European Commission

Smart Cities Marketplace

INTELLIGENT MOBILITY FOR ENERGY TRANSITION – FINAL REPORT

LESSONS LEARNED FROM THE 10 IMET FLAGSHIP PROJECTS

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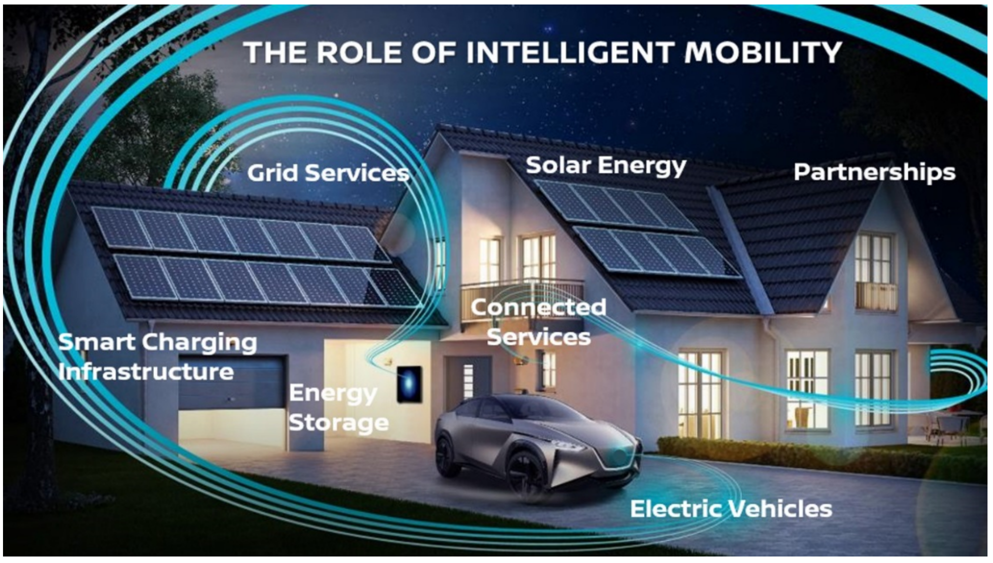
Introduction

The Intelligent Mobility for Energy Transition initiative (IMET)

The IMET initiative was born out of the recognition that today's transport and energy challenges require more holistic solutions and that by convening a network of mobility, energy and smart city stakeholders we could accelerate bringing to market some of the solutions to the energy transition.

Launched in 2017 IMET aimed to foster public-private partnerships that jointly developed intelligent mobility solutions, particularly solutions that enable the integration of electric vehicles (EVs) into the grid, stationary storage, smart charging and smart energy management systems. The image below captures what is meant by intelligent mobility and how these elements are integrated into the wider energy ecoystem.



Source: Nissan Europe

The initiative had two layers, national and pan-European:

- National: IMET recruited ambassadors across the continent who were focused on creating local innovation ecosystems to promote pilot projects including the ones captured in this report.
- Pan-European: Nissan Europe and Ubiwhere provided a pan-regional perspective to the group by coordinating the ambassadors, promoting the initative, seeking endorsers and engaging with influential networks including Polis Network, Eurelectric and AVERE.

The initiave has been supported by the European Smart Cities Marketplace[1], which has given IMET members the opportunity to strengthen links with local, national and European authorities, contributing to increased alignment between policies and market needs.

Purpose of this report

This report builds on the cross-industry white paper IMET published in 2019, "*Accelerating the Energy Transition*".[2] This was a guide for European policymakers on the frameworks that would be needed to realise the EU's ambition for carbon neutrality by 2050.

While the white paper's recommendations still stand today this reports takes a deeper look at the pilot projects run by IMET members and provides an evaluation of the key learnings which we urge policymakers to consider in order to accelerate the deployment of rolling out these solutions across Europe.

IMET members have achieved in accelerating the time to market for certain emerging energy and mobility technologies. Thanks to cross-sector and public-private collaboration in a series of pilot projects the marketability of these innovative solutions has been proven. These projects have also provided a unique opportunity to refine interoperability between the technologies to maximise their collective benefit.

As the deployment of new technologies ramps up it is important to reflect on the key learnings from these pilot projects. Doing so will not only support the defintion of future projects but also provide further guidance to stakeholders on how to prepare society for greater market uptake.

[1] https://eu-smartcities.eu/

[2] IMET white paper, *Accelerating the Energy Transition*, 2019, https://eu-smartcities.eu/sites/eu-smartcities.eu/files/2019-11/IMET%20White%20Paper%20FINAL%281%29.pdf

The 10 IMET Flagship Projects

Introduction

The 10 flagship projects have been selected to provide a comprehensive showcase of impactful case studies demonstrating how intelligent mobility solutions are interacting with energy systems, what benefits they are providing for citizens and the business models behind them. These projects present a clear case for policymakers and regulators and underpin the recommendations of IMET's white paper, *"Accelerating the Energy Transition".*

The projects are classified under three different groups according to their focus area: development of core technology (eg. vehicle-to-grid (V2G) systems); enabling tools (eg. mobile apps), and; market uptake strategies (commercial offers). Each of these workstreams are essential to integrate and optimise solutions in the market.

Development of core technology:

1. *Growsmarter* – V2X demonstrator in an offices building in Spain.
2. *SEEV4City* – V2X demonstrator in an EV charging garage in Norway.
3. *CleanMobilEnergy* – development and testing of Intelligent Energy Management System (iEMS) in the Netherlands.
4. *i-rEzEPT* – V2G pilot at the district level in Germany.
5. *Mobility Areas* – multimodality hubs supporting shared e-mobility in Italy.
6. *INSULAE* – innovative energy demonstrators in Madeira (Portugal) on grid frequency and voltage regulation, and Bornholm (Denmark) on DC grids with interconnected V2G chargers.

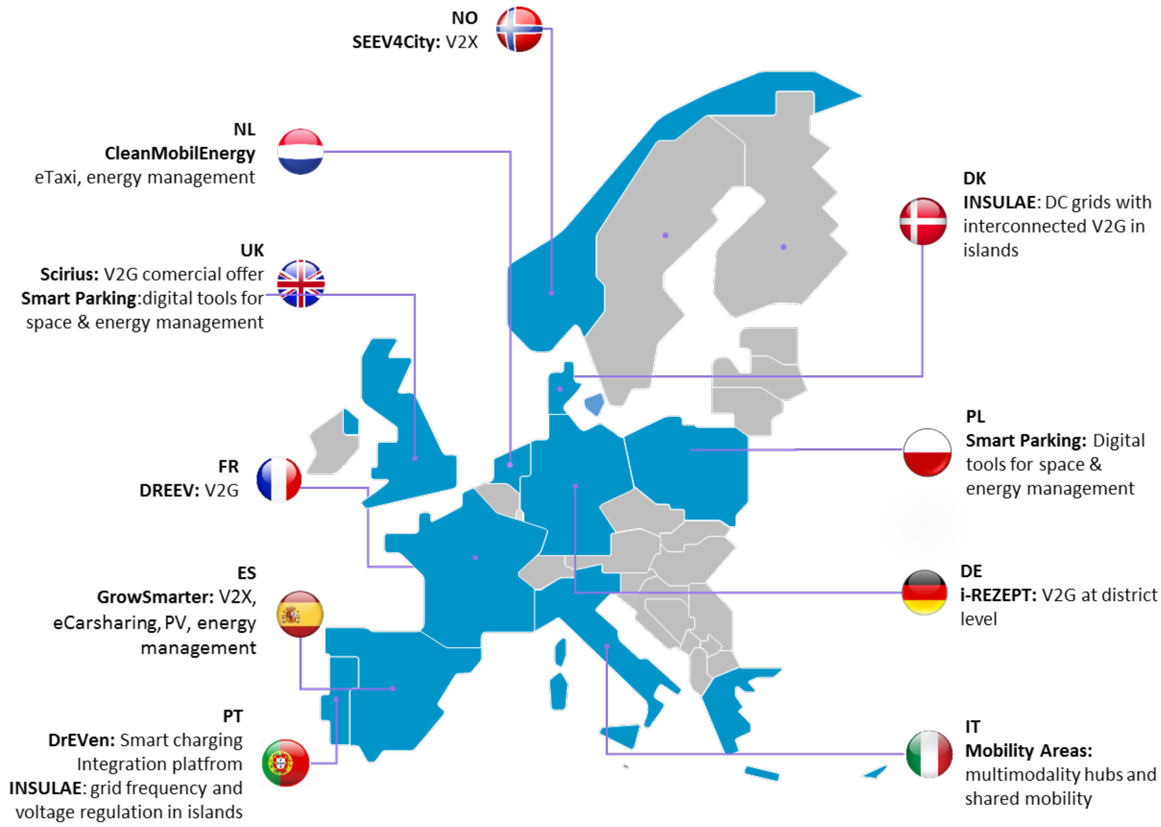
Enabling tools:

7. *Smart parking* solutions in Poland and the UK.
8. *drEVen* – smart charging application development and testing in Portugal.

Market uptake strategies:

9. *Scririus* - V2G pilot in the UK, world's largest residential trial.
10. *DREEV V2G* – V2G trials in France.

Geographically spread across Europe the projects provide rich insights into the diversity of the regulatory environments they operate in.



Source: IMET initiative

Overview of the projects

The following section presents the scope, results and potential scale up or replication of each project. The information has mainly been acquired from interviews with the project partners which have been published on the Smart Cities Marketplace website.[3]

Development of core technology

1. Growsmarter

	Period	Total budget	Public Funds	Coordinator	Website
Growsmarter	2015-2019	29M€	25M€ EU	Stockholm City Council	Click here

[3] https://eu-smartcities.eu/initiatives/839/description

Barcelona demo	2018-2019	1M€	0.7M€ EU	Barcelona City Council	Click here

Scope: GrowSmarter is a smart cities lighthouse project in which Barcelona, Stockholm and Cologne showcased a number of smart solutions to support growth and sustainability in Europe. The IMET demonstrator was established at Nissan's headquarters in Barcelona and sought to explore the potential of V2X (Vehicle-to-Everything).

Details: In partnership with Barcelona City Council and IREC (Catalan Research Centre for Energy), Nissan tested the integration of EVs, buildings and local energy generation in Barcelona through the combination of:

- Two V2G chargers of 10KVA installed at the parking facilities of Nissan's headquarters
- Photovoltaic panels of 11kWp covering the roof of the building
- Three second life batteries of 3.6kW power and 4.2kWh capacity
- An e-carsharing service offering Nissan LEAF (40kWh) to employees who would be using the V2G chargers

This was controlled by an advanced Energy Management System and a SCADA (Supervisory Control and Data Acquisition) system to optimise the energy consumption features.

Key results: The demonstrator proved how EVs are able to offer services other than just mobility by taking advantage of what the vehicle can do while parked. Thanks to this integrated solution the Nissan headquarters reduced energy consumption by 13%, saved 16% of energy costs and cut CO_2 emissions by 17.6%.[4]

Results showed that V2G chargers using the right Energy Management System decrease total energy costs in a magnitude larger than any smart charging application.

[4] GrowSmarter „Final results of technical and social validation" https://grow-smarter.eu/fileadmin/editor-upload/Reports/GrowSmarter_Validation.pdf

Upscaling and replication potential: GrowSmarter results should be the basis for deploying closer to market pilots across Europe aiming to continue improving V2X solutions. This is needed to fill the gaps between the current state of the technology and the real market needs. Following this path the full potential of V2X could be achieved, maximising the advantages of energy storage and energy efficiency.

In this sense, the three main challenges encountered in Growsmarter were the lack of grid codes which made the grid interconnection and certification process slow and costly; the non-favourable energy tariffs which unabled a sustainable business model, and; the lack of consumer awareness.

2. SEEV4CITY

	Period	Total budget	Public Funds	Coordinator	Website
SEEV4City	2014-2020	7M€	6M€ EU	Amsterdam University of Applied Sciences	Click here
Oslo demo	2016-2020	Not available	Not available	Oslo City Council	Click here

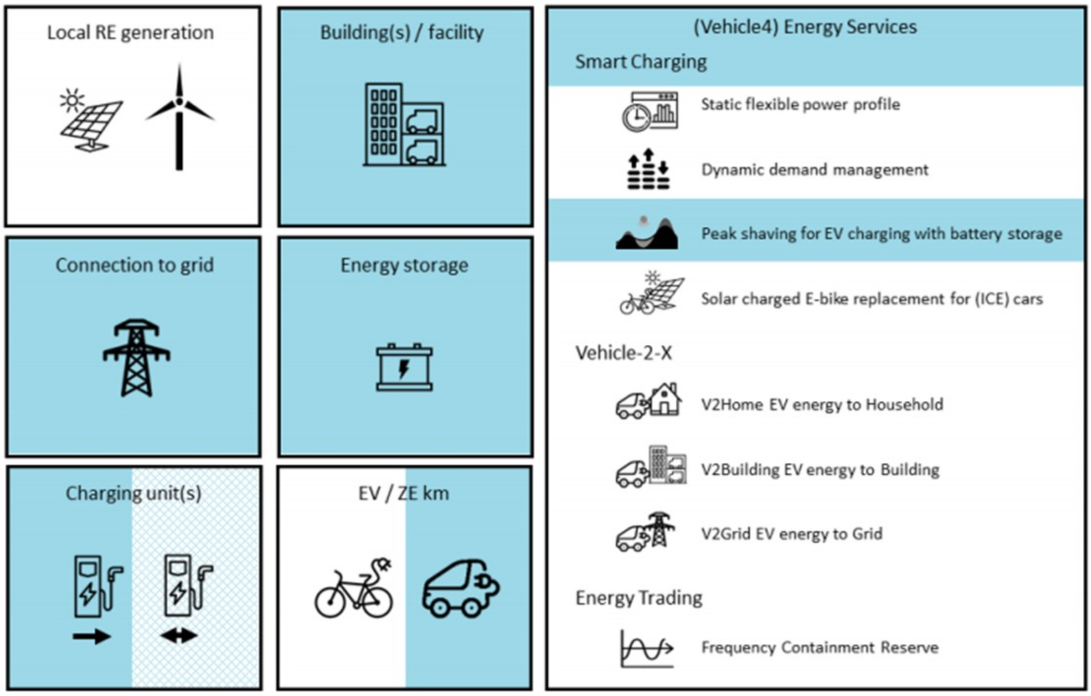
Scope: The SEEV4City project operated six innovative pilots combining electric transport, smart charging, renewable energy, enegy storage, smart grids, V2G and energy management systems. The objective was to introduce the concept of **"Vehicle for Energy Services" (V4ES)** into sustainable business models. The IMET pilot in Oslo aimed to demonstrate the benefits of EVs smart control and the associated energy services to reduce carbon footprint and alleviate stress on the local grid.

Details: The demonstrator in Oslo was installed at Vulkan, one of the largest and most advanced EV charging garages in Europe. With over 100 EV chargers, quick chargers and additional battery storage for smart charging, Vulkan serves both residents and companies. During the day, Vulkan hosts professional EV users (eg. e-taxis, e-freight). At night, Vulkan offers free residential parking. It combines overnight slow charging with (semi-)quick charging during the day becoming a flexible and cost-efficient site to promote EVs.

The pilot integrated EV charging infrastructure, stationary storage, electric transport and smart parking, through several building blocks:

- The local voltage network distributing the energy to the charging stations
- The vehicles using the charging stations to charge their batteries
- Battery energy storage system

- 100 AC sockets semi-fast wall box charging points with smart charging capability (22kW)
- 2x (4 sockets) and DC fast charging (50kW) with ChaDeMo and CCS



Key results: All SEEV4City pilots succeded in reducing energy bills through smart charging, self-consumption, smart energy management or energy arbitrage. They also increased consumer acceptance of innovative EV technology.

The pilot in Oslo saved 912 tons of CO2 emissions per year, exceeding expectations. Now the site at Vulkan serves more than 400 EVs per day and new EV professional users have started their operation from the site providing very positive feedback. The turnover in terms of kWh per week has tripled since the opening in February 2017. The smart grid system at the site, shaves 13% electricity consumption during peak hours.[5] This reduction in peak demand reflects the deferral in grid reinforcement as the required grid capacity is proportional to the peak demand.

Upscaling and replication potential: The success of V4ES depends on battery cost and on being able to accurately quantify their impact on battery life. Battery degradation depends on several factors, including the chemistry of the battery, production and conditions of use. Thus, it is difficult to quantify and current estimates can vary significantly. Accurate

[5] SEEV4City "Final report - Oslo Operational Pilot" https://www.seev4-city.eu/wp-content/uploads/2020/09/SEEV4-City-Oslo-Operational-Pilot_Final-Report.pdf

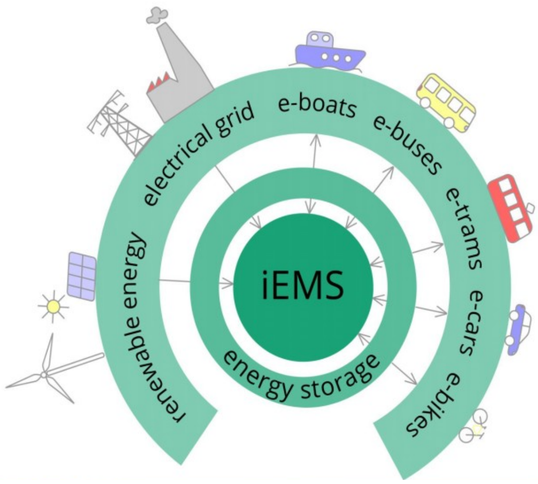
determination of battery ageing mechanisms and state-of-health will enable optimum charging and discharging control strategies without adversely impacting battery life and permit economical V4ES. This will also improve the residual value of EVs and reduce the total cost of ownership for EVs. The key to increasing the confidence of EV users to participate in V4ES is to have a dynamic model for battery state-of-health that can be used in real-time.

Today smart charging remains a more viable business model compared to V2X due to the lower cost of smart charging units and wider availability of compatible EVs. In addition, the existing grids are already able to accommodate this technology.

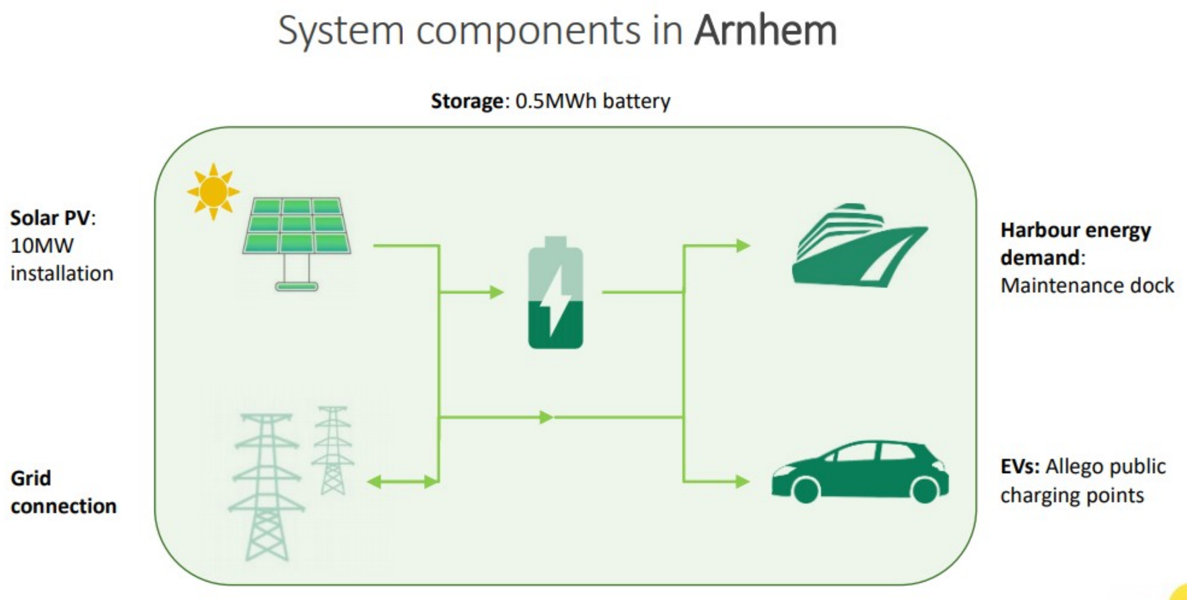
3. CleanMobilEnergy

	Period	Total budget	Public Funds	Coordinator	Website
CleanMobil Energy	2017-2021	7,2M€	4,3M€ EU	City of Arnhem	Click here
Arnhem demo	2016-2021	Not available	Not available	City of Arnhem	Click here

Scope: The CleanMobilEnergy project aims to provide a tool which can increase the amount of renewable energy produced and consumed at city district level without adding extra cables but rather relying on optimised consumption, storage and vehicles for energy services. That tool is a common **Intelligent Energy Management System (iEMS)** that has been developed and is being used at four pilot sites: Arnhem, Notthingham, London and Schwäbisch Gmünd. These pilots range from small towns to large cities and cover different types of renewable energy, storage and EVs in diverse contexts. The IMET pilot in Arnhem showed the complexity of the regulatory environment due to the distribution of connected devices of the electricity grid.



Details: In **Arnhem**, a solar field of 10MW supplies energy to local cars and ships through 160 EV charging stations in the city and an energy intensive shipyard nearby the solar field. The system is supported by a large storage device of 0.5MWh.



The iEMS manages the system by:

1. Forecasting: the iEMS estimates the optimal power flow and uses the storage to prepare for upcoming spikes in supply or demand. The main forecasting areas are: solar generation, grid congestion, initial state of battery charge, optimal power flows, harbour demand and EV charging demand.
2. Monitoring: the iEMS collects data to adjust the storage power flows to ensure optimal distribution of energy and efficient usage of the battery. The main monitoring areas are: real-time solar generation, grid flows, state of battery charge, battery charging and discharging, and energy consumption.
3. Intervention is needed when there is a mismatch in forecasted and actual supply and demand or when grid power quality is at risk. The main interventions are: reducing output, deeper battery charge, shift energy demand.

Key results: One generic transnational iEMS is adapted to the four pilots. Over 2021 the iEMS will be improved combining renewable energy sources (RES), e-mobility, flexible consumption and storage at the neighbourhood level.

The iEMS increases the economic value of renewable energy and reduces CO2 emissions. It makes it possible for RES to be used locally so EVs can be charged with 100% clean energy offered at an optimal price. However, as the business case is very much dependent on policy, at Arnhem, it is not yet clear if there is an economic benefit to buy the electricity from the nearby solar park.

Upscaling and replication potential: Open data is crucial in unlocking the full upscaling and replication potential of this solution. It is needed to ensure a proper integration of multiple devices while ensuring the interoperability of the solution.

The business model is highly dependent on the location of the pilot and the existing local policies. A more supportive policy framework combined with fairer prices for energy is critical to enable a sustainable business model.

4. i-rEzEPT

Period	Total budget	Public Funds	Coordinator	Website
2018-2021	3,8M€	2,4M€ Germany	Nissan	Click here

Scope: The aim of i-rEzEPT is to show use cases of how EVs with **V2X technology (V2H, V2B & V2G)** can improve the use of renewable energies while also reducing total cost of ownerships for EV owners. In the project, EVs are used to:

- Participate in the frequency containment reserve market;
- Maximise the self-sufficiency of fleets and individual households, and;
- Move forward the sector coupling between mobility, electricity and heat through the development of innovative business models. These will cut the cost disadvantage of EV compared to conventional vehicles.

Details: Nissan leads a consortium involving Bosch Software Innovations GmbH, and the Fraunhofer Institutes for Industrial Engineering (IAO) and for Manufacturing Technology and Advanced Materials (IFAM). The consortium installed 15 charging stations to feed a commercial fleet. In addition, 13 chargers were installed in as many households and 13 Nissan LEAFs provided to those households.

Households require a solar system and a local energy management controller developed to monitor the households' energy consumption. This functions as follows: whenever the need for self-consumption is high, the controller decides to feed electricity from the vehicle to the house. Alternately, when demand and prices for energy are high, the controller opts to market the vehicle's energy via the frequency containment reserve market. The controller can also predict when a consumer will arrive and connect their EV to the charging station. This is essential in order to make the right decisions about when the vehicle should feed the grid.

Key results: The project is now in the monitoring phase. In the short-term i-rEzEPT should demonstrate the high flexibility of the system, which is a key success factor to the use case. This will remove consumer concern about the capacity of the system to adapt to situations including the need to spontaneously use the vehicle or to driver a longer route than expected.

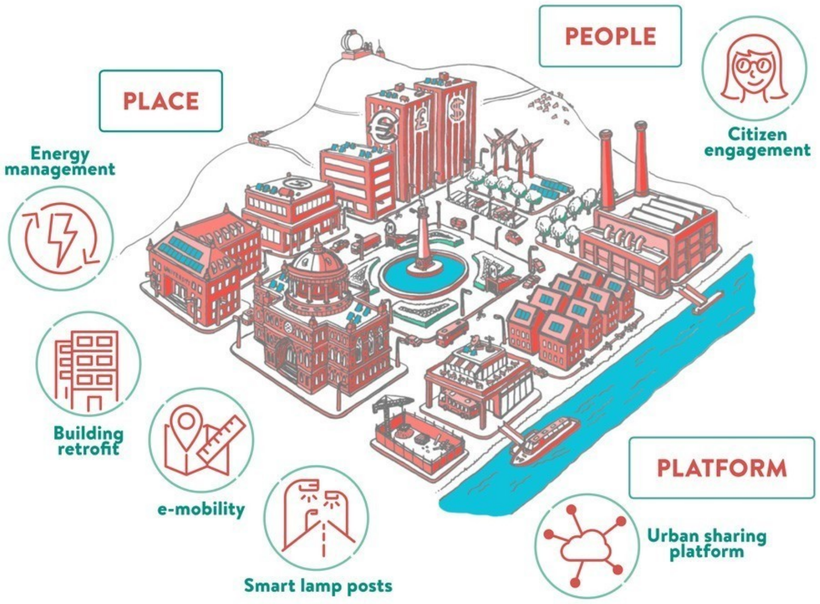
In the long-term the project should prove the business case of V2X by enabling consumers to self-consume, store and sell energy generated by local renewable energy, reducing investment and operating costs of EVs and charging stations.

Upscaling and replication potential: i-rEzEPT attracted more interest than expected with many households participating in the raffle to join the trial. The biggest challenge in the project is the legal restrictions of V2G services which do not allow consumers to feed the electricity back to the public grid.

5. Mobility Areas - Milan

	Period	Total budget	Public Funds	Coordinator	Website
Sharingcities	2016-2020	28M€	24,8M€ EU	Amsterdam Uni. of Applied Sciences	Click here
Milan demo (Mobility Areas)	2016-2020	Not available	Not available	Milan City Council	Click here

Scope: Mobility Areas is a pilot within the smart cities lighthouse project *Sharing Cities*. *Sharing Cities* has tested and validated innovative solutions in London, Lisbon and Milan. The consortium is now working towards market scale-up and replication and has already engaged several cities across Europe.



Mobility Areas focus is on **shared e-mobility** services such as e-bike, e-vehicle and e-scooter sharing. They work as intermodal crossroads for urban mobility and gathers in the same area several innovative and digital services: EV charging, smart parking, car sharing, zero emission energy production, V2X and others.

Details: Milan's shared e-mobility measures in the *SharingCities* project include: 10 new EV charging stations with 60 charging points, 20 of which are fastchargers, 2 EVs for car-sharing, 11 EVs for e-logistics, 150 e-bikes and 175 smart parking places. Most of these measures have been implemented through Mobility Areas located in public spaces, at junction points with public transport and other shared mobility services.

Each Mobility Area is equipped with four 22kW AC plugs (type 2) and two 150kW DC plugs (Chademo and CCS), connected to the public network. In addition, the Mobility Area in Milan is powered by a 60kW photovoltaic (PV) power plant. The PV system can produce about 70MWh/year that will cover approximately 500,000 km/year of zero emissions mobility. The installation of a storage system interconnected with the PV power plant will be soon evaluated.

Energy flows within Mobility Areas are managed by an Energy Management System (EMS) that also provides power balancing among the different devices. The mobility services are managed by a digital platform that monitors and manages the usage of EV charging points.

Key results: The project is now in the monitoring phase. Expected outcomes must be considered over a longer term period as the aim is to transition to a shared and low carbon mobility, exploiting the synergies among the different services offered. This will foster the reduction of ownership and use of conventional vehicles with a consequent decrease in traffic and related air pollution. The benefits for e-carsharing operators in particular should result in the cost reduction of logistics which represent 70% of sharing services costs.

Upscaling and replication potential: To ensure its replicability, Mobility Areas are being standardised according to the "component-based approach". The measure is broken down in several basic components that can be assembled and tailored to suit specific contexts. The system will work on a Mobility as a Service (MaaS) basis: by integrating different income opportunities through the implementation of shared and digital mobility services, it ensures the use of charging stations and at the same time guarantees other revenues to support the return on investment.

6. INSULAE

	Period	Total budget	Public Funds	Coordinator	Website
INSULAE	2019-2023	12,2M€	10M€ EU	Fundación CIRCE	Click here
Bornholm demo	2020-2023	Not available	Not available	Bornholm Region	Click here
Madeira demo	2020-2023	Not available	Not available	EEM (Electricty utility Madeira)	Click here

Scope: INSULAE aims to contribute to the Clean Energy for EU Islands Initiative[6] by providing an **Investment Planning Tool (IPT)** able to create action plans for the islands to generate their own sustainable energy. A series of demonstrators are taking place at islands in Croatia, Denmark and Portugal. This will result in seven replicable use cases that will validate the IPTand then be applied in four follower Islands in Spain, Germany, Netherlands, and Greece. The chosen islands are complementary in many aspects: location, size, economic development, energy system, etc.

The two IMET demonstrators are:

- In Bornholm (Denmark): DC grids with interconnected V2G chargers
- In Madeira (Portugal): grid frequency and voltage regulation

Details: **Madeira**'s pilot focuses on smart charging. The demonstrator will be installed at the EEM (Electricity utility in Madeira) headquarters and combine four 10kW V2G chargers, two 50kW quick chargers and one fully silicon carbide 50kW fast charger together with a 100kW storage system. It will integrate new functionalities for frequency support and voltage regulation as well as an advanced distribution management system (ADMS) adapted to low voltage microgrids with real-time control functions.

The pilot in **Bornholm** is installed in a crowded area in the city centre. It aims to improve the performance of the distribution grid. The demonstrator will include 180kW PV panels connected through Direct Current (DC) bus to the EV chargers, as well as energy storage devices to provide further flexibility to the microgrid. DC grids can improve the efficiency of the network by over 30% in comparison to Alternating Current (AC) which is the most common mode. DC grids enable the minimisation of the grid connection cost and power losses and allows a higher share of renewable energy production in the grid, and the provision of auxiliary grid services through storage.

Key results: **In Maderia** the expectation is to generate 300MWh/year energy from renewable sources, therefore reducing emissions by 213 tons of CO2 per year. **In Bornholm** the expectation is to achieve a reduction of 5.509MWh/year of fossil fuels and 3.994 tons of CO2 per year.

Upscaling and replication potential: The level of experience a public authority has in these technologies can impact the success of the rollout. Bornholm benefitted from a greater amount of experience in the field and as such the regulation there was more flexible than in Madeira, where there was less capacity to exercise agility whtn it came to regulations.

The IPT is crucial to allow efficient replication. Characterisation vectors were developed forming the basis of a characterisation methodology that links a real island with a set of

[6] https://euislands.eu/

Reference Islands. The IPT will provide new islands with an assessment on their investment plans to support decarbonisation.

Enabling tools

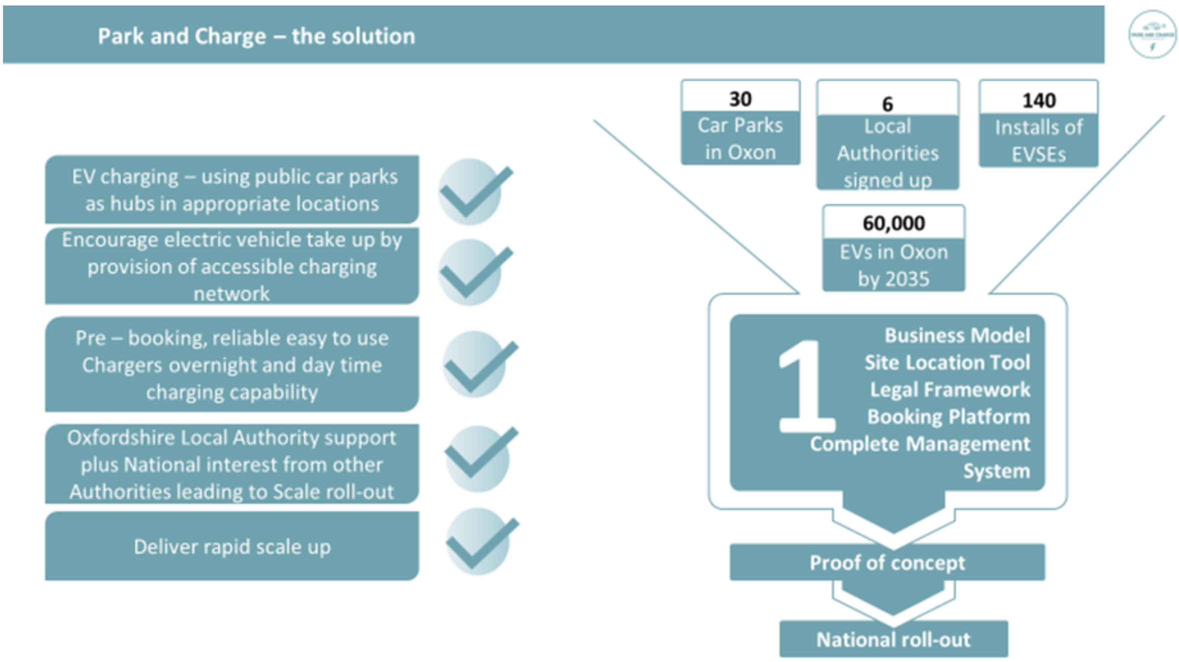
7. Smart parking solutions in UK & Poland

The following two initiatives develop complementary tools aiming to enable parking facilities to become intelligent mobility hubs.

7a. Park and Charge - UK

Period	Total budget	Public Funds	Coordinator	Website
2019-2021	£6.5m	£5.2m UK	Zeta Lighting	Click here

Scope: Park and Charge provides an **EV charging solution** for the 40% of drivers who are unable to charge their EV at home due to the lack of a private parking space. The solution provides easy to use, state of the art chargers within 5 minutes walk of home, by utilising **nearby car parks** operated by the local authorities in Oxfordshire.



The scope of the project is to provide 280 EV charging bays (140 EV chargers with twin type 2 connectors) in hubs of up to 6 chargers with 2 bays per charger.

Details: The Park and Charge consortium involves Zeta Lighting, Urban Integrated, Oxfordshire County Council, and the University of Oxford. The key features of their demonstrator include:

- Rapid 22kWh EV Chargers,
- Easy to use app to locate, use and pay for charging with charger reservation,
- Advanced operations platform & dashboard open to any Charge Point Operator (CPO) providing overview of charging estate including enhanced service management and optimisation,
- Others: parking pay management, subscription models and roaming support.

The pilot will be the basis to build a business model hinged on two revenue streams:

- Regular overnight users will use a subscription based model and will enjoy premium features such as charger reservation and the lowest cost per kWh.
- Visitors will pay a higher price per kWh. They will be encouraged to become subscribers with incentives such as reduced fees for initial use.

The creation of a significant regular user basis provides opportunities for demand shaping and revenue maximisation. Another key component of the business model is the concession arrangement with the car park operators which needs to reflect the investment balance between the car park owner or operator and Park and Charge.

Key results: Due to delays created by the COVID-19 pandemic the project will now finish in 2022. So far, Park and Charge has developed an important scale-up tool: the EV Investment Calculator (EVIC). EVIC determines the return on investment for specific car parks and generates an investment case. The evidence shows strong RoI over five years for many suitable sites.

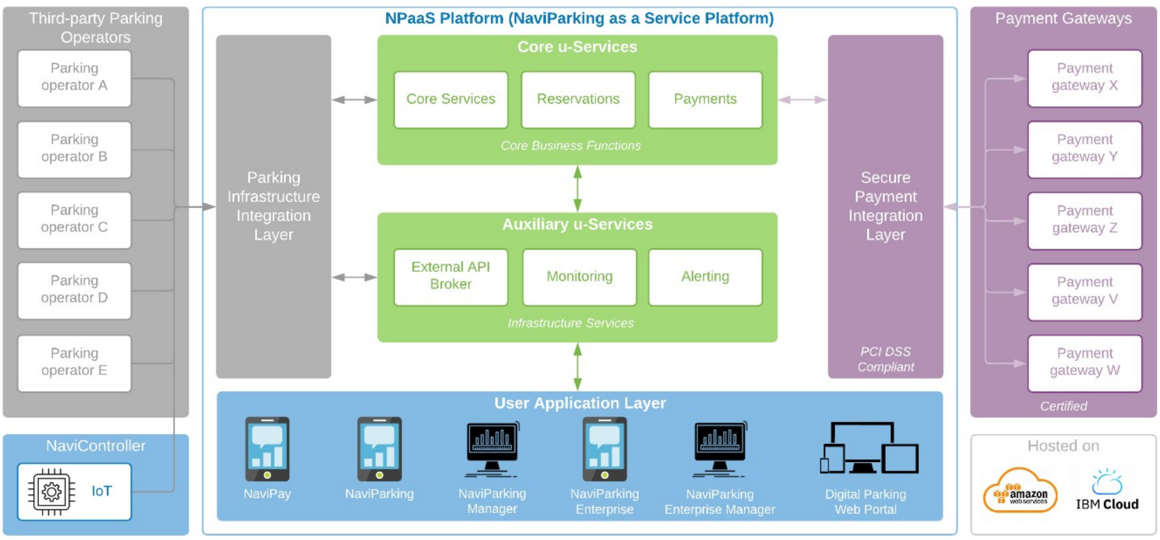
Upscaling and replication potential: The development of a commercially sustainable business model will support the rapid scale up of the solution. Developed initially for Oxfordshire the tool is being developed for the whole of the UK by the first quarter of 2021 followed by an adaptation for the German market.

7b. – NaviParking platform - Poland

Period	Total budget	Public Funds	Coordinator	Website
2019-2021	0.5M€	0	NaviParking	Click here

Scope: This project aims to transform existing off-street parking facilities into e-mobility hubs. The project developed an interoperable, vendor-independent e-mobility platform, opening access to EV chargers located at private off-street parking facilities. The app connects users to these digitalised parking spaces interlinked with other clean transport networks.

Details: The Naviparking platform is based on open Application Programming Interfaces (APIs). It acts as a MaaS provider by integrating data from diverse sources, including parking facilities, e-mobility partners, mobility services providers, etc. An IoT Access Controller is installed in the parking barrier to operate and open every closed and suboptimally used car parking space.



The modular framework decouples parking access from EV charging technology, allowing the standardisation of parking services. The platform can be tailored through different building blocks:

- Infrastructure and energy planning including distributed energy sources
- EV charging stations
- Smart charging accounts for private and fleets charging maintenance
- Parking capacity information for citizens, reducing parking searching.

Key results: The app supports creating sufficient spaces without unnecessary investments by opening access to existing areas. It enables new business models:

- Seamless integration with any third-party parking infrastructure or EV charger provider, regardless of the specific operators or country payment integrators;
- More accessible and affordable EV charging infrastructure, and;
- Reduction of operational costs of private/public facilities.

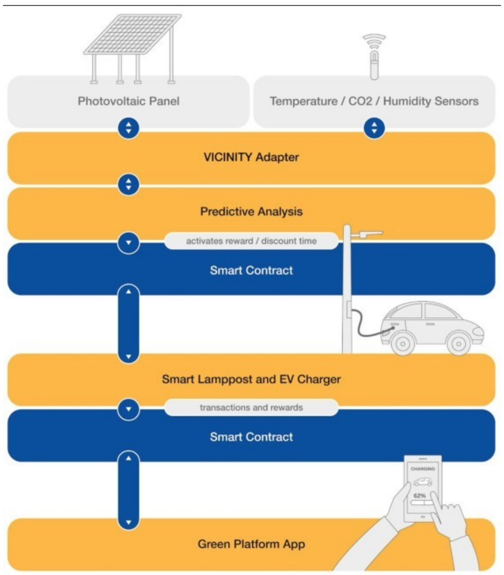
Upscaling and replication potential: The platform enables the connection of a variety of chargers, suppliers, devices or operators via standardised API. In addition, a unified user interface will make it easier to access to park and charge across EU cities.
However, there are challenges from a legal perspective on the selling and invoicing for charging services. Most of the legislation refers to public EV chargers and not to private ones, which hinders the time to market for this solution.

8. drEVen

Period	Total budget	Public Funds	Coordinator	Website
2019	0,1M€	0,06M€ EU	Ubiwhere	Click here

Scope: drEVen aimed to create an intelligent system to encourage shifting casual EV charging energy consumption to periods of higher energy production. For that purpose, the drEVen project used data from VICINITY's platform - an open virtual neighbourhood network connecting IoT infrastructures and smart objects – to determine the best timing for EV charging based on photovoltaic energy production and storage capacity as well as market conditions.

Details: Advanced EV charging solutions from Magnum Cap (project partner) were integrated into smart lampposts at Enercountim's Solar Lab facilities in Alcoutim, Portugal. The data collected from IoT sensors, integrated into VICINITY's platform, designated the best timing for EV charging based on production and storage capacity and market conditions. The mobile app notified drivers with the best timings for charging and enabled payments through an integrated cryptocurrency wallet. The settlement and billing solutions were powered by an open and public blockchain and dedicated smart contracts. These smart contracts are the key component enabling trustless transactions between any unknown supplier of energy and charging station and the EV owner. The energy tariff is transparently stored on-chain ensuring nothing can tamper with the monetary transactions.



Key results: drEVen proved its impact in promoting and rewarding sustainable behaviours hence maximising the use of renewable energy sources.

The app is a good basis for the decentralisation of the EV charging ecosystem as it is integrated with the Open Charge Point (OCPP) protocol and uses open blockchains. Energy providers can double-up as charging operator, fostering a new decentralised circular economy. As a result, it unlocks a new revenue stream for these players, motivating EV drivers to manage their energy consumption more efficiently, and enabling energy providers to balance the grid more effectively.

Upscaling and replication potential: While the solution proved to work as intended, the adoption of public blockchain technology for direct payments might be more challenging to be accepted by the industry given the existing regulation. In addition, in order to enable an efficient scaling up of the solution, communities need to have access to a decentralised network of highly-available EV charging stations.

Market uptake strategies

9. Scirius

Period	Total budget	Public Funds	Coordinator	Website
2018-2020	5M£	3,1M£ UK	Ovo Energy	Click here

Scope: The Scirius project seeks to demonstrate that V2G technology works at the residential level, proving the business case for residential customers and the value of V2G to vehicle manufacturers.

Details: OVO Energy has installed over 320 bi-directional EV chargers manufactured in the UK by Indra Renewable Technologies. This is the largest **residential V2G** trial in the world. Participants who own or lease a Nissan LEAF take part in this grid balancing platform developed to provide electrical support to grid operators during peak energy demand times. OVO is exploring and testing commercial propositions to identify a viable long-term business model. Consumer behaviour and receptiveness is being measured to provide insights into EV owners' attitudes and their response to V2G products and services.

Key results: With OVO's V2G tariff, EV drivers saved over £800/year on their bills, allowing them to drive effectively for free. The trial has shown V2G can enable intelligent charging of EVs so that energy is being used at cheaper and greener times, and allows owners to sell surplus energy back to the grid, effectively turning households into mini green power stations.

In terms of customer insights, a significantly higher level of engagement has been found in V2G than under other forms of EV charging. Most customers plug in every day, as opposed to twice per week. They plug in for longer periods because they understand the value of doing so and they engage with the technology significantly more than in standard EV charging or smart charging.

The project is also highlighting the importance of V2G for the stability of a grid powered by renewables. In early November 2020 OVO's V2G customers responded to a call to plug in to support the grid during a forecast electricity supply crunch caused by low wind speeds. Over 150 vehicles responded and contributed to avoiding a power shortage.

Upscaling and replication potential: Many of the barriers to scaling up V2G technology have been broken down through the Scirius project. It was possible to manufacture V2G units at scale and install a large number in customer homes.

The rolling out of the technology on a commercial basis is heavily influenced by policy and technology standards. There is a dependency on the availability of V2G capable vehicles. Currently only a handful of vehicles are V2G capable and the dominat charging standard in Europe (CCS) is still in the process of enabling V2G. There is a niche market today for users who wish to maximise the benefit from their solar panels or flexible tariff.

10. DREEV V2G trials

Period	Total budget	Public Funds	Coordinator	Website
2017 - ongoing	Not available	Not available	DREEV	Click here

Scope: DREEV develops software technology for V2G and aims to pave the road to developing the V2G market. It builds strong commercial and industrial relations with the ecosystem, especially with vehicle and charging station manufacturers.

Description of the demonstrator: DREEV offers smart management of vehicles on the basis of network signals. DREEV has run a year of trials in France and the UK in collaboration with Izivia, the French EDF charging point operator, ABB and Nissan. The consortium recieved support from the Occitanie region that is subsiding V2G charging stations and their installation with up to 100 units. With an 11kW V2G charging station, they expect to reach 1MW and aim to participate in the primary reserve in 2021 with their first mini Virtual Power Plant (VPP).

Key results: Trials are ongoing but they are expected to prove V2G potential to generate up to 20€/EV/month. V2G thereby reduces the total cost of ownership and further boosts the adoption of EVs. Bi-directional chargers also help smooth the flow of uneven generation of electricity from renewable sources such as solar and wind.

Upscaling and replication potential: More V2G bi-directional chargers will be installed in France, followed by installations in the UK, Italy, Belgium and Germany. Few EVs currently support V2G but it is expected to become a dominant technology within the next five years. A modular approach will bring the entire ecosystem together but standardisation and open architecture are critical enablers to unlock the full replicability potential.

Proven benefits of the technologies

All of the IMET projects focus on the interaction of EVs with the surrounding infrastructure; the energy system in particular. They all represent a transformation in the way vehicles are integrated into society and how they are powered.

Those IMET projects focusing on the development of core technology have succeeded to prove the capacity of the solutions **to reduce energy consumption and increase the use or integration of renewable energy sources, thus cutting CO2 emissions and energy costs** of the systems under study.

The pilots developing the enabling tools have evidenced the impact in **promoting sustainable behaviours.** The applications developed open the door to seamless integration with any infrastructure or service provider regardless of the specific stakeholder or context. Based on open standards and interoperability, they contribute to the decentralisation of the energy ecosystem by **empowering the consumer**.

The third group of projects focusing on market uptake strategies have succeeded **to prove a sustainable business model** for intelligent mobility solutions, mainly benefiting consumers and energy providers.

These positive results evidence the revolutionary potential of intelligent mobility solutions both to enable the full electrification of mobility and to accelerate clean energy transition.

Lessons learnt and recommendations

Each project has been analysed against the following criteria:

- Contribution to IMET objectives in accelerating the electrification of mobility, particularly passenger vehicles and the decentralisation of the energy system.
- Challenges faced, in the different market conditions and in different policy and regulatory frameworks.
- Scale up and replicability, the potential to ramp up the solution and the blockers it faces in doing so.

Invariably, due to the diversity of the projects in terms of area of focus and different geographical contexts the findings shine a light on a range of challenges that exist in both the design and operating environment of intelligent mobility solutions. The following section aims to consider in turn the key lessons learnt and present recommendations for policymakers and regulators that would reduce the obstacles to achieve wider rollout and scale of these solutions.

Technology

Due to its **low maturity** there is a **lack of availability** of the technology in the market. That narrows choice of suppliers, constrains procurement and hinders rollout. Related devices in the market are expensive which has a significant negative impact on business models. This was one of the major challenges faced by the ***Scirius*** project: V2G chargers were too expensive. This barrier was overcome by manufacturing the chargers at a reasonable scale.

Compatibility of ancilliary devices was another important challenge in the ***Scirius*** project. As V2G is a holistic service there are many interconnecting parts: the vehicle, the charging station, the grid, and the energy management software tools. Furthermore, currently most EV models do not have V2G capability and only one charging standard, CHAdeMO, currently supports this.

Standardisation and **open architecture** is essential to solve the compatibility issue and enable the roll out of the technology on a commercial basis, as found by projects such as ***Park & Charge UK***, ***Scirius*** and ***DREEV V2G***.

Recommendation

- EV uptake should be further encouraged to bring down the cost of the related technology and stimulate energy storage at end-user level.
- Public financial support schemes should be established to help scale up the solutions in the short term. Pushing the volume up short-term will trigger further investment from manufacturers and drive cost reductions in the mid-term thanks to economies of scale.
- Public authotities should encourage the installation of energy storage, renewables and V2G infrastructure in new building and housing developments by running targeted bids.
- Smart metering and cross-border interoperable charging infrastructure is essential:
  - Smart metering will ensure interoperability procedures, data models and communication interfaces.
  - Standards must be extended to encompass vehicle integration with smart grid and home energy management systems.
  - The benefits of V2G should be recognised in network planning standards.

- Type approval for V2G chargers should be established to accelerate their roll-out onto the market.
- The development of standards should be coordinated at EU level; the European Commission should oversee the development processes, closely collaborating with manufacturers and other relevant sector stakeholders.

Configuration and certification

Projects need to be **tailor-made** as every context presents different challenges and needs. Intelligent mobility solutions are complex and there is no one-size fits all system, this is a very important aspect to consider to enhance the scalability and replicability potential. Again, standardisation is needed to pave the path of innovation.

As in the ***Mobility Areas*** in Milan, solutions need to be based on a **flexible approach** so that they can be adapted to the context depending on several variables including; regulation, smart city strategy, community needs, climate and geography, infrastructure etc. To scale up and replicate solutions they need to be standardised according to a "component-based approach" (as done with the Mobility Areas) breaking down the measure in several basic technical components that can be assembled in different ways and tailored to suit specific city contexts, and different business models to exploit the solution's full scalability potential.

In the ***smart parking*** projects in Poland and UK, the approach was also to design and implement a flexible modular platform that can be easily expanded by pluggable building blocks, standardising services such as Park & Charge, Park & eRide and Park & eTaxi.

It is also worth noting the complexity provided by the many **different data sources** that need to be handled. The systems proposed in pilots need to merge different data collection systems including, not only the newly installed sources but also pre-existing facilities such as solar panels or the grid itself. In ***GrowSmarter***, for instance, one of the main outcomes of the project was the advanced Energy Management tool combined with a SCADA (Supervisory Control and Data Acquisition) system developed to holistacally optimise the energy consumption features of the demonstrator building.

Data security and privacy adds additional layers of complexity to some solutions and requires additional expertise on data security and privacy from both the technical and regulatory level. This is something that the ***Naviparking*** and ***drEVen*** projects tackled specifically.

In addition, the **market characteristics** will also contribute to shape the solution. The requirements from the different stakeholders may differ in every market. For instance, Distribution Network Operators in every country may work with different rules on installation and operation behind the meter as experienced in cross-national projects such as ***SEEV4City*** or ***CleanMobilEnergy***.

Given the described complexity, the **support of national and local authorities** and their collaboration with the industry and research centres is important to be secured at the planning phase. As an example, the ***Mobility Areas*** project had valuable support from the Municipality of Milan. The City Council has a "Smart City" department with a clear and long-term strategy for urban transformation, and this should be the commitment of every local entity. They worked in tandem with the project consortium during the design phase of the Mobility Areas. This ensured that the infrastructure would meet the local regulations and at the same time ad-hoc legislation could be developed for the new smart services.

The latter is especially important given the difficulties encountered to certify new solutions due to the existing regulation framework.

Hardware certification has been a major challenge faced by the; ***GrowSmarter***, ***SEEV4City***, ***CleanMobilEnergy***, ***i-rEzEPT***, ***Scirius*** and ***Insulae*** projects. Due to the novel nature of devices such as V2G chargers, grid codes in many countries do not recognise EVs as a distributed energy storage resource able to inject power into the network. Therefore, the grid interconnection and certification process is slow, expensive or prohibited. For instance, in the ***Scirius*** project, the lack of rules for grid codes or changes in related regulations produced a significant delay on the grid certification processes, impacting the installation of V2G in homes that already have export capability from microgeneration.

Certification of innovative services has also been a difficulty for projects such as ***Smart parking*** in the UK and Poland. Selling and invoicing for EV charging services is complex from a legal and accounting perspective because most of the legislation regarding e-mobility refers to public EV chargers not private ones, which hinders the time to market for this solution.

Recommendation

- As the electrification of transport accelerates policymaking to deliver low-carbon transport and energy sectors must no longer be dealt with in silos.
- Public authorities should closely collaborate with stakeholders guiding them to efficiently develop solutions adapted to local needs.
- The legislative framework should ensure non-discriminatory and easy access to relevant vehicle data (including key battery dynamical parameters such as the state of charge, and the global state of heath of the battery) required to operate smart-charging services.
- Easier grid connection and technical procedures for market access should be provided at national level.
- Grid codes need to take into account and support new solutions including V2G, distributed energy generation and self-consumption systems.

- Requirements and specifications for future ancillary and flexibility services procured by Energy Services Operators (ESOs) and Distribution Network Operators (DNOs) should be designed such that they do not hinder participation from EV fleets.
- Grid data collection and sharing at lower voltage level should be supported to enable a better understanding of the capacity and potential constraints on local networks that could be improved by flexible charging.

Business models

The innovative business models developed in the IMET projects integrate **different income opportunities** through the implementation of valuable digital energy and mobility services. This approach is investment-attractive as the integration of different services will ensure the use of the related facilities (eg. charging stations) and at the same time guarantee the necessary revenues to support the return on investment, as proven in the ***Mobility Areas*** project.

However, it remains the case that the more disruptive technologies face greater challenges in proving widescale and robust business cases. As evidenced in ***SEEV4City***, in most cases, the business model for smart charging technology is currently more attractive than V2G as the former is already widely available. The cost of V2G chargers and the lower availability of the technology, which is not yet offered by most vehicle manufacturers, hinders achieving sustainable business models. **Battery cost** also has an important impact on the business model. However, as experienced in ***SEEV4City***, it is currently not possible to accurately quantify the impact of energy services on battery life. This area needs to be further developed as the optimisation of operations to protect battery health will also improve the residual value of the EV and reduce the total cost of ownership of EVs.

Overall, a favourable **policy framework** is the main enabler of a sustainable business model for intelligent mobility solutions. In ***CleanMobilEnergy***, existing policies and tariff schemes made it too expensive to consume energy from the solar power plant, hence discouraging sustainable energy choices. In ***i-rEzEPT***, the biggest challenge was the legal restrictions against V2G services: consumers were not allowed to feed the electricity back to the public grid. That prevented any realistic business model, reducing the use of V2G solutions to demonstration purposes only.

The **electricity market design** has a significant impact on the business case of most intelligent mobility solutions. To create sustainable business models, energy systems need to be decentralised and energy tariffs re-designed to better reflect the real-time value of energy and capacity in the power system. However, markets with favourable feed-in tariffs are rarer in the market. According to the ***GrowSmarter*** consortium, many buildings are not exposed to environmental friendly tariffs or do not have the capacity charges which enable them to optimally schedule V2X charging and discharging.

In the UK, as found by the ***Scirius*** project, residential V2G is not yet able to participate in valuable grid services such as Firm Frequency Response (FFR) due to factors including stringent metering requirements. It is therefore reliant on a variable electricity price for price arbitrage. Despite the increase in need for flexibility on the grid, current policy changes such as the Targeting Charging Review (TCR) are creating a flatter pricing structure which make V2G less favourable in the short term.

Recommendation

- Regulation must be in line with new business models and technologies to effectively support the clean energy transition (eg. cost-reflective network charges will be essential to harnessing the potential of V2G charging).
  - National authorities should introduce favourable flexible energy demand tariffs supporting the business case of more sustainable energy choices.
  - Establishing signals in the market that reward EV drivers for charging in ways that support the energy system should be encouraged (eg. incentivising network operators to procure flexibility from domestic users to ease local grid constraints).
  - Future rules and regulations, including the upcoming "Access and Forward Looking Charges Significant Code Review," should ensure cost-reflective network pricing and take into consideration likely V2G use cases when considering changes to network charges.
- At EU level, the effective implementation of the Clean Energy Package should allow for full market participation of flexible electric loads such as smart charging infrastructure and V2G solutions, as well as flexible tariff structures, across the EU.
- Implications of 'grid parity' of combined self-production and storage, modifications to the regulatory and tariff frameworks should be assessed to anticipate effects of load defection and the risks of mass grid defection.
- At present many countries have a fixed weekly request to bid for power, this interval is too rigid to support profitable V2G operations. Moving to a shorter interval to bid for power will be beneficial to V2G and create a more adaptable and flexible system.
- Households need lower entry barriers to be able to bid into flexibility markets with the storage available in their assets.
- Tools to accurately calculate the impact of energy services on battery life could play a helpful role in optimising the operations to protect battery health.
- Public authorities should learn from best practices: open electricity markets such as the USA, Denmark and the UK, make it easy and accessible for new entrants to provide new products and service supporting the integration of EVs.

Customer engagement

Intelligent mobility solutions are to some extent held back by the nature and level of collaboration that is required between the ranges of stakeholders including the customer. The standard EV customer journey does not yet fully introduce the customer to these innovative services in a systematic way.

Customer recruitment and citizen engagement was a challenge faced by ***Insulae***, ***Scirius, Mobility Areas*** *and* ***Park & Charge UK*** projects. The conclusion here was the issue needs to be approached from two sides.

Firstly, the offer to participate in the pilots or to purchase the solution needs to be well designed to make it as attractive as possible. In this case, **co-designing** the offer with all relevant stakeholdrers (including end users) is the best method, as evidenced in the ***Mobility Areas*** and the ***Park & Charge UK*** projects. Engaging the end users in the co-design process supports developers to understand in-depth the requirements of each area, district and community and will enhance the project's overall success. In this way, each solution adopts the "bottom-up" approach and follows real demand.

Secondly, citizens need to be educated. As found in the ***Insulae*** project, a good **awareness campaign** supported by public authorities to help citizens understand the benefits of the technologies for them and the environment helps to build trust and consumer acceptance.

Recommendation

- Local authorities should look to engage citizens in the design process of urban transformation.
- Education and engagement campaigns should be launched and financed by public authorities to increase citizen's understanding of the benefits of the technology and manage concerns such as data security, battery aging and range anxiety.
- Public authorities should support demonstrator projects as they enable citizens to see how technology can be used in real cases.
- Whilst the energy and regulatory frameworks in UK and Denmark are more conducive to V2G technologies and trials, other nations need to make progress towards empowering customers to contribute.
- Consumers should be rewarded for choosing the sustainable energy options. They should be empowered through the provision of appropriate prices incentives through tariff structures and flexible pricing contracts.
- Taxation legislation and subsequent barriers need to be resolved in order to facilitate the process for consumers becoming prosumers. This includes revising the European Energy Taxation Directive so that consumers are able to receive tax exemptions on the energy stored in their batteries, to be used for grid services. This combined with

the favourable taxation of electricity consumed off-peak could be set in order to encourage storage/consumption at off-peak times.

The End

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