Part funded by

Smart Mobile Energy

Dissemination Report

- March 2017

Project Partners

Project Overview

Smart Mobile Energy

Smart Mobile Energy (SME) is a 6-month feasibility study, part funded by Climate KIC to explore the potential for EVs connected to smart charging and vehicle-to-grid. Three European cities have been considered; Birmingham, Berlin and Valencia.

The partners have sought to understand the grid and environmental impact an increasing number of EVs might have to the cities individually. Each city is at a very different level of EV uptake evolution, making the business case assessment an interesting one.

Birmingham

- 5 car parks across the city assessed.
- Standard, smart and V2G charging evaluated.
- £975,000 potential savings in infrastructure upgrades from smart charging by 2045.
- 88% EVs projected by 2045, equating to 2750 EVs across all 5 car parks.

Berlin

- The potential of V2G in commercial fleets has been assessed.
- Grid capacity and regulatory framework conditions are limiting factors for V2G solutions in Berlin.
- A cost advantage per vehicle per year of around 207 EUR is possible for fleet operators.
- The maximum earning potential is 13.20EUR per vehicle per year.

Valencia

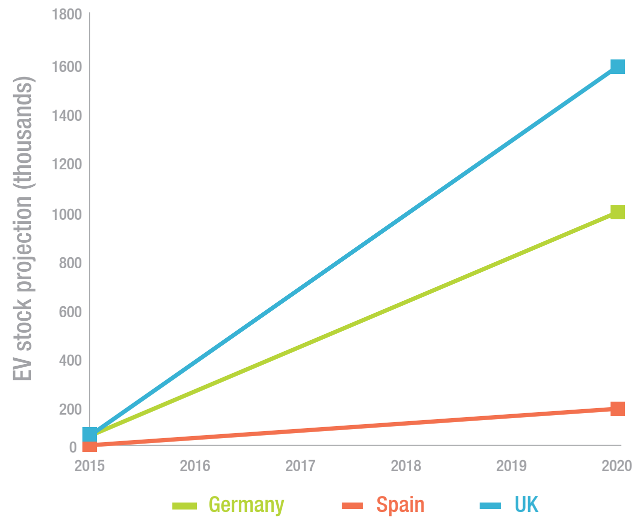
- The Investment return analysis for a 20 years period for V2G:
  - NPV: 2,119,912.14 €
  - IRR: 15.51%
  - Payback: 8 years

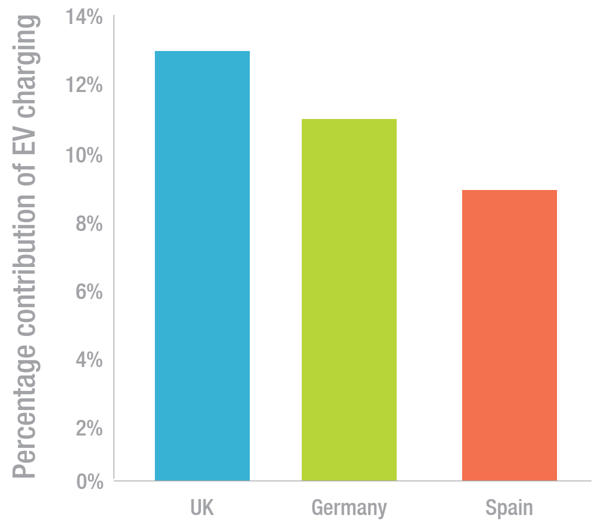
Next Steps

This project has acted as a due diligence assessment for smart charging and V2G in three major urban cities across Europe. Due to the successful identification of the financial benefits of EVs with smart charging and V2G, the next step is to demonstrate in a practical sense the potential of smart charging with V2G across the three cities.

National EV Projection Figures

The projected uptake figures for EVs for the UK, Germany and Spain by 2020 are shown here, as estimated by IEA. This shows there will be a dramatic increase in the number of EVs by 2020, demonstrating the need for significantly more infrastructure and grid loading could create issues where previously there were none.



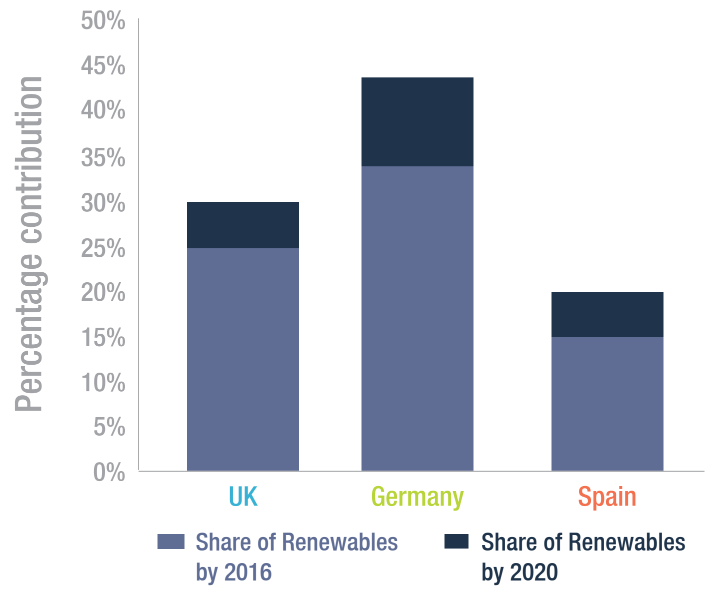


Percentage Contribution of EVs to National Demand by 2050

The projected increase in total national electricity demand as a result of EV charging is shown here, as calculated by the European Environment Agency (EEA). The need for managed charging and V2G is clear, with a not insignificant proportion of the demand for all three countries contributed to by EVs. This will also have a significant impact on the network, with an increase in power demand meaning network upgrading could be required unless charging and power draw can be managed.

National Contribution of Renewables

The renewable contribution for each country is expected to increase by 2020, as is demand, meaning a greater share of EVs with have low carbon credentials. As a large amount of this will be in the form of distributed generation, power flows across the distribution network in all three countries will be impacted.

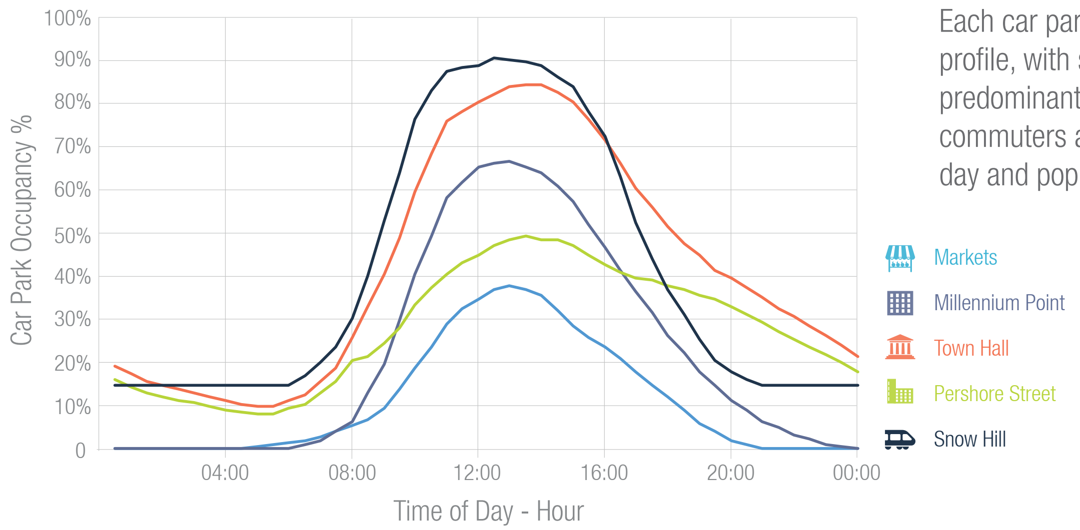


Birmingham

Smart Mobile Energy

Analysis of 5 council owned car parks in Birmingham looked to establish how a public charging network might profit from deployment of smart charging or V2G.
- 7kW fast chargers were considered, along with the V2G-capable variant.
- Sales to the Firm Frequency Response (FFR) market via V2G technology was compared directly to smart charging (simulated by incorporating peak shaving methods) and standard charging models.
- In each case the profitability was determined by considering that the electricity tariff is greater during peak hours, and factoring any grid infrastructure upgrades that may be required as a result of EV charging.
- Solar PV as a source of power was considered to offset power-draw from charging and add extra income from selling energy back to the grid. The cashflow benefit from this is substantial, however there is no overall economic benefit due to the significant financial outlay for the solar panel infrastructure and diminishing Feed-in Tariff payments.
- It is assumed the smart charging and V2G scenarios are managed by an aggregator.

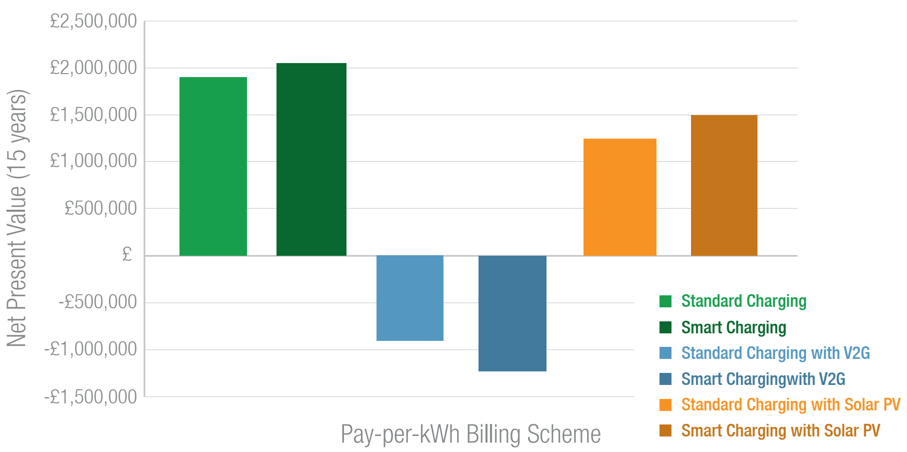
Electric Vehicle Occupancy



Each car park has a different demand profile, with some being used predominantly during the mid-week for commuters and some open 24-hours a day and popular during the weekend.

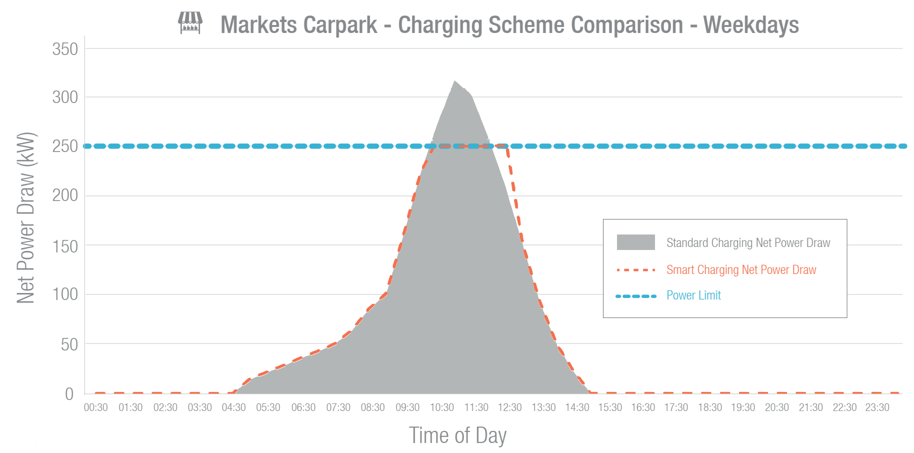
Net Present Value (NPV)

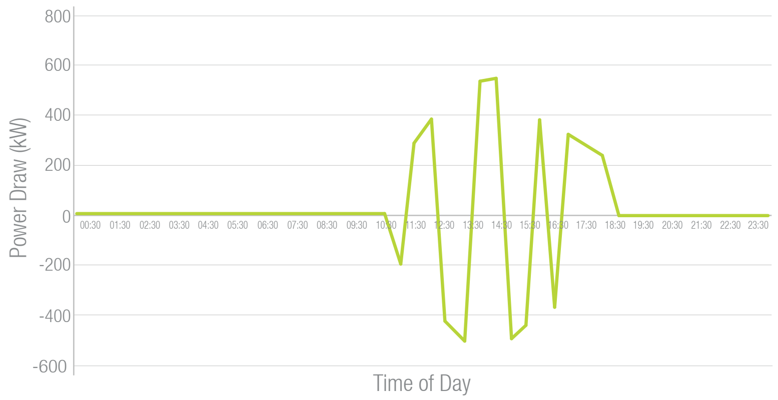
The NPV includes factors such as inflation, increase in EV uptake over time and therefore further infrastructure upgrades.
The analysis looks at the potential income generation from all 5 car parks.



Smart Changing

In order to eliminate or reduce grid infrastructure upgrades, smart charging delays the charging of certain EVs to provide peak shaving when demand is lower.
One car park is used here as an example of the smart charging operation.





V2G in Firm Frequency Response (FFR) Market

The FFR market is an outlet where V2G can be utilised to sell the battery storage of an EV.
Consenting EV users set a minimum charge-level they require (e.g. 80%) and the remaining can be used to charge or discharge into the FFR market.
National Grid pays anyone who can provide this service for either charging or discharging.

Public Network Pricing Structure

Three billing schemes were considered as shown in the adjacent table.
Based on these prices, it was identified that the pay-per-kWh billing scheme offered the most profit to the carpark owner, while also remaining a reasonable cost to the EV user.
This analysis shows the annual estimated profit for all 5 car parks for the standard and smart charging operations.

Billing Scheme	Base Price	Standard	Smart
Pay-per-charge	£1.00	-£22,758.90	-£42,031.55
Pay-per-30min	£0.25	-£22,758.90	-£42,031.55
Pay-per-kWh	£0.16	£220,603.18	£201,330.53

Conclusions

Smart-charging is very effective in reducing the costs associated with network infrastructure upgrades, thereby increasing the profitability over a long period of time.
In the standard or smart charging scenarios we assume that charge-points are vacated upon the EV reaching its maximum state of charge. However, in the V2G scenario the number of charge-points is increased significantly because the EV must be at a charge-point all day. This, along with the increased cost of a V2G-capable charge-point, means that even with additional income from the FFR market there is a net decrease in profits as compared to standard/smart charging.

Berlin

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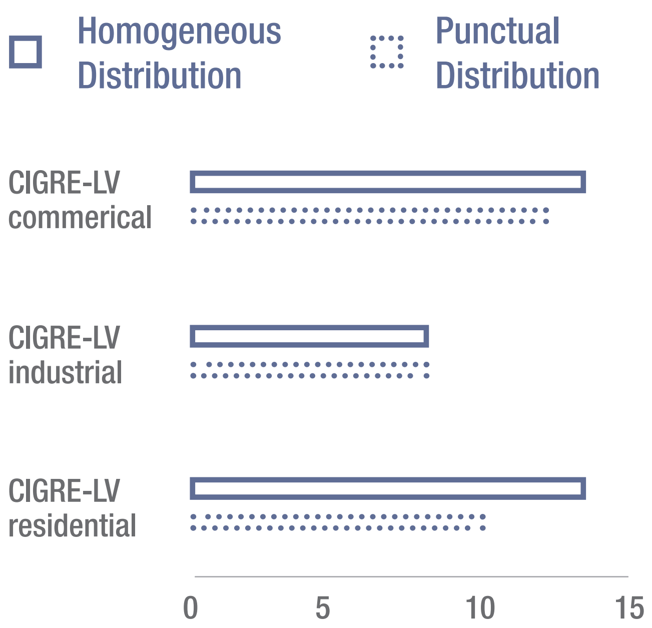
The number of EVs in Berlin is lacking behind the envisioned goals of the federal government, however is continuously growing. 75% of all registered electric vehicles in Berlin are used for commercial purposes. Thus, the Berlin case:
- explored the potential of realizing V2G of EVs in commercial transport fleets across the city
- evaluated the potential income generation/savings that could be made
- and identified the most suitable markets for V2G intervention.

Distribution Grid Limitations

13 EVs can be charged simultaneously in a commercial grid, when 50% of the grid capacity is being used e.g. 8 AM. Regulatory framework conditions for participating in the national electric energy market and local technical limitations (max. number of EVs that can charge at the same time in the same distribution grid) require:

- aggregate a certain number of vehicles to fulfill the minimal market conditions, which also requires to aggregate vehicles city-wide due to the limited network capacities,
- develop charging strategies in order to fulfill the guaranteed minimum performance for the case of a physical request without limiting the mobility of the fleet,
- develop charging strategies in order to generate benefits for the fleet operators.

Maximum number of simultaneously charging EVs simulated on CIGRE networks with a basic load of 50%



Contractual Terms of the Business Model:

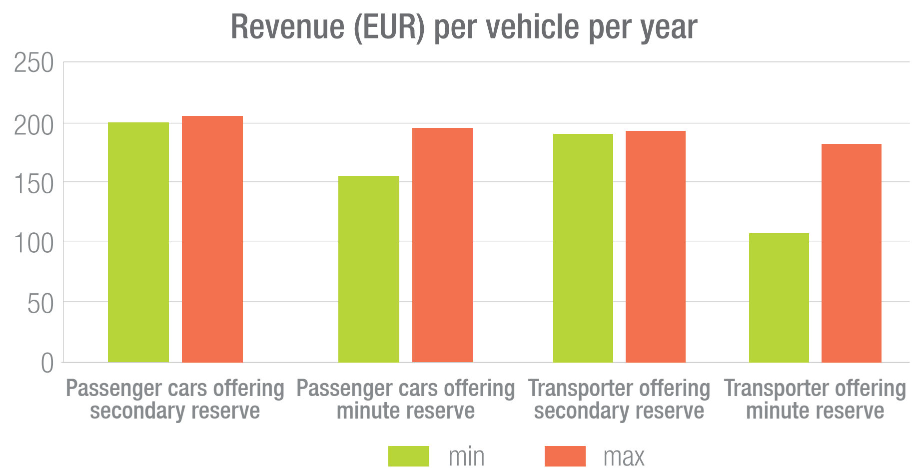
1. Companies guarantee to have to the contracted amount of vehicles for certain periods of the day with a minimum battery state of charge.
2. The aggregator guarantees a fixed price per kWh for a contracted quantity and provides an appropriate charging strategy based on the distribution grid in which the EVs are located. They organize the charging management and guarantee the energy available for the fleets operation.

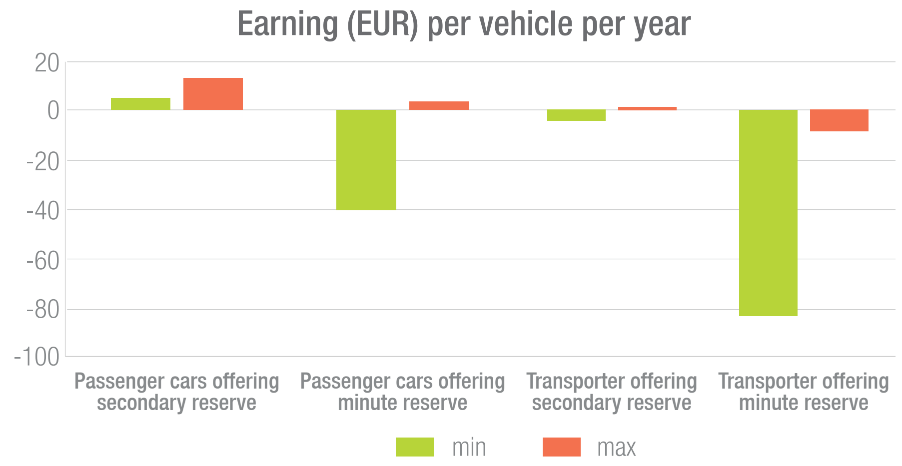
Electricity Markets Considered:

1. **Wholesale Market** - Day-ahead market
2. **Control Power Market** - Secondary reserve and Minute reserve

Berlin Example Business Model Inputs

Business Models for Commercial Transport Fleets	Number of Vehicles		Price advantage (Cent/kWh) in comparison to standard tariff		Communication Cost		Other Pool-Coordination
	min	max	min	max	min	max	
Passenger cars offering secondary reserve	1630	3259	5.65	5.71	168	172	22
Passenger cars offering minute reserve	610	947	4.3	5.49			
Transporter offering secondary reserve	1755	3509	5.74	5.81			
Transporter offering minute reserve	528	1056	3.36	5.53			





Conclusions

The result of the analysis highlights the power regulation system and distribution grid capacity in Germany as the main constrains for V2G solutions. The calculation also shows yearly earning per vehicle seem to be larger in the segment of the passenger car and by offering secondary reserve control power. The sum of the earnings (maximum 13.20EUR per vehicle per year for the best option) are not profitable for an aggregator to run the proposed business in a successful manner and a fleet operator to motivate him sign a contract with an aggregator.

However, it is imagined that the listed costs (for aggregator) can be reduced for example by smart meters that automatically communicate with the aggregator. The aggregator can reduce the fixed part of the costs by contracting larger fleets.

Valencia

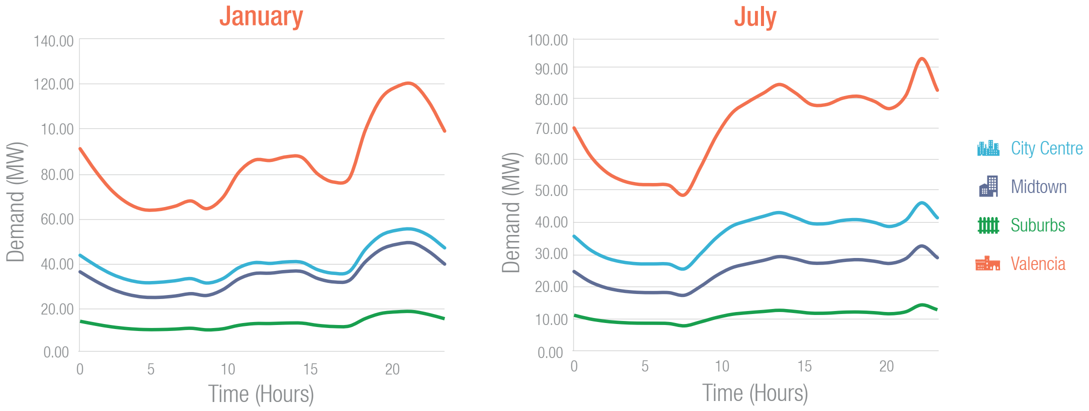
Valencia business case has focused on the point of view of a “gestor de carga”, which is the electrical stakeholder whose role is to manage the electric vehicle charge. At the same time, this business case has taken into account all the main areas of the city of Valencia where V2G could be installed, such as residential areas, commercial areas, work cores and universities. The main aim of this business case has been to study the feasibility of V2G deployment across the city.

e-Mobility

- e-Mobility is taking off in Spain now.
- The Comunitat Valenciana is one of the leaders of e-Mobility deployment.
- Valencian Public administration is committed with this objective.
- Comunitat Valenciana has the fourth electric vehicle park of Spain which counts with 1,415 EVs, and the third biggest charging infrastructure of Spain with 415 charging points.

Valencia Energy Profile

- Mainly household and commercial energy consumption.
- Low industrial presence.
- Significant difference between peak and valley profile.



V2G Market

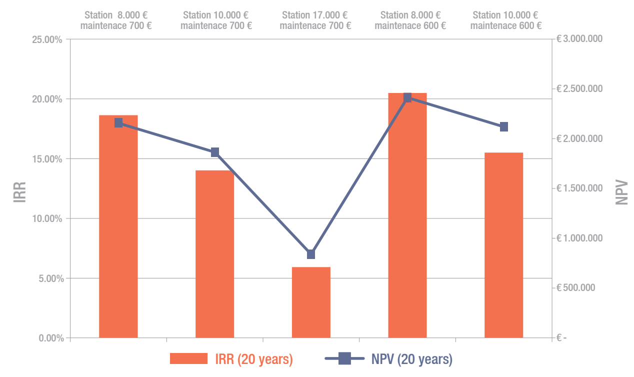
- Spanish electric regulation does not allow V2G.
- Aggregators do not exist in Spanish electric market.
- V2G technology may offer ancillary services to the grid through the following markets:

  Daily, Secondary Regulation, Tertiary

MARKET	AVERAGE PRICE
DAILY MARKET	39.667 €/MWh
SECONDARY REGULATION	0.7588 €/MWh
TERTIARY REGULATION	1.451 €/MWh
DEVIATIONS	0.266 €/MWh

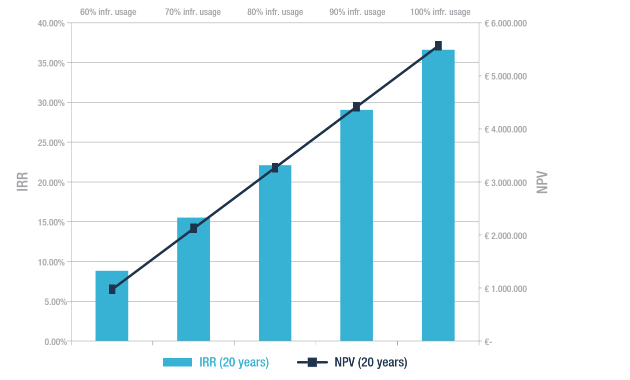
Conclusions

V2G is profitable in from all perspectives, both technical and economic. From a “gestor de carga” perspective with 150 V2G stations, the payback period ranges between 7 and 10 years, and its internal return rate rounds 15%. In addition, V2G deployment would be convenient for the electric distribution grid to flatten the demand curve and avoid massive charging during peak hours.’



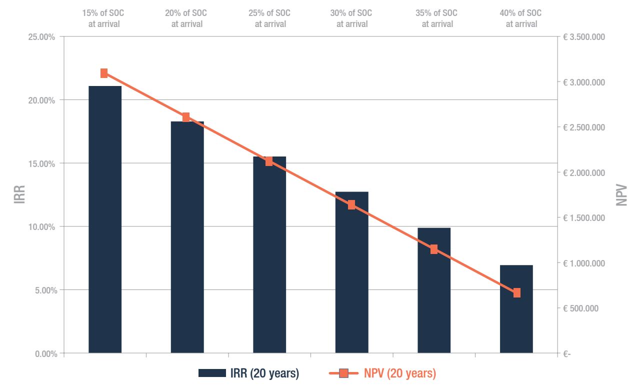
1. Infrastructure Cost Analysis

Direct impact of charging infrastructure acquisition and maintenance costs in the return parameters.



2. Infrastructure Usage Analysis

Usage rate direct linear relationship
^ 10% usage ^ 6.6% IRR

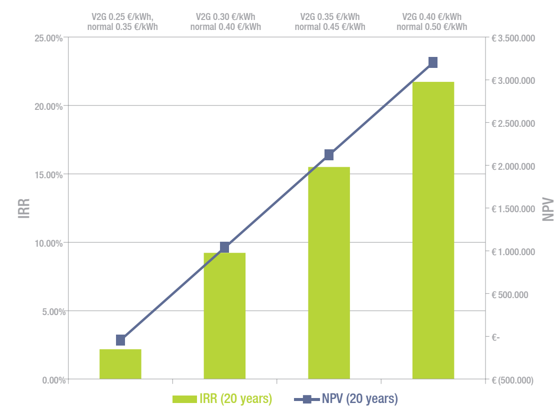


3. Charging Characteristics Analysis

At arrival SOC rate inverse linear relationship
v 5% SOC ^ 2.8% IRR

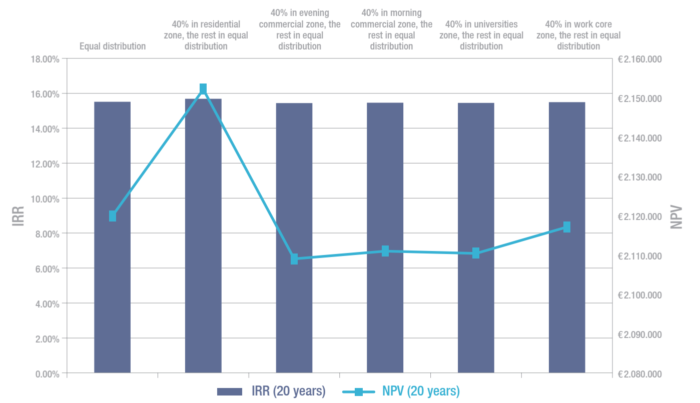
4. V2G Feasibility Analysis

The greater V2G acceptance and grid injection, the higher business benefits are.



5. Charging Session Price

Reducing charging prices more than 0.10€ incurs in business losses.



6. Charging Stations’ Location Analysis

Valencia lifestyle suits every V2G location and timetable.

Notes

Smart Mobile Energy

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