Innovative Vehicle to Grid model for electric mobility deployment in Europe

Project acronym *(eVolution2G - V2G)*

Start date of project: 1st June 2018 Duration: 24 months

D3.1 – High level analysis of V2G future impact on the DSO network and energy markets

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Summary

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1 INTRODUCTION

The objective of this deliverable is to give an overview of future technological, technical and financial/economic impacts of Vehicle 2 Grid on energy networks (mainly MV and LV networks managed by DSOs) but also, thanks to new technical legislation on demand side management and demand response at energy markets levels in several European countries, on dispatching and ancillary markets.

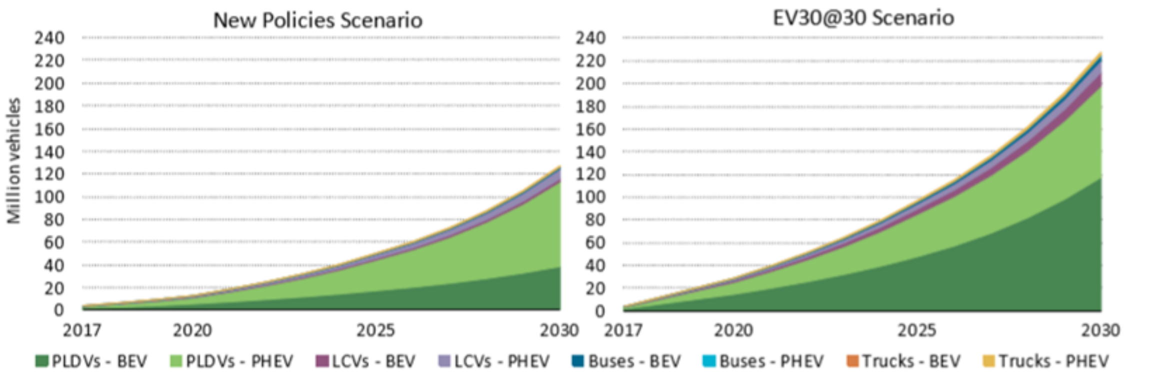
After an overview of current EV rollout scenarios and related energy and power impacts on the energy systems, the document will analyze possible benefits coming from "smart charging" and V2G solutions for peak shaving and shifting but also other services to networks and markets.

2 EVS & ENERGY

2.1 2.1 DATA AND PROJECTIONS OF EV SALES, BOTH SHORT TERM AND LONG TERM.

Global EV sales are growing at a very fast rate, we all know this, but it is of absolute importance to know the magnitude of this growth with accurate projections in order to develop an efficient set of scalable solutions to the challenges this new segment presents. As of 2017, the global stock of EVs worldwide amounted to 3,7 million units (excluding two- and three wheelers), but there's no real consensus for the long term growth of the worldwide sales. Using two different reports as an example[1], we can see that the differences in the projections are pretty consistent, up to 100 million units difference[2]:

Figure 6.1 • Global EV stock by scenario, 2017-30



Notes: PLDVs = passenger light duty vehicles; LCVs = light commercial vehicles; BEVs = battery electric vehicles; PHEV = plug-in hybrid electric vehicles.

Chart 1, IEA Analysis developed with the IEA Mobility Model (IEA 2018).

While the New Policies Scenario projects a global stock of EVs of 13 million units by 2020 (up from 3,7 million in 2017) and nearly 130 million vehicles by 2030 (always excluding two- and three-wheelers from the equation), the EV30@30 Scenario projects a global stock of EVs that it's nearly double of the New Policies Scenario's figures, a rather optimistic point of view. Concerning yearly sales figures, the total new EVs in the market will amount to roughly 4 million in 2020 (3 times more than in 2017) and this figure will grow up to 21,5 million by 2030. This corresponds to a 24% average year-on-year sales growth over the projected period, per the New Policies Scenario. On the other hand, looking at the final figures of the graphs, the EV30@30 Scenario projects a global stock of 228 million EVs by 2030, which is roughly 100 million more than in the New Policies Scenario by the same year. In order to achieve this lofty electrification goals, a strong policy support is as vital as the technology advancement and the

[1] New Policies Scenario Report and EV30@30 Scenario.

[2] IEA Mobility Model analysis, in IEA Global EV Outlook, 2018, pag. 78.

investments in the necessary infrastructures.
Let's have a quick glance at the past development of just the European market before we move on. The growth is steady and is spiking up, especially in the BEVs, reaching 2 years ago more than 230.000 units overall (with more than 110.000 fully electric vehicles).

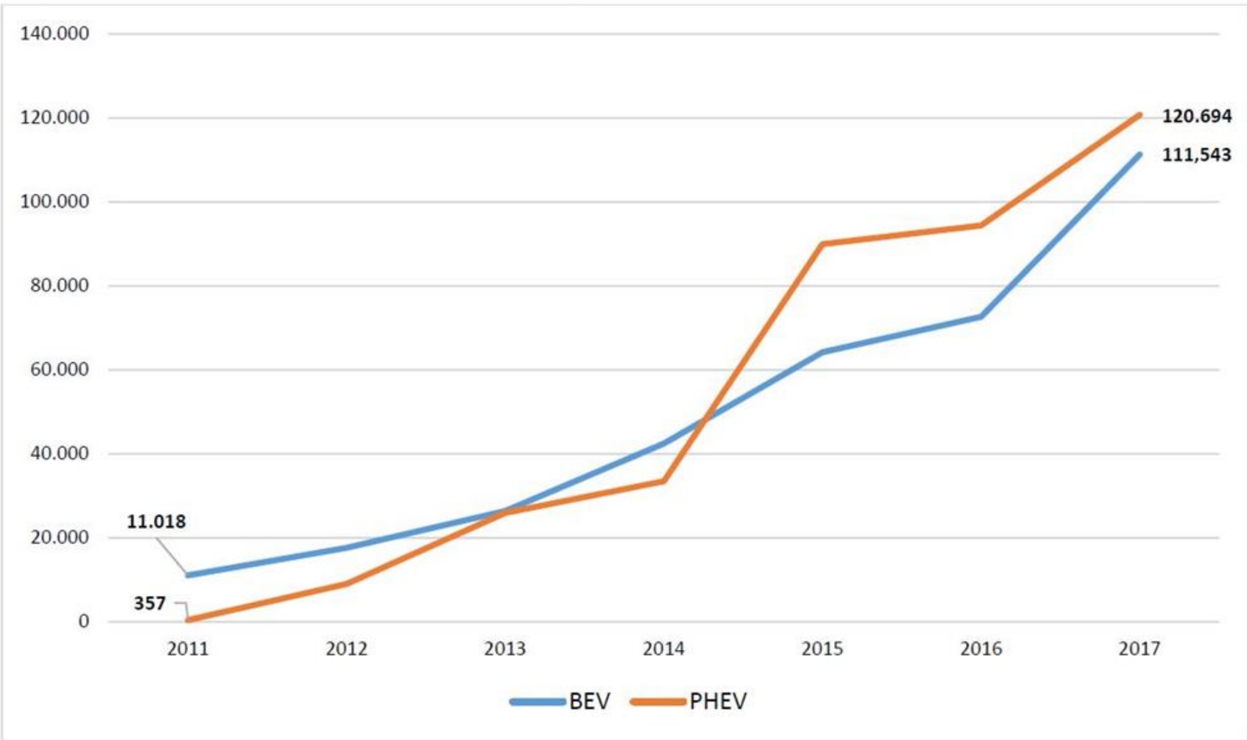


Chart 2, BEV - PHEV comparison.

With these figures in mind, let's shift our attention to a more important topic for our deliverable, and that's the impact of these numbers on the pre-existing energy infrastructures operated by the various utilities across the world.

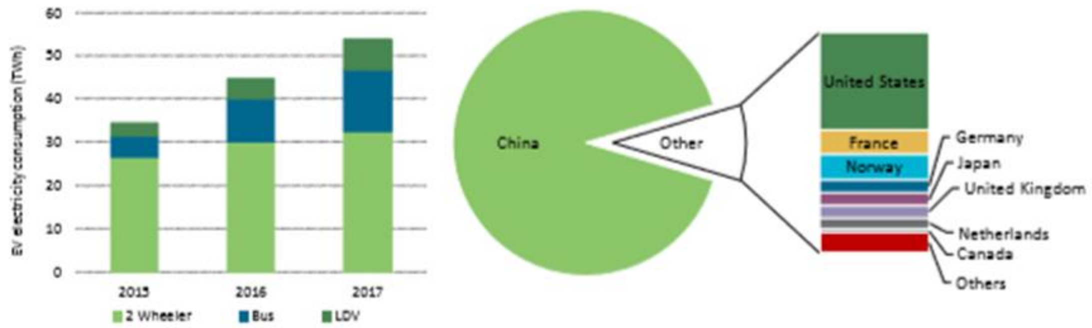
2.2 GLOBAL EV ENERGY CONSUMPTION AND THEIR IMPACT

Concerning the impact of electric EVs on the global energy consumption numbers, there is a general consensus that, while it would undoubtly increase the values of gross consumption, a massive increase in EV recharging would only slightly affect the figures. By 2035, Sebastian Gruter, James Moore &, Capital Goods Research[3] estimate only a 3% global electricity demand increase, roughly a 0,2 annual growth, which is really manageable by the utilities, especially when one considers the general increased efficiency

[3] "Capital Goods: Exit, Pursued by a Bear", Sebastian Gruter, James Moore &, Capital Goods Research, Redburn, London, July 2018.

in power consumption that will naturally come with the technologies' progress. This report underlines one of the main critical points that we'll discuss later on in this deliverable, and that's peak time energy consumption, but more on that later. As far as figures go, current data has the annual global energy consumption for EVs at a modest 54 TWh[4] (2017) and that's predominantly because of the really developed chinese market, which takes about 91% of this number[5]

Figure 4.1 • Total electricity demand from EVs by country, 2017



Notes: TWh = terawatt-hours. The pie chart refers to 2017 data. The assumptions are: passenger vehicle consumption 20-27 kWh/100 km, annual mileage 8 500-18 800 km; two-wheelers consumption 3-5 kWh/100 km, annual mileage 5 900-7 500 km; electric urban bus consumption 135-170 kWh/100 km, annual mileage 28 000-47 000 km, (the range indicates the variation across countries). The share of electric driving for PHEVs is assumed to be 36% of the annual mileage. Charging is assumed to have an efficiency of 90%.

Chart 3, IEA analysis based on country submissions.

The projected figures long term assess themselves at about 1.800TWh by 2040, per the aforementioned report[6], a figure that amounts only to 5% of the projected worldwide gross electricity demand of 2040[7]. As massive as this growth might seem, it's really not that challenging from a gross production perspective, and that's because of the well-known efficiency of the EVs compared to their ICE-powered counterparts.[8]

[4] IEA analysis based on country submissions, 2018.

[5] IEA Global EV Outlook 2018.

[6] *Ibidem*.

[7] Between 2035 and 2040 we can observe a 2% increase in global electric energy consumption directed towards EV recharge. These 5 years should be the most intense in terms of EV impact growth.

[8] The increased efficiency and general energy savings totally justify this slight increase. The resources should be directed towards more electric energy production, but nonetheless there will be countless beneficial effects with this transition.

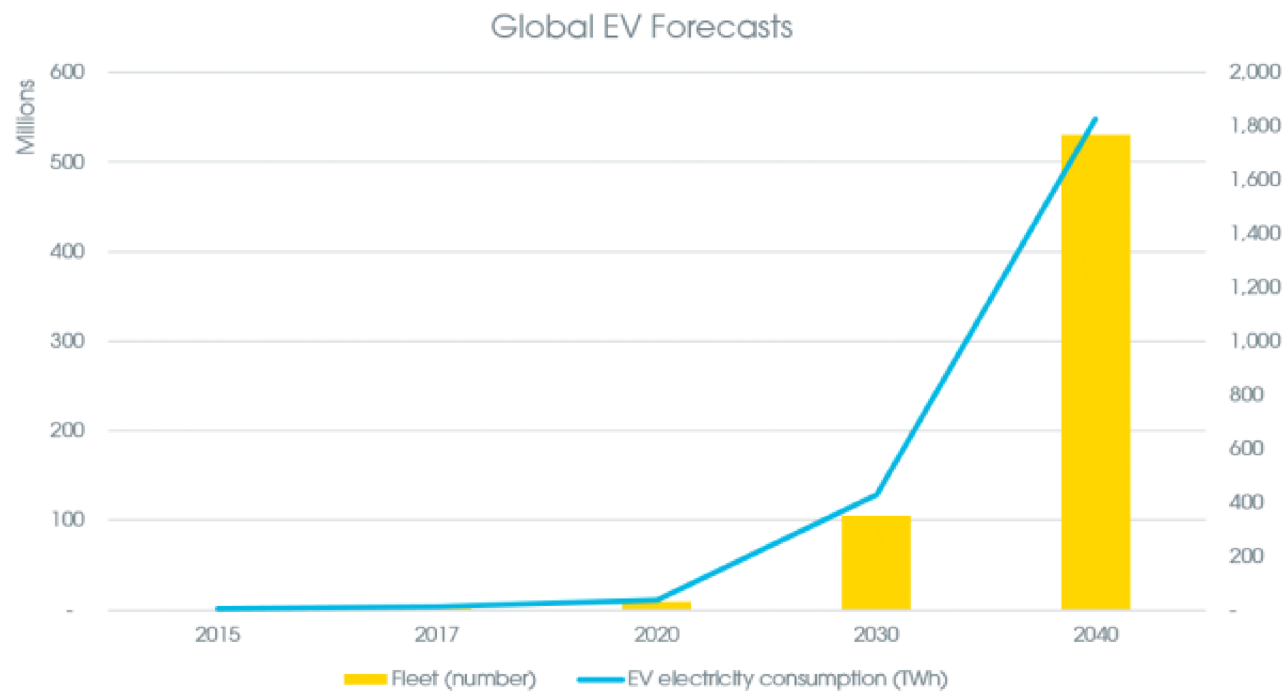


Chart 4, Source: Bloomberg New Energy Finance Report.

So far we have been through some general, or we should rather say global numbers, but let’s dig a bit further in the small figures that each EV brings as energy demand to the grid. According to the Canadian award-winning information and technology company Fleetcarma[9], the average EV who covers 40 km per day[10] needs 6-8 KWh to be recharged[11] (depending of course of their range capabilities), and that’s about the same energy consumption of a small household[12], effectively doubling the local grid’s needs in terms of energy and probably creating some issues in terms of grid stability if charging occurs at peak hours. Professor Mohammed Beshir of the University of Southern California confidently states that: «The utilities have plenty of time to plan ahead, […] If each home on a block gets one electric vehicle, that’s probably equivalent to double that block’s existing power load[13].» and the critical point will be reached when more than 15% of the running vehicles will be fully electric. So without further ado let’s focus our attention on the impact that EVs have on the grid.

[9] https://www.fleetcarma.com/impact-growing-electric-vehicle-adoption-electric-utility-grids/

[10] A rather long commuting distance, by European standards at least.

[11] Every day, on average, in order to be fully charged. The energy demand for a full 0-100% charge is obviously more.

[12] Source: https://www.fleetcarma.com/impact-growing-electric-vehicle-adoption-electric-utility-grids/

[13] From Mr. Beshir’s WIRED interview: https://www.wired.com/story/electric-cars-impact-electric-grid/

3 EVs & DSO GRIDS

3.1 CURRENT CHARGING INFRASTRUCTURES AND RECHARGING MODELS

Most of the charging in the current EV landscape, about 80%, is absorbed by private charging, either in parking lots, garages or in office buildings[14], and things shouldn't really change that much in the future, mainly because of the short distances that the average European commuter covers on a daily basis (between 20 and 80 km per day). Low speed AC charging is the most common fixture, as most of the recharges, predictably, occur during night time, so the energy needed to recharge the vehicle is diluted through many hours, as the average battery pack of a BEV approximately needs from 6 to 10 hours in low speed AC charging in order to be fully recharged.

TYPE	RAPID CHAdeMO or CCS	Type 2 - FAST T2	Type 1 - STANDARD T1	Type 1 - PORTABLE T1
Power Supply				
Rate of Charge	300 km / hr	25 - 150 km / hr	25 – 50 km / hr	12 km / hr
Max Rate of Charge	50 kW / 3 Phase 80 amps	22 kW / 3 Phase 32 amps	10 kW / 40 amps	1.5 kW / 8 amps
$ / hr @ 20 c/kWh	Billed at 25 c/kWh + 25 c/min	$0.70 - $4.20 / hr	$0.70 - $1.40 / hr	$0.30/ hr
Location	Public	Public Commercial Private	Public Commercial Private	Private

Chart 5, Most common charging standards in the World, Tesla not included.

[14] A. Wargers, J. Kula, F. Ortiz De Obregon, D. Rubio, *Smart charging: integrating a large widespread of electric cars in electricity distribution grids*. EDSO technology committee, march 2018.

	Battery Size	Charge Time from 0%			
9 kWh	Audi e-Tron			3 hrs	6 hrs
22 kWh	BMW i3			6 hrs	12 hrs
7 kWh	BMW i8			2 hrs	6 hrs
17 kWh	Holden Volt			4 hrs	6 hrs
12 kWh	Mitsubishi Outlander	< 10 min to 80%		3 hrs	6 hrs
22 kWh	Nissan e-NV200 Van	< 20 min to 80%		6 hrs	12 hrs
22 kWh	Nissan Leaf	< 20 min to 80%		6 hrs	12 hrs
9 kWh	Porsche Cayenne			3 hrs	6 hrs
22 kWh	Renault Kangoo Van	< 20 min to 80%		6 hrs	12 hrs
22 kWh	Renault Zoe			2 hrs	12 hrs
90 kWh	Tesla Model S	< 90 min to 80%	4 hrs	11 hrs	56 hrs
90 kWh	Tesla Model X	< 90 min to 80%	4 hrs	11 hrs	56 hrs

Chart 6, Charging times depending on the adopted standard (see chart 5).

As of now, the basic preexisting infrastructures do not seem powerful enough to fully guarantee an adequate support for the EV market growth and its potential both in terms of ecological impact and possible economic revenues. Because of the previously mentioned current recharging methods, mostly low voltage and domestic, the DSO operators will have to manage carefully the low voltage distribution networks, who could be challenged in terms of peak time power management. Because of the expensive nature of diffused upgrades throughout the whole distribution networks and grid reinforcements, we should now take a more detailed look at the on-grid impact of EVs in order to assess the importance of innovative solutions concerning the EV recharging topic.

3.2 DSO AND GRID PROBLEMS CAUSED BY EVs DIFFUSION

What are the biggest risks involving the interaction between many EVs and a standard electric grid? If no real load management measures are applied, a large amount of the distribution system would have to be strongly upgraded: transformers, feeders, etc.[15] First and foremost, EVs seem to affect the weak link of the big picture, and that's the power transformers who deliver the grid's energy to the various applications. Using the USA system as a comparison, we can observe that the transformers in danger of overloading if every household doubles their electricity needs, a scenario that could easily happen according to numerous sources[16]. Per Fleetcarma: «If multiple electric car owners use the same distribution transformer (such situation is referred to as clustering), they may cause damage or outages from overloading the equipment or by shortening their normal cool-down period. A single overloaded transformer can, in turn, degrade power quality in other residential feeders. Some studies suggest that higher penetration rate of electric vehicles increase transformers' loss-of-life factor, even by up to 10,000 times. And this comes with a hefty price tag. The Sacramento Municipality Utility District, for example, has recognized that about 17% of the company's transformers may need to be replaced as a result of EV-

[15] Ivi, pag. 10.

[16] See: note 13, 14.

related overloads, at an average estimated cost of $7,400 per transformer.[17]». If there was an instant switch from all existing vehicles to EVs, the annual increase of electric consumption would assess itself around 30%[18]. The EDSO report resonates Fleetcarma's gloomy scenario and stresses out the possible impact at the low voltage level (houses), where the large additional load that comes from the EV charging would add a steep increase in overall energy consumption. This scenario would cause, in the case of multiple households having to recharge their EVs simultaneously (for instance during the evening), to the ineluctable need to reconfigure the whole residential grid, and that's not even factoring the quality issues that might come up[19]. In Europe, where the average electric network is more powerful and stable than in the USA[20], the need of replacement figures would probably be much lower than the 17% previously mentioned. A true game changing solution would be the heavy implementation of VPPs, where the EVs also play an important role as decentralized ESS systems.

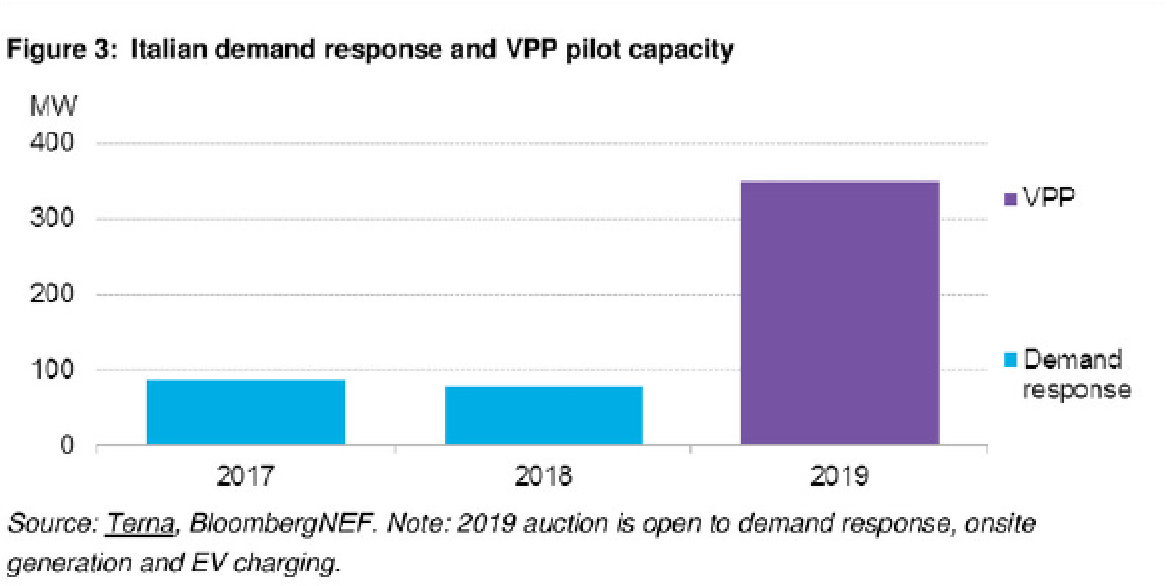


Chart 7. Source cited above.

As shown by the graph above, the pilot capacities of the two main alternatives for traditional DSO networks are still very small in terms of energy output, but should rapidly grow into a solid energetic reality.

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[17] https://www.fleetcarma.com/impact-growing-electric-vehicle-adoption-electric-utility-grids/

[18] That's an estimation for the USA, but the number should be pretty close to even for European countries.

[19] A. Wargers, J. Kula, F. Ortiz De Obregon, D. Rubio, Smart charging: integrating a large widespread of electric cars in electricity distribution grids. EDSO technology committee, march 2018.

[20] Both operate at 60 hz but Europe's domestic standard is operated at 220 VAC, whereas overseas many of the grids are 120 V, something that increases safety in potentially deadly situations, but makes the grid more fragile, especially in peak times.

Another important impact on the energy networks, especially in urban areas, will be the one of charging infrastructure for public transport: current preferred models of centralized charging stations in dedicated bus hubs charging almost simultaneously during the night several buses with batteries reaching 350 kWh could cause some issues in terms of peak load and network stability. Decentralized charging infrastructures at bus stops, coupled with reduced on-board battery packs could improve grid stability in a long term without less investments on the energy grids.

3.3 THE SMART CHARGING HORIZON

Before we start discussing the benefits of the V2G, let's just take a step back and assess more in general the need to update our infrastructures to the "smart" paradigm that seems to permeate every economic and social sector of our society. "Smart" charging means first and foremost communicating and connected infrastructures, coordinated by a central operation unit or, maybe even better, through a IoT network. Smart contract with incentives for customers to shift their energy consumption from peak times to off-peak periods.

This is the first real step every public body in charge of planning a large rollout of e-mobility should aim at to ensure both technical and financial sustainability for all involved stakeholders (DSOs, EMPS and CPOs, energy markets….). Let's have more general look on the smart energy use as a strategic asset, so we can underline a couple of further reoccurring themes. First of all, the main topic that needs to be addressed is the peak shaving capability of the whole electric architecture revolving around the demand response mechanisms. Bloomberg's research[21] indicates that the combined action of demand response and energy storage, something that can be done through the usage of EVs as energy storage devices too, significantly and favorably alters the peaks in energy consumption, as illustrated in the graph below:

[21] Bloomberg NEF global demand response forecast 2018.

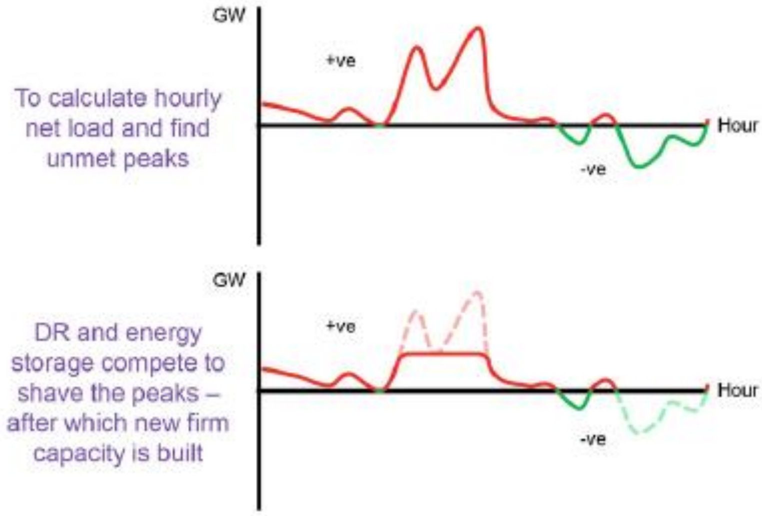

Chart 9, Source: Bloomberg NEF.

Concerning peak shaving and peak shifting, let's round out the topic with a general overview of the benefits for the DSO/Utility. The first benefit for the utility through the usage of EVs as ESS is the possibility of expensive peaking plants replacement: the EVs are able to store energy during off-peak periods and discharge it during on-peak hours. The benefits also include savings from necessary upgrades to the transmission and distribution network, as we have already stated before, and it guarantees that the whole distribution system won't collapse because of the aforementioned peaks. Last but not least among the principal benefits is the lack of energy losses in the supply chain, even if in Europe the problem is way less significant than in other areas of the world.

Another solution related to peak shaving and peak shifting is the so called "demand response" and "energy response" architectures, who compete to eliminate the highest and narrowest peaks of the energy consumption spectrum by using flexible loads to provide services to the power system. The global demand response market, specifically, will double its figures in the next 12 years, according to Bloomberg[22] again:

[22] Bloomberg NEF 4Q decentralized energy strategy trends.

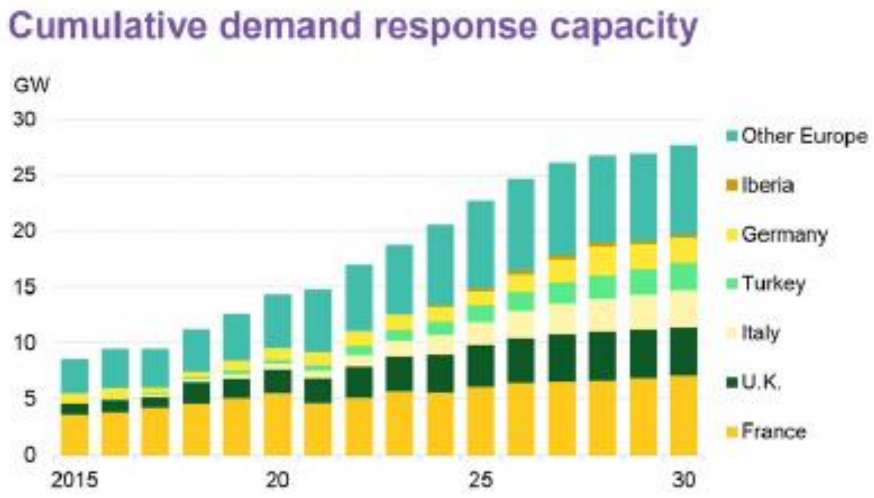

Chart 10, Source Bloomberg NEF.

The market shares of decentralized energy activities concerning EV charging and micro grids is steadily growing in the last 3 years, but it needs further enhancement through dedicated dynamic pricing policies. This is a delicate point, because it needs to be approved by all the energy authorities involved, that right now do not have sets of rules to enable this kind of innovative solutions. It must be clear, as the EDSO Report clearly underlines, that the so called “open loop” smart charging can be a bit static and not enough in order to comply with the future needs of the ever-growing EV market share.

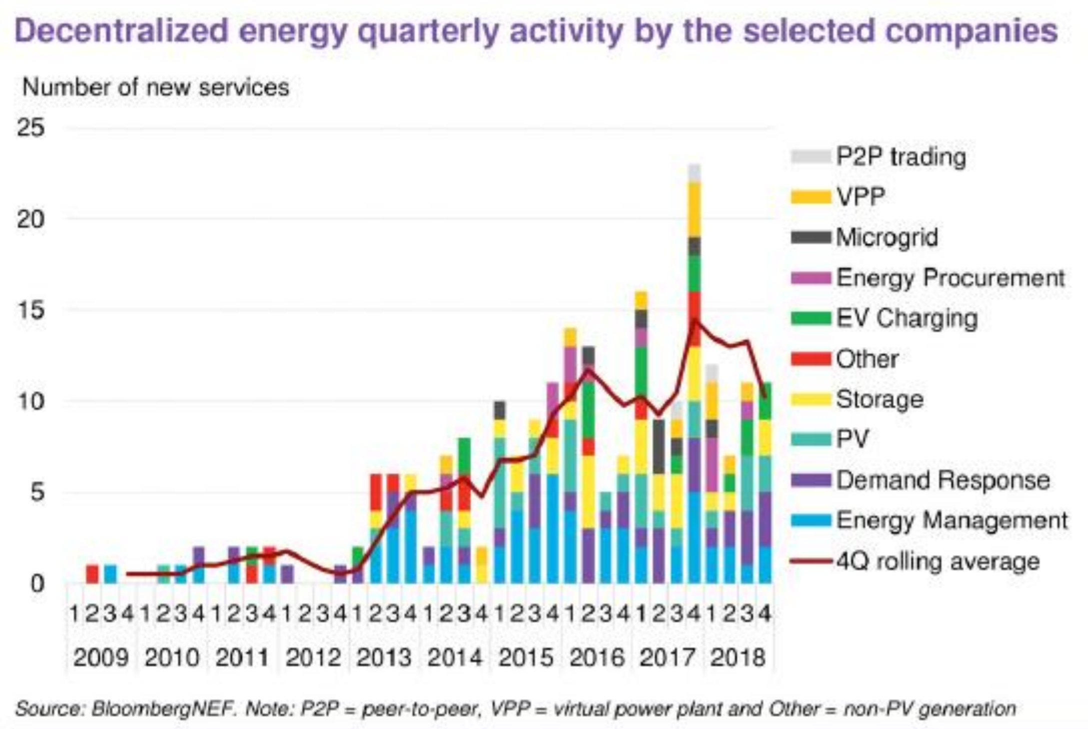

Chart 11, Source cited above.

This sort of dynamic pricing will be adjusted based on the local nature of the DSO congestions and loads, that may very well differ much from one another, so specific pricings will need to be conceived for all the different zones. A good example of this local balancing market system is the EU "Winter Package" initiative, that encourages DSO-TSO cooperation[23]. Because of the legislative deficiencies, in the medium to short term there will be only a certain demand side management concerning the dynamic pricing of aggregate services, like the EVs recharging, in the frame of the European dispatching and ancillary markets, a topic that we'll touch on later in this deliverable, namely in the last chapter.

3.4 POSITIVES OF THE V2G TECHNOLOGY CONCERNING THE GRID

Since we showed that there can be substantial problems and costs to overcome by deploying a traditional grid to vehicle architecture, the natural extension of smart charging is the vehicle-to-grid technology. Because of onboard power electronics, intelligent connections to the grid, and interactive charger hardware control, BEVs can be now thought as energy storage reserves too, and V2G applications in general can provide safety blankets in case of need for power reacting support in peak time demand hours. Money savings would for the users still probably qualify as the strongest suit of this technology though: estimates concerning money savings range from 90$ to 4.000$ in the US, depending on location,

[23] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0761

power and energy market value, with net social benefits ranging from 300$ to 400$ per a report.[24] As stated for the grid, there are differences between US pricings and EU pricings, especially when it comes to off-peak and on–peak pricing, where the difference is smaller between the two extremes, so the saving figures would be, again, smaller than the US ones. This would still strongly boost, at least marketing-wise, both the energy providers and the potential EV customers to take on the burden of a new lifestyle, but a fairly advantageous one.

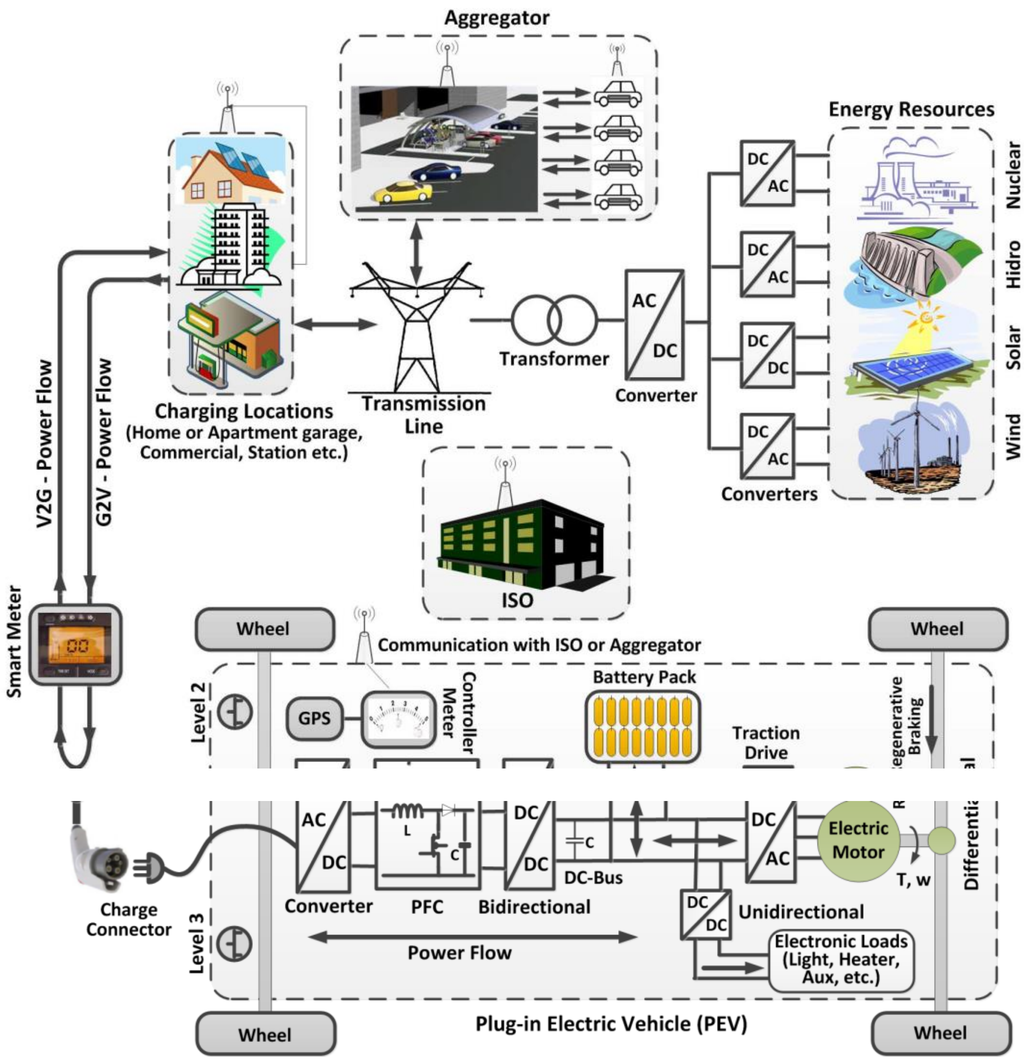

Chart 12, Detailed representation of a V2G application. Source: M. Yilmaz, P. Krein. Review of Benefits and Challenges of Vehicle-to-Grid Technology .

[24] B. Peterson, J. Whitacre, and J. Apt, "The Economics of Using Plug-in Hybrid Electric Vehicle Battery Packs for Grid Storage," J.Power Sources, vol. 195, no. 8, pp. 2377–2384, 2010. In M. Yilmaz, P. Krein, "Review of Benefits and Challenges of Vehicle-to-Grid Technology", University of Illinois at Urbana, 2012.

4 EVs & V2G

4.1 V2G FUNCTIONING AND APPLICATIONS

What could be a solution to this threat? Obviously a diffused upgrade to the electrical grid would be the safest solution, but recently there's been a new solution emerging among others: the Vehicle To Grid technology. This solution requires a power connection to the grid, a communicating connection with the grid operator/energy markets intermediated by and Aggregator (a pretty important factor because of the large amount of information exchange that will take place in a complex V2G architecture) and adequate metering of the energy consumption, but guarantees several beneficial effects., V2G applications could help manage the energy loads by discharging and charging when the market needs it. This load shifting capabilities of the technology would save many resources in terms of money and energy efficiency, but, most importantly would reduce the need of new power plants in order to supply the massive peak recharging requests, since cars only run at most 5% of a day so there's plenty of time for recharge, it just needs to be optimized[25]! The V2G is especially ideal to further enhance the renewable energy expansion, because the EVs function as a storage reserve for the electric power, stabilizing the intermittency that's intrinsic in renewable energy production and is often not fully exploited.

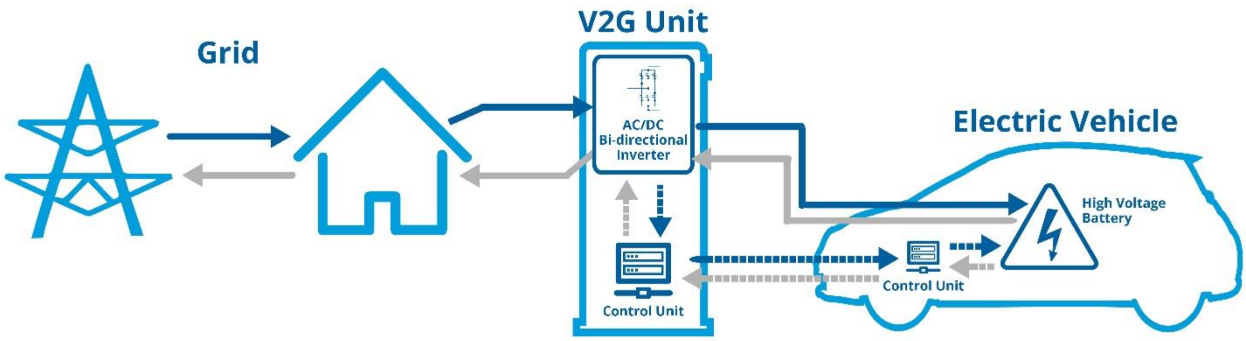

Chart 13, stylized representation of a V2G interaction between Grid, House, Unit and Vehicle.

[25] A. Wargers, J. Kula, F. Ortiz De Obregon, D. Rubio, Smart charging: integrating a large widespread of electric cars in electricity distribution grids. EDSO technology committee, march 2018.

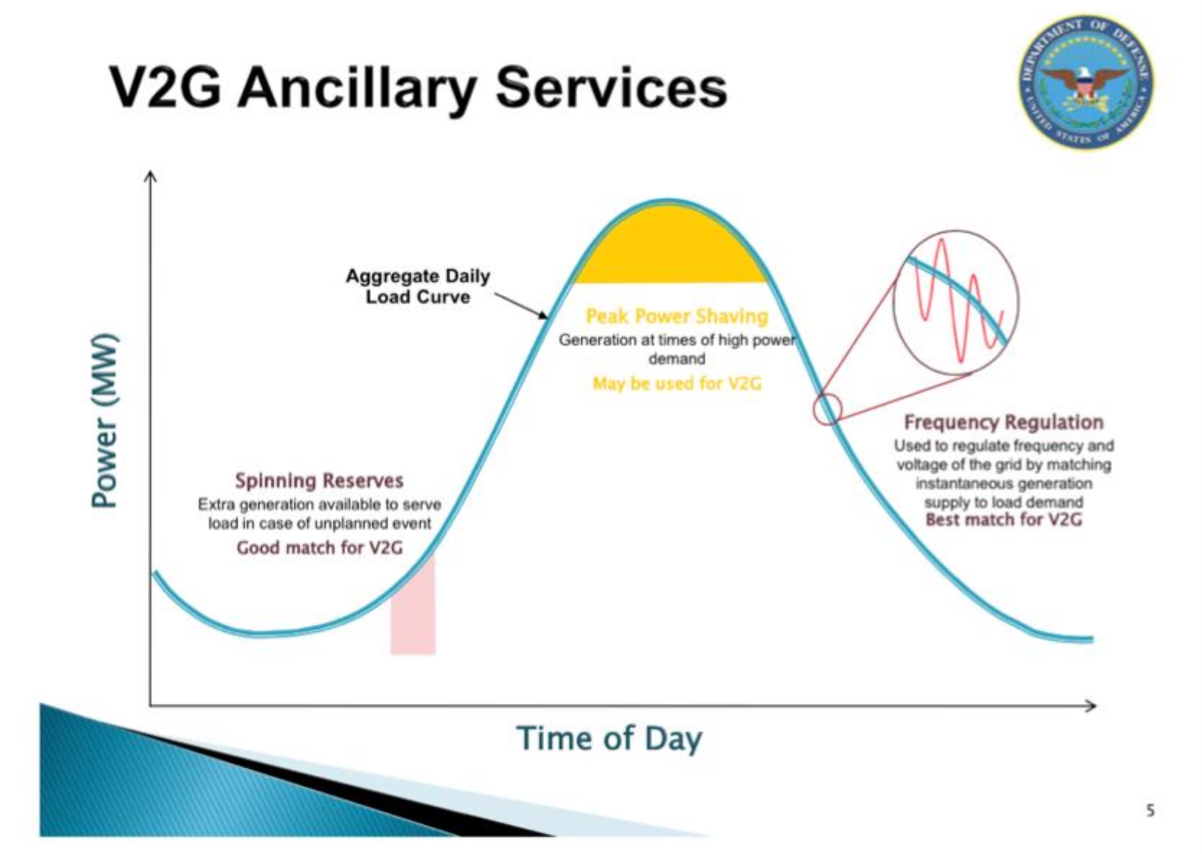

Chart 14, How peak power shifting from V2G services may work.

4.2 PROBLEMS OF THE V2G ARCHITECTURE

If there's only positives, why hasn't the V2G already become a mainstay in every up-to-date city worldwide? Aside from vehicle related reasons (there aren't enough BEVs at the moment), the main problem is that the constant recharge and discharge could affect the battery life of the vehicles, effectively multiplying the recharging cycles through day and night when the grid asks for power. From a financial point of view the lost life cycles would drastically reduce the economic benefits of the grid and additional expenses would still be needed concerning infrastructures. Per Yilmaz and Krein, «The cost could significantly impact the reliability, security, efficiency, and economy of newly developing smart grids due to possible loss of transformer life. Degradation in the life of a typical distribution transformer can be reduced considerably by using a controlled charging scheme. Different penetrations of PEVs were studied based on transformer insulation life using a thermal model in. The results showed that a large penetration of PEVs can have great impact on the power grid—particularly with poor coordination of charging times. At a PEV penetration of 50%, transformer life is reduced by 200-300%[26]». There are many voices who disagree with this view though, like for instance Ian Cameron, head of innovation at UK Power Networks, and Francisco Carranza[27], director of energy services at Nissan, who actually think that an intelligent control of the recharge through a smart charging network connected to the V2G could increase the life of the battery, and Nissan even has thought about a specific V2G standard needed in order to guarantee the battery warranty.

[26] M. Yilmaz, P.T. Krein, Review of Benefits and Challenges of Vehicle-to-Grid technology, University of Illinois at Urbana.

[27] https://www.current-news.co.uk/blogs/inside-v2g-the-challenges-benefits-and-potential-of-vehicle-to-grid

5 MARKET IMPLICATIONS

As described above, EV large rollout could impact the energy networks but, if correctly managed and planned in all its aspects, could also represent a resource for several actors of the energy world.

Electric vehicles, from an energy market point of view, will represent a new energy demand (not so fluctuating as RES because of what we discussed about domestic charging impacting for more than 80%) that networks should support without major drawbacks on assets management and quality of service for all the other users.

In such a picture, smart charging and V2G could represent the turning point to reach EV large rollout sustainability:

- For DSO, which could benefit from a distributed source of flexibility (and storage) on their network granting network stability without major costs for assets renovation:
- For final EV users/owners, that could have cost reductions/incomes related to potential grid/market services (already feasible or enabled in the following years)
- For Aggregators, which could have more private customers or fleets to aggregate and used to bid for the services stated in the previous point.

Up to now, there are only few pilot projects at national markets level enabling the participation of V2G in dispatching markets mainly for frequency and power regulation. Capacity markets, local balancing, reactive power support, load shifting, RES fluctuations storage could play important roles in future energy markets assets. Some of these pilot projects are currently granting final users between 400-550 euro (France) and 1.400 euro as average earning for EV owners. What will be the economics related to final market configurations will strongly depend on the effective numbers of users, whose willingness to participate will be strongly influenced also by technical outcomes on battery degradation due to V2G. It is also important to say that probably Aggregators participating in these projects, given the early, are giving up most of their incomes (leaving them to final users) just to attract EV owners and do trials on effectiveness, reliability and profitability.

Experts' outlooks (i.e. Bloomberg) are considering a very limited V2G adoption in energy market for at least 4 to 5 years: commercial fleets will be involved for sure before private users.

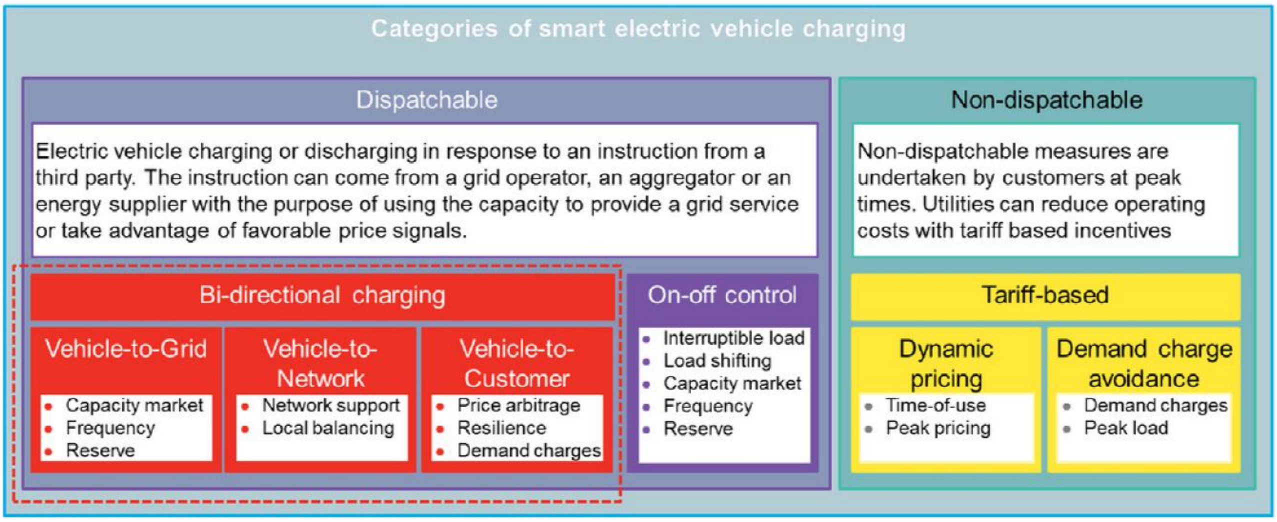

Chart 15: V2G and smart charging dispatchable and non-dispatchable potentials (source: Bloomber gNEF)

In the figure above, market potentials are divided between dispatchable (meaning controlled by a third party aggregating or intermediating with the grids and/or markets) and non-dispatchable (directly decided and controlled by the customers themselves).

Dispatchable use cases could refer to on-off control (also known as V1G) and dynamic charging, while the bidirectional systems could enable:

- Vehicle to Grid: meaning the possibility to charge and discharge vehicle battery based on markets/grid needs, and in particular
  - Frequency regulation;
  - Demand Management (balance of supply and demand at TSO level);
  - Reactive power and voltage control.
- Vehicle to Networks: services for DSO networks (once national regulation authorities will set the rules), mainly local balancing and peak demand shifting at local level (MV/LV dispatching).
- Vehicle to Customers: meaning all the services related to local usage of V2G at customer premises
  - Price arbitrage: where dynamic pricing is a reality also for final customers, the possibility to charge at low price and discharge at high prices. This is not realty for example in Italy, where energy costs fluctuations for final users are not so impacting;
  - Backup/domestic storage in private home or business;

V2G widespread at domestic level will be also strongly affected by the technological development of affordable DC charging solutions: current prices of DC VS AC charging infrastructures are not sustainable. Extra price of V2G charging infrastructure must be considered when evaluating business models.

One last, remarkable point is the one brought to us by the just published RES report, which focuses on the last governmental impulses [Art. 1, comma 11, law 27, December 2017, n. 205 (2018 Budget Law] recently given to our topic, especially when integrated within a renewable energy growth framework. The new regulation states that there ought to be different new entities, named UVA (Virtual Abilitated Units) whose nature is defined by TERNA, responsible for the integrity, transmission and safety of the Italian grids. The V2G services fall under the UVAM category (Virtual Mixted Abilitating Units), and the document also offers an example of a B2B V2G service. Starting from a comparison between the V1G and the V2G, the document states that the main difference, both in terms of economy and in terms of energy management, is that the V2G, intrinsically because of the double nature of the energy exchange occurring between Grid and Vehicle, the energy movement is about 7 times bigger than the net recharging value, per the algorithm (3 MWh compared to 20 MWh). What this means is that there are much bigger VAT expenses, but the participation of the V2G energy to the market makes it still profitable, as seen in the graph below:

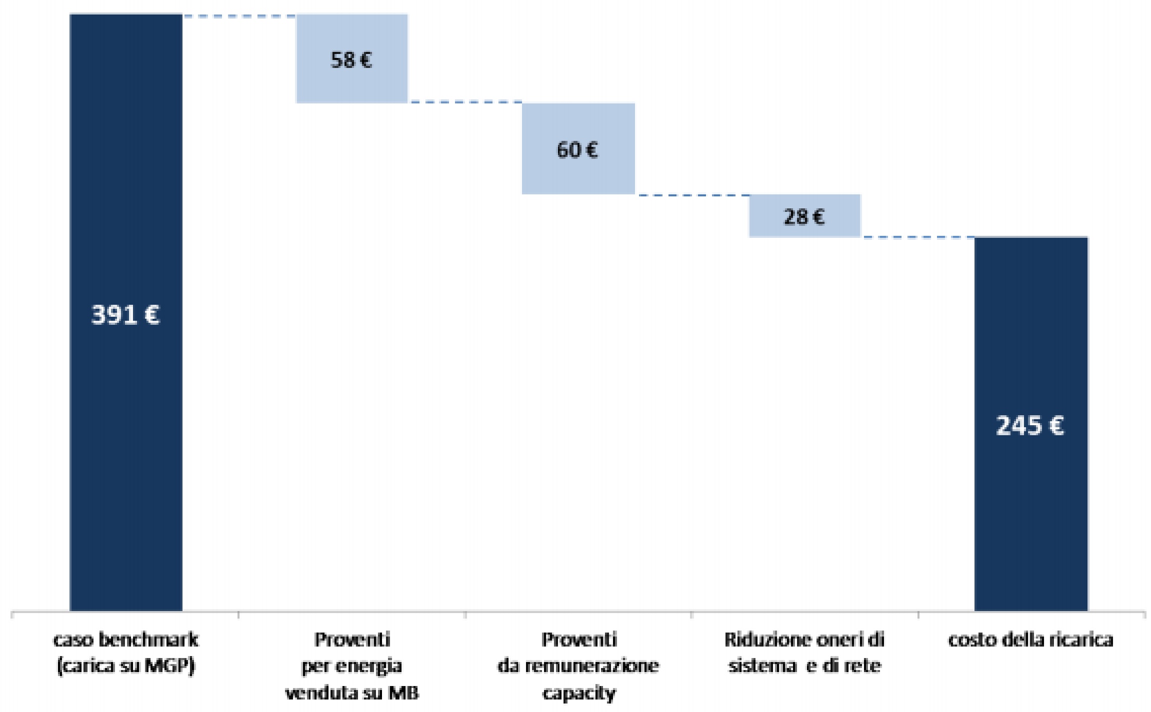

Chart 16.

These figures are realistic but not entirely accurate, because the vehicle would have to be extremely connected to the market, and therefore to the grid too. More practically, any factors will come into play, namely the battery life cycles and their limits, as well as their range, but also their warranty, which is a much discussed topic in the automotive industry.