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Energy transition in a business company – solar PV for a car fleet

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Abstract

Fossil fuels are increasingly limited in today's world, causing an energy crisis due to external factors, increasing prices in international markets. To solve this global problem, the energy transition related to mobility in companies that oversee their car fleets is highlighted. This transition to electric mobility influences several economic, technical, and social aspects, thus it becomes crucial for companies to adapt their infrastructure and dynamics to have more sustainable practices. According to the 2021-2022 EIB Climate Survey, 55% of Portuguese young people consider climate change when looking for a job. Furthermore, when asked about future car purchases, 84% of Portuguese car buyers say they will purchase either a hybrid or electric car, making Portugal the EU No. 1 country in terms of intentions to purchase electric cars. These statistics show the urgency for companies to adapt to future needs, as well as align with the European goals of reducing greenhouse gases emissions to 45% by 2030 and to zero by 2050.

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Keywords: Energy efficiency; Energy markets; Renewable energy; Sustainable cities.

1. Introduction

Due to population growth and industrial development, the need for burning of fossil fuels to produce electrical energy has increased, leading to a drastic increasing level of pollution on Earth, resulting in effects that are directly linked to climate change and to the phenomenon known as global warming. Over the years, the development of

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technology allows, more and more, to obtain alternatives to polluting energies. Obtaining electrical energy through alternative technologies, such as solar energy, contributes not only to environmental savings, but also, in some cases, to capital savings by those who opt for these alternatives, such as companies. The use of renewable energy can diversify in their application, from consumption in buildings, to sale to distribution entities, as well as application in own infrastructures, as is the example of charging stations for electric/hybrid vehicles. As a matter of fact, global electric car sales broke records in 2021, more than doubling the values achieved in the previous year, even in face of supply chain bottlenecks (IEA, 2022). Ambitious government policy announcements, strategies and budgetary commitments also characterized electric vehicles (EVs) developments in 2021.

In general, businesses succeed when they can meet people's needs with solutions that people want, and when a rewarding business model can be established around that interaction (Pedersen, 2018). Encouraging and implementing measures on intrinsic internal dynamics of companies will allow progress towards economic, social, and environmental sustainability. Among such measures, the implementation of photovoltaic (PV) charging stations for EVs stands out, stimulating the transition to electric mobility, not only on an individual basis, but also as a business (Pardo-Bosch et al., 2021). The creation of these infrastructures will contribute to the decarbonization of the economy, progress in infrastructure modernization, reduction of energy dependence, reduction of financial charges related to fuels, reduction in carbon footprint and increased energy efficiency for transportation (Yang et al., 2021). It is based on these principles that companies should act, carrying out energy efficiency interventions and investing in infrastructures that reduce energy dependence. The commitment to these actions will allow companies not only to reduce their annual energy bill, but also offer their employees a more sustainable and healthier lifestyle.

Adding a Vehicle-to-Grid (V2G) configuration to the system results in a bidirectional flow of energy between an EV and the charging station. In addition to offering complete control over the charging process and load-balancing, V2G charging systems can reduce energy bills for businesses and individuals by feeding energy back to the grid at peak times whilst charging during cheap periods. The first remarkable advantage of using this solution is that the dynamic load can be placed on a local substation by EV charging – for instance, in the early evening peak. The second one solves an energy storage problem, using the vehicles as mobile energy storage systems that can be charged off-peak and discharged at peak times (Lauinger et al., 2017). Furthermore, due to the current geopolitical situation and the energy crisis, it is increasingly necessary to seek solutions that respond to the SGDs, increase energy independence, and solve energy and environmental obstacles for society in cohesion.

Thus, the present study aims to represent the clear benefits for companies that this type of infrastructure provides, having a strong economic and social impact. After the study is presented, some considerations and iterations will be made on some possibilities to optimize results. An approach will also be made to estimate the possible impact at national level resulting from the use of this type of technologies and methodologies.

2. **Photovoltaic stations for EVs charging**

Charging with self-generated electricity from a photovoltaic system is becoming increasingly interesting in a business context, bringing benefits in its operating dynamics (Ala et al., 2021). Nowadays, even electric company fleets can be intelligently controlled and charged with photovoltaic electricity in a very cost-efficient manner, as shown in Fig. 1.

As mentioned, the purchase of EVs by the population has been increasing over the years, as has been expected. Sales of EVs reached another record high peak in 2021 despite the Covid-19 pandemic and supply chain challenges, including semiconductor chip shortages. Looking back, about 120,000 electric cars were sold worldwide in 2012. In 2021, that many were sold in a week. After increasing in 2020 despite a depressed car market, sales of electric cars nearly doubled year-on-year to 6.6 million in 2021. This brought the total number of electric cars on roads to over 16.5 million. As in previous years, battery electric vehicles (BEVs) accounted for most of the increase (about 70%) (IEA, 2022).

The possibility of having at home the energy needed to power the vehicle with very affordable conditions attracts more and more people to this trend. Furthermore, this solution is seen as environmentally friendly, which attracts most of the population concerned about the environment. As for companies, for example, when buying a car with an acquisition cost of 50,000 €, adding VAT, the price of the car would immediately rise to 61,500 €. For an electric car, VAT is deductible, which means that the company would not have to pay this tax, paying only the 50,000 €.

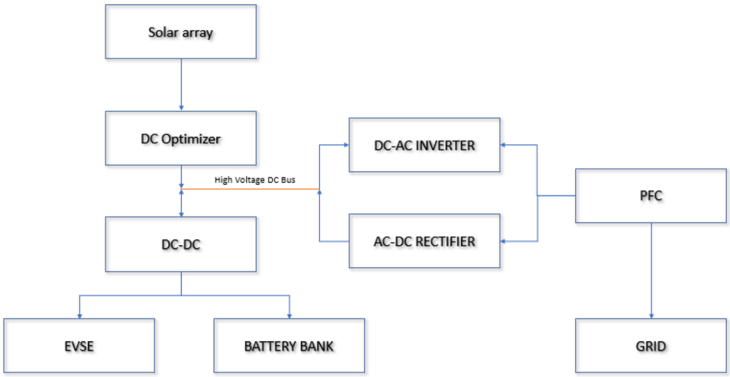

Fig. 1. V2G Power Architecture.

To the value of the car, in Portugal, the autonomous taxation must also be added, a tax independent from the Corporate Income Tax (IRC) which, for diesel or gasoline passenger vehicles, can range from a minimum value of 10% to a maximum rate of 35% on the value of the company with the car. Given the cost of the vehicle in this example (50,000 €), autonomous taxation would correspond to the maximum rate, that is, you would still have to pay 35% of the value of depreciation and other expenses associated with the vehicle, such as tolls, maintenance costs, insurance, fuel, etc.

As for electric vehicles, they are again exempt from this tax, and the company will not need to pay autonomous taxation on any charge it has with the car. Due to this increase of EVs within the population and companies, as also benefits and advantages, the number of investments in charging stations has been increasing significantly (Pande and Report, 2022). In 2021, there were roughly 375,900 public charging stations for electric vehicles in Europe. The number of these infrastructures grew consecutively between 2010 and 2021, with exponential increases observed in 2011, 2012, and 2016 (Statista, 2022).

3. **Case study**

The company in this case study is active in water distribution, wastewater drainage and treatment, rainwater drainage, waterline management, seafront management, energy management and promotion of environmental education and sustainability in the city of Porto – Portugal. From the point of view of environmental sustainability, the company concluded in 2018 an electricity production project from renewable energy that is worth 330,000 €, more specifically, installed a photovoltaic plant on the roof of its headquarters. The estimated annual energy production is 462,396 kWh, of which 72.7% will be used for self-consumption (included for EVs charging stations, as represented in Fig. 2), with the remaining 159,162 kWh being sold and injected into the national grid. The carbon dioxide emissions (CO_2) avoided represent 217 tons CO_2 per year. A 50% reduction in costs associated with the portion of active energy consumed at the company' Headquarters in the first year of production was expected, which allowed the amount invested to be amortized in about eight years.

Fig. 2. Electric vehicle charging stations.

This energy efficiency project resulted in annual savings between 38,000 € and 67,000 €. In 25 years, the estimated useful life for the photovoltaic park, under the current consumption scenario, the company expects to save about 740,000 € in electricity costs. To promote electric mobility, the company acquired 84 vehicles on a leasing plan, of which 52 are fully electric, 8 hybrids and the rest combustion, totaling more than 1,500,000 €. It is estimated a 30% reduction, in liters, in the fuel consumption and, consequently, a significant decrease in CO_2 emissions.

The photovoltaic plant was installed on the roof of the park where the company's fleet is parked, as shown in Fig. 3. The inverter and DC/AC switchboard are installed in the technical area, minimizing losses. The interconnection from the photovoltaic system to the existing electrical system is low voltage. The characteristics of the main equipment are described in Table 1.

Table 1. PV power plant main features.

PV power plant technical features	
Location	Porto - Portugal
Number of modules Q-Cells. Plus L-G4.1 345	357
Total installed power [kWp]	123
Rated output power on the inverter [kVA]	25
Number of SMA 250000 TL inverters	5
Orientation modules	235º
PV slope	8º

Fig. 3. Overview of the implemented PV plant.

4. Economic and environmental analysis

Using the licensed software, PV*SOL, and according to the data presented, the photovoltaic plant displays the values listed in Table 2.

Table 2. PV power plant main energetic features.

PV power plant energetic features	
Energy produced by the PV power plant [kWh/year]	167,277
CO_2 emissions avoided [kg/year]	78,620

As mentioned earlier, the case study company sells the energy produced as surplus to the distributor. Therefore, estimating that about 75% is consumed by electric vehicles for charging, it is possible to conclude that about 41,820 kWh are injected into the grid. Adding to the 159,162 kWh surplus from the previous project, it results in the injection and sale of an estimated 200 982 kWh, resulting in an annual financial return of 7 034.37 € (estimated sale value of 0.035€ per kWh). The combination of energy efficiency projects results in an estimated reduction of approximately 295.6 tons of CO_2 emissions avoided per year.

4.1. Impact on CO_2 emissions

According to European statistical data, the total CO_2 emissions attributed to the Portuguese road transport sector in 2020 was around 800 Mton CO_2 (European Environment Agency, 2019). Assuming that 3% of the cars registered in Portugal that run on fossil fuel belong to car fleets of companies that have invested in the energy transition, traveled the same annual distance in number of kilometers as the European average (estimated 14,000 km) (European Environment Agency, 2019) and that they would make the same investment in photovoltaic park infrastructure for charging vehicles, this would mean an annual reduction of 451,151 or 647,665 ton CO_2, depending on whether the fleet consumes gasoline or diesel, respectively, representing between 6% and 8% of total CO_2 emissions in Portugal transportation sector in 2019.

4.2. Contribution to achieve Sustainable Development Goals

This work brings an original contribution, with a practical case, as it presents a couple solutions that address some specific Sustainable Development Goals (SDGs), as follows:

- *SDG 3 – Good health and well-being* – The improvement in the facilities of this type of infrastructure promote the quality of the services provided by the companies, reducing the exposure of its employees to polluting agents, as well as creating a welcoming space that promotes values which benefit the environment, contributing to mental well-being;
- *SDG 7 – Affordable and clean energy* – The creation of a charging infrastructure will allow to obtain clean energy, with investments that reflect favorable returns in the short/medium term. The main objectives of this infrastructure were to reduce energy dependence, to reduce the annual energy bill associated with fossil fuels in the vehicle fleet and to reduce annual CO_2 emissions associated with the use of vehicles belonging to the fleet;
- *SDG 8 – Decent Work and economic growth* – The modernization of infrastructures will allow the improvement of working conditions for company employees. For companies, this modernization will mean a competitive advantage and advancement in the market compared to other companies;
- *SDG 9 – Industry, innovation, and infrastructure* – Industry investment in new infrastructures, technologies, strategies, and renewable energy paves the way for progress and increased competitiveness in the market. These strategies can be implemented at the national level, promoting innovation, through investment in new technologies and infrastructures;
- *SDG 11 – Sustainable cities and communities* – This project is associated with energy sustainability, which reduces the energy footprint, and consequently, the negative environmental impacts per capita, and is also adapted to climate change;
- *SDG 12 – Responsible consumption and production* – Highlights the importance of clean energy production and responsible consumption. In the present case, the excess production is sold to the distributor so that it can be integrated and distributed in the national electricity grid;
- *SGD 13 – Climate action* – The investment made in electric mobility by the case study company will significantly reduce GHG emissions associated with the use of its vehicle fleet. This decrease, although not very significant at a global level, can serve as a stimulus for other companies to follow the same path, making a joint effort in the investment in electric mobility and the positive effects become quite significant at a national level, as well as at a global level;
- *SGD 17 – Partnership for the goals* – The case study company's strategy focuses not only on the individual aspect as a company, but as a government partner to achieve the European goals outlined for 2030 and 2050. This company aims to increase the supply of EVs' charging points, being able to include articulation with energy production infrastructures and Vehicle-to-Grid (V2G)/Grid-to-Vehicle (G2V) configurations. Highlighting the Vehicle-to-grid (V2G) configuration, this operation describes a system in which plug-in electric vehicles

communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate. Since at any given time 95 percent of cars are parked, the batteries in electric vehicles could be used to let electricity flow from the car to the electric distribution network and back (Texas Instruments, 2016).

5. Conclusions

The implementation of the proposed measures, combined with a previous energy efficiency project, had a very considerable impact, representing a saving in the annual energy bill estimated between 45,034 € and 74,034 € and an estimated reduction of 295 tons of CO_2 emissions per year. It was also possible to conclude that the injection of surplus energy into the national grid, although not quite profitable compared to the investment in the short or medium term, reinforces the robustness of the project payback time, reducing the annual energy bill and having a direct impact in the national and European goals outlined for 2030 and 2050, decreasing energy dependence and CO_2 emissions associated by its energy and fossil fuels consumption. In addition, it increases the amount of green energy produced in the country, contributing favorably to the energy mix of electricity distributed on the national grid, lowering the CO_2 emission factor per kWh. Additionally, V2G configurations will allow an increase in the energy efficiency of the system, resulting in an increase in the annual savings of the energy bill.

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