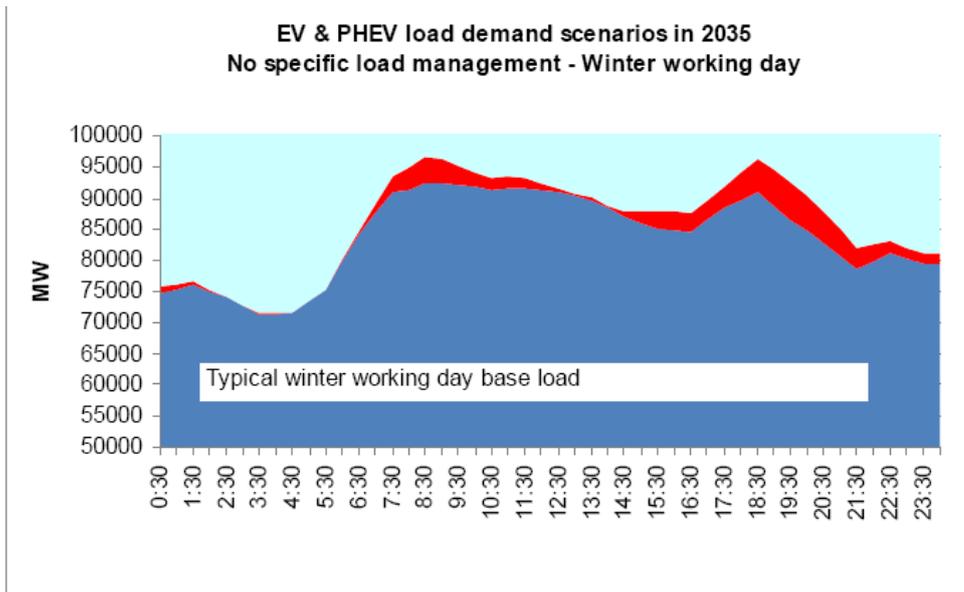
- cost overrun of network facilities
- network safety problems
- the increase of peak-load production resources, often fossil fuel consuming and highly GHG emitting

### **Impact on load profile**

As an insight on the probable impact on load profile the following results show simulations, carried out by EDF, of load demand scenarios at horizon 2035 considering a fleet of 7.5 million of EVs and PHEVs and a classic winter working day.

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<sup>13</sup> Energy Regulation Committee – [www.smartgrids-cre.fr](http://www.smartgrids-cre.fr) – Electric Vehicle folder



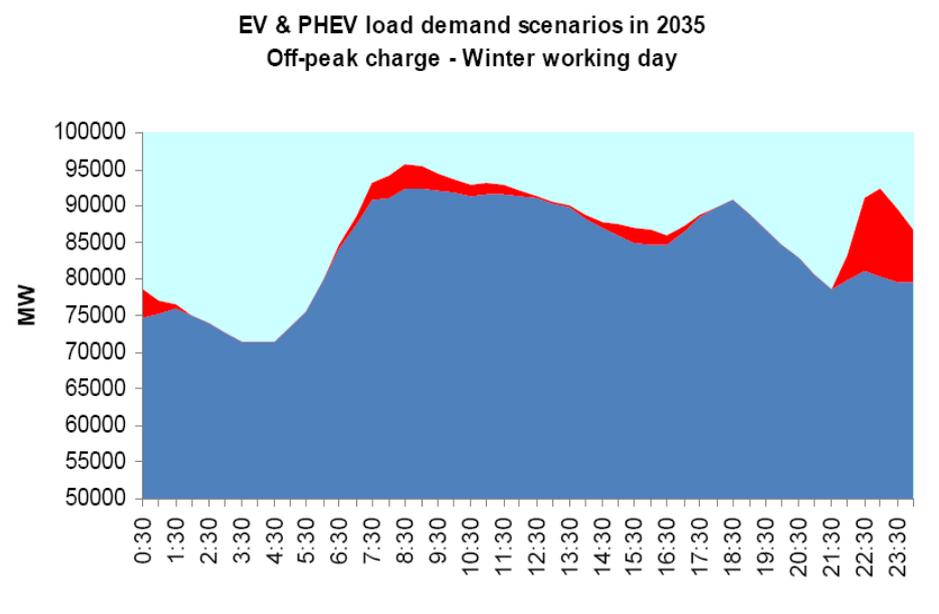
Free charge generates peaks at the beginning of the work period and in late afternoon till early evening



Figure A-13: First load scenario.

The first load demand scenario (Figure A-13) considers that there are no specific load management. It can be seen that the surplus demand of energy due to EV's batteries charging (in red) contributes to the already existing peaks.

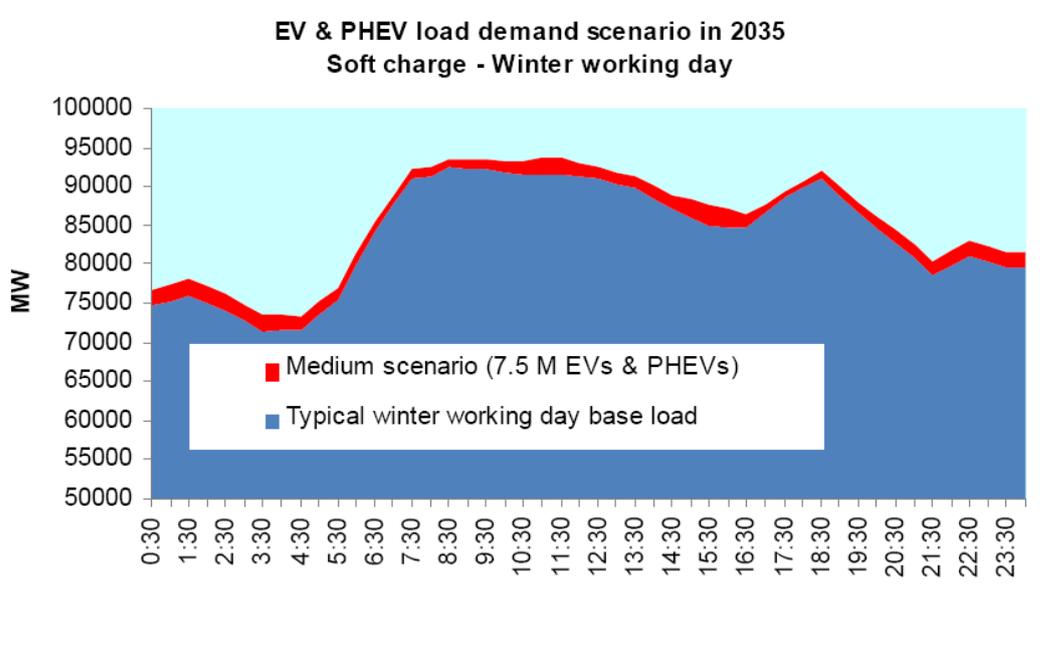
The two other load demand scenarios (Figure A-14 and Figure A-15) show two different load management strategy: off-peak charge and soft charge (which corresponds to a distribution of the whole charge on the entire day). They are two among various possible load management scenarios.



Off peak at night charge generates peaks as well that could be problematic in some local grid configurations



Figure A-14: off-peak charge scenario.



Soft charge is very efficient in getting rid off peaks  
Soft charging EV appears as a steady load throughout the day



Figure A-15: Soft charge scenario.

These results are not presented as a defined and precise solution but rather as an insight on the fact that load management will be strictly required (on a long-term and when EVs will be deployed on a large scale) in order to have an operational electric network.

#### **A2.4.2 Command, Counting and Communication technologies**

During the forum of October 2010 on EVs and organized by the CRE (Energy Regulation Committee), ERDF presented a four stage EV recharge control plan in order to minimize local and national peak production.

The four stages and the corresponding equipment necessary are the following:

- The first stage is located at the client level
  - Charging terminal: the terminal will handle a temporal and power regulation
  - Energy manager's<sup>14</sup> energy meter: the energy meter will handle a financially optimized energy distribution, therefore lowering the costs for the client but also for the Energy manager
- The second stage is at the distribution network level
  - Energy meter: an energy meter permits to optimize the energy distribution depending of various parameters like the TURPE (public electricity network use cost), local network congestion, etc.
- The third and last stages are at the transmission network and the national supply-demand balance levels. Theses stages work like the second stage but at higher scales.

Communication between the different stages will need to be developed to ensure an efficient control plan of EVs recharge.

On the client side, manufacturers seem to wish to develop their own applications (for smart phones for example) for giving information and charging control options to the client.

The green book published by the government puts the emphasis on two levels of energy supply and counting: the charging facilities manager level and the client level.

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<sup>14</sup> The charging facilities will be run by an energy manager which will subscribe to an electricity supplier

On the manager side, a simple counter is necessary in order to charge the energy consumed by the charging facility. The charging facility manager should therefore conclude a contract with the energy provider of his choice.

On the client side it is different. The client should pay for a charging service which incorporates the energy provision costs of the charging facility manager. The manager can then modulate the cost of the charging service depending of various parameters such as charging time, period of the day, charging power level, etc.

The green book recommends a development of billing solutions in two stages:

- Short term stage: the billing solution must be simple, progressive and cheap. The payment will be immediate when carrying the charging of the vehicle. It will be a temporary solution only.
- Long term stage: the billing solution should evolve toward a roaming solution where the client will be able to choose to pay directly at the charging facility, or to pay for a monthly rate letting him charge his vehicle in any facility.

The green book recommendations for the electronic banking solution are the following: RFID (Radio Frequency Identification) reader should be first developed and should evolve toward the NFC (Near Field Communication) technology.

### **A2.4.3 Energy Storage**

The use of EVs as energy storage devices which can deliver electricity in some cases (as backup energy supply for example, or to avoid peaks in the production, which are often highly carbonated, when peak demand occurs) is not yet put forward by industrials.

It is likely that these secondary usages of EVs will be developed by industrials as soon as the market takes off, that EVs represent an important part of the national vehicle fleet and consequently start to have a strong impact on the electric grid.

## **A2.5 Pilot Projects and experiments**

In France the first major experimentations on EVs for the general public started in the late 90s. PRAXITELE and LISELEC are the first two projects (situated in Saint-Quentin-en-Yvelines and in La Rochelle) in which a fleet of EVs and a few charging facilities are available for individual public usage.

In 2003 a national plan grants 40 millions of euros for the research and development of EVs for commercial availability in 2010. During the years 2000, car and equipment

manufacturers developed a few projects on their own (“Cleanova”, “Blue Car”, “I-stars” which developed the start-and-go system, etc).

These pilot projects will be detailed and their results published in the sub-task 6 of task XVII.

## **A2.6 Conclusion**

The deployment strategy of EVs in France has been well studied and is supervised by the government as well as the concerned actors (manufacturers but also network managers).

The strategy consists in controlling the good deployment of EVs by managing the charge of the EVs’ batteries throughout a carefully defined charging structure (facility characteristics, proposed services, etc).

The French energetic mix is a favourable context for EV deployment. Indeed, the French well-to-wheel CO<sub>2</sub> emissions are lower than 20g<sub>CO<sub>2</sub></sub>/km, one of the lowest levels in Europe which is mainly due to the importance of nuclear power in the French energetic mix. Furthermore, the associated industry (car and battery technology and commercial offer) is now well established.

In this context, the government’s plan for EV deployment is an objective of 2 million of vehicles until 2020 and 4.5 millions of vehicles until 2025.

Recommendations have therefore been made by the government in order to manage at best this deployment of EVs. There are recommendations on the charging facilities, which should be able to propose three charging powers, 3, 22 and 43 kVA. But these recommendations also stipulate that the slow charge (3 kVA) must be used for 90 to 95% of the needed energy.

Concerning the charging schemes, the various competent authorities have not given precise recommendations yet. Various scenarios are considered concerning the load distribution: night charge, soft charge (equally distributed on the entire day), etc., but none has yet been preferred or chosen. Indeed a lot of parameters need to be taken into account, and they are sometimes in contradiction, like the impact of the charge on the load profile which will be much different at local levels than at national levels.

## Appendix 3 Present situation of EV in Austria

Rusbeh Rezania

### A3.1 Technologies in use and their present situation in Austria

In 2011 there were 4.5 million vehicles in the Austrian passenger car fleet of which 989 were battery electric cars were registered in Austria (see Table A-5). While the number of hybrid cars increased steeply in the last years the number of electric cars remained on a very low level.

Table A-5: Fleet penetration of hybrid and electric cars (2006-2011) (Data Source: Statistics Austria, 2010)

	2006	2007	2008	2009	2010	2011
<b>Passenger vehicles</b>	4204969	4245583	4284919	4359944	4441027	4513421
<b>Battery electric vehicles</b>	127	131	146	223	353	989

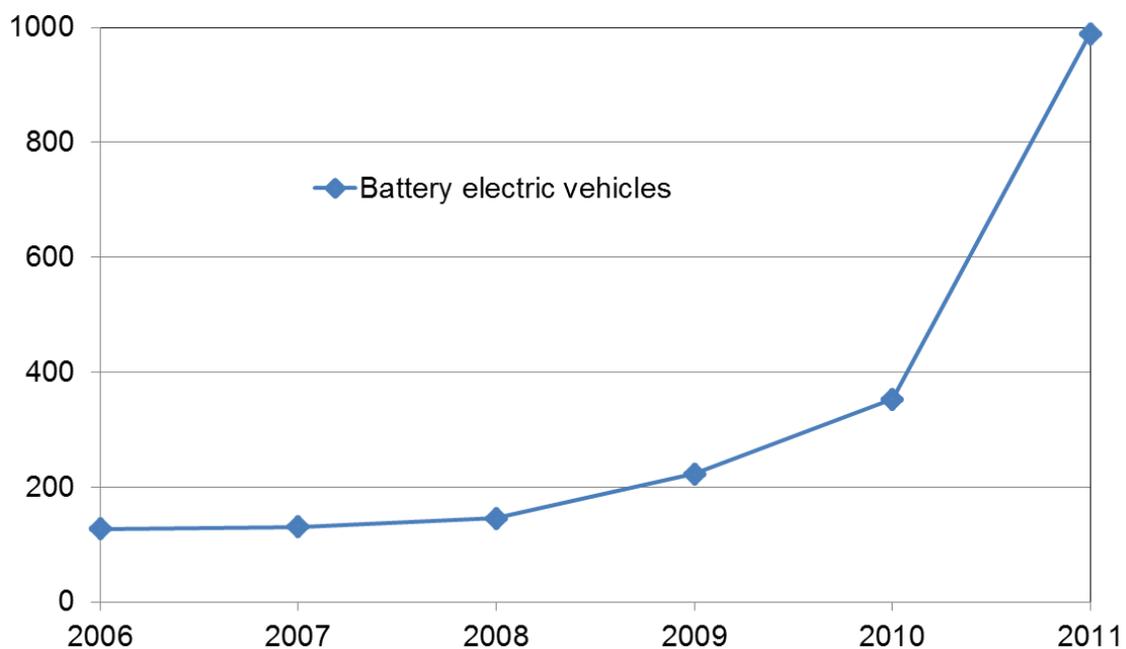


Figure A-16: Hybrid and Electric cars in the Austrian passenger car fleet (2006–2011); (Data Source: Statistics Austria, 2011).

### A3.2 Standardization of EV charging – initiatives in Austria

In Austria the initiative “e-connected” (see <http://www.e-connected.at>) focused within several workgroups on possible future Austrian EV developments and necessary steps towards a sustainable system integration of electric mobility. One of those workgroups focused on EV charging stations and corresponding EV charging standardization. Therefore, the main findings and recommendations of this initiative (see e-connected, 2009 & 2010) is summarized below.

In the area of EV charging stations many products evolved during the last years leading to compatibility problems of a future EV charging infrastructure. Thus, Austria has to consider world-wide and European standards for EV charging. Such standards are currently developed or existing ones upgraded (compare IEC 62192–2 and ISO/IEC 15118-1).

Different types of charging station are mainly defined by the place of charging leading to the following distinction:

- Private charging (EVs are charged at private properties such as garages)
- Semipublic charging (charging takes place on private properties which are accessible publicly e.g. parking lots or shopping malls)
- Public charging (charging takes place on publicly owned properties)

Furthermore, the situation of EV charging in Austria currently allows all types of plug solutions, but in the long term a consolidation towards a standardized plugging system following the IEC 62196 seems to be likely. Regarding fast charging (> 30 kW) solely DC charging following the CHaDeMO-Standard18 (with a YAZAKI-Plug) is expected to become a standard solution.

Battery change systems as proposed e.g. by Better Place (see [www.betterplace.com](http://www.betterplace.com)) offers the opportunity to reduce grid load especially in peak consumption periods. On the contrary, acceptance of car manufacturing companies towards such standardized battery change systems still is limited. Therefore, Austrian EV suppliers currently do not offer such solutions.

### **A3.3 EV Policies in Austria**

#### **A3.3.1 Fiscal Policy**

In Austria electric cars are excluded from tax on ownership and tax on acquisition (up to 16 %). (Source: Austrian Federal Ministry of Finance)

### **A3.3.2 Subsidies**

There is one nationwide subsidy program that supports the acquisition of electric vehicles for commercial fleets of up to 10 cars or light-duty vehicles (with curb weight lower than 3.5 t) with 2500 € respectively 5000 € in the case that renewable electricity is used. The subsidy is financed by the “*klima aktiv mobil*” initiative supported by the Austrian federal ministry of environment. (Source: [www.klimaaktiv.at](http://www.klimaaktiv.at))

There are also subsidies for the acquisition of electric cars in three of the nine federal states: up to 5000 € in Lower Austria, 1500 € in Styria, 750 € in Burgenland.

Furthermore, there are subsidies in cities and municipalities. (Source: [www.e-connected.at](http://www.e-connected.at))

### **A3.4 Charging infrastructure, metering and ICT - developments in Austria**

In the following, charging possibilities and infrastructure needs for private, semi-public and public charging technologies are discussed in the context of the current Austrian situation (see again e-connected, 2010).

- **Private charging**

Expert estimations as well as recent project results (Vlotte, 2010) indicate that private charging places and adequate infrastructure will be of major importance in Austria. According to IEC 61851 (Charging mode 1) charging via one or three phases is allowed in private installations if a Residual Current protective Device and overcurrent release mechanisms are installed properly. Thus, the maximum charging capacity results at an allowed charging current of 16 Ampere to approximately 3.7 kW. In order to reduce peak charging events in addition to actual peak demand periods an adequate bidirectional communication solution needs to be implemented between private charging stations and the system aggregators.

- **Semipublic charging**

Operators of semipublic charging stations will decide whether they offer a conventional or fast charging infrastructure. Accordingly they will reflect cost for infrastructure installation in their business models and corresponding charging fees. In general, existing legal framework and upcoming charging fee regulations need to be abided. It is further foreseen to implement recommendations for public charging infrastructure design.

- **Public charging**

Public charging stations should serve on the one hand for public awareness building as well as to provide charging infrastructure to EV customers. However, it is recommended, that solely 1-5% of total charging infrastructure should be public which demands standardization in order to offer services for all EV customers regardless of the region of supply. Especially the high cost for public charging stations will hinder a very broad implementation. For fast charging appliances these high cost in the long run will be reflected in higher service fees compared to conventional charging solutions.

The issue of metering addresses topics of gauging, as each customer per charging plug needs to be billed separately according to national law. Smart Meters are applicable in principle if they provide values added such as e.g. load management. In order to identify the customer for the billing the national experts discussed different system authorization technologies.

- Authorization via RFID Card (Radio Frequency Identification)
- Authorization via Bank Account Card
- Authorization via SIM Card (Subscriber Identity Module)

In order to provide sufficient communication bandwidth for billing services (including roaming) as well as load management several ICT option are available. Two applicable solutions for EV charging and billing needs were discussed to be:

- PLC (PowerLine Communication)
- GSM (Global System for Mobile Communications)

The corresponding communication protocol of TCP/IP is recommended as it enables the possibility of bidirectional communication, acceptable costs, no limits in data types, well known administration as well as easy integration into existing infrastructure systems.

### **A3.5 Experiences derived in Austrian fleet tests**

In December 2008 the project “VLOTTE” - focusing on the demonstration of e-Mobility - started in the province of “Vorarlberg” situated in the western part of Austria. The core motivation of the project leading team thereby can be cited as (see [www.vlotte.at](http://www.vlotte.at))

“The Vorarlberg Electric Vehicle Planning and Consulting Corporation (VEA) – an enterprise of illwerke vkw – is primarily responsible for the implementation and support

of the VLOTTE and serves as the platform for all partners which are necessary for a successful and effective execution of the VLOTTE project.

One of our tasks is worldwide monitoring of new technologies in connection with electro-mobility. With the execution of on-road tests new technologies are being checked for “mass suitability”.

Further tasks are centralised buying, negotiation of frame contracts, installation and coordination of service points and a vehicle-oriented monitoring. Moreover, the corporation is responsible for a carbon neutral supply of energy.”

Within this demonstration project e-mobility data on vehicle travel was analyzed in order to derive charging profiles and estimate impacts on the existing grid infrastructure (compare Schuster, 2010 a&b). As shown in Figure A-17 collected charging behavior of VLOTTE EVs (Think! electric cars with Zebra batteries) was analyzed to derive probability functions whether EVs are charging, are connected to the charging infrastructures or not. Correspondingly, most of the EVs have finished charging until 4 a.m. whereas almost all cars are in standby charging state between 7 and 8 a.m. During the day, charging events tend to increase whereas most of the cars start charging between 4:30 and 7:30 p.m. resulting in an average charging power of 0.74 kW/vehicle.

Furthermore, the performed data analysis focused on charging losses, driving behavior and plugin times by suiting the VLOTTE cars with GPS loggers (for detailed descriptions it is referred to Schuster 2010 a&b). As most of the cars are used within business units the charging profiles are representative for business consumption. Residential consumption, charging behaviors and corresponding charging profiles are currently analyzed in further Austrian projects that are summarized in the following subsection.

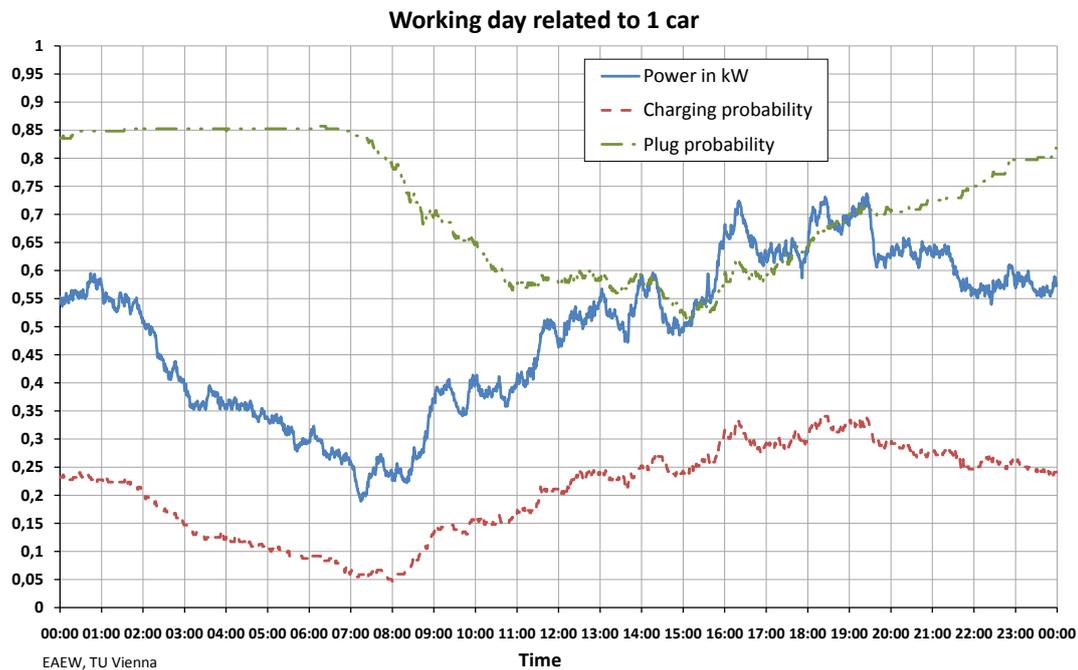


Figure A-17: Mean charging profile as well as the probabilities of charging and plugging at a working day referred to one electric vehicle (Source: Schuster 2010b)

### A3.6 Further Austrian research and demonstration projects

The following selected Austrian research and demonstration projects, model regions as well as technology development initiatives addressing the topics of electric vehicles and system integration have recently been performed or are currently ongoing:

#### A3.6.1 Model regions

Currently five e-mobility model regions exist in Austria, which are

- *VLOTTE* (western Austria); The VLOTTE model region is one of Europe's biggest model region. The second phase of the implemented business concept towards e-mobility will address EV renting stations for customers. The granted investment subsidies so far are € 5.2 million.
- *Electrodrive Salzburg* (central Austria); The special design of the Electrodrive initiative offers e-mobility leasing models directly to customers. An investment subsidy of 1.2 million € was granted in 2009 for this model region.
- Model region *e-mobility on demand* in Vienna (eastern Austria); This model region will initiate publicly available e-mobility and charging infrastructure until 2012 via an e-mobility card in combination with Viennese public transport. Hundreds of EVs and charging stations should be installed in Vienna during this time period. Investment subsidies of 1.3 million € were allocated in 2010.

- *E-mobility Graz* (southern Austria); In Graz the introduction of EVs and charging infrastructure will be done from a mobility system perspective. Above all, the utilization of EVs and public transport should become more attractive within the city of Graz. Investment grants of 1.6 million € were accepted in 2010.
- *Model region Eisenstadt* (eastern Austria); In this model region the introduction of electrified taxis in combination with car sharing and car pooling is foreseen. Investment subsidies of 560 k€ were granted in 2010 as well.

### **A3.6.2 Technology development initiatives**

Besides EV related model regions, in Austria special technology development initiatives were introduced (by the Austrian Climate and Energy Fund; see [www.klimafonds.gv.at](http://www.klimafonds.gv.at)).

In the first phase of this research program the project EmporA won the competition. The Austrian Verbund AG as project leader performs fundamental research towards EV development, system integration and future business and marketing models together with the companies Siemens, Infineon Technologies, EVN, MAGNA STEYR, Raiffeisen-Leasing and The Mobility House. The strong interconnection of these project partners to other European EV related research and demonstration project strengthens the aim of becoming an innovation leader in e-mobility system design. For further details it is referred to the website [www.austrian-mobile-power.at](http://www.austrian-mobile-power.at)

A second project, which qualified for subsidies in the first program phase, was the initiative Clean Motion Oberösterreich (upper Austria) trying to make Austrian businesses fit for e-mobility. Project Partners of this project are ALPINE-ENERGIE Österreich, Automotive Solutions, STEYR MOTORS, voestalpine Stahl Linz and several other players. Especially the innovation competences and market situation of Austrian businesses in the car-producing sector should be improved in the context of e-mobility. As a result job creating potentials as well as regional awareness increases should be main outcomes of the project.

In 2010 three projects qualified for research in investment subsidies (in total 9.2 million €) in the second phase of the research program. Those are:

- Second stage of the project EmporA – EmporA2
- Second stage of the Clean Motion Oberösterreich initiative as CMO – Clean Motion Offensive
- and the project eMORAIL - Integrated eMobility Service for Public Transport.

### **A3.6.3 Selected research projects (addressing system integration of EVs)**

- **Vehicle to Grid - Strategies**

Technical, economic and ecological impacts for Austria's energy system (until 2050) due to massive e-mobility penetrations are examined. The options of system related e-mobility integration in urban and rural case studies are analyzed developing active grid integration as well as new business models (e.g. loading strategies, balancing services) for Grid to Vehicle and Vehicle to Grid concepts. As key results a tailor made guideline and action plan for Austrian decision makers are derived.

Project status: ongoing

Project type: research project

Coordination: Vienna University of Technology – Institute of Energy Systems and Electric Drives “Energy Economics Group “

Contact: [www.eeg.tuwien.ac.at](http://www.eeg.tuwien.ac.at)

- **Vehicle to Grid - Interfaces**

New concepts for user interfaces (visualisation and graphical user interface) for e-mobility costumers within the Smart Grids model region of Salzburg are developed; parameters and cost/benefits of a future Vehicle to Grid implementation will be evaluated by this feasibility study. Based on this, an implementation plan for suitable software developments (experimental development) as well as a demonstration phase are derived.

Project status: ongoing

Project type: research project

Coordination: Salzburg AG

Contact: [www.salzburg-ag.at](http://www.salzburg-ag.at)

- **VehicleGrid**

This project enables the possibility to estimate the impact of EVs on the Austrian energy system and estimates the necessary management system (communication between the participants and proper optimization) which is necessary that such a system can be successful. Additionally, it is planned that

the results of this project will be gathered in a follow up project and constituted in a demonstration project..

Project status: ongoing

Project type: research project

Coordination: Vienna University of Technology – Institute of Computer Technology

Contact <http://energyit.ict.tuwien.ac.at/>

- **SEM - Smart Electric Mobility**

This project works out the challenges of power systems and chances of electric mobility in order to develop solutions therefore. Focus is set to the use of battery storages in vehicles. They are used for mobility and balancing of fluctuating renewable energies. Furthermore the charging process is of high importance in order to derive effects on the electric grid infrastructure and expansion demand of charging infrastructure. Both aspects are analyzed in coordination with the vehicle users' needs in a technical and economical way.

Project status: ongoing

Project type: research project

Coordination: Vienna University of Technology – Institute of Energy Systems and Electric Drives

Contact: [www.ea.tuwien.ac.at](http://www.ea.tuwien.ac.at)

- **KOFLA - Kooperatives Fahrerunterstützungssystem für optimiertes Lademanagement von elektrischen Fahrzeugen**

This project considers the new mobility behavior induced by electric vehicles and their frequent need to recharge the batteries. We propose a cooperative solution approach in which a centralized broker mediates between the moving electric vehicles (EVs) requesting service and the recharging stations offering recharge capacity. The broker finds the best match for each user and balances the service load and the electric grid load between recharging stations.

Project status: ongoing

Project type: research project

Coordination: The Telecommunications Research Center Vienna (FTW)

Contact [www.ftw.at](http://www.ftw.at)

- **Consumer demand and willingness-to-pay for alternative and electric mobility in Austrian regions: Implications for environmental goals and policy (ELMAR)**

The main goal of this study is to produce new fundamental knowledge on the market potential of alternative vehicles (AVs, e.g. Electric Vehicles (EVs)) through estimating consumer demand and willingness to pay (WTP) for various types of vehicles in Vienna and its surroundings. The research design will identify the main driving forces that influence the consumers' WTP – including, for instance, demographic and socio-economic factors, mobility patterns, political incentives as well as environmental and technological attitudes. Also, the relative importance of the vehicles' attributes, such as purchase prices or range, can be investigated and the main trade-offs identified. The outcomes of the consumer demand model will serve to calculate the share of AVs in the road transport system and the greenhouse gas and pollutant reduction potential. As a result, this research will provide a firm basis for future technology-, energy- and climate policy in the transport sector, especially with regard to implementation plans and programs for alternative mobility.

Project status: ongoing

Project type: research project

Coordination: UMWELTBUNDESAMT GMBH (Environment Agency Austria, EAA)

Contact [www.umweltbundesamt.at](http://www.umweltbundesamt.at)

- **Challenges of the large-scale introduction of battery-powered electric vehicles in Austria (e-mobility 1.0)**

In an integrated assessment the overall technical, economic and ecological challenges of a large-scale introduction of e-mobility in Austria are modeled and assessed, combining and expanding existing models for the time-dependent electricity demand and for the electricity system response.

Technical, economic and organizational aspects of battery charging infrastructure as well as related pricing and accounting systems are examined. Perspectives and recommendations related to necessary framework conditions and required developments for an optimal integration of large-scale introduction of e-mobility into the Austrian electrical power system are developed in interaction with relevant stakeholders from the electricity and automotive industry sector.

Project status: ongoing

Project type: research project

Coordination: JOANNEUM RESEARCH

Contact [www.joanneum.at/](http://www.joanneum.at/)

For further projects it is also referred to the mobility program (see A3 Plus at [www.bmvit.gv.at](http://www.bmvit.gv.at)) of the Austrian Ministry of Technology and Innovation as well as the Austrian Climate and Energy Fund.

## References of the Austrian national report

e-connected 2009.: Final report part 1; [www.e-connected.at](http://www.e-connected.at); Vienna, 2009

e-connected 2010.: Final report part 2; [www.e-connected.at](http://www.e-connected.at); Vienna, 2010

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## **Appendix 4                      Present situation of EV in Spain**

Asier Moltó-Llovet

Regarding the Spanish case the present situation of electric vehicles could be defined as a first phase of implementation. In fact, even if the current penetration is very low, the regulatory framework and the Spanish electric, ICT and automotive sectors are working in being prepared for the next phases of the EV market.

One point of big interest in Spain that should drive many of the future developments is the role of “aggregator”. An aggregator of electric vehicles is the commercial middleman between a collection of PEVs and electric system agents (TSO, DSO, retailers). From the TSO perspective, the aggregator is seen as a large source of generation or load, which can provide ancillary services and can also participate in the electricity market with supply and demand energy bids.

REE as TSO would undertake the measures needed to guarantee the reliability of the system independently of PEV features integration (fast charges, slow charges, valley charges, etc.). However PEV integration impacts on the electric system would be very different, and therefore the measures.

For example, if managed charging is not adopted at all REE foresees a significant impact on its national load curve. In the worst case foreseen (all vehicle electric vehicles fast-charging when arriving home at evening) there could be an increase of 6000–7000 MW of the peak load. In this case, the system would require at least 7000–8000 MW of new generation and probably transmission assets.

On the other hand, at least 6.5 million PEVs could be charged without any additional investment in generation and transmission if smart charging is implemented and most of the additional PEV consumption is allocated during valley periods.

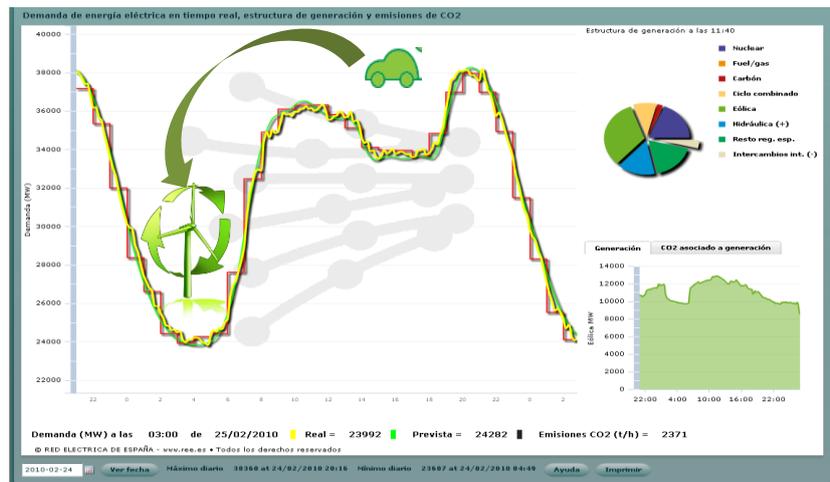


Figure A-18 Smart charging for PEV's

Consequently, it is really important to promote smart charging in the development of PEV technology and the aggregator could play a key role in this issue.

## A4.1 Current Spanish Market

During 2011 only 450 PEVs were sold in Spain (Source: ANFAC), among this EV, the most sold was the Peugeot Ion (125 cars) followed by the Citroen C-Zero (85 cars) and the Nissan Leaf (59 cars).

## A4.2 Regulatory Framework

The Spanish government has launched different initiatives in order to promote the integration of EVs. On the 6th of April 2010 a Comprehensive Plan for the Development of Electric Vehicle was published. Its main objective is to promote the development of electric vehicles and related infrastructures on the first development's stages. It establishes goals for 2014 in the whole country: 252.000 electric vehicles and more than 300.000 charging points. Four working areas have been defined in order to fulfil this objective:

- Promotion of EV sales: monetary incentives for EV purchase and infrastructure development have been established (% of the EV cost up to 6.000€).
- Industrialization and R&D: companies can benefit of financial resources in order to support the industrialization and EV development by means of national industry. Some of the most important EV R&D projects in Spain benefits of that kind of support; for example the VERDE project above mentioned.
- Promotion of charging infrastructure and side management services:

- Horizontal programs: regulatory framework and legal barriers suppression, communication programs, promotion and training of new specialized jobs, etc.

As far as the regulatory framework some important changes has already been made. The Electricity Sector Act (ley 54/1997) has been modified in order to include a new actor, the “Load manager” (therefore the regulatory framework for the aggregator has been created), and a consumer with the capability to resell energy for charging EVs, and a new activity, the “Charging services”. The text of the law relates those new figures with EVs and renewable integration. Some others minor changes have been introduced in order to facilitate infrastructure installation in residential buildings. Finally, new super off-peak tariff has been designed for EV consumption.

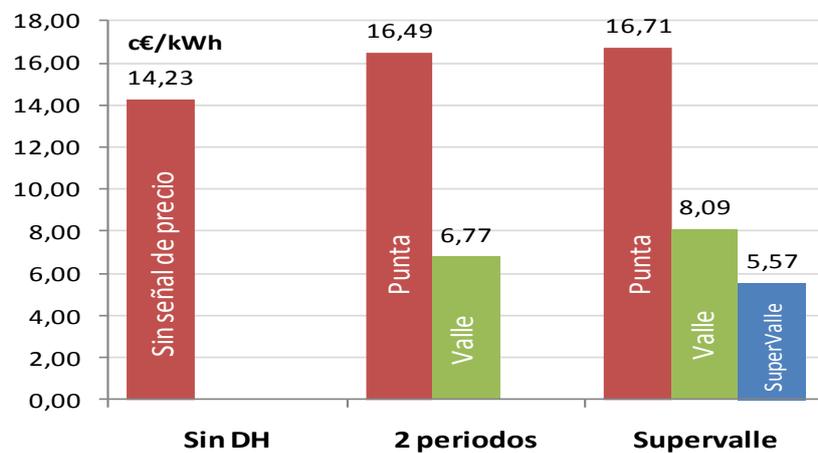


Figure A-19: Spanish EV super off-peak tariff.

In addition the Ministry of Industry is working on a new Technical Instruction in order to legislate all aspects about the needed infrastructure for charging EVs. Nowadays a draft of this document is under discussion.

### A4.3 Spanish studies and pilots

In addition to the European projects in which Spain is involved, there are two national projects in this field: VERDE project and DOMOCELL project.

- **VERDE Project**
  - *Participants:* Electric utilities (REE; ENDESA, IBERDROLA), car manufactures (SEAT, LEAR, FICOSA), others manufacturers (CEGASA,

SIEMENS, CIRCUTOR, ETC.), engineering (TECNICAS REUNIDAS, COBRA), TICs (AIA), research institutes (LABEIN, IIT, CIRCE, etc.)

- *Time period:* September 2009 to March 2012
- *Project Description (objectives/goals):* The project's main goal is to investigate the key issues to solve in order to manufacture and integrate successfully EV in Spain. The main areas of work are: mechanical and electrical technologies, energy storage systems, propulsion systems, design and control of converters, local infrastructure and integration in the electric system (infrastructure, services, energy and environmental balances).
- *Demo, Study vs. Simulation:* The main goal of the project is to obtain demo results at vehicle, infrastructure and communication level. However, simulations would be performed in order to extend the results and conclusions.
- *Vehicle Type and Quantity:* 1 SEAT PHEV prototype

- ***DOMOCELL Project***

- *Participants:* Electric system (Gas Natural-Unión Fenosa, REE), others (INDRA, CITEAN, Universidad Politécnica de Valencia, Universidad Carlos III, ORBIS, Socoin, Neoris, Amplia, Ncaza, etc.)
- *Time period:* 2010-2012
- *Project Description (objectives/goals):* The objective is to create a charging system which enables a smart management of the vehicle charging process providing services to the electric system.
- *Demo, Study vs. Simulation:* Demo project.
- *Vehicle Type and Quantity:* 4 PHEV. A smart charging communication platform will be developed for its installation in public garages

#### **A4.4 Spanish market forecasts**

In Spain, the Comprehensive Plan for the Development of the Electric Vehicle in Spain forecasts that an integration of PEVs integration which could lead to 1.7 million

electric vehicles by 2020. More conservative scenarios lead to 1 million. Those values would imply an increase of the annual loadenergy consumption of 2-5 TWh (0.6–1.5 % of the forecasted annual load for 2020).

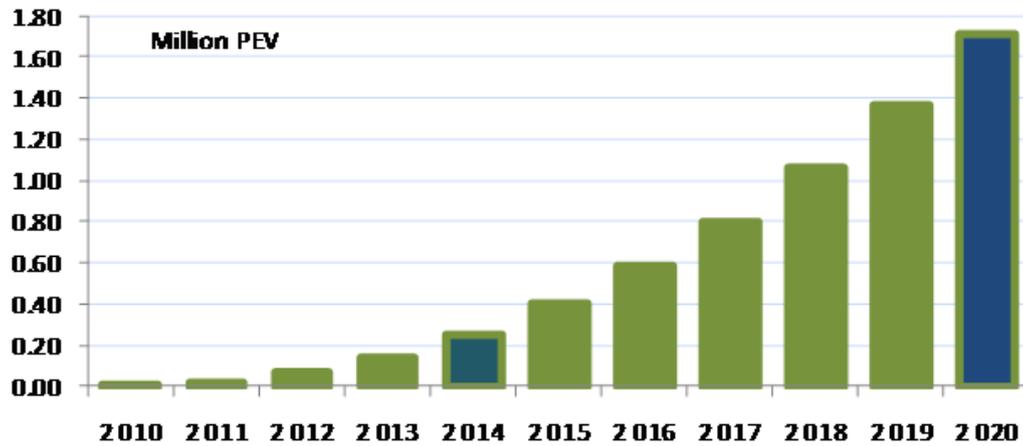


Figure A-20: PEV's penetration in Spain (aggressive scenario).

## **Appendix 5            Present situation of EV in the Netherlands**

André Postma, Enexis.

### **A5.1            Introduction**

At this moment there are approximately 7.8 million cars present in the Netherlands. These cars predominantly run on conventional carbon-based propulsion technologies such as petrol, diesel and gas. However, due to economic changes, geographical factors, environmental issues, legislation, dependency on fossil energy sources and a growing concern with regard to climate change a shift to a sustainable electric automotive solution is eminent. Next to offering a feasible solution for the negative aspects of conventional vehicles, zero emission electric vehicles offer great potential for the near future. In The Netherlands there are many initiatives for electric vehicles (further: EV's) and the charging infrastructure for EV's and both are deployed in a rapid pace.

The developments regarding EV's are on-going and EV's already offer a driving experience that is comparable or even superior to conventional cars. With the current generation of battery packs and powerful electric motors, EV's can already easily participate in the daily traffic with a sufficient cruising range. The electric car is becoming inevitable and nearly every major automaker has an active program to develop and introduce EV's, ultimately providing the consumer a broad range of options. Next to state-of-the-art EV's a widely spread charging infrastructure is of utmost importance for a successful breakthrough of full scale electric transportation. A much heard constraint for potential users with regard to buying an EV is the limited cruising range combined with the absence of a covering number of charging facilities. Several parties acknowledge this issue and in the near future a rapid rollout of charging facilities is envisioned.

Before 2008 the theme EV was hardly an issue in the Netherlands. In the governmental paper of January 2008 "Een prijs voor elke reis"<sup>15</sup> the item EV was mentioned and in this paper the climate round EV was changing in a positive way. It was noted that e-mobility may be in interesting development.

### **A5.2            First steps to mass EV deployment in the Netherlands**

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<sup>15</sup> A price for every drive

In 2008, the first pilot projects for deploying an infrastructure were developed. However, at this moment these charging infrastructure projects are not aligned with one another. Because of this separate “poles” of charging infrastructure suppliers are emerging. Each column is centred on a supplier of infrastructure with his own: charge spots, identification cards, electricity plug, communication technology, charging technology, etc. Simultaneously it was recognised that the availability of EV’s was very poor. So several initiatives were started to retrofit cars with an ICE to an EV. But this obviously is no base for mass deployment; therefore OEM cars are inevitable.

To investigate the possibility of mass e-mobility deployment the government decided to install a task force by the Formule e-team. The aim of this team is to realise a break through regarding charging infrastructure, batteries and EV availability.

At the same time it was recognised that standardisation and interoperability are key. So the first steps were to consult stakeholders as much as possible how to reach an agreement regarding plugs, charge mode and identification authorisation. At the same time some stakeholders like the majority of the Dutch DNO’s took their responsibility and launched the initiative to develop, deploy, install and operate the public infrastructure for the first 3 years. All these initiatives have led to the current situation:

Interoperability is guaranteed by a stakeholder agreement laid down in the Dutch Technical Agreement NTA 8623.

Basis agreements:

- The used plug will be type 2 (Mennekes) according IEC 62196-2
- The charge mode will be mode 3 according IEC 61851
- The identification will be via NFC (near Field Communication) With radio frequency 13,56 MHz Tag 1 functionality according ISO/IEC 14443A

These agreements guarantees that every customer will be serviced at any public charge pole whatever his service provider or charge pole operator may be.

### **A5.3 Penetration of EVs in The Netherlands**

In 2009 the Dutch aim for deployment of EV was established. There were three scenarios investigated how the deployment of EV's towards 2050 could happen; called Fast, Medium and Slow <sup>16</sup>.

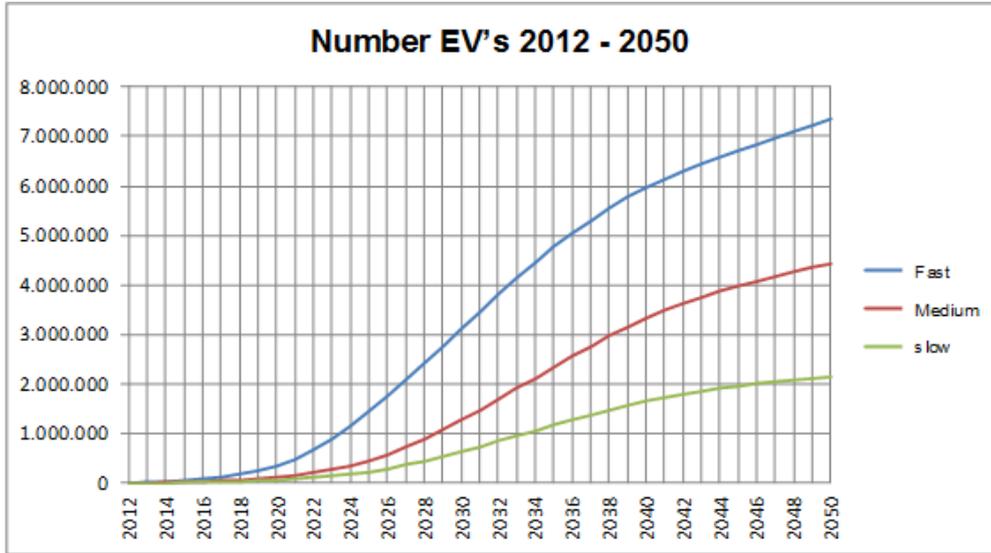


Figure A- 21: Scenarios of EV deployment in the Netherlands.

From these investigations the Dutch *target* until 2025 was formulated as follows. This is somewhere between the Fast and Medium scenario.

Table A-6: Target for amount of electric vehicles

<b>Year</b>	<b>Electric vehicles on the road</b>
2015	15.000 to 20.000
2020	200.000
2025	1.000.000

The reality shows a slightly slower deployment as projected. In 2011 there were about 1600 EV's, and in May 2012, 2126 EV's.

<sup>16</sup> Source Movaris

Looking at the deployment of the personal EV's from 2009 until 2012 the amount of cars roughly doubled every year. If this trend continues the amount of personal cars in 2015 can be 6300 (see Figure A-23).

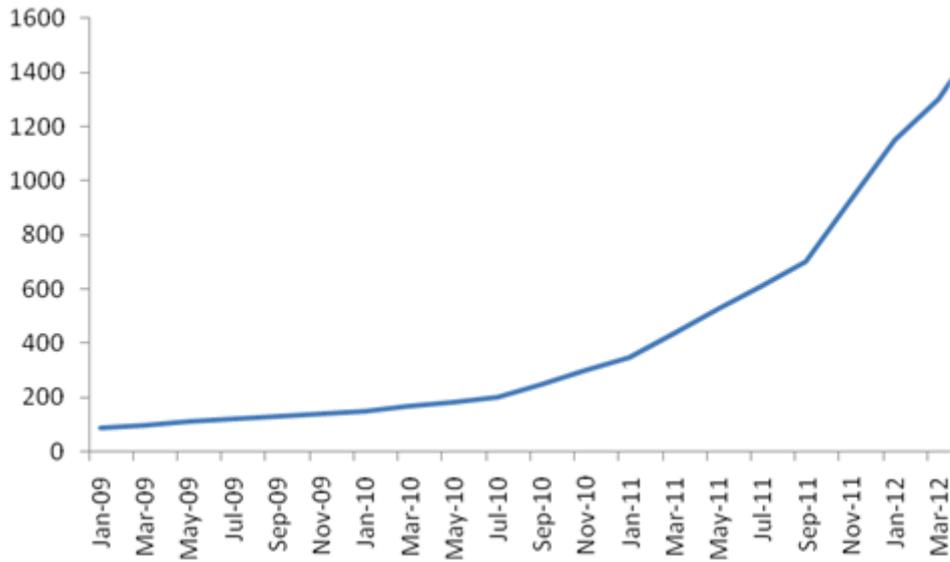


Figure A-22: The development of the number of personal electric vehicles in the Netherlands.

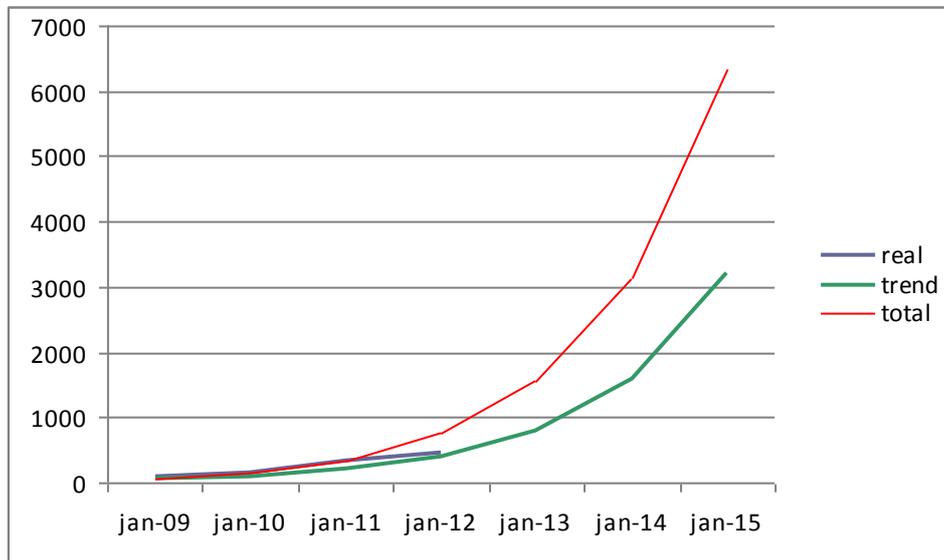


Figure A-23: The projected number of personal cars in the Netherlands. The “real” and “trend” lines show the number of new cars, “total” shows the cumulative number.

The amount of EV can be distinguished into several types of cars. In the following table the different types EV and the numbers in the first quarter of 2012 are depicted.

Table A-7: The development of the amount of different types of electric vehicles in the Netherlands.

<b>Type of vehicle</b>	<b>1-1-2011</b>	<b>31-01-2012</b>	<b>29-02-2012</b>	<b>31-03-2012</b>
Personal car	1124	1289	1338	1418
Company car < 3500 kg	164	196	251	295
Company car > 3500 kg	21	21	22	22
Bus	91	90	90	90
Three-wheeler	191	187	200	210
Motorbike	96	91	91	91
<b>Total</b>	<b>1596</b>	<b>1874</b>	<b>1992</b>	<b>2126</b>

EV's need to be charged and for that charge spots are necessary. There are many initiatives for the deployment of charge poles already mentioned. As well normal charge spots (AC 1 phase 16A to 3 phase 23 A) as high power DC charge spots <sup>17</sup>.

These poles can be distinguished in public, semi-public and private. For the public and semi-public area the amount of installed charge poles are depicted in the following table.

Table A-8: Amount installed charge poles in the Netherlands.

Standard charge pole	Number installed on 31 <sup>st</sup> March 2012
Public	1634
Semi public	887
Fast charge pole	
public	–
Semi public	31

<sup>17</sup> All equipped with the CHAdeMO protocol

## A5.4 Impact on the electricity grid

The table below shows simulation results in a district of 100 homes. If there is no charging intelligence, already 10 EV's can raise the peak power above 70 % of the LV transformer. If charging intelligence is present, 25–30 EV's can be charged without problems.

*Table A-9: Simulation results from NL about the EV impacts on transformers peak power in cases with and without charging intelligence.*

Average number of EV's per household	Peak power as percent of transformer capacity	
	without charging intelligence	with charging intelligence
0.01	57 %	56 %
0.1	77 %	60 %
0.25	109 %	67 %
0.40	142 %	74 %
0.5	164 %	79 %
1.0	273 %	102 %

## A5.5 EV actors and their role in liberalized Dutch market

At the same time the agreements regarding the infrastructure were made and the deployment of infrastructure started some investigations regarding the market model, the role model and the business models started. In these studies most of the important issues like interoperability, billing and roaming, smart charging, V2G etc. are considered. Although these studies are not finished some trends are available. One model which is embraced by most stakeholders is depicted in the following diagram.

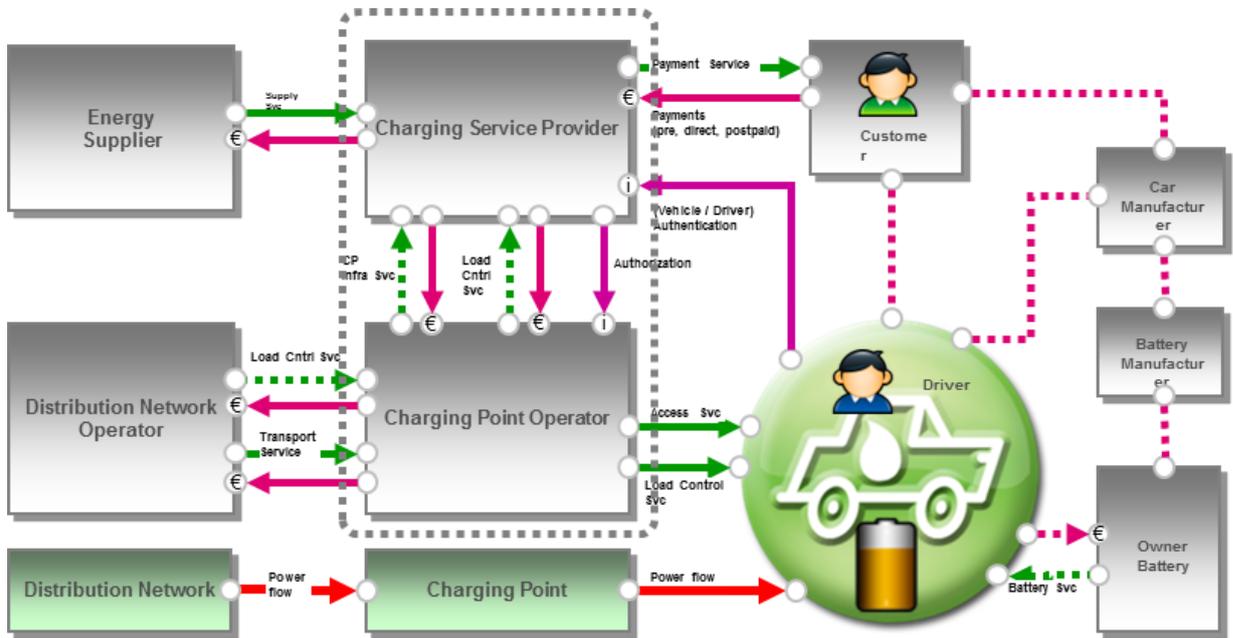


Figure A-24: Market model chosen as one of the possibilities.

## A5.6 Conclusions

The following conclusions can be drawn:

- It is absolute necessary to have a broad accepted vision regarding the EV infrastructure before starting a mass deployment.
- There is not a single perfect architecture for EV.
- To accelerate and promote the transition toward electric mobility it is recommended to start with normal AC charging combined with a few DC high power chargers at strategic places.
- In 2020, home charging, public charging and high power DC charging must have competitive cost compared to the ICE-equipped car with the battery costs inclusive.
- Without smart charging the amount of cars might be very limited (some 10%) and high investments in grid infrastructure expansion are necessary.
- With smart charging grid expansions can be avoided. Which can lead to savings up to 70 € per household per year. If smart charging results in postponing/delaying expansion of the grid, it can save up to 45 € per household per postponed year<sup>18</sup>.

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<sup>18</sup> Source TNO Netherlands

## Appendix 6 Overview of the IEA Demand-Side Management Programme

### IEA Demand Side Management Programme

The Demand-Side Management (DSM) Programme is one of more than 40 co-operative energy technology programmes within the framework of the International Energy Agency (IEA). The Demand-Side Management (DSM) Programme, which was initiated in 1993, deals with a variety of strategies to reduce energy demand. The following 16 member countries and the European Commission have been working to identify and promote opportunities for DSM:

Austria	Netherlands
Belgium	Norway
Canada	New Zealand
Finland	Spain
France	Sweden
India	Switzerland
Italy	United Kingdom
Republic of Korea	United States

Sponsors: RAP

**Programme Vision during the period 2008 - 2012:** Demand side activities should be active elements and the first choice in all energy policy decisions designed to create more reliable and more sustainable energy systems

**Programme Mission:** Deliver to its stakeholders, materials that are readily applicable for them in crafting and implementing policies and measures. The Programme should also deliver technology and applications that either facilitate operations of energy systems or facilitate necessary market transformations

The Programme's work is organized into two clusters:

- The load shape cluster, and
- The load level cluster.

The 'load shape' cluster will include Tasks that seek to impact the shape of the load curve over very short (minutes-hours-day) to longer (days-week-season) time periods. Work within this cluster primarily increases the reliability of systems. The 'load level' will include Tasks that seek to shift the load curve to lower demand levels or shift between loads from one energy system to another. Work within this cluster primarily targets the reduction of emissions.

A total of 24 projects or "Tasks" have been initiated since the beginning of the DSM Programme. The overall program is monitored by an Executive Committee consisting of representatives from each contracting party to the Implementing Agreement. The leadership and management of the individual Tasks are the responsibility of Operating Agents. These Tasks and their respective Operating Agents are:

Task 1 International Database on Demand-Side Management & Evaluation Guidebook on the Impact of DSM and EE for Kyoto's GHG Targets - *Completed*  
Harry Vreuls, NOVEM, the Netherlands

Task 2 Communications Technologies for Demand-Side Management - *Completed*  
Richard Formby, EA Technology, United Kingdom

Task 3 Cooperative Procurement of Innovative Technologies for Demand-Side Management – *Completed*  
Dr. Hans Westling, Promandat AB, Sweden

Task 4 Development of Improved Methods for Integrating Demand-Side Management into Resource Planning - *Completed*  
Grayson Heffner, EPRI, United States

Task 5 Techniques for Implementation of Demand-Side Management Technology in the Marketplace - *Completed*  
Juan Comas, FECSA, Spain

Task 6 DSM and Energy Efficiency in Changing Electricity Business Environments – *Completed*  
David Crossley, Energy Futures, Australia Pty. Ltd., Australia

Task 7 International Collaboration on Market Transformation - *Completed*  
Verney Ryan, BRE, United Kingdom

Task 8 Demand-Side Bidding in a Competitive Electricity Market - *Completed*  
Linda Hull, EA Technology Ltd, United Kingdom

Task 9 The Role of Municipalities in a Liberalised System - *Completed*  
Martin Cahn, Energie Cites, France

Task 10 Performance Contracting - *Completed*  
Dr. Hans Westling, Promandat AB, Sweden

Task 11 Time of Use Pricing and Energy Use for Demand Management Delivery- *Completed*  
Richard Formby, EA Technology Ltd, United Kingdom

Task 12 Energy Standards  
To be determined

Task 13 Demand Response Resources - *Completed*  
Ross Malme, RETX, United States

Task 14 White Certificates – *Completed*  
Antonio Capozza, CESI, Italy

Task 15 Network-Driven DSM - *Completed*  
David Crossley, Energy Futures Australia Pty. Ltd, Australia

Task 16 Competitive Energy Services  
Jan W. Bleyl, Graz Energy Agency, Austria  
Seppo Silvonen/Pertti Koski, Motiva, Finland

Task 17 Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages  
Seppo Kärkkäinen, Elektraflex Oy, Finland

Task 18 Demand Side Management and Climate Change - *Completed*  
David Crossley, Energy Futures Australia Pty. Ltd, Australia

Task 19 Micro Demand Response and Energy Saving - *Completed*  
Barry Watson, EA Technology Ltd, United Kingdom

Task 20 Branding of Energy Efficiency  
Balawant Joshi, ABPS Infrastructure Private Limited, India

Task 21 Standardisation of Energy Savings Calculations  
Harry Vreuls, SenterNovem, Netherlands

Task 22 Energy Efficiency Portfolio Standards  
Balawant Joshi, ABPS Infrastructure Private Limited, India

Task 23 The Role of Customers in Delivering Effective Smart Grids  
Linda Hull. EA Technology Ltd, United Kingdom

Task 24 Closing the loop - Behaviour change in DSM, from theory to policies and practice  
Sea Rotmann, SEA, New Zealand and Ruth Mourik DuneWorks, Netherlands

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