NEW BUSINESS MODELS TO COPE WITH ECAVS/ESAVS DIFFUSION

VERSION 1.0

Andrea Grotto

Stefano Osti

Roberto Vaccaro

30 June 2022

INTERNAL REFERENCE

Deliverable No.:	D 5.1 (2022)
Deliverable Name:	New business models to cope with ECAVS/ESAVS diffusion
Lead Participant:	Eurac Research
Work Package No.:	WP5
Task No. & Name:	T 5.2
Document (File):	EVA_D5.1
Issue (Save) Date:	31/07/2022

DOCUMENT STATUS

	Date	Person(s)	Organization
Author(s)	2022-01-31 Outline and content of the deliverable	Roberto Vaccaro, Andrea Grotto, Stefano Osti	Eurac Research
	2022-03-14 Literature review (reported)	Andrea Grotto, Stefano Osti	Eurac Research
	2022-03-14 Semi-structured interviews for identify-cation and validation of crucial canvas elements for specific actors	Andrea Grotto, Stefano Osti	Eurac Research
	2022-03-14 Interviews on elements of the BM canvas that might be influenced by ECAV and collection of inputs on how to consider them in the development of BMs	Andrea Grotto, Stefano Osti	Eurac Research
	2022-05-30 analysis of information gathered and elaboration of the first draft of the deliverable	Andrea Grotto, Stefano Osti	Eurac Research
	2022-06-20 collection of feedback from partners	Andrea Grotto, Stefano Osti	Eurac Research
	2022-07-31 Finalization of the deliverable	Andrea Grotto, Stefano Osti	Eurac Research
Verification by	2022-03-08	Albedo Bettini	SUPSI
Approval by	2022-09-30	Roman Rudel	SUPSI

DOCUMENT SENSITIVITY

☐	**Not Sensitive**	Contains only factual or background information; includes no new or additional analysis, recommendations, or policy-relevant state-
☐	**Moderately Sensitive**	Contains some analysis or interpretation of results; contains no recommendations or policy-relevant statements.
☒	**Sensitive**	Contains analysis or interpretation of results with policy-relevance and/or recommendations or policy-relevant statements
☐	**Highly Sensitive Confidential**	Contains significant analysis or interpretation of results with major policy relevance or implications, contains extensive recommendations or policy-relevant statements, and/or contains policy-prescriptive statements. This sensitivity requires SB decision.

TABLE OF CONTENT

Disclaimer

About ERA-Net Smart Energy Systems

ERA-Net Smart Energy Systems (ERA-Net SES) is an international joint programming platform of 30 national and regional funding partners for initiating co-creation and promoting energy system innovation. The network of owners and managers of national and regional public funding programs along the innovation chain provides a sustainable and service-oriented joint programming platform to finance projects in thematic areas like Smart Power Grids, Regional and Local Energy Systems, Heating and Cooling Networks, Digital Energy and Smart Services, etc.

Co-creating with partners that help understand relevant stakeholders' needs, we team up with intermediaries to provide an innovation ecosystem supporting consortia for research, innovation, technical development, piloting, and demonstration activities. These cooperations pave the way towards implementation in real-life environments and market introduction.

Beyond that, ERA-Net SES provides a Knowledge Community, involving key demo projects and experts from all over Europe, to facilitate learning between projects and programs from the local level up to the European level.

www.eranet-smartenergysystems.eu

1 LIST OF FIGURES

2 LIST OF TABLES

3 INTRODUCTION

The proposed deliverable aims at combining two elements that have intrinsic efficiency value: business models and ECAVS (Electric Connected Autonomous Vehicles)/ESAVs (Electric Shared Autonomous Vehicles) diffusion (see the previous Deliverables (Grotto, Zubaryeva, et al., 2020), (Grotto, Cellina, et al., 2020) and (Veiga Simão et al., 2021) for a detailed analysis of ECAVs diffusion and future scenarios). In our approach, we consider, on the one hand, the integration of ECAVS/ESAVS into the electric grid (according to *Figure 1*), and on the other hand, the economic efficiency of business models tailored to new forms of mobility, exploring how the two dimensions may interact.

New ECAVs designs challenge the traditional position of the conventional car. When a product or service is created with the business model, it attempts to identify its weaknesses and strengths. In this case, we want to understand the impact of using connected vehicles on the electric grid, considering connected vehicles as a type of smart charging in that they can be controlled in space and time.

Given the specific context and state of development of ECAVs, we rely on interviews and questionnaires designed to fit significantly to the focus of the study. To this end, we will look specifically at the integration of the electric grid with connected vehicles, but in parallel, we will address the business models that lend themselves effectively to aspects of this sector (Gavrilescu, 2017).

The proposed methodology is based on interviews that were intended to go beyond the conventional mechanism by using some of the more unusual elements to help build guidance for DSOs and mobility stakeholders in South Tyrol and Ticino.

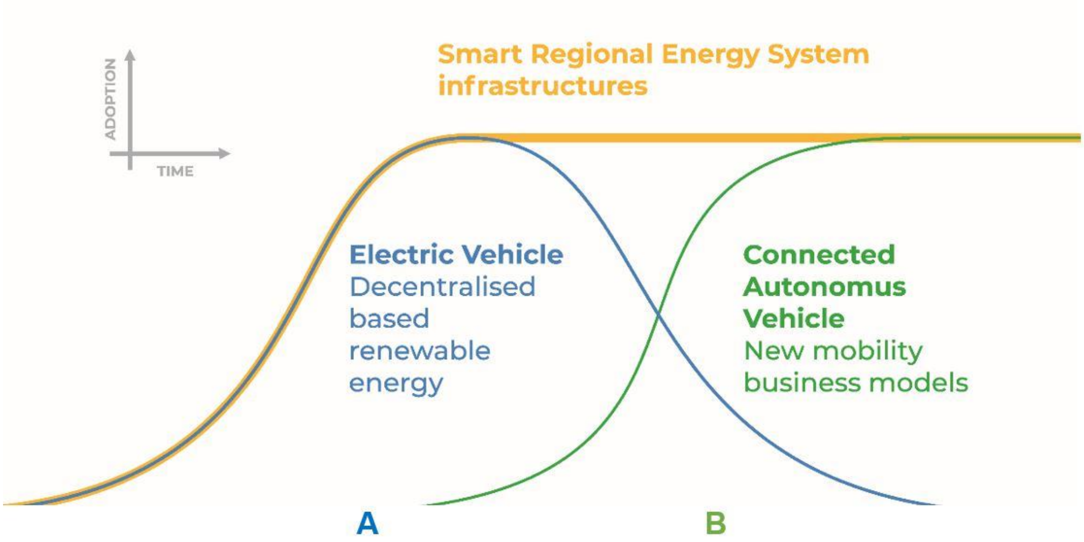

Figure 1 Dissemination of ECAVs/ESAVs and regional smart charging infrastructure (*EVA Project – ERA-NET EVA Project*, 2022)

4 METHODS AND MATERIALS

4.1 Scope of the analysis

This analysis aims to investigate how ECAVs/ESAVs can be integrated in to the electric grid, through the study of archetypal business models. Electric vehicles and charging stations can communicate with each other and enable intelligent electricity transmission. This ecosystem involves agents that, if not coordinated properly, can affect the speed at which ECAVs/ESAVs can be integrated in to the electric grid.

The possible impacts of autonomous mobility on existing business models operating in the two sectors will be explored based on available scientific literature and a series of interviews with stakeholders and experts in the mobility and energy sectors.

4.2 Methodology

Autonomous mobility is still a niche area of research and development in terms of enabling factors, even within the scientific community. However, some practical applications in pilot projects have sprung up and are developing (Veiga Simão et al., 2021). Despite this, practical applications are not at such an advanced stage that quantitative results can be applied ("AV-Use Case," 2020) to existing and future mobility scenarios. Usually, to retrieve this data, different tools are employed ("AV-Use Case," 2020):

- Dynamic driving simulator: integrating physiological variables and subjective evaluations of drivers in different driving situations;
- Survey questionnaires: comparing and evaluating different criteria based on the experience of autonomous vehicle drivers;
- Focus groups: workshops with drivers of automated vehicles to collect characteristics and challenges that influence acceptance;
- Literature review: collection and evaluation of the available literature in studies related to AVs
- Social media data.

The main objective of this study is to develop a business model based on:

- Existing scientific literature;
- Qualitative information was collected from mobility sector experts through semi-structured interviews;
- Previous EVA deliverables, in particular (Veiga Simão et al., 2021), where future mobility scenarios have been proposed;
- The researcher's analyses and investigations applied to the business model development.

Figure 2 maps out the main actors involved in the transition to autonomous mobility to identify the stakeholders to be contacted for interviews.

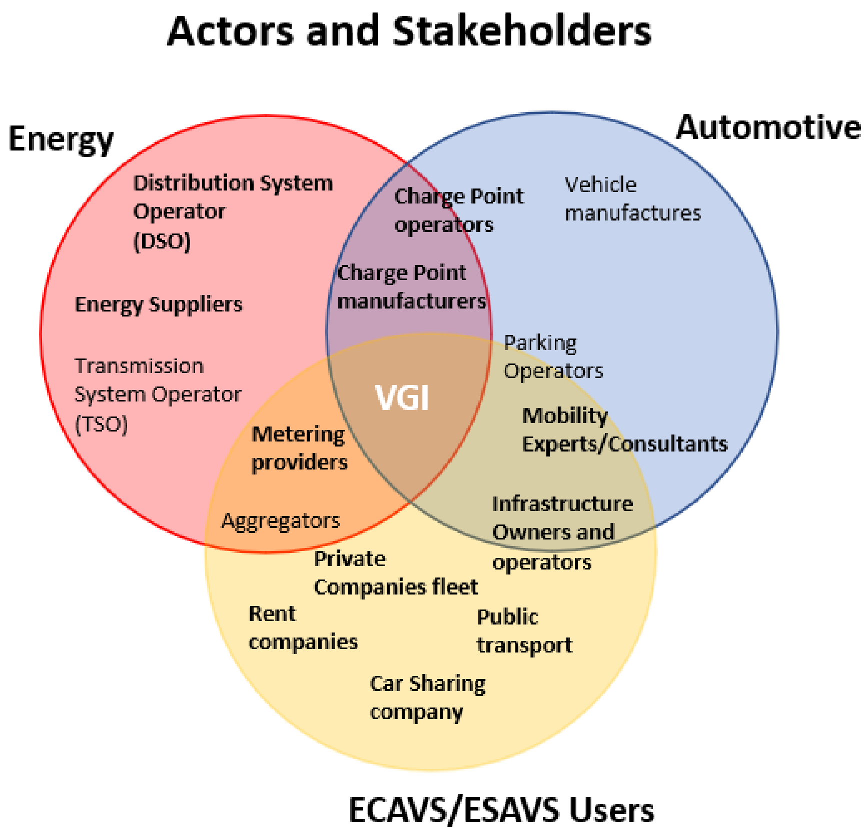

Figure 2 Identification of actors and stakeholders (adapted from (Corchero Garcia, 2022))

Three main categories of stakeholders can be identified (Corchero Garcia, 2022): energy, transport, ECAVS/ESAVS users. Both categories of stakeholders must be considered to achieve successful integration between autonomous vehicles and the electric grid. We interviewed only a portion of them: selected stakeholders are highlighted in bold in **Errore. L'origine riferimento non è stata trovata.**. As can be seen, ECAVs/ESAVs users were the focus.

Analyses have been carried out jointly for the two pilot areas, considering that new regulations and business models will not be significantly affected by local specifications. Therefore, the pool of experts and stakeholders identified and involved in the analysis does come indiscriminately from South Tyrol and Ticino.

4.2.1 Methodology applied

For the same reason expressed in the introduction paragraph 4.2, the specific methodology adopted is a combination of several methodologies: different fields of study were considered, as also evidenced by the materials used. The most important step was to identify the actors and stakeholders involved in integrating electric vehicles with the electric grid.

The available methodologies to collect the insider's knowledge of the mobility sector experts have been evaluated according to the criteria of behavioral economics.

The methodology chosen (semi-structured interviews) appeared to be the more effective and efficient way to collect valuable qualitative information to be subsequently applied to the development of innovative business models.

A semi-structured interview is a data collection method that relies on asking questions within a predetermined thematic framework (George, 2022). However, the questions are not set in order or in phrasing (George, 2022). In research, semi-structured interviews are often qualitative in nature (George, 2022). They are also common in field research with many interviewers, giving everyone the same theoretical framework, but allowing them to explore different aspects of the research question (George, 2022). We try to avoid "interviewer social bias" in which he tends to confirm ideas put to him, during group interviews and ask neutral questions.

Initially, the literature was considered to understand, on the one hand, the issues regarding electric vehicles and their integration with the electric grid. On the other hand, assumptions were made to adapt it to the concept of autonomous and connected vehicles. The main stakeholders were identified, and questions were created for respondents to answer. A special focus was given to analyzing the situation specific to the two project areas, better understanding the current trends through the interviewees' perspectives.

4.3 Materials

We selected material that came as close as possible to the analysis of connected vehicles and their integration into the electric grid. Articles concerning business models and the power grid were also selected. The research was conducted using the following keywords:

- autonomous, electric, connected vehicles;
- business model;
- vehicle grid integration;
- electric grid management;
- DSO, TSO;
- V2G and Smart charging.

The goal was to adapt the current literature on electric mobility and grid management to connected and autonomous mobility, as this topic appears not to be fully developed. When searching for scientific articles, it is easy to find articles that discuss electric vehicles and business models, but it is more difficult to find articles that discuss connected vehicles integrated with the electric grid. In particular, we attended two conferences related to the integration of electric vehicles into the electric grid (*Managing Integration*, 2022) and one on business models applied to electric mobility (*Public Charging*, 2021). A detailed review of the scientific literature on autonomous mobility was carried out in the deliverables related to WP3. Therefore, in this study, the focus will be on the literature specific to the impacts of autonomous mobility on existing business models and the electric grid.

4.3.1 Stakeholder Analysis

The stakeholder analysis (Figure 2) was structured from the knowledge gained through the literature review on the topic of business models related to autonomous mobility. Thus, possible future roles were identified, then people who would be interesting to interview and topics to discuss.

Particular consideration was given to the breakdown and description of business models according to the so-called Business Model Canvas, which was of direct support in the interviews.

Stakeholders were identified based on the categorization made in 4.2. After that, possible local contacts were listed for each category, and all identified persons were personally contacted by phone or email. An attempt was made to limit the total number to 10, so that the interview-related activities would not weigh too heavily on the report's analysis. Most of the experts responded positively or indicated a more suitable person to contact. Interviews were thus arranged individually so that there was a one-to-one conversation.

As mentioned in 4.2.1, the semi-structured interview methodology was chosen as the most suitable for discussing future developments in the interviewee's activities, so that he or she would feel as free as possible to express even personal opinions, not necessarily in line with those of the company or institution represented. The interview and the topics to be discussed were tailored to the individual interviewee's field of work and expertise so that the interview could have maximum added value for the purposes of the present study.

The interviews always began with an introduction of the EVA project and the purposes of this analysis, citing data and information gathered from the literature review. At this point, the expert was asked about their working relationship with the topic of autonomous mobility, based on the interviewee's answers and expertise each time a different discussion developed. Finally, the focus was returned to the impact of autonomous mobility on the business models of which the expert was competent.

4.4 Criteria for the regulation and policy analysis

Regulation depends on how ECAVs impact the network. In one sense, there has been an attempt to understand the barriers to the spread of autonomous vehicles. On the other hand, there has been an attempt to understand the impacts on the grid due to the increase in the number of electric vehicles.

5 REGULATION AND POLICY ANALYSIS

Ineffective use of AVs vehicles can increase safety risks, distance traveled, emissions, congestion, and social inequalities instead of reducing them (Azaria et al., 2020). The future of self-driving cars is not solely dependent on technology: if a solution does not overcome cultural hurdles and clarify elements of ethics and law that social life demands, in addition to economic and technical evaluations, it cannot really spread (Azaria et al., 2020). Enrico Al Murden, in his interview, (Volvo Car Italia, 2022) stated that Avs is technically mature and the main barriers are legislative. According to the same interviewee, standards are the main drivers for deployment, especially at the level of communication between the car and its environment. Infrastructure is also a barrier, which requires a lot of public funding to adapt. The previous deliverables (Veiga Simão et al., 2021), (Grotto, Zubaryeva, et al., 2020), (Grotto, Cellina, et al., 2020), describe how the whole system relies on understanding who is responsible for what. This is whether it is the owner, the vehicle manufacturer, or the programmer of the vehicle learning algorithm. Damages will also need to be regulated, causing a disruption in the current regulatory system. Guido Calabresi, in the same interview, says that safety will always be the key issue, as it will be integrated both during the design phase and during vehicle production. Safety must also consider socio-cultural aspects and thus go beyond the basic requirements (Azaria et al., 2020):

- AVs as a Service (AaaS) vs. personal use of Avs: the importance of testing autonomous shuttles and buses as well as ride-hailing pilots rather than individually owned and operated vehicles;
- Public acceptance: governments see it as crucial to the development of Avs. A rigorous safety process and communication of the results can help to achieve it;
- Insurance: regulators and insurers are working on AVs insurance solutions. Regulators specify a minimum amount of insurance required, while others only require insurance;
- Liability: so far, the various states have relied on existing laws and regulations. ((Veiga Simão et al., 2021), (Veiga Simão et al., 2021), (Grotto, Cellina, et al., 2020))

This will be particularly problematic in the transition phase when both autonomous and conventional vehicles will be on the road. Calabresi believes that it is impossible to plan for all scenarios and in particular, code cannot always model reality. Does he also ask who is responsible for making laws: committees? Manufacturers? Each state can choose its own path depending on the social and environmental context (Volvo Car Italia, 2022). Argo AI, supported by Ford and VW, launched a fully driverless car service in Miami and Austin (Gastelu, 2022) for its employees in Austin and Miami, as it develops the app. Peter Rander, president of Argo, stated: "We can go to multiple cities, where consumer demand for autonomous services is high, and drive naturally and safely in the heart of these areas (Gastelu, 2022)." This sentence illustrates the importance of having a high demand for autonomous mobility, and therefore the importance of having to study cultural and social aspects in which autonomous vehicles are installed. This report (Azaria et al., 2020) defines and lays the foundation for creating an optimal AV regulatory environment, based on safety, decongestion, equity in mobility, employment generation, economic growth and the development of sustainable mobility. The following figure summarizes the main challenges in regulating AVs:

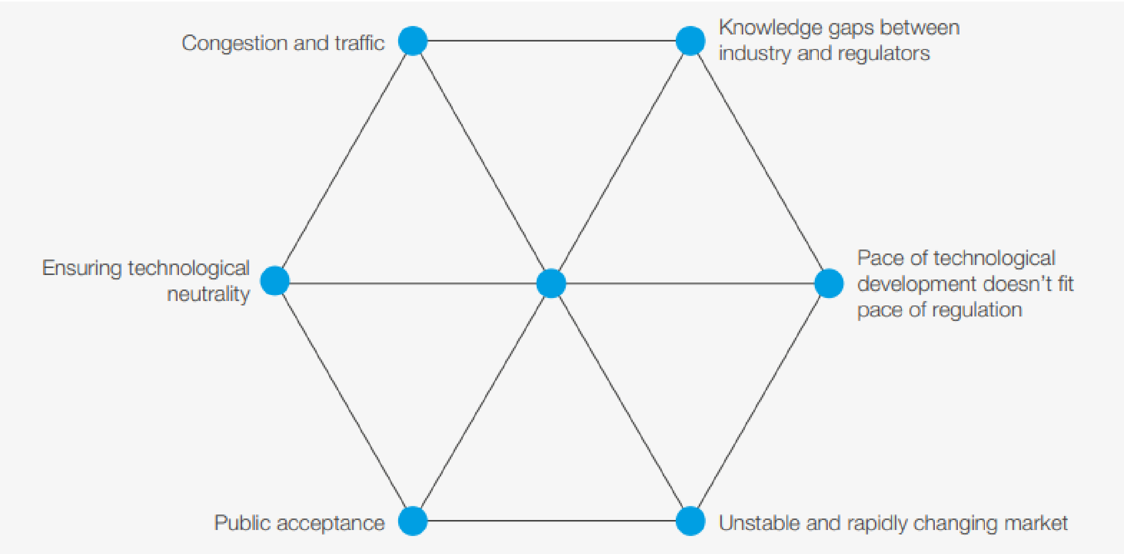

Figure 3 Challenges in regulating autonomous vehicles (Azaria et al., 2020)

Figure 4 illustrates the main recommendations for the widespread use of autonomous vehicles:

Figure 4 : Recommendations for proper dissemination of AVs-(Azaria et al., 2020)

5.1 Current status of the regulation in distinctive countries (EU members and non-members)

AVs diffusion regulation has been considered and explored in previous EVA deliverables ((Veiga Simão et al., 2021), (Grotto, Cellina, et al., 2020)). Findings of such deliverables have been taken into account when assessing the possible impacts on the network from ECAVs/ESAVs. Assuming that the majority of AVs will be electric vehicles (see D3.2) , adequate charging stations will be needed. Considering Figure 5 it is possible to understand the number of public charging points has changed over time in Europe (EU-27) (*Charging for Phase-Out*, 2022). From 2018 to 2021, the points are tripled following the profile of the number of electric vehicles in parallel (increasing from 0.7 million to 3.8 million).

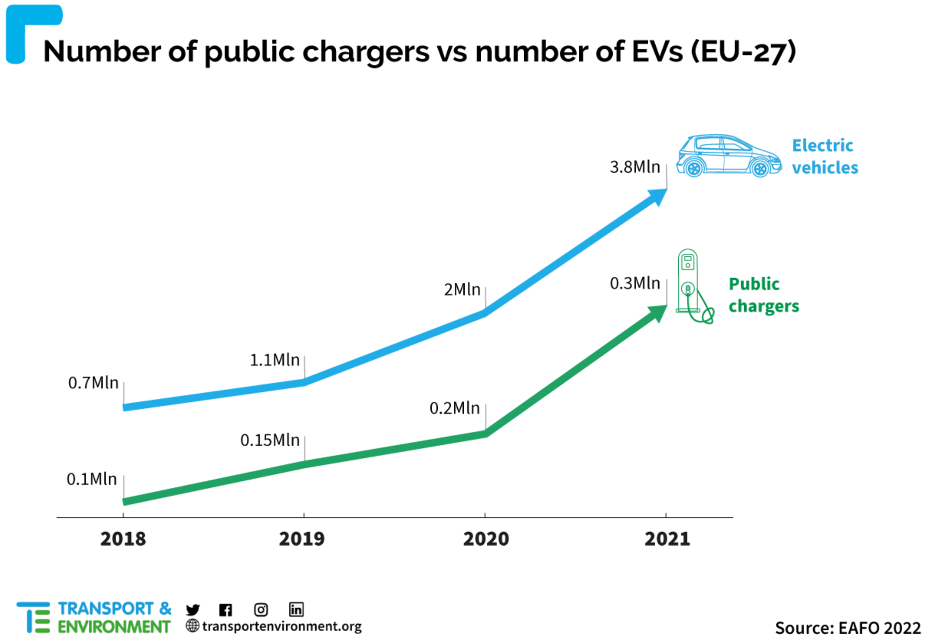

*Figure 5 Number of public chargers vs number of EVs (EU-27) period: 2018-2021 (*Charging for Phase-Out, *2022)*

European-level predictions are shown in Figure 6: according to these estimates, electric vehicles will increase from 18.6 (in 2025) to 131 million (in 2035), becoming 7 times more numerous. As the electric car market enters mainstream and grows in all countries, more public charging stations will be needed in the coming years. In July 2021, the European Commission proposed a regulation on the deployment of alternative fuel infrastructure to ensure member states ramp up their public networks on time (*Charging for Phase-Out*, 2022). Member states must always ensure that their respective EV fleets have access to a public charging network sufficient to meet their charging needs. At the very heart of this proposal lies a 'fleet based target' – requiring at least 1 kW of public charging power to be available per each battery vehicle – that increases in line with EVs registered in a country (*Charging for Phase-Out*, 2022).

To determine the actual demand for public charging in the future Figure 6, three main factors are decisive:

- the share of public versus private charging: public charging is likely to play a less important role than often assumed by some, not exceeding 30 percent of all charging events;
- the network utilization rate: (i.e., the average time of use of one charge per day);
- the expected electricity consumption of future electric vehicles.

To determine the profile in Figure 6, the following assumptions have been made:

- Given the ubiquity of the electric grid, private charging at home, at work or during daily errands will remain the dominant form of charging. This has the added benefit of being cheaper for motorists. (*Charging for Phase-Out*, 2022)
- The utilization rate of the grid will have to increase to enable a solid business case; in this analysis T&E assumes a utilization rate of between 8.6 percent and 12.5 percent. (*Charging for Phase-Out*, 2022)
- The energy consumption (or efficiency) of new electric vehicles is constantly improving; for example, Mercedes recently announced an all-electric vehicle with an average consumption of 10 kWh/100 km. In this analysis T&E assumes a moderately conservative efficiency of 14.8 kWh/100km.(*Charging for Phase-Out*, 2022)

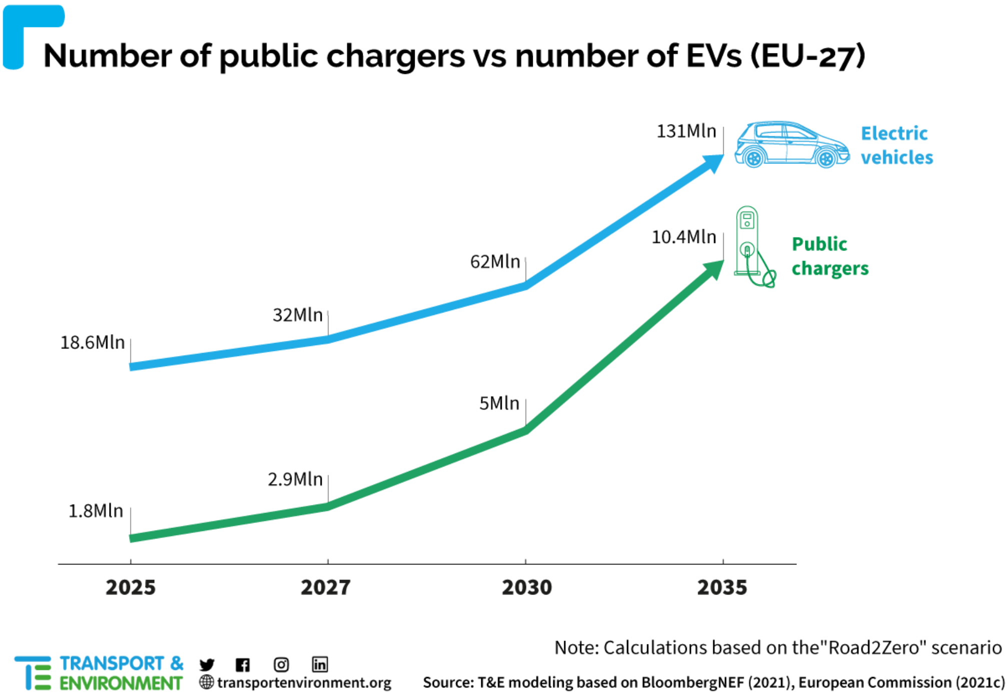

*Figure 6 Number of public charger vs number of EVs (EU-27)- 2025–2035 predictions (*Charging for Phase-Out*, 2022)*

T&E also analyzed the scenario with the power per EV recommendation from the EU car industry lobby (ACEA), which wants 3 kW per BEV (and 2 kW per PHEV) (*Charging for Phase-Out*, 2022). Using these targets, member states would have to deploy between 9.8 and 14.4 million chargers by 2030, rising to between 24.6 and 31 million chargers by 2035. While more public chargers might be appealing at first glance, the concerns with these high numbers are many fold. Low utilization rates - below 5% - would mean the public charging infrastructure would need to be continuously subsidized. For EV markets that are just getting started, lower utilization rates can be a necessary side effect. The political goal should be to ensure that a charging network is economically viable in the medium to long term. A network must therefore be financially sustainable. This is only possible if the utilization rates increase significantly over time. A recently commissioned report by ACEA points out that the network's average utilization rate needs to be at 15% to make a network economically viable. The ACEA AFIR recommendations however would make it impossible to ever reach this rate. It would essentially undercut it by more than three times.

In addition, we considered investigating vehicle-to-grid V2G.

According to (*V2G-Home*, 2022) we can define it as a "technology enabling bi-directional energy transfer from/to plug-in electric vehicles. Power from the vehicle's battery can be fed (back) to a home, an office building, a street or the national electricity grid. This way, an electric vehicle can be used as a battery, supporting a future of smart grids and decentralized renewable power production. This is distinct from 'dumb' one-way charging and 'V1G' or 'smart' charging where the rate and time of charge can be varied. "

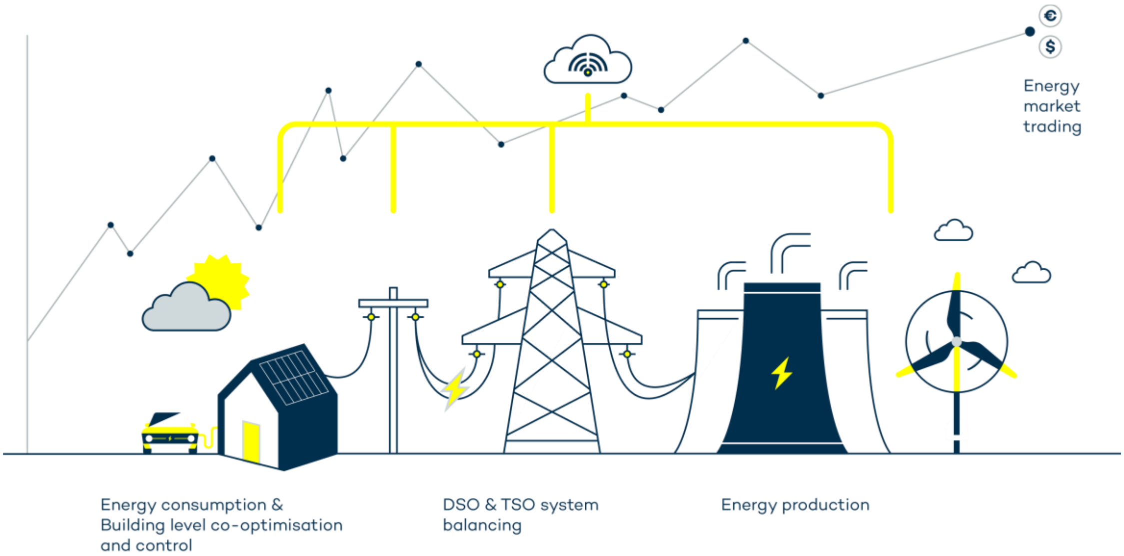

Figure 7 Vehicle-to-grid technology (V2G-IMG, *2019)*

We did not consider it as a form of smart-charging, but as something extra that would smooth out power peaks.

Figure 8 Unmanaged EV charging, Smart EV charging, V2G- (Corchero Garcia, 2022)

According to (Corchero Garcia, 2022) there are currently 50 projects around the world on V2G experimentation: 25 in Europe, 18 in the USA and the rest in Asia.

Projects in Asia focus more on V2H (Vehicle to Home) and V2L (Vehicle to Load) aspects. Two projects in which two effects on V2G regulation were identified are reported here:

- Nissan launched a pilot program under the Nissan Energy Share initiative in partnership with vehicle-to-grid systems company Fermata Energy in 2018 to use bi-directional charging technology to partially power Nissan North America's headquarters in Franklin. Fermata Energy's bidirectional electric vehicle charging system became the first to be certified the North American safety standard, UL 9741, the Standard for Bidirectional Electric Vehicle (EV) Charging System Equipment, in 2020.(*Fermata Energy*, 2022)
- A 2015 report on potential earnings associated with V2G found that with proper regulatory support, vehicle owners could earn $454, $394, and $318 per year depending on whether their average daily drive was 32, 64, or 97 km (20, 40, or 60 miles), respectively. ("V2G-Pr," 2022)

5.2 Benchmarking

This section considers Norway, which currently has the highest percentage of PHEV cars in the world (almost 18%) (Skotland, 2022). This information provides insight into whether the integration of electric vehicles caused a major impact on the electric grid.

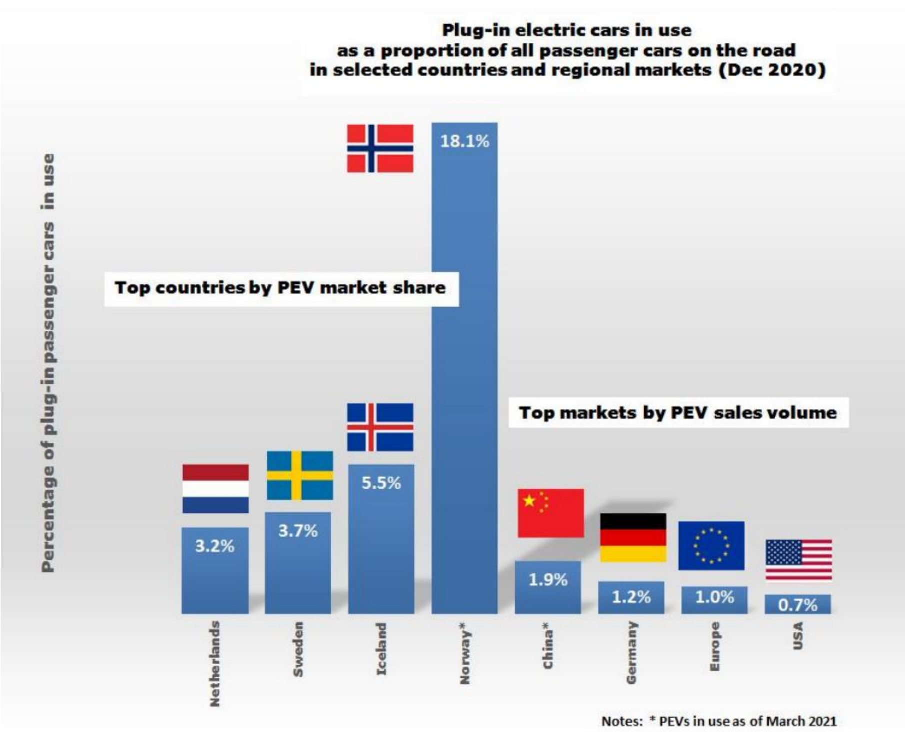

Figure 9 Percentage of PHEV compared with other states (Skotland, 2022)

It can be an interesting case study since it allows us to predict the impact of electric vehicles on the electric grid. Despite the high proportion of PHEVs in Norway, the network continues to function properly and serve utilities. In comparison with Germany (Figure 10), which has only a 1.2% share of electric cars, the following results are obtained:

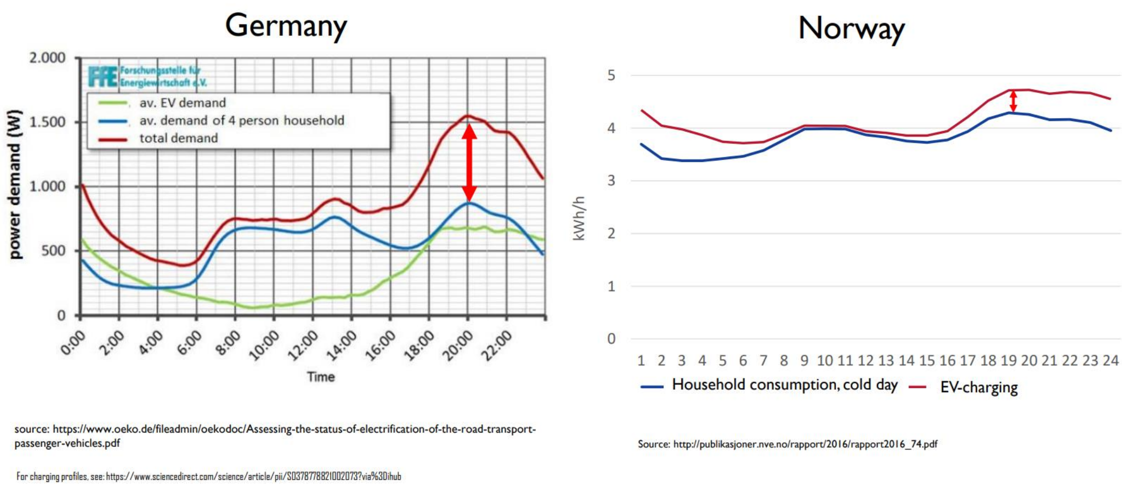

Figure 10 Household demand and EV-charging: Germany vs. Norway (Skotland, 2022)

Two electric power demand profiles are shown in the graph: one for electric vehicles (in green) and one for a four-person household. When comparing Germany with Norway, it is possible to see that although there is a difference in absolute power demand (Norway has the world's highest per capita electricity consumption), the difference at 8 p.m. between the power demanded by households and the total power demanded does not change. Even though the Norwegian electric grid is responding well to the introduction of electric vehicles, the government has decided to introduce incentives to reduce grid costs. The goal is to shift the peak overnight since Norway does not have a high percentage of PV power generation, taking advantage of the flexibility of hydropower (95 % of total production). The following regulations were implemented:

- New capacity-based tariffs (ongoing process since 2015): you try to encourage charging during non-peak hours;
- Connection fee: this is applied in case there is a fast charging type client and a cost is paid only if the network capacity is not enough. The incentive increases smart home charging, since if people have to increase their fuse, they have to pay the grid companies, but if they can balance their load behind the fuse, they do not have to pay;
- Non-firm connection: This allows grid companies to curtail consumption on terms agreed upon with customers, and it allows them to connect customers faster and postpone or avoid grid investments.

6 STRUCTURE OF THE BUSINESS MODEL CANVAS

6.1 Findings from preliminary analyses

A business model is simply a plan describing how a business intends to make money. It explains who your customer base is and how you deliver value to them and the related details of financing. The business model canvas lets you define these different components on a single page. It is a strategic management tool that lets you visualize and assess your business idea or concept. It's a one-page document containing nine boxes that represent different fundamental elements of a business. (Athuraliya, 2019)

"Bringing charging infrastructure into the public domain is still not a sustainable stand-alone business model. To encourage growth and investments, we need to be more courageous and radical in finding a different mechanism so that companies can create business and value."

Mathias Wiecher, Global Head of eMobility, E.ON

Considering the analyses performed and the main findings from the literature review, many sectors will be impacted or can participate in the nascent business opportunities related to the deployment of ECAVs/ESAVs.

As already pointed out, also in previous EVA deliverables, the autonomous mobility paradigm shift involves so many variables to make the employment of a deterministic approach counterproductive when defining future scenarios. To handle the high level of uncertainty and avoid the risk of overcomplexity, few assumptions have been made:

- Future regulation of the energy and mobility sector will be in line with the current expectations of Regulators, from the most recent available documents (e.g., papers from ACER[1] and CEER[2])
- Future mobility scenarios will be in line with findings from EVA deliverables, in particular (Veiga Simão et al., 2021)

6.1.1 Literature review

We mainly followed the webinar:

"Managing grid integration of electric vehicles", Moderated by Per Anders Widell, Energy Analyst, Sustainability, Technology and Outlooks, IEA (*Managing Integration*, 2022) Specifically, we focused on this presentation: "Managing grid integration of

[1] https://www.acer.europa.eu/

[2] https://www.ceer.eu/

electric vehicles" presenter: Cristina Corchero (Corchero Garcia, 2022). She discussed how electric mobility integrates with the grid. Actors and stakeholders in this ecosystem have been identified. It has been established that smart charging or the introduction of V2G technology, which allows electricity to be fed into the grid, are two ways to reduce peak demand. For this purpose, the former was rated as "crucial" and the latter as "powerful." It was pointed out that electrified vehicles can be seen as a controllable load and as a distributed storage if it is possible to implement V2G technology.

It was also possible to understand what the main policy recommendations are: consider electric vehicles as DER (Distributed Energy Resources), that the residential sector must be ready for the advent of electric vehicles (through the installation of appropriate infrastructure), the importance of having smart charge pricing and smart charging technologies.

"Premium meets responsibility" - presenter Moinka Dernai, Teams Lead Sustainability, Mobility, BMW Group- (Dernai, 2022). The presentation was similar to the previous one, but this time we were able to see a practical example of smart charging, which allows vehicles to be recharged at specific times of the day via a BMW-controlled platform. In this way, renewable energy that is produced at certain times of the year can be stored.

"EVs in Norway Impact on the grid and how to deal with it" – presenter: Christer Skotland, Senior Engineer, Norwegian Water Resources and Energy Directorate (NVE) (Skotland, 2022) . The presentation focused on the case study of Norway, which has the highest percentage of PHEVs in the world (almost 18%). In this case, three grid-level regulations were analyzed in order to shift peak demand over time (see section on regulation).

We then attended the following webinar:

"Public Charging infrastructure deployment strategies and business models", Moderated by Per Anders Widell, Energy Analyst, Sustainability, Technology and Outlooks, IEA (*Public Charging*, 2021)

"Strategizing city networks and charging infrastructure": Sara Pasquier, Country Manager France, Fastned (Pasquier, 2022): During this presentation, business models for fast charging were analyzed. It was possible to understand the importance of placing fast charging at strategic locations, such as highways. In this case, the business model focuses on increasing the usability of the infrastructure.

Regarding ethical and regulatory aspects as a barrier to their spread:

Guida Autonoma - Nuove regole della mobilità fra Etica, Diritto e sviluppo di Prodotto [13.01.2022] - Volvo Car Italia (Volvo Car Italia, 2022)

Autonomous Vehicle Policy Framework: Selected National and Jurisdictional Policy Efforts to Guide Safe AV Development | World Economic Forum (weforum.org) (Azaria et al., 2020). Recommendations for the correct deployment of autonomous mobility were reported in this report.

Regarding the spread of charging infrastructure:

'Charging' for phase-out – Transport and Environment: Historical trends and forecasts of charging infrastructure installations are analyzed

6.1.2 Results of the interviews

Following the criteria introduced in 4.2 and 4.3.1 and the considerations made in 6.1, the following stakeholders have been interviewed:

DSO/Infrastructure owner	NEOGY/EDYNA – Massimo Minighini
Utility/energy supplier/retailer	ALPERIA – Alessandro Costa Aziende Municipalizzate di Stabio – Giampaolo Pontarolo
Public transport companies	STA – Helmuth Moroder VCO Trasporti – Roberto Tomatis
Car sharing company	Carsharing Alto Adige – Leonhard Resch
Local administration	Municipality of Bolzano – Mobility Coucillor – Stefano Fattor
Mobility agency	Greenmobility – Sebastian Bordiga Ranigler
EV fleet owner	ALPERIA – Anita Inama
Mobility experts/consultants	PROTOSCAR – Giorgio Gabba

Table 1 Interviewed stakeholders

The following paragraphs summarize the main results of the interviews, grouping them by theme. Statements are not associated with the individual stakeholder to ensure that interviewees could freely express their opinions without necessarily having to adhere to the official view of the institution represented.

General remarks

The majority of the experts interviewed concur that, although autonomous mobility is a topic they have extensively discussed at the general level, in conferences and meetings, more detailed analyses of the practical aspects are still almost completely lacking. Also, it is believed that we are still far from application in authentic contexts, since operators in the transport sector have not been involved in these developments yet.

It is a common opinion that the need for mobility will probably always take priority over the need to optimize charging, greatly limiting the possible benefits and opportunities related to the optimal utilization of electric vehicles to support the energy system.

All but one stakeholder agrees that the number of vehicles on the road will decrease significantly as a result of autonomous driving (further confirming the results of (Veiga Simão et al., 2021)), since it will not be necessary to own a private vehicle to get to the last mile (work, home, etc.): from vehicle owning to mobility as a service. The autonomous vehicle is likely to be a shared vehicle: as long as a vehicle is available whenever it is needed, it will no longer make sense to have a private one. Mobility will become a pure service that is easily accessible. For the one expert in disagreement, this effect will not be so assured unless driven by strong bans to curb climate-changing emissions, but he also quoted Prof. Sergio Savanesi (Politecnico di Milano – Automation and control in vehicles) who expects that the use of autonomous driving will have the effect of reducing the Italian car fleet by 90 percent: from about 40 million to 4 million. Many confirmed that, given the currently ever-increasing traffic trend, the answer cannot be only and always to increase the capacity of arterial roads, not least because the scientific literature says it often achieves the opposite effect, incentivizing even more private road traffic. There must be another solution pushed by regulation, and in this autonomous driving could help provide a technological solution, reducing traffic for the same service.

Few highlight that all these changes are certainly not automatic and should be "guided" by high political and administrative levels since they need a cultural change as well: regulatory aspects and directives are important, but research centers also play a key role in disseminating problems and opportunities.

The general idea is that the main current business models related to energy will undergo changes if they can take advantage of the opportunities for additional revenues from electric fleet management, but they will not change substantially. They will only have a few more sources of revenue (or cost optimization).

Connection to the grid

A common view among all those surveyed is that the impact of the autonomous vehicle network will not be substantially different from that of nonautonomous electric vehicles, except for the positive impact that may result from a pronounced decrease in the number of private vehicles on the roads. In their opinion, ownership will become entirely superfluous when last-mile transportation can be managed with ease through autonomous mobility.

An expert mobility consultant speculates that autonomous vehicles could give more support to the network by being able to "force" them to connect whenever possible. Doing so would maximize the potential in terms of V2G. In contrast, we know that the human user does not always take advantage of this possibility, due to "laziness" or other factors. However, it should be kept in mind that autonomous vehicles will have very high utilization factors, close to 100% (at least during the day, less so at night), so the time they will actually be connected to the grid cannot be very high. This effect certainly contrasts with the previous one, so one would expect them to offset each other.

Market trading and V2G
Demand-side management will be even more fundamental than today in future energy scenarios. In Switzerland, for example, the distributor has long been able to control hot water storage tanks to avoid excessively high peak loads. Wallboxes could be managed in the same way, at least until a standard business model emerges. A Swiss grid operator confirms that major increases in household loads are already occurring. So, if everyone will have an electric car soon, it will certainly not be possible to size the grid to the theoretical maximum peak, to avoid absurd oversizing. It will be necessary to make this demand somehow controllable. Also, since some substations might be difficult to upgrade, it might make more sense (certainly cheaper) to build from the scratch some hubs where high powers can be guaranteed and leave the household grid untouched.

Aggregation
Experts expect that the aggregation of the energy capacity and power potential from EVs and CAVs will mainly come from specific aggregators that will operate at the single vehicle level, creating direct relationships with the single owner. Therefore, EMPs (E-Mobility Service Provider) could act as aggregators, but not necessarily, just like energy companies. EMPs will be destined to decrease as a result of the selection processes; at present there are far too many more than the optimum, partly because so many still operate at a loss.

Considering the structure of current electricity prices, it is difficult to think that in the future the average user could be incentivized to make his or her car available to an aggregator (and thus increase wear and tear) or to change his or her charging behavior for small economic returns that are difficult to appreciate. Different might be the case for owners of large fleets of cars. In general, there would have to be greater economic incentives than at present to really get V2G off the ground.

Mobility opportunities
According to the stakeholders contacted, in cities where there is effective public transportation, the demand for mobility is already changing: many people realize that the costs associated with owning a car are not justified by the additional services provided. In this sense, autonomous driving may potentially bring the same change to suburbs not yet reached by public service because not economically sustainable. In large cities today, the car is not needed; according to many, it probably will not be needed in the suburbs tomorrow either. Autonomous driving could add the most value to the last mile, thus complementing the public transportation that already covers the rest, but without competing with it. There are likely to be charging

centers at strategic locations in the area, acting as hubs and intermodal interchanges for autonomous mobility.

“If we want to reduce mobility-related emissions, the most effective way is definitely public transportation, which should be the first choice whenever possible. For example, for long trips, one should have a specific reason to choose a self-driving car instead of a train. Of course, public transport should be improved and optimized where it is not already excellent, for example, through more frequent cadencing.” A key factor will be ease of use for the user. The more convenient, immediate, and interconnected the mobility service is, the more it will be perceived as a comprehensive and reliable service and thus used, making a greater impact on reducing the number of vehicles on the road. The role of public transport in this is crucial, in ensuring effective and efficient intermodality, avoiding redundancies that would burden the territory. The most difficult part will probably be managing the transitional phase and optimizing the integration of the different mobility offerings.

Public transport experts warn, however, that, unlike autonomous cars where it will obviously be the individual user who will make the decision to use them or not, the introduction of autonomous driving on buses or people carriers is likely to be more difficult. In fact, a vehicle carrying 50 or 100 people must guarantee foolproof safety levels. Fear of the technology will probably severely limit its adoption compared to the automobile sector.

Drivers availability

The public transport operators we contacted all expressed the difficulties they face in this historic moment in finding drivers and more generally, skilled workers for their companies. The reasons are many and will not be explored in depth in this study, but certainly the demographic trend has a strong impact. One can easily imagine that these issues will be increasingly present in the future, not only in the transportation sector but also in the personal care sector and many others. The trend already underway is precisely to reduce staffing wherever possible to the bare minimum, for example on trains where in just a few years we have gone from having several controllers, train conductor and driver, to very often having only the driver. Interviewees recount how drivers are often brought in from abroad and how there is a real struggle between companies to grab available drivers. In this context, autonomous driving would certainly represent a huge opportunity for the entire transportation sector, indeed it would become almost necessary to meet the challenges of the future.

Regulatory aspects impact on innovation

On the regulatory level, respondents would expect to see a stronger stance, given the importance and priority of climate change mitigation measures. Multiple respondents indicated that this slowness could largely be attributed to a defense of established special interests within the institutions that should be responsible for driving a change that would also strongly impact their own activities.

Operators who participate in public transport tenders tell us about the difficulties they have in making innovative investments in their fleets, mainly because of the allocation system now in place in South Tyrol, but also throughout Europe. Often the territory is divided into small lots and the service awarded by tender. On the one hand, this rightly favors local operators with experience and rooted in the territory, but on the other hand, the size of these companies does not allow them to have a research and innovation department. In addition, the tenders are downward and often on a 10-year duration, this forces the winners to provide the service at the lowest cost in order to be able to return on investments during the award period, preventing them from making the necessary investments for an electric fleet or for an autonomous future. Thus, it must be highlighted how the investments made today in a diesel fleet, will be operational for about 10 years, having a great future impact.

Some public transport managers warn that operating an automated fleet could bring up a whole range of technological difficulties that small and medium-sized transport companies would probably not be able to handle. This transition will also need to be accompanied by careful regulation and public support to avoid negative spillover effects on transportation services.

It is widely believed that many changes and innovations are left to the choices and "courage" of individual "visionaries," instead of being supported and incentivized by regulation that takes into account sustainability aspects and compares with future mobility scenarios.

Urban and road planning

According to local administrators, one factor that will have a great deal of influence on how mobility will develop is city planning, which may favor or hinder certain paradigm shifts. Also, some of the arterial roads, which today are managed independently by local governments, will definitely need to be prepared for autonomous driving and maintained with certain standards that are not always met today.

Just one example is that in Bolzano, city planning regulations still dictate that today new apartment of at least 70 m^2 must have its own garage. In order to change mindsets and thus also approaches to mobility, work would have to be done in this area as well, starting, for example, by imposing obligations on new construction or renovations, as has been done for the energy consumption of buildings. Likely, local governments will also begin to take decisive action against climate change by imposing strong restrictions on private traffic, as is beginning to be seen in some European cities. Indeed, many of those interviewed pointed out that if efficient public transportation is desired, it is necessary to limit the traffic that often clogs city arteries. "Although some very ambitious decisions could trigger harsh protests from the population." Given their decision-making power at the city and regional levels, local governments will have an important role to play in accompanying mobility developments and thus greatly influence future business models.

DSO role

In Europe, the DSO's activities are strictly limited by the authority that issues the distribution service by concession, so it will certainly not be a key player in exploiting the business opportunities related to autonomous driving. However, its role will be crucial in other aspects: it will certainly have to react to signals coming from electric mobility operators and support change by adapting the local electric grid. In addition, stakeholders already see DSOs being present in associations that guide choices in electric mobility, fostering an exchange of information and practices that is certainly beneficial to all. For example, identifying and choosing locations for charging stations based on the needs of the grid. Another key role of the DSO is to report back to the authority and operators the signals coming to it from below, from users, facilitating timely interventions and adjustments. A recent trend in South Tyrol and Italy is the increase in requests for connection via three-phase connection, when in Italy, the standard for the domestic end-user is single-phase, as opposed to the rest of Europe (including Switzerland). This innovation at the moment is being hindered by the Italian authorities who want to preserve a historical situation despite the advantages that the change would bring (ensuring more power and more control) and that it is evidently very much pushed by the users themselves.

Costs and accessibility

All experts interviewed agree that individual mobility will gradually decrease in favor of shared and/or public transportation. Also considering the demographic trend (stable or even negative) in many European countries, which will make optimizing mobility supply more manageable since part of individual mobility will be absorbed by shared transportation.

In Switzerland for example, national authorities are actively discouraging individual transport and favoring public and shared transport; this has been a trend for many years.

If the optimization of transportation costs promised by autonomous mobility occurs (higher vehicle utilization factors, battery cost reduction, etc.), mobility expenses for end users may decrease accordingly, further supporting the reduction of private traffic. A mobility and public transport expert from Alto Adige highlights how car sharing is already cost-effective up to 10,000 km traveled per year. Above this threshold, which is already very high, it might make sense to have a private car. In the future, car sharing is likely to be even more profitable.

Experts emphasize that public transport accessibility will have to be guaranteed in any case. Even if it will be difficult or expensive, contributing to climate goals is a mandatory step. It is not a question of if, but how: an appropriate structure will have to be found to do so. Transportation for individual citizens could and should be seen as a citizen's right and guaranteed as such. There should be more ambitious policy directives that do not leave all sector development in the hands of the market.

Car sharing

The South Tyrol car sharing company follows the topic of autonomous mobility closely as it would represent a very promising development for their business, also reducing operating cost and improving the quality of the service. Many carsharing activities could be automated, from driving to cleaning the vehicles, making the business much easier to manage than at present. In fact, the most complex and expensive activities for a carsharing operator are precisely related to logistics: the movement of vehicles and their maintenance.

According to experts, the presence of carsharing service is necessary to reduce the need to own a car, it will therefore play a key role in the transition to more sustainable mobility. To do this, the number of available cars must be sufficient to show users that the service is always ready and available.

A local mobility expert advises that users should always be given several options (bus, train, bike, carsharing), they should not be forced to one vehicle, so integration of different business models will be important.

Carsharing companies in the near future should be able to provide specific services to companies and hoteliers, giving the possibility to outsource mobility services and reducing the number of private fleets wherever possible.

Fleet vehicles

Companies operating large vehicle fleets that we interviewed told us that for the time being, the topic of autonomous mobility is not considered in strategic development discussions. Fleet choices will always be based on cost logic, and thus a reaction to current developments. Companies have then noticed from their experience with EVs that exposing themselves on technologies with very strong growth and development has the inherent risk of having vehicles that become obsolete very quickly. It is a risk factor that they take into account and often mitigate by relying on long-term leasing.

The companies themselves pointed out that a large part of their fleet consists of operational or commercial vehicles (vans and minivans used with working material and tools) and only a minority are assigned to administrative. For this reason, the possible use of self-driving vehicles would not greatly affect the number of vehicles used, which could be reduced by 10-15%. One respondent proposes that these vehicles could be shared among several companies or even public.

Companies are open to V2X but doubt that it can have much bearing on operations except overnight, as operational assets have high utilization factors and must be ready for use at all times.

Gas stations

One business that will inevitably be impacted by both the spread of electric and autonomous vehicles is the fuel station. They will certainly have to reinvent themselves, becoming, for example, a hub (itself automatic) for charging, energy exchange, washing, V2G, as we mentioned earlier. The alternative is probably to disappear.

The Italian case is particular because there is a massive presence of gas stations, in fact there are about 23,000, compared to 16,000 in Germany, 14,000 in France and 3,500 in Switzerland[3]. This is despite a smaller population (compared to Germany and France) and a smaller circulating car fleet: 39.5 million in Italy, 47.7 million in Germany[4].

Refueling stations could also become places for battery replacement in the future, should the possibility of standardized battery replacement alongside charging emerge and spread (as some expect). Here again, the regulator's role in defining obligations and standards, guiding technological development in favor of sustainability, would be crucial. This possibility would ensure very short refueling times, which could also be automated. Extracted and recharging battery modules waiting to be reinserted could become a major storage stock, truly transforming former refueling stations into large-capacity storage stations, with all the business opportunities that follow.

Business opportunities for prosumers

The energy experts we interviewed also see possibilities for the development of autonomous mobility in parallel with energy communities and more generally with PV power plants. Indeed, energy communities could also provide charging services to the outside public and thus optimize their energy positions, taking advantage of surplus. Participating individuals might want to take advantage of new business opportunities and install overcapacity to provide services to the outside public. This would further stimulate the role of energy communities in the ecological transition, as well as boosting the increase of PV capacity. Important in this scenario is the role of the regulator who should frame the possibility of these exchanges, but also the role of the service provider to engage, empower and activate end users.

6.2 Characterization of BMs / BMs' archetypes

Below are broad descriptions of possible configurations that the most important players could exploit to date in the mobility and energy sectors.

DSO and energy utilities are interested in leveraging the smart charging/discharging of ECAVs/ESAVs to improve their positioning in energy markets (profiting from them) or manage their infrastructure (avoiding new investments). Using autonomous vehicles as added energy assets to optimize their portfolio.

On the other hand, private companies can leverage autonomous vehicles to offer new and innovative mobility services. While public companies, tied to the public transportation service they must provide, will use self-driving vehicles to optimize

[3] Anagrafe impianti distribuzione carburanti (mise.gov.it)

[4] Statistics | Eurostat (europa.eu)

the management of services under their charge. At the same time, both will be able to benefit from additional energy services provided by the vehicles.

Typical business opportunities linked to the management of the electrical storage installed within EVs and CAVs derive from the inframarginal rent between the price of the electricity used to charge the vehicle (lower) and the price of the electricity sold from the vehicle (higher), also considering possible ancillary services provided by the battery itself. Those prices can vary widely depending on how the energy is produced (e.g., from a proprietary PV plant or bought from a retailer), who is sold to and the specific value of the additional services provided by the vehicle's battery (e.g., peak shaving, frequency/voltage control, etc.).

Those prices are set by electricity market auctions or by bilateral contracts stipulated among the parts, typically with the utility/retailer/aggregators who guarantees a price to the end users and takes charge of exploiting the aggregated potential capacity from the vehicles on electricity markets (providing energy or ancillary services).

6.2.1 DSOs role and opportunities in the EU

The European Commission *Clean Energy for All Europeans*[5] package define the role of DSOs, highlighting their growing importance in the energy sector. The local nature of DSOs places them at the center of the ongoing ecological transition. (*DSO Role*, 2017) (*DSO Future*, 2015)

DSOs oversee the final delivery of electric energy, carrying it from the transmission grid (responsibility of the TSOs) to individual consumers, being residential or commercial end users. DSOs are usually assigned the responsibility for the distribution grid and distribution substations, ranging between 2 kV and 35 kV (medium and low voltage). This involves the physical maintenance of the network and the investment necessary to guarantee the safety and quality of the service (adequacy of the system[6]) following the evolution of the electricity demand. To do this, it is clear that DSOs must be prepared to handle the technological developments of the near future, adapting the network to accommodate them. The investments required for network development are usually remunerated through prefixed terms. Also, a fee is owed to the distributor for access to and use of the local distribution network. The tariffs are usually established by the National Regulatory Authority (the NRA, in Italy the ARERA) and charged on the electricity bill. The tariff components and these revenue streams represent the main DSOs' cash flows.(*DSO Role*, 2017) (*DSO Future*, 2015) (*DSO Future*, 2015)

Electricity distribution is an activity of public interest and strategic importance, reserved for the state (so-called natural monopoly) and attributed to DSOs under a

---

[5] https://energy.ec.europa.eu/topics/energy-strategy

[6] https://www.terna.it/en/electric-system/dispatching/adequacy

concession assigned by grant of a specific Authority (in Italy, the Ministry of Economic Development) according to procedures defined by law. To ensure the rationalization of the electricity system, only one distribution concession should be issued per municipal area (*DSO Role*, 2017) (*DSO Future*, 2015).

DSOs are also subject to strict regulations that limit their activities to those stipulated by their function and obligate them to provide specific services (i.e., the obligation to connect to its networks all entities that request it). In EU electricity distribution businesses must be carried out under societal unbundling from the other energy sector activities (production, transmission and sale). Given the current regulations, DSOs are clearly unable to directly exploit the business opportunities that will emerge from the spread of autonomous mobility. Equally clearly, their operations will be greatly impacted by the presence of EVs and CAVs, so it will be in their interest to accompany the electrification of the transportation sector by optimizing the management of the network under their control (*DSO Role*, 2017) (*DSO Future*, 2015).

One of the future role of DSOs could be to inform about the potential impact on the network of where to install charging points (single or bi-directional). Currently, the choice is almost always made only based on the commercial convenience of the operators of the charging stations. There will certainly have to be more cooperation between the different interests of network operators and EMPs (*DSO Role*, 2017) (*DSO Future*, 2015).

6.2.2 DSOs role and opportunities in Switzerland

In Switzerland, the responsibility for supply lies with energy supply companies. As of 2018 it had 630 distribution grid operators, 70 percent (430 companies) are purely distribution companies that do not own power plants. The vast majority of Swiss power supply companies, nearly 90 percent, are owned by public entities, namely cantons and municipalities (UFE, 2018).

After the opening of the market for large consumers, these entities can also purchase electricity on the free market and supply it to their customers. Small consumers (households and small commercial customers), i.e. more than 99 percent of all end customers, cannot purchase electricity on the free market and are tied to the local electricity supply company. The current situation can be compared to that of a market in which 630 bakers operate. The small consumer, however, can only buy bread from one of these bakers. Customers would not tolerate such an obligation in any other market. For this reason, the current Electricity Supply Act (ELA)[7] (UFE, 2018) (*EU-SW*, 2022).

[7] https://www.eda.admin.ch/europa/en/home/europapolitik/ueberblick.html

In total, the Swiss electricity grid covers 200,000 kilometers, most of which belong to local and regional distribution networks, while only 6700 km belong to the transmission network (high and extra-high voltage lines), which has 41 connections with foreign countries[8] (*RS 734.7*, 2021).

Since Switzerland joins the European Economic Area through bilateral agreements[7], it is imaginable that it will follow, even indirectly, the directives of the European Union. To give an example, the regulation on cars is a 1:1 copy of the European one, with very small but very specific differences, and so in the other sectors. However, given the complex situation of the current situation, it seems unlikely that the negotiations will lead to the conclusion of a real agreement on electricity.

6.2.3 Electricity retailer/seller/aggregator/utility role and opportunities in the EU

According to (Corchero Garcia, 2022) , in order to favor a good integration between EVs and electric grid (VGI) in the ecosystem represented in Figure 2 , it is necessary to consider EVs as a DERs (Distributed Energy Resources).

(DER, 2022) defines DERs as small-scale units of power generation that operate locally and are interconnected to large power grids. Solar panels, small natural gas generators, and controllable loads, such as HVAC systems or electric water heaters, are also DERs.

In order to use renewable energy sources, it is necessary to connect, manage, and store multiple renewable sources due to their intermittent nature. For hardware such as wind turbines, solar panels, and tidal generators, energy storage such as batteries is needed. DERs are also used to manage a number of smaller power generation and storage methods in residential, commercial and industrial sectors. Power sources and storage devices must be tightly managed by way of electronic management devices, such as inverters and software-defined as Storage Distributed Resource Schedulers (SDRS).(DER, 2022)

Starting from the DER concept, aggregators can increase their revenues through:

- The possibility to buy electricity at a lower price from aggregated vehicle storages than the clearing price set by the wholesale electricity market or by electricity supplier. This is because at certain hours of the day there can be elevated renewable energy production or higher production than demand.
- Peak shaving and load shifting: containment of peak of electricity demand in order to better follow the profile stipulated on the wholesale markets and avoid penalties or more costly line of action.

[8] https://www.fedlex.admin.ch/eli/cc/2007/418/it

A key impact of AVs lies in the ability to implement fleet management policies tailored to the two points discussed above through control systems, that is, to be able to have SDRS technologies inside the EVs. Aggregators can then control AVs in space and time, increasing their revenues. In another sense, this can be considered a smart charging system, which directly controls the electric vehicle instead of controlling the charging strategy.

As analyzed in the parallel SUPSI project MERA (Autonomous Renewable Electric Mobility), which focused on aspects related to Ticino DSOs, AVs will only have a quantitative impact rather than a qualitative: as a result of the electrification process and the possibility of grid arbitrage, changes at business grid level won't be qualitative, but will only affect energy quantities.

Of course, a whole range of completely new and innovative BMs could emerge that to date are unimaginable, such as the detailed configurations these will take. We will, therefore simply be thinking about how BMs, those that will be "forced" to relate to or integrate autonomous mobility into their activities, will be impacted and be able to take advantage of the new opportunities generated by the transition to fully autonomous driving.

6.3 Proposed BMs

Developing a business model from scratch requires very detailed information about the entity that will apply it, its specific characteristics, means available, objectives, etc. This effort is difficult within the present analysis and would go beyond the scope of the deliverable. It was therefore chosen to identify two generic actors, one for the public transport sector and one for the electric sector, and to analyze all possible impacts on their current businesses using the Business Model Canvas as a reference.

In addition, business possibilities and impacts of autonomous mobility on all actors in the two sectors were discussed extensively in the interviews (reported in the section 6.1.2).

6.3.1 Energy company

KEY PARTNERS	KEY ACTIVITIES	KEY RESOURCES
Users and the various proprietary structures of autonomous vehicles are possible new partners and suppliers. DSOs, charging points owners and managers, EVs and CAVs owners/users, electricity consumers, developers, …	Key activities, in addition to the current, will be related to innovative management of the increasing number of vehicles participating in energy businesses (V2X, services, trading, peak shaving…) and the related potential energy exchanges. Stronger coordination needed with DSOs, aggregators, EMPs and actors in the energy/mobility sector to leverage and remunerate distributed capacity.	Small operators may not be able to take advantage of new opportunities, not having the key resources to invest and pursue innovation themselves, needing returns from investment quickly. These will simply apply the technologies that gradually become standard, to avoid risk. Resources needed are less "human" and more "technological".
VALUE PROPOSITION	**CUSTOMER RELATIONSHIPS**	**CUSTOMER SEGMENTS**
Deliver fully sustainable electricity to current and new customers, integrating mobility services into an innovative offer. Provide additional services and revenues without affecting the main use of the mobility/energy assets. Cities more livable with less private transportation.	Energy companies always try to exploit emerging business opportunities leveraging the direct relationship with consumers. At the beginning incorporating the additional service in the energy offer, but once it becomes stable and autonomous it is often separated into a dedicated company.	Energy consumers will remain the main customers, but their relationship will have to evolve to enable a broader characterization of them: from prosumers, to participants in energy communities, to service providers. Companies will need to expand their ability to manage different segments, providing value and services to all.
CHANNELS	**COST STRUCTURE**	**REVENUE STREAM**
Energy service providers will always play the role of aggregator and mediator between users and the energy system. By managing and optimizing energy exchanges but also the dissemination and user awareness aspect, implementing new models.	May want to exploit the economies of scope between the energy and the mobility sector, leveraging the potential power capacity from EVs and CAVs to offer remunerative services on electricity markets (more in terms of cost reduction/optimization than a source of revenue, experts say).	Given the current market price structure, energy companies do not see interesting and substantial potential revenues from V2G. Need for higher potential inframarginal rents, but the more the number of V2G vehicles increases the less margin there will be (opposing trends).

Table 2 Business Modes proposal for energy companies

6.3.2 Transport company

KEY PARTNERS	KEY ACTIVITIES	KEY RESOURCES
Users and the various proprietary structures of autonomous vehicles are possible new partners and suppliers. DSOs, charging points owners and managers, EVs and CAVs owners/users, electricity consumers, developers, …	Providing additional services without impacting on the normal user needs (mobility), competing with new players. Managing intermodality will become increasingly important: connection between autonomous vehicles and the main public transport corridors. Building and managing intermodality and charging hubs will be an additional possible activity for companies.	Need for big investments in research to keep up with the changing paradigm (i.e., dedicated charging infrastructure in bus depots). Likely there will be a substantial market concentration. A vehicle fleet with integrated PV panels could foster even more the concept of car as an energy asset. Positive impact on current difficulties: recruitment of drivers, fuel supply, …
VALUE PROPOSITION	**CUSTOMER RELATIONSHIPS**	**CUSTOMER SEGMENTS**
Integrating existing mobility services and offers to as part of the energy sector, positively contributes to the ecological transition. Reduced emissions with fewer people with the need for a private vehicle.	Public transport can become more attractive when the last mile problem is managed by autonomous vehicles, integrating and completing the public transport offer. Public transport users will be active players in determining mobility supply; more interaction with users and other modes of transport, including newcomers, is needed.	Creating value for people: cities more livable and sustainable with less private transportation and more effective public transport. Users must perceive the public service as accessible, effective, and always available. This will require investment and support from the regulator, but it is a critical step toward climate goals.

CHANNELS	COST STRUCTURE	REVENUE STREAM
Companies must be able to integrate and take advantage of all innovative means to provide transportation services, which is also seen as a right to mobility. Local governments must support the establishment of direct channels with citizens and users of public transportation, given the public interest in the service provided.	Possibility to efficiently manage public transport and offer in peripheral areas and last mile, optimizing costs and routes. Possibility for cost optimizations: drivers, no empty rides, etc. All experts interviewed expect lower costs for fleet management and mobility services. Higher costs for PT related to higher frequency of buses and trains necessary to offer a competitive service.	Additional revenues from a smart management of charging. Buses and larger vehicles have higher potential to generate attractive rents also for mobility providers. New revenues from smart charging and provision of energy services are not so relevant since the binding use of vehicle.

Table 3 Business Modes proposal for energy companies

7 CONCLUSIONS

The present analysis was carried out from a review of the scientific literature and is built on the information collected and processed in the previous deliverables of the EVA project. Given the lack of specific data on the impacts of autonomous driving on existing energy and mobility systems, interviews with the most relevant players in the two sectors were key to gathering perspectives on the development of business models that will manage autonomous mobility.

It is interesting to note that many of the views expressed in the individual interviews, even the more futuristic ones, are broadly shared by almost all interviewees from different sectors and with different expertise, expressing a need for more ambitious and environmentally conscious policies.

As the interviews revealed, the role of local governments will be crucial in designing the context in which autonomous mobility will be employed, being able to facilitate its introduction. For this reason, will require local governance with vision and capable of setting ambitious goals to lead the ecological transition and contribute substantially to the climate change mitigation through a careful management of the increasingly integrated mobility and energy sectors. This particular topic will be covered more extensively in the dedicated deliverable of the project EVA 5.3 “Guidelines for the ECAVS transition on the regional level”, which will be made public at the end of October 2022.

7.1 Comparison between pilot areas

Given the inherent uncertainty about future business models that will manage autonomous mobility and the geographic and economic similarities between South Tyrol and Ticino (already expressed in particular in the (Grotto, Cellina, et al., 2020)), it was chosen to treat the two territories indiscriminately. The results and insights obtained from stakeholder involvement apply to both the project areas.

The only issue that currently differentiates Italy and Switzerland is the regulatory framing of the DSO's role, as discussed in the dedicated section. However, it can be assumed that in the time horizon in which autonomous driving will be available and widespread, Switzerland will apply the same unbundling principles valid in the EU and the US for the energy sector.

7.2 Main findings

From the interviews we can summarize that:

1. The AVs will have high utilization factors and therefore limited flexibility (they must always be ready for use);
2. As more players (aggregators of individual EVs) participate in power exchanges through V2G, the more the price differential will decrease due to the inherent behavior of electricity markets, thereby reducing revenue opportunities;
3. For small economic returns that are difficult to appreciate, it is difficult to see in the future that the average private user would be incentivized to make his or her

car available to an aggregator (changing his or her charging behavior and increasing wear and tear). Different might be the case for owners of large fleets of cars;

4. Fleet decisions are always based on cost logic, and thus react to current trends. With EVs, companies have learned that exposing themselves to technologies with very strong growth and development carries the inherent risk of having vehicles that become obsolete very quickly. This risk factor is taken into account and often mitigated through long-term leasing;
5. It is important to place fast charging at strategic locations;
6. Avs could add the most value on the last mile, thus complementing the public transportation that already covers the rest.
7. Current investments on electric charging infrastructure play an important role on the diffusion of electric mobility. As set out in the previous points, these infrastructures must be positioned at the most strategic points in the territory, considering technical, social and economic variables. Investments for new charging facilities for ECAVs should be aimed at having infrastructures that will necessarily actuate smart-charging techniques and if possible also bi-directional flows with the grid (V2G).

8 BIBLIOGRAPHY

Athuraliya, A. (2019, October 25). Business Model Canvas Explained | A Step-by-Step Guide with Templates. *Create Blog*. https://creately.com/blog/diagrams/business-model-canvas-explained/

Autonomous vehicles—Automated vehicles use case. (2020). *Diamond-Project.Eu*. https://diamond-project.eu/automated-vehicles/

Azaria, M., Ben Dror, M., & Laviv, R. (2020). *Autonomous Vehicle Policy Framework: Selected National and Jurisdictional Policy Efforts to Guide Safe AV Development* (November 2020; p. 76). https://www3.weforum.org/docs/WEF_C4IR_Israel_Autonomous_Vehicle_Policy_Framework_2020.pdf

Charging for phase-out. (2022, April 21). Transport and Environment. https://www.transportenvironment.org/discover/charging-for-phase-out/

Corchero Garcia, C. (2022). *Managing grid integration of electric vehicles GEF Global Programme to Support Countries with the Shift to Electric Mobility*. https://iea.blob.core.windows.net/assets/0174051d-c567-489d-b23d-324e46df9312/CristinaCORCHERO_Managinggridintegrationofelectricvehicles.pdf

Dernai, M. (2022). *Premium meets responsibility*. https://iea.blob.core.windows.net/assets/fe8de3f2-2c9c-4620-a6e6-cb1f268204c0/MonikaDernai_Premiummeetsresponsibility.pdf

European Energy Regulators' White Paper # 2 The Role of the DSO Relevant to European Commission's Clean Energy Proposals. (2017).

EVA Project – ERA-NET EVA Project. (2022). https://evaproject.eu/

Fermata Energy. (2022). Fermata Energy. https://www.fermataenergy.com

Gastelu, G. (2022, May 18). *Ford and VW-backed Argo AI launches fully driverless car service in Miami and Austin* [Text.Article]. FOXBusiness; Fox Business. https://www.foxbusiness.com/lifestyle/ford-vw-argo-ai-driverless-car-service-miami-austin

Gavrilescu, I. (2017). Effective business models for electric vehicles. *Proceedings of the International Conference on Business Excellence*, *11*. https://doi.org/10.1515/picbe-2017-0004

George, T. (2022, January 27). *Semi-Structured Interview | Definition, Guide & Examples*. Scribbr. https://www.scribbr.com/methodology/semi-structured-interview/

Grotto, A., Cellina, F., Vettorato, D., Grotto, A., & Zubaryeva, A. (2020). *REPORT ON TEST SITE MOBILITY ANALYSIS*. https://evaproject.eu/wp-content/uploads/2021/01/EVA_D22.pdf

Grotto, A., Zubaryeva, A., Veiga Simão, J., & Cellina, F. (2020). *REPORT ON STATE-OF-THE-ART OF ELECTRIC AND AUTONOMOUS MOBILITY POLICIES AND BUSINESS MODELS*. https://evaproject.eu/wp-content/uploads/2020/10/EVA_D21.pdf

Home: V2G Hub | V2G Around the world. (2022). [S]. https://www.v2g-hub.com/

Managing grid integration of electric vehicles—Event. (2022). IEA. https://www.iea.org/events/managing-grid-integration-of-electric-vehicles

Overview-Relations between Switzerland and the EU. (2022). https://www.eda.admin.ch/europa/en/home/europapolitik/ueberblick.html

Pasquier, S. (2022). *Strategizing city networks and charging infrastructure*. https://iea.blob.core.windows.net/assets/e3e8065a-7cc6-4c66-b6e1-ae38377b34bd/Sara_Pasquier_Fastned_Strategizingcitynetworksand-charginginfrastructure.pdf

Public charging infrastructure deployment strategies and business models—Event. (2021, December). IEA. https://www.iea.org/events/public-charging-infrastructure-deployment-strategies-and-business-models

RS 734.7—Legge del 23 marzo 2007 sull'approvvigionamento elettrico (LAEl). (2021, January 6). https://www.fedlex.admin.ch/eli/cc/2007/418/it

Scotland, C. (2022). *EVS IN NORWAY Impact on the grid, and how to deal with it*. https://iea.blob.core.windows.net/assets/606da64a-4c32-4456-b188-b5d3397330b7/ChristerSkotland_EVsinNorwayImpactonthegrid%2Can-dhowtodealwithit.pdf

The Future Role of DSOs A CEER Conclusions Paper. (2015).

UFE. (2018). *Scheda informativa 2 – Il mercato elettrico svizzero*. https://www.newsd.admin.ch/newsd/message/attachments/54050.pdf

Vehicle-to-grid. (2022). In *Wikipedia*. https://en.wikipedia.org/w/index.php?title=Vehicle-to-grid&oldid=1097047207

Vehicle-to-Grid (V2G): Alles was Sie wissen müssen. (2019). https://www.virta.global/de/vehicle-to-grid-v2g

Veiga Simão, J., Cellina, F., Grotto, A., Osti, S., & Vaccaro, R. (2021). *MOBILITY OF TOMORROW SCENARIOS: DIFFUSION OF AUTONOMOUS VEHICLES AND THEIR*

IMPLICATIONS. https://evaproject.eu/wp-content/uploads/2021/11/EVA_D32.pdf

Volvo Car Italia (Director). (2022). *Guida Autonoma—Nuove regole della mobilità fra Etica, Diritto e sviluppo di Prodotto [13.01.2022]*. https://www.youtube.com/watch?app=desktop&v=jiRoRpBpsCU

What is distributed energy resources (DER)? - Definition from WhatIs.com. (2022). WhatIs.Com. https://www.techtarget.com/whatis/definition/distributed-energy-resources-DER

FUNDING

This document was created as part of the ERA-Net Smart Energy Systems project no. 91188 - EVA, funded from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 775970 (RegSys).