ANALIZA BENEFITA KORIŠĆENJA ELEKTRIČNIH AUTOMOBILA NA PRIMERU FLOTE PROCREDIT BANKE U SRBIJI

BENEFIT ANALYSIS OF THE UTILISATION OF ELECTRIC CARS ON THE EXAMPLE OF PROCREDIT BANK SERBIA'S CAR FLEET

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U radu je opisan primer korišćenja električnog automobila (EV) Volkswagen E-UP u floti vozila ProCredit banke u Beogradu. Cilj rada je da se prikažu ekološke prednosti korišćenja savremenih EV nad konvencionalnim dizel automobilima. U tom smislu dat je uporedni prikaz proračunatih emisija gasova sa efektom staklene bašte (eng. Green House Gases – GHG) na praktičnom primeru paralelnog korišćenja EV i dizel automobila. U radu je prikazan i primer korišćenja punjača za EV nominalne snage 22 kW koji koristi solarne panele snage 4,5 kW za napajanje. Konačno, u radu su prezentovani i ekonomske koristi, kao i preporuke za implementaciju eventualnih dodatnih mera stimulacije na makro nivou, koje bi doprinele povećanoj tražnji na tržištu Srbije za ovakvim vidom transporta gradjana i privrede.

Ključne reči: zagađenje vazduha; električni automobil; emisija štetnih gasova; obnovljivi izvori energije; ekološki i ekonomski benefiti

This paper provides an example of use of the electric vehicle (EV) Volkswagen E-UP, which belongs to ProCredit Bank's car fleet. The aim of this paper is to stress the ecological advantages of the use of the contemporary EV in comparison with conventional diesel vehicles. In this regard, a comparative overview of the emissions of Green House Gases, based on a practical example of the parallel use of EV and diesel vehicles, is given. Also given is an example of the use of a charger for EV with nominal power of 22 kW which uses solar panels with the power of 4.5 kW as a source of energy. Finally, economic benefits are presented, as well as recommendations for the implementation of additional incentivising measures on the macro level, which could further accelerate the demand for this type of transportation on the Republic of Serbia's market.

Key words: air pollution; electric car; emissions; renewable energy; ecological and economic benefits

Abbreviations:

EV	Electric Vehicle
HEV	Hybrid Electric Vehicle
GHG	Greenhouse Gas
EMS	Environmental Management System
SPP	Solar Power Plant
DV	Diesel Vehicle
CO ₂	Carbon Dioxide

1 Introduction

Over the last several years, the issue of how to combat climate change has been strongly debated, with focus on the issue of mankind's sustainable growth along with a decreased impact on the environment. The Paris Agreement of 2015 served to define an objective, this being to stop the increase of global warming and to sustain said to a level substantially below 2°C compared to the pre-industrial period [1]. In order for this objective to be achieved, it is necessary to undertake a number of measures regarding adaptation and mitigation, those measures being relative to the use of energy, materials and

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other resources. A separate issue within the measures for pollution reduction and impact on climate changes refers to the future of transportation.

Transportation is one of the key causes of air pollution, which is particularly notable in urban areas. The transportation sector is the fastest growing source of CO₂ emissions from fossil fuels. This situation significantly affects the deterioration of overall human health. According to the World Health Organisation, around 100,000 premature deaths in Europe are connected to air pollution. It is specifically pollution from the transportation sector that substantially contributes to this situation [2]. It is estimated that in the decades to come the transportation sector's contribution to pollution will be significant. It should be noted that urban driving typically covers distances less than 6 km. This is to say that with such short distances, the efficiency of catalysts is very low and consequently average gas emissions per kilometre are very low in urban areas [3].

Due to all of the above noted, it is necessary to do research and come up with alternative solutions within the transportation sector. One potential solution in mitigating the negative impact of transportation on the environment and human health is the use of EVs.

Today, electric vehicles are once again gaining in popularity. The number of EVs worldwide in 2016 was in excess of 2 million. China, the US, Japan and several European countries had the highest growth. Reasons for this increased interest lie in several factors: strong technological progress, reduced costs (especially battery related costs), support through purchase incentives, advantages relative to parking and driving and wider availability of public chargers [4].

As regards our country, currently there are 148 EVs, of which more than a half are cars. The network of chargers is not sufficiently developed and accordingly there are around 30 chargers of which only 5 are fast chargers [5]. Bearing in mind that ProCredit Bank was one of the pioneers in terms of the use of this type of vehicles, this paper will show a practical example of EV use, along with an analysis of environmental and economic benefits, all this vis-à-vis the use of the conventional diesel vehicle.

2. EVs as a part of ProCredit Bank Serbia's car fleet

2.1 Environment management system within the Bank

ProCredit Bank is a development oriented commercial bank which provides premium quality full service to small and medium-sized enterprises and private individuals interested in saving [5]. It was over ten years ago, that the Bank implemented the basic principles of environmental protection by implementing its *Environmental Management System (EMS)*. The System includes three major pillars, as follows: 1) Internal Environmental Management System, 2) Environmental and Social Risk Management in Lending and 3) *Green finance* (promoting energy efficiency investments, renewable sources of energy and other so called green measures).

As a part of the first pillar, the Bank monitors on a systemic basis, energy and resource consumption in its operations. This refers to monthly monitoring of the consumption of energy and heat, of water and paper, kilometrage and fuel consumption and, ultimately, GHG emissions. The values are monitored in their absolute amounts but also in relative amounts, for the sake of comparison. Based on this monitoring system, the Bank identifies potential measures the undertaking of which strives to generate savings in terms of energy and resource consumption and consequently to contribute to reducing harmful GHG emissions. In other words, the purpose of the internal EMS is to diminish the Institution's negative impact on the environment. ProCredit's EMS is aligned with ISO 14001:2015 standards.

Since the focus of this paper is transportation, the paragraphs below provide information on the Bank's fleet of cars and technical features which are of relevance for analysis and conclusion purposes.

2.2 Overview of the Bank's car fleet

As at the end of Q1 2018, ProCredit Bank Serbia had 53 cars in its fleet, of which 40 were diesel vehicles, 6 hybrid vehicles and 7 electric vehicles. An overview is presented below in Table 1.

By way of comparison, data for 2016 show that the car fleet consisted of 84 cars, of which 80 were diesel vehicles and 4 were HEVs. In July 2016, ProCredit Bank included in its fleet 7 EVs as well. Over the two years, the share of low-emission vehicles (EVs and HEVs) in ProCredit Bank's car

fleet grew by 4.7%, reaching 24.5%, whereas the objective is for the share of these vehicles to reach 50% in 2018. This objective will be achieved by purchasing additional HEVs and EVs, while existing diesel vehicles will be written off.

Table 1: Overview of the Bank's car fleet as at 31 March 2018

<i>Car make and model</i>	<i>Number</i>
Škoda Superb	3
Škoda Octavia	6
Škoda Fabia 1.6 TDI	10
Ford Fiesta 1.6 TDCi	21
Toyota Prius 1.8 Hybrid	6
Volkswagen E-UP	7
Total	53
Share of hybrid and electric cars	24.5%

Said cars are distributed in Belgrade Head Office locations as well as the branches in Kragujevac, Novi Sad, Subotica, Pančevo and Niš. In this way, distributed cars are, to the greatest extent, used for visits to clients within the entire territory of the Republic of Serbia. 25 out of 53 cars are located in the Bank's Head Office and are used both for visits to clients outside Belgrade and for urban driving.

2.3 Technical features of the Volkswagen E-UP electric vehicle

As already noted, in the middle of 2016, the Bank included in its fleet the EV – Volkswagen E-UP whose technical features are listed below:

- Engine power: 60 kW, with rotational momentum of 210 Nm
- Battery capacity (lithium-ion battery): – 18.7 kWh
- Charging time: 5 hours with battery charging power limited to 3.7 kW
- Maximum distance: 160 km
- Maximum distance depends on various conditions (number of passengers, baggage, air temperature and AC operation) and under reasonable conditions reaches speeds ranging between 120 and 140 km
- Acceleration 0-100 km/h: 12.4 seconds
- Maximum speed: 130 km/h
- Energy consumption per specification: 11.7 kWh/100 km

The image below shows the ProCredit Bank's fleet of electric cars.

Fig. 1: ProCredit Bank EV

Apart from Belgrade, ProCredit Bank's EVs are also charged on chargers connected onto existing facility networks and accordingly are powered by energy produced by the Republic of Serbia power system. A solar system for EV power supply was installed in ProCredit Bank's Head Office in September 2017 and the features of this system will be shown in the section below.

2.4 Technical features of chargers and the solar power plant

For EV charging purposes, the Bank invested in the installation of a charger and the SPP (solar power plant), which are located in Belgrade. The total installed power of the small SPP, which works as an EV charger, is 4.5 kW. The solar system consists of 18 polycrystalline solar panels of 250 W each. The solar system contains a 5 kW three-phase solar inverter, Fronius Primo, which allows for the conversion of direct current into alternating current, with its power ranging from 3 kW to 8 kW. The system is connected with the existing installation via a 5x6 mm copper cable to the Bank's switchbox which allows energy generated from the SPP to be transferred to the existing system and then to use energy from this system to supply power for the charger via a different cable. The system was installed in this manner in order to reduce SPP investment costs, on the one hand, i.e. in order for batteries not to be installed, and on the other hand to allow a constant power supply for the charger, which will not depend on the time of day or on weather conditions.

The installed charger is the Schneider – EV link Smart Wallbox 22 kW. This is a three-phase device with an adjustable power supply of 3.7 kW. When the EV's battery is being charged, there is a special converter located at the end of the cable, which allows for the conversion of alternating current into direct current and thus limits it to the appropriate level while charging the car's battery. The projected annual output of SPP is 3,607 kWh of electric power. Although in theory output potential on the basis of medium daily solar irradiance in Novi Beograd (New Belgrade) is 5,220 kWh due to shadows cast by surrounding buildings, the projected output is lower by 31%. Images of charger components which use solar panels are shown in the figures below.

Fig 2- 4: Solar power plant overhang; Inverter Fornius Primo; Charger Shneider EV link Smart Wallbox 22 kW

3. Benefit analysis of the use of EVs compared to DVs

3.1 Comparative analysis of GHG emissions – EV charging on non-solar energy network

For this comparative analysis of the emission GHGs produced by EVs compared to DVs we have used the example of Volkswagen E-UP, whose features are described in Section 2.3. and diesel cars used at the Bank's Head Office – Ford Fiesta Econetic 1.6 TDCi with an engine power of 66 kW.

For EV charging from the existing system network, with regard to equivalent emission calculations, the energy share of output is observed, i.e. where this energy is obtained from. Taking into account the energy share of electric power production in the Republic of Serbia, where 71% of power is produced from coal, 28% from water potentials, i.e. less than 1% from other modern renewable sources of energy, the CO₂ emission factor with which the calculation is made is 0.711 kgCO₂eq/kWh [7]. Data used for DV emission calculation refer to actual consumption and energy value of diesel which amounts to 10,033 kWh/l [8] and, on the other hand, the emission factors of diesel itself, amounting to 0.267 kg CO₂eq/kWh [9].

For the purposes of this paper, we have compared a vehicle from the Bank's Head Office, which approximately and commensurately covered an appropriate distance in March 2018, as the observed

EV. The Ford Fiesta Econetic 1.6 TDCi covered 373 km, for which distance it consumed 21 l of diesel. Therefore, the average consumption was 5.63 l/100 km. On the other hand, the EV which was used at the Head Office during the same month covered 286 km, with a total consumption of 47.1 kWh, i.e. an average of 16.46 kWh/100 km. Both vehicles were used for urban driving. Calculation overviews are shown below.

Table 2: Calculation consumption and GHG emissions

Parameters (March 2018)	Electric vehicle E-UP	Ford Fiesta Econetic 1.6 TDCi
a) Actual monthly consumption	16.46 kWh/100 km	5.63 l/100 km * 10,033 kWh/l = 56.48 kWh/100 km
b) Emission factor	0.711 kgCO ₂ eq/kWh	0.267 kgCO ₂ eq/kWh
Emission per 100 km a) x b)	11.7 kgCO₂eq	15.1 kgCO₂eq

Based on the shown results, the equivalent CO₂ emissions referring to EVs charged on the network from the energy mix in urban driving conditions is lower by 22.51% compared to the DV's equivalent CO₂ emission.

Given the limitations of the particular EV model, the maximum distance of 120 km which may be covered in one charging, the use of these vehicles is mainly intended for urban driving and shorter distances. On the other hand, the use of DVs is not related to urban driving only and when driving on the open road, they consume less – 4.5 l/100 km, this adding up to a total consumption of 45.15 kWh and emissions of 12.05 kgCO₂eq per 100 km, and so emissions savings relative to the use of EVs reduce to as little as 3%. If DV's consumption is even lower, which is possible with more economical cars, there are no CO₂ savings. However, with a more significant change in energy share, which is expected once wind farms are connected onto the system (till 2020), the emissions factor will also reduce and consequently emission savings of EVs will be higher.

3.2 Comparative analysis of GHG emissions – EV charging via the SPP

The SPP installed in March 2018 for the purpose of using charger energy, produced 125 kWh. During the same period, the EV consumed 47.1 kWh for 286 km covered, so it can be concluded that the total consumption of this vehicle is compensated through production from a renewable source of energy. Energy surplus was used for the Bank's Head Office purposes. So, in this particular case, the total reduction in CO₂eq when the EV was used compared to the diesel car is 100%.

If we take into account the fact that the distance covered by the EV in Q1 2018 was 846 km, then the average monthly covered distance was 282 km. If this is extrapolated to a one-year period, it can be expected that the EV will cover 3,384 km. Based on the average consumption of 16.64 kWh/100 km, the total consumption for the given annual kilometrage would be 563 kWh. On the other hand, projected solar power output is 3,607 kWh/per annum, which allows for total annual compensation for the EV's consumption and also provides for the possibility to compensate additional EVs.

Finally, in order for us to calculate the maximum kilometrage to be set off against this SPP, we will use a reverse calculation, i.e. we will divide the maximum projected electric power output by average consumption and thus we get: 3,607 kWh / 16.6 kWh/100 km = 21,728 km.

3.3 Analysis of EV's cost-effectiveness

This section will present an analysis of cost-effectiveness throughout the EV's useful life. The analysis includes investment in the car, solar charging installation related costs, fuel costs and regular maintenance costs.

In accordance with the current average electric power price of EUR 0.08/kWh for low voltage, including system access costs, costs relative to EV consumption of 16.6 kWh/100 km, this amounts to approximately EUR 1.32/100 km. Conversely, the average consumption of the observed DV amounts to 5.6 l/100 km, which based on the current price of EUR 1.37/l amounts to EUR 7.7/100 km. This is 6 times the cost of the EV per 100 km. This calculation takes into account that EVs are 100% power supplied via solar energy, which the previous calculation also showed, and accordingly the cost of this electric power is EUR 0.

For the purpose of calculating annual fuel costs that will be taken into account is that based on the existing solar system with a projected annual electric power output of 3,607 kWh and EV's average consumption of 16.6 kWh/100 km, it is possible to cover a distance of 21,728 in urban driving without

using electric power from the network. On the other hand, bearing this in mind, with DV's average consumption of 5.63 l/100 km, 1,223 l of diesel are required to cover that many kilometres in urban driving.

The table below shows the calculation of savings.

Table 3: Overview of investment and other costs, with annual savings calculations

Parameters	Volkswagen E-UP	Ford Fiesta Econetic 1.6 TDCi
Investment value of new vehicles	EUR 29,000 + EUR 14,000 for charger and SPP = EUR 43,000	EUR 12,900
Fuel costs	EUR 0/kWh	EUR/l 1.37
Registration costs	RSD 18,000	RSD 22,000
GPS costs	RSD 12,240	RSD 12,240
Washing costs	RSD 6,000	RSD 6,000
Tyre replacement costs	RSD 4,000	RSD 4,000
Service – battery check, filter replacement, cab air, pollen filter	RSD 6,000	RSD 30,000
Other costs – solar charger	RSD 12,000	RSD 2,000
Total maintenance costs	RSD 58,240 (EUR 500)	RSD 76,240 (EUR 650)
Maintenance savings	EUR 650 - EUR 500 = EUR 150	
Fuel consumption for 21,728 km	3,607 kWh * 0 EUR/kWh = 0 EUR	1,223 l * EUR/l 1.37 = EUR 1,675
TOTAL SAVINGS (fuel and maintenance)	EUR 1,675 + EUR 150 = EUR 1,825	

In this manner we get the total annual EV related savings from a maintenance and fuel cost reduction of EUR 1,825. If we take into account a higher investment in terms of EVs and the solar charger, compared to the purchase of a Ford Fiesta at EUR 30,100, we get a simple investment return period of 16.5 years. The calculation and relative investment return graph are shown below.

$$\text{Simple RoI} = \frac{\text{difference in investment} - \text{EUR (29,000+14,000)} - \text{EUR (12,900)} - \text{EUR 30,100}}{\text{savings/p.a.} \quad \text{EUR 1,675+150} \quad \text{EUR 1,825}} = \mathbf{16.5 \text{ years}}$$

Graph 1: Overview of simple RoI in EVs with the SPP powered charger

This calculation does not take into account macroeconomic parameters, such as: increase in diesel price, further reduction in investment in the SPP and EVs, possible additional emission-related taxes, or battery repair costs following the expiry of the eight-year warranty, which costs at this time are unknown. The compound return period would also include the effect of the discounted rate and amortisation costs, which are not part of the simple return period calculation, i.e. they are not the subject of this paper.

4. Conclusions

Based on obtained data, it can be concluded that driving the EV Volkswagen E-UP charged from the existing electric power network compared to driving the DV Ford Fiesta does not have any substantial benefits in terms of GHG emissions. Savings in GHG emissions of the observed EV in urban driving compared to DVs amount to 22.51% while for open road driving of DVs (lower consumption), calculated savings amount to 3%. However, if we take into account future changes of Serbia's energy share, savings effects regarding the use of EVs would be significantly higher.

On the other hand, driving this particular EV, which is charged via solar panel chargers allows 100% savings in emissions, which has a positive impact on pollution reduction, especially in urban areas. The observed SPP in ProCredit Bank allows for the compensation of emissions relative to EVs for an annual distance of 21,728 km, which based on current indicators of annual projected kilometrage of EVs allows for annual emission compensation for 6 such vehicles.

From a financial point of view, such an investment, with current financial parameters has a long investment return period. Nevertheless, if future investments were to be analysed, further reductions in investment costs for EVs and the SPP should be taken into account, and also possible increase in fuel prices and introduction of additional taxes for gas emissions which have adverse effects on human health and the environment.

Despite the relatively unfavourable cost-effectiveness of EV utilisation, ProCredit Bank in Serbia has decided to continue procuring these vehicles, along with installing additional resources for solar energy utilisation. Major reasons for this are the Bank's commitment to environmental protection and sustainable growth of the market in which it operates but also a direct impact on the market by means of reductions in investment costs relative to alternative means of transportation.

Finally, in order to intensify demand for EVs, it is necessary to render decisions on a macrolevel, which are already very topical in EU countries, those being primarily import and custom duty reliefs for these kind of vehicles, EV purchase subsidies, cost-free vehicle registration, as well as free parking in cities and the possibility of using a so called yellow lane, which is intended for city buses and taxis only.

5. References

- [1] <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>
- [2] <http://www.euro.who.int/en/health-topics/environment-and-health/Transport-and-health/data-and-statistics/air-pollution-and-climate-change2>
- [3] <http://www.who.int/sustainable-development/transport/health-risks/air-pollution/en/>
- [4] http://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/IRENA_Electric_Vehicles_2017.pdf
- [5] https://www.b92.net/automobili/vesti.php?yyyy=2018&mm=07&nav_id=1420413
- [6] <http://www.procreditbank.rs/s>
- [7] CO₂ Emissions from Fuel Combustion Highlights 2015; International Energy Agency
- [8] Emission factors from cross sector tools (2012) - GHG protocol. Based on IPCC 2006 Guidelines for National Greenhouse Gas Inventories
- [9] GGF - ENERGY AUDIT GUIDEBOOK FOR ENERGY AUDITORS, Requirements and Approach, Version 8 (November 2015).