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# *Cost benefit Analysis of the E-Mobility Concept in Montenegro - Case Studies*

**Study prepared by Energy Institute Hrvoje Požar | Zagreb | February 2019**

Energetski institut Hrvoje Požar

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| AC | Alternating current |
| EEAP | Energy Efficiency Action Plan |
| MNE | Montenegro |
| $CO_2$ | Carbon dioxide |
| DC | Direct current |
| DFC | Discounted Cash Flow |
| EE | Energy Efficiency |
| EIB | European Investment Bank |
| EC | European Commission |
| ENPV | Economic Net Present Value |
| ERR | Economic Rate of Return |
| EU | European Union |
| FDR | Financial Discount Rate |
| FNPV(C) | Financial Net Present Value of the Investment |
| FRR(C) | Financial Internal Rate of return on Investment |
| IRR | Internal Rate of Return |
| NPV | Net Present Value |
| PBP | Payback Period |
| PI | Profitability Index |

# SUMMARY

The purchase of an electric vehicle under current market conditions requires a considerably greater investment of financial resources compared to the purchase of a conventional car of the same class. On the other hand, regular maintenance of electric vehicles requires less expenses, and the costs of motor fuel are also lower.

The study conducted cost-effectiveness analysis of the purchase of electric vehicles and their respective charging devices in the observed period of 15 years, for the civil sector and for individual cases in the public and private sector, and all analyzes took into account the specific characteristics for Montenegro in terms of the use of personal vehicles and market conditions.

The analyzes carried out resulted in the conclusions with regard to the need to establish incentive mechanisms for the purchase of electric vehicles, then with regard to the general use at the state level and to in the context of the integration of electric vehicles into the electric power system.

For the civil sector and public sector, the analysis has shown that direct **incentives to buy electric vehicles had a crucial role in the profitability of such investments.** In case of no incentive, financial indicators are only favorable if the vehicle exceeds 20,000 km per year but still are not attractive for investment. It was therefore concluded that it was necessary to establish certain incentive mechanisms for the purchase of electric vehicles for the civil sector and public sector in order to initiate the development of e-mobility in Montenegro. For the private business sector, due to the diversity of business activities and ways of using transportation means, it is not possible to make a general conclusion on the need and the Incentive amounts for the purchase of electric vehicles. In this particular case, analyzed in this study, financial indicators are positive for investment in a high-class electric vehicle without any financial incentives. However, it is likely that individual analyzes in many private entities would still show that incentives played a crucial role in assessing cost-effectiveness and making a decision on purchasing electric vehicles. Other, above all, promotional effects should also be taken into account if, by granting financial incentives, a number of business entities decided to purchase electric vehicles.

By achieving a scenario where the successive increase in the share of electric vehicles in the total number of registered passenger vehicles in Montenegro in the next thirty years will have a significant positive effect on society. The positive externality, in terms of avoided $CO_2$ emissions, is an impact that has no impact on the investor, but they can be monetized in the context of a positive effect on the society. In the period up to 2050, the total **monetized social benefit of avoided $CO_2$ emissions**, due to the introduction of electric vehicles, could amount to approximately EUR 530,000,000. Additionally, the increase in the number of electric vehicles carries the related development of charging infrastructure as well as the development of new associated services, which will bring significant benefits at the level of the states that are not quantified in the analyzes within this study and will result from the overall development of e-mobility. This refers to the increase in tourism revenues due to the increase in arrivals of foreign tourists using electric vehicles, and the growth of e-mobility increases the attractiveness of Montenegro as a tourist destination and environmentally conscious state at the same time. The developed infrastructure for charging electric vehicles also enables the development of new services and business models and the creation of added value, and all this adds to the creation of new jobs and the strengthening of the state economy.

The development of e-mobility will open space for **greater integration of renewable energy sources into the power system, reduce greenhouse gas emissions, local emissions of pollutants, and dependence on imported fossil fuels.** If we look at the year 2050, electric vehicles will generate additional load for the existing power system with an additional 300 MW peak load. In the context of flexibility of the power system, in 2050, electric vehicles with the potential distribution tank capacity of

approximately 16 GWh may be an active participant in the context of balancing the system. The available capacity at a given moment will depend on several factors, such as the share of vehicles that are connected to the power system at a given time via slow chargers, battery charge status, and vehicle owner's default settings.

# INTRODUCTION

## *Document Purpose and Goal*

The Cost Benefit Analysis (CBA) aims to determine the justification for the investment in electric vehicles, taking into account direct financial benefits for the investor, as well as the benefits and costs that the investment may have for the society as a whole.

Since the purchase of an electric vehicle under current market conditions is considerably more financially demanding than the purchase of a conventional car of the same class, and on the other hand, the costs of regular maintenance of electric vehicles and the costs of motor fuel are also lower, it is necessary to conduct cost-effectiveness analysis (CEA) of the purchase of electric vehicles and related charging devices, for the civil sector and for individual cases in the public and private sector.

It has been determined that the analysis would be carried out over a period of 15 years, and it is necessary to take into account the key features specific to Montenegro, such as the average mileage of personal vehicles, the expected range (autonomy) of vehicles of individual users, fiscal policy of the country (customs duties, excise duties, taxes) and the energy market situation.

The aim is to make conclusions regarding the need to establish incentive mechanisms for the purchase of electric vehicles, then with regard to the general use at the state level and in the context of the integration of electric vehicles into the electric power system.

## *Document Structure*

The document is structured in two general sections: (i) a description of the general principles of carrying out cost and benefit analysis in this study; and (ii) case studies of the introduction of electric vehicles in the driving fleets in particular sectors.

The first part describes the basic determinants of the conducted financial and economic analyzes and defined baseline assumptions used in further calculations.

The second section presents three case studies for the introduction of electric vehicles in the driving fleets, for the civil sector, public sector and private sector.

The document ends with the conclusions arising from all the analyzes carried out in this study, taking into account the findings from previous studies developed within this project (Situational Analysis of the Montenegrin Legislative, Institutional and Financial Framework for E-Mobility, Analysis of E-Mobility Market in Montenegro).

# PRINCIPLES OF CARRYING OUT COST BENEFIT ANALYSIS

The Cost and Benefit Analysis was conducted in accordance with the guidelines of the European Commission and the European Investment Bank (EIB)[1].

The CBA analysis is carried out in a way to determine differences in benefits and costs between the baseline and alternative scenarios. The baseline scenario is the absence of investment in electric vehicles, i.e. it assumes the continuation of the current behavior pattern in the context of vehicle purchases for private or business purposes (the so-called Business As Usual (BAU) scenario). Due to the lack of investment in electric vehicles, significant costs of the $CO_2$ emissions are expected in the baseline scenario.

Alternative scenario assumes investment in electric vehicles, resulting in lower maintenance costs as well as significantly lower $CO_2$ emissions.

## BASIC SPECIFICATIONS OF COST BENEFIT ANALYSIS CARRIED OUT

The Cost and Benefit Analysis is based on a variety of different perspectives. The financial viability of the project was considered separately from the citizen's perspective, and the socio-economic analysis was carried out from the state perspective. In addition, the analysis was carried out also in the context of the public sector, from the perspective of the introduction of electric vehicles into the Podgorica Communal Police Department and in the private sector, where the introduction of electric vehicles into the fleet of a private travel agency providing road passenger transfer services was considered.

### Financial Analysis

The financial analysis objective is to:

- Assess the project's consolidated profitability,
- Confirm the financial sustainability of the project and specify the key feasibility conditions, and
- Describe the cash flows that support the calculation of socio-economic costs and benefits.

The financial analysis was prepared based on the following requirements:

- The financial analysis was carried out using discounted cash flow (DFC).
- Only cash inflows and outflows were taken into account. Depreciation, provisions and other accounting items that did not correspond to cash flows were neglected.
- The financial analysis was carried out from the vehicle owner's perspective.
- In order to calculate the present value of future cash flows, an appropriate financial discount rate (FDR) was applied.

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[1] *European Investment Bank, The Economic Appraisal of Investment Projects at the EIB, March 2013*

- The financial analysis was carried out at constant (real) prices, i.e. at fixed prices determined in the baseline year. Consequently, FDR is expressed in actual amount.
- VAT is included in the analysis in case the user has no VAT refunds

Once the investment, labor and maintenance costs and funding sources are determined, it is possible to determine the project's profitability. Project profitability is measured through the following indicators:

- financial net present value of investment (FNPV(C))
- financial internal rate of return on investment (FRR(C)).

The net financial investment net present value (FNPV (C)) and the financial internal return rate (FRR (C)) are aimed to compare the costs of investing with the net income (benefits or savings) of the project in order to ascertain whether and to what extent the investment will be paid exclusively on the basis of net income (in this case savings), without taking into account the sources of funding.

The financial net present value of an investment is defined as the sum obtained when the expected investment and operating costs of the project (discounted) are deducted from the discounted value of expected revenue.

$$\text{FNPV (C)} = \sum_{t=0}^{n} a_t \, S_t = \frac{S_0}{(1+I)^0} + \frac{S_1}{(1+I)^1} + \cdots + \frac{S_n}{(1+I)^n}$$

Where:

$S_t$ is the balance of cash flow in time t,

$a_t$ is a financial discounted factor selected for discounting at time t, and

$i$ is a financial discount rate.

The financial rate of return on investment is defined as the discounted rate resulting from the zero FNPV, i.e. the FRR is given as the result of the following equation:

$$0 = \sum \frac{St}{(1+FRR)^t}$$

The FNPV is expressed in absolute amount (EUR) and must be proportional to the size of the project. FRR is a percentage. FRR(C) is used to estimate the future outcome of an investment in comparison with other projects or to compare the return rate with a reference value.

This calculation makes it possible to make a decision whether the project requires additional funding or support (subsidy): if (FRR (C)) is lower than the discount rate used (or if FNPV (C) is negative) then the revenue is not sufficient to cover investment costs and the project needs additional financial support. The justification of financial support is confirmed by the implementation of economic analysis.

## Economic Analysis

The purpose of the economic analysis is to determine whether the net benefit in the form of lower costs for the society as a whole is sufficient to justify the cost of investing in electric vehicles. After quantifying and evaluating all costs and benefits of a project, it is possible to measure the economic performance of a project by calculating the following indicators:

- Economic Net Present Value (ENPV) - the difference between discounted total social benefits and costs
- Economic Rate of Return (ERR) - the rate at which ENPV is zero

In principle, any project with an ERR lower than a social discount rate or a negative ENPV should be rejected, as it does not generate enough added value for the society as a whole. Namely, a project with a negative economic rate of return uses too much socially valuable resources and achieves too little benefits for citizens.

Compared to financial analysis, the benefit of the project is identified as a reduction in $CO_2$ emissions resulting from the reduction of fossil fuel combustion.

### Sensitivity Analysis

Since the financial and economic analysis are carried out for the expected value of the input parameters, it is necessary to analyze the sensitivity of the final results to a change in input parameters. Specifically, the impact of changes in investment costs was analyzed by introducing different rates of co-financing from the Eco Fund. In addition, the impact of changes in the average annual mileage generated by a specific vehicle was analyzed, which ultimately directly influenced the amount of operating costs.

# DEFINITION OF INITIAL ASSUMPTIONS

The analysis included an economic evaluation of the purchase of electric vehicles in various segments related to the civil (state) sector, public and private sector. Regardless of the different perspectives, the underlying assumptions are unified and used as described below.

### Calculation and Discount Unit for Cost Benefit Analysis

In the financial analysis, the discount rate has to reflect the opportunity cost of capital. As a reference value, a real discount rate of 4% was taken, which is the value recommended by the European Commission for the period 2014-2020.

The discount rate used in the economic analysis should reflect the opportunity cost of capital from the perspective of society. As the reference value, a discount rate of 5% was taken, which is the value recommended by the European Commission for the period 2014-2020 for the Cohesion countries.

### Project Life

Financial calculations from the perspective of citizens, public and private sectors were implemented for a period of 15 years and the remainder of the project value after 15 years is zero. Namely, it is presumed that the electric vehicles currently offered on the EU market, despite the gradual reduction of battery capacity, have been able to fully satisfy all the needs of citizens throughout the lifetime of the 15-year exploitation and to serve the regular activities of the private and public sector. On the other hand, due to the poorly developed secondary automotive market, the assumptions about the residual value of an electric vehicle r after a few years would be very unreliable.

Economic analysis in the context of the state was conducted for a period of 30 years. In the context of electrification of the road traffic from the point of view of the state, it is necessary to observe the long-term period. The target year in this respect is 2050, for which there are defined basic guidelines and objectives that are being considered and which have already been partly defined by the European Union, with a view to reducing greenhouse gas emissions in road traffic.

## Source of Financing

Financing with own capital (self-financing) is assumed, reducing the dependence on the financial market and reducing the problem of solvency maintenance, i.e. the ability to pay because there is no loan, and with it no repayment of annuity. The starting point in the considered scenarios includes the fact that a new vehicle is needed. Consequently, the analyzes are focused on cost-effectiveness only in the context of procurement or an electric vehicle or a conventional-fueled vehicle.

In the sensitivity analysis, the co-financing of the initial investment amounted to EUR 2,500.00, EUR 5,000.00, EUR 7,500.00 and EUR 10.000,00 from the Eco Fund.

## Investment in Fixed Assets

Investments are related to the purchase of an electric vehicle, i.e. electric vehicles (if the entity purchases more vehicles). In addition, if an entity purchases its own charger, the investment also includes purchasing/ installing the charger and a fee for connecting to the electric power distribution system. The investment is fully realized in the first year of the project.

## Determining Benefits

The benefits, or savings, arise from the savings made on the basis of differences in operating costs between electric vehicle traffic and conventional vehicle operation. Savings are manifested in the variety of supplies required to maintain and supply fuel (the price difference between gasoline, diesel fuel and electricity).

## Determining Expenditures

Expenditure refers to the cost of additional investment in the replacement battery of an electric vehicle, if it is necessary within the projected lifetime of the project for technical reasons.

# CASE STUDIES – COST BENEFIT ANALYSIS

Cost and benefit analyses were carried out through three case studies of the introduction of electric vehicles in the driving fleets, for the civil sector, public sector and private sector. For each case study, the input assumptions and the scenario created for the purpose of the analysis are described, an analysis of the financial viability of the introduction of electric vehicles was carried out on the basis of which some conclusions were ultimately drawn up.

## CIVIL SECTOR

In the civil sector, two aspects were analyzed. One refers to the financial viability of purchasing an electric vehicle by an individual, and the other refers to the country-wide economic benefits that are manifested in the long term due to the transition of citizens to electric vehicles and the development of all elements of e-mobility in general.

### Financial Analysis from the Citizens' Perspective

In Montenegro there is a great potential for the use of electric vehicles by citizens, as some of the restrictions are almost neglectable and globally represent the most common barriers to the development of e-mobility. Among others, the key factor is the range (autonomy) of electric vehicles currently available on the market, which is often a barrier to the decision to purchase an electric vehicle. By analyzing the situation and analyzing the market through a public survey, it was established that the vast majority of currently available electric vehicles could fully meet almost all citizens' needs with regard to travelling particular routes.

On the other hand, the relatively higher price of electric vehicles compared to the equivalent conventional ones is a key factor that prevents or discourages citizens from purchasing them. Therefore, the cost-effectiveness analysis of the purchase of electric vehicles by citizens in different scenarios led to conclusions on the need to introduce certain incentive mechanisms.

#### Scenario and Input Assumptions

For the purpose of financial analysis, a scenario was developed in which a citizen was considering the purchase of a new electric vehicle in comparison to a conventional diesel car. A period of 15 years was observed and the calculation did not take into account any extraordinary costs of car failure or possible replacement of the battery.

Input data for calculating initial investment, maintenance costs, and energy consumption are approximately equivalent to a large number of electric vehicles and equivalent conventional cars, and are largely based on data corresponding to the VW e-Golf electric car and the VW Golf diesel car.

Financial performance indicators for different combinations of annual mileage and vehicle fuel incentives are calculated according to the following table.

*Table 1 Combinations of annual mileage and sum of incentives for the purchase of vehicles*

| | **The Incentive amount to buy EV** | | | | |
|---|---|---|---|---|---|
| Annual Mileage | ***EUR0*** | ***EUR2,500*** | ***EUR5,000*** | ***EUR7,500*** | ***EUR10,000*** |
| **10,000 km** | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* |

| | | | | | |
|---|---|---|---|---|---|
| **13,000 km** | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* |
| **16,000 km** | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* |
| **20,000 km** | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* | *NPV, IRR, PBP, PI* |

Other assumptions used in the analysis are described in the following table.

*Table 2 Assumptions for analysis - citizens*

| Assumption | Description |
|---|---|
| Vehicle maintenance | The total cost of vehicle maintenance is 50% lower for electric vehicles than conventional ones. The maintenance cost includes all costs borne by the owner during the period of vehicle exploitation except registration, insurance and fuel costs. |
| Fuel prices | For calculation purposes, it is assumed that diesel and petrol prices will remain at today's level over the next 15 years, including excise and VAT.<br>The calculation used a price of 1.3 EUR/l of diesel. |
| Electricity prices | For calculation purposes it is assumed that electricity prices will remain at the present level for all customer categories, including VAT.<br>The calculation used a price of 0.097 EUR/kWh of electricity. |
| Infrastructure for charging EV | The analysis includes the costs of setting up the appropriate infrastructure for charging electric vehicles at their own parking space. |
| Electricity - connection | It is assumed that for charging purposes using own charger it is not necessary to build a new electric power connection or to rent additional power capacities. |

## Determining Project Cost-Effectiveness

Following the input assumptions and the developed scenarios, by investing additional funds for the purchase of an electric car, the total investment of this project amounts to EUR 18,800.

In order to determine the feasibility of the project, the following indicators were used:

- the net present value (NPV) of the project is determined at a discount rate of 4%,
- Internal Rate of Return (IRR),
- Profitability Index (PI)
- Discounted Payback Period (PBP)[2]

NPV, IRR, PBP and PI are determined on the basis of the financial flow, and the financial calculations are summarized in the table below.

**NPV**

In case the vehicle has an average annual mileage of 10,000 km, the net current value is negative in case of no incentive as in the case of incentives in the amount of EUR 2,500 and EUR 5,000 for the purchase of EV. With an incentive of EUR 7,500 and above, the net present value of this project is positive.

In case the vehicle has an average annual mileage of 13,000 km, the net present value is negative in case of no incentive as in the case of a EUR 2,500 incentive for EV. With an incentive of EUR 5,000 and above, the net present value of this project is positive.

In case the vehicle has an average annual mileage of 16,000 km, the net present value is negative only in case of no incentive for the EV. With a EUR 2,500 and larger incentive, the net present value of this project is positive.

In case the vehicle has an average annual mileage of 20,000 km, the net present value of this project is positive in case of no incentive.

[2] *the minimum number of periods (years) in which the discounted net cash flows will repay the investment costs*

*Table 3 Civil Sector - NPV*

**NPV**

| NPV (EUR) | Incentive amount for the purchase of EV | | | | |
|---|---|---|---|---|---|
| Annual Mileage | ***EUR0*** | ***EUR2,500*** | ***EUR5,000*** | ***EUR7,500*** | ***EUR10,000*** |
| **10,000 km** | -6,265 | -3,765 | -1,265 | 1,235 | 3,735 |
| **13,000 km** | -3,814 | -1,314 | 1,186 | 3,686 | 6,186 |
| **16,000 km** | -1,363 | 1,137 | 3,637 | 6,137 | 8,637 |
| **20,000 km** | 1,906 | 4,406 | 6,906 | 9,406 | 11,906 |

**IRR**

The internal rate of profitability is lower than the discount rate in cases involving an average annual mileage of 10,000 km with an incentive of up to EUR 5,000, an average annual mileage of 13,000 km with an incentive of up to EUR 2,500, and an average annual mileage of 16,000 km with no incentives. In all other cases, the IRR is higher than the discount rate.

*Table 4 Civil Sector – IRR*

**IRR**

| IRR | Incentive amount for the purchase of EV | | | | |
|---|---|---|---|---|---|
| Annual Mileage | ***EUR5,000*** | ***EUR7,500*** | ***EUR10,000*** | ***EUR7,500*** | ***EUR10,000*** |
| **10,000 km** | -1.3% | 0.5% | 2.7% | 5.5% | 9.5% |
| **13,000 km** | 0.9% | 2.8% | 5.2% | 8.3% | 12.7% |
| **16,000 km** | 2.9% | 5.0% | 7.5% | 10.9% | 15.8% |
| **20,000 km** | 5.4% | 7.6% | 10.4% | 14.2% | 19.6% |

**PBP**

In case the vehicle has an annual average mileage of 10,000 km, the investment payback period is more than 15 years in case of no incentive to buy EV and with the incentive of 2 EUR,500, and 15 years with the incentive of EUR 5,000. With the highest Incentive amounts of EUR 10,000, the investment payback period is 9 years.

In case the vehicle has an annual average mileage of 13,000 km annually, the investment payback period is more than 15 years in case of no incentive to buy EV, and 15 years with the incentive of EUR 2,500. With the highest Incentive amounts of EUR 10,000, the investment payback period is 7 years.

In case the vehicle has an average annual mileage of 16,000 km, the investment payback period is equal to 15 years without the incentive to buy EV. With the highest Incentive amounts of EUR 10,000, the investment payback period is 7 years.

In case the vehicle has an annual average mileage of 20,000 km, the investment payback period is 13 years without incentives to buy EV. With the largest Incentive amounts of EUR 10,000, the investment payback period is 5 years.

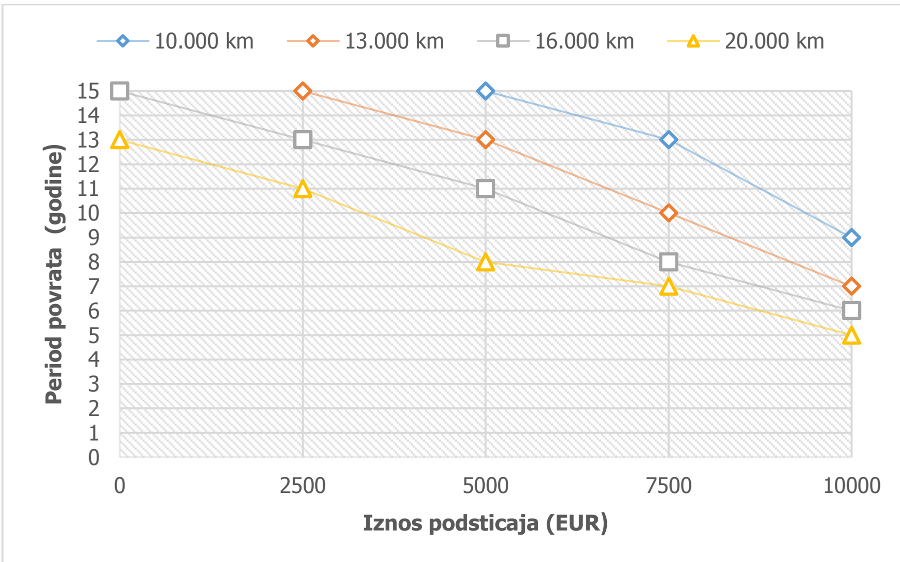
*Table 5 Civil Sector - PBP*

**PBP**

| PBP | Incentive amount for the purchase of EV | | | | |
|---|---|---|---|---|---|
| Annual Mileage | ***EUR5,000*** | ***EUR7,500*** | ***EUR10,000*** | ***EUR7,500*** | ***EUR10,000*** |

| | | | | | |
|---|---|---|---|---|---|
| **10,000 km** | >15 | >15 | 15 | 13 | 9 |
| **13,000 km** | >15 | 15 | 13 | 10 | 7 |
| **16,000 km** | 15 | 13 | 11 | 8 | 6 |
| **20,000 km** | 13 | 11 | 8 | 7 | 5 |

The figure below shows clearly the investment payback period expressed in years, depending on the Incentive amount to buy EV, for the different average mileage that the specific vehicle travels on an annual basis.




**Payback Period (years) – Incentive Amount (EUR)**

*Figure 1 Civil sector - PBP*

## PI

In case the vehicle has an annual mileage of 10,000 km, the profitability index is less than 1 in the case of no incentives to buy EV and with incentives up to EUR 5,000. With the highest incentive amount of EUR 10,000 to buy EV, the Profitability Index is 1.4.

In case the vehicle has an annual average mileage of 13,000 km, the profitability index is less than 1 in the case of no incentives to buy EV and with incentives up to EUR 2,500. With the highest incentive amount of EUR 10,000 to buy EV, the Profitability Index is 1.7.

In case the vehicle has an average annual mileage of 16,000 km, the Profitability Index is less than 1 in the case of no incentive to buy EV. With the highest Incentive amounts of EUR 10,000 to buy EV, the Profitability Index is 2.0.

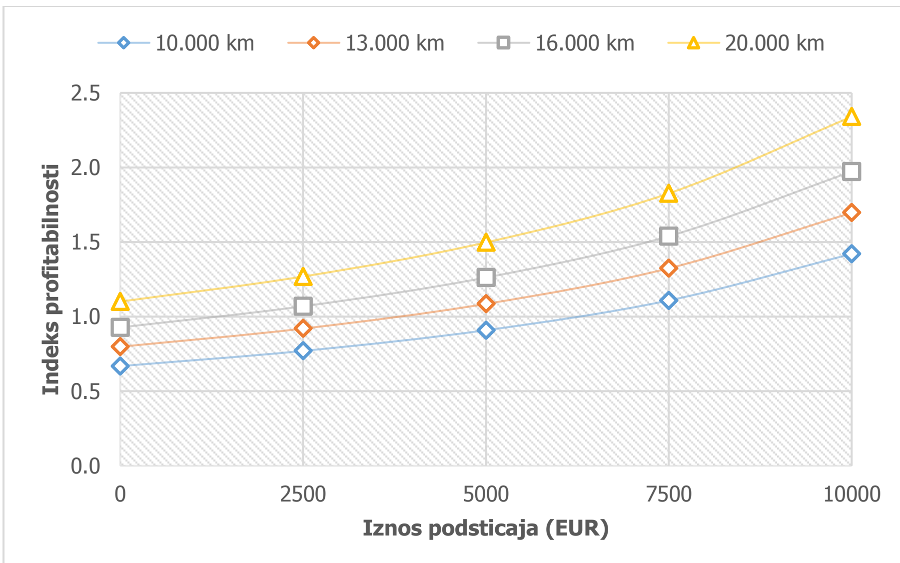
In case the vehicle has an average mileage of 20,000 km a year, the profitability index is more than 1 in the case of no incentive to buy EV. With the highest incentive amount of EUR 10,000 to buy EV, the profitability index is 2.3.

*Table 6 Civil sector - PI*

| **PI** |
|---|

| **PI** | **Incentive amount for the purchase of EV** | | | | |
|---|---|---|---|---|---|
| Annual Mileage | ***EUR5,000*** | ***EUR7,500*** | ***EUR10,000*** | ***EUR7,500*** | ***EUR10,000*** |
| **10,000 km** | 0,7 | 0,8 | 0,9 | 1,1 | 1,4 |
| **13,000 km** | 0,8 | 0,9 | 1,1 | 1,3 | 1,7 |
| **16,000 km** | 0,9 | 1,1 | 1,3 | 1,5 | 2,0 |
| **20,000 km** | 1,1 | 1,3 | 1,5 | 1,8 | 2,3 |

The figure below shows clearly the profitability index depending on the amount of EV incentive for the different average mileage that the specific vehicle travels on an annual basis.




***Profitability Index – Incentive Amount (EUR)***

*Figure 2 Civil sector - PI*

## Conclusion

According to the analysis of the current market situation, the vehicles of half of the citizens travel up to 10,000 km annually (see Figure below).

**ANNUAL MILEAGE**

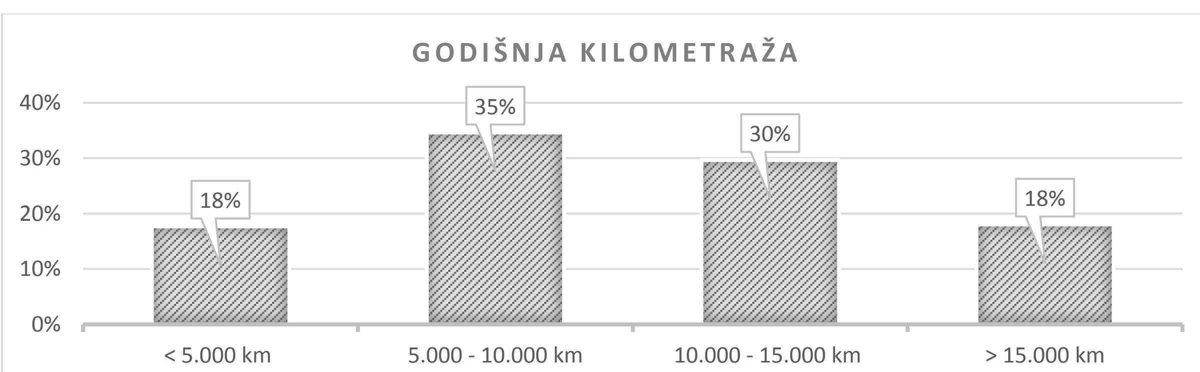



Figure 3 Vehicle usage - public survey

Taking into account the results of the survey conducted and the results of the conducted financial analysis it is clear that it is **necessary to establish certain incentive mechanisms for the procurement of electric vehicles by citizens in order to initiate the development of e-mobility in Montenegro.** Namely, financial analysis clearly showed that the project for the purchase of electric vehicles for citizens who travel more than 10,000 km per year was viable only with the incentive of EUR 7,500. However, in the present case, regardless of the financial viability during the vehicle life, the purchase of EV becomes attractive only with the incentive of EUR 10,000 when the investment payback period is below 10 years.

In addition, the survey found that about 18% of citizens annually travelled more than 15,000 km per year. The results of financial analysis show that this group of citizens can achieve very attractive profitability indices, with the incentive of EUR 7,500, and it is assumed that this segment of citizens can pioneer the introduction of EV into the fleet of registered vehicles in Montenegro.

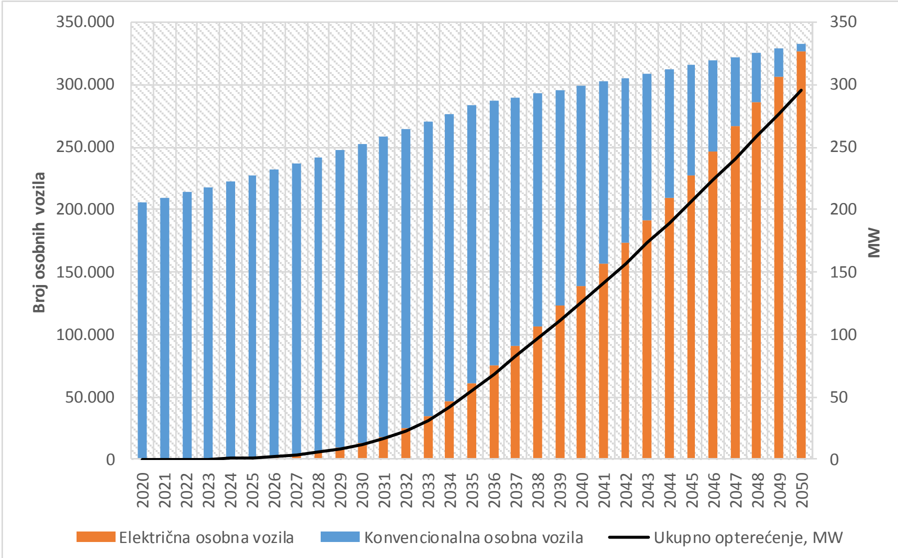
It is unambiguous and clearly affirmed by the financial analysis in conjunction with the market survey that for a more significant initial EV proliferation in Montenegro, at this stage of market development, it is necessary to establish an incentive mechanism in order to primarily make an investment in the EV in one's lifetime financially viable and at the same time, with the appropriate amount of incentive, it has to be brought as close as possible to the wider public.

## Economic Analysis from the State's Perspective

In the context of the dynamics of electrification of road traffic, modeling has to take into account the factors of the level of technology development and its related infrastructure, the preparation of business models for private investors and the affordability of electricity as an alternative option for end users, resulting in realistic constraints in terms of market development in the period up to 2035 (the basic modeling principles described in the *Situation Analysis of the Montenegrin Legislative, Institutional and Financial Framework for E-Mobility*). In accordance with the related specifications, the schedule of electrification by 2050 was also defined (shown in the picture below). **The so-defined scenario implies that the share of electric vehicles in 2050 will be more than 95%**, and the total number of passenger vehicles will be approximately 333,200.

Assuming that in 2050, 90% of charging will take place on slow low-power (home) chargers and the remainder of vehicles will use a combination of fast chargers (power> 22kW), an impact that the vehicles in question might have on the electric power system in the context of increasing peak load was determined by modelling. **The potential peak load that will be initiated by electric vehicles in 2050 is approximately 300 MW.**

In the context of the power system flexibility, **the total potential electric vehicle battery capacity for providing the flexibility services in the scenario in question is about 16 GWh in 2050.**




**Number of personal vehicles / Electric Personal Vehicles – Conventional Personal Vehicles – Total Load, MW**

*Figure 4 Dynamics of road transport electrification by personal vehicles and the resulting load for the electric power system*

The **social benefit** of avoided $CO_2$ emissions is calculated according to the principles applied by the European Investment Bank and the European Commission, using the following formula:

*Benefit of avoided $CO_2$ emissions = amount of avoided $CO_2$ emissions * unit cost of $CO_2$*

The prices of emission units by 2050, which were prepared by the European Commission for the elaboration of national energy-climate plans[3], were used as a starting point in the analysis of the avoided cost of *$CO_2$* emissions. Current market prices also show higher values than those recommended by EC. Based on such trends, alternative price trends were estimated until 2030, reduced to the euro in 2015. The target values (shown in the table below) were used in the analysis of avoided cost. It is important to note that these are not market prices, but prices that reflect the actual cost of $CO_2$ emissions for the society.

*Table 7 Price of emission units*

| **Price of emission units** | **2025** | **2030** | **2035** | **2040** | **2050** |
|---|---|---|---|---|---|
| **EUR'15/t$CO_2$** | 29.9 | 34.3 | 43 | 51.1 | 92.1 |

$CO_2$ emissions are defined in terms of total energy consumption from tank to wheel. Emission factor values recommended by the Intergovernmental Authority for Climate Change (table below) were used.

*Table 8 Conventional fuel emission factors*[4]

| **Emission factor** | **t$CO_2$/TJ** |
|---|---|
| **Petrol** | 69.3 |
| **Diesel** | 74.1 |

[3] *EU Reference Scenario 2016*

[4] *IPCC Guidelines for National Greenhouse Gas Inventories 2006*

**In the period up to 2050, the total monetized social benefit of avoided $CO_2$ emissions, due to the introduction of electric vehicles according to the scenario assumptions, will amount to approximately EUR 530,000,000.**

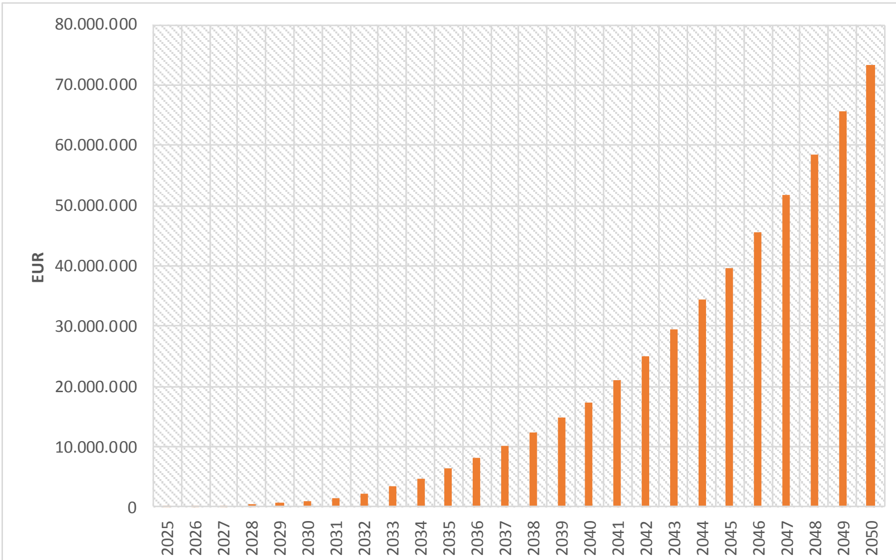



*Figure 5 Benefit of avoided $CO_2$ emissions (TTW)*

In the event that the State decides to encourage the purchase of electric vehicles through a co-financing measure in the private or public sector, it is necessary to specify each cost savings item (avoided $CO_2$ emissions) that will result in the implementation of the measure. The tables below show the incurred cost (expressed in EUR) per unit of $CO_2$ avoided in the vehicle life span, for different levels of potential incentives for the purchase of electric vehicles and different levels of average annual mileage travelled or to be travelled by the vehicles in question. The cost of saving is, for example, reduced in half where the incentive amounts to € 7,500 for the purchase of a vehicle that annually travels 20,000 km, rather than the incentive of € 10,000 for a vehicle that annually travels 13,000 km.

*Table 9* Cost of savings per unit of $CO_2$ emissions

**Cost of Savings (EUR/tCo2)**

| **EUR/tCO₂** | **Incentive Amount for the Purchase of EV** | | | | |
|---|---|---|---|---|---|
| Annual Mileage | ***EUR5,000*** | ***EUR7,500*** | ***EUR10,000*** | ***EUR7,500*** | ***EUR10,000*** |
| **10,000 km** | 0 | 89 | 178 | 267 | 356 |
| **13,000 km** | 0 | 68 | 137 | 205 | 274 |
| **16,000 km** | 0 | 56 | 111 | 167 | 223 |
| **20,000 km** | 0 | 45 | 89 | 134 | 178 |

# PUBLIC SECTOR

A number of state and local organizational units were considered for the case study of cost and benefit analysis in the public sector segment. The Podgorica **Communal Police** Department was selected for analysis, after assessing the condition of the vehicle fleet, the characteristics of the vehicles used and the availability of relevant data.

The Law on Communal Police regulates the tasks and powers of communal police, organizations and other matters of importance for the work of the communal police. Communal police activities include municipal oversight and provision of communal services in accordance with the law regulating the area of communal activities and other areas in which the municipality carries out its own affairs or tasks under the authority of the state administration that have been transferred to it by law or entrusted to it under the law.

## Scenario and Input Assumptions

In the performance of their duties, the communal police have a fleet of nine own vehicles (**Error! Reference source not found.**). Two vehicles have a diesel engine, and seven vehicles use petrol fuel. The average age of the fleet is 10 years and the average annual mileage is 14,100 km.

*Table 10 Vehicle Fleet of Communal Police (2019)*

| No. | Fuel Type | Engine Power (kW) | Year of Manufacture | Vehicle Type | Euro standard | Average Consumption [l/100 km] | Annual Mileage |
|---|---|---|---|---|---|---|---|
| **1** | Diesel | 81 | 2016 | Škoda Octavia | 6 | 6.5 | 13,900 |
| **2** | Petrol | 55 | 2008 | Dacia Logan | 4 | 9.5 | 10,200 |
| **3** | Petrol | 43 | 2000 | Renault Clio | 2 | 8.5 | 12,600 |
| **4** | Petrol | 66 | 2014 | Dacia Stepway | 5 | 7.5 | 11,100 |
| **5** | Diesel | 55 | 2015 | Dacia Sandero | 5 | 6.6 | 15,600 |
| **6** | Petrol | 55 | 2005 | Dacia Logan | 3 | 10 | 16,200 |
| **7** | Petrol | 55 | 2005 | Dacia Logan | 3 | 10 | 16,130 |
| **8** | Petrol | 55 | 2007 | Dacia Logan | 4 | 10 | 15,800 |
| **9** | Petrol | 55 | 2007 | Dacia Logan | 4 | 10 | 15,650 |

Each vehicle has its own parking space, thus fulfilling an important prerequisite for setting up the appropriate infrastructure for charging electric vehicles. The parking places are 20 meters away from the Communal Police administrative building, and each parking place is connected and marked. The distance between the parking spaces and the electrical installation of the building is 20 meters.

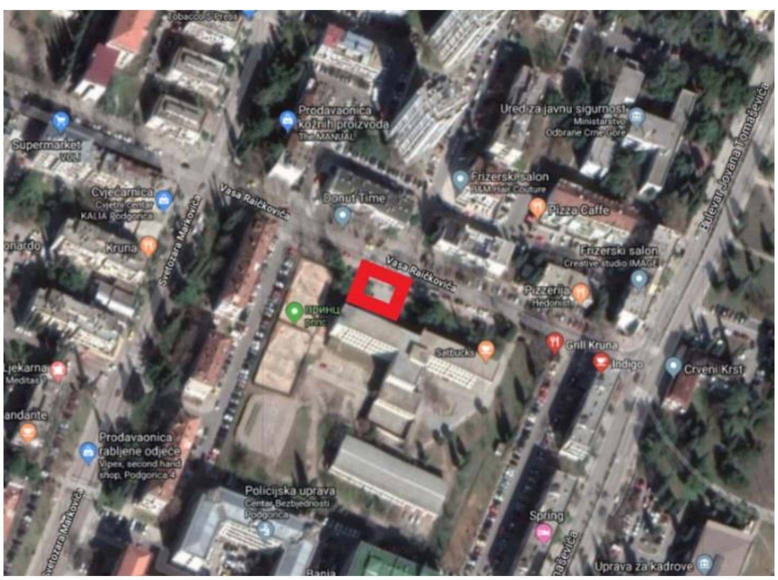



*Figure 6 Own parking lot of the Communal Police*

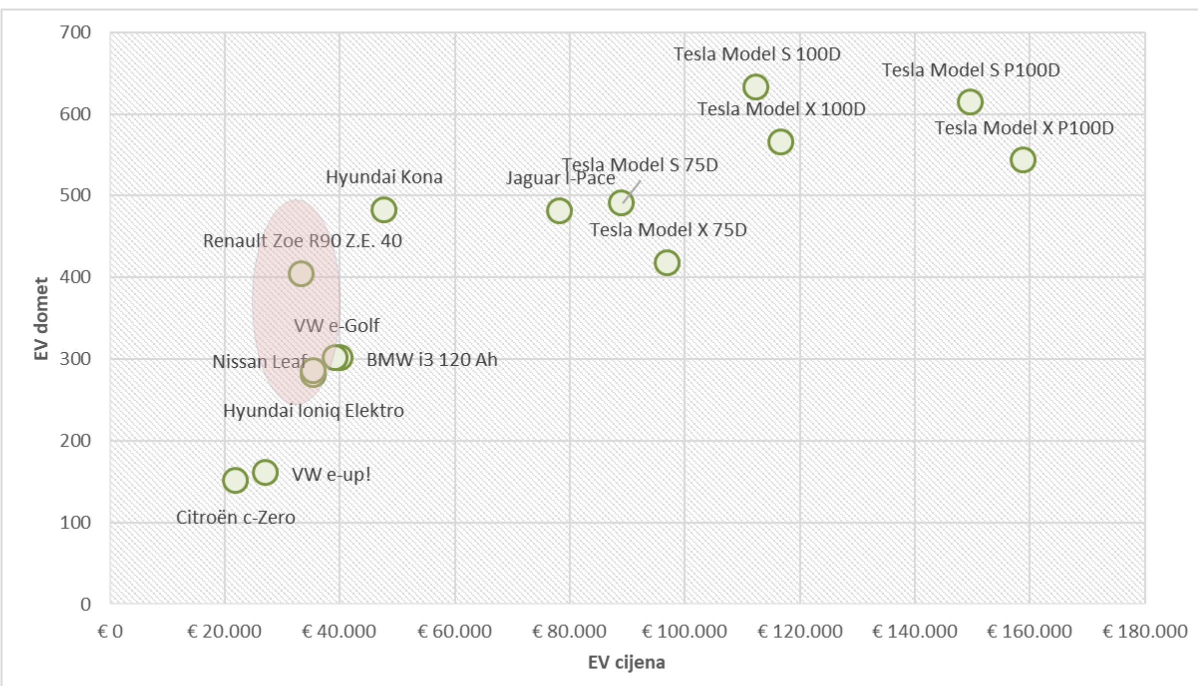
According to the information gathered, four vehicles from the current fleet are currently being replaced. For the purpose of analyzing the costs and benefits in this study, **a scenario was developed in which four vehicles (Table 11) were replaced by new vehicles of the same characteristics or corresponding electric vehicles.** Therefore, it is assumed that new vehicles will travel the same annual mileage as the replaced vehicles.

*Table 11 Vehicles in the vehicle fleet of the Communal Police that need to be replaced*

| Fuel Type | Engine Power (kW) | Year of Manufacture | Vehicle Type | Euro standard | Annual Mileage |
|---|---|---|---|---|---|
| **Petrol** | 43 | 2000 | Renault Clio | 2 | 12,600 |
| **Petrol** | 55 | 2005 | Dacia Logan | 3 | 16,200 |
| **Petrol** | 55 | 2005 | Dacia Logan | 3 | 16,130 |
| **Petrol** | 55 | 2007 | Dacia Logan | 4 | 15,650 |
| | | | | **Total** | **60,580** |

According to the information gathered, almost every vehicle of Communal Police is used in three shifts, and vehicles are used on weekends. Vehicles typically exceed 120 km per day, and except in specific situations, no vehicle exceeds 200 km in one day. It is therefore concluded that the majority of currently available electric vehicles available on the EU market can meet all the needs of the Communal Police.

Since there is still a relatively small number of electric vehicle models in the EU market available, it is not possible to accurately determine the equivalent of an electric vehicle compared to a conventional one. Therefore, for this analysis, an overview of the offer of electric vehicles was prepared with regard to their range and approximate price, and the average price of several vehicle models of the same segment was used for further calculations. A group of vehicles that respond to the needs and requirements of the Communal Police is shown in the chart below. These are electric vehicles with an autonomy of about 250 to 500 km and a price of about EUR 25,000-40,000. Nissan Leaf and Renault Zoe are the current representatives of this segment.




**EV range – EV price**

*Figure 7 EV Market Overview*

Other assumptions used in the analysis are described in the table below.

*Table 12 Assumptions for the analysis – public sector*

| Assumptions | Description |
|---|---|
| Vehicle Maintenance | The total cost of vehicle maintenance is 50% lower for electric vehicles than conventional ones. The maintenance cost includes all costs borne by the owner during the period of vehicle exploitation, other than the registration, insurance and fuel costs. |
| Fuel Prices | For calculation purposes, it is assumed that fuel prices will remain at the present level over the next 15 years, including excise duties. The price of 1.19 EUR/l for petrol (excluding VAT) was used for calculation purposes. |
| Electricity Prices | For calculation purposes it is assumed that the prices of electricity will remain at the present level, for all categories of buyers.<br>The price of 0.077 EUR/kWh of electricity (excluding VAT) was used for calculation purposes. |
| EV Charging Infrastructure | The analysis includes the costs of setting up the infrastructure for charging electric vehicles. It is a control unit with a total of four sockets, 2x Type2 11kW and 2x schuko socket 3.7kW. The cost is estimated at EUR2,900 (excluding VAT). |
| Electricity – connection | It is necessary to build a new electricity connection and lease capacity of 30 kW. The cost of this item is estimated at EUR 3,000 (excluding VAT). |
| Annual Mileage Travelled | It is assumed that new vehicles will travel the same mileage as those that are replaced.<br>An average mileage of 15,100 km per year was used for calculation purposes. |
| Incentive Level | Financial indicators are calculated in the analyzes given the various amounts of direct subsidies for the purchase of electric vehicles. Subsidy levels of EUR 2,500, EUR 5,000, EUR 7,500 and EUR 10,000 were used for calculation purposes, as well as the option without subsidies. |

## Determining Project Cost-Effectiveness

Based on the input assumptions and the developed scenario, the total investment for this project amounts to EUR 84,400, including additional funds for the purchase of 4 electric vehicles, the procurement of the appropriate charging infrastructure and the cost of connecting to the power grid.

In order to determine the feasibility of the project, the following indicators were used:

- net present value (NPV) of the project is determined at a discount rate of 4%
- Internal Rate of Return (IRR)
- Profitability Index (PI)
- Discounted payback period (PBP)

NPV, IRR, PBP and PI are determined on the basis of the financial flow. A summary of financial calculations is shown in *Table 13* below.

*Table 13 Results of financial calculations – Communal Police*

**Financial Analysis Results**

| | Incentive Amount for the Purchase of EV | | | | |
|---|---|---|---|---|---|
| | ***EUR 0*** | ***EUR 2,500*** | ***EUR 5,000*** | ***EUR7,500*** | ***EUR 10,000*** |

| | | | | | |
|---|---|---|---|---|---|
| FNPV (EUR) | -15,541 | -5,541 | 4,459 | 14,459 | 24,459 |
| IRR | 1.2% | 2.9% | 5.0% | 7.6% | 11.1% |
| PBP | 15 | 15 | 13 | 11 | 8 |
| PI | 0.8 | 0.9 | 1.1 | 1.3 | 1.6 |

**NPV**

The net present value is negative in case of no incentive as in the case of a EUR 2,500 incentive for the purchase of EV. In the case of an incentive amounting to EUR 5,000 and above, the net present value of this project is positive.

**IRR**

The internal rate of profitability is higher than the discount rate in cases with incentives equal to or greater than EUR 5,000.

**PBP**

The payback period of the investment is longer than 15 years in case of no incentive to buy EV, and equals 15 years with the incentives of EUR 2,500. With the largest incentive amount of EUR 10,000 per EV, the investment payback period is 8 years.

**PI**

Profitability index is less than 1 in the case of no incentive and with an incentive of EUR 2,500. With the biggest incentive amounting to EUR 10,000 per one EV, the profitability index is 1.6.

## Conclusion

It can be concluded from the financial analysis that the introduction of electric vehicles into the Communal Police fleet becomes **financially viable only in case of incentives in the amount of EUR 5,000 or more**. From the point of view of the Communal Police as a part of the public sector, it can be estimated that the investment with the positive FNPV is justified.

In addition to the results of the financial analysis, other factors should be taken into account when deciding on the introduction of electric vehicles into the Communal Police fleet. Considering that the communal order is one of the key factors determining the quality of life of citizens, the Communal Police are working to raise communal discipline in the Capital City in three shifts, on a daily basis, on work days, on weekends and holidays. Thus, **by the introduction of electric vehicles into the Communal Police fleet, general public awareness will be raised and their concern for the environment and the quality of the environment will be demonstrated by own example.**

# PRIVATE SECTOR

Several companies providing courier services, taxi services and tourist services were considered for the analysis of the introduction of electric vehicles in the private companies' fleets. Following discussions with all stakeholders and analyzing the specific characteristics of the activities of each individual company resulting in certain forms of vehicle use for carrying out activities, it was concluded that a case study would be carried out for the travel agency **TA Grand**.

The Travel Agency Grand was established in May 2004 and is one of the leading travel agencies in Montenegro. In a wide range of services including organizing package tours and cruises, booking air tickets, and providing car rentals, TA Grand also offers VIP transfer services to any point in Europe with professional driver service. Most VIP transfers involve the transport from/to Podgorica Airport to destinations such as Budva, Tivat or Dubrovnik. It is in this segment that the potential for the introduction of electric vehicles into the TA Grand fleet is recognized, to be used for providing transfer services.

## Scenario and Input Assumptions

TA Grand has two vans and three high-class passenger cars with luxurious accessories (*Figure 8*). For the purposes of this case study, a scenario was created in which TA Grand had the need to purchase an additional vehicle for the provision of the service in question and therefore considered the option of purchasing an electric vehicle.


Mercedes E class 220 (Model 2012)

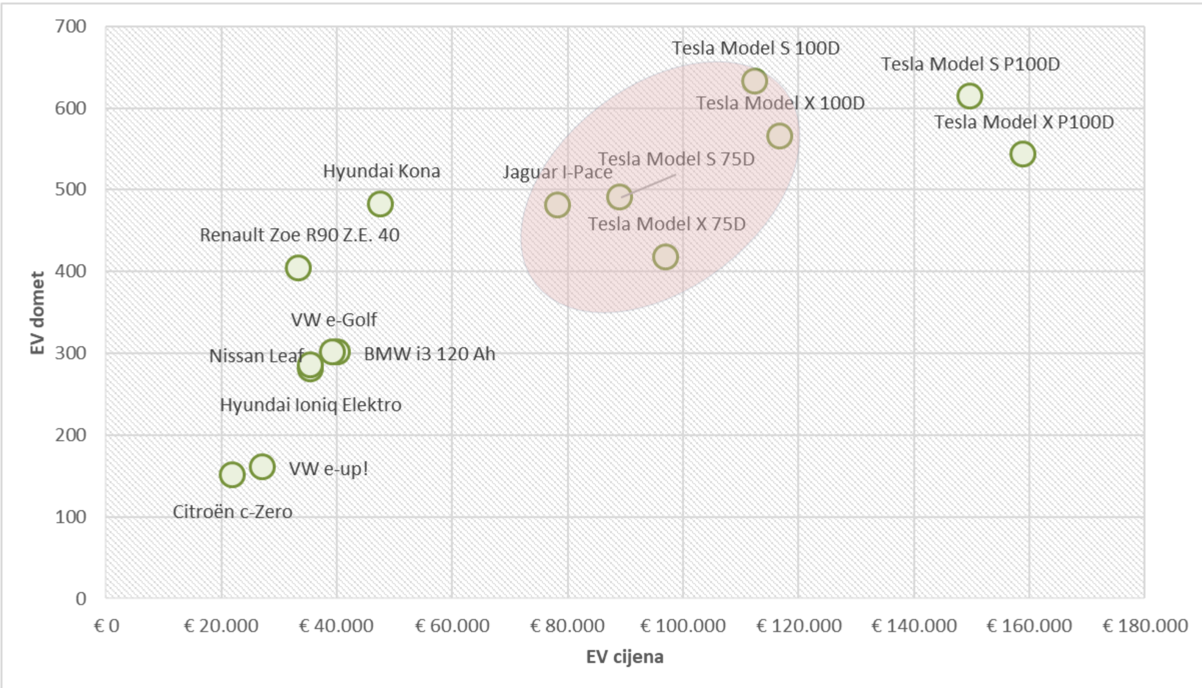
Mercedes S class 350 Bluetec Long (Model 2013)

Mercedes S class 350 Bluetec Long (Model 2015)

*Figure 8 Vehicle Fleet TA Grand (personal vehicles)*

For the selection of an electric vehicle that would fit the existing fleet and be in line with the level of service currently provided, the market of the high segment of EV was analyzed. The basic criteria for the EV range of more than 350 km and the price of EUR 75,000-120,000 (including VAT) are met by several electric vehicles, mainly Tesla models (**EV range – EV price**

*Figure 9*). For this reason, the calculation used the data based on the electric vehicle Tesla Model S 75D (*Figure 10*), which cost approximately EUR 70,000 without VAT. The electric vehicle procurement project was analyzed in comparison to the purchase of a conventional vehicle for which the input data were based on the vehicle Mercedes E class AMG estimated at EUR 58,000 without VAT.




**EV range – EV price**

*Figure 9 EV Market Overview*

*Figure 10 Tesla Model S (Source: Tesla)*

The basic features of the car Tesla S are shown in the following table.

*Table 14 Basic features of Tesla S model (Source: Tesla)*

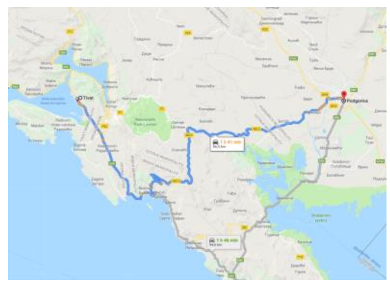
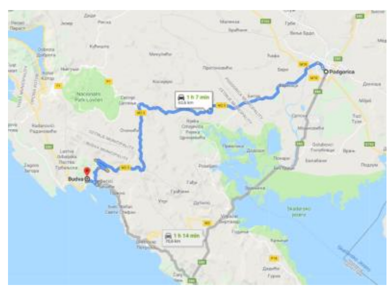
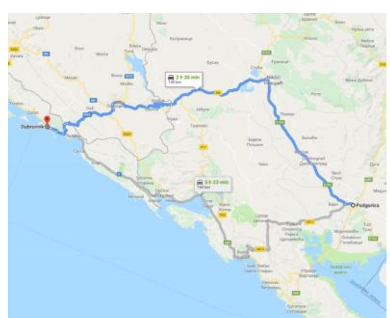
| **Model** | **Tesla S 75D (standard range)** | **Tesla S Long Range** |
|---|---|---|
| **Drive** | All 4 wheels | All 4 wheels |
| **Battery capacity** | 75 kWh | 100 kWh |
| **Approximate charging time on AC charger at a power of 16.5 kW** | 5h 15m | 7h |
| **Range** | 450 km (WLTP cycle) | 610 km (WLTP cycle) |

| | | |
|---|---|---|
| **Maximum speed** | 250 km/h | 250 km/h |
| **Acceleration 0-100 km/h** | 4.2 s | 3.8 s |
| **Base price in Germany (without tax)** | EUR 69,300 | EUR 77,000 |

Besides purchasing a vehicle, it is also necessary to set up a suitable vehicle charging infrastructure. Since it is a private charging point for just one vehicle, the analysis is based on the installation of a home charger with a Type2 connector of 11 kW. With such a charger, the Tesla S 75D (standard range) can fill 80% of its capacity in about 6 hours.

The characteristics of transfer services provided by TA Grand are recognized as being highly advantageous for using an electric vehicle, in particular due to the predictability of the time, duration and distance of the transfer to be made. Since most transfers are pre-arranged, it is possible to plan the time it takes to charge the vehicle so that it is ready to perform certain tasks at the exact time.

*Table 15 Typical transfers TA Grand*

| Transfer | Distance (one way /both ways) | Route |
|---|---|---|
| Podgorica – Tivat | 90/180 km |  |
| Podgorica – Budva | 65/130 km |  |
| Podgorica - Dubrovnik | 150/300 km |  |

Other assumptions used in the analysis are described in the following table.

*Table 16 Assumption for analysis– private sector*

| Assumption | Description |
|---|---|
| Vehicle Maintenance | The total cost of vehicle maintenance is 50% lower for electric vehicles than conventional ones. The maintenance cost includes all costs borne by the owner during the period of vehicle exploitation, other than the registration, insurance and fuel costs. |
| Fuel Prices | For calculation purposes, it is assumed that fuel prices will remain at the present level over the next 15 years, including excise duties. The price of 1.075 EUR/l for petrol (excluding VAT) was used for calculation purposes. |
| Electricity Prices | For calculation purposes it is assumed that the prices of electricity will remain at the present level, for all categories of buyers.<br>The price of 0.077 EUR/kWh of electricity (excluding VAT) was used for calculation purposes. |
| EV Charging Infrastructure | The analysis includes the costs of setting up the infrastructure for charging electric vehicles. It is a home charger of 11kW. The installation cost is estimated at EUR1,600 (excluding VAT). |
| Electricity Connection | It is necessary to build a new electricity connection and lease capacity of 11 kW. The cost of this item is estimated at EUR 2,600 (excluding VAT). |
| Annual Mileage Travelled | Several scenarios of annual averaged mileage were assumed: 40,000 50,000 and 60,000 kilometers. |
| Incentive Level | It is anticipated to replace the battery in the 7$^{th}$ year of the project, and the cost is estimated at EUR 5,800 (excluding VAT). |
| Incentive level | The analyzes were made on the assumption that direct subsidies for the purchase of electric vehicles would not apply to this vehicle segment. |

## Determining Project Cost-Effectiveness

Based on the input assumptions and the developed scenario, the total investment for this project amounts to EUR 15,150, including additional funds for the purchase of an electric vehicle, the procurement of the appropriate charging infrastructure and the cost of connecting to the power grid.

In order to determine the feasibility of the project, the following indicators were used:

- net present value (NPV) of the project is determined at a discount rate of 4%
- Internal Rate of Return (IRR)
- Profitability Index (PI)
- Discounted payback period (PBP)

NPV, IRR, PBP and PI are determined on the basis of the financial flow. Summarized financial calculations are shown in *Table 17*.

*Table 17 Results of financial calculations – TA Grand*

| Financial Analysis Results | | | |
|---|---|---|---|
| | **Annual Mileage (km)** | | |
| | ***40,000*** | ***50,000*** | ***60,000*** |
| **NPV (EUR)** | 11,333 | 17,983 | 24,632 |
| **IRR** | 13% | 18% | 23% |
| **PBP** | 8 | 5 | 4 |
| **PI** | 2.0 | 2.4 | 2.9 |

**NPV**

The net present value is positive in all cases. With the minimum mileage of 40,000 km per year, NPV is EUR 11,300, and with the maximum mileage of 60,000 km, NPV is EUR 24,600 per year.

**IRR**

The internal rate of profitability is higher than the discount rate in all cases.

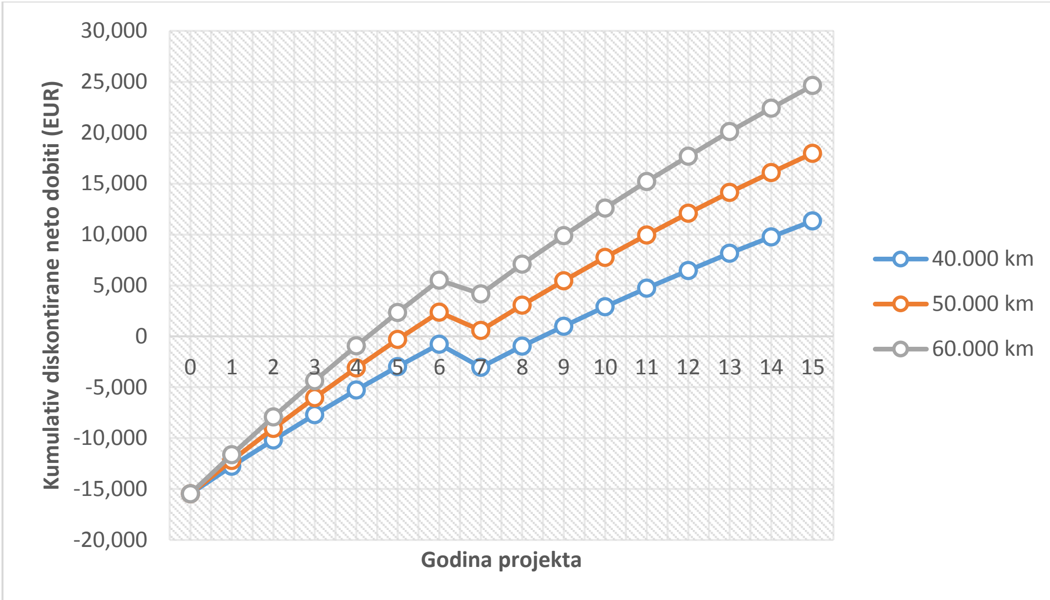
**PBP**

The investment payback period is 8 years for a mileage of 40,000 km per year, 5 years for a mileage of 50,000 km per year and 4 years for a mileage of 60,000 km per year.

**PI**

Profitability Index is greater than 1 in all three cases. At an annual mileage of 60,000 km the profitability index is 2.9.

The cumulative discounted net profit, where a drop in the seventh year of the project is observed due to an investment in replacing the battery of the electric vehicle, is shown in Cumulative discounted **net profit - Project Year**
*Figure 11*.




**Cumulative discounted net profit - Project Year**

*Figure 11 Cumulative discounted net profit*

## Conclusion

Financial Analysis based on established assumptions showed that the project was profitable for all indicators. However, it should be noted that there are very few vehicle models on the electric vehicle market and therefore it is difficult to determine the equivalent of a conventional vehicle. Particularly, this refers to the segment of luxurious vehicles that are considered in this case study, so it should be borne in mind that financial indicators may vary considerably with regard to the models of vehicles that are being compared.

**In addition to the positive financial performance indicators of the project, the introduction of an electric vehicle to the fleet for the purpose of providing transfer services is accompanied by an innovative approach to the creation of tourism offerings and high standards of business,** characterizing the TA Grand.

# CONCLUSIONS

The purchase of an electric vehicle under current market conditions requires a considerably greater investment of financial resources compared to the purchase of a conventional vehicle of the same class. On the other hand, regular maintenance of electric vehicles is less costly, and the costs of consumed energy are also lower. As a part of this study, cost-effectiveness analyses were conducted regarding the purchase of electric vehicles and corresponding charging devices in the observed period of 15 years, for the civil sector and for individual cases in the public and private sector.

All analyses took into account the characteristics specific to Montenegro, such as the average mileage of personal vehicles, the expected range (autonomy) of vehicles owned by individual users, the fiscal policy of the state (customs, excises, taxes) and the energy market situation.

The analysis resulted in the conclusions on the need to establish an incentive mechanism for the purchase of electric vehicles, and then regarding general benefits at the state level, and finally in the context of the integration of electric vehicles into the electric power system.

## INCENTIVES FOR PURCHASING ELECTRIC VEHICLES

Financial analysis showed that direct incentives for the purchase of electric vehicles in the public and private sector played a crucial role in the profitability of such investments. In case of no incentive, the net present value is positive, the investment payback period is less than 15 years, and the profitability index is greater than 1 **only when the vehicle exceeds 20,000 km per year or more**. The previous market research found that only 18% of the population annually exceeded 15,000 km. Based on this, it is concluded that it is necessary to establish certain incentive mechanisms for the purchase of electric vehicles by citizens in order to initiate the development of e-mobility in Montenegro.

The same goes for the public sector, where the financial indicators are even more unfavorable, which is because of using the input parameters based on the purchase of electric vehicles in comparison with the conventional low-priced vehicles.

With regard to the private sector, the diversity of business activities and the way of using transport means makes it impossible to make a general conclusion about the need and the amount of incentives for the purchase of electric vehicles. In this particular case, analyzed in this study, financial indicators are positive for investing in a high-class electric vehicle compared to high-class conventional vehicles that provide transfer services without any financial incentives. It seems that the analysis in many private entities would nevertheless show that incentives play a crucial role in assessing cost-effectiveness and making the decision to purchase electric vehicles. Other, primarily promotional effects should also be taken into account if, by granting financial incentives, a number of business entities decided to purchase electric vehicles.

## POTENTIAL BENEFITS

A significant positive impact on the society will result from achieving a scenario in which the share of electric vehicles in the total number of registered passenger vehicles in Montenegro will successively increase over the next thirty years. Namely, the positive externality, in terms of avoided $CO_2$ emissions, is a result that has no impact on the investor, but it can be monetized in the context of a positive effect on the society. In the period up to 2050, the total monetized social benefit of avoided $CO_2$ emissions, due to the introduction of electric vehicles, could amount to approximately EUR 530,000,000.

The increase in the number of electric vehicles carries the related development of charging infrastructure as well as the development of new associated services. Therefore, it is also important to point out that there are significant benefits at the state level that are not quantified in the analyses within this study and will result from the overall development of e-mobility. This is primarily related to the increase in tourism revenues due to increased arrivals of foreign tourists traveling by electric vehicles. Developing e-mobility increases the attractiveness of Montenegro as a tourist destination and at the same time an environmentally conscious country. Furthermore, the developed infrastructure for charging electric vehicles enables the development of new services and business models and the creation of added value. All this adds to the creation of new jobs and the strengthening of the national economy.

## IMPACT ON ELECTRICAL GRID

The development of e-mobility will open space for greater integration of renewable energy sources into the power system, reduce greenhouse gas emissions, local emission of pollutants, and dependence on imported fossil fuels.

Looking at the year 2050, electric passenger vehicles will generate additional load for the existing power system with an additional peak load of 300 MW.

In the context of the power system flexibility, in 2050, electric vehicles with the potential distribution tank capacity of approximately 16 GWh may be an active participant in the context of balancing the system. The available capacity at a given moment will depend on several factors, such as the share of vehicles that are connected to the power system at a given time via slow chargers, battery charge status, and vehicle owner's default settings.

For the functioning of a system in which electric vehicles represent a distributed energy storage for intermittent energy sources, and then the potential for providing the flexibility service, certain preconditions need to be met, which can be divided into technical, legal and regulatory, and economic requirements. In technical terms, the basic precondition for providing flexibility is the existence of infrastructure, vehicles and other parts of the system that support bi-directional electricity flow and data exchange, where all elements are integrated into the smart grid concept. From the legal and regulatory viewpoint, it is necessary to recognize the elements of the e-mobility concept in terms of providing new services, including the ability to provide flexibility to the power system, and their definition within the legal framework. Finally, the need to manage the entire process of providing flexibility services opens up space for creating new business models in which various stakeholders will find their interests, one of the basic conditions being the existence of a sufficient number of electric vehicles and adequate infrastructure for economic justification of such processes.

# LIST OF FIGURES

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