

# Economic study of the different scenarios

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# Deliverable

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## Economic study of the different scenarios, with the assumptions and data sources used

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## Statement of Originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

## Abbreviation list

|                |                                  |
|----------------|----------------------------------|
| BPS            | Basis Points                     |
| CPO            | Charging Point Operator          |
| DERs           | Distributed Energy Resources     |
| DoA            | Description of Action            |
| DSO            | Distribution System Operators    |
| ECB Statistics | European Central Bank Statistics |
| EMSP           | e-Mobility Service Provider      |
| EOL            | End of Life                      |
| EV             | Electric vehicle                 |
| FIT            | Feed-in Tariff                   |
| ICV            | Internal combustion vehicle      |
| NPV            | Net Present Value                |
| PV             | Photovoltaics                    |
| RD             | Royal Decree                     |
| SLB            | Second Life Battery              |
| SOH            | State of Health                  |
| TSO            | Transmission System Operators    |
| V2B            | Vehicle to Building              |
| V2G            | Vehicle to Grid                  |
| V2M            | Vehicle to Market                |

# Executive Summary

*The objective of this report was to conduct an economic viability study regarding Vehicle-to-Grid (V2G) participation across diverse scenarios of electricity and battery prices projections. Six scenarios were analysed: Electricity price stability with stability of EV battery prices (1), Electricity price stability and with decrease of battery price (2), Electricity price increase with stability of EV battery prices (3), Electricity price increase and with decrease of battery price (4), Decrease of electricity prices, with stability of EV battery prices (5), Decrease of electricity prices and with decrease of battery price (6).*

*The calculations to assess the economic viability were centered on a 10,000 km/year driving range, comparing an EV owner to an internal combustion vehicle owner, and an EV owner (with V2H/V2B) to an EV owner integrated with V2G services. Key indicators such as payback time and Net Present Value (NPV) were employed to evaluate economic feasibility. Multiple factors were considered, including initial investment (EV cost and charging infrastructure), operating expenses, service/maintenance fees, depreciation, fixed costs (insurance, road tax and other mandatory costs), residual value after 7 years, total ownership cost per month and per km, savings, net savings, and payback time.*

*The report also incorporated insights from regulatory, market barriers, and technological risks identified in WP2 and WP3. The findings will shape subsequent tasks in WP4, particularly due to the significant impact of electricity prices on total ownership costs. The results can empower EV owners to assess servitization schemes, vehicle ownership options, and potential integration of photovoltaic systems. At the same time the results of this report are relevant for the aggregators as they provide a complete picture of what other services or schemes can be proposed to the users to make sure that they maximize the results of the V2G technology.*

## **Key findings**

- 1. Regardless of the scenario, NPV and payback time remain relatively constant, indicating a consistent relationship between standard EVs and those with V2G capabilities. This holds true unless V2G income sees significant increases.*

2. *Battery cost influences calculations as it is an important cost, however by running the different scenarios energy cost yields greater significance in the comparison between electric and fossil fuel vehicles.*
3. *Examining total ownership costs per month, the scenarios closest to internal combustion vehicles are those with low battery prices and low energy prices. The next scenario that is close to the total cost of ownership to the internal combustion vehicle is the 'low battery/stable electricity price', which underlines that lower battery prices enhance the appeal of the business proposition.*
4. *This analysis is limited to the case of the EV owner, as such these calculations underline the EV owners' benefit, and not the possible gains of the other stakeholders such as aggregators. By entering into an agreement with an aggregator the EV owner will possibly lock in an energy price and not really take advantage directly of any of the energy price fluctuations.*

*Vehicle-to-Grid (V2G), as demonstrated by various scenarios, has the potential to bridge the affordability gap for the average consumer. In fact, it can even outperform traditional petrol-driven cars, a significant and pivotal achievement in the context of the energy transition. This outcome addresses a crucial element in making electric vehicles (EVs) more accessible and attractive to a wider range of consumers.*

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# 1. Introduction

The European Union's envisioned energy transition, aimed at being implemented by its member states, offers long-term benefits for both the energy security and economic stability of Europe and its environmental preservation, with the ambitious goal of limiting global warming to 1.5 degrees Celsius by 2050. To achieve these objectives, it's essential to recognize that the current transmission and grid infrastructure was established during a time when consumer energy needs vastly differed from the present context.

These tried and tested base cases have been challenged by an ever-increasing production of new renewable energy sources, which due to its nature (that of relying on the forces of nature) is uneven and predictable, and is occurring at a mismatch with household consumption patterns. Additionally, this surge in renewable energy has underscored a critical issue—the lack of efficient storage capacity. Frequently, instances arise where renewable energy assets produce power during periods of favorable weather conditions (e.g., wind or sunlight), yet the surplus energy cannot be utilized due to reduced consumption or insufficient storage capabilities. Consequently, this surplus of valuable green energy often goes to waste.

Addressing these challenges is pivotal to a successful energy transition. By adapting the energy infrastructure to accommodate the intermittent nature of renewable sources and by enhancing energy storage capabilities, Europe can optimize the use of renewable energy and minimize wastage. This shift is integral not only for bolstering energy security and environmental sustainability but also for aligning with the EU's broader climate goals.

## Energy transition

The challenges associated with transitioning from fossil fuel-based electricity to renewable energy extend beyond the mere installation of solar panels and wind turbines; in fact, they mark just the initial phase of a broader issue. While those behind photovoltaic (PV) installations and wind parks are understandably concerned about reduced Feed-in Tariffs (FiT) affecting their returns, they truly feel the profound repercussions of an inadequate grid when the Transmission System Operator (TSO) must disconnect the production of PV fields and wind parks. This disconnection occurs because the grid is incapable of absorbing the surplus energy during periods of insufficient demand. This in turn has a negative impact on return calculations and affect the willingness of bankers and investors to support the development of further PV fields and wind parks.

## Inflationary implications

Energy plays a pivotal role as a concealed driver of inflation, extending beyond and surpassing the two primary factors of transportation and housing costs, as documented by European Central Bank statistics. A surge in energy expenses not only amplifies clothing expenses through heightened transportation costs but also exerts upward pressure on the prices of essential commodities like food and beverages. The impact of fluctuating energy costs is intensified by the necessity to incorporate a safety margin within pricing structures. This is prevalent across diverse sectors, ranging from bakeries, breweries, and dairy businesses to even the aviation industry. This safety buffer accounts for the unpredictability of potential energy cost escalations and, regrettably, contributes to exacerbating the overarching problem of inflation.

## The grid is taken for granted

It is easy to think about solar and wind parks as the easy solution in the energy transition, but little attention is paid to the physical grid which somehow takes energy produced in a certain part of a country or Europe to other parts, ultimately powering from household washing machines to industrial production.

Whilst the power cables crisscrossing Europe, look a familiar sturdy piece of technology, very little attention is paid by all of us that it is only the delivery channels of a fine art what the TSO's and DSO's perform in matching and anticipating, the ever-changing production and consumption patterns. Even more so, when the patterns of production are shifting ever more to time horizons where there is very little demand, the work for the grid operators becomes ever more complicated, and their only solution before decoupling is to store energy on a short-term basis.

A further issue, when it comes to the grid, is the fact that there is a big discrepancy between the approval processes for PV & wind parks which on average is 3 years (and even faster time frames under recent EU laws) and the approval process for new grid infrastructures which is around 12 years. These numbers are exacerbated when one is taking into consideration the build out process which adds a few years to the Grid expansion compared to a few months for a PV installation and years again for wind generation. Furthermore, the cost of upgrading the grid is uncontestedly higher than the one of implementing different storage solutions, all of which are calling for rapid solutions such as V2G.

## The Value of V2G for electricity system operation

A recently published analysis in “The Drive Towards a Low-Carbon Grid: Unlocking the value of vehicle-to- grid fleets in Great Britain”<sup>1</sup> also suggests that:

- “with a lower penetration of 50,000 V2G-enabled EVs, each EV could reduce system operation costs by approximately £12,000 per annum and CO2 emissions by around 60 tonnes per annum.”<sup>2</sup>
- “Reduced wind curtailment and more efficient frequency response provision through V2G are the main drivers of these cost and emission savings.
- The value offered by V2G EVs for system operation falls with larger fleet sizes. With 150,000 EVs on the system, the marginal value per EV is approximately £600. Competing flexibility sources could also diminish overall operational cost savings from V2G”<sup>3</sup>.

## The human factor and V2G as a possible solution

The conversion from fossil fuel powered vehicles to EVs and the transition to EVs is a major jump for many market participants across the user spectrum, from individuals to fleet operators. Due to the fact that these users have been brought up with the notion that petrol-powered vehicles are easily managed at petrol stations around the clock conveniently and rapidly ensuring a high range, the lack of reliable charging infrastructure and the range anxiety are still the major concerns when it comes to possible EV users.

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<sup>1</sup> The Drive Towards a Low-Carbon Grid: Unlocking the value of vehicle-to- grid fleets in Great Britain, January 2021, pg 4, [https://www.researchgate.net/publication/349948445\\_The\\_Drive\\_Towards\\_a\\_Low-Carbon\\_Grid\\_Unlocking\\_the\\_value\\_of\\_vehicle-to-\\_grid\\_fleets\\_in\\_Great\\_Britain](https://www.researchgate.net/publication/349948445_The_Drive_Towards_a_Low-Carbon_Grid_Unlocking_the_value_of_vehicle-to-_grid_fleets_in_Great_Britain)

<sup>2</sup> Ibidem, pg4

<sup>3</sup> The Drive Towards a Low-Carbon Grid: Unlocking the value of vehicle-to- grid fleets in Great Britain, January 2021, pg 4, [https://www.researchgate.net/publication/349948445\\_The\\_Drive\\_Towards\\_a\\_Low-Carbon\\_Grid\\_Unlocking\\_the\\_value\\_of\\_vehicle-to-\\_grid\\_fleets\\_in\\_Great\\_Britain](https://www.researchgate.net/publication/349948445_The_Drive_Towards_a_Low-Carbon_Grid_Unlocking_the_value_of_vehicle-to-_grid_fleets_in_Great_Britain)

However, “global EV sales reaching 6,75 million units in 2021, 108 % more than in 2020”<sup>4</sup>, a trend which is expected to grow exponentially, and the batteries powering such vehicles are a hidden and spare resource which can overcome the limitations of the grid, by acting as a storage, by possibly taking up energy when it is available in abundance and consequently cheap and feeding it back to the grid when demand is high, and conversely prices are higher.

By harnessing the combined spare capacities in many of these vehicle batteries V2G could support the net in balancing its frequency or power needs.

## EV and V2G in local flexibility markets

Today, large quantity of electricity cannot be stored cheaply or at all, “in fact the overall amount of electricity fed into the power grid must always be equal to the total amount of electricity consumed, otherwise there would be a malfunctioning in the power system, potentially leading to power cuts.”<sup>5</sup> Electricity storage needs are growing rapidly globally, this is driven by the inherent mismatch between renewable generation and consumer needs/demand.

“Electricity production and trading are no longer limited to large centralized generators and retailers. With the integration of distributed energy resources, electricity flows in both directions: from the grid to the consumer and vice-versa, from the consumer to the grid. This means that consumers can produce electricity for their consumption “Prosumers” or are able to sell it on the market via bidirectional electricity flows. Consumers can take control of their energy, not only achieving energy savings, but have a financial benefit from participating in the electricity markets”<sup>6</sup>.

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<sup>4</sup> Global EV Sales for 2021, Roland Irle, EV-volumes.com, <https://www.ev-volumes.com>

<sup>5</sup> D3.2 Report on flexibility local market potential, opportunities for V2G in local distributed markets, OMIE and Holaluz, page 58

<sup>6</sup> Ibidem

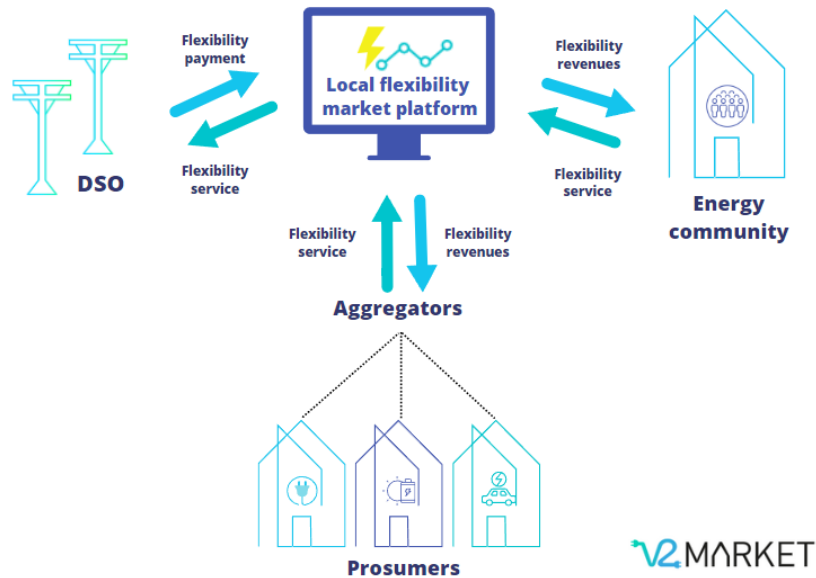


Figure 1 Flexibility service and revenues local flexibility market stakeholders (OMIE and Holaluz)<sup>7</sup>

Prosumers, due to their own energy resources will have the possibility to participate in local flexibility markets by modifying their consumption or generation. With these resources they might be able to participate either directly or through intermediaries such as “aggregators or energy communities to facilitate the integration of these resources into the market”<sup>8</sup>. V2G fleets could have “an important role to play in local and flexibility markets due to the capacity of their batteries, when aggregated, can respond to DSO’s flexibility requirements in areas where maybe another type of resources cannot”<sup>9</sup> as such solving their grid constrains.

## 2. Methodology

An economic analysis can be run by using a variety of methods, albite they are similar in approach, such as:

- the payback period method
- the internal rate of return method (IRR)
- the net present value (NPV)

<sup>7</sup> D3.2 Report on flexibility local market potential, opportunities for V2G in local distributed markets, OMIE and Holaluz, page 59.

<sup>8</sup> Ibidem.

<sup>9</sup> Ibidem

In general, for low investments as the ones being analyzed in this report, with a short duration the widely accepted, and easiest methodology to follow, is the payback period method.

The methodology used for in this report had a starting point the Norma VALERI “Valuation of Energy Related Investments” which provided the team with a description on how to gather, evaluate and document information in order to create solid business cases. The calculations however are based on the own internal know-how of the ESC team and some elements of the VALERI methodology such as: Net Present Value (NPV) had been included. The NPV captures the difference between the discounted value of present and future value of all cash inflows and outflows, and it tells an investor whether the proposed investment opportunity is achieving a target return for at a given initial investment. This indicator can be directly used in the decision-making process.

On top of the NPV the following elements have been included in the financial spreadsheet to assess the economic viability model for an EV user **vs** an internal combustion (IC) vehicle user and an EV user **vs** EV with V2G services in accordance to the payback period method:

- Initial investment: EV cost, charging infrastructure cost
- Operating costs: fuel/electricity and car wash
- Service/maintenance fees- tires, consumables
- Depreciation
- Fixed costs: Insurance, road tax and other mandatory costs
- Residual value after 7 years
- Total cost of car ownership per month
- Savings: cost per km Fuel vs EV
- Total cost of ownership per km
- Net Savings Petrol vs EV
- Net Savings EV vs EV +V2G
- Payback time period
- Net Present Value

Due to the fact that in this phase within the V2M project, the pilot phase has not started, the current analysis is based on information gathered from either the consortium partners, publicly available information and a couple of assumptions and presuppositions that will be disclosed in the next section of this report.

## The 6 different scenarios

For the economic viability studies in 6 different scenarios proposed to be assessed are:

- a. electricity price stability with stability of EV battery prices (1),
- b. electricity price stability and with decrease of battery price (2),
- c. electricity price increase with stability of EV battery prices (3),
- d. electricity price increase and with decrease of battery price (4)
- e. decrease of electricity prices, with stability of EV battery prices (5),
- f. decrease of electricity prices and with decrease of battery price (6)

In order to be able to assess the different scenarios the following assumptions have been taken:

### 1<sup>st</sup> Assumption

The analysis of the electricity price is limited to the scope and research data for the last 3 years due to relevance and data accessibility. The analysis is only relevant if it takes in consideration the last 3 years (2019- to date), this is in particular due to the energy crises (as a result of the Ukraine situation) whilst simultaneously capturing the Covid-19 pandemic period. The hike in electricity prices that the market has seen since the Ukraine crises impacts the overall expectations on the market evolution. As such the price analysis will only focus on the last 3 years to avoid the dilution of the current hike in price.

In order to assess the different scenarios, the highest electricity price from the last 3 years was used in the increase in electricity price scenario. The lowest electricity price from the last 3 years was taken in consideration for the decrease in electricity price scenario. Finally, an average of the electricity price from last 3 years was used in the electricity price stability scenario.

A caution to the reader is that realistically a substantial decrease in electricity price it is not anticipated in the next coming years as a result from disruptions due to the current energy crises.

## 2<sup>nd</sup> Assumption

The electricity price taken in consideration reflect individual households and not the business rates as those are more varied and are mostly a result from tailor made negotiations and agreements.

In Spain in, December 2021 the price of electricity was 0,2816 eurocents per kWh<sup>10</sup>, and varied between 0,2390 eurocents in 2019 per kWh and 0.2298 eurocents per kWh in 2020 <sup>11</sup> which includes all components of the electricity bill such as the cost of power, distribution and taxes. The highest price per kWh in 2022 in Spain was registered in March with 0.2830 eurocents<sup>12</sup>.

## 3<sup>rd</sup> Assumption

This assumption is related to the battery cost: the same rational was followed as in the case of the electricity prices. The prices used will be the ones from the last 3 years, for the same reasoning as in the electricity prices. Due to the fragility of the supply chain when we are referring to batteries although initially anticipated to decrease (before the Ukraine-Russian conflict and supplier chain issues) BloombergNEF's (BNEF) forecasted that the "average battery price will climb to \$135 per kilowatt-hour in 2022, some 2% higher than a year earlier"<sup>13</sup>. In prior years the price for kwh of battery power decreased in a meaningful way from 2019 219 USD to 2020 140 USD and in 2021 reaching a temporal low of USD 132 dollars<sup>14</sup>.

## 4<sup>th</sup> Assumption

Although a powerful incentive in the increased adoption of EV's and installing charging infrastructure, subsidies for acquiring an EV were not included in the calculation model. The rationale behind such a decision, is that neither the amount of such subsidies and timelines are predictable and they change depending on political decisions and as such are difficult anticipate.

<sup>10</sup> Statista, Electricity prices for households in Spain from 2011 to 2021, semi-annually, <https://www.statista.com/statistics/418085/electricity-prices-for-households-in-spain/>

<sup>11</sup> Statista, Electricity prices for households in Spain from 2011 to 2021, semi-annually, <https://www.statista.com/statistics/418085/electricity-prices-for-households-in-spain/>

<sup>12</sup> Statista, Average monthly electricity wholesale price in Spain from January 2019 to July 2022, <https://www.statista.com/statistics/1267552/spain-monthly-wholesale-electricity-price/>

<sup>13</sup> BloombergNEF July 15, 2022, Race to net zero: Pressures of the battery boom in five charts

<sup>14</sup> Ibidem

Furthermore, the viability of a business case should be positive without the inclusion of such subsidies as they are not constant attributes, but occasional ones.

### 5<sup>th</sup> Assumption

As mentioned in the findings of WP3 when it comes to individual EV owners to participate directly to capacity market or any other type of services (peak shaving grid balancing, intra-day electricity market) they can only do so as part of an energy community or with the support of an aggregator due to regulation and market conditions. However, for the scope of this project in the current economic study the viability of such a case of an individual EV owner was analyzed as stated in the DoA.

As such the calculation will focus on the financial benefits of an EV with V2G technologies which will in turn represent the minimum of what an aggregator can generate via V2G.

## 3. Battery price and different scenarios of degradation

The last 5 years registered the most significant increase of EV acquisition. This is due on the one hand to the increased policy push and subsidies offered by governments, and on the other by increased battery performance/range and price decrease of the batteries resulting in lower EV costs.

Furthermore, investments into charging infrastructure (also due to public incentives), the development of fast charging and bidirectional charging, net-zero commitments of the different stakeholders and market players, the increased rollout of EVs from automakers combined with the growing comfort of consumers with EV's<sup>15</sup>.

Batteries are the EV major highest cost item, is also a key element in terms of performance limitations and user concerns (such as range anxiety) are built in general around the battery limitations.

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<sup>15</sup> Battery Pack Prices Fall to an Average of \$132/kWh, But Rising Commodity Prices Start to Bite, 30 Nov 2021, [https://about.bnef.com/blog/battery-pack-prices-fall-to-an-average-of-132-kwh-but-rising-commodity-prices-start-to-bite/#\\_ftn1](https://about.bnef.com/blog/battery-pack-prices-fall-to-an-average-of-132-kwh-but-rising-commodity-prices-start-to-bite/#_ftn1)

According to the BloombergNEF's (BNEF) yearly survey regarding battery prices evolution, "the average cost of EV storage systems declined by 13% between 2019 and 2020, and lithium-ion battery packs, the most common in the EV industry, which were above \$1.200/kWh in 2010, have fallen by 89% in real terms to \$132/kWh in 2021<sup>16</sup>". The cost of an average battery pack is expected to go below \$100/kWh on a volume-weighted average basis by 2024<sup>17</sup>, however the price increase of raw material is suggesting that the predicted \$100/kWh could be delayed with 2 years. "The threshold for price parity with gasoline engines, according to BNEF, is around \$100/kWh"<sup>18</sup>.

However, due to the current situation regarding the increase price of raw materials, the average pack price is predicted to increase in 2022 to \$135/kWh (in nominal terms) from \$132/kWh in 2021. The numbers used in the economic viability as mentioned in the prior section are the ones listed by the BloombergNEF for the last 3 years including the prediction for 2022<sup>19</sup>.

The supply for raw materials, such as manganese from currently known reserves, is predicted to be sufficient to meet demand up to 2050. However, "to assure the balance for the other metals needed such as lithium, nickel and cobalt will require the formulation of a strategy that will require all stakeholders i.e., governments, auto producers, cell manufactures and recycling facilities to collaborate. The EV battery recycling process can also help EV owners to obtain revenues back due to the sale to a third party"<sup>20</sup>.

The following table shows the comparison of the different types of batteries in terms of their cost, specific power, safety, energy density, performance and life span.

<sup>16</sup> BloombergNEF, "Battery Pack Prices Cited Below \$100/kWh for the First Time in 2020, While Market Average Sits at \$137/kWh," Dec 2020. Available: <https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/#:%7E:text=This%20indicates%20that%20on%20average,prices%20will%20be%20%24101%2FkWh>

<sup>17</sup> Ibidem

<sup>18</sup> BloombergNEF, "Electric cars are about to be as cheap as gas powered model", <https://www.bloomberg.com/news/articles/2020-12-16/electric-cars-are-about-to-be-as-cheap-as-gas-powered-models#xj4y7vzkg>

<sup>19</sup> Ibidem

<sup>20</sup> BloombergNEF, "Battery Pack Prices Cited Below \$100/kWh for the First Time in 2020, While Market Average Sits at \$137/kWh," Dec 2020. Available: <https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/#:%7E:text=This%20indicates%20that%20on%20average,prices%20will%20be%20%24101%2FkWh>

Table 1 Comparison between the different types of batteries<sup>21</sup>

| Specifications                    | Lead-acid        | NiCd                          | NiMH               | LCO                    | LMO         |
|-----------------------------------|------------------|-------------------------------|--------------------|------------------------|-------------|
| Specific energy density (Wh/kg)   | 30–50            | 45–80                         | 60–120             | 150–190                | 100–135     |
| Internal resistance (mΩ)          | <100             | 100–300                       | 200–300            | 150–300                | 25–75       |
| Cycle life (80% discharge)        | 200–300          | 1000                          | 300–500            | 500–1000               | 500–1000    |
| Fast charge time                  | 8–16 h           | 1 h                           | 2–4 h              | 2–4 h                  | 1 h or less |
| Overcharge tolerance              | High             | Moderate                      | Low                | Low                    |             |
| Self-discharge/month (room temp.) | 5%               | 20%                           | 30%                | <10%                   |             |
| Nominal cell voltage (V)          | 2                | 1.2                           |                    | 3.6                    | 3.8         |
| Charge cutoff voltage (V/cell)    | 2.4              | Full charge detection         |                    | 4.2 V                  |             |
| Discharge cutoff voltage (V/cell) | 1.75             | 1.00                          |                    | 2.5–3.00               |             |
| Peak load current                 | 5 C              | 20 C                          | 5 C                | >3 C                   | >30 C       |
| Best result                       | 0.2 C            | 1 C                           | 0.5 C              | >1 C                   | <10 C       |
| Charge temperature (°C)           | –20 to 50        | 0–45                          |                    | 0–45                   |             |
| Discharge temperature (°C)        | –20 to 50        | –20 to 65                     |                    | –20 to 60              |             |
| Maintenance requirement           | 3–6 months       | 30–60 days                    | 60–90 days         | Not required           |             |
| Safety requirements               | Thermally stable | Thermally stable, fuse common | stable, protection | Protection circuit man |             |
| Toxicity                          | Very High        | Very High                     | Low                | Low                    |             |
| In use since                      | Late 1800s       | 1950                          | 1990               | 1991                   | 1996        |

Source: *Feasibility of utilising second life EV batteries: Applications, lifespan, economics, environmental impact, assessment, and challenges*, Alexandria Engineering Journal, Volume 60, Issue 5, 2021

Based on the various “manufacturers’ descriptions and the existing literature, “once EV batteries reached 70–80% of their nominal capacity, their role as EV first life batteries is

considered to have reached its end. The main reason behind is that these kind of batteries (that reached 70-80%) will result in lower mileage and speed. The percentage of residual capacity represents the battery SOH (State Of Health). This degradation is estimated to be happening around 5–8 years of usage or the equivalent to 100,000 miles (160,000 km) of travelling. However, the retired EV batteries, even with lower SOH, could still be re-purposed in other applications such as residential households or power variance in grid-scale PV plants [...SOH] are estimated to have another 7–10 years of the lifespan before reaching the End of Life (EOL) as Second Life Batteries (SLB).”<sup>23</sup>

Based on the research on Second Life Batteries (SLB) “the cost of re-purposing and the selling price vary from optimistic estimation to reasonable and to relatively high. For example, it was estimated that the selling price of SLB would be around \$44/kWh, including the cost of re-purposing set at \$20 [...] The study projected that the selling price would drop to \$43/kWh in 2030. Casals *et al.* investigated the economics of using SLB in a residential application and concluded that buying SLB becomes profitable for consumers if it is bought at €38.3/kWh.”<sup>24</sup>

Regarding battery degradation some manufacturers, such as Nissan, are claiming that in a real environment via monitoring and smart optimization of the charging cycles (charging/discharging) no major impact will be registered on the batteries’ lifetime (meaning that it will not degrade faster than a normal usage of the EV battery). However, the second life of the battery is an interesting and vital aspect that was explored briefly in this section as it is also a financial item taking in account in the economic model as part of the residual value of the EV.

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<sup>21</sup> Mohammed Hussein S. M. H. , Jia Woon Lee, Gobbi Ramasamy, Eng Eng Ngu, Siva Priya Thiagarajah, Yuen How Lee, Feasibility of utilising second life EV batteries: Applications, lifespan, economics, environmental impact, assessment, and challenges, Alexandria Engineering Journal, Volume 60, Issue 5,2021, Pages 4517-4536, Online Source: <https://www.sciencedirect.com/science/article/pii/S1110016821001757>

<sup>22</sup> Ibidem

<sup>23</sup> Ibidem

<sup>24</sup> Ibidem

## 4. Regulation, market risks and technologies

### Regulation and Legal barriers in relation to EV's presence and V2G in the electricity market in Spain

As presented in D3.1 Analysis of the electricity markets and its potential for integrating V2G to be able to provide generation services and participate in the market, aggregators need to possess a set of technical criteria and comply with regulatory criteria.

In the global market case in order to provide generation services and participate to the market the following criteria need to be fulfilled:

- **“Aggregated capacity:** Minimum bidding of 0,1 MWh enables the participation of aggregated resources. A V2G aggregated fleet could reach the minimum bidding size by aggregating less than 50 electric vehicles.”<sup>25</sup> This minimum bidding is the same in Spain in the minimum bidding on the Day-ahead and intraday markets.
- **Service duration:** The minimum period is 1 hour and 15 minutes. “Shorter service timers represent an advantage for V2G, since it has the possibility to charge/discharge for short periods if possible.
- **Time to activation:** The operation on the intraday market is as minimum confirmed 1 hour in advance the moment of the energy delivery/consumption, which would be enough time to activate available V2G capacity.

At the moment it is not possible for V2G to participate in wholesale electricity markets as it is not an approved storage asset type. It is necessary to amend regulation related to electricity storage to include storage facilities and V2G services in the market scheme. The participation of storage in the electricity markets is reduced to pumped hydro storage and storage associated with solar power”.<sup>26</sup>

Deliverable D3.1 Analysis of the electricity markets and its potential for integrating V2G in Chapter 7.5 Legal barriers and considerations for EV to enter the electricity market in Spain

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<sup>25</sup> D3.1 Analysis of the electricity markets and its potential for integrating V2G, OMIE and Holaluz, Pg 89.

<sup>26</sup> D3.1 Analysis of the electricity markets and its potential for integrating V2G, OMIE and Holaluz, Pg 89.

had performed a thorough and complete regulatory framework analysis, of EU and local legislation for the participation of aggregators in the electricity markets in Spain.

The following have been identified as possible barriers that can hinder the V2G implementation of V2G technology in Spain:

1. “Interoperability of the infrastructure: there is a clear need for the development of interoperability standards for communication and control between the different distributed resources (for example, the different brands of electric vehicles, as well as the charging stations and systems).
2. Attributes for EMSP and CPO: also, regarding EV charging regulation, the fact that the figure of the EMSP does not include at all the attributions of a flexibility services aggregator, nor are energy exchanges in the direction from vehicle to grid envisaged or regulated, is a barrier for V2G.”<sup>27</sup> For more details please consult D3.1 Analysis of the electricity markets and its potential for integrating V2G.
3. “Representation in TSO markets: regarding rules for participation in the markets, currently, if the market participant is a representative on behalf of another (direct representation), it must act with the programming unit of the owner of the production or storage facility. On the other hand, if the market participant is a representative in its own name (indirect representation) of installations with an installed capacity greater than 1 MW or groups of installations whose sum of installed capacities exceeds 1 MW, it may act with its programming unit or with the programming unit of the owner of the production or storage facility.

For EV battery aggregation it will be necessary to regulate for the possibility of the aggregator to participate with its own operative unit, regardless of the type of representation.

4. Regulation for storage in wholesale electricity markets: it is necessary to review the regulation and Market Rules.
5. Regulation on flexibility services for DERs: furthermore, there is a need for a definition of the rights and obligations with respect to storage, (for the purposes of this work, distributed storage through EV batteries) of regulated figures, namely, the DSO and TSO, as well as non-regulated figures, such as independent aggregators or energy communities, in relation to their participation in the market.
6. Update of technical codes: from the technical perspective, ITC-BT 52 is the technical instruction that regulates the connection of the infrastructure for the recharge of electric vehicles. This instruction needs to be revised in light of V2G and V2B technological

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<sup>27</sup> D3.1 Analysis of the electricity markets and its potential for integrating V2G, OMIE and Holaluz, Pg 101-102

developments in order to define minimum standards for deployment of recharging facilities which are capable of bidirectional energy flows.

7. Promotion of V2G: finally, from a business model perspective from the aggregator's point of view there will be many different issues to consider when dealing with the value proposition for EV users. For example, under the current VAT regulation in Spain, receiving recurrent income, regardless of its amount, entails the obligation of registration with the tax authority and making quarterly VAT declarations. This administrative burden could easily draw away the interest of a residential EV owner to participate in V2M, especially if the returns from such participation are not very high.”<sup>28</sup>

## V2G infrastructure costs, regulation and technological barriers

Deliverable 3.1 Analysis of the electricity markets and its potential for integrating V2G makes a thorough analysis on the current EU and Spanish regulation regarding the recharging infrastructure, as such the same data will be used in this Deliverable.

**“The EU and Spanish regulation related to recharging infrastructure is the following:**

| Regulation   | Description  |
|--|--|
| <b><i>Directive 94/2014 on the deployment of alternative fuels infrastructure</i></b>  | Sets a common framework of measures for the deployment of an infrastructure of alternative fuels with the aim of achieving long-term oil substitution in transport.  |
| <b><i>Regulation (EU) No 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network</i></b> | Sets the guidelines for the creation of a Trans-European transport network with the aim of promoting the growth and cohesion of member states. This transport network is based on the principals of efficiency and sustainability, aiming to achieve a significant reduction in CO2 emissions. |

<sup>28</sup> D3.1 Analysis of the electricity markets and its potential for integrating V2G, OMIE and Holaluz, Pg 101-103

**Royal Decree 639/2016 establishing a framework of measures for the implementation of an infrastructure for alternative fuels**

This Royal Decree transposes into Spanish legislation the provisions of Directive 94/2014. However, this regulation falls very short in ambition, providing no specific commitments and only some very general guidelines regarding infrastructure for alternative fuels, including recharging points for electric vehicles and refueling points for natural gas and hydrogen.

### Regulation

### Description

**Royal Decree 1053/2014 passes a new Complementary Technical Instruction, ITC-BT-52 “Facilities for special purposes. Infrastructure for recharging electric vehicles”**

This Technical Instruction regulates from the electrical point of view the connection of the infrastructure for the recharge of electric vehicles.

**Royal Decree 647/2011 which regulates the load manager activity of the system for the performance of energy recharge services**

This Royal Decree has been practically all repealed by Royal Decree-Law 15/2018, which eliminated the load manager figure and thus liberalized the provision of recharge services. Still in force are the additional and final dispositions which regulate tolls.

**Royal Decree 15/2018 of urgent measures for the energy transition and the protection of consumers**

Repeals most of RD 647/2011 and simplifies the regulation on energy recharge services.

**Royal Decree Law 24/2021 for the transposition of EU Directives. Directive 2019/1161, on the promotion of clean and energy-efficient road transport vehicles is transposed**

It transposes Directive 2019/1161 into Spanish legislation. This regulation establishes emission thresholds for the public sector when purchasing road transport vehicles which are set at 0 g CO<sub>2</sub> /km from January 1<sup>st</sup> 2026.

***Royal Decree-Law 29/2021 by which urgent measures are adopted in the energy field to promote electric mobility, self-consumption and the deployment of renewable energies***

This Royal Decree-Law modifies art. 48 of ESL defining the scope of the energy recharging service. Also, it simplifies the requirements and duration for obtaining authorizations for installing recharge infrastructure on roads and in municipalities<sup>29</sup>.

| Regulation  | Description  |
|---|--|
| <p><b><i>Royal Decree 184/2022 which regulates the activity of providing energy recharging services for electric vehicles</i></b></p> | <p>This regulation develops article 48 of the ESL by setting the requirements for the provision of energy recharging services for electric vehicles. It introduces for the first time in Spanish regulation the figures of Charging Point Operators and eMobility Service Provider.<sup>30</sup></p> |

In the economic viability model the data used when it came to the cost of V2G infrastructure were the one provided by the consortium partners and also based on the Market study and data provided in D3.1 Analysis of the electricity markets and its potential for integrating V2G in the Figure 2 “prices are dropping faster than projected but still vary depending on power ratings for example for V2G from 7 kW to 150 kW.”<sup>31</sup>

<sup>29</sup> D3.1 Analysis of the electricity markets and its potential for integrating V2G, OMIE and Holaluz, Table 4 - Regulation in Europe and Spain regarding recharging infrastructure, April 2022, Pg 37-39)

<sup>30</sup> Ibidem, Table 5 Regulation in Europe and Spain regarding recharging infrastructure, April 2022, Pg 39.

<sup>31</sup> Ibidem, Pg 27-28

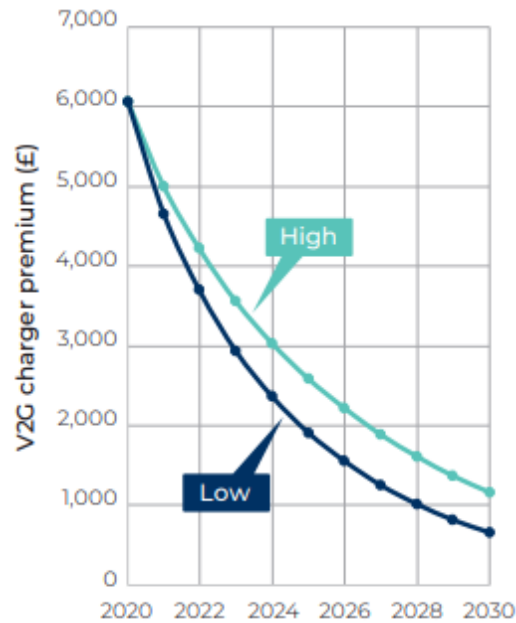


Figure 2 Projected V2G charger premium price<sup>32</sup>

Regarding the EV deployment the ICCT (International Council of Clean Transportation) in a published study predicts that by 2030 approximately 69% of EV owners will charge their EV at home, this translates into approximately 3.45 M residential charging points in Spain. The forecast made by the Spanish Association of vehicle manufacturers regarding the public charging infrastructure is that of 360.000 public charging points by 2030.<sup>33</sup>

Due to the high number of electric vehicles a shift in “the residential demand curve may generate potential risks to grid congestion caused by peak hours due to EV charging.”<sup>34</sup> “Uncoordinated charging demands of EVs increase the load during peak hours, which in turn has a negative impact on the stability of power grids due to its sizable rating. Typically, an EV draws approximately 7 kW power from the grid, which is significantly higher than the peak demand of most of the residential households. Moreover, EV owners tend to charge their EVs after returning from work, which is also usually the time of peak demand in the grid, thereby coinciding with the power drawn from EV and household peaks. This scenario leads to a significant increase in system peak demand and threatens the stability of the power grid.”<sup>35</sup> This is why the V2G concept is crucial in supporting of the grid and increased energy demand.

<sup>32</sup> D3.1 Analysis of the electricity markets and its potential for integrating V2G, OMIE and Holaluz, Figure 8 - projected V2G charger premium price, Pg 27-28

<sup>33</sup> Ibidem, Pg 84.

<sup>34</sup> D3.1 Analysis of the electricity markets and its potential for integrating V2G, OMIE and Holaluz, Figure 8 - projected V2G charger premium price, Pg 84-85

<sup>35</sup> Ibidem Pg 84-85.

The integration of renewables is increasing exponentially in Spain, according to the Spanish Energy and Climate Plan 2021-203, by the year 2030- 42% of the energy must be renewable, in order to reach the abatement targets of the greenhouse gas emissions.<sup>36</sup>

“The largest increase in installed power technology corresponds to solar PV generation [...] Solar generation begins to decline in the afternoon when electricity demand begins to increase. This means that the necessary increase or ramp of conventional production in the afternoon and evening hours will be much more accentuated. This leads to the fact that, if there is no flexibility available such as storage, demand-response or bidirectional EV the rest of conventional technologies, must quickly enter in the mix generating electricity during those hours, causing prices to rise at those periods of the day and generating a large price difference between the central hours of the day and peak price hours. However, this scenario can be avoided thanks to the change in consumers behavior, the introduction of the bidirectional electric vehicle, the adoption of demand response strategies and the incorporation of storage systems.”<sup>37</sup>

## 5. Conclusions-Economic Viability

### The scenarios

The calculations to assess economic viability model were made on a 10 000 km/ year of driving range for an EV owner of a Nissan Leaf (40 kWh) **vs** a diesel vehicle owner of comparable model- Volkswagen Golf VI and EV owner of a Nissan Leaf (40 kWh) **vs** and EV owner of a Nissan Leaf (40 kWh) with V2G services integrated.

The items taken in calculation were:

- Initial investment: EV cost, charging infrastructure cost with installation
- Operating costs: fuel/electricity
- Service/maintenance fees- tires, consumables
- Depreciation
- Fixed costs: Insurance, road tax and other mandatory costs
- Residual value after 7 years (70000 km)

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<sup>36</sup> D3.1 Analysis of the electricity markets and its potential for integrating V2G, OMIE and Holaluz, Figure 8 - projected V2G charger premium price, Pg 84-85

<sup>37</sup> Ibidem.

- Total cost of car ownership per month
- Savings: cost per km Fuel vs EV
- Total cost of ownership per km
- Net Savings Petrol vs EV
- Net Savings EV vs EV +V2G
- Payback time period
- Net Present Value

The above mentioned items are present in the base case scenario calculations, however in the rest of the 5 scenarios the following 2 items have been introduced in order to include the Electricity price variation (high, low, stable) **New energy cost for 10 000 km range p.a.** and **Back out energy cost** and 2 items have been included to enable the battery price variations **Back out battery constant at average cost** and **Insert battery cost according to scenario** (high and low, base case).

### **Electricity price stability with stability of EV battery prices (1)**

When comparing 2 cars of a similar power and volume class, we decided to compare the base Golf VI with the Nissan Leaf both being a hatchback for up to 5 passengers, with 110 kWh power and both being able to exceed the legal speed limit in Europe.

Whilst the operating cost of the 2 types of vehicle could be considered similar, the resale value of the Nissan is much lower, this means a higher amortization rate for the Nissan. However, this is a general trend in the EV market at present, as at present, the battery represents something of an unknown factor in the second-hand EV market, hence pushing down on values, which generally will prevail until more data is available of life expectancy batteries. As such there is no possibility to calculate a payback or NPV for this case.

The second case is the comparison of the Nissan Leaf in a V2G environment and one without V2G capability, but only V2H or V2B. We based on the data received for our consortium partners we have assumed the cost of 2305<sup>38</sup> euro with installation for a bidirectional charger

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<sup>38</sup> Including the current subsidies in Spain (of maximum 70% capped at 5000 euro). The study assumed 60% subsidies in the calculation on the bidirectional charger.

and 4584<sup>39</sup> Euro with installation for bidirectional charger that is V2G capable including software<sup>40</sup>. This is an important cost item, as such with the price of infrastructure decreasing, the total cost of ownership of the EV's without V2G should be a lot lower than the one of the fuel vehicles.

Here the finding is that the V2G participating car, assuming a discount rate 5,5% which is assumed based on the Spanish risk-free rate of return of presently 2,5% majorated by 300 BPS to reflect the private borrowing premium, would generate over a 7-year period an NPV of 1553,76. This then equates to a payback of 3,379 years.

This in turn would mean, assuming 10 000 km driven p.a. that the pure operating cost of the EV (with V2G capability) would be app. 19 Euros per month vs. 40 euro in the case of the EV without such capabilities<sup>41</sup>, which is not a negligible amount when compared to a median household income of 28 365 Euro p.a. in Spain in 2021.

Whilst our calculation ends after 7 years and considers that the vehicle is disposed and charger are disposed as well, this is a highly unrealistic scenario, as any EV owner will purchase a new EV, which in-turn will be using the already written off charging infrastructures, which in-turn will greatly improve the return numbers going forward.

As a general comment which is valid for all the different scenarios is that the NPV and the payback time do not change in value to do the relationship between the EV and EV with V2G capability which is more or less constant if the income from the V2G does not increase significantly. Regarding the total cost of ownership per month as it is presented in Table 2, the closest total cost of ownership to the VW Golf VI is the low battery price and low energy price. The next scenario that is close to the total cost of ownership to the VW Golf VI is the 'low battery/stable electricity price', which underlines that the more the battery price will drop the more attractive the business proposition will be. This analysis is limited to the case of the EV owner, as such these calculations underline the EV owners' benefit, and not the possible gains of the other stakeholders such as aggregators. By entering into an agreement with an

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<sup>39</sup> The cost of the bidirectional charger included the current subsidies in Spain (of maximum 70% capped at 5000 euro). The study assumed 60% subsidies in the calculation on the bidirectional charger. The cost for the V2G capable Nissan is higher because it comprises 2 chargers, in both private and business location in order to be able to maxims the V2G financial benefits.

<sup>40</sup> [https://wallbox.com/en\\_catalog/quasar-dc-charger](https://wallbox.com/en_catalog/quasar-dc-charger)

<sup>41</sup> The difference between the two numbers is given by the V2G "income" generated.

aggregator the EV owner will possibly lock in an energy price and not really take advantage directly of any of the energy price fluctuations.

Table 2 Comparison on the Total Cost of Ownership<sup>42</sup> based on the 6 scenarios (without including EV subsidies in the acquisition cost)<sup>43</sup>

| Total cost of car ownership per month                 |            | Standard         | V2G capable      |
|---|------------|------------------|------------------|
|   | VW Golf VI | Nissan Leaf 40kw | Nissan Leaf 40kw |
| Base case (Stable battery price /Stable energy price) | € 482,04   | € 554,50         | € 498,30         |
| Low battery price/ Low energy costs                   | € 482,04   | € 541,25         | € 485,05         |
| Low battery price / High energy cost                  | € 482,04   | € 549,89         | € 493,68         |
| High battery. price / Highy energy cost               | € 482,04   | € 561,44         | € 505,24         |
| Base case battery price / Low energy cost             | € 482,04   | € 552,80         | € 496,60         |
| Low battery price/ Base case energy cost              | € 482,04   | € 542,95         | € 486,75         |
| Base case battery price / High electricity cost       | € 482,04   | € 561,44         | € 505,24         |

Table 3 TOC of different scenarios on EV with V2G scenarios (without including EV subsidies in the acquisition cost)

| EV with V2G               |            |          |          |          |          |          |
|---------------------------|------------|----------|----------|----------|----------|----------|
| Total Cost of Ownership € | € 498,30   | € 486,75 | € 505,24 | € 493,68 | € 496,60 | € 485,05 |
| NPV                       | € 1.553,76 |          |          |          |          |          |
| Payback time              | 3,38       |          |          |          |          |          |

In Table 3 the data presented is a summary of the numbers of the monthly Total cost of ownership of the EV with V2G capabilities. The numbers are clearly underlining that the best-case scenario for the EV owner is the low electricity price combined with a low battery price, followed closely by the stable electricity price with a low battery cost.

<sup>42</sup> The TCO for the Standard Nissan Leaf is actually presenting the case of a Nissan Leaf with V2H/V2B capabilities

<sup>43</sup> No subsidies for the acquisition of the EV was included in the calculation. For more details go to Assumption 4 of this report.

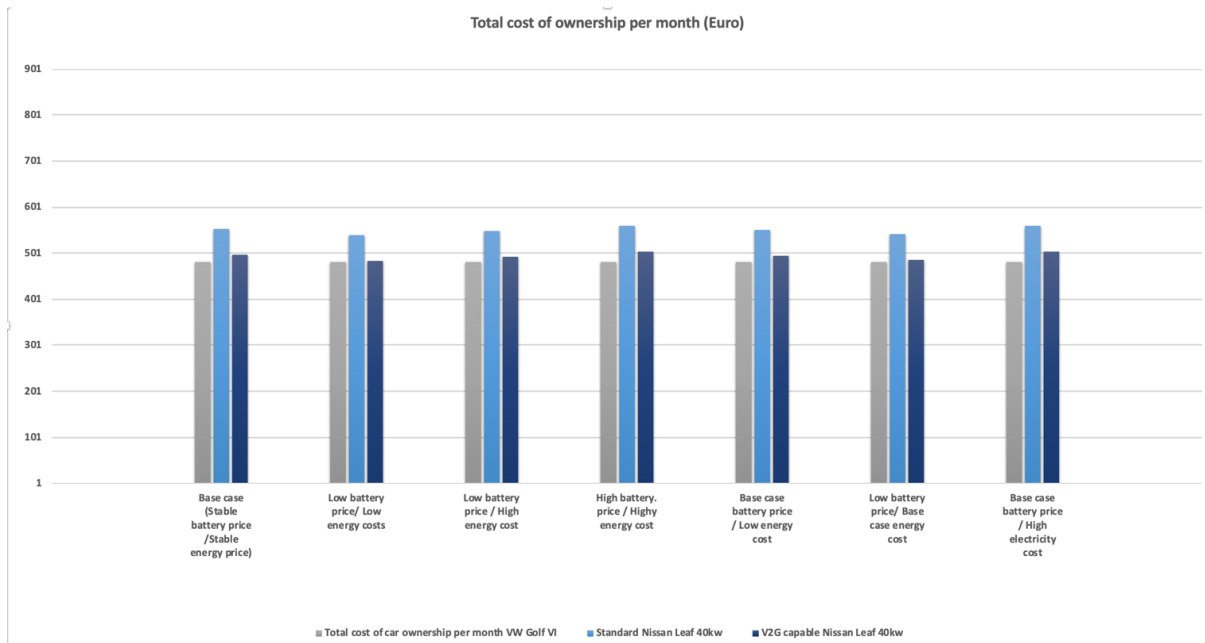


Figure 3 Total cost of ownership per month comparison between VW Golf vs Nissan Leaf vs Nissan leaf with V2G

As Figure 3 shows the difference between the TCO per month between EV with V2G capabilities and an ICV in 2 of the scenarios analyzed is insignificant. Which in turn means that if the infrastructure cost would decrease then the TOC per month for the EV with V2G capabilities would be a far more attractive financial proposition in the future compared to an ICV.

### Electricity price stability and with decrease of battery price (2),

This scenario is the second best due to the substantial decrease in the battery price between 2019 from 216 euro per kWh to 130,69 euro per kWh in 2021. As such the lowest price in battery combined with an electricity price is an interesting scenario for the EV owner.

### Electricity price increase with stability of EV battery prices (3),

The electricity element is the one that affects the total cost of ownership (per month and per km) significantly, as such if the cost of battery is constant, and the electricity price goes up then there is an increase of the total cost of ownership. This scenario is the one that has the highest cost of ownership which underlines how important the increase in the electricity price is for an EV owner even if the battery price remains stable.

### Electricity price increase and with decrease of battery price (4)

The electricity element is affecting the total cost of ownership of the EV owner (per month and per km) significantly, as such if the cost of battery is lower, and the electricity price goes up then there is an increase of the total cost of ownership, even if the battery cost is lower. From a total cost of ownership perspective this scenario is the 3<sup>rd</sup> most favorable, which means it is more advantageous than the stability one (stable price for both items – battery and electricity) and it is a better scenario compared to the electricity price increase with stable battery price evidently. For the aggregator an increase in electricity price could mean an increase in their income from V2G, however this might not spill directly in the financial benefit of the EV owner, because the agreement that they will enter with an aggregator would mean a locked energy price.

### Decrease of electricity prices, with stability of EV battery prices (5),

From a total cost of ownership (per month and per km) this scenario is still more advantageous than the stability one (stable price for both items – battery and electricity). The interesting reflections that come out of this scenario is that compared to the one in which the electricity price is stable and battery price decreases this scenario is 10 euro more expensive per month in the total cost of ownership than the scenario 2.

### Decrease of electricity prices and with decrease of battery price (6)

This is the best-case scenario in terms of cost of ownership of the EV vs ICV and also between EV vs EV with V2G capabilities. Which makes the case for the addition of PVs in the proposal to continue to decrease the cost of energy on the EV owners side and be able at the same time to be a more attractive “partner” for an aggregator due to the energy generated from the PV. This aspect will be explored in the next tasks that are part of WP4 including a servitization scheme related to the ownership of the battery.

The various economic models analyzed in this report have shown that;

- The key in the total ownership cost picture is the **presently much higher depreciation of EV's vs. fossil fuel vehicles.**
- Whilst the battery cost is a key element in the electric vs. fossil fuel powered vehicles calculation, however by running the different scenarios is evident **that the cost of the**

**energy used to power vehicles is a far more important cost item making the case for home generated PV electricity.**

## 6. Further considerations

The energy transition is a complex “problem” to solve, having to do as much with affordability as this report has shown, but at the same time it has to do with social and human factors which are very often underestimated.

In the context of climate change, humanity is standing at a grave impasse as the tools that are at our disposal are not enough:

- Nuclear power, although was declared a transitional energy source by the EU Parliament in the EU Taxonomy, during summer month when the rivers are either too warm or run too low to cool reactors or when there is a drought (which is currently the situation worldwide) it is not optimal to use– which in “ultima ratio” means, that such generation capability will need to go off grid.
- The same is true for the most sustainable “hydropower”. When a river or a reservoir runs low, then the energy generation capability is substantially reduced.
- Furthermore, whilst not forming part of this report, it becomes implicitly clear that **for V2G purposes, the EV model which will ultimately store the energy is irrelevant.**
  - a kWh of storage capacity i.e, battery in a Tesla or in a Nissan Leaf is having similar production costs
  - key is the ability to provide for the aggregator a predefined timeframe of around 14 hours to maximize the V2G services and still be able to manage the own consumption of households.
- Even more, whilst not being in the scope of this particular report one conclusion is that **V2G needs to be linked with PVs in order to be able to maximize the entire process of storage capacity and grid balancing and become a reasonable proposition for the users.**

The reality is however, that the grid providers even if they would the needed funds available to upgrade the grid they are still looking at capital allocations as every commercial enterprise and might prefer solutions which are less capital intensive than a grid upgrade, and V2G is a

fast and relatively cheap solution. Even if it would go for a grid expansion, the timing mismatch between today's available sustainable production capacity and those capabilities which are coming online shortly and the grid capability will aggravate further, calling for rapid solutions. It takes considerable amount of time to upgrade the net, all having to do with the various approval processes followed by lengthy construction timelines<sup>44</sup>.

This will further be aggravated by the EU's recently approved shortened approval timeframe for new PV installations and even more, the new regulation to mandatorily equip buildings with solar generation capability<sup>45</sup>, which will in turn worsen for the next 10 to 15 years the mismatch between generation and consumption. This in turn will push the grid even further to its limits, and calling for rapid storage solutions. The easiest solution would be using EV's batteries particularly as cars are parked for 95% of their time<sup>46</sup>.

Simply put, the grid will not be able to balance the mismatch between sustainable energy generation and the time when this energy will be consumed. V2G is one of the immediately available solutions, and one which can be implemented relatively fast subject to connection capabilities, which in turn will help in smoothing the bumps between generation and consumption going forward.

Whilst clever management and balancing between hydro and solar & wind has a lot of merit, solar and wind will not be able to function properly if the storage issue is not resolved, and here V2G has a significant role to play.

Vehicle-to-Grid (V2G), as demonstrated by various scenarios, has the potential to bridge the affordability gap for the average consumer. In fact, it can even outperform traditional petrol-driven cars, a significant and pivotal achievement in the context of the energy transition. This outcome addresses a crucial element in making electric vehicles (EVs) more accessible and attractive to a wider range of consumers

The concern for the world that future generations will inherit is not limited to the affluent individuals who can afford luxury electric vehicles. Even the medium to low-income population,

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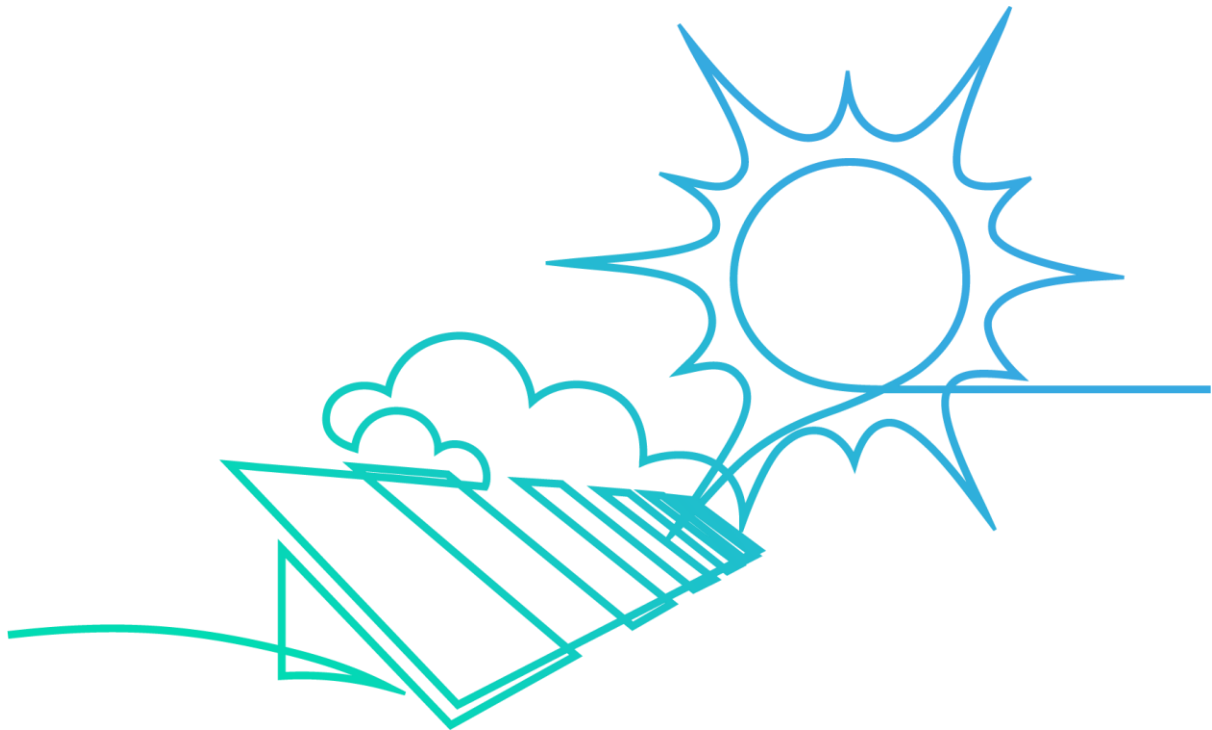
<sup>44</sup> Cleantechnica, <https://cleantechnica.com/2022/08/04/the-u-s-power-grid-added-15-gw-of-capacity-in-1st-half-of-2022/#:~:text=Clean%20Power-,The%20U.S.%20Power%20Grid%20Added%2015%20GW,in%201st%20Half%20of%202022&text=The%20US%20power%20grid%20is,the%20first%20half%20of%202022>.

<sup>45</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A221%3AFIN&qid=1653034500503>

<sup>46</sup> Unparking, MIT study, <https://senseable.mit.edu/unparking/>

who can manage to invest in more affordable options such as a Nissan Leaf or second-hand electric vehicles, share the same deep-seated worries about the world they will pass down to their offsprings.

V2M with all participants acting together for a better world has the ability to rapidly bridge the gap between sustainable energy generation and the consumption thereof, which in turn, by smoothing out the peaks and troughs is able to reduce the overall energy costs for everyone, whilst rewarding the storage owners for their willingness to do so. What easier than allowing access to the battery of an EV in a risk fenced business model with a fair reward. It however means that the various actors need to be transparent, and create a fair business model. It's imperative for all stakeholders in the energy market to recognize that we are collectively embarked on the same journey. To navigate the complexities of the energy transition effectively, mutual support and collaboration are essential. Embracing a spirit of cooperation is key to achieving successful outcomes and ensuring a smooth transition to a more sustainable energy landscape.



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