The Green eMotion project – preparing the future of European electromobility

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The Green eMotion project
A joint effort for European electromobility

After four years Green eMotion comes to an end in February 2015. The project has defined and demonstrated a European framework that connects all stakeholders for a seamless and cost-efficient electromobility ecosystem.

Starting in 2011, the project developed prototypes to connect the islands of electromobility existing at the time. An overarching ICT architecture was defined and standards, especially for ICT interfaces, were set.

New business models for public charging infrastructure were analysed and ways shown for its optimised integration into the grid.

The results of the Green eMotion project are presented under the following headings:

■ Social acceptance
■ Freedom of movement
■ Economic challenges

Together with the experience gained in the 10 demo regions and two replication regions, the project results are described in this booklet.
Results from the Green eMotion demo regions
Make it happen

Since defining Europe-wide standards for electromobility was a primary objective of the project, the test of their practical usability was a major goal for Green eMotion.

In the Green eMotion demonstrations all 12 demo regions were connected to the marketplace and the feasibility of this solution, especially for roaming between all the demo regions, was successfully demonstrated. Due to the multitude of local electromobility projects the awareness and experience of the customers was increased. Feedback on solutions for enhancement of driver’s convenience, such as easy location of suitable charging stations or easy access to public chargers, was very positive. Technical issues like integration of renewable energy sources and power quality aspects were analysed by the technical experts under real-life conditions.

The standards developed and tested by Green eMotion have become de facto standards for electromobility in Europe.
Demo region Austria

The project activities in the Austrian demonstration region were centred around the integration of diverse charging systems into the Green eMotion clearing house platform, and the roaming demonstration. In addition, electromobility for special target groups was thoroughly analysed, and besides creating standards for integration of EV charging infrastructure in buildings, the use case Park & Charge was thoroughly researched.

The Brenner EV corridor and the Rally to Brussels were major projects to demonstrate the roaming capabilities when connecting to the Green eMotion marketplace. This required the integration and software adaptation of charging stations from Siemens, ABB, KEBA, and PDTS.

Another issue to resolve was the deployment of charging points in parking areas at supermarkets (REWE) and in multi-storey carparks (APCOA) to enable the Park & Charge use case. Another aspect of this was the research into EV ready buildings, and the development of fast-charging concepts for commuters.

Conclusions & recommendations

- Although the Green eMotion roaming solution works fine, EVSP will have to integrate other European roaming solutions, too.
- Parking and energy infrastructure intelligently planned simplify EV integration (garages & buildings)
- Fast-charges were increasingly used in afterwork hours (way home)
- Supermarkets will install fast chargers only in sites with sufficient space left for ICE parkers
- For multi-storey carpark applications, business integration is crucial, and a legal framework is required

Partners involved in this work: Verbund
Demo region DE1 – Berlin

The project activities focussed on roaming and smart charging with a Plug & Charge demonstrations (ISO/IEC 15118). The region demonstrated that pan-European roaming is possible by using the RWE “e-kWh” smartphone app via the Green eMotion marketplace.

One of the app’s biggest benefits is the convenient management of the charging session by smartphone – and access to all charging stations in Berlin. The result: over 5,000 Plug & Charge sessions and, in addition, more than 60,000 charging sessions within four years – leading to an impressive 4 million kilometers powered by green energy only.

Just as successful: the region’s demonstration that pan-European roaming is possible, effectively proved during the Rally to Brussels with 141 kWh charged during 17 charging sessions by users from Austria, Italy, Ireland, France and Germany.

Conclusions & recommendations

- The Rally to Brussels has shown that roaming between several nations can work.
- Electromobility service providers should be encouraged to connect to roaming platforms
- Europe-wide harmonisation of customer ID’s is still lacking which hinders cost-efficient operation.

Partners involved in this work:
RWE
Demo region DE2 – Stuttgart/Karlsruhe

In Stuttgart and Karlsruhe, the project partner Bosch together with EnBW concentrated on important aspects for enabling pan-European electromobility: searching for charging stations, roaming between different regions and multi-marketplace communication.

The search interface allows users of the Green eMotion app to locate 760 charging stations in the demo regions DE2 and FR1, including information about each station’s current status via the Green eMotion app.

Access to charging stations within the region is limited due to commercial offers of the local EVSE operator EnBw. At the same time, people living close to the border regularly conducted roaming transactions, proving that roaming is an essential feature requested by end customers.

Due to the already existing Crome marketplace, connecting to the Green eMotion marketplace required a low implementation effort for partners in the region, proving that communication between different marketplaces is a manageable task.

Conclusions & recommendations
- Roaming is an essential and requested feature of EV users in the region
- Technical and business (financial and contractual) constraints have a strong influence on the success of future roaming
- Standardisation is key for all ICT related services

40,000 roaming requests
2,000 roaming transactions

Search process initiated by CROME partner

Communication flow of partners in the region

Partners involved in this work:
Bosch, EnBW (external), EDF
The city of Copenhagen has logged data from four of its EVs – information that gives valuable insights to EV manufacturers looking to improve battery technology. In co-operation with Greenabout and the city of Malmö, a showcase for roaming between Denmark and Sweden was implemented.

Various events were staged to promote electromobility during the project duration. For example, almost 1,700 persons participated in a competition held by the city of Copenhagen and BMW. The 58 winners each borrowed a BMW i3 for one day and filled out a questionnaire afterwards, documenting their user experience.

Similar data was gathered at the Danish island of Bornholm: 3 x 10 families participated in an EV test performed in co-operation with the Copenhagen based company Better Place and handed in questionnaires about their user experience. To look into the possibilities of roaming between Copenhagen, Malmö and Bornholm, a roaming demo case was implemented.

Conclusions & recommendations
- 72% would consider buying an EV next time
- New/young drivers are educated to use EVs and participate in sharing programs

This cross-border operation covered infrastructure from Copenhagen to Malmö and onward to Bornholm, with a connection from the Swedish city Ystad. The demo case proved that roaming is working, but due to lack of users, electromobility between Denmark and Sweden is still limited.
Demo region ES1 – Barcelona and Málaga

In Barcelona, Endesa eParking with more than 20 EV chargings every day allowed studying the impact of charging processes on the local grid. In Málaga, the project partners Endesa, Renault and Siemens looked into the potential of AC load management and DC fast charging.

The Endesa eParking facility is equipped with 20 slow CP, one fast CP and one V2G 10 kW charger. For eight months, the power quality data has been analysed to implement a local energy management system for optimised energy consumption. In Málaga, 10 Siemens CP500A charge points capable of load management and one 50 kW fast charger with an energy storage system consisting of a second lifetime battery and a 20 kW bidirectional converter have been installed and tested.

Conclusions & recommendations

- **Endesa eParking:**
  - Quality of supply is excellent
  - On-board slow chargers’ harmonics emissions are well below the maximum admissible limits
  - The whole infrastructure supports the overall maximum charging power without showing a significant voltage drop

- **AC load management:**
  - Load management is a useful action to adapt power demand and use of EVSE to grid operation requirements
  - AC load management with PWM signaling can fulfill most requirements, but better energy control will be achieved in the future with ISO/IEC 15118

- **DC fast charging with storage:**
  - The developed system allows reducing the impact of the EV fast charge on the electric grid: it reduces the maximum demand of the system and at the same time compensates the reactive power consumed by the charger

*DC charging curve with the different functionalities applied*

**Partners involved in this work:**
Endesa, Málaga, Renault, Siemens
Throughout the duration of the Green eMotion project, several EV fleets and CPs were monitored. In addition, the region had a closer look at infrastructural actuations and evaluation concerning the integration of renewables and supply quality study. Furthermore, service implementation and applications like roaming service, smart grid functionalities and an electric minibus service were tested.

From all the static and dynamic data gathered, a lot of knowledge could be acquired: the time spent during charging, the related required power, the distance driven between successive charges as well as the state of charge before and after charging. Analysis from this data has led to important conclusions in terms of drivers’ behaviour for two fleet models: private car-pooling and public car-sharing.

These insights enabled the project partners to overcome typical hurdles related to electromobility such as battery range, charging infrastructure availability, and EV’s total cost of ownership.

In Madrid and Biscay, electric buses delivered the expected performance and avoided the emissions of 100 tons and 45 tons of CO₂ respectively. Other analyses showed that the effects and distortions generated by charging points are insignificant, even when high power chargers (EMT) are used. By adding energy generated from renewable sources to the CP’s infrastructure, EVs could be charged with renewable energy, leading to minimised losses of energy, as long as the renewable sources are local.

Conclusions & recommendations

- Initial objectives successfully achieved: a representative number of EVs and CPs provided valuable information on EV performance (charging and trip patterns)
- Thorough charging infrastructure planning required to develop EV penetration
- Inclusion of renewables in CPs for ecological benefits
- Future evaluation of the integration of EVs in a smart grid solution

Partners involved in this work: Iberdrola, CARTIF
Demo region FR – Strasbourg, France

The main objective of the demonstration region was to achieve the interoperability between the existing charging infrastructure in the Strasbourg region (developed in the French/German cross-border project, CROME) and the Green eMotion clearing house/marketplace systems.

The integration required the coupling of CROME and Green eMotion systems to provide an interoperability solution for roaming charging services. This included matching interfaces as well as software adaptations, founded on intense communication between the EDF/ Sodetrel back-ends, the CROME back-end operated by Bosch, and the Green eMotion clearing house. As a result, the public charging infrastructure in Strasbourg is accessible for Green eMotion users with registered RFID cards.

Conclusions & recommendations

- The successful coupling of different electromobility information systems has been proven, but requires defined interfaces
- The standardisation of identification means should be promoted
- The accessibility of charging stations and their capabilities need to be improved

Partners involved in this work:
Bosch, Sodetrel, EDF
Replication region GR – Kozani and Athens

In Greece the Green eMotion project implemented a real green-field installation of an electromobility system by replicating proven solutions from other demo regions. This covered charging infrastructure and the connection to the Green eMotion marketplace for roaming.

One of the main achievements was the installation of a rural and urban charging infrastructure, consisting of 8 public charging posts in Kozani and 7 public charging posts in Athens and 15 leased EVs. By working on the installation, connecting it to the grid and operating public charging posts, obstacles were identified and solutions investigated.

The pilot project raised public awareness for the potential of electromobility and brought together the authorities responsible for the creation of the proper institutional frame. Next to successfully implementing roaming, the pilot project allowed addressing various practical issues and laid the foundations for easier implementation of future electromobility projects.

Conclusions & recommendations

■ The objective of the Greek pilot – a start-up of electromobility in Greece with public charging posts – was successfully achieved
■ Regulatory issues in combination with public awareness should be addressed in order to assist the implementation of e-mobility
■ Roaming and smart charging also investigated in the project provided valuable information which must be further investigated to form a possible business case

Partners involved in this work:
PPC
Replication region HU – Budapest

The city of Budapest replicated the full functionality of the Berlin demo region, aiming to demonstrate smart charging and roaming using the RWE “e-kWh” smartphone app as well as integrating the Budapest replication region into the Green eMotion marketplace.

Budapest, Green eMotion’s single replication region in central Eastern Europe, has been setting up a charging infrastructure by ELMÜ since 2010. This included installing 10 public smart charging stations automatically linked to the marketplace. The RWE “e-kWh” smartphone app allowed users convenient usage of all charging stations.

In addition, all ELMÜ public smart charging stations provided free electricity throughout the Green eMotion project. In 2014, the installation of Green eMotion chargers resulted in a dynamic increase of charging sessions. During the entire project duration, a total of 3,400 Green eMotion charging sessions were counted, of which more than 880 alone took place in the timespan between 2013 and 2014.

Conclusions & recommendations
- Duplication of public chargers in Budapest by Green eMotion contributed to creating basic infrastructure in the city
- Roaming between several European countries without problems
- Access to extensive public charging infrastructure enables growth for e-mobility in Budapest

Partners involved in this work:
ELMÜ, RWE
Validating interoperability between Green eMotion partners, testing and demonstrating the roll-out of three demo cases, evaluating end user experiences and providing recommendations based on the results obtained: Those were topics focussed on in Italy.

In co-operation with Enel, three asynchronous updates of Italy’s public EVSE network were connected to the Green eMotion website. Statistic data export from Enel’s EMM plattform is also used for the demo regions ES1 and GR. All data available for EVSE search is gathered by Enel and implemented in the end-user application Enel Drive.

To give end users to access to smart charging programmes, the EVSE operational back end provides all the necessary data via web services to the DSO. This allows external stakeholders to analyze the modulated recharge for reporting or billing purposes. Load management operations also demonstrated the possibility of managing DSO modulation requests, thus optimising the power available in different conditions in a specific load area.

Tests by Enel and Endesa proved that the IT services designed and put in operation with Green eMotion are capable of providing interoperability between EVSE operators and EVSP.

An RFID authorization service project connecting Enel’s EMM platform with the Green eMotion marketplace proved that the IT services designed and put in operation with Green eMotion are capable of providing interoperability between EVSE operators and EVSP. Furthermore, the demo region Italy showed that Green eMotion IT services, infrastructure and field equipment opened the possibility for future EVSP to access the e-mobility marketplace without the necessity of investing in charging infrastructure.

Load management request performed with Enel EMM system and tracking of real charging process behaviour
Demo region IE1 – Ireland

As a key demo region in the Green eMotion project, Ireland has been a test bed for many of the smart technologies and systems in the EV space. In addition, this demo region has greatly supported the marketing and dissemination of the project results and collated and analysed Europe-wide data on EV fleets.

Amongst the project highlights were marketing and dissemination activities such as the Fully Charged 2012 event with over 270 attendees, a drive from Belfast to Brussels in an EV and an electric taxi try-out in Dublin.

In addition, Soft Open Point was successfully tried out in Ireland’s electricity system, allowing smarter control of EV load. The implementation of an induction charging system developed by fka, Alstom and Siemens was demonstrated in an EV sharing scheme.

At the time, data from EV fleets across Europe was analyzed to gain greater knowledge of fleet experiences and understand industry trends. Furthermore, an EV portal brought added value to EV users by providing greater flexibility of EV control and extra information on charge point suitability and availability, while interoperable roaming was demonstrated via the Green eMotion marketplace.

Conclusions & recommendations

- Smarter integration of EVs into electricity systems
- Added value to EV users through ICT systems
- Ireland ready for mass market uptake of EVs

Partners involved in this work:
ESB, TCD, Codema, Cork
In the city of Malmö, several public charging points were installed and connected to the Green eMotion marketplace. The project’s aim was to demonstrate the search for charging points, roaming and different identification methods in a real-life, cross-border demonstration between Malmö and Copenhagen.

Both the Green eMotion search function and roaming through the Green eMotion marketplace were successful. For identification tests across borders, RFID and the Green eMotion smartphone app were used. The test turned out successful: Danish customers charged their EVs in Denmark, drove via Öresundsbron to Malmö, found a charge spot there and charged their EVs again using the same identification via RFID or smartphone app.

Conclusions & recommendations

- Successfully demonstrated real-life cross-border charging using roaming technique
- Importance of an open, accessible and easy-to-use infrastructure

Demo region SW – Malmö

Partners involved in this work:
Malmö, Greenabout, Chargestorm (external)
Social acceptance is high on the list  
More than range, costs and charging

To enable a mass roll-out of electromobility in Europe, social acceptance is a prerequisite. Social profitability in regards to actual benefits and costs for all players in the EV ecosystem may be reached soon.

However, major concerns of the customers are the costs and the range of EVs. Only with clear commitments from all levels of policymakers, from the municipality level to the national and European level, will a holistic and consumer friendly future mobility incorporating EVs happen. Incentives and the installation of a suitable public charging infrastructure will be required. All measures should be aligned with the needs of target groups like commuters or owners of fleets to achieve a maximum impact with the lowest possible costs.
**EV deployment from an environmental point of view**

An increasing number of EVs on our roads will have a major environmental effect. To find out just how big an effect at the local, regional and European level was one of the Green eMotion tasks.

To evaluate the environmental implications of a mass deployment of EVs, through a consistent comparison between EVs and ICVs, using a life cycle assessment (LCA) approach, six impact categories were evaluated (primary energy demand, global warming potential, mineral or fossil depletion potential, acidification potential, eutrophication potential, photochemical ozone creation potential).

Vehicle stock level proved to be a key input in this methodology for determining the total amount of energy demand and emissions of the transport sector. In a life cycle assessment, battery production amplifies the comparative environmental footprint of EVs in most categories, while supplying renewable power to EVs clearly enforces their environmental advantages. On average, with today’s European energy mix for electricity production, an EV emits less CO₂ than an ICE car.

**Conclusions & recommendations:**
- Decarbonising the electricity system is essential to maximise the environmental benefits of EV ("essential", where EVs are used, “important”, where the car and batteries are produced).
- More investment should take place in environmentally-friendly batteries (negative environmental impact of EV with regards to acidification or eutrophication can be minimised).

**Samples of Environmental Impact (Global Warming Potential and Acidification)**

**Partners involved in this work:** Imperial College, CTL, RSE, BMW, CIDAUT, Rome, EDF, DLR
The European electric vehicle fleet in figures

Knowing more about driving and charging behaviour is important for future planning. The data gathered from 2,700 CPs, 200,000 charges, 689 EVs, and 95,000 trips over three years in the 12 Green eMotion demonstration regions in eight countries ended up being the largest database on European electromobility to date. The experience gained in the project serves as guidance for the publication of other European electromobility projects (JRC Report, EC).

The data shows a high correlation between energy consumption and outside temperature, different for southern or northern countries. In terms of grid impact, the driving-charging pattern shows a great percentage of high charge processes in peak hours.

As observed in previous analysis, the utilization and effectiveness of charging points depend on the location. Household and public access parking are used three times more than charging points located in the street.

Overall, EVs are being charged 58% of the time they are connected to a charge point and the parking patterns in terms of plug-in time present differences statistically significant depending on the charge point location.

Conclusions & recommendations:
- The Green eMotion electromobility database is a powerful tool to answer scientific and technical questions
- Analysis of electromobility data can help to:
  - Determine future optimal CP locations
  - Estimate number of CPs needed based on real-life monitored routines
  - Evaluate future electric grid impact and requirements
  - Identify driving and charging patterns
The “truth” about EV usage

In the Green eMotion demonstration regions, data was collected from the charging infrastructure and the EVs involved throughout the project. This data was analysed and used to describe typical EV user behaviour profiles for both charging and travel patterns. Policymakers can now take better informed decisions.

EV car users tend to charge their cars in regular patterns, regardless of the remaining range available to them. While most recharges are realised at household and workplace charge points, charge durations are short (1 to 3 hours) with energy consumption considerably below vehicle battery capacities (2 to 9 kWh).

For households and private users, peak demand for charging was in the evening hours (17:00 to 21:30 hours). The state of charge (SOC) before recharging was above 50% on average, and low levels of night-time charging were recorded for all users.

At the same time, the distances travelled between charge events were relatively short (2 to 15 km), with daily travel distances typically less than 45 km, following established commuter travel patterns. Trips were also significantly shorter than the range of the vehicle batteries.

Conclusions & recommendations:
- The charging activity peaks in the evenings and the low levels of night-time charging recorded demonstrate the need for smart charging to change user behaviour
- The provision of household and workplace charge points should be considered a priority
- Provision of fast charging facilities will increase user confidence in the range of their vehicles
- The provision of real-time information to users regarding their available range and the location of the nearest charging infrastructure would increase user confidence and change user behaviour positively

Partners involved in this work:
TCD
Consumer preferences and attitudes affecting EV demand?

EVs are a new product on the mass market. In order to assess the reasons for the low penetration of EVs, a survey was set up. It had to collect data on individuals’ preferences and attitudes towards EVs and estimate their willingness to pay.

To achieve this, the most important factors for demand stimulation were identified, with EV and charging characteristics high on the list, followed by individual attitudes. Then a methodology was set up to study individual preferences and attitudes. From the information gained, market share elasticity for specific EV characteristics and recharging options was computed and allowed for comparison among demonstration regions. The study also measured the impact of having used an EV in real life on preferences and attitudes. In addition, it showed the importance of performing more panel studies to estimate how preferences and attitudes change over time.

In the three analysed countries Denmark, Ireland and Italy potential customers are particularly sensitive to the purchase price of the EV, more than to any other attributes including range. The driving range is however the second most important attribute.

Customers consider as important the availability of fast charging stations, i.e. the possibility to drive up to 110 km after a 20-minute charge.

Conclusions & recommendations:

- EV needs to be improved in terms of purchase price, range, and numbers of fast charging stations
- Specific policies oriented towards small/city cars especially for city centres
- Policies targeted at the “attitude” of a population
- Policies tailored for each specific country
- People need to be informed and learn about the EV range actually required

Partners involved in this work:
DTU, TCD, RSE, IREC, ECN, EDF, Enel, BMW, Daimler, DLR, Rome
Electromobility in urban environments

Concrete policies and strategies have been identified by the Green eMotion WP2 members through the evaluation of hurdles and successes experienced and surveys on the implementation of urban electromobility in diverse scenarios.

Hurdles:
- EV: Long recharge periods, low range, high cost, lack of standardisation in charging methods
- Infrastructure: Lack of standard plugs and standard billing systems, high infrastructure costs, little experience in the installation process and the proper location of CPs
- Incentives, marketing and communications: No agreement between related government stakeholders, absence of regulation to provide a clear business model for investors

Successes:
- Policy processes: Cities that seek to address climate change locally have adopted EVs as key to the future – zero emissions and zero noise
- Collaborative policies: Multi-modal travel options and ‘Smarter Cities’ are enhanced with the deployment of EVs

Conclusions & recommendations:
- Coordination and co-operation, regulations, support and promotion are the key strategies for the development of electromobility
- Increase the demand for EVSE by stimulating private initiative with subsidies and well-defined market regulation to boost investment and create demand in municipalities
- The normative rules to install CPs in public spaces should be active as soon as possible
- Targets should be set and monitored for the deployment of EVs in public authority vehicle fleets

Survey: Main policy drivers in regions/cities

Partners involved in this work:
Copenhagen, Barcelona, Iberdrola, CTL, Málaga, DTU, Nissan, Enel, Renault, Rome, TCD, Cork, EDF, BMW, Greenabout, IREC, Malmö
A major task for Green eMotion in preparing the large-scale roll-out of EVs was to identify current gaps and barriers to incorporating actual benefits and costs for all players in the EV ecosystem, and to investigate the requirements for a suitable commercial and regulatory framework.

During the project, the lack of an interoperable infrastructure was found to be a major gap, while high cost, slow charging, range anxiety, uncertain resale value, maintenance costs and battery life, as well as fiscal cost of lost fuel duties and subsidies were detected as main barriers.

Other investigations included a Social Cost-Benefit Analysis (SCBA) of all costs and benefits at efficient non-market prices (i.e. pre-tax/subsidy, including external costs). Peak charging could be nine times the cost of off-peak charging. In addition, the project determined at what levels of battery cost and oil/carbon price the costs of EVs and ICVs are the same. A most promising opportunity was found in the high EV utilisation combined with convenient charging, e.g. for lengthy commutes, rentals, or as second cars.

**Conclusions & recommendations:**
- Social profitability by 2020 requires high oil price, continued decline in battery cost and off-peak charging
- Maintenance cost advantage of EVs against ICVs has a significant impact
- Battery cost – economic barrier, range and charging rate – acceptance barriers
- Key commercial and regulatory barriers are interoperability, roaming, and inefficient electricity pricing
- Subsidies may be justified to overcome some barriers
- All SCBA should be conducted at efficient fuel, carbon and electricity prices (i.e. pre-tax/subsidy, including external costs)

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**Equivalent “fuel” cost comparison between EVs and ICVs**

**Partners involved in this work:**
Imperial College, ECN, Tecnalia
Supporting an effective integration of EVs in the EU

The task of this work group was to identify needs for and possible issues with the large-scale deployment of electric vehicles in the EU. Wherever issues were detected, solutions had to be developed to overcome them. And, finally, a list of actions was developed for various stakeholders.

The main needs identified for a large-scale EV roll-out are customer acceptance, attractive business cases, a stable and efficient grid, interoperable charging networks, and the right governmental actions. Related to these needs, 18 issues were identified, eight of which had high priority.

### Conclusions & recommendations:

<table>
<thead>
<tr>
<th>High priority issues</th>
<th>Solution and actions</th>
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<tbody>
<tr>
<td>Low utilisation of public charging posts</td>
<td>■ Subsidise vehicle adoption and the realization of unprofitable charging infrastructure</td>
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<tr>
<td>Costs due to peak demand</td>
<td>■ Enable smart charging; provide drivers with the right incentives to use smart charging</td>
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<tr>
<td>Car purchase cost</td>
<td>■ Lower TCO by incentives, provide information about TCO</td>
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<tr>
<td>Match with services</td>
<td>■ Identify the right matches, according to the characteristics of services offered</td>
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<tr>
<td>Gaps in standards</td>
<td>■ Further joint efforts to develop and implement standards</td>
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<tr>
<td>Range anxiety</td>
<td>■ Provide drivers with information on charging possibilities and optimal behaviour</td>
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<tr>
<td>Local grid congestion</td>
<td>■ Smart grids; set up the right frameworks. Develop demand forecasts to identify grids that might be congested</td>
</tr>
<tr>
<td>Hardware installation costs</td>
<td>■ Require some degree of preparedness for charging infrastructure in building codes and tenders</td>
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Best practices for the roll-out of large-scale infrastructure for EVs

Policymakers are looking for guidance when rolling out large-scale infrastructure for EVs in cities and regions or developing electromobility strategies and policies. The Green eMotion project offered possibly the broadest ever approach within its consortium of 42 different participants – municipalities, research and development labs, industrial partners, universities, etc. – to offer such guidance.

### General recommendations for policymakers
- **Have a plan:**
  Express your vision and objectives, identify barriers. How many EVs expected? How many public charging posts necessary? Where?
- **Engage stakeholders**
- **Create a cross-departmental taskforce**
- **Optimise licensing process to limit time between application and realisation**
- **Gain knowledge by monitoring progress**
- **Choice of policy measures depending on local circumstances**
  There is no silver bullet

### Policy toolbox of measures to regulate, support and promote
- **Emission-free driving and parking zones**
- **Local/regional electromobility forum or platform**
- **Help with joint procurement**
- **Wider time windows for electric vehicles to deliver goods in city centres**
- **Use of special lanes**

### Practical experiences of implementing measures
- **Germany:**
  Before September 2014, no federal law allowed for reserved parking at charging locations for EVs, so spots could be occupied by conventional cars; new law allows exclusive (PH) EV access to parking and special zones and lanes
- **Sweden/Malmö:**
  Conflicts with broader transport sustainability goals. Free parking for EVs was introduced in 2007, but stopped in 2009, as it did not support the goal of reducing car use in city centre

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**Partners involved in this work:**
ECN, CTL, Málaga, TCD, Cork, Malmö, Rome, Nissan, Renault, BMW
Freedom of movement
An international approach is needed

To allow convenient EV traffic throughout Europe, a standardised, interoperable electromobility system is required, creating new business cases and making investments future-proof. Green eMotion has defined the European ICT architecture that is needed to ensure a proper connection of all market participants. It will allow open and convenient access by EV drivers to public charging infrastructure.

The ICT systems of all participating companies are networked by means of a so-called marketplace. While users get easy access to charging infrastructure independent of the equipment operator, service providers can offer their services to all market participants. In addition, value-added services like reserving a charging point can make e-driving a more convenient experience.

Standards are the basis for an interoperable electromobility system creating new business cases and making investments future-proof.
Roaming – the user’s view
Experience in demo regions & Rally to Brussels event

One of the key aspects of the Green eMotion demonstration regions was to prove the interoperability of the European charging network from a user’s (EV driver’s) perspective.

To achieve this, Green eMotion created a complete roaming solution, allowing drivers to use their own RFID card and/or smartphone app to charge in other demonstration regions. At the Rally to Brussels this solution proved its viability with different partners driving to Brussels and an on-site roaming demo. As for identification, RFID proved to have many obstacles for interoperability, whereas the smartphone app worked flawlessly. Yet, system response times of all components need to be acceptable for the user, and EVSE search routines must provide reliable data on location, type, and status.

Conclusions & recommendations:
■ EV drivers need easy-to-use roaming RFID, but several obstacles have to be overcome
■ A smartphone app is a good choice for roaming
■ System response times need to be acceptable for the user
■ New standard needed for imprinting and reading the EVCOID on RFID card

Partners involved in this work:
All Green eMotion demo regions
At the beginning of the Green eMotion project, a scalable ICT solution for roaming was a mere concept, and research was needed to provide a marketplace platform that allowed offering, buying and using eMobility services across partners from all demo regions.

Project activities also included the connection to other marketplaces, e.g. CROME eRoaming. The Green eMotion marketplace was operative from May 2013 on and was used by all demo regions and service providers (nearly 40 accounts). It also hosted big EV service demonstrations, such as the Rally to Brussels or EVS27. In total, 72 services were registered, serving 293 contracts at 300,745 transactions.

**Conclusions & recommendations:**
- IT architecture proved workable, and is scalable and extendible
- Standardisation has to be continued (eM13)
- Standardise electromobility identifiers (EVCO-ID, EVSE-ID)

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**Marketplace – a scalable ICT solution for roaming and more**

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**Partners involved in this work:**
BMW, Bosch, Daimler, EDF, Endesa, Enel, Iberdrola, IBM, RWE, SAP, Siemens, Verbund
Increased EV driver convenience with value-added e-mobility services

Getting electromobility on the road means giving EV drivers access to interoperable infrastructures and letting them enjoy a seamless driving experience.

To achieve this, value-added services will increase the EV driver’s convenience, among them a search engine for EVSEs on the Green eMotion website that collects EVSE data from nine Green eMotion partners and displays approximately 3,000 charging points. In addition, locations and dynamic EVSE data were integrated into the freely available charging app for smart phones and tablets. The app also allows remote starting of charging actions if the infrastructure is capable. In Málaga, Green eMotion tested the smart charging process in terms of user experience and issues like congestion and the integration of renewable energy on 20 EVSEs with a charging management system.

Conclusions & recommendations:

- Services are a must to make the life of an EV driver more convenient.
- Search functionality has to show all available charging posts (independent of operator; best with access information). At the moment, dynamic data is the cherry on the cake for EV drivers.
- To implement IT services with integration of different IT applications, a wide set of standards (e.g. interfaces, business objects) is an essential prerequisite.

Partners involved in this work: Alstom, BMW, Bosch, Daimler, EDF, Endesa, ENEL, Iberdrola, IBM, RWE, SAP, Siemens, Tecnalia, Verbund
**Activities to promote standards on interoperability**

**Electric vehicle drivers require open access to interoperable charging infrastructures in order to enjoy a seamless driving experience.**

- To achieve this, Green eMotion defined an ICT architecture, use cases, business objects and protocols that are representative of the needs of the whole ecosystem of electromobility actors. An important part of this was defining EVCO-ID and EVSE-ID, as well as the required interfaces, and smart grid integration. Further to this, New Work Item Proposals were made, such as communication between EVSE and back-end systems, a unique ID for EV driver contract, and SORDS (standardized on-road driving schedule). In addition, eMI³ (as ERTICO working group) was founded together with other electromobility stakeholders to enable follow-up work on standardisation, and a roadmap was set up for future standard needs.

**Conclusions & recommendations:**
- EC directive or standardisation required for identification of EV driver contract and EVSE based on EVCO-ID and EVSE-ID
- Standardisation of the defined interfaces and other topics from the roadmap
- Evaluate and define future IT standards to increase value-added services
Examples how to push electromobility

In three demonstration regions, Green eMotion investigated consumer acceptance of special target groups and business models for car sharing (intermodal solutions) and co-operation models.

The goal of these investigations was to boost the uptake of electromobility within the demonstration regions.

In Ataun, Spain, the focus was on testing a car sharing system for EVs in a sparsely populated area. A fairly high usage proved that EV car sharing works in rural areas and that drivers were fond of it.

In Austria, the combination of charging with parking and/or shopping was tried out. The main findings: Customers require easy and ensured availability of charging points – and fast charging perfectly fits the bill.

In Scandinavia, Green eMotion tested an integrated and multi-country public/private car sharing system including intermodal co-operation, showing that transportation is a need people have.

Conclusions & recommendations:
■ ES: The evaluation of patterns of EV usage and energy consumption has to be performed in yearly cycles
■ AT: Discrimination-free access to (roaming) and ensured availability of EVSE is key to success
■ DK: Intermodal integration helps the uptake of electromobility. People of all ages and lifestyles are potential customers for EV car sharing, provided it is simple and convenient to use

Use of CPs (number of charges)

Partners involved in this work:
Greenabout, Verbund, Smatrics, Iberdrola
Economic challenges
Make electromobility affordable

As the first EVs have appeared on the market, it becomes apparent that not only the costs of the car, but also the investments in the required infrastructure hinder a quicker upswing of electromobility. A major result of the Green eMotion project: While economies of scale must substantially lower the price of batteries in the coming years, public charging as a sole business case can only be profitable within such mid-term business scenarios if there are highly frequented charging stations. However, a combination with other services in places of high interest will improve the business case.

Costs for grid integration of charging infrastructure can be significantly reduced by intelligent ways of controlling the charging time and power. Smart EV management can also optimise the integration of intermittent renewable output such as solar and wind by aggregating and controlling the power demand for so-called load areas.
How will the mass EV roll-out affect the EU electricity system?
A comprehensive system and grid reinforcement perspective

The task of this work group was to identify possible issues with the large-scale deployment of electric vehicles in the EU. Wherever issues were detected, solutions had to be developed to overcome them. And, finally, a list of actions was developed for various stakeholders.

Green eMotion set out to quantify the impact of EV roll-out on the cost of system operation and necessary investment into generation, transmission and distribution infrastructure, as well as on carbon emissions. A major result was the evidence that different approaches to EV charging control have an impact on both costs and emissions. For the analysis, the ITRES software was developed, a tool to quantify the impact of EV uptake on reinforcements, in particular LV distribution networks. The software is publicly available. Key results were a possible cost reduction of more than 50 percent per EV by using smart charging technologies, while at the same time significantly reducing the carbon impact of supplying EV demand.

Conclusions & recommendations:
- Significant value of smart EV charging for system cost savings and emission reductions
- Smart charging avoids substantial investment into grid reinforcement
- There is a need for commercial arrangements that deliver adequate revenues to flexible EV owners
- Network planning tools need enhancing to capture the specific features of EV charging demand

![Graphs and charts showing the impact of EV charging on system costs and emissions.](image)

Electricity cost per EV

CO₂ emissions per EV

Cumulative LV network reinforcement cost

Partners involved in this work:
Imperial College, DEA, RWE, Iberdrola, Enel, EDF, Siemens
Grid evolution – a DSO’s perspective

The recharging infrastructure is the interface between power grid and EVs. Green eMotion analysed typical recharging infrastructures and identified trends towards a more standardised solution, with fixed costs for infrastructure deployment relatively constant due to costs for civil works and permissions etc.

The DSO’s (Distribution System Operator) perspective also included the grid-supporting opportunities of EVs through smart charging, RES integration or local storage, as well as assessing reduced grid reinforcement costs thanks to smart charging. On the other hand, harmonic emissions were found to be increasing with charging power modulated (e.g. for smart charging). However, harmonics caused by EV inverters do not provoke network expansion measures in the short run, but constitute a problem for e.g. PLC communication.

Conclusions & recommendations:

- Risk of sunk investments for recharging infrastructure reduced due to more harmonised technical requirements
- OEMs are requested to consider harmonic emissions for inverter design
- Appropriate regulatory framework and further development of standards (e.g. EN 61851-1) are key to exploiting EV’s grid-supporting opportunities

Recharging infrastructure

- Status quo of charging infrastructure in Europe
- Definition of common requirements
- Cost assessment of charging infrastructure

Impact of EVs on the distribution grid

- Grid-relevant parameters of EVs
- Technical and economical effects on distribution grids
- What are the effects of EVs on harmonic distortions?
- Impact on power quality in general
- Analysis of existing grids using ITRES planning tool

Grid-supporting opportunities

- Status quo capabilities of EVs
- Current utility demands
- Charging management strategies
- Evaluation of business opportunities using EVs
- Charge management and harmonic distortions

Results and recommendations for integrating EV in European networks. The DSO point of view

- Common findings, hurdles and prerequisites
- Best practices
- Conclusions and recommendations

Partners involved in this work:
Imperial College, DEA, RWE, Iberdrola, Enel, EDF, Endesa, Tecnalia
The Soft Open Point (SOP) is a prototype device provided to ESB by Alstom Grid as part of the Green eMotion project.

The SOP connects two adjacent feeders, typically with an existing normally open point, and controls the power flow between those feeders. During the project, numerous load test scenarios were employed, including fault scenarios. In addition, power quality, thermal imaging and noise measurements were conducted. The test showed SOP qualified for peak-load balancing and cost savings in low-voltage design.

Conclusions & recommendations:
- The SOP has the potential to balance load across adjacent feeders and control local system voltages. It has cost saving implications for utilities and represents a much more efficient use of the existing network.
- The impact on urban, suburban and rural networks to be analysed in future projects.
- Next version SOP to comply with all relevant power quality, thermal and noise standards.

Partners involved in this work:
Alstom, ESB
To achieve this, a realistic outdoor driving cycle for both city and highway conditions was developed as well as the appropriate technical process to obtain data from a driving vehicle in dynamometer tests. This driving cycle was used in different climate zones to validate EV characteristics in different temperatures etc. In addition, Green eMotion analysed the influence of driving behaviour on EV performance.

**Conclusions & recommendations:**
- Battery capacity reduction less than 10% after 60,000 km
- Heating and defrosting can reduce range by 25%
- Driver behaviour can reduce/increase range up to 50%

**Driving cycle test procedure**

*Partners involved in this work:*
FKA, DTI, TÜV Nord
Viable business models for EV charging infrastructure

EV users must be able to charge their EVs when needed; however, the profitability of publicly-accessible EV charging infrastructures is in doubt.

Green eMotion explored four charging location scenarios, looking two to three years ahead and identifying the required EVSE usage to compete against ICE vehicles. While traffic hotspot are close to profitability, it is more difficult to do business with highway charging. Public roadside charging is not profitable yet, whereas charging at private homes is the cheapest option with better TCO even today, but preferential use and subsidies for EV purchase are needed.

To help unprofitable models, additional revenue could be generated through advertising, or by including charging attached to shops or restaurants, especially with highway fast charging.

Conclusions & recommendations:
- Install EVSEs in highly-frequented public places
- Co-finance EVSEs through advertising, shop/restaurant combination, client attraction, etc.
- Integrate public EVSE deployment in general mobility plans by local governments

Required EVSE usage rate for the EVSE operator to offer competitive prices against diesel vehicles

Partners involved in this work:
Tecnalia, BMW, ECN, Enel, RWE, Siemens, IREC, TCD
A framework demonstration as a role model for replication

A major task of the Green eMotion project was to develop recommendations in a manual of sorts that would help to use project results as a solid foundation for future electromobility projects across the EU.

To this end, a short navigation guide was established to easily exploit Green eMotion’s technical/regulatory analysis heritage. It is based on a successful start-up of a local e-mobility initiative in Greece (with 15 AC charging stations) and its connection to the international framework. The results from the initiative also contributed to the roll-out of the tested prototypes designed in WP 3 in more EU regions.

Conclusions & recommendations:

- New demo regions can follow the steps indicated in the graph on the right to build up an e-mobility initiative
- EVSEs should be installed in a way to comply with EU Directive 94/2014
- A detailed deployment plan can only be designed within a stable regulatory framework, with clear responsibilities over charging station ownership and operation
- It is recommended to locate the chargers in both urban and suburban areas

**E-mobility deployment steps**

- Define the infrastructure location
- Select the type of charging unit and sockets
- Study the regulatory issues
- Consider the interoperability and standardisation
- Recharging infrastructure

**Partners involved in this work:**
PPC, Enel
More detailed information can be found on

http://www.greenemotion-project.eu/dissemination/deliverables.php
### The project partners of Green eMotion

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