Work Package 3
Deliverable: 3.3

Title:

List of identified barriers and opportunities for large scale deployment of EV/PHEV and elaboration of potential solutions

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Date: 31.08.2011.

Version: Final

STATUS

in process (Y / N)	N
in revision (Y / N)	N
approved (Y / N)	Y

Confidential (Y / N)	N

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement No. 241295.

Track changes

Name	Date	Version	Changes	
			Subject of change	Page
Vera Silva, Marianne Entem		V1		
Marko Aunedi, Anser Shakoor	05.08.2011.	V2	Included sections on economic, environmental and regulatory aspects; General editing and formatting	
Vera Silva	18.08.2011	V3	Added introduction, analysis of the high impact barriers and conclusions sections	

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1. Introduction

It can be expected that the impacts of large-scale deployment of EV on electricity grids will be different for systems in different countries. The requirements of the grid will also differ from one part of the system to another. Therefore, detailed recommendations with respect to efficient integration of EV should be elaborated country by country. There are, however, common characteristics and some of the impacts are likely to be similar across different countries.

The identification and classification of impacts needs to take into account three technical points:

1. *Existing capacity of distribution networks*: countries in southern Europe traditionally have slightly weaker networks (especially at LV levels), which might require network reinforcements already at a low EV penetration rate.
2. *Level of basic electricity consumption (before EV)*: the impact of EV charging at e.g. 3 kW will be more pronounced for a user with a peak demand of 3 kW than for a 15 kW user.
3. *Flexibility of the power system*: EV as a demand or storage resource could provide additional flexibility to the electricity system, but some power systems need more flexibility than others, depending on the generation mix and transmission network capacities.

Some of the above mentioned impacts represent opportunities to use EVs as distributed storage devices that can be used to support power systems operation. EV can potentially be an attractive form of responsive demand that can be used to provide operation flexibility. It has to be noted that this new type of flexibility will compete with other conventional sources of flexibility (flexible generation, transmission, storage and other flexible demand). This flexibility takes a more prominent role due to forecast uncertainties and variability related to intermittent generation (as wind) and demand, which are expected to increase the need for flexibility in future power systems.

To decrease operational costs and reduce investments in generation and network capacity, EV charging needs to be displaced from peak times and spread through the night, or shifted to periods with excessive intermittent renewable generation. Moreover, charging power might need to be limited to slow charging and/or controlled in real-time in more constrained networks.

Controlling EVs and taking advantage of their flexibility to support their cost-efficient integration into the system have clear benefits; however they cannot be pursued without the implementation of the appropriate regulatory framework, market design and technical infrastructure.

The pricing regime needs to be able to encourage time-of-use or dynamic pricing, and local intelligence might be needed to integrate customer-side constraints.

There is uncertainty as to how to attract customers to sign into flexible charging schemes, as well as how to encourage the retailers to offer recharging facilities with dynamic time-based pricing to customer.

Coordination between retailers/aggregators and DSOs should be established to take full advantage of benefits of smart charging schemes (for both supply and distribution businesses). A retailer/aggregator typically faces centralised market constraints, while DSOs operate under local network constraints. As a minimum, retailers/aggregators will need to inform the DSO and TSO of real-time signals sent to its customers (price signals or direct load control) to increase the visibility of local demand from the DSO's side. The main challenge of such coordination is for the retailer/aggregator to detail its actions load area by load area, and for the DSO to make day-ahead network simulations. This scheme has been studied in the ADDRESS project[1], however, some issues still remain open, such as the size of load area, and handling of network constraints by the DSO.

Finally, the financing of public charging points needs to be clarified, in particular for fast charging points which require network reinforcements. It is understood that few fast public charging points will be necessary because most cars will spend most of their time parked at home or at work. Nevertheless, some public charging points might still be necessary as back-up and to instil confidence in the early stages of deployment, and they might be unprofitable, i.e. require public subsidies. This might be considered unacceptable by the customers, given that the network usage charges are already relatively high for end-consumers.

It is clear from these considerations that for an efficient deployment of EVs (especially if done on the large scale) many aspects need to be taken into account and significant

[1] "Active Distribution network with full integration of Demand and distributed energy RESourceS", European Community's FP7 project funded under grant agreement n° 207643.

coordination is required between actors such as regulators, system operators, network operators, retailers and EV users. In order to provide an insight into some of the key aspects that are at stake, this report presents the impacts, barriers and their classification in terms of magnitude, and concludes with high-level recommendations that could be applied to different systems.

This report does not aim at repeating what has already been done in other WPs and contained in the corresponding deliverables, which detail the work carried out to identify different barriers and propose technical solutions. Instead, the intention is to obtain WP leaders' interpretation of the results obtained in respective WPs in terms of major barriers, solutions and policy recommendations. Moreover, in this work we aim at identifying how different impacts will be experienced by different power system parties and how they can benefit from different technical solutions.

2. Methodology for identifying barriers, opportunities and solutions for the deployment of EV

2.1 Structure of the methodology

Given that the elaboration of this report involved an active involvement of all project partners, a methodology has been proposed that could be applied to all partners. The aim was to support a structured analysis of the results obtained by different WPs, based on a common approach for sharing information.

The methodology for the identification or barriers and opportunities of the EV deployment was then structured in terms of the following key steps:

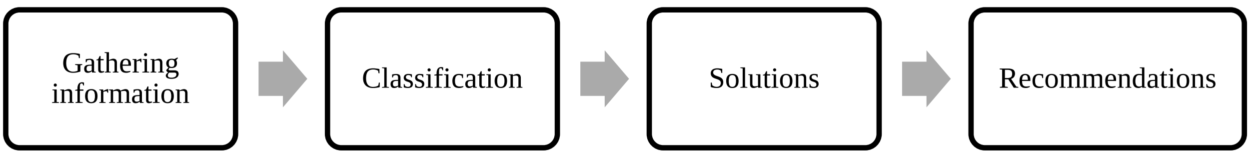

Figure 1 Main steps of the methodology

Each of these steps involved the following specific tasks:

1. **Gathering information:**
   a. collecting impacts identified in different WPs:
      i. positive impacts => opportunities
      ii. negative impacts => barriers
   b. identify sources of impacts
2. **Classification/identification**
   a. Classification of magnitude of these impacts
   b. Identify EV penetration from which impacts become visible
3. **Description of solutions for the elimination of barriers and make use of opportunities:**
   a. Propose solutions for:
      iii. Elimination of barriers
      iv. Use opportunities
   b. Identification of actors that benefit from solutions
   c. Benefits to the overall power system efficiency

4. **Elaboration of recommendations for implementing the solutions**

2.2 Application of the methodology

The application of the methodology is based on a set of procedures and techniques that were applied to complete each of these steps described above.

1. Gathering information:

A questionnaire has been distributed to the leaders of work packages 2, 3, 4, 5 and 6 to collect the information about

- Impact of EVs on:
  - Overall system economic performance
  - System and market operation
  - Regulation and markets
  - Distribution networks
  - Needs for ICT infrastructure
  - Consumer acceptance
  - New services provided by EVs
- Sources of these impacts identified in each WP

2. Classification/identification:

Elaboration of an **Impact Assessment Matrix** has been based on the impacts identified in the previous step, containing:

- Classification of impacts in terms of their relative order of magnitude (low, medium, high);
- Identification of the EV penetration level from which these impacts can be observed;

3. Description of solutions for the elimination of barriers and make use of opportunities:

Using the same Impact Assessment Matrix, a solution or set of solutions is described so that:

- If the impact is negative => solutions to eliminate a barrier
- If the impact is positive => solutions to make use of an opportunity

Using a table structure derived from the Impact Assessment Matrix and for each solution we identify:

- The overall benefits to the system (social welfare) resulting from implementing the solutions
- The actors on the power system that directly benefit from the solution

4. Elaboration of recommendations for implementing the solutions

Using the same table structure of Step 3 for each of the proposed solutions, one or several recommendations are elaborated that would facilitate its implementation. These recommendations can be related to technical, consumer, political and regulatory aspects. In most cases a combination of different types of recommendations is required to eliminate a barrier or use an opportunity. In this work, however, we focus on specific recommendations for each solution and a broader analysis is performed in WP7.

3. Analysis of high impact barriers, solutions and key recommendations

Chapter 4 lists a large number of barriers that have been identified in different Impact Assessment Matrices. These, however, have different levels of impact and are expected to appear at different levels of EV penetration.

Given that barriers with high impact and that start appearing at lower EV penetrations are likely to be the ones which hinder the deployment of EVs the most in the short to mid-term horizons, they are highlighted in this section.

3.1 System economic and environmental performance

From the impact matrices for system economic and environmental performance (Chapter 4, Table 3 and Table 1) the high impact barriers to large-scale EV deployment are:

High Impact Barriers:

Increased requirements for generation and network capacity due to additional EV demand

Increased use of expensive CO_2 intensive peaking plant

The energy consumption of EV in terms of percentage of total energy demand is not high, but the increase of system peak demand can be high if many vehicles are charged at the same time. As a consequence, uncontrolled charging of EV may have a significant impact on peak system demand and significant additional capacity (both for generation and networks) will be required to maintain system security at an appropriate level.

Proposed solution: Control EV charging to shift demand from peak to off-peak and reducing the charging power

In order to avoid heavy investments into new power plants, we have to limit fast charging and shift EV charge to low demand periods.

An example for a system with 2 million EVs:

- 1 million EVs are charging at 6 kW at the same time during a peak demand period, for example, in the evening when people come back home => 6,000 MW of power

- 6 000 MW of peak power plants need to be built *(equivalent to 360 million euros per year in power plants investment costs → €180 per year and per EV)*

If the consumption is shifted towards low consumption times, like in the middle of the night, and spread using slow charging (3,3 kW), we could optimise the use of base load power plants and limit the use of peak load power plants.

Controlled slow charging is better because it avoids building extra power plants that are only used relatively infrequently. The time of charging can be optimised in order to increase the energy provided by wind or nuclear but the environmental effect will be quite low (or potentially even negative) if coal units are base load like in some of the European countries.

Key Recommendation: Incorporate the contribution from EVs into system operation and design practices. Develop mechanisms to encourage EV users to follow beneficial charging strategies starting from an early stage of deployment. These can be based on existing ToU tariffs and evolve with the increase of EV penetrations.

The development of incentive mechanisms is of key importance if the EV load is to be controlled. Nowadays, in many systems the difference between peak and off-peak tariffs is not significant. From the consumer point of view it is not really a new constraint. The issue is more about proper coordination between system operators and electricity retailers in order to send adequate incentives and price signals to the consumers.

Taking the example of the French tariff, charging an EV with 24 kWh (roughly sufficient for 150 km) would cost about €3 at daytime and €2 at night. Under this scenario each EV can reduce its annual electricity bill by €50 (€100 instead of €150 for an average distance of 1200 kWh/year, 7500 km/year) if charging is done during the night. This, however, is based on current electricity prices that are likely to increase due to introduction of EVs. To avoid such an increase, we will require incentives that at an early stage can be based on existing ToU tariffs, and that would evolve with increasing EV penetration.

3.2 Market operation

The large-scale deployment of EV will impact the operation of electricity markets. On one hand, the uncontrolled EV charging can increase the price spread and lead to high prices at peak times. On the other hand, controlled EV charging, especially for larger penetrations of EV, can lead to flatter total system demand and lower price spreads.

From the impact matrix of system/market operation (Chapter 4, Table 5) the barriers with the highest impact are:

Difficulties for the deployment of EV as ancillary service providers due to high costs of deploying the infrastructure required, and efficiency losses and EVs' batteries life time degradation generated by use of V2G

To mitigate these barriers and reap the benefits of EV flexibility, solutions are required both in terms of technology and market design, including the creation of new functions. Moreover, the pricing of V2G services needs to be based on a full cost/benefit analysis of batteries lifetime and assets utilization.

One of the key solutions identified in this work is:

Implementation of functions, such as the aggregation function, to facilitate the provision of ancillary services from EV. Combining functions such as aggregation and retail to reduce the implementation cost by making use of synergies between functions.

Economic benefits of the aggregation function will be highly dependent on the pricing of the EV flexibility offered to market and ancillary services. Given that EVs are competing with existing technologies and other flexible demand, this pricing will play a key role.

Pricing of ancillary services coming from EVs is a function of charging/discharging cycles of the batteries, the cost of the batteries, life time and infrastructure usage.

From the work performed it is possible to highlight the following key recommendations:

Perform cost/benefit analysis of aggregated EV flexibility services.

Support further research on battery losses and battery wear and tear effects of V2G.

Create co-ordinated and bilateral communication channels between EV owners and agents in charge of controlling the EVs schedule (aggregators).

3.3 Regulatory framework

An appropriate regulatory framework can play a decisive role for a successful deployment of EV. Given the large investment required, need for subsidies, involvement of local authorities and political implications (related to environmental targets and tax), lack of clarity in terms of regulation can be a major barrier to EVs.

The installation cost for an Energy Charging Gateway (ECG) with charging power of up to 43 kW in public areas, amounts to about 7,000-10,000 €. Therefore, it might be very difficult to generate sufficient revenue from selling electricity to cover the installation cost of the ECG. Nevertheless, charging infrastructure in public places is deemed necessary for the development of EV, therefore it may require subsidies and incentives as well as the involvement of public entities such as local authorities.

The tax on petrol also plays an important role. At an early stage and low penetration of EVs the government may choose not to tax the electricity for EVs. However, when the number of EVs increases, the government could take measure to recover the revenue lost through reduced volume of petrol tax, and a new tax on electricity used for EV charging may be created. In this case the tax will need to be well designed, taking into account grid constraints.

Among different barriers presented in the impact assessment matrix (Chapter 4, Table 7) we would like to highlight two for their short-term relevance:

The development of charging infrastructure needs to keep pace with the developing market to ensure consumer confidence in terms of their ability to recharge their vehicles with least inconvenience.

Loss of government revenues presently arising from taxation of conventional transport fuels. Their compensation through shifting of such taxes to electricity (when used for EVs) may affect the business case of market players.

Lack of standardization of charging infrastructure.

If a mass-scale deployment of EVs is to be attained, there will need to be solutions implemented to remove these barriers. From the work performed the following key solutions are identified:

Public incentives or subsidies for adequate provision of public charging infrastructure, in particular at initial stages when penetration of EV is low.

An in-time policy and regulatory clarity on such issues is deemed necessary for smooth and large roll-out of electro mobility.

Developing standards for sockets, plugs, technical description of batteries (or battery packs), communication protocols etc.

The development of these solutions requires a strong engagement of several parties, such as government, regulatory and standardization bodies, power system utilities, automobile manufacturers, etc.

This, however, needs to be done to avoid compromising the development of EVs. Key recommendations are therefore elaborated as follows:

Develop clear policies and regulatory framework required for the development of all types of charging infrastructure (i.e. private, semi-private and public) alongside with standardization efforts.

Establish clear roles and interactions among relevant actor such as DSOs, retailers, municipalities etc.

3.4 Distribution network planning and operation

Previous sections have discussed the impact of controlling EV charging to avoid peak energy prices and the need for new generating capacity. In the same way, DSOs and TSOs could avoid network reinforcement if EV charging is controlled in a way that takes into account network constraints.

Considering that EVs will be connected to the distribution network, especially at low voltage level, and represent a new form of demand that was not considered at the stage of distribution planning, their impact in terms of local constraints is likely to be high. These costs are aggravated if a large amount of fast charging stations and private quick recharging poles are deployed. These impacts can hinder a cost-efficient deployment of EV and some high impact barriers have been identified in Table 9, with the following having a high impact:

Network overloads at LV level and anticipated need for network investment.

Network reinforcement including upgrading the connection to the network of the consumer in terms of capacity and type of connection (single phase or three-phase).

In order to avoid high investment costs that will need to be socialised and an inefficient utilization of assets, a set of solutions are proposed in Table 9 from which the following are extracted as key solutions:

Implementation of EV charging control strategies so that their load is shifted and/or charging power is reduced in response to network constraints.

Development of smart grids that can evolve from simple to more advanced solutions and allow active participation of DSO and small consumers in EV control strategies.

For the implementation of solutions to eliminate barriers to the deployment of EVs related to the distribution network, a set of recommendations is presented in Table 10 of which the following are considered to be key recommendations:

Deployment of smart grid up to the household network.

Implement control strategies from low penetration of EV using simple solutions at an early stage that are upgradable according to needs.

Smart meter with incentive tariff to facilitate the activation of control strategies for both DSO and retailer (e.g. many registers dedicated for the retailer and for the distributor, or a load curve with 10/15’ points used for billing).

3.5 ICT infrastructure development

It has been stated in the previous sections that the implementation of EV charging control strategies is a key solution for the integration of EV. The implementation of pragmatic and advanced strategies will require an ICT infrastructure that enables the interaction between different actors (such as DSO, retailer/aggregator, system operator) and the EV. However, the fact that EVs are moving devices that can be connected in different areas of the network may raise certain challenges in terms of billing.

An inadequate ICT infrastructure can become a barrier to the deployment of EV as described in Table 11. Among the different barriers the ones with a high impact are:

Need for a new advanced ICT network infrastructure

Need for roaming solutions

The implementation of new services and advanced control strategies requires a new ICT infrastructure, which requires substantial investments in terms of money and time. If such infrastructure is required from an early stage of EV development, it will greatly increase the total cost of infrastructure that will be hard to recover due to a limited number of users.

Roaming solutions allow charging the EV in places that do not belong to the contracted aggregator/retailer whilst paying for the use of electricity to the same aggregator/retailer. This, however, increases the cost of the information and communication as well as the complexity of the metering and billing procedures. Given that the electricity represents a small part of the total cost of using public/semi-public infrastructure (less than 10%) alternative options should be considered.

Some solutions to barriers related to ICT are presented in Table 11, of which the following are considered of key relevance:

The development of ICT infrastructure should be made in a gradual way, using upgradable solutions, to keep the investment low and perform additional investment according to needs and sustained by cost/benefit analysis.

At an earlier stage of EV deployment, to avoid the costs of roaming, a prepaid option or a payment at the gateway should be considered

The mitigation of ICT barriers requires a timely implementation of the proposed solutions. A set of recommendations to facilitate these is presented in Table 12, of which the following are considered to be of key importance:

Take advantage of current ICT infrastructure in order to minimise new infrastructure investment and upgrade it according to needs.

Aggregators/Retailers should consider the prepaid option as a priority when the user has no contract.

3.6 Consumer's role

The technical infrastructure plays an important role for the deployment of control strategies to activate the services that these can enable. None of this, however, can be implemented without the engagement of the consumer.

It is important to first understand the drivers and barriers that lead a consumer to adopt or reject EVs for fulfilling their mobility needs. Simultaneously, we need to understand which are the drivers and barriers for the participation of consumers in EV charging control strategies.

The social studies performed in WP3 allowed for the identification of a set of impacts listed in Table 13. The ones with the highest impact are:

Majority of people prefer to recharge their car at home or work whenever possible, which may lead to morning and evening peaks alongside the low utilisation of public and semi-public infrastructures.

Low acceptance of bidirectional charging schemes (V2G services) due to anxiety factors regarding the State of Charge (SOC) of the battery when they need the car and the effects on the battery.

In order to implement control strategies it is important to raise the awareness of the consumer about the active role that he can play in avoiding the increase of the cost of electricity. It needs to be clear that accepting some conditions such as having a delay in charging his EV and/or accepting that the SOC at departure time is lower than expected may not necessarily have an impact on his mobility, while it can improve the economic and environmental performance of the electricity system. This acceptance of allowing an actor (such as retailer/aggregator, DSO, etc.) to control the charging of the vehicle, however, needs to be done while respecting a set of consumer-defined requirements, such as for example: “I want my vehicle battery at least 60% full at 5:00 PM”, or: “I want it 80% full at 7:00 AM”.

This type of active participation from demand has already been implemented for other types of load. For instance, in France, the electric water heater is controlled: water is heated during the off-peak tariffs periods and stored for daily use. There are currently 10 million consumers engaged in this type of demand-side participation, who accept that to shift these loads to the night sometimes results in the water temperature in the evening which is lower than desirable. The consumer is free to override the night option if needed, however, at the cost of higher electricity price. This type of experience can be used as a basis to deploy new or enhance the existing control strategies to be applied to EV demand.

Solutions to mitigate consumer-side barriers to the control of EV charge are also proposed. The key solutions, which can also be considered as recommendations, are:

The acceptance of control strategies can be stimulated via financial incentives but schemes need to be tailored to individual countries’ situation.

Further testing of user acceptance of delayed, off-peak charging in demonstration projects is required.

Use the awareness about the use of EVs, which may reduce some of the anxiety factors, to enhance control strategies.

Nonetheless, more detailed consumer behaviour studies in different countries and the understanding of experiences from large demo projects such as Green eMotion will allow for increasing the knowledge about the consumer needs and willingness for participation in demand-side control initiatives.

3.7 Business case for EV aggregation

It is clear that in order to have a cost-efficient deployment of EV the deployment of control strategies to access the flexibility that this load can provide is of key importance. This will require the development of functions that facilitate the implementation of strategies and the deployment of this EV flexibility. Considering that one isolated EV has little impact and can only provide a marginal amount of flexibility it is important to look at the EV as an aggregated load. This aggregation is also essential to make up services of tradable size that can compete with conventional solutions.

In order to utilise the flexibility from EVs, a new function is considered, designated as aggregation. This could be taken up by either a new or an existing actor. The business model for the aggregation function includes the provision of several services to various stakeholders.

This function and the provision of these services will only appear if there is a business case and the benefits obtained are higher than the costs of implementing it. As a consequence, factors that compromise this business model can be seen as a barrier to the deployment of some flexibility services. These questions have been analysed in WP2 and Table 14 presents the impacts identified. High-impact barriers include:

If no coordination exists between the DSO and the retailer/aggregator, the provision of services to different actors (including ancillary services to the TSO) can cause an increased load in some areas of the network and lead to local constrains.

The needs for investment in an advanced infrastructure to implement flexibility services, especially under an uncertain policy and regulatory framework, can hinder the implementation of the aggregation function.

Considering that aggregation is required to provide most flexibility services and that, if competitive, these services can improve the economic and environmental performance of the system, it is important to implement solutions to remove these barriers.

In this work the following key solutions have been identified:

Establish coordination processes, that can be just declaration of forecasts of services to be provided or active distribution congestion management actions, between retailers/aggregators and DSO.

Reduce the uncertainty for investments in infrastructure by defining electro-mobility policies, regulatory framework and standards.

4. Impact Assessment Matrices, Solutions and List of Recommendations

4.1 Economic Performance of Electricity Systems

The increased demand of electricity as a result of a large-scale roll-out of EVs will make a significant impact on the electricity system operation and development and require the development of a comprehensive recharging infrastructure. Shifting significant amounts of energy demand from transport sectors into electricity, if not properly managed, would require significant additional infrastructure investment and could massively reduce the already low system capacity utilisation levels if the paradigm of the system operation is unchanged. Delivering the carbon reduction targets cost-effectively through appropriate EV charging will require a fundamental shift from a passive to an active philosophy of network control. This shift, enabled by the incorporation of demand management into system operation and design, can be achieved by the application of an appropriate information, communication and control infrastructure.

This section has been prepared by Imperial College London, based on the findings of Task 3.1, as elaborated in Deliverable 3.1.

Table 1 Impact assessment matrices and proposed solutions for economic performance of electricity systems

Economic Performance of Electricity Systems

Impacts	Drivers/sources of the impact	EV penetration	Impact classification	Potential solutions to eliminate barriers and/or make use of opportunities
Increased requirements for generation and network capacity due to additional EV demand	Uncontrolled charging of EV may have a significant impact on peak system demand, which will require significant additional capacity of system infrastructure (generation and networks) in order to maintain system security at an appropriate level.	System-dependent	**Medium/High**	Development of incentive mechanisms to facilitate the EV users to follow EV charging strategies that are beneficial for the system in terms of reduced infrastructure requirements.
Reduced operation cost as a result of controlled EV charging	EV charging strategies can have a major impact on system operation costs; controlled charging has the potential to reduce the cost of supplying additional EV demand	System-dependent	**High**	System operation practices need to become able to account for EV contribution and the benefits from controlled charging. This requires appropriate technical features of charging infrastructure and supporting regulation.
Controlled EV charging may improve the system's ability to efficiently integrate intermittent renewables	Controlled charging of EV in systems with inflexible conventional generation and wind may result in economic benefits from avoiding the curtailment of wind energy.	System-dependent	**Medium/High (system dependant)**	Smart/optimised control of the EV charging process should be pursued even at lower penetrations of EV to maximise the associated economic benefits.

Benefits of V2G concept for system operation cost do not seem significant	Economic benefits of bidirectional (V2G) control of EV charging/discharging seem to be small compared to controlled unidirectional charging.	System-dependent	**Low/Medium**	Further analysis is needed involving all relevant costs (ICT, battery life, efficiency losses etc.) to study the feasibility of bidirectional (V2G) control of EV charging/discharging process.

Barriers (negative impacts)

Opportunities (positive impacts)

Table 2 Recommendations to facilitate solutions – economic performance of electricity systems

Economic Performance of Electricity Systems

Solutions proposed	Actors that may benefit from the solution	General benefits to the system and to social welfare	Recommendations to facilitate the solutions
Pursue EV charging strategies that are beneficial for the system in terms of reduced capacity requirements.	Customers, TSO	Reduced cost of supplying electricity to consumers	Incorporate the contribution from EVs into system operation and design practices. Develop incentive mechanisms to encourage EV users to follow beneficial EV charging strategies.
Exploit EV contribution to improve the economic performance of the system.	Customers, TSO, RES generators	Reduced cost of supplying electricity to consumers	Develop a favourable regulatory framework and appropriate technical standards for the charging infrastructure enable economically efficient operation and development of future electricity systems.
Explore the magnitude of economic impacts of EV charging for each individual system.	Customers, TSO	Understanding of the value of controlled EV management for any system in question	Policy or regulatory considerations of EV integration should be adapted to incorporate the distinct features of individual systems, as results obtained for one system cannot be generalised to apply to other systems.

4.2 Environmental Impacts and Opportunities

Transport sector is a major contributor to the environmental emissions resulting from the energy sector (for example, road-based transport accounts for approximately 22% of the UK CO_2 emissions), and therefore reducing the reliance on carbon-based fuels in this sector is seen as a practical solution to reduce the overall CO_2 emissions. EVs have the capability to deliver sustainable transport and lower carbon emissions. The overall emissions-related impact of shifting transport energy demand from fossil fuels towards electricity will greatly depend on the technology (or the mix of technologies) which is used to provide the additional electricity required by EVs. Net emission benefits could be very significant in systems where additional electricity is provided by low- or zero-emission technologies (such as hydro, nuclear or wind).

This section has been prepared by Imperial College London, based on findings of Task 3.1, as elaborated in Deliverable 3.1.

Table 3 Impact assessment matrices and proposed solutions for the environmental performance of the electricity system

Environmental Performance of Electricity Systems

Impacts	Drivers/sources of the impact	EV penetration	Impact classification	Potential solutions and resulting benefit
Increase of the use of expensive and CO2 intensive generation	If EVs are charged around peak periods the use of peaking plants is increase. These plants often have high CO2 emissions. This represents a risk of supplying electricity for motion from plants with high emissions loosing part of the environmental benefits expected from electric transportation	System-dependant	**High**	Control EV charging so that low carbon generation is used to charge the batteries.
Reduction of CO_2 emissions as a result of optimised EV charging	Under the assumption that more carbon-intensive technologies are also the more expensive ones, controlled EV charging can greatly reduce carbon emissions.	System-dependent	**Medium**	Similar to economic considerations, adopting system operation practices that take advantage of EV charging flexibility may lead to reduced environmental emissions from electricity systems.
Reduction of emissions due to reduced wind curtailment	Controlled EV charging offers additional flexibility in the system that can be used to follow wind fluctuation and improve system's ability to absorb intermittent renewable output. In doing that, they also reduce the need to use peaking thermal plants, and hence the	System-dependent	**Medium**	Optimised control of EV charging should be incorporated into system operation practices to maximise the associated environmental benefits.

	emissions.			
Positive environmental impact on national level	Given that European electricity systems are expected to become less carbon intensive by using more renewables and other low-carbon technologies, substituting mileage driven by fuel-driven engines with EVs may bring substantial environmental benefits.	System-dependent	**Medium**	Same as above

Barriers (negative impacts)

Opportunities (positive impacts)

Table 4 Recommendations to facilitate solutions – environmental performance of electricity systems

Environmental Performance of Electricity Systems			
Solutions proposed	**Actors that may benefit from the solution**	**General benefits to the system and to social welfare**	**Recommendations to facilitate the solutions**
Pursue EV charging strategies that are beneficial for the system in terms of reduced environmental emissions.	Customers, TSO	Reduced carbon emissions from electricity supply	Incorporate the contribution from EVs into system operation and design practices. Develop incentive mechanisms to encourage EV users to follow beneficial EV charging strategies.
Exploit EV contribution to improve integration of intermittent renewables into the system.	Customers, TSO, RES generators	Increased renewable electricity supply, reduced usage of fossil fuels	Same as for pursuing economic benefits.

4.3 System and Market Operation

It is expected that large fleets of electrical vehicles (EVs) may need to be integrated into power systems in the relatively near future. EVs represent a new load that will be added to the already growing electricity demand. Moreover, EV load will be connected to LV and MV networks that were originally planned without any consideration of electro-mobility. It is therefore expected that EV demand will have a considerable impact the power system at both system and local level. As opposed to conventional demand, EVs are equipped with a battery that enables them to act as micro-storage devices, if enabled by an appropriately higher degree of control on the demand side. This will enable a granular EV-demand side response that can be effectively used to aid in drawing the daily operational plans of the power system. This evolution, however, should be gradual and done in response to the needs of the system.

The input to this section has been prepared by Chalmers and Vattenfall, based on their work carried out in WP6.

Table 5 Impact assessment matrices and proposed solutions for system and market operation

System/Market Operation				
Impacts	**Drivers/sources of the impact**	**EV penetration from which the impact becomes significant system**	**Impact classification**	**Potential solutions and resulting benefit**
Increase wide system demand at peak periods	Uncontrolled EVs charging at peak hours	Medium penetration	**High**	Implement control strategies for EVs' charging scheduling
Difficulties for the deployment of EV as ancillary service providers	High costs associated with ancillary service provision from EVs	Any	**High**	The cost of providing services using the EVs storage capacity is a function of the battery technology and infrastructure costs. It is difficult to propose a solution.
Higher demand for balancing services. EVs being connected to the grid in a "random" way generating unscheduled demand deviations	Uncontrolled EVs charging	Medium/high penetration	**Medium**	Implementation of scheduling control schemes in order to mitigate uncertainty of the EVs charging.
The use of V2G incurs efficiency losses and reduces EVs' batteries life time	Controlled V2G for provision of ancillary services	Any	**High**	The pricing of the EVs V2G services needs to be based on a full cost/benefit analysis of batteries

				lifetime and assets utilization
Difficulties to schedule a general fast charging using traditional power system operating tools	Controlled EVs charging	EVs characteristics dependent	**Low/medium**	Modify operating tools to capture the impacts of shorter, but higher power injections into the system
Reduction of revenues to peak generation and increased usage of mid-merit generation	Controlled charging	System dependent and EVs characteristics dependent	**Medium**	Deferral of needs for investment in peaking generation
Increased demand and consumption flexibility by charging or discharging EV batteries at times of abundance of low-cost generation and spare network capacity	Improved possibilities for market actors, e.g. DSO/TSO, to control, by the approval of the consumer, power flow and network capacity limits in regard to price signals, supply and demand, weather conditions, existing intermittent generation, etc	Locally even relatively low penetration - e.g. demand peaks, existing intermittent generation, etc	**Medium/Low**	Benefits could be a more evenly distributed, less sharp load peaks, improved network utilization balance and reduced demand for additional network reinforcement.
Peak shaving: Reduction of the wide system demand at peak periods	Controlled EVs' charging and discharging on V2G mode	Any	**High**	Less heavy loading of system assets. Reduction of energy prices. Procurement of higher levels of security and/or cheaper "security" provision.
Conventional generation displacement by EVs for reserve provision	Controlled EVs charging	Medium/high EVs charging/discharging rates	**Medium/high** **System dependent**	Reduction of the total operating costs due to more competitive reserve provision from EVs

Facilitators for the introduction of RES	Controlled EVs charging/discharging	Medium/high	**Medium/high** **System dependent**	Combined RES-EVs output that is smoothed by the buffering capabilities of the EVs

Barriers (negative impacts)

Opportunities (positive impacts)

Table 6 Recommendations to facilitate solutions – system and market operation

Benefits and Barriers to the Solutions Proposed for Mitigating the Impacts

Solutions proposed	Actors that may benefit from the solution	General benefits to the system and to social welfare	Recommendations to facilitate the solutions
Provide the single consumer with improved possibilities for active demand utilizing the EV battery as a buffer for increased demand at low-cost periods and in-house use of stored energy at high-cost times	Consumer	For the individual consumer this may be of significant benefit to level out demand peaks and in total reduce energy cost	Improved power control facilities required at each consumer site. Perhaps existence of aggregator services for control of consumer's active demand is a requirement.
Implement control strategies for EVs' charging scheduling. Mitigation of uncertainty in the EVs charging process	EVs owners TSO DSO Retailer /Aggregator	Higher profits for some of the participants (retailers) Less prices volatility Higher/cheaper security margins	A co-ordinated and bilateral communication channel between the EVs owners and the agent in charge of controlling the EVs schedule. Similarly the proposal of different control strategies in order to make the controlled charging process attractive to the EVs owners. Adjustment of forecasting tools that take into account the different daily and seasonal driving patterns and its impacts on the system demand.
The pricing of the EVs V2G services	Retailer /Aggregator	Higher benefits to the EVs owners and	The pricing of the ancillary services coming from EVs is a function

needs to be based on a full cost/benefit analysis of batteries lifetime and assets utilization	EVs owners	to the aggregator. Equally reduction of the total system operating cost, given that the ancillary services coming from EVs are competitive.	of the charging/discharging duty cycles of the batteries, the cost of the batteries, life time and infrastructure usage. In order for these services to be competitive its costs needs to be lower marginal cost of these services in the current markets conditions (i.e. with no EVs in the system)
Modify operating tools to capture the impacts of shorter, but higher power injections into the system	TSO DSO EVs owners	Makes a more efficient use of the EVs capabilities	Adapt and/or propose new operating tools to capture the higher level of granularity the a wide spread co-ordinated operation of micro-storage devices and the system scheduling processes simultaneously

4.4 Regulatory Framework

Establishing a clear market, regulatory and policy landscape will be necessary to enable an efficient and secure deployment of EV at a large scale. This should encompass the key relevant elements of the system: charging infrastructure, distribution grid; ancillary services as well the information and communication infrastructure. It is also very important that the future policies and regulation in the electro-mobility area should ensure appropriate standardisation of equipment, infrastructure and the various procedures involved to facilitate a smooth uptake of EVs.

This section has been prepared by Imperial College London, based on findings of Task 3.2 reported in Deliverable 3.1 (Chapter 5).

Table 7 Impact assessment matrices and proposed solutions for regulatory requirements for efficient integration of EV

Regulatory Requirements for efficient integration of EVs

Impacts	Drivers/sources of the impact	EV penetration Impact is noticeable	Impact classification	Potential solutions and resulting benefit
Lack of adequate public and private charging infrastructure	One of the key requirements in the wide spread implementation of electro mobility is the provision of charging infrastructure. The development of charging infrastructure will need to keep pace with the developing market to ensure consumer confidence in terms of their ability to recharge their vehicles with least inconvenience.	All	**High**	Roll-out of public charging infrastructures (PCIS) may not be a profitable business case at initial stage of EV penetration in the system; however, it would be a prerequisite for large scale EV deployment. Therefore, public incentives or subsidies will potentially be required for adequate provision of PCIS, in particular at initial stages when penetration of EV is low.

				Further actions may include; • Establish facilitated procedures to obtain the right to install charging stations in public spaces. • Introduce facilitated procedures to obtain authorizations to perform works in public spaces, when required for the installation of a public infrastructure (for example construction/ground works needed to place cables).
Lack of standardization of charging infrastructure (CIS)	For large scale deployment of EV most of the EV users should be technically able to benefit from most of the CIS.	Low to high penetration of EV	**Medium/High**	Keeping in view the long and successful tradition of inter- and intra-industry standard setting, we recommend that industry along with (semi)-public bodies should take lead on an international level with respect to developing standards for sockets, plugs, technical description of batteries (or battery packs) , communication protocols etc. Also the standardisation should cover all types of charging infrastructure i.e. public, semi-public and private charging infrastructure.
Tax on electricity consumed for Electro-mobility	Another potential issue is some loss of government revenues presently arising from taxation of conventional transport fuels. Their compensation through shifting of such taxes to electricity (when used for EVs) may affect the business case of market players.	Medium to high penetration of EV	**Medium/High**	An in-time policy and regulatory clarity on such issues is deemed necessary for smooth and large roll-out of electro mobility.

Lack of data security	[2]Implementation of the Smart grid concept for efficient integration of EV will inevitably require detailed application of Information, Communication and Control technologies. Application of ICT will involves exchange of large data between various market players. Therefore appropriate use of this data and its overall security will be critical for proper functioning of electricity systems with EV.	Low to high penetration of EV	**Medium**	Regulation must ensure security of the metering data also including; ownership, storage, transmission, retrieval as well as maintaining the privacy of the customer. This is considered essential for effective application of ICT in electro-mobility.
Promotion/evolution of EV charge control strategies	Uncontrolled charging of EV may have a significant impact on peak system demand, which will require significant additional capacity of system infrastructure (generation and networks) in order to maintain system security at an appropriate level.	Low/medium	**High**	Future regulation will need to encourage those charging strategies that lead to cost optimal infrastructure (generation, transmission, and distribution). Here adequate incentives could also be provided to facilitate the EV users to follow EV charging strategies that are beneficial for the system in terms of overall system and operation costs.
Provision of ancillary services by EV	EVs with their inherent large storage capacity can offer multiple system support services. Furthermore this would also support the integration of intermittent energy sources. The overall gains vary among different incumbent systems.	System-dependent	**Low/Medium**	Regulation must ensure a non-discriminatory access of EV/demand side to participate in ancillary services markets and removal of existing barriers. Remuneration schemes also need to be made clear and for various services offered by EV such as; – Capacity payments.

				– Regulation down - simply charging the battery when it is optimal for the system, and be paid. – Regulating up is however more costly. degradation costs, cost for electricity already stored, and the expected revenue from providing regulation up is low.

Barriers (negative impacts)

Opportunities (positive impacts)

Table 8 Recommendations to facilitate solutions – Regulatory Requirements in Future Electricity Systems for Efficient Integration of EV

Regulatory Requirements for efficient integration of EVs

Solution proposed	Actors that may benefit from the solution	General benefits to the system and social welfare	Recommendations to facilitate the solutions
Improve transparency and clarity for the development of standardised charging infrastructure and necessary network reinforcements	Customers, DSOs, electro-mobility providers	Stable environment for the development of charging infrastructure	Develop appropriate policies and regulatory framework required for the development of all types of charging infrastructure (i.e. private, semi-private and public); the approach will need to be harmonised and coordinated at the European level, with standards adopted to enable most of the EV users to benefit from the CIS.
Adopt incentives for developing the Public Charging Infrastructure (PCIS)	Customers, DSOs, e-mobility providers	Enabling a more rapid uptake of EVs	Adopt public incentives or subsidies to enable an adequate provision of charging infrastructure, with particular emphasis on the initial stages with low EV penetration.
Review existing network planning and operation rules to account for smart charging control strategies and promote non-network solutions	DSOs, Customers	Cost-efficient development of future networks	Review the regulatory framework to support non-network solutions (smart grid approach) for cost-optimal development of networks. Establish clear roles and interactions among relevant actors such as DSOs, retailers, municipalities etc. Grid-related services should be accessible under the

			same conditions to all electro-mobility players. Draft the "right to the plug" regulation, which should clarify all the installation aspects both for the customers and the DSO. Ensure that all grid investments related to electro-mobility are fairly remunerated through an update of existing remuneration practices. Develop mechanisms for DSO and TSO to access and employ the load flexibility as part of their network operation flexibility.
Tap into the potential of EVs to provide system support services	TSOs, Customers	Cost-efficient provision of ancillary services	The contribution of EVs to ancillary services will require a fair, non-discriminatory access to relevant markets (capacity, energy and balancing), as well as clarity on the remuneration schemes. The approach to this should be harmonised at the European level, while respecting the specific features of individual system. Grid code amendments may be required to allow for the use of EV for system management, with an option to aggregate EVs to achieve a larger-scale impact. Establish the benefits of using EV for reserve provision compared to conventional sources (hydro or thermal), and allocate gains appropriately among relevant players. Size of balancing bids may need to be adjusted to accommodate EV – smaller bid sizes would encourage EV participation in providing regulation capacity, having in mind the pragmatic implications for network operation.

Ensure a secure, standardised and cost-effective application of ICT infrastructure for a large-scale roll-out of EVs	DSOs, TSOs, Customers	Cost-efficient, standardised and transparent provision of electro-mobility services	Retain an option for an upgradeable ICT infrastructure to keep pace with the increasing EV penetration levels. Harmonize ICT interfaces and their compatibility within national boundaries as well as across EU to facilitate the usage of EVs. Assure the security of data, including storage, transmission, retrieval and the privacy of the customer. Exploit intelligent ICT solutions to enable separate metering of electricity consumption for e-mobility from other consumption (where required). For E-roaming to become effective for large-scale EV penetrations, there is a need to clearly define the terms and conditions of the roaming-related agreements among involved market players. Establish transparency in the flow of information and settlement of bills among retailers, as well as between the retailers and EV customers. Promote customer-friendly operation of ICT infrastructure (e.g. automatic/remote software upgrading) and billing systems to enhance the smooth integration of EV.

4.5 Distribution Network

Large-scale introduction of EVs is expected to require challenging improvements in the development and operation of (many) distribution networks, taking into account the peculiarities of future mobile customers. Controlled EV charging offers several opportunities for a more efficient design and operation of networks by exploiting the inherent energy storage and flexibility of EVs. Development of new and modification of existing rules will be required for economically efficient and secure reinforcement and operation of future networks with large-scale integration of EV, to take into account the impact of smart charging control strategies. The development of adequate EV charging infrastructure will need to keep pace with the developing EV market to ensure consumer confidence in their ability to recharge their vehicles with least inconvenience.

The input to this section has been prepared by Enel and EDF R&D, based on their work in WP5 and WP6.

Table 9 Impact assessment matrices and proposed solutions for distribution networks

Distribution of Electricity				
Impacts	**Drivers/sources of the impact**	**EV penetration from which the impact becomes significant**	**Impact classification**	**Potential solutions and resulting benefit**
Generate local constraints and anticipated need for network investment	Deployment of public quick recharging poles near residential area	Medium Low in some networks	**Medium**	Control strategies for shifting EV charge to periods with spare network capacity. Contractual rules (maximum power limited or controlled with penalties in case of exceeding these limits
Network overloads and anticipated need for network investment	Deployment of public/semi public quick recharging poles	High	**Low**	Control strategies for moving loads in the hours at low loads in the network. Contractual rules (maximum power limited or controlled with penalties in case of exceeding these limits
Network overloads at LV level and anticipated need for network investment	Deployment of private slow recharging poles	Medium	**High**	Development of smart grids and active participation of small consumer in EV control strategies

				Battery charging during the valleys of the load curve (at fixed or variable power) controlled using smart grid technologies
Network reinforcement including upgrading the connection to the network of the consumer in terms of capacity and type of connection (single phase or three-phase)	Deployment of private quick recharging poles	Low (system dependent)	**High (system dependent)**	Combination of the type of battery charging with the capacity of the electrical installations
Reduction of the quality of supply (harmonics, transient, …)	Charging poles: different powers for G4V & V2G	All	**Low**	Creation of new norms
Security and reliability of the electrical system	Active management of EV (G4V & V2G)	Medium	**High**	Efficient & sure ICT

Barriers (negative impacts)

Opportunities (positive impacts)

Table 10 Recommendations to facilitate solutions – Distribution networks

Benefits and Barriers to the Solutions Proposed for Mitigating the Impacts

Solution proposed	Actors that may benefit from the solution	General benefits to the system and to social welfare	Recommendations to facilitate the solutions
Installation cost by the customer without private parking in exchange for a guarantee of a EV seat for every car owned in the city block	Private customer	Faster deployment of EV system	New EC directive for agreement with EV system and Municipality
Development of smart grids and active participation of small consumer	Small consumer	Reduce socialised investment cost	Deployment of smart grid till the household network
Battery charging during the valleys of the load curve (fixed or dynamic) managed by a more or less sophisticated smart grid	Consumer / DSO / retailer	Reduce socialised investment cost	Smart meter with incentive tariff to promote the battery charging during the valleys of the load curves for both DSO and retailer (e.g. many registers dedicated for the retailer and for the distributor (or load curve with 10/15' points used for billing)). The smart meter or another device manages the electricity consumption in order to optimise the cost and the comfort for the consumer
New or updated norm for the supply	DSO, consumer, car and charging pole	To maintain the	Update of the existing quality of supply standards taking into account the battery charger

voltage characteristics	manufacturers	quality of supply	(including working as inverter –V2G)
Efficient & reliable ICT	TSO, DSO, producers	Reliability and efficiency of the power system	Definition and implementation of the mandatory requirements in order to insure the reliability and the efficiency of the system.

4.6 Impacts on ICT Infrastructure

The electrification of transport represents a challenge for the development of the appropriate ICT solutions that can deliver an increase of efficiency for the transport and the electric sector. The security requirements for the electric vehicles infrastructure need to be appropriately considered in light of security enforced in the electricity sector and telecommunications. The interface with the EV user is important for the charging process, which has to unequivocally identify the user, enable an efficient communication flow between different actors, and ensure privacy of the EV user's personal information. There is a range of communication technologies that could be used for exchanging EV intelligence with the charging station or other electronic devices, also ensuring that the recharging process of the batteries complies with the technical requirements set by the battery manufacturer. Such communication should also provide a bidirectional "smart" cooperation between vehicles and infrastructure in order to enable the provision of smart grid-based services.

The input to this section has been prepared by Endesa based on the results of WP4.

Table 11 Impact assessment matrices and proposed solutions for ICT infrastructure

ICT Infrastructure

Impacts/Barriers	Drivers/sources of the impact	EV penetration from which the impact becomes significant system	Impact classification	Potential solutions and resulting benefit
Need for new ICT network infrastructure	New services need a new ICT, which represents great investments in terms of money and time	Medium/High (system dependant)	**High**	Gradual transition to ensure affordable investments during new EV infrastructure implementation
Standardization communication protocols	- As now each vendor could use a different communication technology, incompatibilities can arise - New standards could increase cost or make early investments obsolete	All	**Medium**	- Ensure interoperability and connectivity between the electricity supply point and EV - Agree on new standards as soon as possible, before massive EV deployment
Need for Roaming	Impossibility of charging the EV in places that do not belong to the contracted aggregator/retailer	All	**High**	A prepaid option should be considered
Cyber security	More access points (smart meters and charging poles) can facilitate the access to information of network	All	**Medium**	Adapt cyber security standards and requirements to this new situation

	operation and private personal data			
Use of smart metering	Metering requirements can make early technologies obsolete or require upgrades for early adopters	Medium/High (system dependant)	**Low**	Metering devices that allow retrofit solutions with minimum cost

Barriers (negative impacts)
Opportunities (positive impacts)

Table 12 Recommendations to facilitate the implementation of the solutions – ICT

ICT Infrastructure

Solution proposed	Actors that may benefit from the solution	General benefits to the system and to social welfare	Recommendations to facilitate the solutions
Metering devices should allow retrofit solutions with minimum cost	DSO Aggregator/Retailer	Enlarge lifespan of hardware Reduction of amortization	New services should be added as software updates, avoiding replacement of hardware
Gradual transition to ensure affordable investments during new EV infrastructure implementation	DSO, E mobility provider Aggregator/Retailer	Minimise investment in new ICT infrastructure	Take advantage of current ICT infrastructure in order to minimise new infrastructure investment
Ensure interoperability and connectivity between the electricity supply point and EV	EV manufacturers and charging pole vendors Aggregator/Retailer DSO	Facilitate the recharge of EV in public and semi public areas	EU should push involved companies for the standardization of communication regarding EV
Agree on new standards as soon as possible, before massive EV deployment	EV manufacturers and charging pole vendors	Facilitate the recharge of EV in public and semi public areas	EU should push involved companies for the standardization of communication regarding EV

	Aggregator/Retailer DSO		
Prepaid option	Aggregator/Retailer EV user	Reduction of investment needed in ICT infrastructure and actors involved Reduction of charging costs in roaming situations	Aggregators/Retailers should consider this option as a priority when the user has no contract with them
Adapt cyber security standards and requirements for EV ICT infrastructure and data	Aggregator/Retailer E mobility provider DSO User	Increase in security for all involved actors	Actors should promote more strict standards in order to avoid external cyber attacks

4.7 Consumer Acceptance

Most analyses related to the market introduction of electric vehicles (EVs) currently revolve around technical issues related to the vehicles and infrastructure. However, user preferences will also play a large role in the process and can be a determining factor for a successful uptake of EVs. Due to different characteristics of EVs compared to conventional cars, in particular the lack of familiarity with the recharging process and expectations towards vehicle performance, users may need to adopt modifications in their usual travelling and refuelling patterns, that can influence their overall willingness to adopt the EV technology.

The input to this section has been prepared by ECN, based on its work in Task 3.3 (including the online survey conducted to assess the preferences of potential future EV users), as elaborated in Deliverable 3.2.

Table 13 Impact assessment matrices and proposed solutions for consumer acceptance of EV and EV control strategies

Consumer behaviour

Impacts/Barriers	Drivers/sources of the impact	EV penetration	Impact classification	Potential solutions and resulting benefit
Peak demand from recharging EV likely to occur in residential areas and locations were people recharge during working hours (e.g. large office parks, parking lots)	Majority of people prefer to recharge their car at home or work whenever possible	Low/Medium (system specific)	**High**	Outcomes of demo projects can help to better predict peak demand More detailed studies to behaviour in different countries (G4V had only a small sample that can provide

				tendencies)
Constrained battery use for bi-directional services (on average 70km have to remain always in a battery with 120km total capacity)	Low acceptance of bidirectional charging schemes (V2G services)	All	**High**	Acceptance can be stimulated via financial incentives, but different impact across EU. Schemes need to be tailored to individual country situation.
Peak demand shifting possible during night time and working hours	High acceptance of delayed charging services (first users prefer home/work recharging), further increase of participation through financial incentives to shift behaviour towards home/work recharging	Low	**Medium**	Further testing of user acceptance of delayed, off-peak charging in demonstration projects

Barriers (negative impacts)
Opportunities (positive impacts)

4.8 New services provided by EV

With large-scale introduction of EVs, it is possible to envisage a range of new services potentially provided by EVs. Traditional stakeholders in existing industries might also be interested in and capable of providing new functionality with respect to electro-mobility. Therefore, new business models and opportunities are expected to emerge to enable the participation of EVs in markets for energy and ancillary services, as well as for the providers of electro-mobility services. Along with the potentially positive environmental effects from introducing EVs, there will also be economic implications such as business opportunities for various stakeholders, or the need for substantial investment in infrastructure. The identification of attractive business models is important in order to enhance the attractiveness of the concept to investors.

The input to this section has been prepared by TU Dortmund, based on its work on EV business models in WP2.

Table 14 Impact assessment matrices and proposed solutions for the implementation of services from EV

Products and services from EV

Impacts/Barriers	Drivers/sources of the impact	EV penetration	Impact classification	Potential solutions and resulting benefit
Increased load within the distribution grids due to new services provided by EV aggregation	The business model of the retailer/aggregator includes the provisioning of several services to various stakeholders. These services may constitute an additional load of the distribution grid.	Medium/high	**High**	Establishment of coordination processes between aggregators and DSO's that limit the activities of the aggregators with respect to grid restrictions within the distribution grid
High efforts on accounting and invoicing the EV customer due to the new character of roaming/straying loads	The use of several products/services of different stakeholders during the charging process at different charging poles requires a sophisticated accounting system	All	**Medium**	Establishment of a Clearing House that manages the invoicing between the EV customer and all involved stakeholders.
Investment barriers with regard to the charging infrastructure	Regulatory framework for the operation of charging poles is not defined which entails unsure revenues	All	**High**	Reduce of uncertainty for investments in infrastructure by legislative initiatives for more legal certainty

Barriers (negative impacts)

Opportunities (positive impacts)

Table 15 Recommendations to facilitate the implementation of services from EV

Products and services from EV			
Solution proposed	**Actors that may benefit from the solution**	**General benefits to the system and to social welfare**	**Recommendations to facilitate the solutions**
Establish coordination between aggregators and DSO's	DNO (distribution network operator)	Avoiding excessive grid reinforcements	Coordination processes require standardizations by the regulators.
Establishment of a Clearing House that manages the invoicing between the EV customer and all involved stakeholders.	Data Warehouse Provider, ICT Stakeholders, Customer	Reduction of costs regarding invoicing of products/services; Enabling of roaming by EVs	Clearing Houses can be a regulated task of the grid operators or a business model in a liberalised market. In the case of a regulated Clearing House the requirements towards the Operator of it should be formulated in legal provisions. In the other case ICT requirements should be worked by standardization bodies.
Reduce of uncertainty for investments in infrastructure by legislative initiatives for more legal certainty	DNO, Retailer, Charging Pole Operator, Car Park Operator, Filling Station Chain	Enabling of public and semi-public charging; Reduction of risk costs due to investment security	Clarity in terms of policy and regulation

5. Summary

This report has presented an overview of barriers, solutions and recommendations for the large-scale deployment of EVs, based on the findings of different G4V Work Packages.

Given the large scope of work undertaken in the G4V project, which addressed technical, social, business and regulatory issues, the goal of this work was to bring different findings together within a common analytical framework.

A methodology has been presented to identify and classify impacts (whether barriers or opportunities) and elaborate recommendations. The application of this methodology provided a basis for a common thinking between different project partners, regardless of whether they are responsible for technical, social or business aspects. This allowed us to develop a vision of:

- The barriers that the deployment of EV can face and where they come from
- The solutions that can be put in place to mitigate these
- The opportunities that EVs can represent if used to support system operation and development
- The actions to be taken if these barriers are to be removed and the opportunities explored

The identification process resulted in a large list of impacts and solutions of different kinds and from different sources. This process was then complemented by classifying these impacts and linking them to a particular EV penetration, in order to obtain an understanding of what issues need to be addressed first, and what options are available to do it.

Finally, with this information in hand, tailored recommendations have been derived on how to implement different solutions.

Based on a critical analysis of different findings presented in this report it can be concluded that the impact of EV deployment is not purely a technical issue, but rather a combination of economic, regulatory and social factors, and will therefore require a comprehensive approach to enable EVs to participate in achieving sustainable and efficient future electricity systems in Europe.