Opportunities for e-mobility and grid services for microgrids in the context of an industrial area in Switzerland

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Abstract

This paper describes first the impact of electric mobility and Vehicle-To-Grid (V2G) on the energy balance of a microgrid in a real case - an industrial park at Yverdon in Switzerland. Secondly, potential business models for the value created from different scenarios for taking advantage of battery electric vehicle flexibility are described. This study set the stage for the demonstration and application of the microgrid concepts developed in a real case at Y-PARC Swiss-Technopole.

Keywords

Electric Mobility, Microgrid, V2G, Grid services, Business models, Electric vehicle, Distributed storage

1. Introduction

Photovoltaic is a decentralized, local energy production, currently developing very fast. Self-consumption on site is currently the most interesting way of using it. On the other hand, electric vehicles share in the private mobility sector is increasing much faster than expected in developed countries. What will happen when a substantial number of roofs will be covered with photovoltaics and electric cars will become the norm? Indeed, electric mobility can enhance self-consumption. Moreover, cars can be charged in a smart way, while their batteries might help mitigating the impact of massive PV development on the power grid by providing crucial load shift capacities for intermittent, weather-dependent power generation and day-night dynamics. Key question, though, is which business models can be built out of this new opportunity? Who are the actors involved? Can new players on the energy market, along with traditional stakeholders, cooperate to integrate the new complexity of decentralized microgrids in their products and offers? What are the gains for the end-users?

Various scenarios have been proposed not only to integrate electric mobility in itself but to take advantage of the decentralized storage capacity that electric cars do indeed constitute for the power distribution grid. Among those future visions, so-called vehicle-to-grid (V2G) architectures have been put forward, in which the embarked batteries can be contracted – typically on the workplace – to deliver ancillary services to the grid. In a V2G scheme, a swarm of car owners in a given place agree to put part of the battery capacity at disposal of the local power utility, that can use it to stabilize the grid with or without local PV production. V2G schemes can present certain advantages in given conditions and depending on the local constraints but must take into account several parameters including the lifetime of batteries, the individual preferences of car owners and, of course, the different power tariffs proposed by utilities. Other schemes towards the integration of electric cars have been proposed [1] and future configurations will probably include a variety of configurations, besides V2G, including so-called vehicle-to-home (V2H).

The results presented here are from the European Interreg RegEnergy project, which aims at rethinking existing structures to increase the use of renewable energy in the northwestern regions of Europe. At the same time, the project

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allows identifying the right framework and local conditions that could foster V2G schemes in given situations, e.g. on industrial sites. At Swiss level, the project consists in studying the replicable case of the Y-PARC industrial zone and in evaluating the technical and economic impacts and opportunities of the deployment of renewable energies and electric mobility in the framework of a microgrid.

2. Impact of Electro-Mobility on the Microgrid

The industrial zone studied is the Y-PARC zone in Yverdon-les-Bains. Currently, 170 companies are located there and 1,500 people work there daily. The development of the zone continues and it is already foreseeable that by 2025, about 3,000 employees will work in the zone.

2.1. 100% solar scenario

The "100% solar" scenario calls for the installation of 5,370 kW of photovoltaic installations, which represents the realistic hypothesis of photovoltaic installation deployment of all the buildings of Y-PARC. The scenario variants studied are based on:

- 100% solar: 5370 kWp of PV installations;
- 100% solar and battery: 5370 kWp of PV + 20 MWh of stationary battery;
- 100% solar and mobility: 5370 kWp of PV + 1500 electric vehicles;
- 100% solar and mobility + battery: 5370 kWp of PV + 1500 vehicles and 20 MWh of battery.

The electricity consumption is high compared to the solar power production capacity considered in the 100% scenario. Without batteries or mobility, 77% of the solar energy produced is already consumed directly on site, as shown in the Fig.1. The battery, which allows to store solar energy instead of feeding it into the grid, would increase the self-consumption rate to 97%. 40 % of Y-PARC's needs are covered with solar energy, compared to 32 % in the variant without a battery. Electro-mobility increases the total consumption but also increases the self-consumption rate to 90%. It is important to note here that vehicles are considered only as consumers. The potential of V2G is discussed in the next chapter. Finally, a combination of electric mobility with a battery can achieve almost 100% self-consumption.

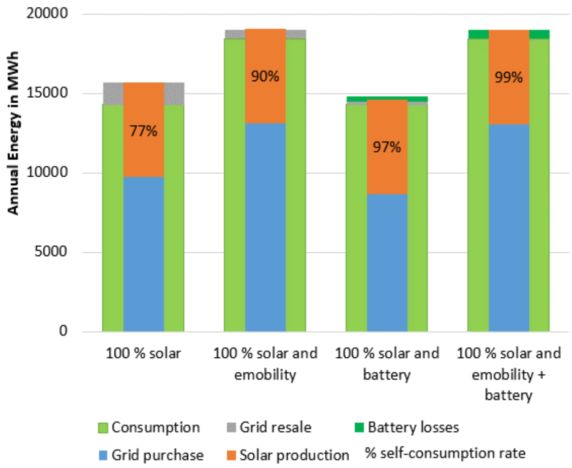

Figure 1: Balance of the different variants for the 100% solar scenario

Considering that the photovoltaic electricity produced is consumed in priority by the building, the following balances distributed by type of needs are obtained in the Fig. 2.

	100 % solar	100 % solar and emobility	100 % solar and battery	100 % solar and emobility + battery
Solar production	5945	5945	5945	5945
Self-production	32%	29%	40%	32%
Share of solar energy in vehicle power supply	n.a.	19%	n.a.	25%
Share of solar energy in the power supply of buildings	32%	32%	40%	34%

Figure 2: Breakdown of the energy balance by type of use

2.2. 200% solar scenario

The "200% solar" scenario calls for the installation of 10 520 kWp of photovoltaic installations, which represents the optimistic hypothesis of photovoltaic installation deployment of all the buildings of Y-PARC. The scenario variants studied are based on the same variants of electric mobility and battery as the 100% scenario.
The doubling of the PV production implies that a smaller part of this production can be consumed directly on the Y-PARC. Self-consumption rates between 50 and 87% are thus achieved, as shown in the Fig.3. The amount of energy sold back to the grid also increases significantly. However, the impact of mobility and the battery remains important and the same phenomena can be observed between the variants described.

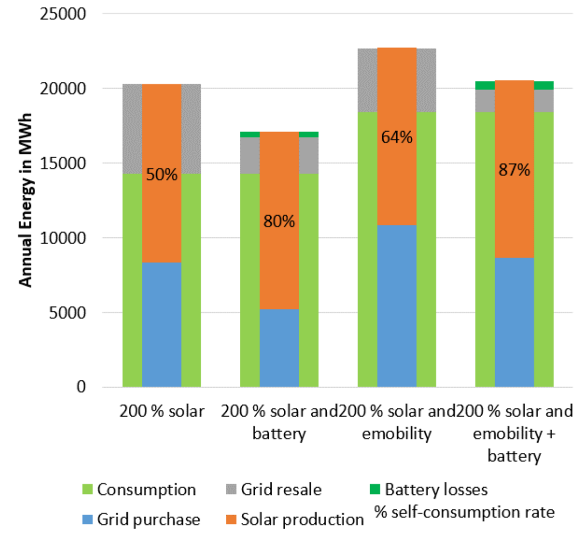

Figure 3: Balance of the different variants for the 200% solar scenario

We could imagine providing solar power to more vehicles or adding a larger battery to increase the self-consumption rate as shown in the Fig. 4.

	200 % solar	200 % solar and emobility	200 % solar and battery	200 % solar and emobility + battery
Solar production	11892	11892	11892	11892
Self production	41%	66%	41%	56%
Share of solar energy in vehicle power supply	n.a.	n.a.	42%	63%
Share of solar energy in the power supply of buildings	41%	41%	41%	54%

Figure 4: Energy balances by type of use

In the two cases presented, the introduction of mobile or stationary batteries also allows for a clear reduction in the amount of energy to be injected into the grid and the constraints in this regard. If mobility increases the power consumed, it does so in a regular way and without uncontrolled power demand peaks. In terms of consumption, the maximum power demand is 2,460 kW without electric mobility and 4,351 kW with electric mobility. For the 100% solar scenario, the power demand due to mobility is higher than that due to photovoltaics. For the 200% solar scenario, this is no longer the case.

2.3. Potential of V2G for peak shaving

If the battery has the ability to discharge to the grid as required, its use can be enhanced in three ways. The battery can be used to store solar energy when it is produced for reuse at night or in bad weather. It can also be used to cover consumption peaks to avoid increasing the power drawn from the grid.
The energy bill is made up of two parts: the amount of energy consumed and the maximum power drawn from the grid. Reducing these power peaks therefore represents an interesting potential of vehicles. If, during a peak consumption, the consumer can call on the available fleet of vehicles to supplement the power withdrawn from the grid, he can make substantial savings.
In the case of an industry with a limited number of short peak loads per month, the potential is very large as shown in the figure 5. Indeed, 3 vehicles with 62 kWh batteries could reduce the power demand by, for example, 30 kW for one hour, i.e. a saving of CHF 145. However, this scenario implies either that the peak is unique in the month, or that the vehicles are also available for the other peaks of the month, without additional gain. Considering the consumption of Y-PARC, it is possible to calculate how many vehicles are necessary to flatten the curve in such a way to reduce the maximum power each month.

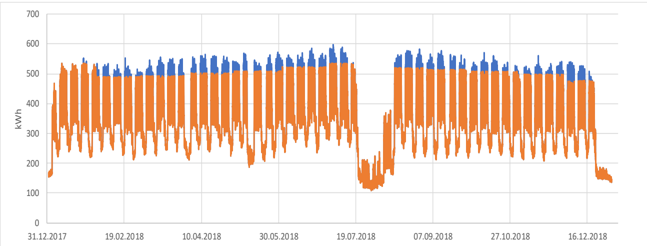

Figure 5: Smoothed consumption curve (orange) for 250 kW less power

3. Business Models

There are different types of approaches that researchers use to ideate and define which business models are most relevant in the case of a given future business concept. In this case, initial interviews fed the design of a workshop that informed the RegEnergy team on new business model options, and new tariff schemes that could make the microgrid project economically interesting for all actors involved. The interviews were held with a selected group of existing companies active in Switzerland in the space of EV charging, microgrid management and grid operations. Interviews were conducted in June 2019 with relevant stakeholders on the supply side of the market (for example those with a technology offering) as well as those on the demand side (such as building investors). At a final workshop in January 2020, three possible tariff structures were defined in the group dealing with the microgrid business model aspects, and in the other group business model aspects relevant to the EV charging and the management of the EVs were explored and further developed. This led to the analysis prepared by Planair based on the combined findings of their modelling work, the insights from the interviews and finally the insights gathered at the workshop.

By conducting interviews with stakeholders at the start of the project with regard to business models possible for the microgrid management, we learned that:

1. The model where the DSO at least appears to be in the centre of the ecosystem as shown in the Fig. 5, could be the most sustainable model when competition is greater and early entrants face new business models emerging from incumbents.
2. The second option (where the microgrid manager has the lead) could be possible if building management companies (and owners of buildings) get into the business, and see the potential for other service offers.

3. The more likely case would be that the microgrid manager has a contract with the DSO for the services that allow for the good function of the microgrid, with the electricity sold or bought at a fixed price or variable price depending on the business model.

Three tariff structures were discussed at the workshop. Finally, insights with regard to the demand side pointed out a few risk areas to explore, such as:

- How to deal with multiple owners on the site and their need to agree before investments are made;
- EV customers are still few today although there is a slowly growing interest.

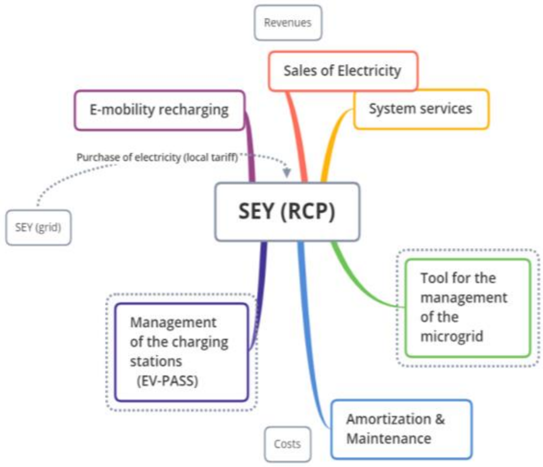

Figure 6: Business model overview for the case of the DSO at the centre of the ecosystem

To conclude, for now this appears to be a DSO-led innovation ecosystem opportunity, with involvement by various innovative start-ups offering different technologies and services. The following business model was designed in the end, following the design-thinking workshop, and serves as the working model by the Planair team for the follow-up demo project named “SunnYparc”. How the relevant RCP and other related regulations evolve over time will play a large role in determining which business models to pursue in the future. It will for example have a large impact on the choice of technology and the choice of service providers for this type of investment.

4. Economic Valorisation of Electro-Mobility

If the battery has the ability to discharge to the grid as required, its use can be enhanced in three ways. The battery can be used to store solar energy when it is produced for reuse at night or in bad weather. It can also be used to cover consumption peaks to avoid increasing the power drawn from the grid. Finally, a large number of pooled batteries can provide capacity for system services.

Vehicle batteries can be used in many ways. However, complex intelligent management is needed to take advantage of these different uses. A charging power of 11 kW and a discharging power of 10 kW are considered.

As seen in the Fig.6, the potential of electric vehicles without the V2G option is very high when considering only the self-consumption optimisation. It represents between 50 and 350 CHF/year per vehicle for the user depending on the situation and can represent a savings of 145 000 CHF/year on the fleet scale of Y-PARC.

Considering again the self-consumption scenario as the only value creation source, the V2G option is only interesting if we consider a case where the number of vehicles is limited and can represent a gain of up to 525 CHF/year for a vehicle. However, when the number of vehicles in the area increased relative to the amount of solar energy available, this value decreases: it represents between 31 and 47 CHF per vehicle per year for the microgrid. If we assume a 100% electric vehicle fleet at Y-PARC, the V2G option brings no added value under the considered circumstances.

	Electric Vehicle Valorisation	Additional value with V2G option		
	Self-consumption Optimisation		Peak shaving	Grid services
One Vehicle	50-350 CHF/year	525 CHF/year	582 CHF/year	50-400 CHF/an
Micorgrid		12400-18800 CHF/year	233 000 CHF/year	20000-160000 CHF/year
Y-PARC	145 000 CHF/year	0 CHF/year	873 000 CHF/year	75 000-600000 CHF/year

Figure 7: Summary table of the possible recovery of electric vehicles and the V2G option

On the other hand, offering a peak shaving service represents a gain of about 582 CHF/year per vehicle for a number of vehicles below 1000, which represents a gain of 582 000 CHF/year in total. Likewise, offering grid services represents a gain of between 50 and 400 CHF/year per vehicle. These last two options seem to be the most promising from the point of view of the valuation of the V2G option at the scale of the industrial zone.

The final value of the complete system services remains to be specified depending on the number of vehicles actually permanently expected on site. The split of the potential gains between the electric vehicle users and third parties involved in the project remains to be determined based on the business model selected.

5. Potential of deployment on a testing site

The SunnYparc pilot project was conceptualized based on the work presented above. It will demonstrate the potential of a microgrid for the optimized integration of decentralized production with electric mobility in the electricity supply of an industrial area. The objective is to test in a real case the integration of electric mobility and to demonstrate how one can optimize the penetration of renewable energy thanks to V2G technology and an intelligent control system coupled to the flexibility market for an industrial zone.

The project has been designed for 250 charging station with 50 bidirectional charging stations deployed in a parking silo in the microgrid. In particular, this work has made it possible, through numerous workshops, to spark interest among various market players for such solutions and to work together to imagine a concrete application, both from the technical point of view as well as from the practical point of view of end users. This preliminary work has led to the definition of a pilot project “outline” which has strategic value in various ways and a strong potential for replication in Switzerland.

6. Opportunities and Challenges of V2G for Utilities

6.1. The point of view of the DSO of Yverdon-les-Bains

The role of the DSO in the SunnYparc demonstrator is central, not only as operator of the microgrid, but also as distributed system operator and main investor. It is in a way the manager of this whole ecosystem. From a broader point of view, the model developed in this pilot project should be replicable in other existing districts of the City of Yverdon-les-Bains, in line with the expected development of a smart city.

From a technical point of view, creating a complete system based on smart metering to facilitate energy exchanges between buildings in a defined area around a district substation, using the existing network infrastructure, is a major challenge. Indeed, a significant increase in decentralised energy production requires the implementation of energy exchange capacities at local level (microgrid), while limiting investments so as to guarantee financial profitability for photovoltaic project developers.In an existing neighbourhood, the current legal framework does not allow such exchanges within a restricted area defined by the low voltage level without paying the network charges of higher levels or the implementation of aggregation for own consumption without the installation of new private interconnection cables on the public domain. This doubling of infrastructure is often financially unbearable and also represents a significant risk in terms of electrical safety. Maintaining a higher level of availability and safety of underground electricity networks requires centralised management of their maintenance and upkeep.

The centralised management of these exchanges is based on the one hand on the precise and rapid measurement of the various flows based on smart metering, which is now being developed on a large scale, and on the other hand

on the development of new intelligent demand management systems. This requires the implementation of load management, either according to the volume of physical flows on the network or according to the financial opportunities generated by the system's capacity to provide control energy.
In this context, the electrification of transport, whether individual or public, offers several opportunities for a DSO. The concentration of 250 EV charging points in the SunnYparc project, of which 50 are bi-directional, on a single microgrid allows for a high level of grid load management. The development of solutions to control charging in terms of timing and/or power is a way of maximising the integration of locally produced solar energy by storing it in the batteries of the vehicles present rather than having to resort to solutions for clipping the power of photovoltaic inverters. In the opposite case, when there are high demands on the microgrid or even at the higher level, the bidirectionality offered by the V2G function makes it possible to support the demand locally. This virtual battery made up of several dozen EVs makes it possible to smooth out the network's peak loads and thus drastically reduce the costs generated by any reinforcement of the network or by the installation of dedicated storage units, whether electrochemical or in other forms, such as H2 with water electrolysis. This cost reduction is ultimately beneficial to all users. This sandbox pilot project also provides a great opportunity for a grid operator to move away from the traditional distribution schemes and test different energy exchange models on its existing infrastructure.
However, this business model is not without risk for the lead investor. Its implementation requires an acceptance of the provision of batteries by the users of the charging points in that area. A detailed explanation of the consequences for the use of private batteries, however small, is essential. The financial compensation induced by dynamic pricing is also a major challenge to ensure that the number of participants is high enough to regulate the flows effectively. The multiplication of players in this value chain must also be precisely regulated so that the grid operator can have an overview and the power to decide on the control of the microgrid.

6.2. V2G for smart cities thanks to the “virtual grid”

Power utilities are obligated to follow the so called NOVA-principle (network optimization before network amplification before network expansion), therefore they look for ways to optimally use the existing infrastructure in a “smart” way with appropriate ICT schemes. By monitoring and steering the existing network in a dynamic, real-time framework, by leveraging on existing transport capacity limits and by adding appropriately dimensioned storage capacities, the “same” copper grid can deliver more services, integrate bidirectionality and cope with broadly changing loads [2]. This new approach constitutes one of the cornerstones of so-called smart cities. Sometimes, authors refer to “virtual power grids”: of course, electrons do not flow in non-physical connections, but an overall dynamic management, including on the demand side, somehow increases the possible functions of the existing grid by playing on flexibility. The batteries of electric vehicles can participate in this new operational space by providing mobile storage capacities either for the distribution power grid (V2G) or for industrial and residential microgrids (V2H). The ancillary services provided by the swarm of embarked batteries allows to displace electric power without relying on physical metallic infrastructure and can thus be figured out as being “virtual”. As a complementary approach to V2G, V2H can: (i) provide an interesting alternative to “simple” grid injection of PV power produced on industrial/commercial roof surfaces during usual daylight working hours (even taking into account possible on-site self-consumption); (ii) give access to renewable-based EV charging capacities to segments of the population that do not have access to PV at their living place, which is typically the case in a country like Switzerland, where the vast majority of the population does not own its apartment or individual house [3].

6.3. Limit of V2G usages

The main limit, apart from the economic, regulatory and technical aspects, is the user. One of the aims of the SunnYparc pilot project is to study the acceptability of the approach. The user must be satisfied, accept that the microgrid operator will use the energy from his battery, know how much he will be paid or how much he will save on the energy bill, but also accept that the use of his battery by an external system affects the vehicle's state of charge. If electric vehicle owners refuse to participate in the V2G concept, then everything in all of these research activities will remain only on paper.
The increase in home office since the Covid crisis also calls into question certain models and the energetic relationships that V2G offers between different neighbourhoods such as a residential area and a work area.
The V2G concept should not be the only flexibility tool in the microgrid as it depends strongly of the availability of the vehicles and user’s behaviours.

6.4. Future market scenarios and policy frameworks

Under today's regulatory framework, the DSO must pay a non-discriminatory compensation to their clients to make use of the clients' flexibility (demand response) [4]. The possible blocking point for the flexibility from V2G is now that the client (the EV owner) is free not to provide this flexibility to the grid, if he or she does not want to offer it.

With the market place for flexibility (available in the near future), we could connect existing flexibility with all the vehicle to grid charging stations, or the client could connect their flexibility to the market place to the shared grid and this could become the new way of the demand response - Demand response 2.0. This kind of marketplace for flexibility in the distribution network is not developed yet in any country, but this is one option for operations here in Switzerland if the evolution of the market and the regulations for energy flexibility permitted such a marketplace. In one business scenario which is already emerging today among the most innovative DSOs in the country, the DSO can obtain the flexibility from a platform and pay the end customer for this flexibility. However, as a temporary arrangement, the continued use of ripple control technology by DSOs remains permitted. Consequently, DSOs using ripple control may collectively disconnect appliances of customers (such as tumblers, washing machines, dishwashers, stoves, etc.) in predefined times of high network load (e.g. 12-1 pm). Under art. 31f the customer may opt-out. However, there is no opt-in or compensation requirement when using existing ripple control technology. Therefore in the case V2G, charging stations would be forced to connect EVs to the grid where there is V2G capability. In the future, once the old ripple control technology has phased-out, the regulatory authorities may require all DSOs to provide marketplaces for flexibility in their distribution networks. Customers would then receive a market compensation for the use of their batteries or other sources of stabilizing and controlling the grid.

Another topic of discussion regarding future regulatory framework conditions for V2G concepts is that of storage. Today the issue of how to treat storage is a highly debated topic in the energy industry [5]. Does storage have a value for the network or not, and who obtains this value, the DSO or the TSO, both or neither? Today we lack a clear storage regulation. Therefore, the regulatory authority follows the industry guideline which differentiates between pure storage (somewhere in the distribution network) and storage in combination with final use of the electric energy (e.g. a battery in the basement of a final consumer). The unclear situation makes it unattractive to go for certain business models based on storage solutions.

Finally, there is the ancillary service market [6] and the regulations for this market influence the potential of new business models for V2G as well. If you have a source of storage, let's say from a source of EVs, it is even a current option to provide value to this market from the V2G concepts if you are stable enough, and also meet the pre-qualification criteria. However, it may be hard to meet the criteria because an investor may have to create something like a swarm intelligent system where you have a large number of EVs such as 100 EVs combined with one control option, to provide jointly some energy to the ancillary service market. Nevertheless if one would have hundreds of cars connected to the grid, it would indeed be a profitable venture to provide ancillary services to the grid from these connected vehicles.

Coming back to demand response and the potential future of demand response 2.0 mentioned before, today the DSO does not have to compensate such customers, for their demand response value when using its existing ripple control technology. When applying new intelligent load control technology, the DSO already under today's regulatory provisions has to obtain consent from its customers and compensate them for their flexibility. However, in the future, the DSO might even be obligated to provide marketplaces for flexibility in its distribution network. Which scenario will dominate the market in the end, we do not know yet. Technology is changing and with today's new technology it is possible to use your car at home as a battery system with which you improve auto-consumption, therefore it is not clear yet whether a customer will offer their battery to the grid at their employers' stations, or at other stations outside of his or her home. More work on such business models is being conducted under another study at the moment by HEIG-VD. In the future peer-to-peer trading of energy will also emerge and a pseudo-free market where all people can buy energy from their neighbors will also influence decisions by EV owners who may wish to use their batteries for other purposes. End customers will most likely have to choose if they want to remain uninvolved, or if they want to become a sort of energy service provider aided by new types of contracts. The EV and auto-consumption home-owner then may obtain a new contract where the utility takes care of his or her energy and they also get their energy from local energy producers. They could be paid based on the ask and the bid of the energy, with options being several such as PV and V2G, or a neighbor that produces power in another sustainable way. Such a concept could be made easy for prosumers. For example, inside your balance group, the utility takes care of your power and you choose your energy mix by yourself.

7. Acknowledgements

This work assessed the technical and economic potential of the synergy between photovoltaic production and the presence of a large number of electric vehicles on the Y-PARC site [7]. A second part concerning the business models applicable to these new uses allowed the identification of several models where all the actors can benefit from the advantages of such combinations, as well as different possible tariffs [8]. The conceptualization of the SunnYparc project allowed to create the opportunity to think about a project with the different actors involved and to bring concrete solutions for the energy transition of Switzerland at the local level.
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8. References

[1] H. Turker and S. Bacha, (2018, Nov.) "Optimal Minimization of Plug-In Electric Vehicle Charging Cost With Vehicle-to-Home and Vehicle-to-Grid Concepts," in IEEE Transactions on Vehicular Technology, vol. 67, no. 11, pp. 10281-10292, doi: 10.1109/TVT.2018.2867428.

[2] M. Rayati, T. Pidancier, M. Carpita and M. Bozorg. (2020). "State Estimation for Medium and Low Voltage Distribution Grids Based on Near Real-time Grid Measurements and Delayed Smart Meters Data," 2020 22nd European Conference on Power Electronics and Applications (EPE'20 ECCE Europe), pp. P.1-P.10, doi: 10.23919/EPE20ECCEEurope43536.2020.9215829.

[3] MJ. Burer, M. Capezzali, M. Carpita, V. Pallotta (2021, March). « BlockChainTechnology for Energy Transition » in book Blockchain Technology and Innovations in Business Processes (pp.153-188). DOI:10.1007/978-981-33-6470-7_10

[4] See art. 8c para. 1 and 2 Federal Ordinance on electricity supply. Available: https://www.fedlex.admin.ch/eli/cc/2008/226/fr

[5] Consentec (2015). «Koordination von Markt und Netz – Ausgestaltung der Schnittstelle», a study mandated by BFE - Bundesamt für Energie

[6] Available: https://www.swissgrid.ch/de/home/customers/topics/legal-system.html

[7] Planair, 2020. "REGENERGY Etude théorique 100 % photovoltaïque et mobilité électrique », Available : https://www.planair.ch/files/163/RegEnergy/RegEnergy_EtudeTh%C3%A9orique_04012020.V3.pdf

[8] MJ. Burer (2020, 22 June). REGENERGY report: "Business Models for the development of local renewable electricity production and electromobility 2019-2020", Available: https://www.planair.ch/files/163/RegEnergy/RegEnergy_BM_Activities_Report_29062020.pdf