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IN GRIDS OF ELECTRICITY

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DELIVERABLE D5.3

SCENARIOS AND ROADMAP FOR DEPLOYMENT OF EV IN THREE EUROPEAN REGIONS: RECOMMENDATIONS FOR POLICY MAKERS AND REGULATORS

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SUMMARY

Deliverable D5.3 aims at providing Policy and Regulatory recommendations to foster the EV integration in relation with electricity grids. D5.1 has analysed agents' roles and possible business models focused on the interaction of EVs with the electricity networks. D5.2, by means of an expert survey, has analysed and identified for several European countries the regulatory and market design barriers that may hinder massive EV deployment.

This deliverable provides a roadmap for EV penetration from a policy and regulatory point of view. As stated in D5.2 three different phases in the EV deployment have been identified. The priorities of each phase will differ very much and therefore the regulatory and policy recommendations should adapt to the main goal of each phase.

1. Phase I: Catalyst Phase
2. Phase II: Consolidation Phase
3. Phase III: Advanced Phase

A coherent roadmap for policy drivers and regulatory recommendations has been set for the three phases in Chapter 2. Because no major differences have been detected among the studied European countries, a common general model, the MERGE model, is presented, in the spirit of a joint European Union. Then specific chapters, as appendixes of the document, are devoted to describe particular concerns of the studied countries: Portugal, Spain, Greece, Germany and UK.

This is a summary of the main policy drivers and regulatory recommendations of the common MERGE model.

CATALYST PHASE

Policy drivers

Phase I
Catalyst
Main Policy Goal

Facilitate EV uptake, prioritizing the appearance of a first layer of EV owners

Phase I
Catalyst
Policy Driver 1

Minimizing acquisition and running costs for the EV owner. Fostering fleets

- Setting economic incentives for buying EVs.
- Avoiding EV charging specific taxes
- Avoiding EV specific separated-metering obligations
- Setting Time of Use (ToU) energy tariffs

Phase I
Catalyst
Policy Driver 2

Disburdening the life of potential EV adopters:

- Considering EV as a normal, non discriminated electricity load
- Exerting EV owner freedom of choice
- Prioritizing simple and cheap solutions for control, metering and billing
- Facilitating and breaking legal barriers related to the installation of the required charging equipments in flat buildings

Phase I

Catalyst

Policiy Driver 3

The electricity sector acting as an allied and not a barrier:

- **Electricity network distribution companies should adapt to this new load and not vice versa**
  - Avoiding any discriminatory rule towards EV loads aimed at protecting their networks
  - Encompassing the necessary efficient investments to serve this new load
- **Minimizing EV negative impact on the electricity sector**
  - Avoiding dumb charging by setting Time of Use (ToU) energy tariffs
  - Assuring efficient incurred network investment costs related to serving EVs are recovered through the regulated revenue mechanism for distribution companies.

Phase I

Catalyst

Policy Driver 4

Facilitating the expected business model

- Developing the figure of Charging Point Manager
- Fostering a minimum public infrastructure

Phase I

Catalyst

Policy Driver 5

Preparing phase 2

- Develop Pilot projects
- Specifications for Frequency Sensitive Charging Equipment
- Work on standardization processes
- Finishing unbundling of retail market

CATALYST PHASE

Policy and Regulatory recommendations

Phase I
Catalyst
regarding

EV Owner

- Set economic, financial and fiscal incentives
- Consider EVs as an additional normal home loads
- Do not impose a separated meter and grid connection point for EVs. It will both help reducing grid needs and reducing EV owner costs.
- Avoid any regulation that may discriminate EV loads
- Set the right to benefit from Energy Time of Use (ToU) tariffs
- In shared buildings, do not impose a common feeder scheme for serving parking slots in the garage
- In shared buildings, individual charging point installation should not require the agreement of the neighborhood community
- New building construction norms must set the obligation to reserve place enough for installing electrical equipment large enough as for serving a full deployment of EVs in the garage, but do not have to impose the instllation of so large equipment till needed.

Phase I
Catalyst
regarding

Charging Point managers (CPM)

- Develop the figure of Charging Point Manager (CPM) as a “final electricity customer” allowed to resell energy for EV charging purposes if it wishes to
- It is a liberalized activity with fully freedom to set its business model (no metering obligation towards the EV users of its installation)
- CPM is the owner and operator of one or several final charging points
- CPM may acquire energy from a retailer or from wholesale markets
- Keep technical requirements and financial liabilities as simple as possible

Phase I Catalyst regarding	**Tariffs and metering**
	• Wherever energy regulated tariff exists set a ToU kind of tariff • Obligation to install dual metering or smart metering in case of existence of smart metering roll-out program • Apply innovative schemes for ToU tariffs to avoid the peaking super-valley initial time problem

Phase I Catalyst regarding	**Distribution System Operators (DSO)**
	• Obligation to serve EV loads without any discriminatory rule • Obligation to invest to meet new connection points or an increase in contracted power • Update the distribution utilities regulated remuneration mechanisms to include EV cost impact in investment needs • Obligation to install a dual-meter or a smart meter for EV owners • Do not own the installation downstream the physical connection point to the grid (the metering point)

Phase I Catalyst regarding	**Additional measures**
	•Develop Pilot projects •Specifications for Frequency Sensitive Charging Equipment •Work on standardization processes •Finishing unbundling of retail market

CONSOLIDATION PHASE

Policy drivers

Phase II

Consolidation

Main Policy Goals

Assure emergence of EV supplier-aggregators (EVSAs) and of controlled charging modes

- Foster Development of Electricity Retail Markets
- Unbundling for small DSOs
- Foster smart grid implementations. It will provide a large communication and information system infrastructure, ready to be use also for EV purposes.
- Implement control over charging
- Deploy public charging infrastructures
- Adapt Balancing and Reserve Markets to EVSAs participation
- Define EVSAs role in Balancing and Reserve Markets in terms of liabilities and obligations
- Set the rules for interaction with DSOs and TSOs
- Integration of EVs charging management in network planning activities

CONSOLIDATION PHASE

Policy and Regulatory recommendations

Phase II Consolidation regarding	**EV Supplier-Aggregators (EVSAs) and markets**
	• Adapt design of energy market and balancing and ancillary services' markets to the characteristic of this new player • Minimum volumes required to participate • Procurement of Reserves not earlier than 24h ahead • Asymmetric –up and down- bids in reserve markets • Liabilities and obligations • Implement risk hedging mechanisms adapted to EVSA • Foster smart metering installation • Eventual implementation of "roaming" kind of approach for the use of charging points

Phase II Consolidation regarding	**EVSAs and controllability of load charging**
	• Foster the implementation of smart grid and VPP concepts • EV controllability and smart charging modes will take advantage of the infrastructure deployed to manage smart grids. It would hardly be justified otherwise only for EV purposes. • Standardize communication protocols

Phase II Consolidation regarding	**• TSOs/DSOs interaction and Access tariffs** • The interaction of EVSAs with DSOs and TSOs should be regulated as far as DSOs/TSOs are regulated activities. • DSOs might have to validate control strategies and market results before they are determined to be feasible, as TSOs already do at the transmission network level. • Study the design of Access ToU kind of tariffs • Study the design of locational Access tariffs • Pilot projects should encompass the integration of EVs charging management in network planning activities.

ADVANCED PHASE

Policy drivers

Phase III Advanced **Main Policy Goals**	**Full integration of EVs capabilities** • EU harmonization of AS markets • EU level Information and Communication requirements that will enable secure EV – DSO – EVS-A – TSO real-time communication • Distribution Grid Code Adaption to allow for agreements between DSOs and EVSA for investment deferrals and congestion management • Assess the impact of EV's in quality of service and include this effect in quality of service incentives • Network Specific Loss Adjustment Coefficients for Distribution Systems

ADVANCED PHASE

Policy and Regulatory recommendations

Phase III Advanced regarding	**DSOs and TSO** • Adapt Distribution Grid Codes to allow for agreements between DSOs and EVSA for investment deferrals and congestion management • Impact of distribution network losses should be considered and reflected in the regulation of the distribution activity • Impact of EV's in quality of service should be assessed and included in quality of service incentives • Full procurement of frequency reserves and voltage services

Phase III Advanced regarding	**EU harmonization and standardization** • EU level Information and Communication requirements that will enable secure EV – DSO – EVS-A – TSO real-time communication • EU harmonization of AS markets • EU standardization of charging equipment with bi-directional capabilities

After the global view of the MERGE model provided in Chapter 2, the next chapters address the situation in the participating countries, namely Portugal, Spain, Germany, UK and Greece. The document describes for each one the present situation both regarding the penetration of electric vehicles and the pilot projects to create the conditions to foster the EV uptake and the introduction of a smart metering program, it briefly summarizes the characteristics of the power sector that, according to D5.2 may have an influence on the EV integration in electricity grids, and it describes the current or on-going legislation for the electric mobility adopted in the country. Finally, it discusses and enumerates a number of measures that should be adopted in the catalyst, in the consolidation and in the advanced phases to further enable the uptake of EV's. This last part is only included when some differences with the MERGE model could be expected or recommended.

In Portugal -Chapter 3-, the current legislation organizes the electric mobility in three activities as follows: retailing of electricity for the electric mobility (under competition), operation of the charging points (under administrative regulations during a transitory period) and management of the operations of the electric mobility network (regulated activity). Therefore among the options discussed in the MERGE model concerning the deployment of public EV charging infrastructure, Portugal has adopted to license it to a regulated company. Also, among specific regulatory measures that are not detailed in the general MERGE model, it is worthwhile to highlight detailed proposal to introduce in the expression determining the regulated amount of the distribution activity in Portugal of a term related with the number of EV's and the introduction of coefficients reflecting the network losses in the distribution use of system tariffs.

In Spain –Chapter 4-, an Integral Strategy and Program to boost the Electrical Vehicle in Spain has been approved in 2010. Under this Plan, a budget to support economic incentives (72M€ for a 6.000€ support for adopting and EV up to November 2012) has been set, R&D resources have been devoted to reinforce EV deployment, a plan of charging infrastructure has been set, and diverse legislative initiatives have been approved. The equivalent to the CPM figure has been created as the owner, in charge of operation and maintenance, of charging points. It is entitled to buy electricity to suppliers or directly to the market, and to resell it exclusively for EV charging purposes. Installation norms in buildings regarding charging points infrastructure is also about to be approved. Also a super-valley tariff has been set. Even if the number of EV sales is increasing, it is still very far to achieve the goals of a catalyst phase as such described in the MERGE Model. Regarding the guidelines to be adopted in the future, Spain could perfectly adapt the MERGE model proposed in this project. The measures taken up to now do not diverge too much from it. A smart meter roll-out program is in place, and that may help the switching to more advanced controlled charging modes in the future, but it will also be linked and dependent on the development of the smart grid concept.

In Germany –Chapter 5-, sales numbers show that electro-mobility is still far from reality, however, the big manufacturers are building up the resources and prepare for a future with higher shares of fleet electrification ahead with a government funding scheme in support of ambitious goals for 2020 and the creation of 8 model regions for field testing. The above described three phases are expected to pertain similar amounts of time in the range of three year periods. Concerning electricity sector segmentation, Germany currently still has a large share of small scale municipal suppliers that own distribution assets, presenting head room for improvements in unbundling. There is no business model for EV charging established yet, however a high potential for further developments and innovations in various areas is asserted. The option of providing feed-in tariffs for renewable energy re-injection is considered. Final customers are not granted government support for the acquisition of vehicles except for low-interest funding. In the long-term induction charging is regarded as a solution for the mass market. The number of charging stations is supposed to increase from 5.000 in 2011 to 900.000 in 2020. There are different types of charging stations, like home charging stations, business charging stations or public charging stations. Installation and operation of 900.000 charging stations in Germany can't be realized without public financial support.

In United Kingdom –Chapter 6-, Government is taking an integrated and pragmatic approach to support market growth, instead of an initial regulation which fosters the market. Two initiatives are in place, one devoted to developing robust industry-led consortia that are capable of supplying significant numbers of vehicles towards the development of a UK-wide fleet, and the other oriented to offer match-funding to consortia of businesses and public sector partners to support the installation of electric vehicle recharging infrastructure in lead places across the UK. Economic incentives for consumers and business are in place such as a support to reduce the upfront cost of vehicles (provision of over £300m), a favourable tax regime, or a Plugged-In-Places programme to match-fund eight pilot projects installing and trialling (£30m available). Installation of charging points at home and at work is being facilitated removing barriers related to planning permissions, ensuring smart metering supports EV smart charging, supporting smart grid projects and adopting policies to include plug-in vehicle recharging infrastructure in new domestic developments. Regarding Recharging in public places Government recognised that although central and local government is currently playing a key role in establishing the early public infrastructure, in the longer term a commercial market needs to develop.

Greece –Chapter 7- proposed approach is very much aligned with the here presented MERGE model. Even though some demonstration projects have been put in place, currently the EV market is virtually non-existent and projections of EV uptake are bound with high degrees of uncertainty. Nevertheless, the section on the Greek power system outlines a regulation that has set clear targets as to what changes are needed for paving the way for functional deployment of many EVs in the three phases. As of right now some tax exemptions apply for the acquisition of EVs, some pilot projects for load shedding on the medium voltage levels are tested, specifications for metering appliances have been defined and transitional methodologies for setting allowed distribution revenues are applied. In the near term, investments in smart meters are favoured, but EVs will initially be regarded as any other load. New legislative provisions for energy reselling by charging point managers and access charges to public charging infrastructure will be required shortly. In the mid-term standardization will have to be further developed, aggregators opportunities and obligations defined as well as the interface with the distributor clarified. Further on, balancing service procurements have to be rethought and local markets for ancillary services established.

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LIST OF ACRONYMS - GRLOSSARY

Acronym	Meaning
AGC	Automatic Generation Control
AS	Ancillary Service
BRP	Balance Responsible Parties
BSP	Balancing Service Providers
CAPEX	Capital Expenditures
CCGT	Combined Cycle Gas Turbine
CI	Customer Interruptions
CML	Customer Minutes Lost
CNE	Comisión Nacional de Energia - Spanish Regulatory
CPM	Charging Point Manager
CUR	Last Resort Supplier/Retailer in Spanish for
CUSC	UK Connection and Use of System Code
DC	Direct Current
EDP Distribuição	Portuguese Distribution System Operator Energias de
DER	Distributed Energy Resources
DSM	Demand Side Management
DSO	Distribution System Operator
ENS	Energy Not Supplied
ENTSO-E	European National Transmission System Operators for
ERSE	Portuguese Regulatory Agency
EV	(Plug-in) Electric Vehicles
EVSA	Electric Vehicle Supplier Aggregator
EVSE	Electric Vehicle Service Equipment
FCDM	Frequency Control by Demand Management
FFR	Firm Frequency Response
HO	Home/Domestic
HTSO	the Hellenic TSO
HV	High Voltage
I&C	Instrumentation & Control
ICRP	Investment Cost Related Pricing
IFI	Innovation Funding Incentive
ILAS	Interruptible Load Ancillary Service
ISO	Independent System Operator
kW	Kilowatts
kWh	Kilowatt-hours
LAC	Loss Adjustment Coefficients
LCNF	Low Carbon Network Funds
LOLP	Loss of Load Probability
LV	Low Voltage
MAR	Maximum Allowed Revenue
MFR	Mandatory Frequency Response
MITYC	Spanish Ministry of Industry

MV	Medium Voltage
NIEPI	Número de interrupción Equivalente de la Potencia
NOIS	Nordic Operational Information System
NORDEL	Former Nordic TSO association representing Denmark,
OFGEM	British Regulatory Authority: Office for Gas and Electricity
OPEX	Operational Expenditures
PIQS	Plan to Improve Quality of Service
PR	Private Area with Public Access
PU	Public Area with Public Access
PYME	Spanish Small and Medium Size Companies
REN	Portuguese Transmission System Operator
RES	Renewable Energy Sources
RKOM	Norwegian Electricity Market Arrangement
RPI-X	Performance based regulation for Setting Network Operators' Allowed Revenues according to a Retail Price Index (RPI) as Inflation Rate and an Efficiency Factor X
RPM	Regulating Power Market
SA	Supplier/Aggregator or Retailer
SBP	System Buy Price
SoC	State of Charge
SSP	System Sell Price
Stattnet	Norwegian TSO
STOR	Short-Term Operating Reserve
TIEPI	Tiempo de interrupción Equivalente de la Potencia
TO	Transmission Owner
ToU	Time-of-Use
TSO	Transmission System Operator
TUoS	Time Dependent Use of System
TUR	Last Resort Tariff in Spanish "Tarifa de Ultimo Recurso"
UCO	Uncontrolled Charge
UCTE	Union for the Coordination of Transmission of Electricity
(D)UoS	(Distribution) Use of System
V2B	Vehicle to Building
V2G	Vehicle to Grid
V2H	Vehicle to Home
VPP	Virtual Power Plant

SCENARIOS AND ROADMAP FOR DEPLOYMENT OF EV IN THREE EUROPEAN REGIONS: RECOMMENDATIONS FOR POLICY MAKERS AND REGULATORS

1 INTRODUCTION

1.1 Methodology

Task 1 of MERGE Work Package 5 has identified the agents and possible business models for the efficient integration of EV in electricity grids. Task 2 of MERGE Work Package 5 has identified major regulatory hurdles (regarding the electricity sector) that currently object a mass deployment of plug-in capable cars.

This report combines the results of Task 1 and Task 2 in order to define global scenarios for three regions of Europe, namely UK and Ireland, the Iberian peninsula (Portugal and Spain) and the Central Eastern Europe (centred in Germany), as well as Greece.

The report takes advantage of the surveys conducted within Task 2 and the general policy and regulatory recommendations derived, to set a reasonable picture of regulatory and organisational development for the integration of EV for these three particular regions.

Because previous tasks haven't identified very major differences among the regulatory and organizational issues concerning the deployment of EVs in different countries, the approach adopted has been that of describing a general common model, that is subsequently denominated the MERGE Model. Then each country within these regions is analysed highlighting the particular issues that may suggest slightly different approaches and recommendations for regulatory changes.

This organization of the report prevents from repeating several times common guidelines for each region and allows better identifying the differential elements that exist between them.

For the common Merge Model a consistent and coherent regulatory and organisational scenario is described. The scenario describes the organisation and interactions of participants, the sharing of responsibilities and decisions, the exchange of information, the monetary flows and the main regulatory changes to be implemented. Regulatory and organisational recommendations are discussed.

The scenarios described take into account the temporal deployment of the three phases identified in Task 2 and represented in Figure 1. The more a recommendation is aimed at a development stage in the future, the less it should be insisted on the detailed and exact implementation of it. Accordingly, the longer the term of the recommendation the more likely it is that new developments and ideas will change the evolution of the scenario.

It should be noticed that, because priorities of each phase may be quite different, the regulatory and policy recommendations may change form one phase to another.

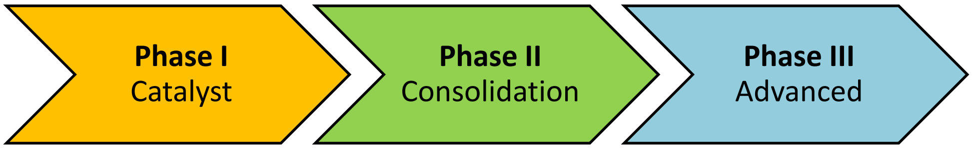

Figure 1: Development Stages of Electric Vehicles

Of course not all the countries analysed may be in the same stage of this general phase-based MERGE Model, so that particular recommendations may change from one to another.

1.2 Structure of this Report

The report addresses first the description of the common MERGE Model. For each one of the three phases considered, first general goals and considerations are set, then a reasonable complete business model is proposed and finally regulatory and organisational recommendations are identified.

Then a country by country (Germany, UK, Ireland, Portugal, Spain, Greece) analysis is performed, summarizing its present situation regarding the penetration of EVs, and identifying the particular issues that may suggest differences from the common MERGE Model previously described.

2 THE MERGE MODEL

This section describes the MERGE Model for each one of the three implementation phases previously identified. The MERGE Model obeys to a coherent and plausible global vision of implementing organizational, regulatory and policy actions to foster and address large penetration of EVs in the electrical grid.

To properly understand and interpret the analysis and recommendations provided in this report it is worthwhile to underline that:

- The MERGE project focuses on the interaction of EVs with the electricity grid. This report does take into account inputs from car and battery manufacturer industries but policy and regulatory recommendations exclusively refer to its interaction with the network and concern mainly the electricity sector.
- Technical recommendations have been addressed in other deliverables of the MERGE project. This deliverable deals exclusively with the regulatory and policy aspects.
- There exist an infinite number of nuances so that there isn't a unique Model to be recommended. However from the study of several countries, the project has come up with the conclusion that there is much more common recommendations to be set than differences to highlight for each country. So an effort has been done to come up with a coherent common Model, the MERGE Model. It should be highlighted however that there are of course a lot of nuances than can be applied to this proposed vision.
- Even if the project has also analyzed more futuristic scenarios regarding the EV-grid interaction, it should be said that the longer is the time horizon addressed (i.e phase 3) the less sensible it is to enter in details. The natural evolution of scenario penetrations and technology development will for sure alter radically the recommendations provided today.

2.1 Catalyst Phase

As discussed in D5.2, the simplest way to characterize this phase is showed in Figure 2.

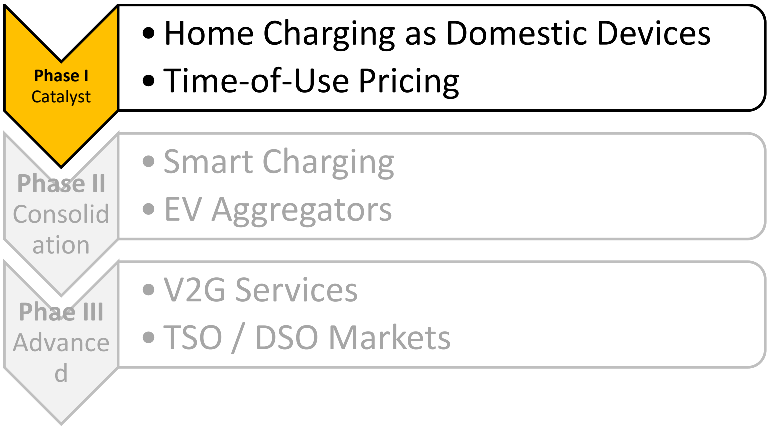

Figure 2: Phase I - Catalyst

2.1.1 Catalyst Phase: Policy goals and general considerations

This section addresses the general policy goals that in our opinion should drive the interaction of EVs with the electricity system in this first phase. More concrete policy and regulatory recommendations will follow in section 2.1.3.

As identified in D5.2 of this Project and discussed in section 2.1.2, the expected general business model for this phase will be mostly centred in home charging, private public access charging (parking business, office and shopping centre parking, ...) together with some fast charging infrastructures (public or private ones).

The observed reality of EV penetration in most European countries shows a promising but still only symbolic number of EVs. Important economic and psychological barriers still remain for potential EV adopters. Therefore in the first phase, for immediate attention, absolute priority concerning policy and regulatory design should be devoted to breaking or lightening these important barriers.

EV owner pioneers will behave as catalysts over their neighbours, acquaintances and colleagues. They are the best way to break psychological barriers. Therefore, in this phase, absolute priority should be given to facilitate the appearance of a first layer of EV owners.

The main goal of this phase is therefore to facilitate EV uptake, prioritizing the appearance of a first layer of EV owners.

Phase I Catalyst **Main Policy Goal**	**Facilitate EV uptake, prioritizing the appearance of a first layer of EV owners**

In order to achieve it, the following drivers should guide the policy and regulatory decisions:

Phase I Catalyst **Policy Driver 1**	**Minimizing acquisition and running costs for the EV owner. Fostering fleets** • Setting economic incentives for buying EVs. • Avoiding EV charging specific taxes • Avoiding EV specific separated-metering obligations • Setting Time of Use (ToU) energy tariffs

The best way to overcome the logical psychological reluctance of car users towards EVs will be getting familiar with EVs running on the streets and roads. Fostering the appearance of commercial fleets (taxis, companies fleets, rental cars, ...) is undoubtedly one of the more effective ways of achieving it. Indeed fleets may allow the appearance of a large number of EVs at a time, and these EVs will be running the streets and roads with high frequency.

However, it is also of most importance to achieve the appearance of particular EV owners that may show to their colleagues, familiars and neighbours both that it is feasible and easy to install the required charging equipment (at home, at the office, ...) and that there is no major problem with charging the car and running with it.

Setting economic incentives for buying EVs.

A two high acquisition cost gap between conventional cars and EVs represents a large barrier. In order to reduce this gap, economic incentives should be applied at this initial phase, counting on economies of scale and on technology maturity effects to be able to suppress them in the future. Several concrete policy recommendations in that sense (mostly based on the Portuguese experience) are presented in section 2.1.3.

Avoiding EV charging specific taxes

Specific taxes associated to EV charging (aimed for example to substitute fuel taxes) should be avoided at this stage. Imposing them has several other implications apart of being a counterincentive, as that of obliging to install a specific meter for the EV charging consumption, which implies new costs for the EV owner.

Avoiding EV specific separated-metering obligations

If specific taxes are avoided at least at this phase, no separated meter is required. This may have a direct impact on the cost for home-charging EV users and also for the whole system. Indeed, a new metering point represents a new supply-connection point for the electrical system. The user will be charged for the contracted capacity (€/kW) associated to this new connection point, besides the variable charges associated to the energy actually consumed (€/kWh). Therefore a home-charging EV user will have to pay for two connection points and for two metering equipments, instead of being charged for a unique connection point and unique metering equipment. In the later case, the user may decide to increment his/her present home-connection point contracted capacity in order to be able to charge his/her EV at any time, or if he/she may prefer to manage and coordinate his/her home loads, including the EV, so that he/she never overcomes the present contracted capacity. In any case, for sure, he/she will save money.

As it has been said, having a single meter represents a clear incentive to the user to manage appropriately his/her home-EV loads in order to be able to contract less capacity. This will help minimizing the need of additional grid investments to meet EV requirements.

Setting Time of Use (ToU) energy tariffs

Finally it is of most importance that the EV user would be able to benefit from the low electricity energy prices that happen at super-valley hours. Indeed, for most of the times, the user will be happy to charge the EV at night time. Assuring that the EV owner will be exposed to the low energy price present at that moment has two beneficial effects. First it is cheaper to charge an EV, making it more attractive. Second it clearly incentivizes de EV owner to charge the EV at super-valley hour, minimizing the impact both on the electricity grid and the whole electricity system.

Phase I Catalyst **Policy Driver 2**	**Disburdening the life of potential EV adopters:** • Considering EV as a normal, non discriminated electricity load • Exerting EV owner freedom of choice • Prioritizing simple and cheap solutions for control, metering and billing • Facilitating and breaking legal barriers related to the installation of the required charging equipments in flat buildings

It is most importance to avoid any discriminatory rule that may affect the EV charging process or that may harm the free choice of the EV owner (as much as possible and reasonable it is). The more the user is free to decide how to manage the charging of his car without specific constraints, the more it helps breaking the initial psychological barriers.

Considering EV as a normal, non discriminated electricity load and Exerting EV owner freedom of choice

It is therefore proposed, at least at this first phase, to consider the EV just as an additional “normal” load. This implies that

- The user is free to decide, as explained earlier, whether to contract a new connection point (with its own separated meter) or to add this new charge to its already existing meter (maybe or maybe not modifying somewhat his full contracted power), just in the same way air cooling devices have been incorporated as new loads years ago.

- It should not be mandatory to install any control device in the common feeder of shared house buildings aimed at interrupting EV load charging for prioritizing domestic loads in the building whenever any capacity problem happens. This kind of proposal has been discussed in some places and in our opinion should be completely avoided, since it will reinforce substantially the psychological barriers. It should be a free decision of the neighborhood community to install such a device and it should count with the acquiescence of the affected neighbors. Of course an end user may decide on his own to install such a device to manage all his own loads, prioritizing his home appliances or his EV charging as preferred, in order to assure meeting the contracted capacity limit of its connection point.

- It will be a passive load, i.e uncontrolled (charging modes from D5.1 with suffix UCO) in real time, except if the owner freely decides the contrary. The owner may decide, for the EV load as well as for his home appliances, to adopt any available demand side management mechanism, but if not, he will not be obliged to make it controllable.

Prioritizing simple and cheap solutions for control, metering and billing

Where possible, regulation should ease the life of early adopters striving towards new and challenging technology. Legislation should facilitate chance instead of creating complicated restrictions. The most ad-hoc and hands on solutions should be favoured with the least requirements for potential participants.

The more advanced smart control schemes studied and analysed in the MERGE project would have undoubted benefits for the electricity system, but they will also need development of quite large metering, billing and bi-directional communications processes that will require non-negligible investments on communication and information systems. As far as the benefits of such advanced smart control schemes will become significant only for a large penetration of EVs, much more simplified systems are recommended for this Phase I. Indeed, it has been proven that the higher priority in terms of benefits (in this case in terms of avoided costs) is incentivising EVs to charge in valley hours (referred to the system electric load profile), and this can be achieved at low cost implementing energy ToUs tariffs.

Our believe is that any more intelligent relationship between the EV load (the car charging process) and the grid (on-line signals or control, V2G, ...) will come later, taking advantage of the investments on communication and information systems that will happen as the more general concept of “smart grids” is developed. The economic justification of such investments will come therefore from a broader approach and not just from the unique EVs perspective. These investments will then be charged to the whole demand and not to a small part of it (the EVs).

Because it will be helpful for EV users, a “roaming” kind of approach for the use of any charging point of the mobility network could be considered. Under this scheme, the EV user will pay for charging according to the conditions contractually set with his retailer, regardless of the physical point of connection he may be using. This scheme breaks the “usual” functioning of retail markets in the electricity sector where an electricity client is univocally related to a connection point of the distribution network. The appearance of “roaming” kind of schemes complicates the contractual relationships between CPMs, retailers and distribution utilities as far as it requires agreements between all of them, a more sophisticated centralised billing systems and higher communication requirements. However, even for this first phase, it should be an option to be considered (for example for countries with a single distribution company, a single licensed CPM, and few retailers), because it will be certainly make easy EV users life.

The link of EV's with the SmartPhone may be of much interest for these issues, as it will allow low investments now, full scalability and future proofing and avoids the need to develop very sophisticated Billing systems. There has been a recent breakthrough in the UK whereby Barclays bank now allows customers to transfer money to different accounts depending on the mobile phone number associated with the account. This would make monetary management of EV Charging Trivial - just pay the money to the phone number written on the EV Charging post and you can go anywhere in Europe!! Similarly access control to the EV Charging Post could be via the customers SmartPhone e.g. send code by BlueTooth to EV Charger to get access. In Japan, Vodafone with Near Field Communications can provide payment and access to the subway.

Facilitating and breaking legal barriers related to the installation of the required charging equipments in flat buildings

Another important barrier might be the difficulty of installing the necessary charging equipment in garages of common buildings. In some countries a large part of the population lives in flats (common buildings) and it is of most importance to set the appropriate regulation that facilitates the installation of the required equipments for charging. Any decision that will require the consensus of the neighbor community will represent a major barrier for the pioneers. Regulation and legislation must break those very relevant barriers.

Phase I

Catalyst

Policiy

Driver 3

The electricity sector acting as an allied and not a barrier:

- **Electricity network distribution companies should adapt to this new load and not vice versa**
  - Avoiding any discriminatory rule towards EV loads aimed at protecting their networks
  - Encompassing the necessary efficient investments to serve this new load
- **Minimizing EV negative impact on the electricity sector**
  - Avoiding dumb charging by setting Time of Use (ToU) energy tariffs
  - Assuring efficient incurred network investment costs related to serving EVs are recovered through the regulated revenue mechanism for distribution companies.

Electricity network distribution companies should adapt to this new load and not viceversa

A clear and common message has to be transmitted to the society from authorities and electricity stake holders in the sense that the electricity sector will not be a barrier for the penetration of EVs. The electricity sector must adapt itself to accommodate EVs and not the contrary. It will be a facilitator and not a barrier towards EV penetration and integration.

The electricity grid which is a regulated business both at distribution and transmission level should consider EVs as new electric loads that must be served as any other load. They will have to face the required efficient investment needed for that, provided that the related costs are appropriately considered in the regulated revenue mechanisms in place in each country.

Minimizing EV negative impact on the electricity sector

This project has shown that provided that some smart charging scheme is adopted, the impact on the electricity sector will be completely assumable, moreover in this first stage. Therefore any "negative" message that may induce the potential EV owner to think either that he will not be free to choose when to charge the car, or that the EV will be considered a low prioritized electricity load, or that he may expect a curtailment if needed, should be completely avoided.

And this can be achieved at this stage without requiring any advanced communication and control devices implementation. Setting a simple energy Time of Use (ToU) tariff scheme will be very much effective.

The use of energy ToU tariffs is seen as a prioritized measure as it presents the following advantages:

- As mentioned previously it allows the EV owner to benefit from low energy prices at super-valley hours, making significantly cheaper the charging of the EV.
- It incentivizes the EV owner to charge in an efficient way minimizing substantially the impact on the electricity system costs: minimizes required grid and generation investments.
- It preserves the freedom of the EV owner to charge whenever he likes. Price is the only driver that will condition his choice. No external constraints, no external imposition, no external discrimination.
- Its implementation is simple and does not require large investments nor large expenses as it is discussed below.

The key requirement for applying energy ToU tariffs is having installed energy consumer meters able to differentiate several time periods. Any present smart meter of course does it. In those countries where a roll-out program aimed at substituting classic meters by smart meters is in place, a solution could be giving priority to EV buyers in the program, so that they will be able to benefit from ToU tariffs. In the rest of countries where installation of smart meters is not still foreseen, standard time of use meters, that have been already applied for several other purposes (night tariffs, ...), will be good enough.

Once the meters are installed, energy ToU tariffs will arise in a natural way for those consumers that are already buying in the free retail market. Retailers will offer energy ToUs tariffs to compete for the consumer. For those other consumers that still benefit from an energy regulated tariff, the regulatory authority will have to implement a ToU tariff. Several countries already have it.

Let's remark that, at this stage, only energy ToU tariffs are proposed. It is also possible to think on designing access tariffs that may distinguish the time of use too, but it is a more controversial and difficult issue, so that it is suggested to face it in posterior stages.

Energy ToU tariffs may have a drawback that must be solved. Indeed, the experience with this kind of tariff is that a peak load happens just in the moment the tariff switches to the low price value, because consumers all together have programmed to connect their appliances at that time. This may not be efficient at all because it causes problems both to the distribution grid and to the system operation. A possible simple solution to avoid this problem may consist in setting different tariff switching times for different consumers.

Phase I Catalyst **Policy Driver 4**	**Facilitating the expected business model** • Developing the figure of Charging Point Manager • Fostering a minimum public infrastructure

Developing the figure of Charging Point Manager

As described in next section and discussed in previous deliverables, the figure of the Charging Point Manager (CPMs) may have an important role in the expected global business model that may arise regarding the EV interaction with the network. Encouraging and facilitating the appearance of this figure may foster the installation of more charging points which is of most importance to provide confidence to potential new EV owners.

CPM will center their business in owning, maintaining and serving with electricity several charging points. As discussed in next section its scope may range from a very simple and small business model (i.e. the private owner of a public access parking garage who installs several charging points and without any energy measurement charges a time-based extra fee to those EV that uses a charging point) to much more complex business models (i.e. the owner of a large number of charging points, geographically dispersed, who buys energy on the wholesale markets as a retailer does, and that resells it to EV owners, metering their exact consumption).

The legislation should admit any of these business models letting to the market forces decide which one will prevail or develop. Therefore the policy recommendations regarding CPM are

- To set a new figure in the legislation, the CPM
- This figure should be a liberalized one, not a regulated one, and therefore regulation must not impose any particular CPM business model, instead it should facilitate a large variety of possible CPM business models.
- It should have the possibility to buy energy to retailers as any final end consumer does but also to resell this energy, if it wishes, exclusively for EV charging purposes.
- It should also have the possibility to buy by itself electricity in energy wholesale markets (as a retailer does). In this case it will have to comply with the same financial guarantees imposed to any agent playing in those markets.
- The CPM owns its own feeders and charging point equipments. The frontier with the distribution grid will be a connection point with an "official meter". The distribution company will charge the access tariff to the owner of this connection point (CPM) either directly (if CPM acts as a retailer) or indirectly to the retailer that sells energy to this connection point.
- In case the CPM is serving several charging points from a single electricity grid connection point, he may or not install individual meters to each charging point. These meters are owned by the CPM and are not controlled by the DSO.

Fostering a minimum public infrastructure

In order to guarantee the existence of a minimum charging infrastructure that will provide confidence to potential EV buyers, it would be probably necessary to mandate a public deployment of both fast charging stations and street based charging points (except if private initiative is seen as being very active). Whereas the model business regarding home garages or private parkings with public access (offices, privately owned garages, …) may seem more clear, non-consensus have been reached on the business model that may be more appropriate for developing charging infrastructures in public sites.

The deployment of the infrastructure as a public good requires the allocation of the charging posts to follow transparent, objective and easily understandable criteria. Public authorities such as regulatory commissions, local governments and municipalities therefore need to derive suitable roll out plans for society as whole. Infrastructure costs are not negligible and therefore significant public funds are at stake. If private initiative does not come to invest in such installations two alternative solutions may be adopted:

- Municipally owned and operated for public benefit, similar to traffic signals, street lights, etc. The municipality may auction the licensing of this activity to potential CPMs. The energy consumed will be managed by the CPM. The licensing may include some price conditions on the energy side. The electricity access tariff will be charged by the distribution company to the CPM. The CPM will charge users by the way of credit cards or by pre-paid cards. Slightly more sophisticated but more flexible approaches as a "roaming" kind of approach for EV supply contracts may be also considered. The link of EVs with Smartphones, as previously commented could be an attractive solution.

- Distribution utility owned and operated for public benefit. Supported in the utility rate base. This will optimize the interaction of the EV public charging infrastructure with the distribution grid investment requirements. Regulation must guarantee that the associated investments costs will be properly recovered by the distribution companies. It will be important to set a coherent remuneration scheme that will not expose distribution utilities to risks (it is a regulated activity). Uncoordinated cross responsibilities between the body legally backed to set the minimum required public infrastructure deployment (i.e. municipalities or regional authorities) and the organism in charge of setting the distribution utilities remuneration rate base (i.e. the Regulator) should be avoided[1]. The EV aggregator associated to each connection point may be also auctioned.

Since it will not be sensible in this phase to charge only EV owners with the investment costs associated to the deployment of this public infrastructure, these costs may be

- Initially shared among all electricity consumers, through a specific charge in the access tariff.
- Initially supported through municipal budgets and recovered for example through taxes:
    - Municipal taxes related to general car (not only EVs) mobility costs (street maintenance, ...)
    - Environmental taxes applied to conventional pollutant cars

[1] A good example of bad practice in this sense could be that of Spain regarding electricity quality of service regulation. Indeed the regional governments (autonomous communities) are backed to set regional quality of services thresholds while it is the national regulatory authority that determines the distribution utility rate based remuneration according to a unique common national quality of service requirement. Inconsistencies between both decisions has caused severe damaged to the distribution companies. The fact that the extra-costs due to an increase in the quality of service requirements, unilaterally decided by local authorities, were not allocated neither to their own budget nor to the consumers in their territory, aggravate the problem. So regulation should be careful about this issue. Either the minimum required deployment of charging stations is set by the same authority who sets the distribution utilities remuneration, or the extra costs associated to a more local decision are charged to the consumers in that territory.

Phase I Catalyst **Policy Driver 5**	**Preparing phase 2**
	• Develop Pilot projects • Specifications for Frequency Sensitive Charging Equipment • Work on standardization processes • Finishing unbundling of retail market

Finally, several additional actions should be undertaken to prepare properly the next phase, the consolidation phase.

As explained in next section, Phase II is devoted to take advantage of the existence of a relevant number of EVs connected to the electricity grid. Aggregators (retailers and/or CPMs) of large numbers of EVs will develop new business models taking advantage of the storage capabilities of the batteries and the controllability of the charging processes. They will manage the added value that these characteristics may have for the electricity grid.

Even if this project has shown promising capabilities of EVs in providing services for the electricity grid, there are still a lot of uncertainties in the real added value that they may actually provide. The deployment of pilot projects with real behaviour measurements are highly recommended as test fields to check their capabilities.

Primary frequency control, within the smart charging concept, looks promising and should be considered in the consolidation phase, especially for island grids. For this reason it is recommended at this phase to develop Specifications for Frequency Sensitive Charging Equipment.

Secondary frequency control through the change of the rate of charging - under the smart charging concept – could also be promising but may require however some further confirmation that battery does not suffer too much. The participation of EV's or EV aggregators in balancing and reserve markets will have to start by some pilot actions that desirable could still be launched in this Catalyst Phase in order to break psychological barriers of existing stakeholders and also to identify and quantify the advantages from the participation of EV's and EV aggregators in the reserve markets. These actions should start with a limited number of participants during an extended period of time to identify the advantages both for the entire system and for the EV's themselves regarding possible revenues

Technical standardization (which is not the subject of this deliverable) should also be strongly boosted. For example the available standards, in particular the ones related with charging points are not adequate, namely the ones in IEC 61851). This situation was eventually created by the faster response of the car industry when compared to the introduction of standards on the electricity network side. This means it is necessary to introduce changes in the available standards so that it is ensured a more flexible charging in view of the control and management of the distribution network.

Finally as the Consolidation Phase is expected to be marked by the role of aggregators-retailers, it would be relevant to foster retail competition in those countries that are still far from it. Unbundling processes at the distribution-retail level should be accomplished along this phase, in accordance with the Europeans Directives.

2.1.2 Catalyst Phase: Description of the Business Model

As identified in D5.1 of this Project, the expected general business model for this phase will be mostly centred in the following charging deployment infrastructures, in this order:

- home charging,
- private public access charging (parking business, office and shopping centre parkings, private fast charging stations, ...),
- together with some public charging infrastructures (fast charging stations or street parking based charging posts).

The particular business model for each of them is described below. Some general considerations common to all of them are:

- Freedom (not regulated or closed entry activity) installation of charging posts. It is not assigned to a particular (regulated) agent for example DSOs. Only for public charging infrastructures it may make sense either to mandate DSOs deploying this infrastructure (provided the distribution utilities' remuneration schemes properly consider those investment costs), or to license the installation, maintenance and operation of the charging posts.
- The installation of final charging points is a private activity, managed by the proprietary of the private home parking lot or by a CPM, or by an EV owner (at home) or by a multi party dwelling community. The installation of the electric equipment from the current metering point (final customer connection to the DSO owned network assets) to charging point (CP) is neither owned nor managed by the DSO, but rather by this private entity. In case of an obligation to install charging points, the responsibility will lie with the municipality or with the community. The DSO will not be obliged to fulfil such requirements.
- The charging of EVs will be treated as any other load, with not distinctions concerning timely prioritizing or quantity restrictions. At this stage it will not be necessary to control the charge.
- The DSO on the other hand, will be obliged to install either a smart meter (if a roll-out program to install smart meters is in place) or a dual-time meter for all customers requesting to connect electric vehicles to the network, such that the access to economic incentives or more concretely to time variable tariffs is assured.

- The role of the charging point manager (CPM) will be
    - The CPM is the owner and operator of one or several final charging points including the electric installation required from downstream the connection point (or connection points) to the distribution grid (distribution company).
    - The CPM is a “final customer” allowed, if it wishes, to resell electric energy for the single purpose of charging EV.
    - The CPM is free to choose its business model. It may decide to resell energy to EVs according to their actual charging consumption (in which case a certified metering equipment will be necessary), or it may decide to charge according to the time of parking lot occupation (with access to recharging facilities) irrespective of the energy actually consumed in the charging process (no metering, nor complex billing processes will be then required). Other business models are also possible.
    - The CPM, as any other “final customer”, may acquire energy from a retailer or directly from the wholesale market (in which latter case it should comply with the appropriate financial and guaranteeing obligations).
- The role of the distribution company (DSO)
    - The DSO is responsible for guaranteeing electricity supply with an adequate level of quality. In that way, the DSO is obliged to face the required investments (in grid installations and network equipment for low to medium voltage levels) to serve the EV load, as it happens for any other kind of load.
    - The DSO has the obligation to install smart meters for EV customers if a smart meter roll-out program is in place, or a dual-time meter otherwise.
    - The DSO will not be allowed to install any equipment devoted to discriminate the EV load with respect to other loads, without the clear consent of the final customer.

It follows a brief description of the different business schemes that may be developed under this first phase. Other business models have been largely described in D5.1 of this project.

Home charging

In the simplest and most probable charging mode, the electricity used for charging the car is priced under a unique supply contract for a residential home (final customer). It is assumed that the home owner will install the EVSE with the EV charging connector while the distributor can play a role as advisor and supervisor of the EV required connector.

Indeed, following the policy drivers proposed in previous section the EV owner should be able to connect its EV as a normal additional load, without requiring contracting a new connection point and without requiring an additional new dedicated meter. This should be the easiest and less costly approach for the potential EV owner, till a larger deployment of EVs may justified more advanced control and sophisticated modes of running. Following the classification of business models introduced in D5.1 of this project it corresponds to the “EV home charging mode: HO-SA-UCO” that is represented in Figure 3.

Of course, even at this early stage, the EV owner may opt for other schemes (as for example installing a dedicated meter) if desired in case attractive commercial offers coming from CPMs or from EV aggregators or retailers require it.

This model is valid both in single dwelling and in multi party dwelling communities. In the latter case legislation should help the potential EV owner to install the required equipment without the interference of the neighbourhood community.

Contracts: The supply contract between the electricity supplier and the residential final customer would be a contract with at least time of use (ToU) prices, i.e. peak and off-peak prices to promote charging at off-peak hours, or it could be a more sophisticated contract with hourly time prices that promotes an integrated management of the EV with the rest of the loads. In the former case a simple dual – time FCM will be enough, in the latter case the FCM should be upgraded to a smart meter in order to measure hourly consumptions. The electricity supplier will pay the distributor for the corresponding regulated network charges.

Communication and charge control: The EV owner would programme his EVC in accordance to his/her driver requirements and simultaneously minimizing electricity payments to the electricity supplier or load aggregator.

Settlement: The settlement of the contract would be based on the total home electricity consumption according to the prices set in the contract. These prices in general would be: i) a demand charge ($/kW-month), and ii) an energy charge ($/kWh) with different ToU rates or hourly prices.

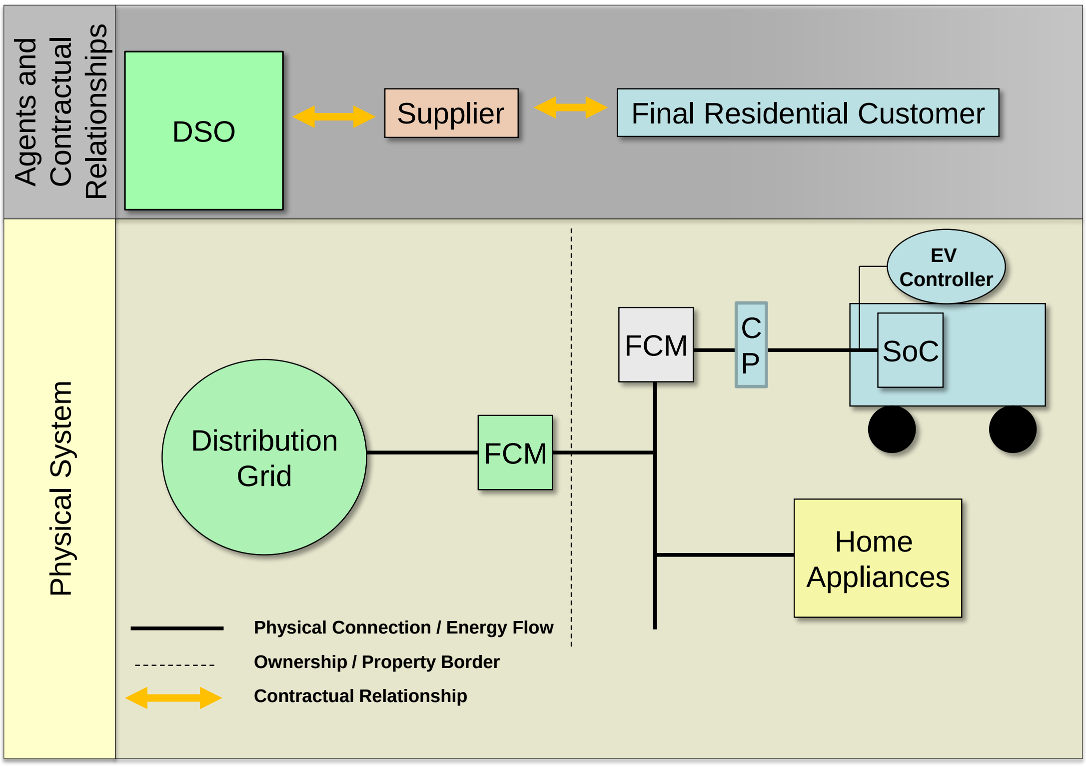

Figure 3: EV charged at home as electrical appliance

Private property with public access (except fast charging stations)

On privately owned property, where vehicle parking access is nevertheless open to the public, such as corporately operated car parks, shopping facilities and commercial office buildings of various use, the deployment of the charging points is undertaken by private entities, CPMs. The core business of owners of such parking places is not charging EVs, even in the case of car parks for which the core business deals with providing room to park for a given last time. EV charging services are primarily to enhance an unrelated business—retail shopping, hotels, restaurants, private parking facilities, etc. Therefore two models may be expected, being the first one the more probable in the first stage.

The first one corresponds to the owner of the parking places being the CPM. In that case it is probable that it will look for very simple solutions to charge EV owners for the EV charging service. It will probably charge flat time-based tariffs for the use of the charging post, without any dedicated metering of the actual energy consumed by the EV in the charging process. It will not be worthwhile to expend time and money in dedicated metering, control and communication equipment for each individual parking place with the need of a more complex settlement procedure. Indeed it is not its core business.

This model is represented in Figure 4

Contracts and settlement: There would be a supply contract between an electricity supplier and the charging station owner (CPM) as a final customer. The supply contract would be settled according to the energy and peak demand measured by the FCM, which should be upgraded to be a smart meter.

The electricity supplier would pay to the distributor the regulated network charges based on the contracted capacity and the volumes measured by the FCM.

Each EV owner will be charged according to the time of use of the connection point. Charging at peak hours could be more expensive than at off-peak hours.

Note that the owner of several parking sites in different geographical sites may operate as CPM of all its parking places in the same way as described above, negotiating maybe a unique contract with a single supplier.

Also, the CPM may access directly to wholesale electricity markets but, because this will require from him to meet exigent and quite complex financial guarantees, it is not expected to be worthwhile, except maybe for very large CPMs.

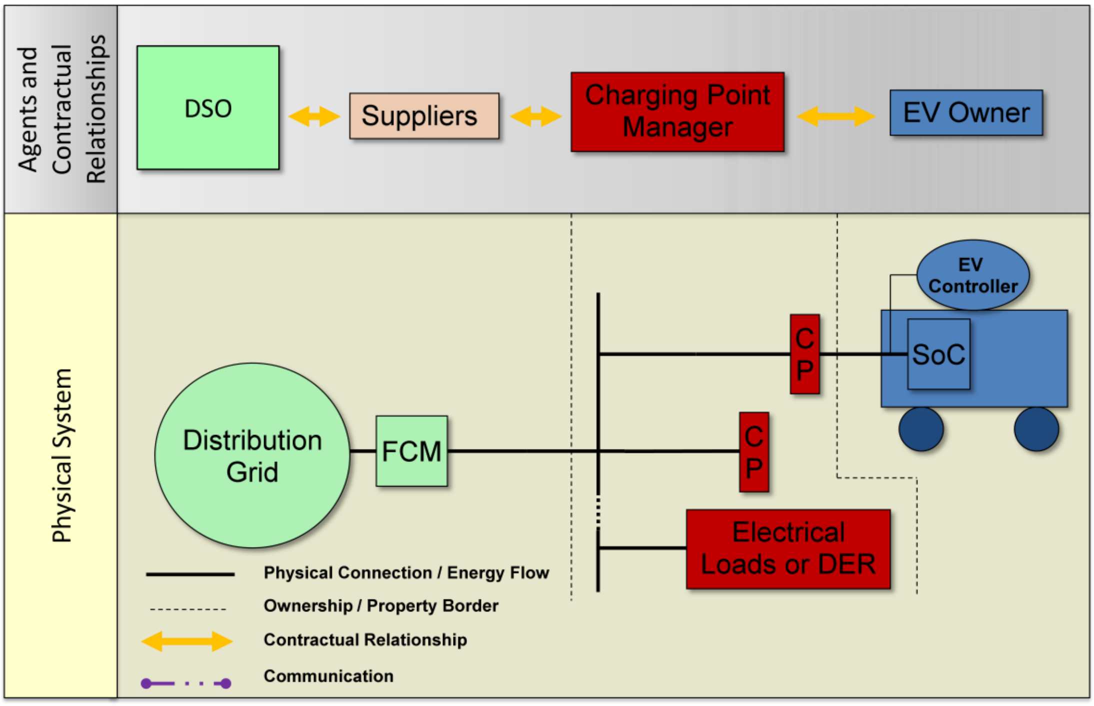

Figure 4: Private property with public access without individual dedicated meters

The second one corresponds to the case where the owner of the parking places agrees with an external specialized entity, a CPM, the owning and managing of the charging infrastructure. In that case it will be probable that, being its core business, the CPM will decide to adopt more complex measurement, billing and settlement procedures. As this case becomes very much close to the one of the private fast charging station, the reader is referred to the following item.

In any case, for this first stage it should be given to the parking places owners the freedom to choice their particular business model. It will be the free market opportunities that will decline for one or another solution.

Private fast charging infrastructures

The deployment of the charging stations may be undertaken by private entities that simultaneously procure and resell energy. A charging station owner acting as CPM installs the required infrastructure. He would buy electricity from an electricity supplier and will provide EV charging services to EV owners. Charging infrastructure may include additional equipment to convert, store, or even produce electricity in order to optimize and diversify the types of charging modes offered to their customers. In case of dedicated charging stations AC/DC converters and associated connection equipment may be required to provide fast and ultra-fast DC charging modes. Furthermore, local stationary storage capacity could, theoretically be useful for energy price arbitrage. For instance, the station could store significant amounts of energy during periods of low demand and inexpensive electricity in order to offer competitive charging prices during peak hours. Finally the combination of this storage capability with local generation sources based for instance on renewable energy can provide this business with additional profits. Something similar could happen under the same model of battery replacement where EVs park in dedicated stations for switching the battery within a matter of minutes. Figure 6 represents this charging mode schematically.

The model could be much more complex compared to the previous one as far as it will be the core business of the CPM. It is schematically represented in Figure 5

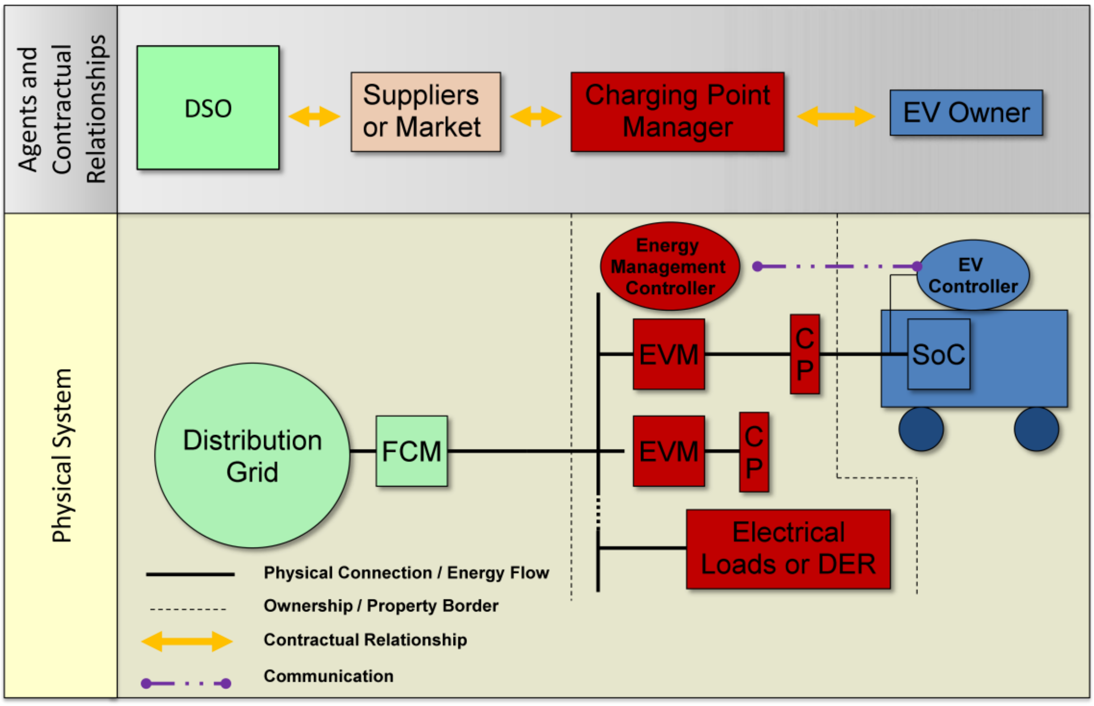

Fig 5. Privately owned charging station offering special services

Communication and charge control: Each EV will communicate its charging requirements through the on-board EVC to the EMC, and the EMC, if there is enough time, might optimize its charge subject to the imposed charging constraints.

Contracts and settlement: There would be a supply contract between an electricity supplier and the charging station owner (CPM) as a final customer, or the charging station could participate directly in the energy market. In the first case, the station owner would negotiate ToU energy rates or hourly prices and maybe demand response services. The supply contract would be settled according to the energy and peak demand measured by the FCM, which should be upgraded to be a smart meter.

The charging station owner would notify the electricity supplier about the required connection capacity and the electricity supplier would forward this information to the distributor. The electricity supplier would pay to the distributor the regulated network charges based on the contracted capacity and the volumes measured by the FCM.

Each EV owner will be charged according to the energy amount transferred to the battery and measured by the EVM, the type of charge (regular, fast or ultra-fast) and the time when the charge was made. Charging at peak hours would be more expensive than at off-peak hours.

The profitability of this business will be determined by the capability of offering differentiated charging services that could not be obtained at home or in public parking areas and would be needed and appreciated by EV owners.

Public charging infrastructures

As already explained in the previous section, in order to guarantee the existence of a minimum charging infrastructure that will provide confidence to potential EV buyers, it would be probably necessary to mandate a public deployment of both fast charging stations and street based charging points (except if private initiative is seen as being very active).

As explained previously, two main models may be adopted:

- Municipally owned and operated for public benefit, similar to traffic signals, street lights, etc. The investments costs will be supported through municipal budgets and recover for example through taxes. The municipality may auction the licensing of this activity to potential CPMs. The energy consumed will be managed by the CPM. The licensing may include some price conditions on the energy side. The electricity access tariff will be charged by the distribution company to the CPM. The CPM will charge users by the way of credit cards or by pre-paid cards. As discussed previously, slightly more sophisticated but more flexible approaches as the "roaming" kind of approach for EV supply contracts may be also considered.
- Distribution utility owned and operated for public benefit. Supported in the utility rate base. This will optimize the interaction of the EV public charging infrastructure with the distribution grid investment requirements. As it has been discussed previously it is important to set a coherent remuneration scheme that will not expose distribution utilities to risks (it is a regulated activity). The entity in charge of imposing the public infrastructure deployment (i.e. municipalities) should be coordinated with the entity in charge of setting the utility rate base (i.e. the Regulator). The EV aggregator associated to each connection point may be also auctioned. The use of pre-paid cards and a "roaming" kind of approach could also be possible[2].

The former model fits with the one represented in Figure 5 already described.

Figure 6 draws a schematic representation of the latter model.

[2] As mentioned previously, the future of EV's may also strongly be linked with the Smartphone, as this allows low investments now, full scalability and future proofing and avoids the need to develop very sophisticated Billing systems.

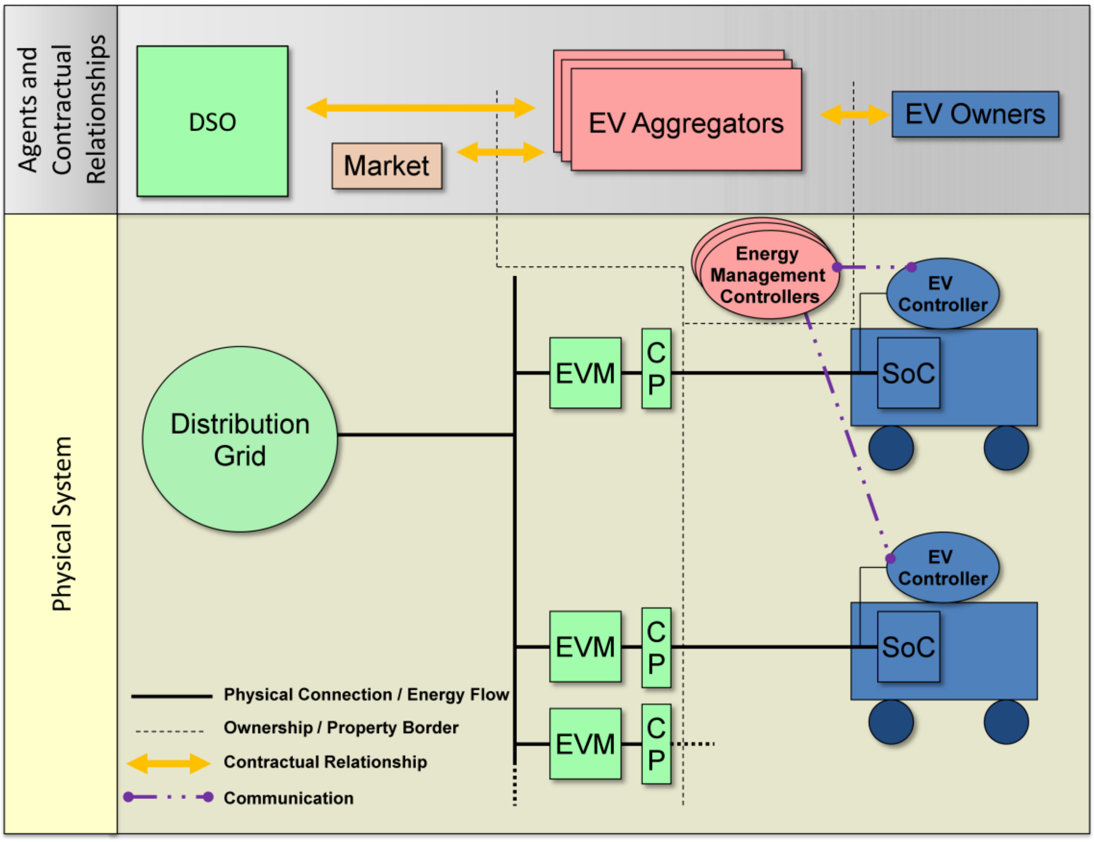

Figure 6. Public street parking area with multiple EV electricity suppliers

Contracts: EV charging posts are installed by the local distributor as part of distribution network in order to have low cost, and fast installation of standard chargers. Billing will follow the same system that distributors have in place for other transactions. Charging points should made accessible to any EVS-A with no discrimination or monopoly practices. EVS-As will sign contracts with EV owners for EV charging. EV owners will pay the electricity bills to the contracted EV electricity suppliers (EVS-A), the same or different from the one that supplies his home, giving the right to charge at any of EV public charging points. The EVS-A would pay regulated network charges to the distributor for paying back grid and charging infrastructure costs.

Settlement: Each EVS-A aggregates multiple contracts with different EV owners with the preference to charge in public parking areas and homes, in order to benefit from load aggregation and other economies of scale. EVS-As, taking the role of the traditional electricity supplier would be obliged to pay regulated network fees to the distributor for the use of the charging point as a function of the energy consumption measured by the EVM, the time of connection, and the required power. In a competitive environment, the EVS-As contract the EV owners and pass on the regulated charges by designing end user tariffs according to the market conditions.

Communication and charge control: Under this scheme when an EV is connected at the parking site the on-board EVC communicates the time of connection and the energy demand to the EMC. Then, the EMC would provide the EVC with a charging schedule that satisfies those requirements. The EVS-A could optimize energy volumes and periods for charging EVs in order to maximize profits. The design of the contracts between EV owners and EVS-As is a key issue in order to achieve the desired profitability.

2.1.3 Catalyst Phase: Regulatory and policy recommendations

This section summarizes a set of policy and regulatory recommendations for the Catalyst phase, derived from the policy goals and the expected business models described previously. Recommendations have been organized according to several items.

Phase I - Catalyst

Policy and regulatory **recommendations** regarding

EV owner

- Economic incentives for buying EVs should be of much importance to reduce the acquisition gap cost between an EV and a conventional car. Several non excluding options could be (already applied in Portugal):
  - Incentives to buy electric vehicles
  - Incentives to eliminate end of life vehicles
  - Fiscal incentives
  - Incentives on the acquisition of electric vehicles by companies (fleets)
- Consider the EV as an additional normal home load electricity appliance.
- Let the house owner -or flat owner in a shared house building- the free option to choose a separated or a single common meter for the EV charging consumption and the others house appliances. A common meter will reduce the cost for the EV owner and will foster a smarter auto-management of all loads connected to the meter in order to minimize the contracted power for this particular connection point.
- Avoid any message/regulation related with the EV load being a low priority load (within a shared house building for example) to be curtail in case of network problems.
- Rather bet on a positive message/regulation: the network and the electrical system would have to adapt to EV penetration (in the very similar way they did to integrate air cooling appliances for last years).
- Assure EV loads would benefit from energy Time of Use (ToU) tariffs

    - Appropriate metering should be installed: smart meters if smart meter roll-out programs are in place, dual meters otherwise
    - Regulator must include ToU tariffs as an option for those consumers still under regulated full electricity tariffs

- For flats sharing the same building and the same garage surface, do not impose any a priori charging installation set up. Two main options exist. Either there is a common feeder that covers the whole garage with different branches serving the parking slots with specific meters for each slot, or, instead, there are individual feeders that reach each parking slot. Even if the former option may seem more efficient it presents some relevant drawbacks, as for example:
    - As far as the distribution utility will not accept to be in charge of uncontrollable inside building electric installations, this solution obliges to share a common connection point with the distribution utility and therefore a common official consumption meter. Additional non official meters inside the garage may be used by the neighborhood community to allocate the consumption to each EV owner according to their actual consumption.
    - In that case the EV owner will not be free to choice its retailer (for example the same that is serving its home appliances consumption), since the retailer will be the one chosen by the neighborhood community.
    - Also, it will not allow the EV owner to share the same meter for its EV and home appliances consumptions.
    - Being a common infrastructure for the community, it will require the agreement of the neighborhood building community and to share the costs. This could represent a strong barrier.
    - It may not be the more efficient decision if the adoption of EV by other neighbors lasts too much.
- For flats sharing the same building and the same garage surface, regulation should guarantee that required installation of individual charging points do not require the agreement of the neighborhood building community. Otherwise potential EV owners will face a strong barrier.
- Legislation related to new buildings construction should include the norms and standards to provide enough space for the wiring and the voltage transformation centre necessary for an electrification of all the vehicles parked in the constructed parking lot in a modular way. That is to say, room should be made but the investment in the installation should only be made or upgraded when the adoption decision of the final users are taken.

Phase I - Catalyst
Policy and regulatory **recommendations** regarding

Charging Point managers (CPM)

- Legislation should develop the figure of Charging Point Manager (CPM) as a “final electricity customer” allowed to resell energy for EV charging purposes if it wishes to.
    - The CPM is the owner and operator of one or several final charging points including the electric installation required from downstream the connection point (or connection points) to the distribution grid (distribution company).
    - The CPM is free to choose its business model. It may decide to resell energy to EVs according to their actual charging consumption (in which case a certified metering equipment will be necessary), or it may decide to charge according to the time of parking lot occupation (with access to recharging facilities) irrespective of the energy actually consumed in the charging process (no metering, nor complex billing processes will be then required). Other business models are also possible.
    - The CPM, as any other “final customer”, may acquire energy from a retailer or directly from the wholesale market.
    - The technical requirements and financial liabilities must be kept as simple as possible to foster the appearance of a large number of small CPMs (for example the owners of private public access parking).
        - However if it decides to participate in wholesale electricity energy markets it will have to comply with similar financial and guaranteeing obligations that other market participants.

Phase I - Catalyst
Policy and regulatory **recommendations** regarding

Tariffs and metering

- The existence of Energy Time of Use (ToU) tariffs is a key point of the regulatory design of the Catalyst Phase. Indeed a super-valley energy tariff will allow reducing significantly the cost, for the EV owner, of the energy required for charging the battery, and also it will assure the grid distribution network been able to cope with a significant EV penetration without facing large problems and without large investment needs.

    - For those customers that still benefit from an energy regulated tariff, the regulator should assure the existence of an electricity ToU tariffs option, based on a Time of Use energy component.
    - For those customers exposed to free market retail markets, retailers will, in a natural way, offer Time of Use tariffs provided metering allows it.
- Metering should allow the application of energy ToU tariffs. It is essential
    - If smart metering roll-out programs are in place, take advantage of it, prioritizing as much as possible the installation of smart metering to EV adopters.
    - Wherever smart meters would not be available, implement dual time meters.
- Innovative schemes must be applied to avoid the peaking super-valley initial time problem. This is a well-known effect related to the existence of ToU tariffs. Loads are scheduled to connect just at the beginning of the super-valley, provoking an important quite instantaneous peak which is worrying for the grid. Implementing controlled smart charging strategies may solve this problem, but till this development is reached (expected for Phase II) other cheaper solutions may be studied as for example that of setting different initial time intervals for different users.

Phase I - Catalyst Policy and regulatory **recommendations** regarding	**Distribution System Operators (DSOs)**

- Distribution utilities will have the obligation to serve EV loads as any other electricity load. The grid and the electricity system will have to face the necessary investments to cope with the EV penetration. In particular they should not be authorized to install any kind of equipment in the feeder of a building that may discriminate the EV load with respect to other consumption uses, except if a clear consent of all final individual customers of the building exists.
- The existence of energy ToU tariffs will surely reduce the impact of EV loads in the grid, minimizing the required investments. However the regulated remuneration mechanisms applied to distribution utilities should be accommodated to guarantee the cost recovery of such required investments. In particular it should be checked that the remuneration scheme in place is sensitive to investments related to
    - an increment in the contracted power,
    - an increment in the energy served,

- and any EV related specific investment obligation imposed by the regulatory authorities, for example concerning
  - mandatory public charging infrastructures deployment
  - mandatory pre-installation of the equipment required to serve a future full EV deployment in flats buildings or office garages.
- In most countries the distribution utility is in charge of the metering. They should be mandate to install shortly a dual-time meter to all EV adopters. Moreover, if a smart meter program is in place, priority could be given to EV adopters.
- Any installation (feeders, charging points) downstream the DSO physical metering point (point of connection to the grid) will not be the ownership of the DSO. It will be a private (CPM, EV owner) ownership.

Phase I - Catalyst Policy and regulatory **recommendations** regarding	**Additional measures**

As stated previously it is also recommended:

- to develop pilot projects that will provide experience from field tests regarding the capabilities of more sophisticated interactions with the grid. In particular the potential advantages of participation of EV's or EV aggregators in balancing and reserve markets will have to be checked by some pilot actions that desirable could still be launched in this Catalyst Phase.
- to develop specifications for Frequency Sensitive Charging Equipment as it is a promising and quite easy to implement service to be provided by the batteries.
- to work on standardization processes looking forward to improve the currently available ones in order to ensure a more flexible charging in view of the control and management of the distribution network
- to foster retail market competition in order to facilitate the appearance of retailer-aggregators

2.2 Consolidation Phase (2)

As discussed in D5.2, the most simplest way to characterize this phase is showed in Figure 7.

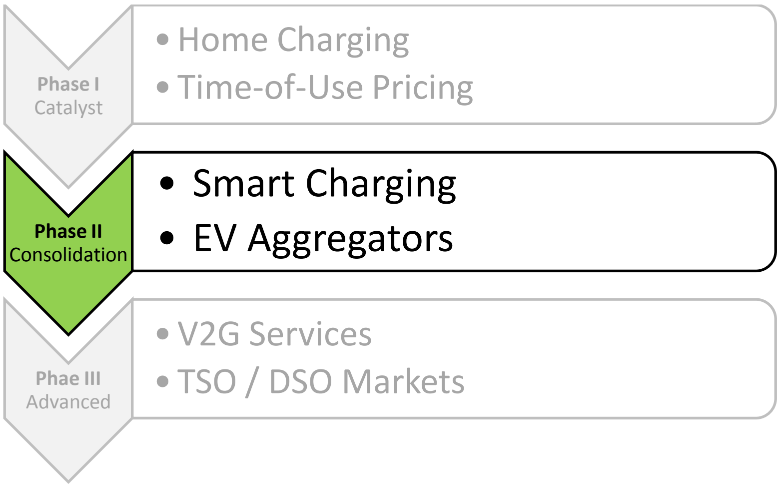

Figure 7: Phase II – Consolidation

2.2.1 Consolidation Phase: Goals and General Considerations

Depending on electric vehicle uptake, which is hard to foresee, the consolidation phase is considered to arise in the mid-term and hence is not of immediate concern. For this phase the electric power sector regulation should allow for the emergence of new business models of EV supplier-aggregators (EVSA) which are capable of managing the contracts of thousands of EV connecting simultaneously at different locations.

Please note that EV loads are not fundamentally different from any other electrical appliances. In fact, it is very well arguable that the demand side measures that can be taken from scheduling electric vehicle charging are always in direct competition to service providers that can perform interumpability or load reduction with any other means, maybe even in a cheaper way. One could even go one step further and argue that EV aggregators should be denoted flexible load aggregators as their service is not necessarily specific to EVs.

Hopefully at this stage, the progress of the VPP and smart grid concepts (advanced monitoring and controllability of local distribution networks to efficiently integrate distributed generation resources, load management and grid operation) will have fostered the development of a large communication and information system's frameworks, together with the deployment of smart meters. Aggregators will take advantage of such deployment to support their activities. Therefore the investment cost for such an infrastructure will be shared with the whole set of loads (not only EVs) and the set of distributed generators, making the cost analysis benefit much more profitable.

Therefore the consolidation phase actually is the phase where smart charging and potentially control of large set of EV's fleets for load management will become significant.

EV supplier-aggregators (EVSA) will play a key role in this phase. Their participation in energy markets, as well as in balancing and ancillary service markets should be facilitated, in order for them to maximise the potential added-value of such a battery deployment connected to the grid. Risk hedging mechanisms will need to develop for assuring a stable functioning of systems.

Primary frequency control, within the smart charging concept, looks promising and can be considered also in the consolidation phase, especially for island grids. Secondary frequency control through the change of the rate of charging - under the smart charging concept - may require however some further confirmation that battery does not suffer too much.

In this phase, because the EV load may become a non-negligible one and its impact in the distribution grid becomes more relevant, Distribution system operators (DSOs) might have to validate control strategies and market results before they are determined to be feasible, as TSOs already do at the transmission network level. It will make sense DSOs managing markets to procure EV services (more generically load and distribution generation service), in the same way TSOs already do at the transmission network level. EVs aggregators will be the appropriate link to participate in those markets.

Therefore in this phase EVSAs will be the key actor for EV been able to provide services to the grid, what could be seen as the first stage of V2G capabilities.

The second stage of V2G capabilities, that is also taking advantage of being able to inject energy into the system, will come later, in the third phase (Advanced phase). However, if the additional costs of getting these V2G functionalities (bidirectional charging equipment, communications, security and protection devices ...) happen to be negligible, it could come also a reality at this stage EVSAs beginning to provide such services at this stage.

At this phase, if not done yet in the previous phase, a “roaming” kind of approach for the use of the connection charge facilities should be implemented, taking advantage of the communication, tele-metering and information systems already in place[3].

Finally the dissemination of charging points both on public and private locations and the good operation of, for instance, mobility cards used to charge EV’s will contribute to create a more confident atmosphere on the increased penetration of EV’s.

Maybe this phase will still need not to eliminate the incentives created in Phase 1, namely fiscal incentives. However, once the consolidation phase is attained, maybe a specific tax (similar to the fuel taxes for conventional cars) is implemented. In that case separated specific meters should be installed.

The main policy drivers for this phase could be then summarized as follows:

[3] As mentioned previously, the future of EV's may also strongly be linked with the Smartphone, as this allows low investments now, full scalability and future proofing and avoids the need to develop very sophisticated Billing systems.

Phase II

Consolidation

Main Policy Goals

Assure emergence of EV supplier-aggregators (EVSAs) and of controlled charging modes

- Foster Development of Electricity Retail Markets
- Unbundling for small DSOs
- Foster smart grid implementations. It will provide a large communication and information system infrastructure, ready to be use also for EV purposes.
- Implement control over charging
- Deploy public charging infrastructures
- Adapt Balancing and Reserve Markets to EVSAs participation
- Define EVSAs role in Balancing and Reserve Markets in terms of liabilities and obligations
- Set the rules for interaction with DSOs
- Integration of EVs charging management in network planning activities

2.2.2 Consolidation Phase: Description of the Business Model

As identified in D5.2 of this Project, the expected general business model will be a sophisticated version of the ones developed in phase I. EV aggregators (EVSAs) will take advantage of the large number of EV deployed to offer more enhanced services both to the EV owner and the grid. EVSAs will control the charging process, according to contractual agreements set with the EV owner, so that better energy prices could be attained. Also the controllability of charging process would make possible to provide services to the system in terms of demand reduction measures, managing critical situations in the network, in exchange for an economic remuneration to the final customer.

When passing to the Consolidation Phase, the EV's and EV aggregators should be induced to participate in balancing and reserve markets as controllable loads. EV aggregators could then present up or down reserve bids and be remunerated for these services. If this scheme is allowed and psychological barriers are eliminated, this could emerge as a new source of revenues for EV owners, contributing to turn the investments on EV's more attractive and thus creating the conditions to further increase the EV uptake.

For that, it will be necessary to standardize communication protocols with the intelligent charging systems located inside the vehicles and a regulation in which the DSO can request services from the aggregator (similar to what TSOs are enabled to do already today).

EVSAs can also be CPMs.

It follows a brief description of a possible business scheme that may be developed under this second phase for home charging. Other business models (commercial buildings, private garages with public access, public infrastructure) have been largely described in D5.1 of this project. Because the conceptual scheme will be very similar to that one, they are not reproduced here.

Home charging with a controlled charge by an EV aggregator.

In this mode the EVS-A acts as an intermediate agent participating in the energy wholesale market while reselling this energy to EV owners who are managed under a charging contract. The EVS-A could conduct an integrated energy optimization by aggregating several charging points at the residential level (HO-SA-UCO) additional to the EV contracts associated with public charging points (PR-CPM-CC). As described before, this scheme allows separate pricing of energy consumed at home for transportation purposes, and therefore it makes it possible to include specific taxes or special rates.

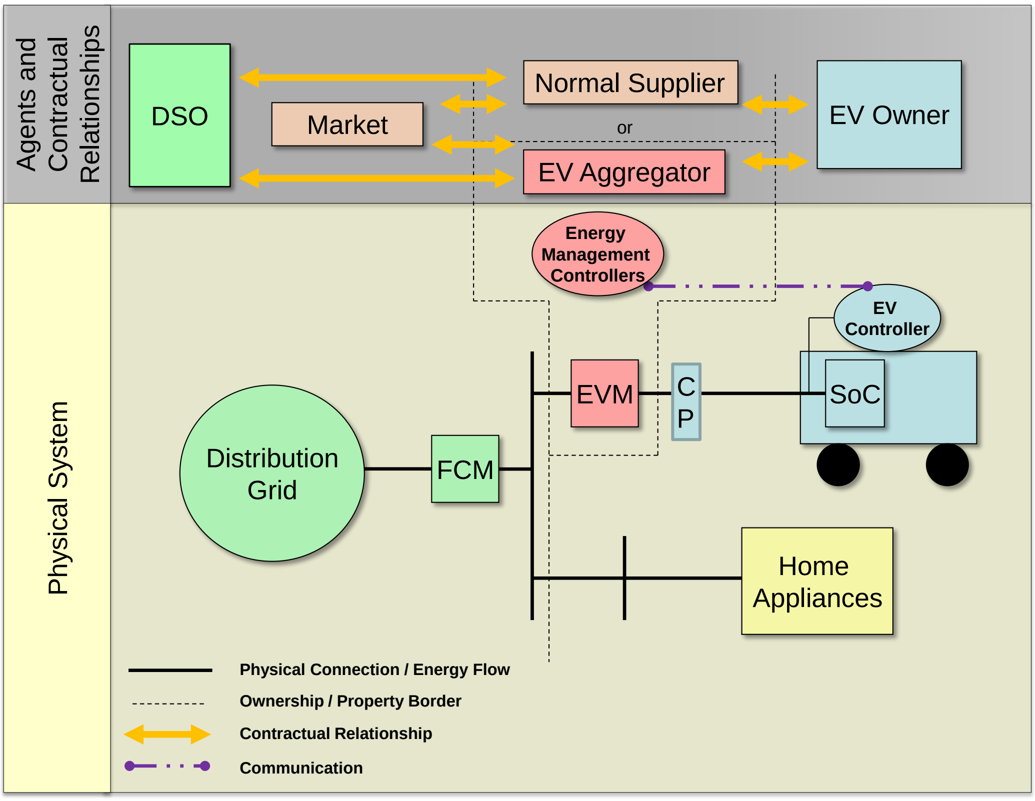

Figure 8. EV home charge under EVS-A management

Communication and charge control: The home owner installs the EVSE and notifies the EV aggregator the maximum required charging power. The EV aggregator will install the EVM and communicate his EMC with the on-board EVC. Under this scheme, the EVC will communicate the time of connection and the energy demand to the EMC when the EV is connected at home. Then the EMC will provide the EVC with a charging schedule that satisfies those requirements. The EV aggregator will optimize energy volumes and periods for charging EVs in order to maximize its profits. There is a need for validation of the scheduling profiles with the DSO, which requires an interaction between the Aggregator and the local DSO.

Contracts: A charging contract between the EV aggregator and the EV owner. On the other hand, the aggregator would sign contracts with other electricity suppliers or would buy energy in the market, while paying network charges for each connection point to distributors.

Settlement: The charging contract between EV aggregator and EV owner will be settled according to the energy volumes and peak power measured by EVM, considering the prices and other conditions agreed upon. The supply contract between other electricity suppliers and the EV aggregator will be settled according to the energy volumes measured by FCM and the agreed prices and condition. The EV aggregator would negotiate one single supply contract for providing energy to many charging points. The EV aggregator would pay network charges to distributors for each connection point according regulated rates and volumes measured by FCM.

2.2.3 Consolidation Phase: Regulatory and policy recommendations

This section summarizes a set of policy and regulatory recommendations for the Consolidation phase, derived from the policy goals and the expected business models described previously. Recommendations have been organized according to several items.

Phase II - Consolidation
Policy and regulatory **recommendations** regarding

EVSAs and markets

New business model of EV supplier-aggregators with thousands of EV contracts connecting simultaneously at different locations requires several issues to be tackled

- Adapt design of energy market and balancing and ancillary services' markets to the characteristic of this new player. Some particular issues have been identified in D5.2.
    - Minimum volumes to participate in those markets should be reviewed
    - Procurement of Reserves should not be earlier than 24h ahead, for reducing EVSA forecast errors
    - Asymmetric –up and down- bids in reserve markets should be allowed.
    - Defining EVSAs role in Balancing and Reserve Markets in terms of liabilities and obligations

- Risk hedging mechanisms adapted to EVSA need to be implemented.
- Smart metering should be implemented to enlarge the contractual possibilities in the relationship of the EVSAs with the EV owners.
- The "roaming" kind of approach should be implemented to make more flexible and attractive the use of charging points.

Phase II - Consolidation Policy and regulatory **recommendations** regarding	**EVSAs and controllability of load charging**

The smart charging and control of EVs for load management are one of the main goals of this phase. Making this real will require the deployment and use of a bidirectional communication and metering infrastructure together with the managing of large information systems.

- Fostering the implementation of smart grid and VPP concepts will help justifying the investment required to set the communication, control, metering and information systems required to actively controlling EV load charging with added value for the grid. Also it will allow an easiest implementation of the "roaming" kind of approach for the use of charging points. Thus, the cost of such infrastructure deployment will be supported by all the electricity loads[4].
- Devices (investments) and protocols standardization should comply with those other initiatives (smart grids, VPPs,…)
- It will be necessary to standardize communication protocols with the intelligent charging systems located inside the vehicles

Phase II - Consolidation Policy and regulatory **recommendations** regarding	**DSOs interaction and Access tariffs**

At this stage and provided the number of EV is significant, distributors will be interested in services to be provided by EVSAs (as well as retailers of other loads

[4] As mentioned previously, the future of EV's may also strongly be linked with the Smartphone, as this allows low investments now, full scalability and future proofing and avoids the need to develop very sophisticated Billing systems.

with controllability features), in order to better control flows and voltages through their grid.

- The interaction of EVSAs with DSOs should be regulated as far as DSOs are regulated activities. Fair, transparent and non-discriminatory rules must be set to organise this relationship. A possible way is that of DSOs buying EVSAs (and other retailer) services through market mechanisms as TSOs already do at the transmission level.

- TSOs will may also be interested in EVSAs (and other retailer) services, for example to increase system load in super-valley hours whenever wind production is being curtailed because of lack of room in the production mix.

- As more a more players interfere in the load flow of the distribution grid it will make sense DSOs might have to validate control strategies and market results before they are determined to be feasible, as TSOs already do at the transmission network level. Clear and transparent rules should assure an efficient and not discriminatory validation process.

- In order to benefit potential EV adopters, the ToU tariff concept could be extended from the energy ToU tariff already proposed for the Catalyst Phase to also a ToU access tariff. Access tariffs usually collect from consumers all the regulated revenues of the electricity sector. Part of these revenues corresponds to grid investment costs which are mainly related to the contracted power. However a contracted power being used only in super-valley hour has a minimum impact on grid investment needs. On the contrary, a contracted power being used at peak load time has a very direct impact on grid investment needs. If a separated meter for EV is applied it may be sensitive to apply a lower access tariff to EV owners that charge in a controllable way at the super-valley time. However this is controversial as far as a contracted power may be used at any time in the day. Only highly controlled and monitored loads could be beneficiaries of such a scheme. But EV may be precisely one of them.

- Also a locational dependent access charge may be thinkable, as largely discuss in D5.2. However, because it is still a highly controversially discussed topic, it will not be set here as a general recommendation.

- The existence of a “roaming” kind of approach may require the design of appropriate Access tariffs. Access tariffs are up to now charged to the owner of the connection point, usually according to both the contracted power and the served energy. In the expected business schemes discussed in this project, the owner of the connection point would be either an EV owner, a CPM or a distribution utility. In the first two cases access tariff will still be charged to the owner of the connection point. In the third case it should be set how the tariff access is recovered. An option is to socialize this cost among the rest of access tariffs or to socialize it among EVs’ or also conventional cars’ owners through specific traffic taxes.

- Regulation should encompass the integration of EVs charging management in network planning activities. Grid network planning activities should in the future take advantage of the smart grid concept, resulting in a more efficient and adapted distribution network. EVs should play a role in it (as well as other controllable loads and distribution generation facilities). Even if nevertheless, this may be foreseen for the advanced phase, pilot projects should test these possibilities at this stage.

2.3 Advanced Phase (3) Scenario

As discussed in D5.2, the simplest way to characterize this phase is showed in Figure 9.

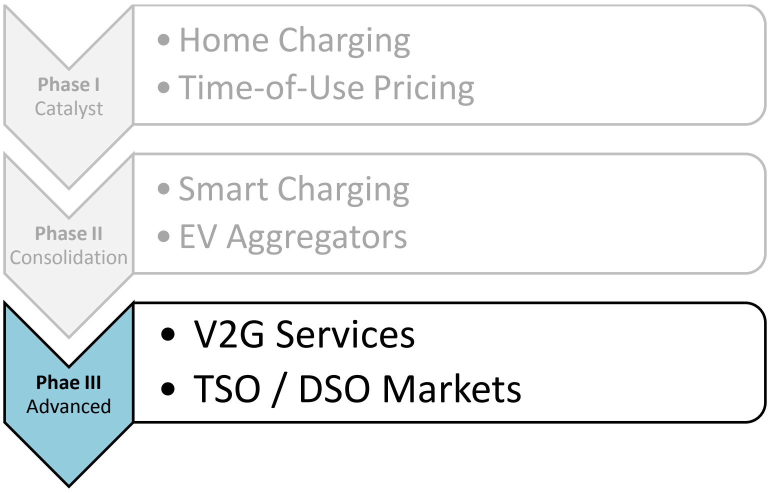

Figure 9: Phase III – Advanced

2.3.1 Advanced Phase: Goals and General Considerations

The advance phase gathers the rather long term and somewhat futuristic scenarios. EVSA playing a substantial role in providing vehicle-2-grid (V2G) services and facilitating the aggregated participation of electric vehicles in balancing and ancillary service markets. At this stage they could be interacting with DSOs in setting up local markets for system services and with TSOs for more system-wide services.

Under this phase it is expected a full participation of EVs in frequency reserves and voltage services under DSOs and TSO requests.

For such a scenario, more sophisticated control, measuring and billing infrastructures need to be put in place. There is a high need for cost/benefit studies to assess the profitability of these businesses before actual investment will take place. Other issues, such as warranty releases for battery performance of car manufacturers, need to be addressed as well.

It is to be noted that the concepts grouped in the advanced phase are not regarded as less important, however they are yet premature and not marketable and therefore need other attention than policies for the immediate deployment.

More sophisticated

- If economically sensible, rollout of V2G (this might evolve with the changes in Phase 2 by itself as aggregators would not want to miss that opportunity).
- Associated with that, advanced potential services to the TSOs/DSOs
- Including EV's effect on losses incentives

Phase III

Advanced

Main Policy Goals

Full integration of EVs capabilities

- EU harmonization of AS markets
- EU level Information and Communication requirements that will enable secure EV – DSO – EVS-A – TSO real-time communication
- Distribution Grid Code Adaption to allow for agreements between DSOs and EVSA for investment deferrals and congestion management
- Assess the impact of EV's in quality of service and include this effect in quality of service incentives
- Network Specific Loss Adjustment Coefficients for Distribution Systems

2.3.2 Advanced Phase: Description of the business model

The business model will be a natural evolution of those present in Phase II, with a more active participation of EVSAs in markets and providing services as requested by the DSOs and the TSO. Eventually, fully V2G capabilities (bi-directionality in the energy interchange) will permit the system to make an efficient use of the storage of electric vehicle batteries. The vehicle to grid (V2G) concept presents more sophisticated EV charging modes that require further technology deployment and contractual arrangements. EVs connected to the grid can be a valuable resource by injecting power into the grid and/or providing frequency regulation reserves that would help to optimize power operation and minimize system costs. EVs would obtain some revenues in exchange.

To make this charging mode possible, EVs would be equipped with an inverter and a control system that would inject power from the battery to the grid or vice versa, and the EV meter would count energy flows in both directions.

The EV aggregator will optimize the EV resources as storage that can be charged in some periods and discharged in others, always subject to driving constraints imposed by EV owners. In addition, he/she could subscribe specific contracts with an Independent System Operator (ISO) to provide regulation reserves or to sell or buy energy in real-time or day-ahead markets. In those cases specific metering and communication equipment should be deployed to meet the requirements to participate in those markets.

As an example it follows a brief description of a possible business scheme that may be developed under this third phase for home charging. Other business models (commercial buildings, private garages with public access, public infrastructure) have been largely described in D5.1 of this project. Because the conceptual scheme will be very similar to that one, they are not reproduced here.

EV connected at home providing V2G managed by an EV aggregator

In this case (see figure 10) the EV aggregator would manage EVs eventually evolving to V2G capabilities to buy and sell energy at the day-ahead and real-time markets to provide regulation reserves under supervision and control of the ISO. The EV management controller (EMC) should have a communication system with the ISO in order to put energy bids and to follow AGC control instructions to provide regulation reserves.

The measurement equipment should be bi-directional such that the EV can deliver both primary and secondary frequency regulation services, while not all the EV owners would have to adhere to these concepts.

For islanded systems, participation in primary frequency control is of utmost importance and should be envisaged through a local autonomous control while for secondary frequency control this should be defined by the TSO from the AGC.

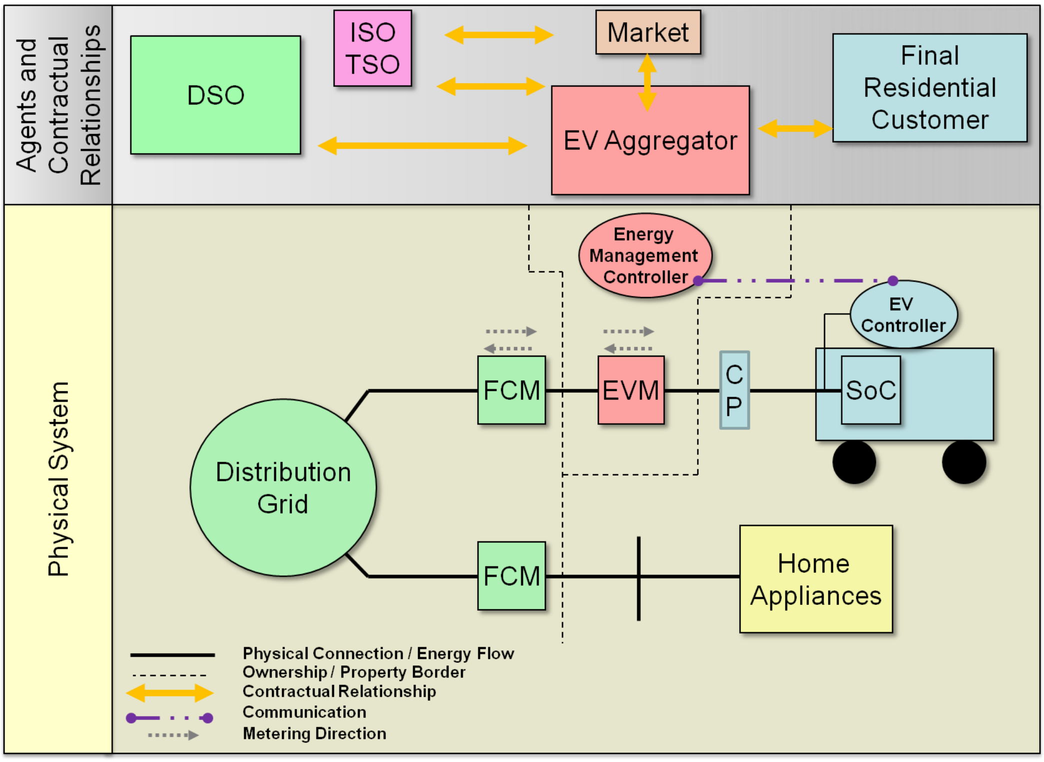

Figure 10. EV aggregator providing V2G services with home connected EVs

The EV aggregator will be compensated by the ISO or TSO for the services provided and he will compensate the EV owners too. The optimization of management strategies and the sharing of profits among the EV manager and EV owners is a complex mathematical programming problem (Beer et al, 2010).

2.3.3 Advanced Phase: Regulatory and policy recommendations

This section summarizes a set of policy and regulatory recommendations for the Advanced Phase, derived from the policy goals and the expected business models described previously. Recommendations have been organized according to several items.

Phase III - Advanced

Policy and regulatory **recommendations** regarding

DSOs and TSOs

After introducing changes in the regulation of the distribution activity as described in Section 2.2.3 for the Catalyst Phase and introducing refinements on these regulations on the Consolidation Phase, further steps can be done in the regulation of the DSO's.

- Distribution Grid Codes should be adapted to allow for agreements between DSOs and EVSA for investment deferrals and congestion management. Phase II should have provide the experience enough to translate the good practices identified to the planning and operational decision making process of the distribution utilities.

- Also, as already discussed in Section 5.3.4.1. of Deliverable D 5.2, the impact of distribution network losses should be considered and reflected in the regulation of the distribution activity. Network Specific Loss Adjustment Coefficients for Distribution Systems will be required to improve the correct allocation of the associated network losses costs.

- In the same way the impact of EV's in quality of service should be assessed and included in quality of service incentives that are already in place in several countries.

- Full procurement of frequency reserves and voltage services. Secondary, tertiary and unbalance management - After inducing the participation of EV aggregators in the reserves and balancing markets as controllable loads, in the Advanced Phase, it should possible to implement control actions associated to EV charging and eventually evolving to the V2G concept in which EV's could inject power to the grid, both allowing the modulation of the charging and discharging periods not only according to the energy prices but also according to up and down reserve prices.

Phase III - Advanced Policy and regulatory **recommendations** regarding	**EU harmonization and standardization**

An effort should be made at European level to harmonize and standardize as much as possible the charging equipment, the communication protocols, as well as the ancillary services markets so thar

- EU level Information and Communication requirements that will enable secure EV – DSO – EVS-A – TSO real-time communication
- EU harmonization of AS markets
- EU standardization of charging equipment with bi-directional capabilities.

3 PORTUGAL

3.1 Present situation

3.1.1 EV penetration Reality

Current state of electric vehicle penetration

Following the work reported in the Deliverable D.3.2, on the "Evaluation of the Impact that a Progressive Deployment of EV will Provoke on Electricity Demand, Steady State Operation, Market Issues, Generation Schedules and on the Volume of Carbon Emissions – Electric Vehicle Penetration Scenarios in Germany, UK, Spain, Portugal and Greece", this Section of D5.3 summarizes the forecasts that were developed regarding the penetration of EV's until 2030. The penetration of EV's was estimated for three scenarios (Scenarios 1, 2 and 3), for three technology types (BEV, EREV and PHEV) and for four vehicle types (L7e, M1, N1 and N2. Based on these estimates, Table 3.1 summarizes for each of the three mentioned scenarios, the estimated number of EV's as obtained in Deliverable D 3.2 of the Merge project.

		Scenario 1		Scenario 2		Scenario 3	
		2010	2011	2010	2011	2010	2011
L7e	BEV	16	36	36	82	80	182
M1	BEV / PHEV / EREV	16	46	36	102	80	228
N1	BEV / PHEV / EREV	3	8	7	18	16	41
N2	BEV	0	1	1	2	2	5
	Total	35	91	80	205	177	456

Table 3.1: Summary of vehicles in the Portuguese EV park, split by vehicle class for 2010 and 2011 in the three considered scenarios (source Deliverable D 3.2 of Merge).

Although it was not possible to get official statistics for the number of sold EV's in 2010 and in 2011, it was possible to obtain some information for the period from January to the end of August of 2011 from the web page http://www.veiculoselectricospt.com/vendas-de-carros-electricos-em-portugal/. According to this private association, in the first 8 months of 2011 128 EV's were sold in Portugal. Making a linear extrapolation for the entire year, one would obtain 192 EV's. This number is clearly larger than the forecasted number of sold EV's for Scenario 1 indicated in Table 3.1 (91 EV's) and it is in fact very close to the estimated number associated to Scenario 2 (205). This suggests that apparently the measures adopted at an official level (for instance, regarding fiscal incentives) and the deployment of the Mobi.E charging network (detailed in the next paragraphs) are, up to now, producing a relevant effect that allows the country to pass from a conservative estimate of the EV uptake (associated to Scenario 1) to a more aggressive EV uptake corresponding to Scenario 2. It should also be mentioned that the webpage indicated above gives important indications regarding the number of EV firm bookings by individual customers for several EV models available in the Portuguese retail market. Despite the economic difficulties affecting the country, this indicates that apparently EV's are at the moment sufficiently attractive so that a relevant uptake is occurring in Portugal.

However, recent indications suggest that the fiscal incentives to the acquisition of EV's as detailed in the next paragraphs will be reduced or eliminated from the Portuguese National Budget for 2012 at the moment under discussion in the Portuguese Parliament. This may turn the investments in EV's less attractive thus eventually compromising the positive developments identified for 2011.

Description of pilot projects, fleet tests and official plans and forecasts for future development

In Portugal there are at the moment two programs that are related with electric mobility. One of them is directly related with the creation of conditions to get a massive penetration of electric vehicles (Mobi.E, www.mobie.pt) while the second is related with smart metering (InovCity, www.inovcity.pt). The next paragraphs detail these two pilot programs.

A) Mobi.E (Portuguese Program for the Electric Mobility, www.mobie.pt)

The development of this program is motivated by the large dependency of the country on fossil fuels as well as by the large environmental impact of the use of these fuels. Therefore, Portugal aims at developing new energy models for mobility that are able to increase the quality of life of the citizens. According to these objectives, the Portuguese government created the Network for the Electric Mobility. It is an integrated network that includes several stations along Portugal, it is managed by the managing entity of the Mobi.E program and it allows charging electric vehicles using a rechargeable card. Its most relevant mission is to contribute to create a more sustainable mobility namely in urban environment while maximizing its advantages and integrating in a natural way the electric energy coming from renewable sources.

According to the Mobi.E webpage, using electric vehicles, each citizen will contribute to improve energy efficiency. As an example, it is indicated that at night the electricity demand reduces, and so when charging the batteries in those periods either at home or on plugs in the streets, we will be contributing to change the electricity generation model allowing an easier integration of electricity produced by renewable sources. On the other hand, electric vehicles offer an improved driving experience, given their smooth acceleration capacity and their reduced noise, and their reduction of pollutant emissions. All these aspects, contribute to turn their use as inevitable in the future.

As a result of these advantages from an individual point of view for each user but also for the entire society, the Portuguese government approved a set of benefits and incentives to help massifying electric vehicles. These incentives and fiscal benefits are as follows:

- Incentives to buy electric vehicles – the individual users that buy one of the first 5000 electric vehicles will have an incentive of 5000,0 € established in the Decree-Law nº 39/2010 of April 26;
- However, the vehicles that can benefit from this incentive are restricted to the ones in a list of approved models as published in the Mobi.E web site. This list is updated as new models are approved by a government agency;
- Incentives to eliminate end of life vehicles – the incentive of 5000,0 € mentioned above can be raised up to 6500,0 € if the acquisition of an electric vehicle is associated with the elimination of an old vehicle in end of life;
- Fiscal incentives – the acquisition of electric vehicles is exempted from the Tax Over Vehicles and also from the Circulation Unique Tax;
- Incentives on the acquisition of electric vehicles by companies – the costs of acquisition of electric vehicles by companies can be deduced on the global profits of companies in order to determine the amount to be paid as Tax Over the Revenues of Companies. On the other hand, the Code of the Tax over the Revenues of Companies allows the increase of the depreciation rate applied on electric vehicles when compared with the rate applied to combustion engine vehicles.
- Other benefits and advantages – having a smaller amount of pieces when compared with the combustion engines, the expenses related with maintenance of electric vehicles are considerable lower.

The Mobi.E system integrates the MOBI.E Network corresponding to an electricity charging network that is available all through the Portuguese territory and that is accessible to all users. It allows charging the batteries of electric vehicles in an easy and reliable way. The developed approach to implement this network allows the users to locate and select charging points of the network, plan routes, know the charging level of the vehicle, among other operations. At any moment, using a personal computer or a mobile phone, the user can activate a number of useful operations as well as analyzing its electric mobility bill in order to optimize the electricity demand. Using the MOBI.E network requires having the MOBI.E card as it will be explained later on.

The pilot MOBI.E network includes the installation of 1300 normal charging points as well as 50 fast charging points in Portugal mainland, all of them in public access areas. These 50 fast points will be located along roads and motorways between the municipalities where normal charging points are installed so that it becomes possible to travel between them as well as in strategic areas in order to ensure emergency and fast chargings. The pilot network including 1300 charging points is installed in public access locations and is being developed in a partnership consortium by MOBI.E, by EDP Inovação, by SGORME and operators and retailers of the electric mobility, as defined in the applicable Portuguese legislation detailed in Section 3.1.3, and it will be completed by the end of 2011.

Apart from the MOBI.E network, there are private operators that are also installing charging points in public places integrated in the MOBI.E system, namely in parking areas, shopping centers, hotels, airports or service stations, thus contributing to increase the range and the capillarity of the system. This means that will be possible for any driver to use his electric vehicle to travel along the country in a reliable and safe way.

As mentioned above, charging a vehicle in the MOBI.E network requires having a MOBI.E card that gives access to all charging points in a simple and reliable way. During the charging period, the user can monitor the charging process using the Mobi.E webpage and configure alert messages to be sent by sms. At the end of the process, it will be included in the Mobi.E account of user EV owner the amount to be paid, corresponding to the electricity demand and an amount for the service that was provided. At any moment, the user can use the Mobi.E webpage to get information on recent charging and the historic of used electricity.

Regarding the charging process using the MOBI.E network, after parking the vehicle in one of the available places, the user should pass his MOBI.E card in the reader located in a central location of the charging point. Then, he should select the charging option and indicate the charging point where the vehicle is parked. In this system it is also possible to run simple operations as the verification of the amount still available in the MOBI.E card or changing the PIN code. Afterwards, the charging point is activated and once the plug is placed in the socket, the charging is initiated. This will change the light indicator in the charging point to green indicating that a charging is going on. During the charging process, the user can access the system using the MOBI.E web page and check for status of the charging. When the charging is over, he will receive a sms and should then get back to central point, pass the MOBI.E card again in the reader and end the process. This will unblock the charging point and turn the light indicator to red. Once the plug is taken out of the socket, the light indicator goes to blue indicating this point is available again.

After the commercial step is started, the users should subscribe a new MOBI.E card associated to an Electricity Retailer for the Electric Mobility. The electricity will be paid to this retailer at a price set on a competitive free market basis, plus a cost due to the use of the infrastructure.

The network available in public access locations allows charging any vehicle and each charging point includes sockets mode 3 with type 2 connectors and sockets type 1 with compatible socket (type Schuko or IEC 60309).

In the future, this network will evolve to charging points having mode 3 charging with type 2 connectors for all 4 wheel vehicles and mode 1 with Schuko sockets for w wheel vehicles. During this initial period, the MOBI.E system will install charging point dedicated to 2 wheel vehicles so that a wider range network is obtained.

New parking facilities in new buildings or rebuilt are already obliged to include a charging point for electric vehicles or an electricity socket to charge batteries of electric vehicles. However, the majority of the private parking facilities are installed in buildings built prior to the approval of the applicable legislation in April 2010. In the case of buildings prior to this legislation, existing sockets can under certain technical and legal conditions be adapted to the electric mobility.

Regarding the mentioned MOBI.E card, it is important to notice that it is personnel and should only be used by driver under which name it was issued. This means that the identification and the PIN code through which users can access the entire system are personnel. During the pilot phase, only indentified pre-paid cards will be available. After this initial stage, the Electricity Retailers for the Electric Mobility will introduce in the market the MOBI.E cards that are considered more adequate to its commercial options. These may include pre-paid anonymous cards, namely for less frequent users, pre-paid identified cards and eventually post-paid cards.

A MOBI.E card can be requested if one is already an owner of an electric vehicle and provided it is already registered in the MOBI.E system. After subscribing a card, an identification and a code will be sent to email indicated by the user that will then enable the access to the system. It is also sent a provisional PIN that can be changed afterwards. As soon as the commercial step is started, the charging modes of each MOBI.E card will be selected by each retailer, and these options will be part of their commercial approaches to the market. In case a MOBI.E is lost or damaged, this should be communicated to the MOBI.E system in order replace it.

B) Portuguese Smart Metering Program (www.inovcity.pt)

At the moment, there is an ongoing program involving EDP Distribuição, the Portuguese regulated DSO, to develop and install smart meters. In the scope of this program, it was selected a medium sized town to install in an experimental stage 30.000 smart meters. According to recent indications, more than 65% of these new meters are already installed.

On April 6 2010, EDP Distribuição presented publicly the InovCity concept related to a new way of conceiving generation and distribution of electricity. This new concept is being implemented under a pilot program in Évora, a medium sized Portuguese town that was commemorating in 2010 the 100 years of its electrification. It was expected that by the end of 2010, 30.000 clients (domestic, small businesses and industrial) in the municipality of Évora were already connected to this new system. The InovCity concept is supported by an industrial, technological and research consortium gathered in the InovGrid project. This consortium includes EDP Inovação, Lógica, Inesc Porto, Efacec and Janz/Contar and it aims at providing the electricity network with information and equipments that are able to automate the network management, improve the quality of service, reduce operation costs, promote energy efficiency and environmental sustainability and creating the conditions to enlarge the penetration of renewable resources. Using the new infrastructures, it will be possible to operate in real time the distribution network, reducing in a significant way the interruptions times due to failures. On the other hand, over this new technologic platform, retailers will be able to provide new tariff schemes to their , more adapted to their needs and requests. Through ESCO's it will also be possible to install integrated systems in order to interact with domestic appliances.

The new electricity infrastructure will create the conditions so that each network user is able to increase the amount of electricity he can generate in his own installation using PV panels or small wind turbines, adapting the technical operation conditions of the network to the level of this generation.

At the domestic level, the traditional electricity meters will be substituted by an Energy Box corresponding to the terminal of the new advanced infrastructure and connecting each domestic installation to the new network. The customers will have a domestic energy manager that, apart from metering the electricity demand, can also meter the generated electricity that is sold to the upstream network. This Energy box also includes the required technology to access to tele management functions, as follows:

- Allow consumers to access information about their demand, which will create the conditions to change the demand profile, ultimately leading to reductions on the electricity bill;
- Have information on the daily hours with larger electricity demand as well as those ones in which the electricity price is more reduced, enabling programming domestic appliances to operate in these periods;
- Activate in a remote way several services as tariff changes, changes on the contracted power and monitor the automatic detection of failures in the distribution network eventually affecting their own installation.

On the other hand, EDP Distribuição is actively involved in the development of a network of charging points for electric mobility. This network can be developed more rapidly and efficiently with the creation of the new distribution infrastructure supported by the dissemination of the mentioned Energy Boxes. This new infrastructure will constitute the support to charging and discharging operations of electric vehicles that will be used to receive electricity from the network when its price is lower and to inject it back to the network when it becomes more necessary associated to an increased price so that an adequate profit is provided to the EV owner. Accordingly, although not directly related with electric mobility, the InovGrid project will contribute to create the technological conditions to the development of the network for the electric mobility and thus to the massification of EV's.

3.1.2 Basic Characteristics of the Electricity Sector

The organization of the Portuguese power system as well as its main regulatory drives was already detailed in Deliverable D 5.2. In brief, the sector is organized in four main activities – generation, transmission, distribution and retailing. Generation is organized in Normal Regime Generation and Special Regime Generation (including hydro stations smaller than 10 MVA, and renewables). Normal Regime Generation should communicate their selling bids to the market operator or establish bilateral contracts with the demand. The demand can also bid on the market. The electricity market has a daily basis and it works in the scope of the Common Iberian Electricity Market established between Portugal and Spain and in operation since July 2007. It is a symmetrical pool market to which all agents should communicate their bids till 11 am each day. After establishing the operation programs, this information is sent to the two system operators for technical validation and at about 16 pm it is obtained the feasible operation program for the next day. Then, the two TSO's contract the requited levels of ancillary services and at about 20 pm starts the first session of the intraday market for the whole period of the next day. There are currently 6 sessions of the intraday market with time intervals of 4 hours typically to contract small amounts of electricity for periods that start 4 hours afterwards. Finally, transmission and distribution wiring activities are regulated and retailing is developed in competition although a regulated retailer still exists namely to supply LV consumers that didn't migrate yet to the free market. This model is detailed in references [3.1] and [3.2].

According to the legislation, wiring distribution is separated from retailing meaning that retailers have the right to supply final customers [3.1]. Retailers are registered in a state agency of the Ministry of Economy and Innovation and are assigned a specific licence to develop their activity. Among the existing retailers, EDP Serviço Universal corresponds to the regulated retailer in the sense that their final customer tariffs are entirely set by the Portuguese regulatory agency. All the other retailers in the market are free to establish their tariffs.

Regarding the retailers for the electric mobility, the same principles apply. These entities should apply for a specific license and the activity of retailing for the electric mobility is developed under competition and it is unbundled from the operation of the charging points and from the management of energy and financial flows.

Since 2006 all customers are eligible. At the moment, all clients except LV have to go to the retail market. There is until now a regulated retailer (this function is at the moment assigned to EDP Serviço Universal, a company inside EDP Group) that provides integral regulated tariffs, namely to LV customers. However, in the near future this situation is likely to change namely because there are several opinions inside political parties that integral regulated tariffs should be eliminated and all clients, including LV ones, should go to the retail market.

Regarding the current level of demand in the market, the most recent figures (March 2011) provided by the Portuguese Regulatory Agency [3.3] indicate the following:

- there are 360.463 clients on the free market, out of 6.000.000 clients. At the moment there are 6 retailers in the free market and almost 90% of the clients connected in EHV, HV and MV are already supplied by retailers in the free market;
- the average demand of the free clients on the 12 months finished in March 2011 corresponded to 22.367 GWh. This represents an increase of about 6% regarding the value obtained in February 2011 and it corresponds to 46,5% of the total demand in the country;
- in March 2011, 4544 clients migrated from the regulated market to the free market, corresponding to 1418 GWh of new demand in the free market. On the other hand, 3305 clients went away from the free market (LV clients that returned back to the regulated market) representing about 23 GWh of demand on an annual basis. In March 2011, 770 clients changed of retailer inside the free market. These clients represented an annual demand of 64 GWh;

- taking into account the changes reported in the previous bullet, the total number of clients in the free market increased by 1239 and the demand increased 1395 GWh;
- regarding voltage levels, almost 90% of the clients connected in EHV, HV and MV are already supplied by retailers in the free market. Regarding LV clients it is important to distinguish between Special LV (contracted power larger than 41,4 kW) and Normal LV (contracted power below 41,4 kW). On SLV, about 51% of the clients are already on the free market while on NLV (including domestic clients) almost 90% of them remain in the regulated market.

According to the Portuguese Tariff Code [3.4], the distribution wiring activity is regulated using a Revenue Caps strategy. According with this approach, the Regulatory Agency approves the maximum value that the regulated revenue can reach as a function of some variables emulating the cost structure of the activity under analysis. Once this remuneration is approved, it is then converted into the tariffs for the Use of Distribution Networks. These tariffs are split in tariffs for the HV network, for the MV network and for the LV network and all of them are set in terms of prices on the contracted power and on the peak power.

The Revenue Caps scheme adopted to regulate the distribution activity, [3.4], is based on expression (3.1).

$$R_t^D = \sum_{j=1}^{2} \left(F_{j,t}^D + P_{j,t}^D . E_{j,t}^D - \Delta_{j,t-2}^D \right) \tag{3.1}$$

In this expression:

- j – takes the value 1 for HV and MV networks and the value 2 for LV networks;
- t – takes the values 1 to 3, depending on the year of each regulatory period to be considered;
- R_t^D – regulated revenue of the Distribution activity in year t;
- $F_{j,t}^D$ – fix component of the regulated revenue in year t, depending on the voltage level j;
- $P_{j,t}^D$ – per unit component of the regulated revenue in year t, depending on the voltage level j;
- $E_{j,t}^D$ – supplied energy per voltage level j in year t;
- $\Delta_{j,t-2}^D$ – adjustment term of the regulated revenue to be recovered in year t and resulting from deviations between estimated and true values in year t-2.

The fix and the per unit components for each voltage level, $F_{j,t}^D$ and $P_{j,t}^D$, are set by the Regulatory Agency for the first year of each regulatory period and then they evolve on the two subsequent years according to an RPI-X recursive rule.

According to the Tariff Code, [3.4], this revenue caps mechanism is complemented by incentives to reduce the losses in distribution networks and to improve the quality of service. Regarding this one, the Regulatory Agency, sets a reference value for the Energy Not Delivered, END, by MV networks. Based on this reference value, the Regulatory Agency establishes a symmetric scheme to prize or to penalize the DSO if END is below or above the reference value.

The Access Tariffs to be paid by all consumers, free market consumers and regulated consumers, are the addition of three specific tariffs:

- Global Use of the System Tariff – that pays the ancillary service and control center costs, the budget of the Regulatory Agency, the contribution of Portugal mainland to the overcosts in the Azores and Madeira Archipelagos, the subsidies to the Special Regime Generation (namely, renewable), and stranded generation costs due to the elimination of old PPA agreements;
- Transmission Network Tariff – pays the operation, maintenance and investments costs of EHV and HV transmission networks and it is regulated by revenue caps. This tariff is established in terms of prices on the contracted power and on the power in peak hours;
- Distribution Network Tariff – pays the operation, maintenance and investment costs of HV, MV and LV networks and it is regulated by revenue caps. This tariff is established in terms of prices on the contracted power and on the power in peak hours.

Regarding the ownership of metering devices, the distribution network equipments are considered in the asset basis of the DSO. Regarding smart meter there is an on going discussion on whether their costs should be internalized in the tariffs. The most recent information on this issue, indicate that the regulatory agency will accept that part of the development and installation costs of the smart meters are included in the tariffs. However, this percentage is still under discussion.

Regarding the equipments related with the electric mobility network, the legislation passed in April 2010 [3.5] indicates that the electric mobility system comprises an activity performed under competition (retailing for the electric mobility) and two regulated activities (the operation of the charging points and the management of the energy and the financial flows). The costs of these two regulated activities lead to the access tariffs to the electric mobility system. Once added to the retailing tariff, one obtains the final EV user tariff. The paragraph 1e) of article 11 of [3.5] indicates that each retailer for the electric mobility shall pay to the regular retailer the amounts corresponding to the demand in the charging points where EV clients of that specific retailer charge their EV's plus an amount associated to the losses in the distribution and transmission networks. This amount shall be determined in proportion of the energy consumed by the clients of each retailer for the electric mobility.

3.1.3 Current Legislation

In Portugal it was passed in 2010 new legislation aiming at inducing the dissemination of EV's and creating the corresponding legal and infrastructural conditions. The model adopted in the Decree-Law nº 39/2010 of April 26th on the electric mobility [3.5] organizes the system for the electric mobility in three activities as follows:

- retailing of electricity for the electric mobility. This activity corresponds to the wholesale acquisition of electricity and the retailing of electricity to supply EV, aiming at charging the corresponding batteries in the charging points integrated in the electric mobility network. This activity is performed in competition and the interested agents should obtain the corresponding licence that covers the entire country;
- operation of the charging points of the electric mobility network. This activity is performed according to administrative regulations during a transitory period and it will be opened to competition afterwards. It includes the installation, operation and maintenance of the public or private charging points of the electric mobility network;
- management of operations of the electric mobility network, that includes the management of the energy and financial flows associated by the operation of the electric mobility network. This is a regulated activity, that it is not admitted to be opened to competition in the future.

It is important to mention that the legislation creates specific retailers for the electric mobility but it is clear from the text of [3.5] that existing retailers can also develop this activity provided they get the corresponding license.

On the other hand, the charging points correspond to infrastructures exclusively dedicated to the charge of batteries of EV and operated by a licensed operator. Other services can be associated to this activity but conventional plugs are excluded. These points can have public or private access. The private points can be of exclusive use of the owner or their use can be shared by several users. They can correspond to normal charging points if the power is less than 40 kVA in ac or less than 40 kW in dc. They are faster charging points if the power is larger than these values.

The article 4º of the mentioned Decree-Law establishes the general guidelines for the operation of the system as follows:

- universal and equal access of all users to the charging service of batteries;
- freedom of choice of the retailer for the electric mobility;
- freedom of access to every charging point integrated in the electric mobility network for the purpose of battery charging, independently of the retailer for the electric mobility and without having to establish any kind of contract or legal arrangement with the operators of the charging points;
- existence of interoperability conditions within the electric mobility network and the different types of batteries and their charging systems.

On the other hand, the paragraph 4 of the article 4 in [3.5] states that the calculation and the setting of the remunerations of the regulated activities mentioned in the beginning should follow the next guidelines:

- equality of treatment;
- remuneration uniformity, in terms of applying the same principles and parameters to all operators of charging points;
- uniformity of the access cost to the charging points so that the prices associated to the regulated activities are universally applied to all clients and charging point, regardless of their geographic location;
- adoption of the tariff additive principle already in place in the tariff setting process in use in the electricity sector, so that cross subsidies are avoided and it is ensured that each user pays for the costs that is creating in the system.

The legislation for the electric mobility requires that there is a specific infrastructure for the electric mobility as well as retailers having a specific license for this activity. On the other hand, the legislation requires that the tariffs to be paid by the users are additive, meaning that they should include a term directly associated to the remuneration of the retailer together with regulated terms regarding the activities of the operation of the charging points and the management of the electricity and financial flows. This indicates that the tariff system should avoid cross subsidies and so specific measurement devices have to be installed, for the purpose of measuring these demands. The legislation does not specify the kind of cost allocation method to be used but it clearly organizes the final EV user tariff in two terms:

- an access tariff that is regulated and that covers the costs of operation of the charging points and of the management system to control the electricity and financial flows. This term should be universally fixed so that every EV owner pays the same regardless of their geographic location;
- a retailing tariff to be set by the retailers for the electric mobility under competitive conditions.

As mentioned above, the Decree-Law nº 39/2010 of April 26th separated the retailing activity from the operation of the charging points. The operator of the charging points is charge of installing, operating and maintaining the charging points (while receiving a regulated tariff for this service) and it should allow:

- any regular retailer to supply electricity to electric mobility network;
- any retailer for the electric mobility to receive that energy and supply its clients;

EV owners will not have to maintain any legal relation with the operator of the charging points, because the access to these charging points is free, provided the corresponding access tariff is paid. The retailers for the electric mobility should:

- buy the required electricity in wholesale markets;
- establish the required agreements with the operators of the charging points;
- set the final EV-user tariffs incorporating the energy price and the regulated access tariff to the electric mobility network.

In the business model adopted in Portugal, the charging network is accessible to all users, and each user has a card that provides access to the charging points and it is also used for billing purposes.

In order to receive electricity in the electric mobility system, the energy will flow by the distribution and transmission networks. However, the legislation [3.5] is not clear on whether the users of the electric mobility system will pay in their tariffs the existing access tariffs to use the infrastructure of the already existing power system. It is our belief that these access tariffs should be incorporated in the tariffs to be paid by EV users which means that the access tariffs to existing infrastructure should a term in the access tariffs to the electric mobility system.

Once again according the Decree-Law that was already mentioned, according to the legislation in [3.5], the activities in the electric mobility system comprise retailing, the operation of the charging points and the management of the energy and financial flows. The first is provided under competition while the second (at least in transitory period) and the third one are regulated. Since retailing is free and the legislation is recent, we have no information on the type of contracts that will be offered to EV users.

It is our belief that tariffs to be paid by EV customers should include different terms both in terms of energy versus time and / or an occupied space term. These terms could be used to induce the adoption of more adequate charging patterns by EV customers, namely to transmit the idea that some specific charging periods are more interesting from the point of view of the whole power system rather than other periods.

The legislation passed in April 2010 on the electric mobility network defines the operation of charging points as a regulated activity. The regulated cost of this activity together with the regulated cost of energy and financial flow management will lead to access tariff to electric mobility network. This legislation does not contain any indications regarding the remuneration of specific costs incurred by the DSO in terms of expanding or reinforcing existing distribution networks. It is our opinion that if such investments become required, the existing regulatory approach in force for the distribution wiring activity shall have to be adapted. If that is the case, such an incremental term in the revenue caps scheme given by expression (3.1) will not be difficult to be considered because from a regulatory point of view it would only be required to introduce a new parameter in the summation in this expression. This would mean that the regulatory agency was recognizing that the cost of the distribution wiring activity was affected by the variation of the number of EV's from one year to the next one and would consider reasonable to introduce should a parameter in the revenue expression. The value of the unitary cost that would multiply by the variation of the number of vehicles would then have to be estimated based on the investment and operational costs incurred by the company in a given year.

The legislation passed in April 2010 on the electric mobility network [3.5] defines the operation of charging points as a regulated activity. The regulated cost of this activity together with the regulated cost of energy and financial flow management will lead to access tariff to electric mobility network. This legislation does not contain any indications regarding the remuneration of specific costs incurred by the DSO in terms of expanding or reinforcing existing distribution networks. It is our opinion that if such investments become required, the existing regulatory approach in force for the distribution wiring activity shall have to be adapted. If that is the case, such an incremental term in the revenue caps scheme given by expression (3.2) will not be difficult to be considered because from a regulatory point of view it would only be required to introduce a new parameter in the summation in this expression. This would mean that the regulatory agency was recognizing that the cost of the distribution wiring activity was affected by the variation of the number of EV's from one year to the next one and would consider reasonable to introduce should a parameter in the revenue expression. The value of the unitary cost that would multiply by the variation of the number of vehicles would then have to be estimated based on the investment and operational costs incurred by the company in a given year.

On the other hand, this revenue caps expression is used for the whole network, without any kind of geographic discretization. In order to further refine this revenue caps mechanism it could be important to obtain the revenue amounts per geographical area, namely if the penetration levels of EV's were very different from one area to the area. However, such a geographic differentiation is not allowed in the current regulations since they determine that the access tariffs are universal and all clients in the same conditions (for instance, voltage level) should pay the same tariffs to use the electric infrastructure.

Finally, the large integration of EV's will require a larger monitorization and control of distribution networks. This would require extra investments in control devices, in hardware and in software tools that have depreciation periods different from other equipments. This situation suggests that a more refined revenue caps strategy is adopted for the distribution wiring activity to accommodate these investments.

3.2 Catalyst Phase

3.2.1 Goals and General Regulatory Principles

The next paragraphs detail the goals and the general regulatory principles to be achieved in Portugal in the Catalyst Phase.

- Absolute priority to facilitate EV uptake, by disburdening the life of potential EV adopters;
- Basic consideration of electric vehicles as new loads, which are passive, i.e uncontrolled (charging modes from D5.1 with suffix UCO) in real time. The simple scheduling is done by the EV owner via fixing the start time of the constant charging process at the typical power rates household sockets;
- Implementation of incentives to induce a faster up take of EV´s and to create conditions to obtain peak shaving.

As mentioned in Section 3.1.1 about the pilot program for the Electric Mobility, Mobi.E, the current legislation in force in Portugal considers a number of incentives as follows:

- Incentives to buy electric vehicles – the individual users that buy one of the first 5000 electric vehicles will have an incentive of 5000,0 € established in the Decree-Law nº 39/2010 of April 26. The vehicles that can benefit from this incentive are restricted to the ones in a list of approved models as published in the Mobi.E web site. This list is updated as new models are approved by a government agency;
- Incentives to eliminate end of life vehicles – the incentive of 5000,0 € mentioned above can be raised up to 6500,0 € if the acquisition of an electric vehicle is associated with the elimination of an old vehicle in end of life;
- Fiscal incentives – the acquisition of electric vehicles is exempted from the Tax Over Vehicles and also from the Circulation Unique Tax;
- Incentives on the acquisition of electric vehicles by companies – the costs of acquisition of electric vehicles by companies can be deduced on the global profits of companies in order to determine the amount to paid as Tax Over the Revenues of Companies. On the other hand, the Code of the Tax over the Revenues of Companies allows the increase of the depreciation rate applied on electric vehicles when compared with the rate applied to combustion engine vehicles.

As indicated in Section 3.1.1, these incentives have apparently worked well in 2011 since until the end of August 128 EV's were sold in Portugal, so that an estimate of about 192 EV's will be sold along the entire year. However, the financial difficulties affecting the country may originate that these fiscal incentives are reduced or even eliminated from the Portuguese Budget for 2012, thus compromising the uptake of EV's detected in 2011, which is in fact in line with Scenario 2, described in the mentioned Section 3.1.1. It should be recalled that Scenario 2 was qualified as a more aggressive scenario for EV uptake than it is expected to occur in reality. Despite this increased aggressiveness, the reality was apparently more in line with it than with the more conservative Scenario 1. This more aggressive EV uptake is certainly related with the conditions being created by the Mobi.E pilot program and to the still existing fiscal incentives to the acquisition of EV's. The reduction or elimination of these incentives is thus likely to disrupt this evolution.

Regarding the implementation of Time-of Use Tariffs this is considered as an appropriate approach to price the energy used by EV's to charge the batteries and not so interesting on the Access Tariffs due for the use of networks. In fact, Access Tariffs reflect transmission and distribution network costs and these are largely related with investment costs so that the corresponding tariffs are usually set using power terms (for instance, using contracted power or power in peak hours). This ultimately means that introducing some time differentiation in the Access Tariffs is not easily justified. On the other hand, if one accepts that Access Tariffs apply in an universal way to all consumers connected to a network, if some differentiation was introduced in the power terms, then these differentiations would also be applied to all other LV clients connected to the same network. Regarding the energy term of the tariffs to be paid by EV's it seems much more appropriate to introduce this time differentiation. In early stages and while smart metering is not generalized, a load profiling approach specific for EV's should be developed. As EV's uptake develops, smart metering will also be more justified and so ToU energy tariffs will be more easily applied. These ToU energy tariffs should be applied in a careful way, namely if no control measures regarding charging periods are adopted. If no time modulation of the charging exists then an avalanche effect of consumers aiming at charging their EV's in off peak hours may occur, causing in effect a new peak period where off peak previously existed. This avalanche effect should be counteracted namely by introducing different time of use periods along the day for different customers groups in order to induce a larger dispersion of the demand or to allow the an aggregating entity has direct control over the charging of a large amount of EV's in order to distribute the charging along a wider period.

Any more intelligent relationship between this load (the car charging process) and the grid (on-line signals or control, V2G, ...) will come later, taking advantage of the investments on communication and information systems that will happen as the more general concept of "smart grids" is developed. The economic justification of such investments will come from a broader approach and not just from the unique EVs perspective. These investments will then be charged to the whole demand and not to a small part of it (the EVs).

3.2.2 Description of the Business Model

- Business Model in force in Portugal

As detailed in Section 3.1.3, the Decree-Law nº 39/2010 of April 26th on the electric mobility defines the model to be implemented to allow the development of the electric mobility in the country. This model comprises three activities as follows:

- retailing of electricity for the electric mobility. This activity corresponds to the wholesale acquisition of electricity and the retailing of electricity to supply EV, aiming at charging the corresponding batteries in the charging points integrated in the electric mobility network. This activity is performed in competition and the interested agents should obtain the corresponding licence that covers the entire country. Since retailing is free and the legislation is recent, we have no information on the type of contracts that will be offered to EV users. It is important to mention that the legislation creates specific retailers for the electric mobility but it is clear that existing electricity retailers can also develop this activity provided they get the corresponding license;
- operation of the charging points of the electric mobility network. The charging points correspond to infrastructures exclusively dedicated to the charge of batteries of EV, they are operated by a licensed operator and other services can also be associated to this activity. This activity is performed according to administrative regulations during a transitory period and it will be opened to competition afterwards. It includes the installation, operation and maintenance of the public or private charging points of the electric mobility network;
- finally, the management of operations of the electric mobility network, that includes the management of the energy and financial flows associated by the operation of the electric mobility network. This is a regulated activity, that it is not admitted to be opened to competition in the future.

The article 4º of the mentioned Decree-Law establishes the general guidelines for the operation of the system as follows:

- universal and equal access of all users to the charging service of batteries;
- freedom of choice of the retailer for the electric mobility;
- freedom of access to every charging point integrated in the electric mobility network for the purpose of battery charging, independently of the retailer for the electric mobility and without having to establish any kind of contract or legal arrangement with the operators of the charging points;
- existence of interoperability conditions within the electric mobility network and the different types of batteries and their charging systems.

The legislation for the electric mobility requires that there is a specific infrastructure for the electric mobility as well as retailers having a specific license for this activity. On the other hand, the legislation requires that the tariffs to be paid by the users are additive, meaning that they should include a term directly associated to the remuneration of the retailer together with regulated terms regarding the activities of the operation of the charging points and the management of the electricity and financial flows. This indicates that the tariff system should avoid cross subsidies and so specific measurement devices have to be installed, for the purpose of measuring these demands. The legislation does not specify the kind of cost allocation method to be used but it organizes the final EV user tariff in two terms:

- a regulated Access Tariff that covers the costs of operation of the charging points and of the management system to control the electricity and financial flows. This term should be universally fixed so that every EV owner pays the same regardless of their geographic location. In any case, since the energy for the electric mobility flows through the transmission and distribution networks, the legislation is not clear whether the access tariffs for the electric mobility will also include a term to pay the access to the transmission and distribution grids. If cross subsidies are to be avoided, it seems clear that transmission and distribution tariffs will have to be added to the access tariff for the electrical mobility;
- a Retailing Tariff to be set by the retailers for the electric mobility under competitive conditions.

The Decree-Law nº 39/2010 of April 26th separates the retailing activity from the operation of the charging points. The operator of the charging points is in charge of installing, operating and maintaining the charging points (while receiving a regulated tariff for this service) and it should allow:

- any regular retailer to supply electricity to electric mobility network;
- any retailer for the electric mobility to receive that energy and supply its clients;

EV owners will not have to maintain any legal relation with the operator of the charging points, because the access to these charging points is free, provided the corresponding access tariff is paid. The retailers for the electric mobility should:

- buy the required electricity in wholesale markets;

- establish the required agreements with the operators of the charging points;
- set the final EV-user tariffs incorporating the energy price and the regulated access tariff to the electric mobility network.

In the business model adopted in Portugal, the charging network is accessible to all users, and each user has a card, the Mobi.E card, that provides access to the charging points and it is also used for billing purposes.

- General description of the scheme:
  - The described scheme is very flexible and it implicitly considers a roaming principle. It considers freedom (not regulated or closed entry activity) installation of charging points since this is not assigned to a particular (regulated) agent for example DSOs;
  - On the other hand, from an organizational point of view, the electric mobility is organized in Electricity Retailing, Operation of Charging Points and Management of the Activities of the Mobility Network.
  - The retailing of electricity for the electric mobility is a specific activity performed under competition by agents specifically licensed to buy electricity and sell it to EV's. The legislation allows existing retailers to extend their activity to the electric mobility;
  - The Charging Points are managed by specific licensed operators. In a transitory period, this activity is conducted in a regulated way, but in the medium term it will be opened to competition. This activity includes the installation, operation and maintenance of the public or private charging points of the electric mobility network;
  - The Management Activity is conducted under a regulated non competitive basis, and it provides an upper level layer aiming at ensuring the interoperability of entire the system. Under this scheme, an EV owner has a contract with a retailer and this allows him to charge the batteries in any Charging Point. This design was adopted to turn the system as flexible as possible, disseminating as much as possible the number of Charging Points that EV owners can use. In some sense, this design mirrors the one that was adopted in Portugal to debt bank cards. These cards are issued by particular banks and the owner of a particular card has a contractual relation with a particular bank. However, any card can be used in any bank teller machine independently of its physical location. This roaming capability is crucial to enlarge the number of points that the users have available and this facility exists because there is an upper hardware and software layer interconnecting all systems. In a similar way, the Management of the Electric Mobility Network corresponds to this upper layer allowing the broader use of all charging points by all EV owners;
  - The charging of EVs will be treated as any other load, with not distinctions concerning timely prioritizing or quantity restrictions. It is not necessary that there is any direct control over the charge;

- The DSO is responsible for guaranteeing the electricity supply with an adequate level of quality. In that way, the DSO is obliged to invest in required installations and network equipment for low to medium voltage levels. This obligation is not different from the existing responsibility to serve any other load;
- The DSO on the other hand, will be obliged to install a smart meter for all customers requesting to connect electric vehicles to the network, such that the access to economic incentives or more concretely to time variable tariffs is assured;
- The DSO is not allowed to install any equipment that would allow the discrimination of EV load with respect to other uses, without the clear consent of the final customer.

3.2.3 Required Regulation

This section describes the necessary regulation, and eventually legislation to be avoided, in the Catalyst Phase.

- Tariffs:
  - Study the adoption of ToU type tariffs with economic signals to induce the efficient charging of electric vehicles for avoiding peak charging. Given the complexity of these tariffs, it will be more likely that they will only be adopted in the Consolidation Phase;
- Regulation of the Distribution Activity:
  - The remuneration of the distribution activity should take into account any efficient investments by the DSO related with the penetration of EVs. In Spain current regulation already considers the effect on investments of demand growth both in terms of energy and contracted power of the final customers. However, it would be necessary to explicitly consider additional investments caused by EVs, for example if there was an obligation for the DSO to provide a certain number of public charging stations or if there was an obligation to dimension the feeding of new house blocks in order for all parking slots to be able to charge simultaneously, ... (but since we are not proposing those regulatory options for this scenario, there is nothing special to recommend);
  - In Portugal, the regulated remuneration of the DSO's is set using expression (3.1). For each voltage level, the regulated remuneration depends on a variable term that multiplies the energy flow in the respective voltage level and on fixed term. According to this expression, distribution voltage levels are organized in two groups, HV and MV on one side and LV on the other. If a large uptake of EV's occurs leading to a significant variation of distribution costs, it is reasonable that the Portuguese Regulatory Agency accepts adapting the mentioned expression by including, for instance, a term

associated to the variation of the number of EV's from year n-1 to year n as illustrated in expression (3.2).

$$R_t^D = \sum_{j=1}^{2} \left(F_{j,t}^D + P_{j,t}^D . E_{j,t}^D + \Delta NEV_{t-1 \rightarrow t} . UCEV_{j,t-1 \rightarrow t} - \Delta_{j,t-2}^D \right) \quad (3.2)$$

This expression closely follows expression (3.1) currently in force in Portugal to set the regulated remuneration of the distribution network activity. The main difference regarding expression (3.1) is that (3.2) includes an adjustment term given by the product of the change of the number of EV's from year t-1 to year t, $\Delta NEV_{t-1 \rightarrow t}$, by the unitary cost associated with investments, operation and maintenance of the distribution network due to the increase of 1 EV from year t-1 to year t, $UCEV_{j,t-1 \rightarrow t}$. Regarding this expression, it should be noticed that $\Delta NEV_{t-1 \rightarrow t}$ is not dependent on the voltage level j and it simply corresponds to the change of the number of EV's in the geographical area where the distribution network under analysis is implemented. On the other hand, $UCEV_{j,t-1 \rightarrow t}$ does depend on the voltage level. This means that j=2, that is for LV networks, $UCEV_{j,t-1 \rightarrow t}$ represents the unitary cost felt by LV networks due to EV's directly connected to them. For j=1, that is for HV and MV networks, $UCEV_{j,t-1 \rightarrow t}$ corresponds to the unitary cost felt by HV and MV networks given that a new EV is connected to a downstream LV network. This approach can be easily accommodated in the current regulatory approach used in Portugal while being able to internalize in the regulatory distribution network process extra costs due the increase of the number of EV's;

- Obligation to install smart meters. As detailed in Section 3.1.1 regarding the Portuguese pilot smart metering program InovCity, there are currently about 30.000 installations with these equipments. Although the advantages of their installation are clear, namely regarding the possibility of implementing an increased number of functions and enabling the use of time of use tariffs, it is still unclear how the costs of these equipments will be internalized in the electricity system. At the moment, the cost associated to this pilot program involves the development of the equipments themselves together with their installation and the installation of other hardware and software and are being supported by the Portuguese DSO. However, it is clear that if these equipments are to be generalized to all customers, the involved costs are extremely large so that a different cost allocation has to be adopted and accepted by Regulatory Agencies. If a more distributed cost allocation is not adopted, the generalization of smart meters to all customers within a reduced period of time will clearly be compromised. In order to achieve a different cost allocation, Regulatory Agencies should clearly identify the agents in the power system that would benefit from the installation of smart meters (namely, DSO's, consumers, EV owners, EV aggregators, electricity retailers…) and propose an adequate splitting rule of the involved costs among all these agents;

• Installation of equipment on private property

- EV adopters can elide the consent of the entire community of neighbours;
- Freedom to choose between the separation of measurements from the other domestic consumption and the accumulation of both;
- Do not impose any set up a priori. That is to say do not insist on whether there should be a common feeder for a garage with different branches to the parking slots and specific meters for each place or individual feeders for each slot;
- From the point of DSO metering downstream, all installation equipment is owned by the private entity, not the DSO;
- The DSO is not allowed to install any equipment that would allow the discrimination of EV load with respect to other uses, without the clear consent of the final customer.

- Legislation for building construction:
  - Legislation should include the norms and standards to provide enough space for the wiring and the voltage transformation centre necessary for an electrification of all the vehicles parked in the constructed parking lot in a modular way. That is to say, room should be made but the investment in the installation should only be made when the adoption decision of the final users are taken.
- Necessity for Standardization:
  - The available standards, in particular the ones related with charging points are not adequate, namely the ones in IEC 61851). This situation was eventually created by the faster response of the car industry when compared to the introduction of standards on the electricity network side. This means it is necessary to introduce changes in the available standards so that it is ensured a more flexible charging in view of the control and management of the distribution network.

3.3 Consolidation Phase

3.3.1 Goals and General Considerations

- Further uptake of EVs surpassing significant penetration thresholds.
  - In order to achieve this goal, it is important not to eliminate the incentives created in Phase 1, namely fiscal incentives as well as to go deeper in the creation of further incentives as the Time of Use tariffs, namely for the energy used by EV's. On the other hand, the dissemination of charging points both on public and private locations and the good operation of, for instance, mobility cards used to charge EV's will contribute to create a more confident atmosphere on the increased penetration of EV's;

- Emergence and development of aggregators. Apart from the existing one as created by the legislation passed in 2010, in this phase it is expected that a larger competition on the retailing activity develops namely with the emergence of a larger number of aggregators;

- Development of controlled charging model;

- Interaction with distributors.

3.3.2 Description of the Business Model

Description of the foreseen evolution of regulatory requirements compared to the previous stage

- Description of the general set up:

  - As detailed in Section 3.2.2, in Portugal the business model approved in the legislation currently in force indicates there are three activities as follows: retailing of electricity for the electric mobility, operation of the charging points and the management of operations of the electric mobility network. As indicated in the Portuguese legislation, in the first period the retailing of electricity for the electric mobility is performed in competition, the operation of the charging points is performed in a transitory way according to administrative regulations and then it will be opened to competition and the management of operations of the electric mobility network is and will be in the future a regulated non competitive activity. The Portuguese legislation does not specify the duration of the transitory period after which the activity of operation of the charging points will be opened to competition. It indicates that this period will be set in complementary legislation. According to the phasing established in the MERGE project, it is most desirable that conditions are created in order to end this transition step by the end of phase 1, the Catalyst Phase, that is, in the Consolidation Phase the operation of the charging points should already be opened to competition;

  - If the evolution described in the previous point was achieved by the end of Phase 1, that would mean that in the Catalyst Phase, Phase 2, the business model was completed with two activities provided in a competitive framework (retailing of electricity and operation of the charging points) and one provided under regulation (operation of the electric mobility network);

  - Development of aggregators as facilitators between the final customers and the electricity markets, providing services by means of offering attractive end user prices (theoretically the direct charging control within certain margins should enable the aggregator to offer lower prices compared to customers whose reaction prices signals may be subject to uncertainty). On the other hand these services can be beneficial to the system in terms of demand reduction measures, managing critical situations in the network, in exchange for an economic remuneration to the final customer;

- For that, it will be necessary to standardize communication protocols with the intelligent charging systems located inside the vehicles and a regulation in which the DSO can request services from the aggregator (similar to what TSOs are enabled to do already today);
- The intelligence of the network will have evolved due to other reasons (smart networks to deal efficiently with integration of distributed generation, etc.) that are more significant than the existence of EVs. Aggregators will take advantage of such development of communication facilities and information systems to offer advanced smart charging modes. At this phase, V2G functions will start to be considered and developed;

3.3.3 Required Regulation

This section describes the necessary regulation (and legislation to be avoided) in the Consolidation Phase.

- Regulation of new activities:
    - As mentioned above, activity of management of the electric mobility network is provided under regulation according to the Portuguese legislation. This legislation commits the regulation of this activity to the Portuguese Regulatory Agency for the Energy Services, ERSE, that is in charge of contributing to increase the efficiency and the transparency of this activity, namely creating the conditions to protect the rights of the users of the system regarding prices and quality of service, ensure the economic and financial conditions of the regulated activities and contributing to improve the technical and environmental conditions of this regulated activity by promoting the adoption measures to better the quality of service and the environmental protection. Until now there are no indications that this regulatory activity has in fact started, although the Mobi.E society is at the moment in charge of the management of the electric mobility network. As the uptake of EV's develops and increases along time, and more competition arises regarding retailing and finally the operation of charging points is also opened to competition, there will certainly be a larger number of agents using the system. This will turn increasingly urgent the regulation of the activity of management of the electric mobility network;
- Distributors:
    - Following the adaptation of the expression used to set the regulated remuneration in order to reflect increased costs on DOS's due to the uptake of EV's as described in Section 3.2.3 for the Catalyst Phase, when starting the Consolidation Phase it is reasonable to expect that the regulation of distribution activities is refined. As an example of such refinements, the introduction of locational signals in the Access Distribution Tariffs should be studied and evaluated. This issue was discussed in Section 5.3.3.1 of Deliverable D 5.2 and we will now summarize the main aspects in that report on this possibility.

      The emergence of a new class of users, as EVs, places a number of challenges because the large deployment of EVs can correspond to a discontinuity in the natural evolution of the demand. This ultimately means that some of the well-accepted regulatory principles as equality of treatment and opportunities and tariff uniformity should be discussed and eventually some adaptations should be incorporated in tariff codes. As an example, the tariff uniformity principle as it is currently understood indicates that all clients connected at LV pay the same access tariff. This means that some kind of average approach is widely used in order to set the amount of this tariff to recover the global management costs (namely the control center and ancillary service costs), transmission regulated costs, and distribution in HV, in MV and in LV regulated costs. However, if a deployment of a large number of EVs occurs in a specific geographic area this will most likely require extra investments in expansions and reinforcements (that is, investments beyond what it was expected as a result of the natural increase of the remaining loads) together with extra operation costs (for instance, related with network losses).

The current flat rates by voltage connection levels would simply socialize these extra costs by all clients, even though extra costs are due to a particular class of consumers. This seems unfair for customers in areas where costs did not increase and if nothing was done this would also mean that cross-subsidies would be a rule in the Access Tariffs setting process. If such a discontinuity on the demand evolution occurs, it seems there is a contradiction between the tariff uniformity principle on one side and the elimination of cross subsidies on the other, meaning that some decision at the regulatory level should be taken for instance involving the adoption of a tariff scheme that gradates the application of these two principles.

In the limit, if some dependency of the UoS tariffs regarding the location existed, EV owners could be induced to select the locations to charge the batteries according to the available tariffs. In the long run, this would transmit a signal to the users in order to adopt more efficient behaviors. For instance, this would mean charging the batteries in areas where the networks were less demanding in terms of new investments so that the UoS tariffs were more reduced.

However locational dependent UoS tariffs may transmit economic signals that may have implications on investment decisions. Under the assumption of price elastic final consumers, electric vehicles are more likely to be adopted in areas of lower electricity prices. Therefore in the long run, networks with lower "locational" UoS components in the price perceived by the final customer, may be more likely attractive for EV charging and hence for EV uptake. The same implication would be true for localization and siting of industry and production plants, therefore this is a controversially discussed topic;

- Legislation directed at services that DSOs can request from aggregators (or others) for an improved security of the network functionality;

• Standardizations:

  - Aggregators' direct load control or sending of price signals;

- Communications protocols;

- Markets:
  - Secondary, tertiary and unbalance management:
    - The rules currently in force in Portugal and in Spain regarding reserves and unbalance management are very similar, although in some points further steps should be given in order to obtain complete harmonization. On the other hand, one could view the participation of EV's or EV aggregators in these specific procedures prior or after the development of deeper integration between the two national reserve markets. In fact, there are indications that further steps are now being taken by the Portuguese and the Spanish TSO's in order to allow a deeper cooperation regarding the provision of reserves. This will turn it very likely that when the consolidation phase regarding EV's is started, national reserve markets will have evolved to some sort of Iberian markets. In any case, the participation of EV's or EV aggregators will have to start by some pilot actions that desirable could still be launched in the Catalyst Phase in order to break psychological barriers of existing stakeholders and also to identify and quantify the advantages from the participation of EV's and EV aggregators in the reserve markets. These actions should start with a limited number of participants during an extended period of time to identify the advantages both for the entire system and for the EV's themselves regarding possible revenues;
    - When passing to the Consolidation Phase, the EV's and EV aggregators should be induced to participate in balancing and reserve markets as controllable loads. EV aggregators could then present up or down reserve bids and be remunerated for these services. If this scheme is allowed and psychological barriers are eliminated, this could emerge as a new source of revenues for EV owners, contributing to turn the investments on EV's more attractive and thus creating the conditions to further increase the EV uptake;

3.4 Advanced Phase

3.4.1 Goals and General Considerations

- If economically sensible, rollout of V2G (this might evolve with the changes in Phase 2 by itself as aggregators would not want to miss that opportunity);
- Associated with that, advanced potential services to the TSOs/DSOs;
- Further refinements in the regulation of the distribution activity, namely considering the impact of losses on the Access Tariffs;
- Enlargement of the "roaming possibilities" now starting to involve different countries by the adequate development of communication and data interchanges between national electric mobility management systems;

3.4.2 Description of the business model

Description of the foreseen evolution of regulatory requirements compared to the previous stage:

- Description of the general set up:
  - V2G permits the system to make an efficient use of the storage of electric vehicle batteries. Permits more advanced services from the TSOs / DSOs;

3.4.3 Required Regulation

This section describes the necessary regulation (and legislation to be avoided) in the Advanced Phase.

- Distributors
  - After introducing changes in the regulation of the distribution activity as described in Section 3.2.3 for the Catalyst Phase and introducing refinements on these regulations on the Consolidation Phase, further steps can be done in the regulation of the DSO's. As an example already discussed in Section 5.3.4.1. of Deliverable D 5.2, the impact of distribution network losses should be considered and reflected in the regulation of the distribution activity. Following Deliverable D 5.2, current regulations incorporate the cost of network losses in different ways in the tariffs to be paid by the end consumers. One of the procedures corresponds to set the values of the different tariffs for a given voltage level and then adopt coefficients that multiply these values if one wants to translate them to another voltage level.

    As an example, consider a consumer connected at LV. According to the additivity tariff principle typically followed by Regulatory Agencies in designing tariff systems, this consumer pays an access tariff that should remunerate the costs of system management and ancillary services plus the costs of using transmission, distribution in HV, distribution in MV and distribution in LV networks. The problem is that this consumer is connected at LV where all his measurements are performed. So, in order to supply 1 MW of power to this consumer it is necessary to inject a value P_T MW in the transmission system, a value $P_{D,HV}$ in the HV distribution network, a value $P_{D,MV}$ in the MV distribution network and finally a value $P_{D,LV}$ in the LV distribution network and all these values typically follow (3.3).

    $$P_T > P_{D.HV} > P_{D,MV} > P_{D,LV} > 1\,\text{MW} \quad (3.3)$$

    These values can be related by the mentioned multiplicative coefficients, usually termed as Loss Adjustment Coefficients, LAC, so that we obtain expressions (3.4) to (3.7).

    $$P_{D,MV} = \left(1 + LAC_{MV/LV}\right) P_{D,LV} \quad (3.4)$$

$$P_{D,HV} = (1 + LAC_{HV/MV}) P_{D,MV} \quad (3.5)$$

$$P_{D,HV} = (1 + LAC_{HV/MV}) P_{D,MV} \quad (3.6)$$

Accordingly, this consumer will pay a transmission UoS charge that is set at the transmission boundary of the system and that then has to be translated to LV using (3.7). He will also pay the distribution at HV UoS charge set at the distribution HV boundary and translated to LV using (3.8). He also pays the distribution at MV UoS charge set at the distribution MV boundary and translated to LV using (3.9) and he finally pays the distribution LV UoS charge, at the voltage level he is connected to. So, this consumer pays UoS charges given by (3.10).

$$CUoS_{T \rightarrow LV} = (1 + LAC_{TV/HV})(1 + LAC_{HV/MV}) . (1 + LAC_{MV/LV}) CUoS_{T} \quad (3.7)$$

$$CUoS_{HV \rightarrow LV} = (1 + LAC_{HV/MV}) . (1 + LAC_{MV/LV}) CUoS_{HV} \quad (3.8)$$

$$CUoS_{HV \rightarrow LV} = (1 + LAC_{HV/MV}) . (1 + LAC_{MV/LV}) CUoS_{HV} \quad (3.9)$$

$$CUoS_{MV \rightarrow LV} = (1 + LAC_{MV/LV}) CUoS_{MV} \quad (3.10)$$

In these expressions:

- $CUoS_{T}$ - UoS charge set for the transmission system;
- $CUoS_{T \rightarrow LV}$ - UoS charge set for the transmission system and translated to LV;
- $CUoS_{HV}$ - UoS charge set for the distribution HV system;
- $CUoS_{HV \rightarrow LV}$ - UoS charge set for the distribution HV system translated to LV;
- $CUoS_{MV}$ - UoS charge set for the distribution MV system;
- $CUoS_{MV \rightarrow LV}$ - UoS charge set for the distribution MV system and translated to LV;
- $CUoS_{LV}$ - UoS charge set for the distribution LV system;
- $TCUoS_{LV}$ - total UoS charge to be paid by an LV consumer.

Typically, these LAC coefficients are computed in average terms for each of these voltage levels. This approach is certainly adequate for the current use of the networks at different voltage levels. However, if a large deployment of EVs occurs in some networks, network losses will assume different patterns in different geographic areas for the same voltage level. This ultimately suggests that these LAC coefficients should not be set regardless of the networks themselves but some differentiation should be incorporated in this scheme. In the limit, each distribution network at each voltage level should be studied and a specific LAC should then be computed. In order to avoid this level of complexity, we can suggest selecting the values of the LAC coefficients for each network according to some measure of the penetration of EVs in that geographical area.

- This approach would contribute to reduce the cross subsidies associated to network losses that a pure average approach would introduce. However, it would not solve all the problems because in the same networks other consumers than EVs would start paying larger UoS charges due to the increased penetration of EVs in that particular network;
- Legislation directed at V2G services that DSOs (or TSOs) can request from aggregators (or others) for an improved security of the network functionality.

- Standardizations:
  - Bidirectional flows;
- Markets;
  - Secondary, tertiary and unbalance management - After inducing the participation of EV aggregators in the reserves and balancing markets as controllable loads, in the Advanced Phase, Phase 3, it should possible to implement control actions associated to EV charging and eventually evolving to the V2G concept in which EV's could inject power to the grid, both allowing the modulation of the charging and discharging periods not only according to the energy prices but also according to up and down reserve prices.

3.5 References

[3.1] Ministry of Economy and Innovation, "Law of the Electricity Sector", Law 29/2006 of 15th February, February 2006.

[3.2] OMEL, "Operation Rules of the Electricity Market", (in Spanish), available in www.omel.es.

[3.3] ERSE, "Information on the Electricity Liberalized Market, March 2011", (in Portuguese), available in www.erse.pt.

[3.4] ERSE, "Tariff Code", (in Portuguese), December 2009, available in www.erse.pt.

[3.5] Ministry of Economy and Innovation, "Law for the Electric Mobility", Law 39/2010 of 26th April, April 2010.

4 SPAIN

4.1 Present situation

4.1.1 EV penetration Reality

Current state of electric vehicle penetration

For each of the types of technologies and vehicles and for each of the three scenarios already mentioned in the beginning of this Section for Portugal, Table 2.2 summarizes the estimated number of EV's in the Spanish park as obtained in Deliverable D 3.2 of the Merge project.

		Scenario 1		Scenario 2		Scenario 3	
		2010	2011	2010	2011	2010	2011
L7e	BEV	89	201	200	453	443	106
M1	BEV, PHEV, EREV	89	251	200	566	443	1257
N1	BEV, PHEV, EREV	18	45	40	102	89	226
N2	BEV	2	5	4	11	10	25
	Total	197	503	444	1132	985	2515

Table 2.2: Summary of vehicles in the Spanish EV park, split by vehicle class for 2010 and 2011 in the three considered scenarios (source Deliverable D 3.2 of Merge).

Along 2011, 377 EV were sold in Spain (69 in 2010). Instead, 10,350 non-plug-in hybrid EV were sold along 2011 (around 8,470 in 2010).
A large number of models were sold: Peugeot iOn, Citroën C-Zero, Nissan Leaf, Renault Fluence Z.E., Mitsubishi i-Miev and Think City, Mercedes Clase A E-Cell, Smart Fortwo ED, Tazzari Zero, Tesla Roadster, Chevrolet Volt and Opel Ampera.

Description of pilot projects, fleet tests and official plans and forecasts for future development

Since 2010 the Ministry of Industry, Tourism and Commerce has driven an Integral Strategy to boost the Electrical Vehicle in Spain (Estrategia integral para el impulso del vehículo electrico en España) [4.1].

The Plan foresee to work on several issues.

1) EV demand promotion

The strategy focuses first on the commercial fleets as being the more accessible market due to easy interlocution and centralised management of large numbers of cars. The target number of EV for 2014 is 250,000 EVs, 85% of them corresponding to fleets and 15% to individual owners.

The plan estimates that 6.000 euros as a direct incentive for the acquisition of EVs will be enough to close the gap with conventional car acquisition costs. 72 Million of euros were budgeted by the Government to support this incentives till December 2011. The measure has been extended until November 2012.

2) Industry and R&D plans

R&D funds and funds from both the Program of Reindustrialization and Program for Competitiveness will be oriented and devoted to promote the EV automotive industry and to booster R&D in this field.

3) Charging infrastructure

The program foresees a deployment of around 343,350 charging points. 62,000 of them correspond to EV owner houses, 263,000 to parking slots of fleets, 12,150 in public access parkings and 6,200 in streets. Also around 160 fast charging stations are foreseen.

4) Deployment of regulation and norms

It is under this initiative that some legislation has been already set. Section 4.1.3 details it.

4.1.2 Basic Characteristics of the Electricity sector

As indicated in the Deliverable D 5.2, the wholesale electricity market is common for Portugal and Spain under the so called MIBEL market. The specific rules are detailed in OMEL, "Operation Rules of the Electricity Market", (in Spanish), available in www.omel.es. As in Portugal, generation is organized in Normal Regime Generation and Special Regime (including renewable and small hydro units that have specific rules). Normal regime generators should communicate their selling bids to the market operator or establish bilateral contracts with the demand. The market runs in terms of a symmetrical pool to which all agents should communicate their bids till 11 am each day. After establishing the operation programs, this information is sent to the two system operators for technical validation and at about 4pm the feasible operation program for the next day is obtained. Then, the two TSO's contract the required levels of ancillary services and at about 8pm starts the first session of the intraday market for the whole period of the next day. There are currently 6 sessions of the intraday market with time intervals of 4 hours typically to contract small amounts of electricity for periods that start 4 hours afterwards. Finally, transmission and distribution wiring activities are regulated and retailing is developed in competition although a regulated retailer still exists namely to supply LV consumers that didn't migrate yet to the free market.

Any consumer is free to go to the free retail market, however only those with a contracted power above 10 kW are obliged to go to the retail market. Those customers connected to LV and with a contracted power lower than 10kW may stay if they wish under a regulated tariff, the so called Last Resort Tariff (TUR in Spanish for “Tarifa de Ultimo Recurso”). In the future, the kW threshold is expected to diminish. These consumers are supplied by the so called Last Resort Supplier/Retailer (CUR in Spanish for Comercializador de Ultimo Recurso) which are suppliers associated to the incumbent distribution companies. The customers supplied by the CUR’s pay tariffs in which the unitary costs for both the fixed component (contracted-power related) and the energy consumption are regulated by the Ministry of Industry (MITYC).

In case of the free market alternative, the customer’s bill consists of the access tariff set by the MITYC in order to recover the so called system costs, plus an energy purchase term in which the price is established in a competitive way. The access tariff has both a capacity (€/kW) and an energy (€/kWh) term. A two (and up to six depending on the size of the consumption) time period access tariff (ToU tariff) is available. The prices are uniform and without any regional differentiation for the same kind of consumer all over Spain (same the same voltage level and capacity contracted).

The number of consumers supplied through free retailers continues the upward trend started in 2008. The free market supplies recorded in June 2010 have increased by more than 1.8 million costumers over the previous year, reaching almost 4.6 million in total. In terms of energy, these supplies represent 70% of the total energy of the system. 82% of them correspond to the domestic segment and 18% to the Small and Medium size companies segment.

In 2010, most of the consumers in the domestic segment (85%) continue to be fed through a last resort retailer. In this segment, only 15% in terms of number of supply points and 23% in terms of energy are delivered through free retailers.

In the small and medium size companies segment, 79.5% of number of supply points and 88% in energy terms, are provided through free retailers. It is worthwhile to notice that those that remain under a last resort tariff are penalized with a premium so that it is expected that the 20% remaining will soon migrate to free retailers.

In the industrial sector, only 2% of points of supply (0.3% in terms of energy) are still supplied by a last resort retailer.

Regarding the regulation of the distribution activity, the principles for the economic regulation of DSOs in Spain are as follows. The remuneration formula is a revenue cap with four-year periods. Allowed initial revenues for each DSO are determined ex-ante at the beginning of the regulatory period. These are set as the sum of investments, comprising linear depreciation and a cost of capital computed through a representative WACC (same for all DSOs); O&M costs and other distribution costs such as billing, metering, etc. The two last terms are subject to yardstick competition.

Every year, the revenues are updated according to inflation and an efficiency factor equal for all firms. Additionally, the incentives to improve continuity of supply and reduce energy losses are computed with a one-year lag an added to the former revenues. Finally, a term that accounts the variation in costs resulting from the increment in demand in year n-1 is calculated ex-post and added to the allowed revenues in year n. Both the initial revenues and the variation due to the growth in demand are calculated by using of a reference network model (RNM) as a "technical benchmarking tool".

Energy losses are regulated through a bonus-malus scheme. The incentive or penalty is perceived by each DSO with a one-year lag. It is obtained as the product of the day-ahead market price and the difference between some target losses and the actual ones for each hour. The former value is corrected through a parameter representing the percentage of the reduction in losses that is allowed to be kept by the DSO, the rest is benefit for consumers. This incentive is capped to ±2% of the total DSO remuneration in the previous year.

Two reliability indexes are considered within the DSOs' remuneration scheme: TIEPI for time duration and NIEPI for frequency related measurements.

The incentive mechanism to improve continuity of supply is set as follows. This incentive is obtained for each DSO as the sum of two separate incentives to improve TIEPI and NIEPI indices. These are similar to the ASIDI and ASIFI indices, although instead of using the kVA served, the MV/LV transformation capacity and power contracted at MV level are considered. These incentives are calculated yearly for four different types of areas: urban, semi-urban, concentrated rural and scattered rural. The total incentive/penalty, i.e. the sum of both terms, is capped to ±3% of the total DSO remuneration in the previous year.

4.1.3 Current legislation

- Current legislation for the electric mobility in Spain

  In Spain, new legislation directed to electric mobility is under development. For instance, the possibility of having independent meters for EV charging at home is presently being studied by authorities and agents. Individual households may be connected to a single meter. However, in Spain, the urban model in cities consists of flats with an underground parking which makes centralized home metering complex. Moreover, the parking sights are legally independent entities from the residence, so these may anytime be subject to separate legal and economic transactions. In this scenario, individual meters will probably be required. However nothing has been set, yet. There is a draft of technical rules regarding the requisites for EV connection points (ITC-BT-52) [4.2], where it seems that a specific meter will be required but it is not yet closed.

  A super-valley ToU tariff has been approved [4.3].

  Regarding Charging Point Managers, CPM's), there is already a regulation in place. RD 6/2010 for economic recovery introduces the concept of "load manager", comparable to a retailer, who will promote EV energy-related services. The main aspect of this figure is that it is as a final customer allowed to resell energy for EV charging purposes only. This figure has been developed under RD 647/2011 (published on May 9th) [4.4]. This "load manager" will be in charge of the charging points installations (as a CPM) and will either buy the energy to a retailer or directly to the market. It will be a final customer for the distribution company (a meter submitted to the official electrical systems metering rules) will be the frontier between the distribution facilities and the CPM facilities. They are allowed to resell energy for EV charging purposes. In addition load managers should be connected to a control centre so that they can receive set points from the network operators (either a DSO or a TSO).

Some companies have already registered as CPMs. An example is Ibil (50% owned by REPSOL and 50% by EVE, the basque entity for Energy). They are already offering a complete charging point installation for any EV adopter [4.5]. Some electric utilities are also offering such kind of services [4.6].

Separated meters (for EV charging purposes and for their own energy needs) are required for the “load manager” figure. However for those EV charging installations that belong to the final user (the load manager figure is not compulsory and in some cases it will not intervene, for example it could be the case for individual home houses) nothing has been set, yet. There is a draft of technical rules regarding the requisites for EV connection points (ITC-BT-52) where it seems that a specific meter could be required but it is not yet closed.

Anyhow a meter (submitted to the official electrical systems metering rules) should exist in the frontier between the “load manager” or “end-user” private installation and the distribution facilities. Inside its own installations, the “CPM” or “load manger” is free to install secondary meters in order to measure the consumption of each particular connection point (if there are many), but this is not mandatory and the meters will not be submitted to the official electrical systems metering rules (they will have to comply with some control but this is not yet set).

CPMs (“load managers” in the current Spanish regulation) are allowed to participate in the wholesale market (if they comply with the economic, legal and liability related requirements), but they could decide to buy their electricity to retailers in which case their requirements are much more simple ones. A “supervalley” tariff scheme has been implemented with a three period differentiation, including a “supervalley” period that lasts from 1am to 7am.

An important regulatory aspect consists in defining the operation and ownership of the CPMs’ charging infrastructure. There are three possibilities:

- The distribution company is the CPM of the area;
- The distribution company is responsible for the installation and the technical operation of the area. The CPM pays the DSO for the investment.
- Technical specifications are determined by the regulator and infrastructure is developed by private engineering and construction companies. These will be contracted by the CPM and paid for their services.

These options may be complementary. For example the first one seems more reasonable maybe for public areas with public access, in order to avoid monopolistic behaviours, and the third one for private areas with public access.

The Spanish regulation is based on the third option even for public areas.

The two first options may have some advantage as the DSO is responsible for the technical operation of the network. Besides, network reinforcements to provide increasing power limits may be required. These two alternatives, however, may represent an opportunity for DSOs to exercise their distribution exclusivity and charge higher prices or apply barriers for newcomers. In consequence, complex regulatory activity would be required.

Finally, the main concern for CPM business viability is the high pay-back period that will be required to recover the necessary investments. Unless EV deployment is performed at an adequate rate, payment of financial resources will generate liquidity limitations and business uncertainty.

4.2 Required regulation

The MERGE model is completely applicable to the Spanish case. No major specific barriers, other than the already identified in the proposed general model, have been identified. Several regulatory steps have been already done as explained just below, and they generally agree with the MERGE Model. A smart metering roll-out program (substitution to be finished in 2018) is in place, the figure of the CPM has been created, a super-valley ToU tariff has been approved, and several norms and rules regarding installation concerns are under discussion.

Only two issues that are currently under discussion deserves to be highlighted as potentially in disagreement with the MERGE Model. A draft norm on requisites for EV connection points, proposes the mandatory installation of a control device at the feeder of common house buildings in order to prioritize home consumption over EV load consumptions in the building. This kind of message undoubtedly reinforces the psychological barriers of potential EV owners that may think that the charge of its EV may be compromised.

This draft also sets that the installation of charging points in a common building garage should mandatory follow the scheme of a common feeder to serve all parking slots. As it has been discussed for the MERGE Model this option should not be mandatory as it will require an initial investment costs for the neighbourhood community who will for sure disregard it. Only if a large number of neighbours are interested it will go ahead.

This kind of apparently small regulation details is of much importance for EVs to take off, as psychological barriers are one of the more important ones at the initial stage.

However this is still under discussion and no definitive decision has been made yet. We hope that projects as the MERGE one will contribute to improve it.

It is also to make notice that Portugal and Spain share a common electricity market (MIBEL) so that most of the comments discussed in the Portuguese case study are valid for the Spanish case.

4.3 References

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5 GERMANY

5.1 Present situation

5.1.1 EV penetration Reality

In Germany, an advisory board exists on behalf of Federal government. This board is called NPE, which stands for National Platform for Electric Mobility. NPE is responsible to develop, to realize and to optimize a plan for the realization of electric mobility in Germany up to 2020.

The Federal Motor Transport Authority approved 2,307 EVs in Germany at the beginning of 2011. Over 99.9% of all vehicles in Germany, in total 42,301,563, are still working with combustion engines. The integration of EVs is still at the beginning and the market and industry importance low [1]. Meanwhile, the automobile industry in Germany recognized the importance to place self-developed EVs in the market to be able to successfully proceed in the future.

In terms of turnover Volkswagen, Daimler and BMW belong to the top ten companies worldwide for car manufacturing. All launch several new designs of EVs at the moment, either by remodelling of a combustion engine vehicle or by creating a complete redraft. BMW most ambitious demonstration program “MINI E Berlin powered by Vattenfall“ runs since 2009 where more than 50 EVs are tested in real environment. Several partners from the industry and research are involved in the project which is financially supported by the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety. The project was divided up into two phases each with a period of six month. 90% of all trips were uncritical due to the fact that the average daily distance of all private users was about 40km. Participants usually charged the EV only every second or third day on average [2]. Based on the findings and results BMW currently develops the so called AcitveE, designed as Battery EV (BEV). BMW scheduled the ramp-up-phase of field tests with ActiveE EVs in the United States in December 2011, when MINI E trial ends. The field tests are supposed to include 700 EVs and takes place in Los Angeles, San Francisco, New York and Boston. A leasing model is used where applicants pay a leasing fee of $499 a month for 24 months with a deposit of $2,250. ActiveE is produced since 2011 in Leipzig, Germany. Figure 3 summarizes the history of BMW activities and shows the further steps in the next years by launching the BMW i3 [3] and [4].

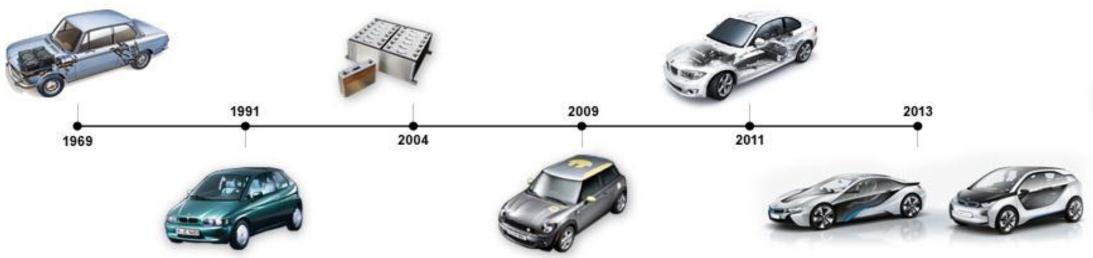


Figure 3: BMW electro mobility history and outlook [5]

Daimler’s most important demonstration project for electric mobility in Germany is e-mobility what took place from September 2009 to June 2011. Within this project 100 smart fortwo electric drive and 50 Mercedes-Benz A-Klasse E-CELL were tested in Germany. RWE as one contributing partner of the energy sector built up 500 charging station in urban areas. Purpose of the project was the introduction of EVs and the technical behaviour under real conditions. In addition the focus was on analysis in the area of customer utility, research on long-term effects of using EVs in cities, development of service departments and customer support. Daimler takes further steps in 2012 towards the project expansion in other urban areas like Berlin. The main focus hereby is the realization of additional pilot projects, further implementation of charging stations and finally to develop solutions in order to decrease the battery cost and increase the battery lifetime [6]. In particular, heating and air conditioning are significant auxiliary consumers, which have an enormous impact on the energy consumption and driving range of the EV. Daimler plans to start the serial production in spring 2012 for smart fortwo electric drive in Hambach, France [7].

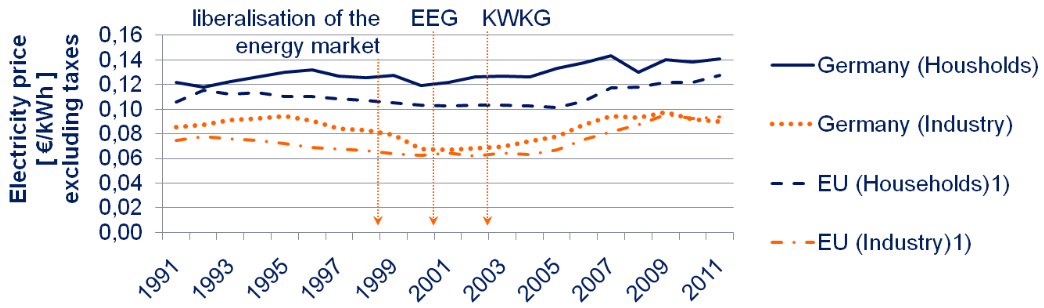
Volkswagen plans to enter the market of electric mobility with two types of EVs which are supposed to be produced in 2013. VW E-Up! is a pure electric concept car with four seats and designed as a city car. Integrated solar cells on the roof provide additional power to the vehicle electrical system. Another ambitious concept car is VW Golf blue-e-motion. As a special feature an active driving profile can be set. The driver can select priorities in advance between maximum range, maximum comfort and maximum dynamics. The selected profile then pre-configures the power of the electric motor, air conditioning control, maximum speed and battery regeneration strategy. VW Golf blue-e-motion is planned to be launched at the end of 2013 [8].

Beside German car manufacturer other OEMs started to offer EVs in the German market. The recently most sold EV in Germany is Mitsubishi i-MiEV with a total number of more than 500 EVs. Most of the EVs are owned by companies. Since the end of 2011 Renault offers a promotion for KANGOO Z.E. People can buy the EV for 20.000€ + VAT and lease the battery for 75€ + VAT per month. The leasing conditions include a 48 months contract and 15,000 kilometres per year [9]. If the client drives more than the 15,000 km per year every additional km is charged with 0.05 € including taxes.

5.1.2 Basic Characteristics of the Electricity sector

The industry in Germany benefit from decreasing electricity prices up to 2000 after the liberalisation of the energy market in 1998. Lower wholesale electricity prices caused by increasing competition were passed to industrial consumers. During 2000 and 2002 the price developments have been moderate whereafter the electricity price increases determined the energy market in this sector up to now, as shown in Figure 4. The price development represent the average electricity prices for household and industry customers in Germany compared to the average electricity price in EU countries whereby taxes are not considered [10]. In order to ensure the further development of renewable energy sources the German government introduced the German Renewable Energy Act (EEG) in 2000. The Act establishes the feed-in priority of renewable energies over other energies and guarantees fixed payments for renewable electricity. The Combined Heat and Power Generation Act (KWKG) was introduced 2002 and establishes the priority of Combined Heat and

Power generated electricity ahead of non-renewable electricity and regulates the payment.



1) prices of EU 15 countries until 2005, thereafter prices represents the average price of EU 27 countries

Figure 4: Electricity prices in Germany compared to average prices of EU countries after the market liberalisation

The EEG cost apportionment was set with 0.08 ct/kWh in 1998 and stepwise adjusted to 3.53 ct/kWh in 2011. With an assumed annual energy consumption of 3.500 kWh for a 3-persons-household the customer has to pay an average gross purchase price of about 24 ct/kWh. According to [11] the energy prices including taxes, fees and allocations for households raised more than 40% since the market liberalization in Germany. Figure 5 provides an overview of the electricity price composition in 2011 according to Bundesverband der Energie- und Wasserwirtschaft (BDEW) and Verband der Netzbetreiber (VDN).

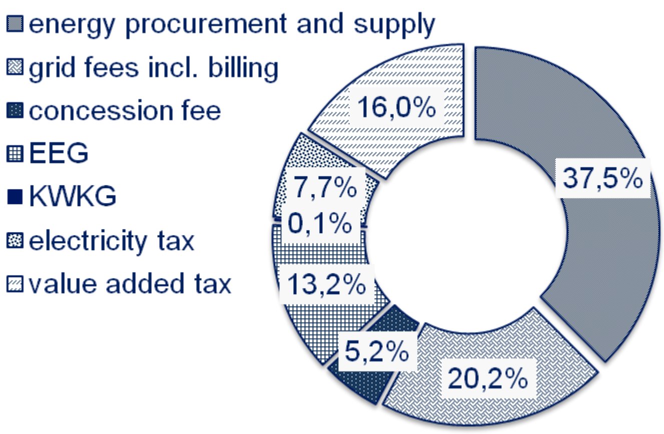


Figure 5: Composition of electricity prices in Germany (2011)

The total installed power capacity in Germany is about 165 GW. A normal load profile over the time of a day in winter seasons varies between 40 and 65 GW. The absolute peak demand in Germany 2010 was in January with 76 GW. As shown in Figure 6 more than 23% of energy used in 2010 was provided by thermal power plants fired with lignite, related to total energy demand of 588TWh. At least more than 16% of the total energy demand could be provided by renewable energy sources. With more than 220 TWh the industry sector had the highest energy demand followed by the energy demand of more than 40 million households with around 140 TWh per year [12].

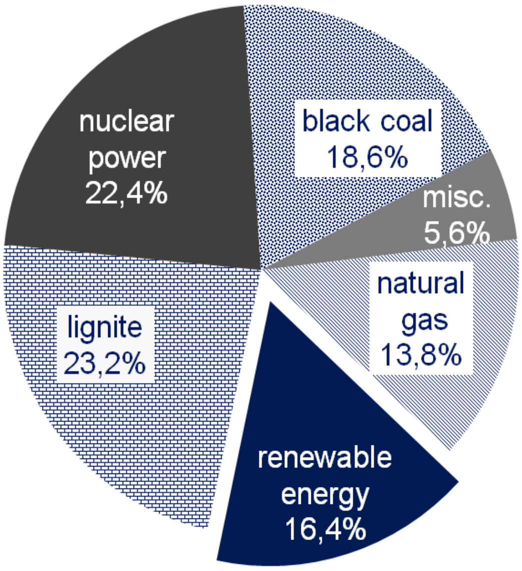


Figure 6: Source of Electricity in Germany 2010 [13]

Moreover there is much more electricity generated in Germany than needed. Beside the electricity generation Germany has a positive balance in the last five years of traded electricity. In the first half of 2011, renewable energies were able to increase its share in electricity from 17% to over 20%. Nevertheless, apportionment under the Renewable Energy Sources Act for 2012 remains stable. The Federal Ministry for Environment, Nature Conservation and Nuclear Safety assumes that a further increase to at least 35% by 2020 is feasible.

There are about 950 retailers in the electricity sector in Germany. More than 50% of this electricity market is dominated by four companies, namely E.ON, RWE, Vattenfall Europe and EnBW, cross-ownerships are not considered. In addition there are approximately 60 regional suppliers and more than 700 municipal suppliers, who have both distribution and retail assets. Almost two third of all households in Germany have taken advantage of the possibilities to change the electricity supplier since 1998. They have either switched to a new supplier or they have chosen a new product offered by their present supplier.

Since January 2010, it is mandatory by law to install smart meters when building new or having major renovations in old homes. Moreover, all conventional meters have to be replaced with intelligent meters by 2020. The smart metering roll out can be helpful in enabling Supplier/Aggregators to provide customers with time variable or load variable tariffs. It is expected, that the data is read every 15 minutes and collected several times per day [15][16].

The European Network of Transmission System Operators for Electricity (ENTSO-E) organizes the trade of the amount of current in Europe. ENTSO-E is divided into five regional groups, which derive from the historic background of the former associations. The regional group of Continental Europe includes 29 transmission system operators of 24 countries, like Germany, France, Spain and Italy. The main task is to keep the frequencies of all five synchronous areas balanced around the 50 hertz standard to ensure a safe power supply. Fundamental market characteristics are necessary to guarantee a balance around the 50 hertz standard Table 1: Primary, secondary and tertiary reserve pre-qualification criteria. After the legal unbundling four Transmission System Operators (TSO) namely 50Hertz Transmission GmbH, Tennet TSO GmbH, Amprion GmbH and EnBW Transportnetze AG are in charge to balance the power demand and supply in their control areas. For this purpose, a call for tenders was established where primary, secondary and tertiary reserve is organized. In order to participate in these tenders pre-qualification criteria are set to guarantee an efficient and reliable operation of the power system. Some pre-qualification are listed in Table 1, further ones are described in the TransmissionCodes, see also [18].

Table 1: Primary, secondary and tertiary reserve pre-qualification criteria

	primary reserve	**secondary reserve**	**tertiary reserve**
minimum capacity	± 5 MW	10 MW	15 MW
minimum increment of bid size	1 MW	1 MW	1 MW
activation time	30 seconds	5 minutes	15 minutes
minimum/maximum duration	up to 15 minutes	up to 15 minutes	up to 1 hour

Since 2010 the tender for primary and secondary reserve takes place weekly. For the tertiary reserve, the tender takes place daily on working days, from Mondays till Fridays. For weekends and public holidays, the tender takes place on the last working day before. As a financial characteristic, primary reserve units are only paid for availability, secondary and tertiary reserve units are paid for both availability and activation.

5.1.3 Current legislation

On behalf of the German federal government the National Platform for Electric Mobility (NPE) plans to increase the number of EVs in Germany to one million by 2020 and make Germany to a leading market for electric mobility. As introduced in the MERGE project three phases are considered for the market development of electric mobility up to 2020. These phases can be seen similar to phases described from NPE. Figure 7 shows in the first row the defined phases of MERGE and in the second the defined phases according to NPE [19].

Figure 7: Time line in three phases up to 2020

To accommodate the further development of the relatively new sector the German government provide an additional €1bn to fund research and development up to the end of the current parliamentary term. This equates to a doubling of the government's efforts in this area. Electric mobility's success in the market will not be decided by who offers the largest package of subsidies, but who has the best technical expertise. For this reason, the government is now boosting its support for research in this field. Investments will be focussing on battery research in particular. According to [19] Figure 8 provides an overview of the planned development of EVs placed in the German market. A differentiation is made between Plug-in Hybrid Electric Vehicles (PHEV), Battery Electric Vehicle (BEV) and Commercial Vehicles (NFZ). It is expected that the development of PHEV and BEV is more or less equal in the upcoming years.

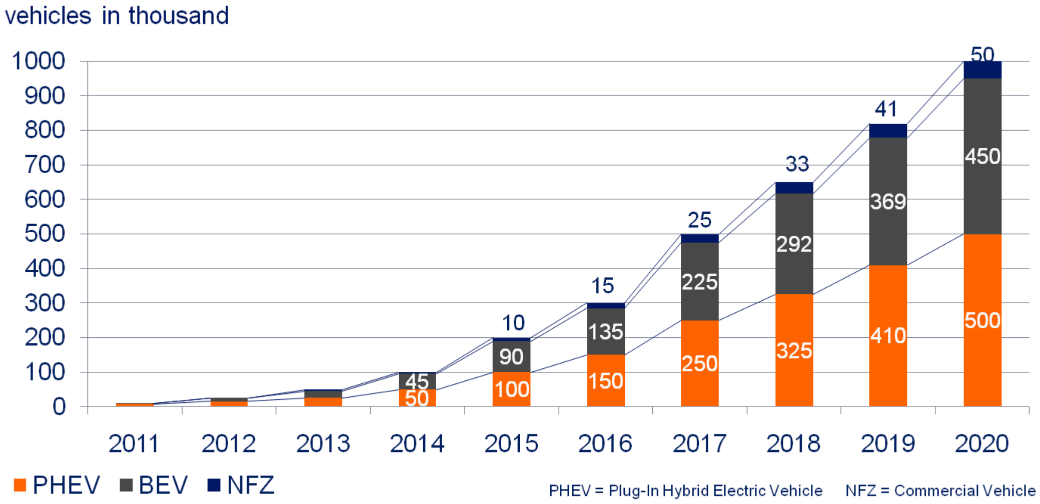


Figure 8: Market development of electric vehicles in Germany up to 2020 [19]

5.2 Catalyst Phase 1 Scenario

5.2.1 Goals and General Regulatory Principles

The first phase focuses on the market preparation up to 2014. Principal goals are on research and development of materials, battery and powertrain. NPE plans to integrate 100,000 EVs on German roads up to 2014. Focus hereby is the implementation of EVs in the main German metropolitan regions. According to this, there are eight model regions namely in Hamburg, Bremen/Oldenburg, Rhine-Ruhr, Rhine-Main, Saxony, Stuttgart, Munich and Berlin/Potsdam [19] as shown in Figure 9.

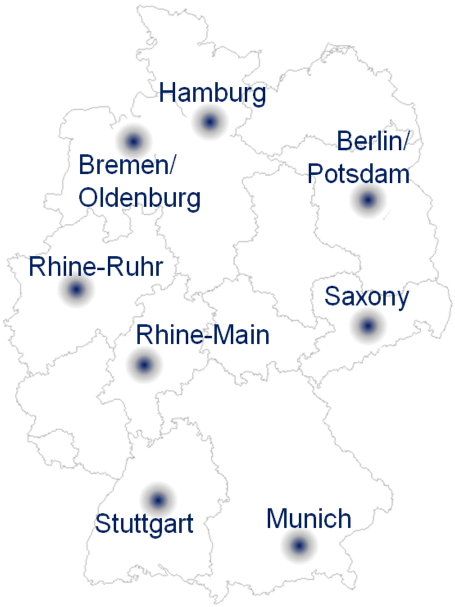


Figure 9: Germany model regions of electromobility

NPE recommends financial incentives, tax incentives and non-monetary benefits for general regulatory principles. The German government mind to give subsidies in order to avoid short-term effects. Incentives are useful to reduce the total cost of ownership. Currently an EV is about 10.000€ more expensive compared to a competitive vehicle with combustion engine what is mainly caused by the battery price. According to [19] the integration of 25,000 EVs up to 2014 seems to be more realistic than a number of 100,000 EVs without incentives.

5.2.2 Description of the Business Model

As mentioned in chapter 5.1.1 currently there are no EVs available to buy for private persons from German car manufacturer. Almost all EVs are owned by companies and used in fleets or in field test studies.

Further changes in course and business models which are likely to address the product placement of EVs in the markets and the development of the charging infrastructure. Both are related with high expenditures why car sharing or leasing concepts are possible models to lower the price for customers. Renault exemplary offers already the KANGOO Z.E. where the customer only pays the car whereby the battery is rented or leased.

Some other companies like energy supply companies are installing charging infrastructure on places which are supposed to be highly frequented by EVs and cooperate with companies which are engaged in the electro-mobility sector as well. Public Private Partnership (PPP) project will take place especially in public areas to build up the infrastructure. In the area of electrical science and software development there is a high potential for start up companies to come up with new ideas and products as complementary products.

New charging algorithms and concepts giving investors and consumers more choice. Vattenfall for instance tested a Wind2Vehicle charging concept during the field test study MINI E Berlin powered by Vattenfall in Berlin. Once a high wind injection is expected the EV battery starts charging. It is well possible that also the injection of other Renewable Energy Sources (RES) will be considered in charging strategies like RES2Vehicle.

5.2.3 Required Regulation

Germany decided to grant no direct subsidies for buying EVs. In order to support the private sector and those customers who want to buy an EV it is necessary to offer credits with low interest. KfW banking group is a German public-law institution operating in domestic promotion, export finance and development finance. On behalf of the Federal government KfW is also responsible for financing credits up to 30.000€ with a maximum interest of 2.5% to be used for acquisition of EVs [19]. The high investment of the charging infrastructure has to be distributed between industry and the public sector. Laws regarding the use of public spaces have to be adapted to consider public charging stations for EVs with all relevant circumstances like parking fines and/or vehicle damage including third party property damages.

Additional opportunities for integrating EVs in Germany are potentially given through the German EEG. Currently there is guaranteed feed-in tariff for photovoltaic plants. Up to 30kWp installed capacity the photovoltaic plant owner receives 28.74 ct/kWh injected to the grid. In case that the owner self-consumes less than 30% of the total injected electricity the kWh is remunerated with 12.36 ct. For higher self-consumption the feed-in tariff is set to 16.74 ct. EVs provide a good opportunity to store energy injected by RES and in combination with the current legislation the higher price incentive for self-consumption can be used.

In order to react on the market development adjustments in the current low has to be made. With an increasing number of EVs connected to the grid also standards for electrical devices have to be considered in order to not violate the operation of the power system. The current harmonic injection of EV power interfaces should comply limits set by standard IEC 61000-3-2. The shifting EV charging loads to low-load hours is recommeded to minimize adverse impacts of EV charging on power quality what goes along with new charging concepts and buiseness models.

5.3 Consolidation Phase (2) Scenario

5.3.1 Goals and General Considerations

The second phase is the medium-term and it focuses market development up to 2017. NPE plans to increase the number of EV from 100,000 to 500,000 in the years between 2014 and 2017. It is another main goal to install up to 500,000 charging stations until 2017 [19].

5.3.2 Required Regulation

Regulations in the medium-term scenario concentrate on smart charging and EV aggregators. NPE suggests to create preferences for EVs in parking areas, to grant a permit for EVs using bus lanes especially on overcrowded streets in the cities centre and to promote new and smart concepts for car-sharing. Discrimination can be stopped by releasing company owned EVs also for private use. Extraordinary depreciation is a tool to increase attractiveness of EVs for business customers. Private customers can ask KfW banking group for credits with low interest. Financial regulations might be an additional lever in terms of tax incentives, depending on the storage capacity of EV, to foster the EV market introduction.

5.4 Phase 3 Scenario

5.4.1 Goals and General Considerations

The third phase focuses high-volume market up to 2020. This phase describes the long term scenario. For realisation of a high-volume market cost reductions are necessary. Moreover, the interaction has to be optimized between vehicles and grids, between demand and supply and between smart systems and the interest of human beings. Private customers ask for fast charging, for less charging processes per month and for less running costs in comparison to vehicles with combustion engine. Regarding to a current study published by C4D, customers accept only four to six charging processes a month. Today, on-going fleet tests from the automotive industry still require at least ten to fifteen charging processes a month. In addition to that, customers accept charging times of 15 minutes or more only at home or at work. Information and communications technology (ICT) will link smart grids with smart transport systems.

5.4.2 Description of the business model

Specific charging stations are free of charge. The implementation of business models like park and charge or advertising on charging station is possible in the future. Gas stations will have to change their business model as soon as the number of EVs increases significantly. Advanced charging technologies with magnetic induction might be developed and introduced by the end of 2020 and provide therefore further opportunities.

The introduction of business models depends on the already available EVs in the market. Virtual Power Plant (VPP) concepts as described in [20] can be adapted by Supplier/Aggregator companies as a tool for realizing the aggregation of their resources. VPP concepts can offset the intermittency of Distributed Energy Resources (DERs) output, irrespectively of the DERs location. EVs differentiating from other DERs in mobility and duality as they can behave either as controllable loads or as controllable micro-generators [21]. Besides storage units, EVs can contribute to balancing forecast errors by utilizing their capacity capabilities. Moreover, EV charging can be implemented within periods when solar and wind generation are high. Therefore the VPP needs to coordinate and manage a critical mass of aggregated EVs to create specific business models and gain economical revenue. For each business model the Supplier/Aggregator has to consider the:

- A(wareness): Percentage of EV users who become aware of the offered contracts and services provided by Supplier/Aggregator companies adapting VPP concepts
- T(rial): Percentage number of users who definitely or might sign a contract if they can get it
- A(vailablity): Percentage of intended triers who can get the product
- R(epeat): Percentage of clients who would have a repeat use of VPP offers

The multiplication of these factors create an estimation of total aware EV users who might be integrated in VPP concepts. Hereby VPP concepts are in competition with other business models. Non the less if EVs are managed through a VPP concept the operator has to consider the individual user behavior preferences as well as further offered products in the energy market based on the available EVs. Figure 10 provides an overview of the VPP flexibilities in interaction with the EV user preferences. The less the EV user wants to pay for charging services the higher the flexibilities of the VPP how to use the virtual aggregated storage unit of the EV batteries.

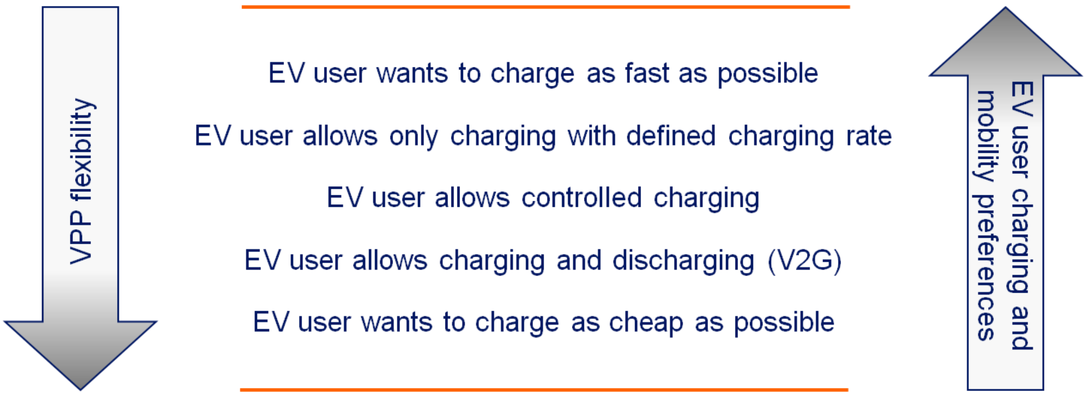
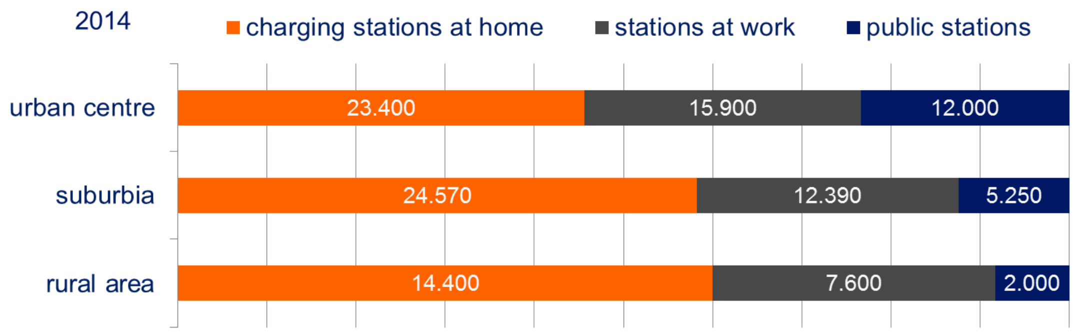


Figure 10: Interaction of VPP flexibility and EV user preferences

Management and ownership relation of VPP sources has to be taken into account, especially with contracted EV users which also want to charge the battery if not connected to a VPP owned or managed charging stations. Therefore roaming models has be adapted into existing IT structures and VPP concepts and considered in the VPP offered contracts with EV users. Open interface communication with user-oriented billing and roaming concepts has to be developed and guaranteed by a clear and comprehensive legal framework.

5.4.3 Required Regulation

Installation and operation of 900.000 charging stations in Germany might be difficult to finance just by selling electricity. Figure 11 provides an overview of the planned development of charging stations in Germany differentiating those which are placed in urban centres, suburbia and rural areas. The NPE propose to consider a proportionate sponsorship of operating costs. This sponsorship could reduce or even neutralize costs which are tax and contribution caused. It is possible to reduce value-added tax (VAT), allocation of feed-in tariff, electricity tax or concession levy.



Development of charging stations in Germany up to 2020

2014	2017	2020
118.000 stations	500.000 stations	900.000 stations

Figure 11: development of charging stations in Germany up to 2020 [19]

In the long term scenario, regulation should concentrate on supporting a demand-oriented infrastructure for charging stations all over the country. If necessary it is also possible to create a legal framework concerning a guaranteed access to public charging stations, an un-lock of the charging process, authentication and authorization, receipt and invoice, possibilities to pay, collection and transport and handling of electronic data as well as concerning energy management and measurement.

5.5 Conclusions

In Germany, an advisory board exists on behalf of Federal government. This board is called NPE, which stands for National Platform for Electric Mobility. NPE is responsible to develop, to realize and to optimize a plan for the realization of electric mobility in Germany up to 2020. Its main task is to connect science, business, associations and policy to set goals and to achieve them with good solutions as well as to promote the new technology of electric mobility towards the domestic population.

NPE plans to increase the number of EVs in Germany to one million by 2020 and turn Germany into a lead market for electric mobility. The time line up to 2020 is supposed to take place in three phases: market preparation up to 2014, market development up to 2017 and high-volume market up to 2020.

Supported by German automobile industry, there are several demonstration projects and fleet tests with EVs. These tests are realized in cooperation with energy companies in metropolitan regions. Focus of the projects were the, testing of EVs under a real world environment, analysis of customer utility, research on long-term effects of using EVs in cities and development of service departments and customer support.

The number of charging stations is supposed to increase from 5.000 in 2011 to 900.000 in 2020. There are different types of charging stations, like home charging stations, business charging stations or public charging stations. Installation and operation of 900.000 charging stations in Germany can't be realized without public financial support according to the NPE. A proportionate sponsorship of operating costs should be considered in cooperation with the industry. This sponsorship could reduce or even neutralize costs which are tax and contribution caused. It is possible to reduce value-added tax (VAT), allocation of feed-in tariff, electricity tax or concession levy.

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6 UNITED KINGDOM

6.1 Present situation

There are two main initiatives:

- <u>Ultra Low Carbon Vehicle Demonstrator competition</u> partially sponsored by the *Technological Strategy Board (TSB)* and launched in 2009. The competition was focused on developing robust industry-led consortia that are capable of supplying significant numbers of vehicles towards the development of a UK-wide fleet of at least 100 passenger vehicles for delivery in late 2009/early 2010. These vehicles would then have been used in a real world environment over a minimum period of 12 months.

The successful bids bring together car manufacturers, power companies, Regional Development Agencies, councils and academic institutions and operating across eight UK locations to deliver low carbon vehicles to consumers.

The project consortia and their members

Project: **Peugeot Electric Vehicles**

Area: Glasgow

Members: Allied Electric Vehicles, Scottish Power, Axeon Batteries, Strathclyde University

Project: **CABLED**

Area: Coventry and Birmingham

Members: Jaguar Land Rover, Mitsubishi, Smart, Tata Motors, EoN Energy, Arup, Coventry City Council, Birmingham City Council, Aston University, Coventry University, the University of Birmingham.

Project: **EVADINE**

Area: Newcastle and Gateshead

Members: Nissan, Smith Electric Vehicles, Liberty Electric Cars, Peugeot, Gateshead Council, Future Transport Systems, Newcastle University

Project: **MINI-E**

Area: Oxford

Members: BMW, SSE, Oxford Brookes University

Project: **EEMS Accelerate**

Area: national

Members: Delta Motorsport, Westfield Sports Cars, Ecotricity Cars, Lightning, AEA Technology, Green Motion Eco Car Hire

Project: **Ford**

Area: North West London

Members: Ford, SSE, Strathclyde University

Project: **Smart**

Area: London

Members: Smart, Nudge Advisory

Project: **Toyota Plug-In Hybrid**

Area: London

Members: Toyota, EDF Energy, MET Police, Transport for London, GCDA.

-"Plugged-in Places programme": partially sponsored by the *Office for Low Emission Vehicles (OLEV).* The scheme offers match-funding to consortia of businesses and public sector partners to support the installation of electric vehicle recharging infrastructure in lead places across the UK.

Data derived from the programme about how drivers use and recharge their electric vehicles will provide the necessary evidence base to shape the design of a national system of recharging infrastructure.

The Government is supporting eight Plugged-In Places:

- East of England
- Greater Manchester
- London
- Midlands
- Milton Keynes
- North East
- Northern Ireland
- Scotland

Charging points are also being installed by councils across the UK and by private sector providers.

So instead of an initial regulation which fosters the market, Government is taking an integrated and pragmatic approach to support market growth:

- The Spending Review made provision of **over £300m** over the life of this Parliament for the **Plug-In Car Grant** to reduce the upfront cost of eligible vehicles to consumers and businesses.

- Consumers and businesses also benefit from a **favourable tax regime,** with plug-in vehicles receiving Vehicle Excise Duty and Company Tax exemptions, as well as Enhanced Capital Allowances.
- The **Plugged-In-Places programme** has made **£30m** available to match-fund eight pilot projects installing and trialling
- Recognising that continued growth in recharging infrastructure will be driven by private sector investment, which could be constrained by the ability to raise finance, there is the potential for the **Green Investment Bank** to provide targeted financial solutions for appropriate plug-in vehicle infrastructure projects.
- The Government is also supporting low and ultra-low carbon vehicle **Research, Development and Demonstration** focusing on priorities identified in conjunction with the UK Automotive Council.

This Strategy sets the framework for the development of recharging infrastructure to support plug-in vehicle owners and industry in the UK. By providing a clarity of approach and removing barriers for those wishing to invest in, provide or benefit from such infrastructure, this Strategy aims to stimulate and accommodate the expected growth in the plug-in vehicle market.

6.1.1 Government Vision for Recharging

Government want to see the majority of recharging taking place at home, after the peak in electricity demand. Home recharging should be supported by workplace recharging for commuters and fleets, with a targeted amount of public infrastructure where it will be most used, allowing people to make the journeys they want.

Recharging at home

The Government is:

- Ensuring that **smart metering** in Great Britain includes the functionality to support smart charging of plug-in vehicles;
- Through Ofgem's **Low Carbon Network Fund,** supporting smart grid projects linked to the PIP projects in London and the North East which will look at how plug-in vehicles and domestic recharging can be best managed;
- Facilitating the installation of domestic chargepoints through the PIP projects;
- Proposing the inclusion of policy on plug-in vehicle infrastructure in the **National Planning Policy Framework** due to consultation in July 2011, encouraging local authorities to consider adopting policies to include plug-in vehicle recharging infrastructure in new domestic developments; and
- Exploring whether **voluntary standards**, such as the Code for Sustainable Homes, can be used to encourage the inclusion of plug-in vehicle infrastructure in new domestic developments.

Recharging at work

The Government is:

- Establishing a **Permitted Development Right** that will allow landowners to install plug-in vehicle chargepoints in car-parking areas without the need to apply for planning permission, removing a barrier for those interested in installing chargepoints;

- Enabling business whose emissions are caught under the **Carbon Reduction Commitment** to discount electricity used to charge plug-in vehicles from their total electricity consumption. This means business with workplace chargepoints will not face additional costs;

- Proposing the inclusion of policy on plug-in vehicle infrastructure in the **National Planning Policy Framework,** due for consultation in July 2011 as we explained previously.

- Looking at enabling provision of information to consumers about plug-in vehicles and workplace recharging as part of the **Green Deal** customer journey-evidence suggests people taking up core Green Deal measures for workplace are also likely to be plug-in vehicle adopters; and

- Supporting the PIP projects to install chargepoints in workplaces.

Recharging in public places

Government recognised that although central and local government is currently playing a key role in establishing the early public infrastructure, in the longer term a commercial market needs to develop.

An extensive public recharging infrastructure would be underutilised and uneconomic. To ensure appropriate targeting and ease of access we are:

- Establishing a **National Chargepoint Registry** that will allow chargepoint manufacturers and operators to make information on their infrastructure, including location, available in one place;

- Supporting a **common standard for plug-in vehicle smartcards** issued by the PIP to access their infrastructure, making it easier for users to access more than one scheme;

- Challenging industry to specify, by the end of 2011, back-office requirements that **enable users to easily access chargepoints provided by different schemes.** As the essential first step we are developing a central system to allow the back-offices of the PIP, and other infrastructure schemes, to communicate with each other (a central whitelist); and

- Supporting the PIP projects to install chargepoints in public places where they are most needed.

To make public infrastructure easier to install and to improve the commercial case for installing it we are:

- Establishing a **Permitted Development Right** that removes the requirement from local authorities and owners of publicly accessible car parks to apply for planning permission to install chargepoints;
- **Working with Ofgem to remove regulatory barriers.** Ofgem will consult this year on an exemption that makes it clear that chargepoint owners and operators can sell electricity via chargepoints at the market rate; and
- **Making data freely available** on how public recharging infrastructure installed through the PIP is used, to help inform commercially viable business

6.1.2 Taking the Strategy forward

Government is asking the Society of Motor Manufacturers and Traders' Electric Vehicle Group, the Energy Retail Association and the Energy Networks Association to, by the end of 2011:

- Specify how the back office functions for recharging infrastructure will operate; and
- Develop recommendations on the most cost-effective way to promote that recharging occurs off peak.

7 GREECE

7.1 EV penetration Reality

- It is estimated that currently approximately 50 electric vehicles are used in Greece. This number suggests an insignificant penetration. Major barriers are the high investment cost contrary to that of the conventional vehicle and also the lack of charging infrastructure. [6.1]
- MERGE predicts different volumes of EVs according to three scenarios that have been described in deliverable D3.2 report on EV uptake by Ricardo [6.2] and are summarized below.
- Currently there is not any official plan in place for the deployment of electric vehicles. PPC participates however in the European Program Green eMotion, with 42 partners from 12 European countries. It is a an ambitious program aiming at unifying all European pilot projects relevant to electric vehicles and to apply the specific experience and standards to 3 new pilot programs, one of which will be implemented in Greece and specifically in Kozani. An initial fleet of 15 electric cars will be deployed and 20 charging points will be created.[6.3]
- As an initiative of EKO and HELIEV the first three EV charging stations have been developed serving demonstration purposes. They are installed at EKO gasoline stations in Glyfada, Marousi and Kifisia, all within the prefecture of Attiki. Charging can be applied both for electric cars and also for motor cycles. Stations can supply charging at level 1 and level 2, as has been defined in [6.4] and are OEM compatible. Data regarding consumption and availability can be stored to be processed thereafter.[6.1]

7.1.1 Basic Characteristics of the Electricity sector [6.5, 6.6]

- With the de-regulation of the electricity market, infrastructure ownership and electricity resale have been unbundled. Supply to final customers is only allowed to supply license holders. Supply licenses are granted to companies by RAE**.** By April 2011 14 suppliers were active in the retail market, including the incumbent. Suppliers have to procure certificates of contracted available capacity which they can buy from producers or through a provisional Regulated Mechanism. Under the Regulated Mechanism the load representatives and Producers are given the alternative choice to participate in the CAM by concluding Contracts with the SO. Contracted available power has to equal at least the peak of clients demand and an additional reserve margin.

  The incumbent company offers retail tariffs that are regulated and include dual tariff option with variations according to season. Suppliers are free to formulate their pricing strategy and costumers are free to choose their supplier (eligible costumers).
- For the purpose of Distribution Use of System (DUoS) charges, consumers are categorised based on their connection voltage and metering capabilities. More specifically, consumers are categorised into five categories: MV consumers,

domestic consumers, LV consumers with maximum demand meters (with and without reactive power metering) and other, non-domestic LV consumers.

For MV customers, 50% of allocated costs are recovered through a capacity charge and 50% through an energy charge. The energy charge is a flat rate with no time differentiation. The capacity charge is charged on maximum demand recorded during peak hours (daily between 11am-2pm).

The percentages for LV customers are 20% capacity charge and 80% energy charge. For domestic consumers, only 10% is charged through a capacity payment. For all LV customers, the capacity charge is charged on the connection capacity (kVA) and therefore is a fixed charge per customer. For LV customers with zonal meters which can record demand during off-peak hours, the energy charge is not charged during the off-peak demand.

All prices are uniform across the country.

- There is no demand side participation in low voltage, however there are some pilot projects in MV where load shedding is considered with load shedding being under the control of System Operator or with the client being equipped with hypo frequency switches.

- Regarding the allowed distribution revenue, there is currently no formal methodology set for its calculation given that the Distribution Code (which will include the methodology for estimating the annual distribution costs) has not yet been adopted. As a transitional measure, the methodology applied is the one currently used for the transmission system.

  The methodology used is a cost-plus methodology and the parameters are set at the end of the year based on the budget for the next year. The Distribution Company submits data for the various parameters, RAE decides on the final annual allowed revenue and resulting distribution use of system tariffs. Parameters include the annual allowed OPEX, where traditionally RAE has applied an efficiency improvement factor of 2%, depreciation and reasonable rate of return on the capital employed, which includes an allowance for the investments budgeted for the year under examination.

- Mandatory provision of ancillary services from all centrally dispatched units according to declared technical characteristics and Grid Code requirements.

- Specifications for metering devices

  - High accuracy according to EN/IEC 62053-21.

  - Long term stability of metering elements.

  - Immunity to EMS (IEC 61000-4-2 and IEC 61000-4-4)

  - Ability to measure the following data:

    - kWh of active energy for electricity

    - Reactive energy

- Instantaneous power
- Power factor
- Voltage
- Current
- Maximum demand
- Export energy (active reactive)
- Selected power quality characteristics

- Time intervals of measurements:

Interval metering, where the consumption is recorded over time periods from 5 minutes up to 60 minutes.

- Sufficient Storage capabilities:

Smart meters should have the capability of storing data for prolonged periods without provision of electricity from the grid.

- Supporting Multiple (and dynamic) tariff.

Smart meters should at least support four tariff programs (two daily programs for two seasons).

7.1.2 Current legislation

A number of favourable legislatory actions for electric and hybrid vehicles have been adopted from early 1992 till today:

->According to the Greek legislation, electric and hybrid vehicles are excluded from vehicle tax and the annual road fund license [Law 2052/92 FEK A! 94 / 5 JUNE 1992] as far as their emissions are within the agreed limits. In addition to this [paragraph 9-b] there is the possibility that in public organizations and services the exclusive use of electric vehicles can be asked under ministerial decision. This has been the first favourable legislative action that has been taken in 1992.

->Electric and hybrid vehicles are exempted from a special sorting tax (eidiko telos taxinomhshs) throughout their lifetime. [Law 2960/2001 FEK A! 265 / 22 November 2001]

-> For electric and hybrid vehicles [Ministerial Decision 1889/Φ.911 ΦΕΚ Β! 1140 / 11 August 2003] any regulation concerning road space rationing does not apply.

7.2 Catalyst Phase 1

EVs at the catalyst phase should be regarded as any other conventional load, i.e. EV users will plug them in for charging whenever they want, by simply fixing the start time of the constant charging process at the typical power rates household sockets. At this stage, there is no automatic control over the charge despite the fact that EV owners may pay time of use electricity tariffs as an incentive to create peak shaving. Major objective at this phase is to facilitate the EV uptake, thus disburdening the life of potential EV adopters and avoid over-complicated charging schemes.

7.2.1 Description of the Business Model

Next diagram presents the prevailed business model for the Catalyst phase, indicating the monetary and information flows with simple arrows.

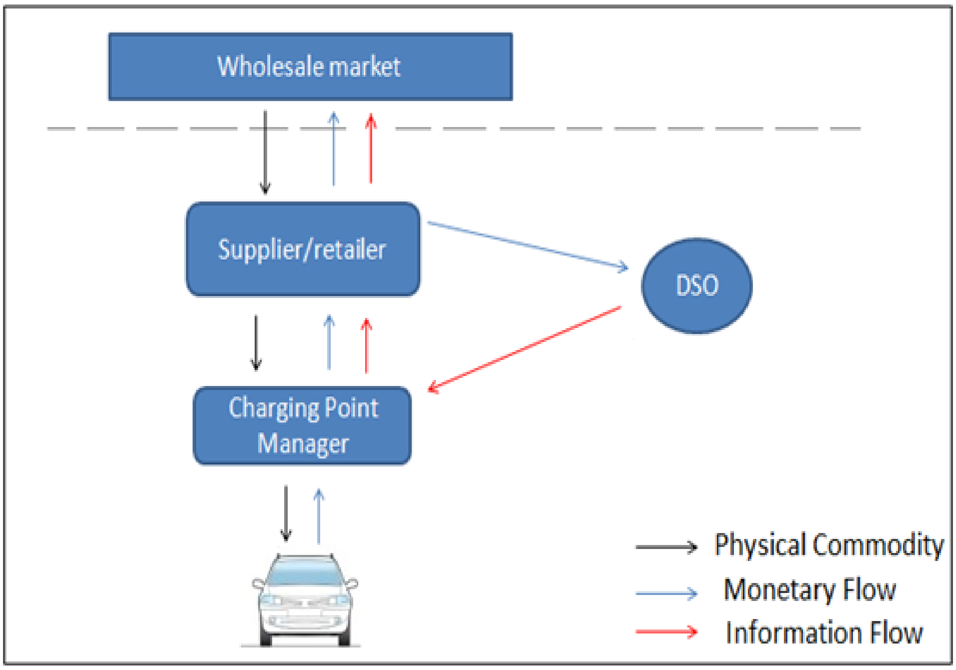

Fig.6.1 Business model-catalyst phase

A. Description of existing agents:

- The supplier/retailer

Electricity supplier or electricity retailer is the agent who sells energy to final customers, the electricity end consumers that is the CPM (charging point manager) that is described shortly after (upcoming agents 2.2.1-B).

<u>Monetary flows:</u>

->The supplier aggregates contracts with final customers so that to supply them with energy procured from the wholesale markets

- Bills of the energy consumed by the final customer according to energy and capacity prices set in the agreed contract.

Information flows:

->The supplier presents bids in the wholesale market for the acquisition of energy.

->Consumption of each final customer (CPM) needs to be metered, but this could be done by certified independent third party metering companies, if not the DSO is required to perform that by legislation and provide supplier with the data needed.

- The DSO

DSO should assure that the customer enjoys an adequate level of technical quality of service.

Monetary Flows

->Invest on network reinforcement according to the forecasted load growth in each distribution area, without making distinction in case it is more EV load added or air conditioning.

-> Invest on the installation of a smart meter for all customers requesting to connect electric vehicles to the network, so that the access to economic incentives can be realized.

-> Consider initially installation of charging points in public areas so that to facilitate the EV uptake and demonstrate the ease of the charging procedure according to relevant legislation if such investments are not initiated by third parties

-> Receive payment from suppliers of electricity for use of the distribution system (which basically suggests transfer of charges billed to final customers)

Information Flows:

->The charging of EVs will be treated as any other load, with not distinctions concerning timely prioritizing or quantity restrictions. Thus DSOs should only communicate to suppliers restrictions having to do with congestion levels and operating constraints.

B. Upcoming agent

- The charging point manager (CPM)/final costumer

The charging point manager installs, owns and operates a number of charging points. In this sense, the EV owner himself can be a charging point manager or at an initial stage it is highly likely that suppliers may be CMP for a number of charging points in public locations. Final customer for this phase could be regarded the CPM.

Monetary flows:

-The CPM makes the charging point investment

- Buys the required electricity to resell it to other EV owners connected to the charging station under a commercial agreement with specific terms and conditions. infrastructure that numerous EVs can access and request charging. For the case of domestic charging point that simply means EV owner pertaining to supplier gets the adequate charging for its driving needs.
- The CPM in general would have a supply contract with a supplier. (The supplier would have to pay the regulated access tariff according to the contracted capacity and consumption measured on the interface to the network).

Information flows:

- Pass information on electricity needs to the supplier.

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7.2.2 Required Regulation

This section describes the necessary regulation (and legislation to be avoided) in the Catalyst Phase.

- CPM provisions.
    - A new legislative provision would be required to enable energy reselling to take place in public places between CPM-final customer and EV.
- Tariffs
    - Need for time of use tariffs that would send the economic signal to incentivize the efficient charging of electric vehicles during times of low load and indirectly “train” EV owners to follow the economic signal so that they would adopt such a behaviour later on that EV charging peak would be more substantial.
    - Avoid the adoption of distinct time tariff exclusively for electric vehicles so that not to discriminate the EV load.
    - Regulated low night tariff by the incumbent so that early limited competition within suppliers will be regulated and secure ease for EV charging.
- Regulation of the Distribution Activity

- Access charges to public charging infrastructure should be designed and reviewed in order to ensure the recovery of investments. For demonstration projects and initial rollout programs approved by the Regulator, DSOs can be allowed to recover investment costs associated with public charging infrastructure through the Regulated Tariffs for LV System Users for the part not recovered from EV owners through the applied charges for accessing the infrastructure.
- Post-fee for the DSO should take into account any efficient investments by the DSO related with the penetration of EVs.
- Appropriate legislation describing DSO obligation to install smart meters that would follow certain specifications.

- Installation of equipment on private property
  - EV adopters should be free to choose between the separation of measurements from the other domestic consumption and the accumulation of both that would later on allow for the cooperation with different suppliers.
  - Regulation should discourage pre-defined solutions with certain specifications, e.g. not insist on whether there should be a common feeder for a garage with different branches to the parking slots and specific meters for each place or individual feeders for each slot.
- Necessity for Standardization
  - While DSO should not be allowed to install any equipment that would allow the discrimination of EV load with respect to other uses, without the clear consent of the final customer, plugs should be standardized to avoid free charging on public locations that could spread the wrong message initially.

Since the monitoring and control over EV charging at this stage is negligible, the DSO may not use them for operational purposes e.g. reduction of losses, voltage control, etc.

7.3 Consolidation Phase (2) Scenario

In this phase it is supposed that EV penetration is becoming significant and this is when the EVS-A agent emerges. Regulation should encourage new business models and the EV participation in ancillary and balancing market.

7.3.1 Description of the Business Model

Contrary to catalyst phase, where only positive messages having to do with the ease of EV uptake where primarily sent, now smart charging and demand side management will be at the centre of the business model. Now it is much more rational to consider an EV owner using various points/locations so that to charge. Also, smart charging and services provision can result in lower charging costs and more diverse charging profiles. Next diagram presents one of the possible business models for the consolidation phase, indicating the monetary and information flows with simple arrows.

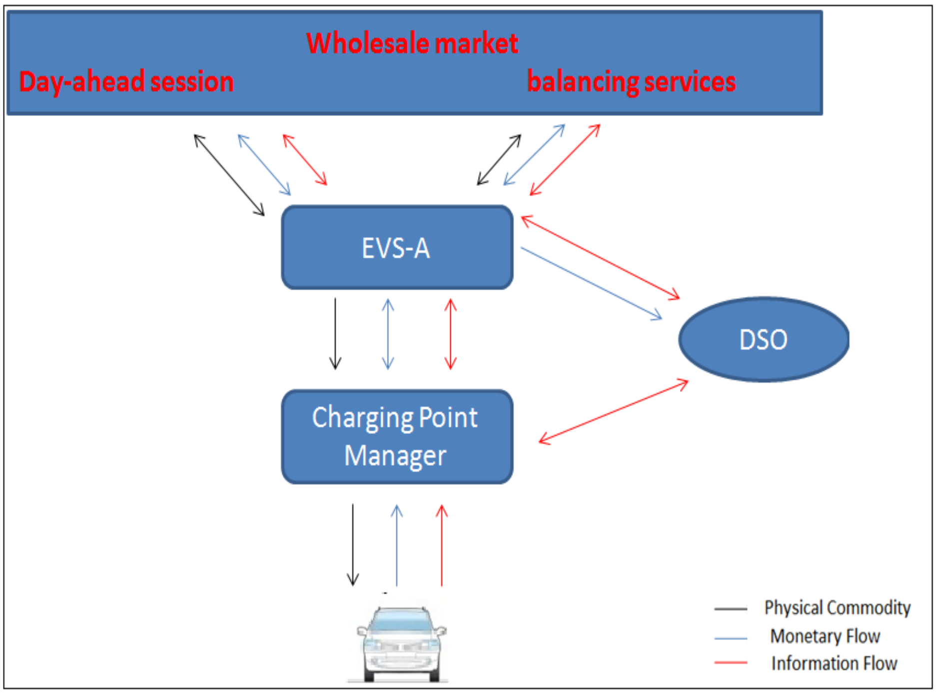

Fig.6.2 Catalyst phase-business model

CPM new definition/role

In the consolidation phase in may be worthwhile defining EVs as eligible customers. In this case the Charging Point Manager CPM) acting as a DSO or closed DSO should provide third party access to suppliers. In order to enable this, every public charging station should include metering and communication hardware that allows EV owners to purchase energy from the supplier of their choice. The CPM will charge the EV owner only for providing access and metering services with transparent and unbundled charges as required by directive 2009/72/EC. This new role is in line with the EVS-A described below.

Upcoming agent:

- The EVS-A

EV electricity supplier-aggregator (EVS-A): EV electricity supplier is a specialized agent that sells electricity to an aggregated number of EV owners. An EV owner can have a supply contract with an EV electricity supplier valid in different charging points. The novelty about this agent is that its contracts are not location based or bound to a single final outlet. EV users will demand mobility and freedom to choose multiple charging points while remaining with the same EVS-A. EVS-A can additionally offer balancing and ancillary services. It is also possible that each EV owner uses more than one EVS-As according to his willingness to pay for charging and the risk he can afford. CPMs will have contracts with one or more EVS-As who would pay an access tariff

Monetary flow:

-Final customer pays the EVS-A according to some contract

-EVS-A presents bids in the wholesale market and through the provision of ancillary services can pass on benefits to the final user. He can also provide balancing services, through demand side management.

-Pays DSO for the use of distribution system

- Pays an access tariff to use several public/private charging points if he is not at the same time the CPM.

Information flow:

-EVS-A declares bids to buy and reserves-bids to sell and updates or reconfigures this information to TSO

-DSO provides information concerning the congestion levels and other operational limits.

-final customer requests charging according to different profiles offered by the EVS-A

Intelligence in communication is a key issue interlinking here, however it can be assumed that network will have evolved due to other reasons that are more significant than the existence of EVs.(smart integration of DG sources). These communication facilities and information systems advances can be exploited from aggregators to offer advanced smart charging modes.

7.3.2 Required Regulation

This section describes the necessary regulation (and legislation to be avoided) in the Catalyst Phase.

- Legislation directed at services that DSOs can request from aggregators (or others) for an improved security of the network functionality. Also methodology and specifications to estimate the cost of the additional investment and how to deal with the uncertainty in planning.

- Standardization of the communication protocols with the intelligent charging systems located inside the vehicles and a regulation in which the DSO can request services from the aggregator (similar to what TSOs are enabled to do already today).
- The EVS-A does not own physical assets, so under the current operating code he would not be allowed to participate in the ancillary services market. This is a first barrier market design must deal with. However system security of supply is the first priority.
- Currently, generating units are not allowed to provide purely downward reserves. This is a basic restriction, as exclusive provision of downwards reserves appears to be the most attractive business case for EVs. This means that symmetric bid requirement should be lifted and the minimum bid imposed should not discourage EVS-A participation
- Currently there is a monthly cleared balancing mechanism rather than a mature balancing market. Establishment of such a market would deploy the benefits EV use has to offer. Tight access rules for the demand-side participation in balancing markets should be avoided. These rules include minimum load and specific site restrictions that constitute constraints, considering the mobile nature of EVs so as not to discriminate this balancing service source.

7.4 Advanced phase- scenario 3

In the advanced phase penetration of EVs would be highly significant and there would be enough experience for the EV owners and trust to EVS-A charging management. Now some attractive system services market may become saturated and V2G capability –if economically sensible- will be exploited. This suggests additional services EVs can offer to TSO and DSO and bidirectional flow of power –(physical commodity).

7.4.1 Description of the business model

The EVS-A participates here in the day ahead market sessions submitting demand bids (buying bids). Selling bids (or negative energy demand bids) could be foreseen however the scope of this should be investigated. The EVS-A still sells reserves basically secondary both upwards and downwards and maybe tertiary if market structure allows to and pricing encourages this participation. EVS-A also provides balancing services again upwards and downwards. This means that EVS-A needs to have further flexibility on managing the clients energy profile and negotiation within EVS-As will also take place so that to perform balancing with less risk on battery life and better forecasting of charging needs. . For the CPM there is also the opportunity to sell services to DSO which can result in locational marginal prices for new services (like trading reactive power for voltage support or further profile management so as to relief voltage unbalance).

Two new players appear and get a more distinctive role than before. The battery manager and the service provider.

Upcoming agents:

- **The battery manager-agent**

  Battery may be owned and managed by a different agent. The battery manager-agent would take on the risk of owning, guaranteeing and controlling the operation of the battery to tackle battery life concerns, and reduce initial purchase premiums paid in comparison to conventional technologies by separating the cost of the storage capacity from the cost of the vehicle. This agent can be the EV owner, the EV manufacturer, the EVS-A or a completely new entity.

- **IT-service provider**

  IT-service providers could act as the link between the different agents such as EV owner and EV supplier, EV supplier and EV aggregator, or EV supplier/aggregator and DSO, while connecting all the different players to electricity market, by providing real time and accurate information. IT-service providers could be commercial players that invest in communication infrastructure and teleconnections, maintain the communication network and profitably IT services to all the previous players.

It is not a sole business model that can be suggested for the advanced phase (which is also the case for the two afore-mentioned phases). The advent of V2G suggests now even more possible business models, depending on the regulations that would be adopted. In the proposed one, EVS-A can offer secondary and tertiary reserves and also balancing services. The CPM can offer local services to the DSO. Batteries can be owned and managed by the EVS-A who can displace batteries after they reach a pre-determined efficiency. In this case EVS-A should have rights on charging profiles other EVS-As can offer to their clients. IT service provider is here a distinct player.

Next diagram presents one of the possible business models for the consolidation phase, indicating the monetary and information flows with simple arrows for one way flow and two way arrows for bidirectional flows.

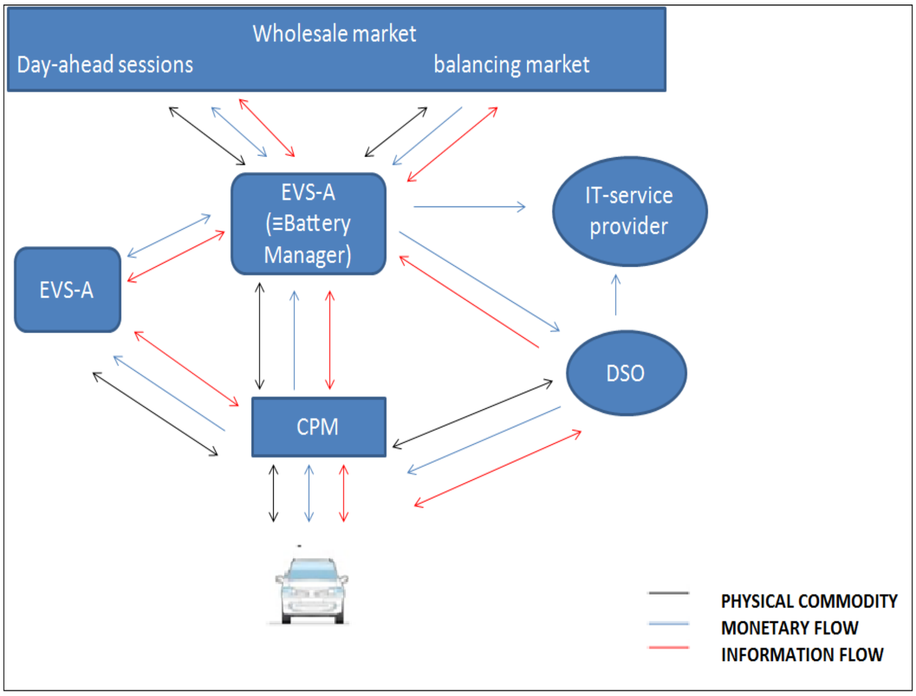

Fig.6.3 business model- Advanced Phase

7.4.2 Required Regulation

Consolidation phase would have already brought regulations that pave the way to the further EV uptake. One thing to be outlined here however is that further enabling legislation will not be just EV driven but –V2G deployment will go side by side with demand side management and DG wider deployment and further policies that will empower the microgrid concept within the networks.

- Legislation should be directed at V2G services DSOs can request from aggregators or directly from CPMs for improved security and flexibility of the network operation.
- Secondary reserves provision with separate bidding for upwards and downwards would already be adopted from the consolidation phase.
- Concerning the provision of tertiary reserves from EVS-As it should be allowed for entities not owning physical capacity to participate. That means that capacity assurance market should be re-organized and compulsory provision of the technical max for ancillary services should be reconsidered. This however is not without the challenges arbitrage with few participating parties entails.
- Establishment of local markets for ancillary services and trade of voltage support or regulation for cpm participation to relieve voltage unbalance when it occurs.

- Alternatively, establishment of site-specific constraints on the reserve provision constitutes a constraint in the participation of EVs in reserves provision. This problem can be aggravated in the borders of control areas, which EVs may cross even on a daily basis. regulation of cpm obligation to contribute to relieve voltage unbalance when it occurs.
- *Information and I&C requirements*: EVs – DSO – EVS-A – TSO real-time communication and real-time measurement should be established. An alternative to real-time measurement for very small units could be that units below a certain size need to produce documentation afterwards to verify that regulation has taken place. On the other hand, with the development of new communication solutions to measure and control even small loads and production units, it could be reasonable to specify real-time measurement for at least all new units (in this case EVs) that can be considered for balance regulation.

7.5 References

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