# Assessment of Commercial EV Demand in Costa Rica


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## Abbreviations

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|---|---|
| AC | Air Conditioning |
| AFD | French Development Agency |
| ARESEP | Public Services Regulatory Authority |
| BAU | Business As Usual |
| BCR | Banco de Costa Rica |
| BEB | Battery Electric Buses |
| BN | Banco Nacional |
| CAGR | Compound Annual Growth Rate |
| CAPEX | Capital Expenditure |
| CF | Cash Flow |
| EIRR | Economic Internal Rate of Return |
| EV | Electric Vehicle |
| FA | Financial Assistance |
| FIRR | the Financial Internal Rate of Return |
| GAM | Metropolitan Area of San Jose |
| GHG | Greenhouse Gases |
| GIZ | German International Cooperation |
| ICE | Costa Rican Institute of Electricity |
| IEA | International Energy Agency |
| LCV | Light Commercial Vehicle |
| TA | Technical Assistance |
| TCO | Total cost of ownership |
| WACC | Weighted Average Capital Cost |
| WTW | well-to-wheel |

# Contents

# 1. Introduction

The objective of this report is to identify the market potential of commercial EVs and outline steps on how to overcome barriers which prevent Costa Rica from materializing the market potential.

The focus is on assessing the 2030 potential market for commercial electric vehicles (EVs) in Costa Rica and contrast this with their current commercial viability. This includes an analysis per vehicle category (buses, taxis, light commercial vehicles) of relevant purchase criteria including the total cost of ownership, total capital and equity investment, profitability and risk. It assesses factors which hinder achieving the potential and looks at the potential impact of financial instruments as well as technical assistance to close the gap. This results in an outline of possible investment areas and projects per vehicle category as well as technical assistance required to close the gap.

The report focuses on pure electric vehicles in the areas of urban buses, taxis and urban freight vehicles. The report partially includes an overlap with the diagnostic report due to each report intended to be a stand-alone report.

# 2. Current Commercial EV Market in Costa Rica

As of end 2020 less than 5 e-buses, less than 5 electric Light Commercial Vehicles (LCVs) and less than 5 electric taxis are circulating in Costa Rica. A pilot project for e-buses is being realized with GIZ (3 buses should start operations early 2021) and the postal system is testing 2 electric LCVs.

A special credit line for electric vehicles including specifically commercial units (buses, fleets) started operations in October 2020 with disbursements through the Banco Nacional (BN), the Banco Popular and the Banco de Costa Rica (BCR). Conditions vary between banks and are fixed also per project and credit subject. The offer of Banco Popular[1] (comparable for BN and BCR) for commercial EVs is currently:

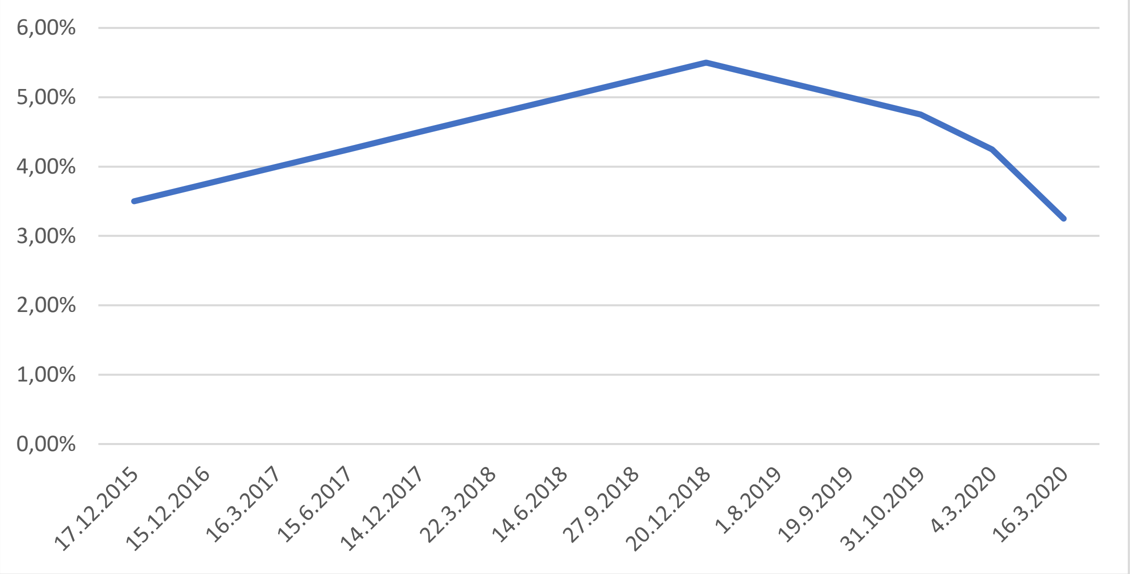
- Loans in national currency or USD;
- USD interest rate is prime rate USA plus 2.5% - this equals to around 7% (see below)[2];
- Commission of maximum 1.5%;
- Tenor up to 10 years (in practice however loans are in accordance with each business and income streams e.g. as concession contracts for buses are for 7 years loan tenors are for maximum 7 years; for taxis BCR finances only for up to 5 years);
- Maximum 80% of vehicle investment (chargers or bus depot upgrades are not included).

The following table shows the US prime rate for the last 5 years. End 2020 the rate was at 3.5%. On average the last 60 months the rate was at 4.5%.

[1] Vehículos eficientes -Créditos Verdes | Banco Promerica Costa Rica

[2] BN fixes the interest rate at 7% for the initial 2 years and then applies a base-rate plus spread. BCR uses as reference rate LIBOR.

**Figure 1: US Prime Rate 2018-2020**




Source: Historical Prime Rate (jpmorganchase.com)

Whilst banks have been quite successful in financing private EVs (which are basically upper-class vehicles; e.g. the Audi e-tron has been one of the most sold EVs in Costa Rica), the demand for commercial EV financing has been limited (involved banks have not yet financed any commercial EVs)[3].

# 3. Commercial EV Market Potential in Costa Rica

## 3.1. Scenarios

The market potential can be assessed against the government targets as expressed in the updated Nationally Determined Contribution (MINAE, 2020) (8% of all vehicles of public transport and passenger cars to be electric by 2030) or against the target to limit the global temperature increase to below 2 degrees Celsius, in line with the Paris Declaration on Electro-Mobility (Paris Declaration on Electro-Mobility and Climate Change & Call to Action, 2015), which asks for 20% of the vehicle stock to be electric by 2030. This has been modelled by the authors with a “high growth scenario” which goes beyond official government targets. It shows the potential EV market for commercial vehicles if an aggressive strategy is pursued and if instruments are in place which enable realization of this scenario. Its core target is that 100% of newly registered vehicles in the targeted commercial vehicle sectors are by 2030 electric. No scrapping policies are required to implement such a strategy as existing fossil vehicles are kept in accordance with their normal commercial lifespan. The potential EV market size is determined for the years 2022 to 2030. With 100% of newly registered vehicles in this area being electric, the 20% vehicle stock target of the Paris Declaration can be met or surpassed by these vehicle categories. To achieve an overall target of 20% of the vehicle stock of all vehicle categories to be electric, the targeted categories (urban buses, taxis, LCVs) which today are already close to being commercially viable, will have to achieve a level above 20% as other vehicle categories such as trucks are still far away from being commercially viable[4].

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[3] See chapters 4 and 5 for reasons
[4] For details on scenarios see Country Diagnostic Report Costa Rica

## 3.2. Urban Electric Buses

The following table shows the projected cumulative and annual number of Battery Electric Buses (BEBs) under the government target and under a high growth strategy.

**Table 1: Market Potential Urban E-Buses: Government Target and High Growth Scenario 2025 and 2030**

| Parameter | 2025 | | 2030 | |
|---|---|---|---|---|
| | Government Target | High Growth scenario | Government Target | High Growth scenario |
| Cumulative e-buses | 120 | 410 | 400 | 2,000 |
| Market share (% of stock) | 2% | 8% | 8% | 40% |
| Sales share (% of new registrations) | 11% | 51% | 20% | 100% |

Source: Grutter Consulting; see database (Grutter Consulting, 2020)

The government target would result in cumulative 400 urban electric buses by 2030 representing 8% of the market share i.e. this target is not commensurate with the Paris Declaration on e-mobility. With a high growth scenario a market share of 40% is targeted by 2030 equivalent to 2,000 electric buses operating in the country. This would go beyond the Paris Declaration on e-mobility which is also a necessity as other vehicle sectors (e.g. inter-urban buses, trucks or private passenger cars) will have far more difficulties in achieving the overall target of 20% of vehicle stock than urban buses.

The main parameters for the high growth market potential are outlined in the following table.

**Table 2: High Growth Market Potential Electric Urban Buses 2022-2030**

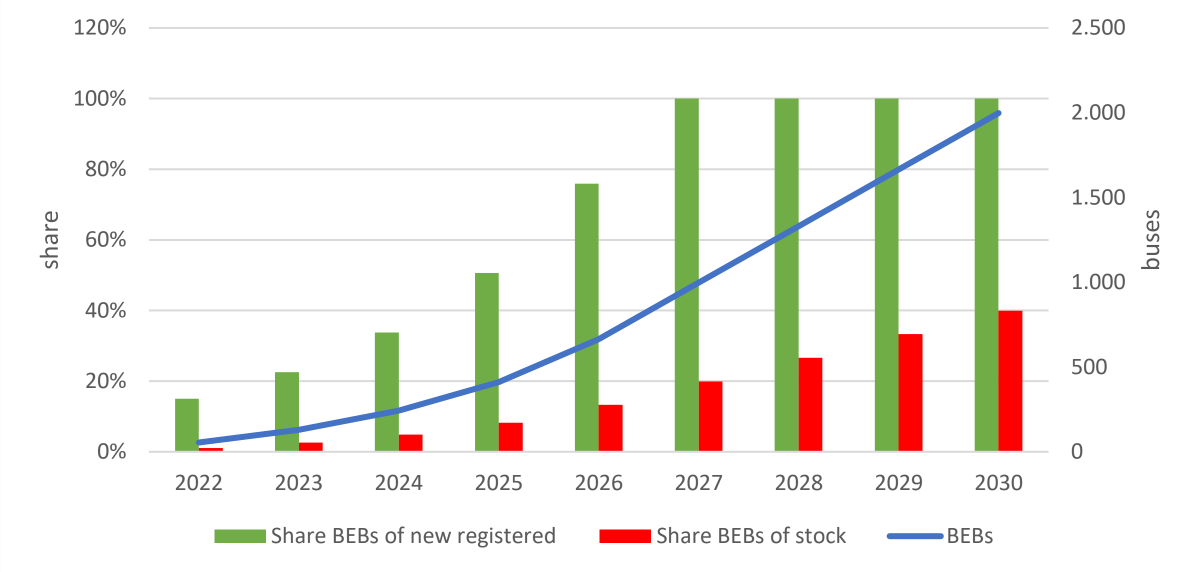
| Parameter | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| Stock buses | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 |
| Market of new buses[5] | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 |
| Target rate BEBs of new registered buses | 15% | 23% | 34% | 51% | 76% | 100% | 100% | 100% | 100% |
| New registered BEBs | 50 | 75 | 113 | 169 | 253 | 333 | 333 | 333 | 333 |
| Stock BEBs | 55 | 130 | 243 | 411 | 664 | 998 | 1,331 | 1,664 | 1,998 |
| Share BEBs of stock | 1% | 3% | 5% | 8% | 13% | 20% | 27% | 33% | 40% |

BEBs: Battery Electric Buses
Source: Grutter Consulting; stock of buses based on data ARESEP; growth rate of fleet 0% based on decreasing mode share of public transport by buses matching increasing travel demand related to population and GDP growth; average commercial lifespan of buses 15 years

The target rate of BEBs is based on starting 2022 with a fleet of 50 units commensurate with a fleet size which can offer attractive financial conditions. The number of newly registered BEBs is then increased by 50% each year, reaching 100% of newly registered units by 2027. As of 2030 nearly 2,000 BEBs or 40% of the stock of urban buses operating in Costa Rica would be electric (the NDC target is 8%).

[5] Replacement plus additional vehicles

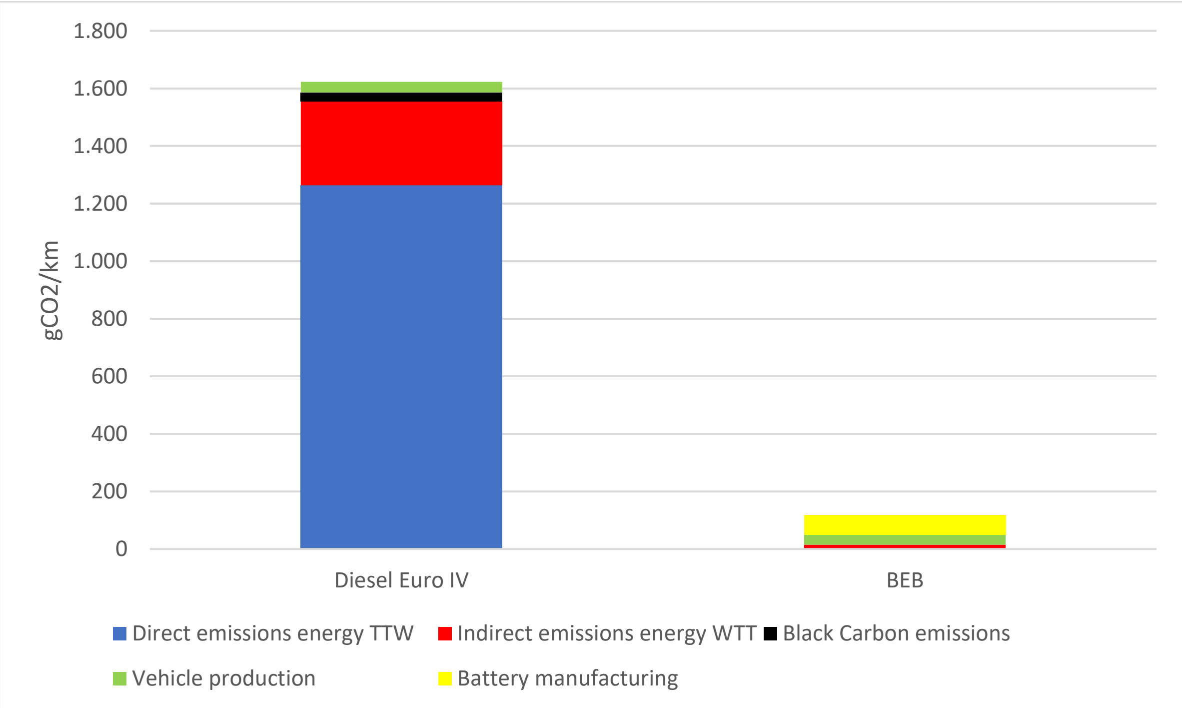
**Figure 2: Urban Electric Bus High Growth Market Potential**




Source: Grutter Consulting

A BEB can reduce well-to-wheel (WTW) Greenhouse Gas (GHG) emissions in Costa Rica by 99% and cradle to grave emissions by 93% (see figure below).

**Figure 3: GHG Impact Urban Bus (12m urban bus)**




Source: Grutter Consulting; mileage and energy consumption based on values for Costa Rica; major assumptions include 60,000km annual mileage; 47 l/100km diesel and 1kWh/km BEB; 15 year lifespan diesel and 16-year BEB; 8-year lifespan of battery; battery set of average 300 kWh; 110kg $CO_2$/kWh battery (ICCT, 2018); grid factor 0.015 kg$CO_2$/kWh; see for details Annex

The following table shows the year 2030 and the cumulative impact over the lifespan of the buses (16 years for BEBs) of realizing the high growth market potential and having around 2,000 BEBs operating by 2030.

**Table 3: Environmental Impact of Implementing the High Growth Market Potential Strategy**

| Parameter | year 2030 | Cumulative |
|---|---|---|
| GHG WTW reduction | 188,000 tons | 3,031,000 tons |
| $PM_{2.5}$ reduction | 6 tons | 88 tons |
| $NO_x$ reduction | 650 tons | 10,400 tons |
| Economic Benefits (USD of 2020) | 8.8 MUSD | 122 MUSD |

Source: Grutter Consulting; baseline bus Euro IV standard; see Annex for details; see for details of calculation including economic cost assumptions Grutter Consulting, 2020, Methodological Note on Country Diagnosis E-Motion Program

The implementation of this strategy could reduce more than 3 million tons of $CO_2$ (over the lifetime of buses) and would have economic benefits of 122 MUSD due to reduced emissions - 99% of economic benefits are due to reduced GHG emissions i.e. of global nature. The projected cumulative Capital Expenditure (CAPEX) in BEBs is around 350 MUSD[6].

## 3.3. Electric Taxis

The following table shows the projected cumulative and annual number of electric taxis under the government target and under a high growth strategy.

**Table 4: Market Potential Electric Taxis: Government Target and High Growth Scenario 2025 and 2030**

| Parameter | 2025 | | 2030 | |
|---|---|---|---|---|
| | Government Target | High Growth scenario | Government Target | High Growth scenario |
| Cumulative e-taxis | 210 | 1,320 | 1,150 | 8,440 |
| Market share (% of stock) | 1% | 11% | 8% | 59% |
| Sales share (% of new registrations) | 6% | 33% | 15% | 100% |

Source: Grutter Consulting; see database (Grutter Consulting, 2020)

As is the case for e-buses the government target falls short of the Paris Declaration on e-mobility whilst the high-growth scenario is compatible with the Declaration. The following table shows the main parameters for the high growth market potential of electric taxis.

**Table 5: High Growth Market Potential Electric Taxis 2022-2030**

| Parameter | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| Stock taxis | 11,421 | 11,748 | 12,084 | 12,429 | 12,785 | 13,151 | 13,527 | 13,913 | 14,311 |
| Market of new taxis[7] | 1,428 | 1,469 | 1,511 | 1,554 | 1,598 | 1,644 | 1,691 | 1,739 | 1,789 |
| Target rate e-taxis of new registered taxis | 11% | 15% | 22% | 33% | 48% | 69% | 100% | 100% | 100% |
| New registered e-taxis | 150 | 225 | 338 | 506 | 759 | 1,139 | 1,691 | 1,739 | 1,789 |
| Stock e-taxis | 250 | 475 | 813 | 1,319 | 2,078 | 3,217 | 4,908 | 6,648 | 8,437 |
| Share e-taxis of stock | 2% | 4% | 7% | 11% | 16% | 24% | 36% | 48% | 59% |

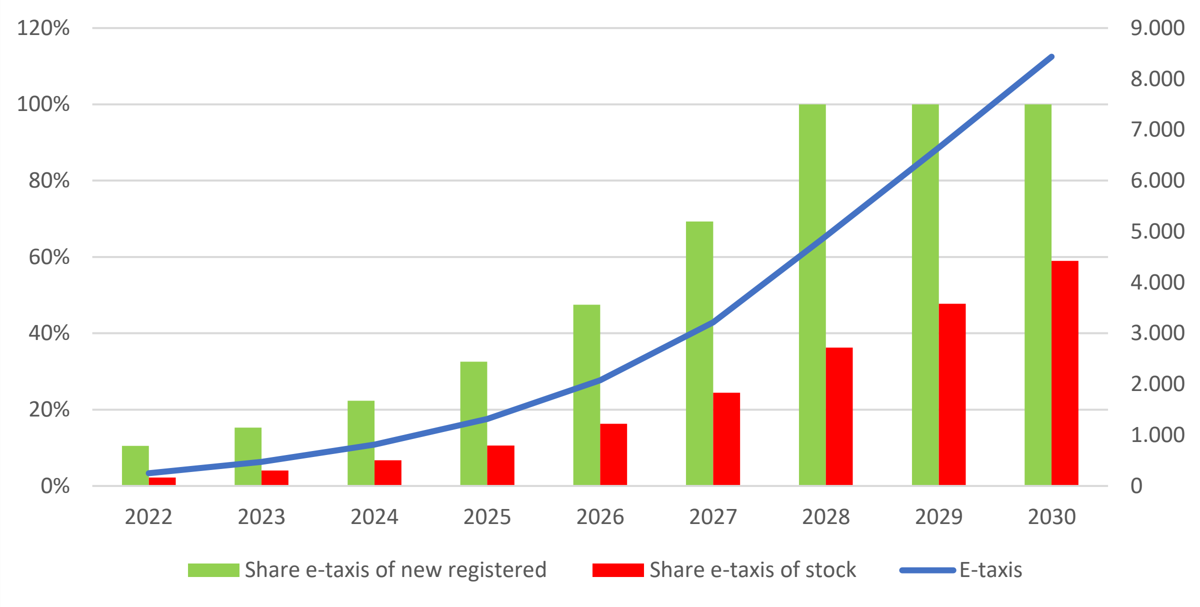
Source: Grutter Consulting; average commercial lifespan of taxi 10 years

The target rate of taxis is based on starting 2022 with a fleet of 150 units. The number of newly registered e-taxis is then increased by 50% each year, reaching 100% of newly registered units by

[6] Calculation by Grutter Consulting based on decreasing bus prices; see Annex for details
[7] Replacement plus additional vehicles

2028. As of 2030 more than 8,000 e-taxis or nearly 60% of the stock of taxis operating in Costa Rica would be electric (the Costa Rican target is 8%).

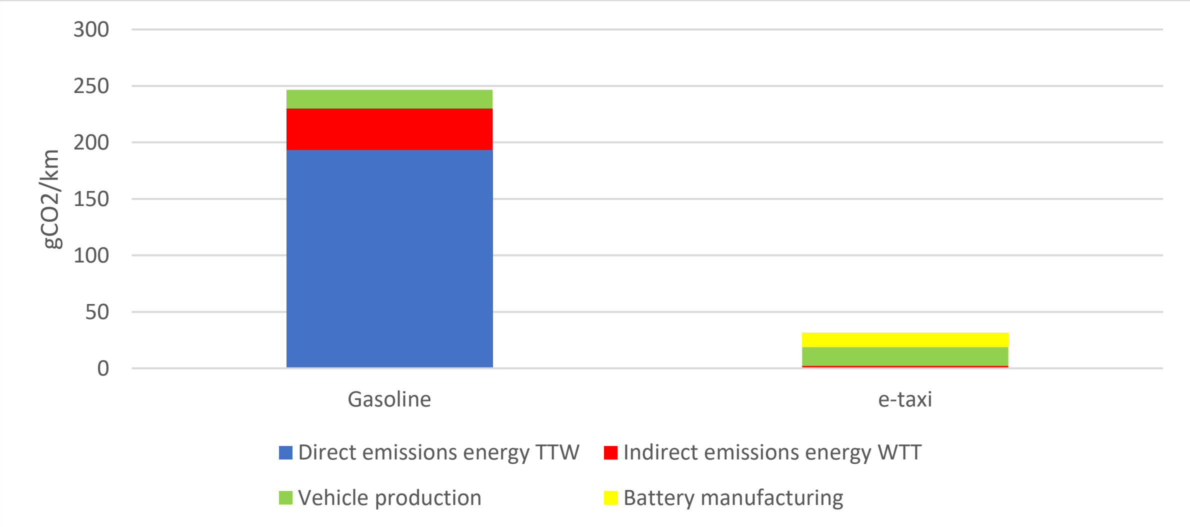
**Figure 4: Electric Taxi High Growth Market Potential**




Source: Grutter Consulting

An electric taxi can reduce WTW emissions in Costa Rica by 99% and cradle to grave emissions by 87% (see figure below).

**Figure 5: GHG Impact Electric Taxi**




Source: Grutter Consulting; mileage and energy consumption based on values for Costa Rica; major assumptions include 52,000km annual mileage; 8.5 l/100km gasoline and 0.16 kWh/km e-taxi; 10 year lifespan gasoline and e-taxi; 10-year lifespan of battery; battery set of 60 kWh; 110kg $CO_2$/kWh battery (ICCT, 2018); grid factor 0.015 kg$CO_2$/kWh; see for details Annex

The following table shows the impact in the year 2030 and the cumulative impact over the lifespan of e-taxis (10 years) of realizing the high growth market potential and having around 8,500 e-taxis operating by 2030.

**Table 6: Environmental Impact of Implementing the High Growth Market Potential Strategy**

| Parameter | year 2030 | Cumulative |
|---|---|---|
| GHG WTW reduction | 101,000 tons | 1,010,000 tons |
| $PM_{2.5}$ reduction | 0.5 tons | 5 tons |
| $NO_x$ reduction | 25 tons | 250 tons |
| Economic Benefits (USD of 2020) | 4.1 MUSD | 41 MUSD |

Source: Grutter Consulting; baseline gasoline taxi; see Annex for details; see for details of calculation including economic cost assumptions Grutter Consulting, 2020, Methodological Note on Country Diagnosis E-Motion Program

The implementation of this strategy could reduce more than 1 million tons of $CO_2$ (over the lifetime of taxis) and would have economic benefits of 41 MUSD due to reduced emissions - 98% of economic benefits are due to reduced GHG emissions i.e. of global nature. The projected cumulative CAPEX in e-taxis over the time-period is around 150 MUSD[8].

## 3.4. Light Commercial Vehicles (LCVs)

The following table shows the projected cumulative and annual number of electric LCVs under the government target (assuming the same target for LCVs as for passenger cars) and under a high growth strategy.

**Table 7: Market Potential Electric LCVs: Government Target and High Growth Scenario 2025 and 2030**

| Parameter | 2025 | | 2030 | |
|---|---|---|---|---|
| | Government Target | High Growth scenario | Government Target | High Growth scenario |
| Cumulative electric LCVs | 2,800 | 2,300 | 22,000 | 58,000 |
| Market share (% of stock) | 1% | 1% | 8% | 22% |
| Sales share (% of new registrations) | 7% | 7% | 30% | 100% |

Source: Grutter Consulting; see database (Grutter Consulting, 2020)

Idem as for e-buses and e-taxis the government targets are not as ambitious as the Paris Declaration on e-mobility. The following table shows the main parameters for the high growth market potential of LCVs.

**Table 8: High Growth Market Potential Electric LCVs 2022-2030**

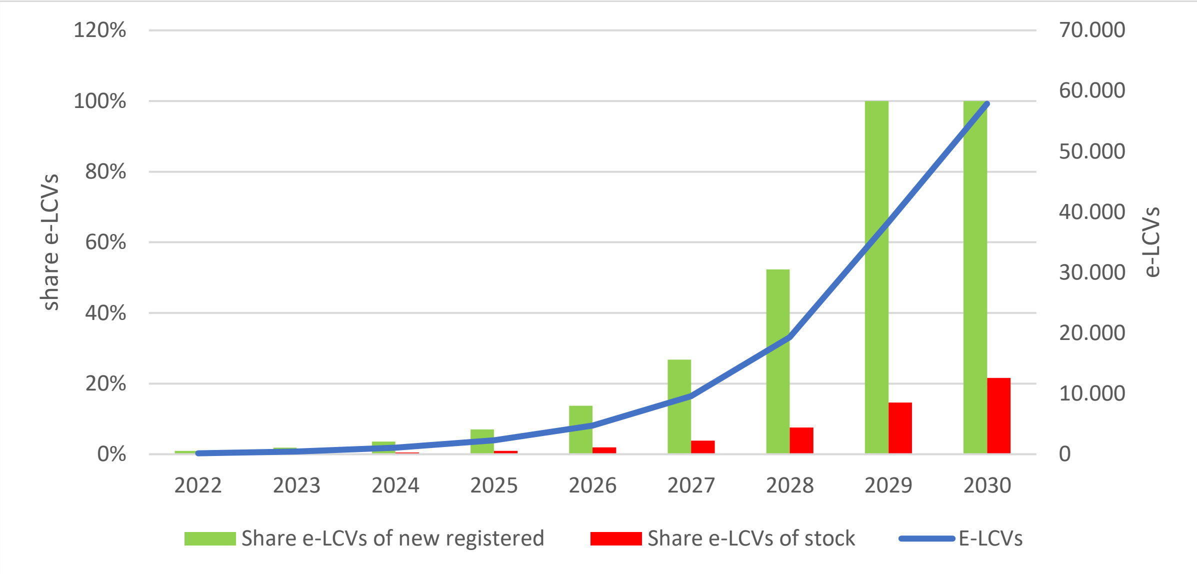
| Parameter | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| Stock LCVs | 221,159 | 226,577 | 232,129 | 237,816 | 243,642 | 249,611 | 255,727 | 261,992 | 268,411 |
| Market of new LCVs[9] | 16,082 | 16,476 | 16,880 | 17,294 | 17,717 | 18,151 | 18,596 | 19,052 | 19,518 |
| Target rate e-LCVs of new registered LCVs | 1% | 2% | 4% | 7% | 14% | 27% | 52% | 100% | 100% |
| New registered e-LCVs | 152 | 304 | 608 | 1,216 | 2,433 | 4,865 | 9,731 | 19,052 | 19,518 |
| Stock e-LCVs | 152 | 456 | 1,064 | 2,281 | 4,713 | 9,579 | 19,309 | 38,361 | 57,879 |
| Share e-LCVs of stock | 0% | 0% | 0% | 1% | 2% | 4% | 8% | 15% | 22% |

Source: Grutter Consulting; average commercial lifespan of LCV 20 years

[8] Calculation by Grutter Consulting based on decreasing e-taxi prices; see Annex for details
[9] Replacement plus additional vehicles

The target rate of electric LCVs is based on starting 2022 with a fleet of 150 units (2 are already existing). The number of newly registered e-LCVs is then increased by 50% each year, reaching 100% of newly registered units by 2029. As of 2030 nearly 20,000 e-LCVs or 20% of the stock of LCVs operating in Costa Rica would be electric (the Costa Rican target is 8%).

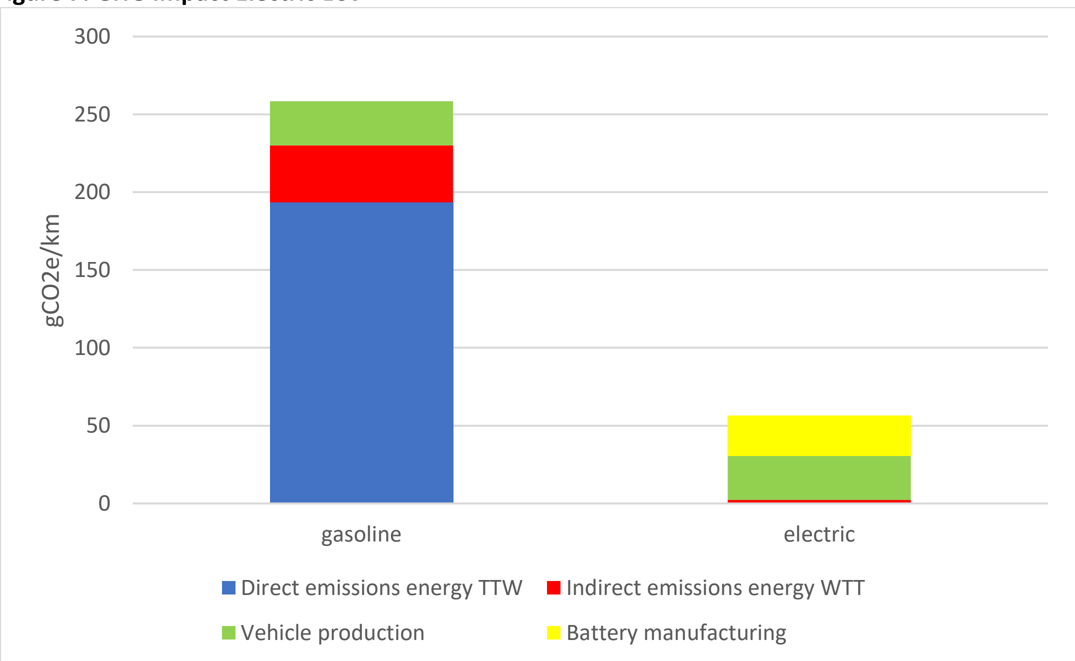
**Figure 6: LCV High Growth Market Potential**




Source: Grutter Consulting

LCVs are a very diverse segment of vehicles with different vehicle sizes and very different usage patterns and therefore also very different mileage as well as lifespan of usage. Based on a LCV as used by many delivery services (500-800kg carrying capacity) an electric LCV can reduce WTW emissions in Costa Rica by 99% and cradle to grave emissions by 78% (see figure below).

**Figure 7: GHG Impact Electric LCV**




Source: Grutter Consulting; mileage and energy consumption based on values for Costa Rica based on Suzuki APV gasoline versus Maxus E-Deliver; major assumptions include 20,000km annual mileage; 8.5 l/100km and 0.15 kWh/km e-LCV; 15 year lifespan gasoline and e-LCV; 8-year lifespan of battery; battery set of 35kWh; 110kg $CO_2$/kWh battery (ICCT, 2018); grid factor 0.015 kg$CO_2$/kWh; see for details Annex

The following table shows the year 2030 and the cumulative impact over the lifespan of the e-LCVs (based on 15 years) of realizing the high growth market potential and having around 58,000 e-LCVs operating by 2030.

**Table 9: Environmental Impact of Implementing the High Growth Market Potential Strategy**

| Parameter | year 2030 | Cumulative |
|---|---|---|
| GHG WTW reduction | 264,000 tons | 3,960,000 tons |
| $PM_{2.5}$ reduction | 1 tons | 19 tons |
| $NO_x$ reduction | 74 tons | 1,100 tons |
| Economic Benefits (USD of 2020) | 11 MUSD | 160 MUSD |

Source: Grutter Consulting; baseline mixture of diesel and gasoline; lifespan average 15 years; see Annex for details; see for details of calculation including economic cost assumptions Grutter Consulting, 2020, Methodological Note on Country Diagnosis E-Motion Program

The implementation of this strategy could reduce around 4 million tons of $CO_2$ (over the lifetime of LCVs) and would have economic benefits of 160 MUSD due to reduced emissions - 98% of economic benefits are due to reduced GHG emissions i.e. of global nature. The projected cumulative CAPEX in e-LCVs over the time-period is around 1,190 MUSD[10].

## 3.5. Summary Market Potential

The following table summarizes the targeted government market of commercial e-mobility and a high growth market potential of commercial EVs in Costa Rica compatible with the Paris Declaration on e-mobility. In both cases market growth is not linear but follows an exponential trend as prices decrease and EVs become more popular.

**Table 10: Projected Market Potential Commercial EVs Costa Rica**

| Parameter | 2025 | | 2030 | |
|---|---|---|---|---|
| | Government Target | High Growth scenario | Government Target | High Growth scenario |
| Cumulative e-buses | 120 | 410 | 400 | 2,000 |
| Cumulative e-taxis | 210 | 1,320 | 1,150 | 8,440 |
| Cumulative e-LCVs | 2,800 | 2,300 | 22,000 | 58,000 |
| CAPEX cumulative EVs | 90 MUSD | 170 MUSD | 550 MUSD | 1,700 MUSD |
| CAPEX without LCVs | 30 MUSD | 110 MUSD | 90 MUSD | 500 MUSD |

Source: Grutter Consulting; see database (Grutter Consulting, 2020)

The difference between the Costa Rican target and the high growth potential is around factor 2. Excluding LCVs, where many vehicles are also used for private purposes and where market uptake is considered to be associated with a higher question mark than compared to other vehicle segments, the estimated investment in electric taxis and urban buses is between 30 and 90 MUSD cumulative by 2025 and between 500 and 1,700 MUSD cumulative by 2030.

The market potential is a target. The current market volume is nowhere close to the market potential. The financial assessment in the following chapter shall give indications what prevents the market volume to resemble the market potential.

[10] Calculation by Grutter Consulting based on decreasing e-LCV prices; see Annex for details

# 4. Financial Assessment of Commercial EVs in Costa Rica

## 4.1. Introduction

The financial assessment is made per vehicle type based on local data. Following parameters are assessed:

- Total cost of ownership (TCO) per kilometre comparing the fossil with the electric unit: The TCO is calculated in financial and economic terms; values are not discounted for the TCO;
- Incremental upfront capital investment required and incremental equity capital required with current financing schemes;
- Profitability of investing in an EV instead of a fossil vehicle by calculating the Financial Internal Rate of Return (FIRR) and the Economic Internal Rate of Return (EIRR) of the incremental capital expenditure: the FIRR is compared to the Weighted Average Capital Cost (WACC) for the transport sector in Costa Rica[11];
- Differential cash flow;
- Discounted payback time of differential investment (using the WACC as discount rate).

The different indicators are used as they point out various criteria important for investment decisions: life-cycle profitability, capital exposure and risk, opportunity cost or benefit and liquidity. Variations of the different parameters (e.g. loan terms) are made to assess the sensitivity of results. This also gives an indication of the types of financial instruments which can be used to promote EVs and their potential impact.

The financial analysis is a comparison of investment options. It does not assess the financial viability of operating the specific vehicle (as example in public transport diesel buses could be operating at a loss and e-buses could continue to be operated at a loss) nor the financial soundness and creditworthiness of an enterprise. For latter other factors need to be contemplated such as revenues, debt and equity levels etc. The financial analysis is a comparison of investing pari passu in electric instead of fossil units.

All calculations are performed in constant real 2020 USD.

**Total Cost of Ownership (TCO)**

Looking at the TCO is a way of assessing the long-term value of a purchase to a company. When comparing the TCO of vehicles the valuation criteria is cost per km. When comparing costs of EVs with such of other technologies only expenditures are relevant which differ between the two technologies. Cost components such as drivers cost or overhead management will not change when using EVs – therefore usage of such company-sensitive data can be avoided. Critical for our purpose and therefore included in the analysis here are the following cost parameters:

- CAPEX: This includes the vehicle, charging infrastructure, grid connections, vehicle depot upgrades, and battery replacement;
- OPEX: This includes energy, maintenance (vehicle plus infrastructure components), and finance costs.

The lifespan of the vehicle (which can be different for EVs and for fossil units) and the annual mileage are other parameters of importance for calculations. Insurance costs are not included as these are not

[11] The WACC is different due to differential loan terms

necessarily tied to the vehicle value and are of minor magnitude. The same holds true of vehicle registration fees. The economic costs of emissions are included for the determination of economic TCOs. Costs are based on national values and include applicable taxes including preferential tax regimes for EVs.

**WACC**

The WACC is calculated with the following equation:

$$WACC = r_e \times W_e + r_d \times W_d \times (1 - T_c)$$

where:
$r_e$ Cost of equity
$W_e$ Percentage of financing by equity
$R_d$ Cost of debt
$W_d$ Percentage of financing by debt
$T_c$ Corporate tax rate

The following table shows the parameters for determining the WACC for Costa Rica for the transport sector.

**Table 11: WACC Transport Sector Costa Rica (all rates in USD)**

| Parameter | Value | Source |
|---|---|---|
| Cost of equity | 14.9% | (UNFCCC, 2019); value for transport sector of Costa Rica |
| Share of equity financing | 20% | Banks are willing to finance 80% with loans |
| Cost of debt EVs | 7.0% | Current average rate for commercial EVs (see chapter 2) |
| Cost of debt fossil vehicle | 8.0% | Current average rate for commercial fossil units based on BN, BCR, other Costa Rica banks |
| Share of debt financing | 80% | Banks are willing to finance 80% with loans (see chapter 2) |
| Corporate tax rate | 30% | Deloitte, 2020 |
| WACC EVs | 6.9% | Calculated |
| WACC fossil vehicles | 7.5% | Calculated |

## 4.2. Financial Analysis E-Buses

### 4.2.1. General Data

Calculations are realized for the standard bus as used in Costa Rica which is a 12m coach-bus unit with 2 access doors and equipped with lift for disabled passengers used for urban operations. 2 options for BEBs have been included in the calculations:

- An overnight charged BEB with a battery set of 350 kWh[12];
- A BEB with batteries capable of fast-charging and a battery set of 250 kWh (C-rate of minimum 0.65) which allows to re-charge for additional 100km within around 20 minutes using a 300 kW charger.

[12] The battery set was determined based on the average distance per workday, the electricity consumption rate, a 20% operational reserve rate (to avoid buses getting stranded), a 10% higher consumption risk rate (e.g. due to high temperatures causing extensive usage of the AC or congestion resulting in additional AC usage or driver with less than average skills) and 20% loss of State of Health (SOH) of batteries over 8 years.

The following tables indicate the general parameters, the diesel bus specific values, the overnight BEB and the fast-charged BEB specific values.

**Table 12: General Bus Parameters**

| Parameter | Value | Source |
|---|---|---|
| Distance driven per bus per annum | 60,000 km | ARESEP |
| Loan tenure | 7 years | Based on concession contracts and bank offers |
| Interest rate for BEBs | 7% | BNB,BCR, Banco Popular |
| Interest rate for diesel buses | 8% | |
| WACC BEB | 6.9% | See above |
| WACC diesel bus | 7.5% | |

**Table 13: Baseline Diesel Bus Parameters**

| Parameter | Value | Source |
|---|---|---|
| Diesel usage | 47 l/100km | ARESEP, in line with COPERT tier 3 model |
| Tyre usage | 0.04 USD/km | ARESEP data for tariff calculation |
| Maintenance engine including materials and staff | 0.07 USD/km | ARESEP data for tariff calculation (55% of cost for liquids and materials and 45% for staff) |
| Repair and spare parts | 0.12 USD/km | ARESEP data for tariff calculation |
| CAPEX | 110,000 USD | bus operators; Euro 4 coach style bus |
| Lifespan | 15 years | standard Costa Rica |

**Table 14: BEBs Common Parameters**

| Parameter | Value | Source |
|---|---|---|
| Specific electricity usage | 1 kWh/km | Chinese average; (ADB, 2018); includes moderate AC |
| Tyre usage | 0.04 USD/km | 10% more than for a diesel bus based on data from operators in China (due to slightly higher bus weight and regenerative braking) |
| Maintenance engine | 0.02 USD/km | 75% reduction (90% reduction materials, 50% less staff cost (less staff but more qualified staff)) |
| Repair and spare parts | 0.10 USD/km | 20% less than diesel bus (less engine repairs but slightly more expensive spare parts; other repairs the same) |
| Lifespan bus | 16 years | Maximum based on battery age (1x replacement) |
| Lifespan battery @ 80% SOH | 8 years | current guarantee levels of BEBs |
| Reduction battery cost in 8 years | 50% | US DOE projections, 2017 have a decrease of 12% per annum; applied to 5 years[13]; |
| CAPEX charger excluding installation per kW | 120 USD/kW | Standard Chinese chargers, 2 nozzles |
| CAPEX charger installation | 2,500 USD/bus | Civil works for chargers; 2 buses per charger; 5,000 USD per charger |
| Cost per bus depot upgrade | 7,500 USD/bus | Coverage of bus and chargers with roof, no paving, includes labour (20m$^2$ per bus, 250 USD/m$^2$ material and 150 USD/m$^2$ labour) |
| Cost grid connection of chargers per bus | 30,000 USD/bus | Compact sub-stations for groups of chargers; 20kV cables from connection substation to the compact substation, 400V cables from compact substation to charger (these are **not** grid upgrades) |
| Lifetime charger | 10 years | standard value provided by ABB |
| Lifetime bus depot upgrades | 20 years | standard value for construction investments |
| Lifetime grid connection | 20 years | standard value used by power companies |
| Maintenance chargers, grid connection, depot | 2% | Percentage of CAPEX |

[13]https://energy.gov/sites/prod/files/2017/02/f34/67089%20EERE%20LIB%20cost%20vs%20price%20metrics%20r9.pdf

**Table 15: BEB Overnight Charged Bus**

| Parameter | Value | Source |
|---|---|---|
| CAPEX bus | 262,000 USD | Based on offers of various manufacturers from China FOB*1.2 plus USD 10,000 for lift for disabled passengers |
| CAPEX batteries | 200 USD/kWh | LFP batteries |
| Battery capacity | 350 kWh | Calculated based on workday range with sufficient margins (see Annex) |
| Charger power | 40 kW | Calculated based on available charging time and daily average electricity usage |

**Table 16: BEB Fast Charged Bus**

| Parameter | Value | Source |
|---|---|---|
| CAPEX bus | 226,000 USD | Based on fast-charged coach bus offers from various Chinese manufacturers; FOB China *1.2 for CIF plus 10,000 for lift |
| CAPEX batteries | 250 USD/kWh | NMC batteries |
| Battery size | 250 kWh | Calculated based on workday range with sufficient margins and battery sets cum C-rates as offered in the market (see Annex) |
| Night charger power | 40 kW | Calculated based on available charging time and daily average electricity usage |
| Fast-charger power | 300 kW | Calculated for additional 100km in 20 minutes |
| Number of buses per fast-charger | 8 buses / charger | Calculated for small fleets (average in PR China 6-10 buses) |

For e-buses it is assumed that only buses are financed and not the charging infrastructure, grid connections and depot upgrades. With company instead of project finance and sufficient collateral of debtors, FIs, would be willing to finance also other investment components. Otherwise they will be reluctant as charger, depot and grid connections are basically sunk costs without re-sale value in case of default. Using them as collateral is thus for banks not acceptable, whilst buses, if insured, can be used as collateral.

### 4.2.2. TCO

The following table shows the results of the TCO calculation.

**Table 17: TCO Calculations (USD of 2020)**

| Parameter | Diesel Euro IV | BEB overnight charged | BEB fast-charged |
|---|---|---|---|
| CAPEX bus | 110,000 | 262,000 | 226,000 |
| CAPEX charging infrastructure | 0 | 7,300 | 12,100 |
| CAPEX grid connection | 0 | 30,000 | 30,000 |
| CAPEX depot upgrade | 0 | 7,500 | 7,500 |
| **Total CAPEX** | **110,000** | **306,800** | **275,600** |
| Battery replacement year 8 | 0 | 35,000 | 31,250 |
| Energy cost | 20,586 | 5,400 | 5,400 |
| Maintenance cost bus | 13,800 | 9,450 | 9,450 |
| Maintenance cost infrastructure | 0 | 896 | 936 |
| Finance cost average p.a. during loan term | 3,888 | 8,018 | 6,917 |
| Economic costs of emissions year 1 | 4,411 | 37 | 37 |
| Lifespan in years | 15 | 16 | 16 |
| **TCO financial per km** | **0.73** | **0.67** | **0.64** |
| **TCO economic per km** | **0.81** | **0.67** | **0.64** |

Source: Grutter Consulting

Following conclusions are drawn:

- Comparing total costs over the bus lifetime of 16 years BEBs have a lower financial TCO than diesel buses and a significantly lower economic TCO than diesel buses;
- The TCO of fast-charged BEBs is lower than of overnight charged BEBs – this option is therefore not only from an operational risk perspective better (in case of higher than expected energy consumption or usage of the bus for longer routes, batteries can be quickly re-charged) but also from a financial perspective.

### 4.2.3. Capital and Equity Investment

A comparison is made of the required capital, in term of loans and as equity (see the following table).

**Table 18: Capital Demand (USD of 2020)**

| Capital investment BEB relative to diesel bus (per unit) | BEB overnight | | BEB fast-charged | |
|---|---|---|---|---|
| | Absolute | % | Absolute | % |
| Additional capital investment | 196,800 | 179% | 165,600 | 151% |
| Additional loan deman | 121,600 | 138% | 116,000 | 105% |
| Additional equity requirement | 75,200 | 342% | 72,800 | 331% |

Source: Grutter Consulting

BEBs require a 2.5-3x higher capital investment than diesel buses[14]. (Special) loans are currently only available for the bus component and limited to 80% of the capital. This means loans will increase by around factor 2. If other than bus collateral is demanded this can cause a problem to the company. Also company debt levels might go beyond tolerable levels. The most important impact is however on the required equity: this increases by the factor 4. Equity is required for the additional investments as well as to par the loans. Due to higher total capital investment keeping a 20% owners capital requirement for a loan results in much higher levels of owners capital needed. This places a serious problem especially, but not only, for small and medium bus operators in Costa Rica. If such an operator wants to purchase 10 BEBs instead of 10 diesel buses he needs to supply owners capital of around 950,000 USD instead of 220,000 USD to access loans. With the same amount of equity the bus owner could opt to purchase 40 instead of 10 diesel buses thus increasing his absolute profits by increasing service levels (one BEB will deliver the same level of revenues as one diesel bus).

### 4.2.4. Relative Profitability

The relative profitability assesses the FIRR of the incremental investment for BEBs (relative to a diesel bus) based on the operational savings of BEBs versus diesel units:

- The FIRR of overnight charged BEBs is 4.6% and of fast-charged BEBs of 7.2%. Former is below the WACC of 6.9% and latter slightly above the WACC.
- The EIRR is 9% respectively 12%.

The investment in BEBs is thus on average not profitable and not commensurate with the risks associated with investing in a new technology with many unknown performance factors and costs (e.g. concerning maintenance cost savings which represent the second largest cost-saving block in OPEX).

[14] 2x higher capital investment is identical to incremental 100%

### 4.2.5. Discounted Payback

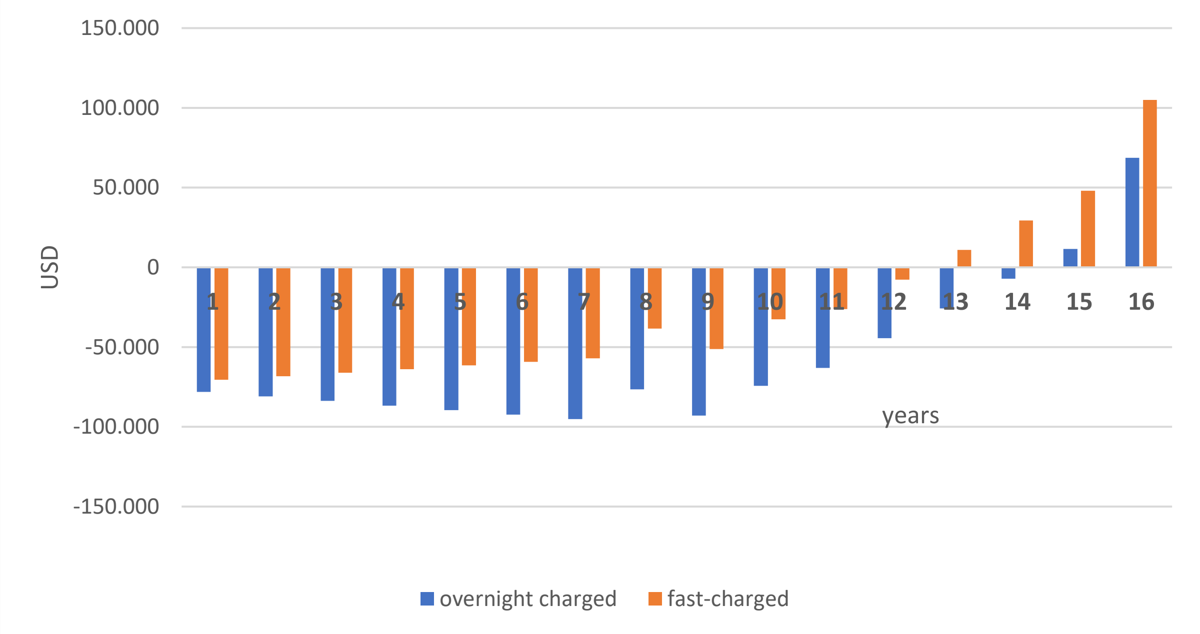
The discounted payback looks at the number of years required to recover the initial incremental investment from savings of BEBs relative to diesel buses. Annual incremental savings of using a BEB versus a diesel bus are discounted. The discounted payback gives a good indication of the risk the entrepreneur is facing and how much time his capital is tied up and not available for alternative investments.

In both cases the discounted payback shows that the initial incremental investment is not recovered i.e. the payback period is longer than the lifetime of the equipment. This points to a non-profitable and high-risk investment.

### 4.2.6. Cash Flow

Cash Flow (CF) calculations are important to assess liquidity aspects of an investment. The CF is calculated without discounting based on the owners capital invested. It is based on the differential outflow of cash for CAPEX and OPEX of a BEB versus a diesel bus. Only cash outflows are considered as revenues (cash inflows) are identical between a BEB and a diesel bus. The following graph shows the CF development.

**Figure 8: Cumulative Incremental Cash Flow BEB versus Diesel Bus (USD of 2020; non discounted)**




Notes / assumptions: 7-year loan with equal monthly instalments; no loan finance of non-bus investments; no loan-finance of battery replacement and charger replacement investment; year 1 CAPEX in day 1 and full operations; negative values mean that BEBs result in increased cash outflow; positive values mean that BEBs result in increased cash-inflows compared to the diesel bus.
Source: Grutter Consulting

The cumulative CF turns positive in the years 13 respectively 15. This goes far beyond the concession period of 7 years and is close to the lifetime of the investment (16 years). This means that the company will have to bear a cumulative negative liquidity impact during more than a decade due to the initial high outflow of cash (from year onwards the annual cash outflows of BEBs are lower than with diesel buses).

### 4.2.7. Summary Financial Assessment

The following table summarizes the financial assessment of BEBs, taking as comparison base the average between the two assessed technology options for BEBs.

**Table 19: Summary Financial Assessment BEBs**

| Criteria | Result | Assessment |
|---|---|---|
| TCO | 10% lower (USD 0.08 per km) for BEBs | Non-discounted the cumulated lifetime costs for BEBs are lower than for diesel buses. |
| Capital investment | 2.5x of a conventional bus | Significantly higher capital requirement incl. higher loan demand; negative impact on debt to equity ratio |
| Equity investment | 4x of a conventional bus | Significantly higher equity demand which might overstretch the capabilities of small and medium enterprises |
| Profitability | FIRR slightly below WACC | Investment in e-buses is not profitable. |
| Discounted Payback | Incremental investment is not recovered with savings during asset lifetime (16yrs) | The investment in e-buses is not profitable and the payback time is extremely long, even going beyond the asset lifetime. This indicates a high risk profile of the investment. |
| Cash Flow | Negative cumulative CF until year 14 | The investment in BEBs will affect the liquidity position of the companies in a negative manner and will affect negatively the solvency ratio and at least for the loan period the working capital ratio. During the loan repayment period of 7 years the cash outflow with BEBs is equal to diesel buses (lower operational expenditures are wiped away by loan + interest repayments). Only from the year 10 onwards a stream of positive CF (compared to diesel buses) sets in to compensate for invested equity. |

Summarized the investment in BEBs with the current financial conditions and business models is not profitable, a high risk, requires a significant increase in owners capital and results in potentially serious liquidity problems. The TCO does give the indication that e-buses are potentially an interesting alternative. However, BEBs will require a different financial structuring and financial incentives to be a viable business proposal in Costa Rica.

### 4.2.8. Variation of Parameters / Incentive Schemes

The impact on financial parameters of using concessional loans and of upfront investment grants is assessed.

**Concessional Loan Usage**

The following table indicates the parameters used for a concessional loan.

**Table 20: Concessional Loan Parameters**

| Parameter | Current conditions | Concessional conditions |
|---|---|---|
| Loan tenure | 7 years | 12 years |
| Interest rate | 7% | 4.6% |
| Lending rate | 80% of bus investment | 80% of total investment |

The concessional interest rate is based on a 1% rate from the GCF (commissions fees factored into the interest rate) for 30% of the loan and 70% of the investment from FAD/co-financers at 2.5% interest rate plus 2.5% spread of the national banking system (loan amounts are too small for realizing direct loans by AFD/Porparco/CAF.

The concessional loan conditions also result in reducing the WACC and discount factor to 3.7% (from 6.9%). The concessional loan conditions are close to a financial leasing approach. A financial leasing system will also require a down payment of around 10% and leasing rates will not be lower than the concessional loan rates. The following table compares the financial results with and without a concessional loan.

**Table 21: Impact of Concessional Loan Conditions**

| Parameter | overnight charged BEB | fast charged BEB |
|---|---|---|
| TCO financial old | 0.67 | 0.64 |
| TCO financial new | 0.69 | 0.66 |
| FIRR old | 4.6% | 7.2% |
| FIRR new | 4.6% | 7.2% |
| Additional equity old | 342% | 331% |
| Additional equity new | 179% | 151% |
| Discounted Payback in years old | none | none |
| Discounted Payback in years new | None | year 16 |
| Positive differential CF old (year) | year 15 | year 13 |
| Positive differential CF new (year) | positive from year 5; negative year 8 to 15 (investment in chargers and replacement batteries) | positive from year 2; negative years 10 to 13 |

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO remains constant. The slightly higher cost with concessional finance is due to having higher total finance costs (higher lending rate, plus lending over total CAPEX) plus longer tenure.
2. The concessional loan does not change the FIRR by logic (the FIRR is calculated without financial costs). However, it lowers the benchmark value (WACC) and both types of BEBs now have a FIRR above the benchmark i.e. the investment in BEBs can be considered profitable versus diesel buses – however, with a marginal difference.
3. Owners capital requirements are reduced with the concessional loan (due to not only financing the bus but all investment components). Owners capital is however still 150-180% above the amount required for diesel buses.
4. The risk and the capital exposure of the entrepreneur can be reduced but the risk profile is still negative. The dynamic payback is only after 16 years which is far too long.
5. The liquidity situation is massively improved. A partially negative CF is still present in the period years 8-14 due to investments in replacement batteries and new chargers.

It can be concluded that the concessional loan basically helps to resolve the liquidity issues and results in an improvement of the investment profitability but investment risks remain high with an unsatisfactory payback time. It is clear that concessional loan conditions are an important feature but are not sufficient to tilt an investors decision with the current risk profile of BEBs in the country. With a concessional rate of 2% instead of 4.6% the payback could be reduced to 8-10 years which is an improvement but still insufficient.

**Investment Grant**

An upfront grant of 20% on the total initial investment combined with concessional finance is modelled. The upfront grant would be 55,000-60,000 UD per e-bus. In terms of cost per $tCO_2$ avoided this represent an investment of on average 39 USD per $tCO_2$ avoided. The following table shows the impact of an upfront grant combined with a concessional loan.

**Table 22: Impact of 20% Upfront Grant + Concessional Loan Conditions**

| Parameter | overnight charged BEB | fast charged BEB |
|---|---|---|
| TCO financial old | 0.67 | 0.64 |
| TCO financial new | 0.61 | 0.60 |
| FIRR old | 4.6% | 7.2% |
| FIRR new | 11.2% | 15.8% |
| Additional equity old | 342% | 331% |
| Additional equity new | 123% | 100% |
| Discounted Payback in years old | none | none |
| Discounted Payback in years new | year 12 | year 9 |
| Positive differential CF old (year) | year 15 | year 13 |
| Positive differential CF new (year) | positive from year 2 | positive from year 2 |

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO reduces slightly thus making e-buses more competitive to diesel units.
2. The FIRR doubles to rates between 11% and 16% i.e. the investment is now profitable.
3. Owners capital requirements are reduced although still double compared to purchasing diesel units.
4. The risk and the capital exposure of the entrepreneur is reduced. The dynamic payback is with 9-12 years still relatively long.
5. The liquidity situation is massively improved. The cumulative cash outflow is for all years lower with e-buses than with diesel units.

It can be concluded that the grant resolves to a large extent the profitability and risk issue. The payback period is still relatively long and longer than the concession contract. Reducing the concessional interest rate to 2% or increasing the upfront grant to 25% would reduce the payback further.

Chapter 5 will assess the importance of changing other framework conditions and potentially business models to make e-bus investments more viable in Costa Rica.

## 4.3. Financial Analysis E-Taxis

### 4.3.1. General Data

Calculations are realized for the standard taxi as used in Costa Rica based on the most popular taxi model in the country (gasoline Hyundai Accent; based on ARESEP this taxi accounts for 55% of all units). The following tables indicate the general parameters, the gasoline taxi specific values, and the e-taxi specific values.

**Table 23: General Taxi Parameters**

| Parameter | Value | Source |
|---|---|---|
| Distance driven per taxi per annum | 52,000 km | ARESEP |
| Loan tenure | 5 years | BNB,BCR, Banco Popular |
| Loan share | 80% | |
| Interest rate for e-taxis | 7% | |
| Interest rate for gasoline taxis | 8% | |
| WACC e-taxis | 6.9% | See above |
| WACC gasoline taxis | 7.5% | |

**Table 24: Baseline Gasoline Taxi Parameters**

| Parameter | Value | Source |
|---|---|---|
| Gasoline usage | 8.5 l/100km | ARESEP |
| Tyre usage cost | 0.01 USD/km | ARESEP data for tariff calculation |
| Maintenance cost | 0.02 USD/km | ARESEP data for tariff calculation |
| Repair and spare parts costs | 0.13 USD/km | ARESEP data for tariff calculation |
| CAPEX | 13,000 USD | ARESEP |
| Lifespan | 10 years | Concession period; taxis can be used legally for 18 years (previously 15 years)[15] |

**Table 25: E-Taxi Parameters**

| Parameter | Value | Source |
|---|---|---|
| Specific electricity usage | 0.16 kWh/km | Nissan LEAF or BAIC taxi |
| Maintenance plus repair total cost | 0.12 USD/km | 10% higher tyre cost; 70% lower maintenance; 20% lower repair cost |
| Lifespan | 10 years | Max. based on battery age (commensurate with concession period) |
| Lifespan battery @ 70% SOH | 10 years | |
| Home charging share | 70% | Assumption; only re-charge if above-average mileage or night shifts |
| Public fast-charging share | 30% | |
| CAPEX e-taxi | 30,000 USD | Nissan LEAF large battery or BAIC |
| CAPEX home charger 7.4kW | 2,000 USD | Includes wall-box installation |
| Lifetime charger | 10 years | standard value based on ABB |

### 4.3.2. TCO

The following table shows the results of the TCO calculation.

**Table 26: TCO Calculations (USD of 2020)**

| Parameter | Gasoline | e-taxi |
|---|---|---|
| CAPEX taxi | 13,000 | 30,000 |
| CAPEX charging infrastructure | 0 | 2,000 |
| **Total CAPEX** | **13,000** | **32,000** |
| Energy cost | 4,199 | 2,030 |
| Maintenance cost | 8,320 | 6,292 |
| Finance cost average p.a. during loan term | 450 | 963 |
| Economic costs of emissions year 1 | 496 | 5 |
| Lifespan in years | 10 | 10 |
| **TCO financial per km** | **0.27** | **0.23** |
| **TCO economic per km** | **0.28** | **0.23** |

Source: Grutter Consulting

Comparing total costs over the taxi lifetime of 10 years e-taxis have a lower financial and economic TCO than gasoline units.

[15] https://outline.com/xpwjxC https://www.nacion.com/el-pais/servicios/antiguedad-de-taxis-se-eleva-de-15-a-18-anos/VWOLYLQKEJBKHEPYLXMWVCCDK4/story/#:~:text=Foto%3A%20Albert%20Mar%C3%ADn.,decir%20aquellos%20carros%20modelo%202003.

### 4.3.3. Capital and Equity Investment

A comparison is made of the required capital, in term of loans and equity (see following table).

**Table 27: Capital Demand (USD of 2020)**

| Comparison e-taxi to gasoline taxis | Absolute | % |
|---|---|---|
| Additional capital investment | 19,000 | 146% |
| Additional loan requirement | 15,200 | 146% |
| Additional equity requirement | 3,800 | 146% |

Source: Grutter Consulting

E-taxis require a capital investment factor 2.5 times that of a gasoline unit. The required equity increases by the same rate. This can place a serious problem for taxi owners. The investor could opt for purchasing 2-3 gasoline units instead of 1 electric one thus increasing considerably his revenue and profit base.

### 4.3.4. Relative Profitability

The relative profitability assesses the FIRR of the incremental investment for e-taxis (relative to a gasoline unit) based on the operational savings of e-taxis versus gasoline units:

- The FIRR is 24% and clearly above the WACC of 6.9%.
- The EIRR is 30%.

The investment in e-taxis is thus profitable. The FIRR is well above the WACC.

### 4.3.5. Discounted Payback

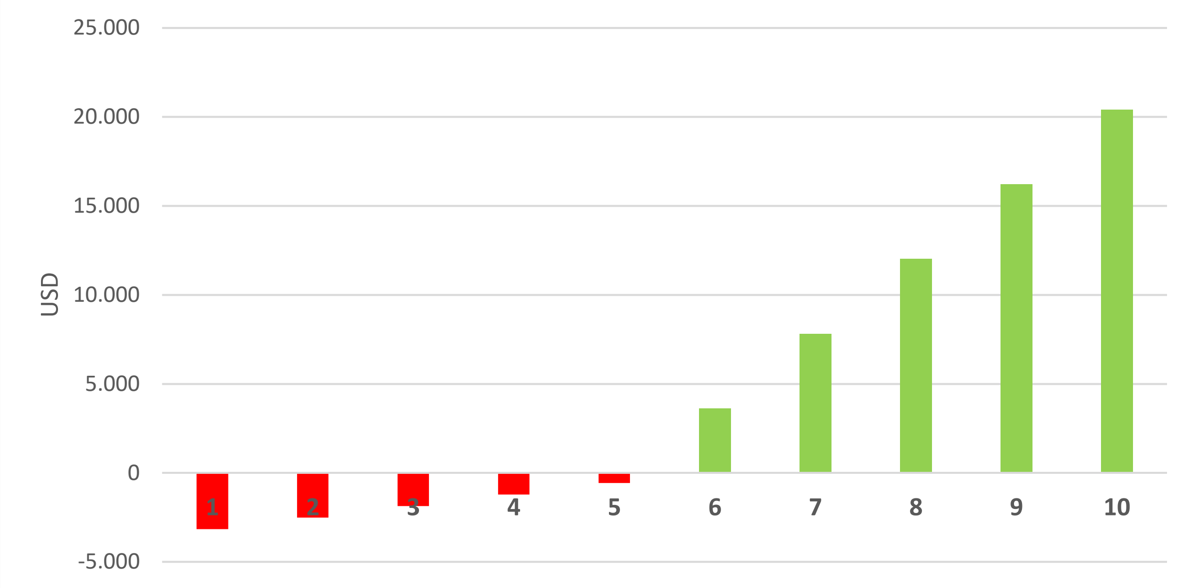
The discounted payback looks at the number of years required to recover the initial incremental investment from savings of e-taxis relative to gasoline units. Annual incremental savings of using an e-taxi versus a gasoline taxi are discounted. The discounted payback gives a good indication of the risk the entrepreneur is facing and how much time his capital is tied up and not available for alternative investments.

The discounted payback shows that the initial incremental investment is recovered in year 7. This indicates that with current financial conditions the investment is risky and has a long payback.

### 4.3.6. Cash Flow

Cash Flow (CF) calculations are important to assess liquidity aspects of an investment. The CF is calculated without discounting based on the owners capital invested. It is based on the differential outflow of cash for CAPEX and OPEX of an e-taxi versus a gasoline unit. Only cash outflows are considered as revenues (cash inflows) are identical between an e-taxi and a gasoline unit. The following graph shows the CF development.

**Figure 9: Cumulative Incremental Cash Flow E-Taxi versus Gasoline Taxi (USD of 2020; non discounted)**




Source: Grutter Consulting; year 1 CAPEX in day 1 and full operations; negative values mean that e-taxis result in increased cash outflow; positive values mean that e-taxis result in increased cash-inflows

The cumulative CF turns positive in the year 6. This means that the taxi owner will have to bear a negative liquidity impact during 5 years as the e-taxi savings due to lower maintenance and energy costs are not sufficient to cover the additional finance outlays and initial equity injection.

### 4.3.7. Summary Financial Assessment

The following table summarizes the financial assessment of e-taxis.

**Table 28: Summary Financial Assessment E-Taxis**

| Criteria | Result | Assessment |
|---|---|---|
| TCO | 15% lower (USD 0.04 per km) for e-taxis | Non-discounted the cumulated lifetime costs for e-taxis are lower than for gasoline units. |
| Capital investment | 2.5x of a conventional taxi | Significantly higher capital requirement incl. higher loan demand |
| Equity investment | 2.5x of a conventional taxi | Significantly higher equity demand which might overstretch the capabilities of taxi owners |
| Profitability | 24% | Investment in e-taxis is profitable. |
| Discounted Payback | Incremental investment is recovered in year 7 with savings | The payback time is long. This indicates a high risk profile of the investment. |
| Cash Flow | Negative cumulative CF until year 6 | The investment in e-taxis will affect the liquidity position of the taxi owner in a negative manner and will affect negatively the solvency ratio and at least for the loan period the working capital ratio. |

Summarized the investment in e-taxis with current financial conditions and business models is profitable but with a considerable risk and higher owner capital requirements. Another major risk is that revenues will be lower when using an e-taxi. The average daily driving range is thereby not the only parameter to consider as peak days have much higher mileage (and much higher income). Taxis are also driven during weekends (Friday to Sunday) or on special days with double shifts or 24 hours as this is the most profitable period. During such days the driving range of the e-taxi will be insufficient without re-charging. Home-charging takes 6-8 hours and is too slow. Also public chargers available are in general too slow (most public chargers available in Costa Rica are 7-14 kW chargers). A fast-charging urban network is required to ensure that e-taxi owners do not lose a significant part of their revenues.

### 4.3.8. Variation of Parameters / Incentive Schemes

The impact on financial parameters of using concessional loans and of upfront investment grants is assessed.

**Concessional Loan**

The following table indicates the parameter used for a concessional loan.

**Table 29: Concessional Loan Parameters**

| Parameter | Current conditions | Concessional conditions |
|---|---|---|
| Loan tenure | 5 years | 8 years |
| Interest rate | 7% | 4.6% |
| Lending rate | 80% of CAPEX | 80% of CAPEX |

The concessional interest rate is based on a 1% rate from the GCF (commissions fees factored into the interest rate) for 30% of the loan and 70% of the investment from FAD/co-financers at 2.5% interest rate plus 2.5% spread of the national banking system (loan amounts are too small for realizing direct loans by AFD/Porparco/CAF.

The concessional loan conditions also result in reducing the WACC and discount factor to 5.5% (from 6.9%). The concessional loan conditions are close to a financial leasing approach. With financial leasing however a down payment of only around 10% is required. The following table compares the financial results with and without a concessional loan.

**Table 30: Impact of Concessional Loan Conditions**

| Parameter | e-taxi |
|---|---|
| TCO financial old | 0.23 |
| TCO financial new | 0.23 |
| FIRR old | 24% |
| FIRR new | 24% |
| Additional equity old | 146% |
| Additional equity new | 146% |
| Discounted Payback in years old | 7 |
| Discounted Payback in years new | 6 |
| positive differential CF old (year) | 6 |
| positive differential CF new (year) | 1 |

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO remains constant.
2. The concessional loan does not change the FIRR (the FIRR is calculated without financial costs). However, it lowers the benchmark value (WACC).
3. Owners capital requirements are not changed.
4. The risk and the capital exposure of the entrepreneur can be slightly reduced.
5. The liquidity situation is massively improved with a positive CF from year 1 onwards.

It can be concluded that the concessional loan helps to resolve the liquidity issues and partially the risk. Together with a fast-charging infrastructure a concessional loan is considered to be a sufficient means to make e-taxis commercially attractive in the country.

**Investment Grant**

An upfront grant of 20% on the total initial investment with standard (i.e. not concessional finance) is modelled. The upfront grant would be around 6,000 USD per e-taxi. In terms of cost per $tCO_2$ avoided this represent an investment of on average 64 USD per $tCO_2$ avoided. The following table shows the impact of an upfront grant.

**Table 31: Impact of 20% Upfront Grant (standard financial conditions)**

| Parameter | e-taxi |
|---|---|
| TCO financial old | 0.23 |
| TCO financial new | 0.22 |
| FIRR old | 24% |
| FIRR new | 49% |
| Additional equity old | 146% |
| Additional equity new | no equity |
| Discounted Payback in years old | 7 |
| Discounted Payback in years new | 7 |
| positive differential CF old (year) | 6 |
| positive differential CF new (year) | 1 |

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO reduces marginally.
2. The FIRR doubles to a very high 49%.
3. Owners capital requirements are 0.
4. The risk and the capital exposure of the entrepreneur is not reduced significantly.
5. The liquidity situation is massively improved with a positive CF from year 1 onwards.

It can be concluded that the grant does not resolve the major problem of risk. Concessional loans are a more appropriate instrument if combined with a public fast charging infrastructure.

## 4.4. Financial Analysis Electric LCVs

### 4.4.1. General Data

Calculations are realized for a standard LCV used for cargo purposes as used in Costa Rica based on data provided by Automercados, a super-market chain which has delivery services. Similar vehicles are e.g. also used by the postal service. The following tables indicate the general parameters, the gasoline LCV specific values, and the e-LCV specific values.

**Table 32: General LCV Parameters**

| Parameter | Value | Source |
|---|---|---|
| Distance driven per taxi per annum | 20,000 km | Automercados |
| Loan tenure | 5 years | BNB,BCR, Banco Popular |
| Loan share | 80% | |
| Interest rate for e-LCVs | 7% | |
| Interest rate for gasoline LCVs | 8% | |
| WACC e-LCVs | 6.9% | See taxis |
| WACC gasoline LCV | 7.5% | |

**Table 33: Baseline Gasoline LCV Parameters**

| Parameter | Value | Source |
|---|---|---|
| Gasoline consumption | 8.5 l/100km | https://www.carsguide.com.au/suzuki/apv; Automercados indicates 9l/100km |
| Maintenance | 0.04 USD/km | Automercados; excludes repairs |
| CAPEX | 25,000 USD | Suzuki APV |
| Lifespan | 15 years | 300,000km lifespan mileage |

**Table 34: E-LCV Parameters**

| Parameter | Value | Source |
|---|---|---|
| Specific electricity usage | 0.15 kWh/km | WLTP for Maxus E-Deliver |
| Maintenance | 0.02 USD/km | 50% of fossil version |
| Lifespan | 15 years | Same as gasoline version; 1x exchange batteries |
| Lifespan battery @ 70% SOC | 10 years | Replacement assumed in year 8 (middle of lifespan) |
| Charging at home average | 90% | In general mileage of less than 50% maximum range and thus limited need for public charging |
| Charging fast-chargers | 10% | |
| CAPEX e-LCV | 31,000 USD | Maxus E-Deliver with 4.8m$^3$ cargo volume; short-wheel base; small battery version[16] |
| CAPEX home charger 7.4kW | 2,000 USD | Wall-box installation |
| Lifetime charger | 10 years | Based on ABB |

### 4.4.2. TCO

The following table shows the results of the TCO calculation.

**Table 35: TCO Calculations (USD of 2020)**

| Parameter | Gasoline | e-LCV |
|---|---|---|
| CAPEX LCV | 25,000 | 31,000 |
| CAPEX charging infrastructure | 0 | 2,000 |
| Replacement battery cost in year 7 | 0 | 3,500 |
| **Total CAPEX** | **25,000** | **33,000** |
| Energy cost | 1,615 | 684 |
| Maintenance cost | 850 | 425 |
| Finance cost average p.a. during loan term | 787 | 1,038 |
| Economic costs of emissions year 1 | 192 | 2 |
| Lifespan in years | 15 | 15 |
| **TCO financial per km** | **0.23** | **0.22** |
| **TCO economic per km** | **0.24** | **0.22** |

Source: Grutter Consulting

Comparing total costs over the LCV lifetime of 15 years e-LCVs have comparable financial and economic TCOs as gasoline units.

### 4.4.3. Capital and Equity Investment

A comparison is made of the required capital total, in term of loans and as equity (see following table).

[16] https://saicmaxus.co.uk/edeliver3/

**Table 36: Capital Demand (USD of 2020)**

| Comparison e-LCV to gasoline LCV | Absolute | % |
|---|---|---|
| Additional capital investment | 8,000 | 32% |
| Additional loan | 6,400 | 32% |
| Additional equity | 1,600 | 32% |

Source: Grutter Consulting

E-LCVs require a 30% higher capital investment than gasoline units. The required equity increases by the same rate. This is not considered to be a serious problem for companies owning LCVs.

### 4.4.4. Relative Profitability

The relative profitability assesses the FIRR of the incremental investment for e-LCVs (relative to a gasoline unit) based on the operational savings of e-LCVs versus gasoline units:

- The FIRR is 12% and clearly above the WACC of 6.9%.
- The EIRR is 17%.

The investment in e-LCVs is thus profitable. The FIRR is well above the WACC.

### 4.4.5. Discounted Payback

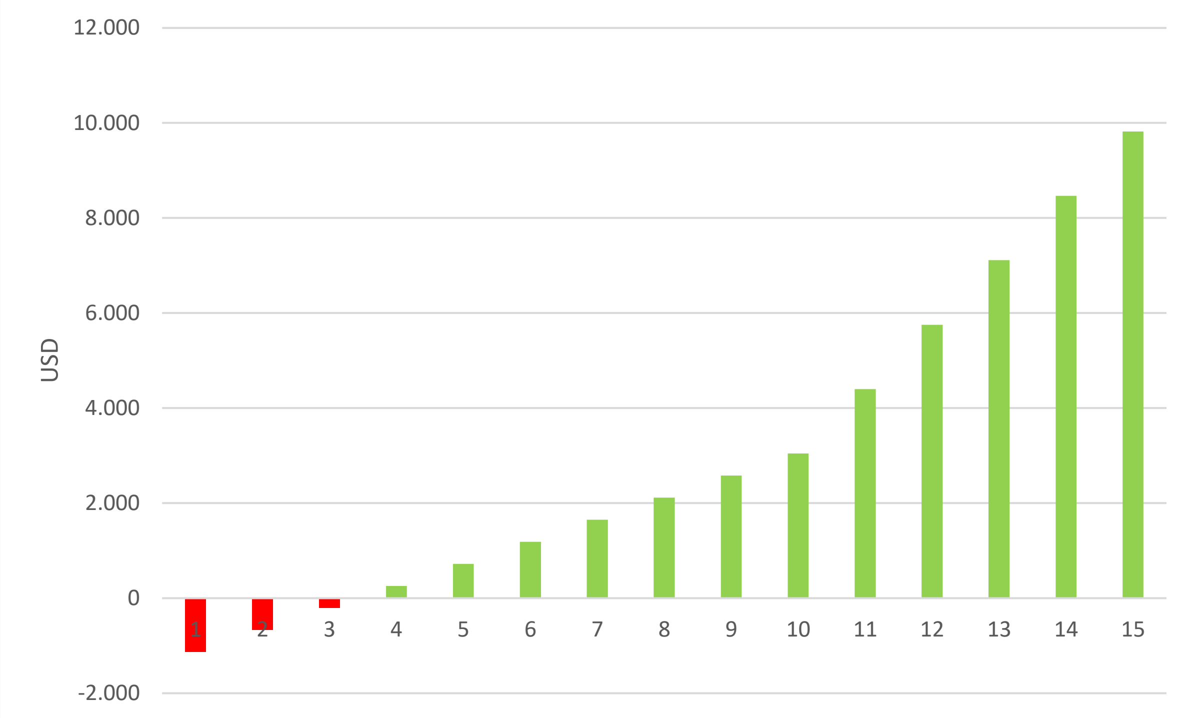
The discounted payback looks at the number of years required to recover the initial incremental investment from savings of e-LCVs relative to gasoline units. Annual incremental savings of using an e-LCV versus a gasoline LCV are discounted. The discounted payback gives a good indication of the risk the entrepreneur is facing and how much time his capital is tied up and not available for alternative investments.

The discounted payback shows that the initial incremental investment is only recovered in year 11. This indicates that with current financial conditions the investment is of high risky with a very long payback period (this is largely due to the low annual mileage).

### 4.4.6. Cash Flow

Cash Flow (CF) calculations are important to assess liquidity aspects of an investment. The CF is calculated without discounting based on the owners capital invested. It is based on the differential outflow of cash for CAPEX and OPEX of an e-LCV versus a gasoline unit. Only cash outflows are considered as revenues (cash inflows) are identical between an e-LCV and a gasoline unit. The following graph shows the CF development.

**Figure 10: Cumulative Incremental Cash Flow e-LCV versus Gasoline LCV (USD of 2020; non discounted)**




Source: Grutter Consulting; year 1 CAPEX in day 1 and full operations; negative values mean that e-LCVs result in increased cash outflow; positive values mean that e-LCVs result in increased cash-inflows

The cumulative CF is positive from year 4 onwards (the loan period is longer than for e-taxis thus facilitating a positive CF). This means that the company will have a positive liquidity impact from year 4 onwards due to savings on maintenance and energy sufficient to cover the additional finance outlays and initial equity injection.

### 4.4.7. Summary Financial Assessment

The following table summarizes the financial assessment of e-LCVs.

**Table 37: Summary Financial Assessment e-LCVs**

| Criteria | Result | Assessment |
|---|---|---|
| TCO | 8% lower (USD 0.01 per km) for e-LCVs | Non-discounted the cumulated lifetime costs for e-LCVs is marginally lower than for gasoline units |
| Capital investment | 30% higher than a conventional LCV | Slightly higher capital requirement incl. higher loan demand |
| Equity investment | 30% higher than a conventional LCV | Slightly higher equity demand |
| Profitability | 12% | Investment in e-LCVs is profitable |
| Discounted Payback | Incremental investment is recovered in year 11 with savings | The payback time is very long. This indicates a high risk profile of the investment. |
| Cash Flow | Positive from year 4 | The investment in e-LCVs has no large negative liquidity impact in initial years |

Summarized the investment in e-LCVs with current financial conditions and business models is profitable but with a high risk and a very long payback time. Also electric LCVs are not common in the market and are not offered by vehicle suppliers in Costa Rica.

### 4.4.8. Variation of Parameters / Incentive Schemes

The impact on financial parameters of using concessional loans and of upfront investment grants is assessed.

**Concessional Loan**

The following table indicates the parameter used for a concessional loan.

**Table 38: Concessional Loan Parameters**

| Parameter | Current conditions | Concessional conditions |
|---|---|---|
| Loan tenure | 10 years | 10 years |
| Interest rate | 7% | 4.6% |
| Lending rate | 80% of CAPEX | 80% of CAPEX |

The concessional interest rate is based on a 1% rate from the GCF (commissions fees factored into the interest rate) for 30% of the loan and 70% of the investment from FAD/co-financers at 2.5% interest rate plus 2.5% spread of the national banking system (loan amounts are too small for realizing direct loans by AFD/Porparco/CAF.

The concessional loan conditions also result in reducing the WACC and discount factor to 4.4% (from 6.9%). The concessional loan conditions are close to a financial leasing approach except that with leasing a down payment of only 10% is in general required. The following table compares the financial results with and without a concessional loan.

**Table 39: Impact of Concessional Loan Conditions**

| Parameter | e-LCV |
|---|---|
| TCO financial old | 0.22 |
| TCO financial new | 0.20 |
| FIRR old | 12% |
| FIRR new | 12% |
| Additional equity old | 32% |
| Additional equity new | 32% |
| Discounted Payback in years old | 11 |
| Discounted Payback in years new | 6 |
| positive differential CF old (year) | 4 |
| positive differential CF new (year) | 1 |

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO, the FIRR and  the additional equity demand remain constant.
2. The risk and the capital exposure of the entrepreneur can be reduced.
3. The liquidity situation is improved with a positive CF from year 1 onwards.

It can be concluded that the concessional loan helps to resolve the payback period cum investment risk and liquidity issues.

**Investment Grant**

An upfront grant of 20% on the total initial investment with standard (i.e. not concessional finance) is modelled. The upfront grant would be around 7,000 USD per e-LCV. In terms of cost per $tCO_2$ avoided this represent an investment of on average 97 USD per $tCO_2$ avoided. The following table shows the impact of an upfront grant.

**Table 40: Impact of 20% Upfront Grant (standard financial conditions)**

| Parameter | e-LCV |
|---|---|
| TCO financial old | 0.22 |
| TCO financial new | 0.19 |
| FIRR old | 12% |
| FIRR new | >100% |
| Additional equity old | 32% |
| Additional equity new | no equity |
| Discounted Payback in years old | 11 |
| Discounted Payback in years new | 11 |
| positive differential CF old (year) | 4 |
| positive differential CF new (year) | 1 |

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO reduces by 10 percentage points.
2. The FIRR increases greatly to over 100%
3. Owners capital requirements are 0.
4. The risk and the capital exposure of the entrepreneur is not reduced significantly.
5. The liquidity situation is massively improved with a positive CF from year 1 onwards.

It can be concluded that the grant does not resolve the major problem of risk. Concessional loans are a more appropriate instrument if combined with technical assistance to show the benefits of electric LCVs and with the establishment of a public fast charging infrastructure.

# 5. Possible Business Models and Investment Projects

## 5.1. Urban Buses

### 5.1.1. Barriers and Interventions Options

The following table summarizes main barriers towards massive e-bus deployment in Costa Rica. The barrier source gives an indication of what type of changes are required from an institutional perspective and the barrier elements which concrete aspects need to be altered.

**Table 41: Barriers towards e-Bus Deployment in Costa Rica**

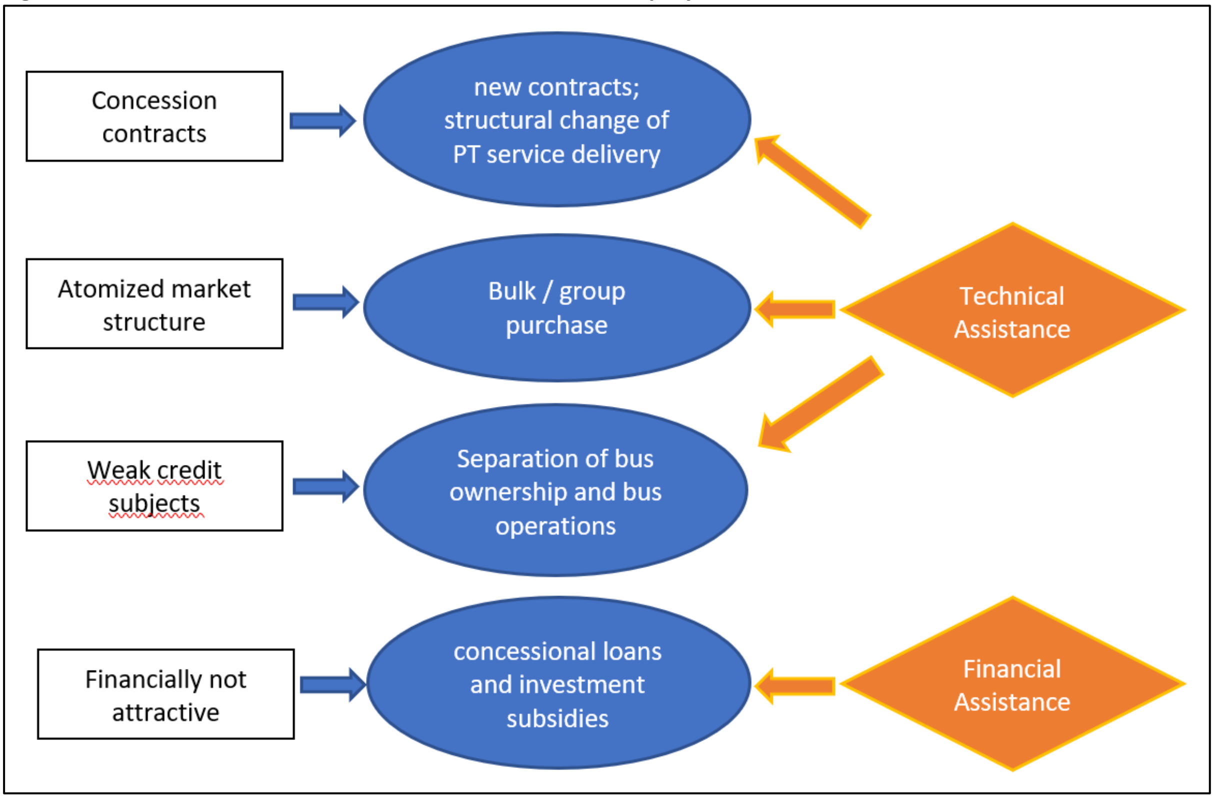
| Barrier Type | Concrete Aspects |
|---|---|
| Concession contracts | 7 year concession contracts limit the loan tenure which is for e-buses very short compared with their lifespan of 16 years. Concession contracts also do not offer to creditors guarantees that assets are kept and operated by another transport operator in case of default or loss of concession. Payments are fixed per route and go directly to the operator i.e. the creditor has no guaranteed direct payment from the fare box. |
| Atomized market structure of bus operators | Many small and some medium-sized operators exist in Costa Rica. Bus renewal, even for the largest operators is thus at very small numbers i.e. 10-20 units. |
| Financially weak operators | Operators have a fragile balance sheet. To access loans they need to provide real guarantees beyond vehicles. As they only take relatively small loans and are considered a high risk, the resultant interest rate is high and loaning levels are low. |
| Financial barriers | BEBs are not profitable. The FIRR is below the WACC and the repayment period for the incremental investment in electric buses is more than 7 years. The investor needs to invest up to 4x the owners capital required for fossil buses, |

| | |
|---|---|
| | increases significantly his debt levels and suffers from a negative cash flow for the initial 10 years with the current market offer for e-buses prevalent in Costa Rica. To reduce operational costs operators also do not insure vehicles against collision damage and full loss. This again makes it impossible to accept vehicles as loan guarantee to banks. |

Source: Grutter Consulting

E-buses have major environmental and societal advantages expressed in large positive environmental and health impacts. Whilst the TCO of e-buses is slightly lower than of diesel units, the capital exposure, risks and lack of profitability make it an non-attractive investment. This combined with market conditions (atomized bus ownership) and a political/contractual framework which hampers e-bus deployment result in e-buses not being deployed. The following figure shows intervention instruments which can overcome these barriers.

**Figure 11: Intervention Instruments to Overcome E-Bus Deployment Barriers**




Source: Grutter Consulting

**Concession contracts** can be updated and changed to incorporate longer periods (e.g. 10 years extendable by 6 years) and with asset turn-over in case of default or concession loss. In the medium term a structural change to the system how public transport is delivered will be required to increase system efficiency and convenience for the customer. This will imply a change of ownership structure and potentially of service delivery structures. However, at first instance the major barrier is to increase the length of concession contracts.

The **atomized market structure** results in very small amounts of buses being purchased. This results in high purchase and maintenance/repair costs and potentially sub-optimal technology solutions. Also, operators lack the know-how on e-bus technologies and are thus dependant on claims of suppliers. Bulk purchase would resolve these problems. This can be based on different organizational models:

- Group purchase based on (ad-hoc) associations;

- Bulk purchase of buses through leading enterprises which thereafter sell buses to smaller companies. This model is favoured by some larger bus operators in Costa Rica, which are also linked up with suppliers. However, it has disadvantages as smaller companies might feel that they are being pushed out of the market by depending on larger operators and financing of such fleets is complex as assets are given along to 3rd parties and operators might not have sufficient solvency for such operations;
- Purchase of buses through a 3rd party and delivery for operations either credit- or leasing-based by operators. This model was extensively discussed with ICE since 2018 and matches the model as established in Chile. However, to the moment ICE has not expressed interest in participating in such a venture.

Technical assistance can be useful to further develop appropriate bulk-purchase business models and link them with concessional financial instruments.

The **weak credit subjects** will result in a problem of accessing loans and having favourable loan conditions. A separation of bus ownership and bus operations, as has been done successfully e.g. in Santiago de Chile or Bogota can bring in other and financially stronger players which can provide the required owners capital and which can access finance at more favourable conditions. This could also be done with the municipality or government purchasing buses and then leasing or renting them to operators as is done e.g. in various cities of Pakistan or in Medellin. To overcome the problem of guarantees and costly financial conditions a separation of ownership and operations is an important condition, especially in market conditions such as Costa Rica with many individual small and weak operators. Technical assistance can help to overcome these barriers and structure financially more viable solutions. To rely on financial assistance alone would be inefficient as this would require far more support resources and would maintain a non-efficient public transport system.

**Concessional loans and investment subsidies** are critical to de-risk the investment and to create an attractive financial framework. This includes longer loan tenures, concessional interest rates, higher lending rates, payment guarantees and upfront investment subsidies worth around 20% of the total CAPEX which allows a 3rd party or a bus operator to invest in e-buses whilst receiving an adequate return on investment, an acceptable payback period, limits his equity and capital investment and financial exposure to a comparable rate  as for fossil buses and allows for a positive cash-flow.

### 5.1.2. Potential Investment Project

A medium-term (by 2023) potential investment project is the purchase of 100 buses for various bus operators. Some 100-200 buses need to be replaced annually by bus operators pre-defined by ARESEP as appropriate for using e-buses (see chapter 4.2. and figure 2 (Grutter Consulting, 2020)). The following table summarizes core characteristics of such a potential investment project.

**Table 42: Potential E-Bus Investment Project**

| Item | Description |
|---|---|
| Project contents | 100 urban 12m standard e-buses[17] |
| Project owner | Not yet defined; for bulk purchase either association/lead operator or 3rd party or municipality as bus owner |
| Total investment | 28 MUSD of which 23 MUSD buses, 1 MUSD charging infrastructure, 3 MUSD grid connection and 1 MUSD bus depot upgrades |
| Loan components | 17.6 MUSD loan for 80% of the net total CAPEX (total CAPEX minus subsidy) @ 4.6% interest rate for 12 years |

[17] Calculations based on fast-charged buses

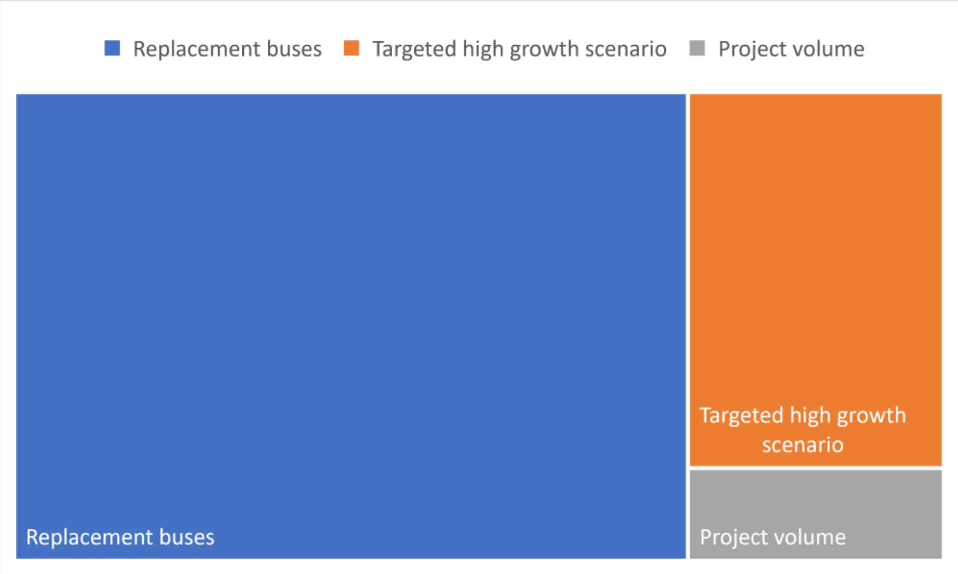
| | |
|---|---|
| Subsidy | 5.5 MUSD (20% of total CAPEX) |
| Financial indicators | FIRR of 16%; initial incremental investment is recovered in year 13; lower cash outflow from year 2 than diesel bus alternative |
| Environmental impact (cumulative lifespan units) | Reduction of 151,000 $tCO_{2e}$, 4.4 tons $PM_{2.5}$ and 520 tons of $NO_x$ worth 7 MUSD economically |
| Cost of subsidy per $tCO_2$ | 37 USD/$tCO_{2e}$ |

Source: Grutter Consulting

### 5.1.3. From Market Potential to Market Volume

The following graph shows the stages from market potential to expected project volume by 2025.

**Figure 12: Market Potential to Project Volume Urban Buses (period 2022-2025)**




Source: Grutter Consulting

Between 2022 and 2025 some 1,300 urban buses need to be replaced in Costa Rica. The high growth scenario would require around 400 of these to be electric (30% of total volume). The project under the Fund would purchase 100 electric buses or 8% of the total market volume. This is considered to be achievable from a market share perspective.

The proposed project might seem small from the market potential. However, it would be an important intervention to kick start the process it will require substantial efforts as well as adequate intervention instruments from the technical and financial area to overcome the current market barriers. Under a Business as Usual Development (BAU) these barriers ill not be resolved and no fleets of e-buses will operate in Costa Rica as the market conditions are not conducive towards adoption of e-buses.

The following technical assistance activities are deemed important to create favourable market conditions for mass deployment of e-buses:

- Structuring of appropriate concession contracts and concession conditions conducive to e-bus deployment incl. concession length, tariff structuring, concession contracts, guarantees etc.
- Structuring of public transport models which result in stronger and fewer operators e.g. in direction of separation of bus ownership and bus operations.
- Structuring of favourable enabling conditions to foster the entry of financially strong players into the public transport business e.g. as bus owners. This could be private companies or a

municipal special purpose vehicle, a public private partnership or municipal/government led purchase of buses. Multiple models are available which need to be assessed to resolve the problem of an atomized bus ownership structure with weak credit subjects.
- Assessment of optimal e-bus technology and charging systems to enable a robust and cost-effective e-bus deployment.
- Structuring of bus tenders and bus contracts in accordance with the special requirements of e-buses.
- Roadmap for e-bus deployment which includes concrete steps and goes beyond just establishing targets.

The following financial intervention instruments are proposed for e-bus deployment in Costa Rica:

- Grant facility covering up to 20% of the initial total CAPEX (bus, charging infrastructure, grid connection and bus depot upgrade);
- Concessional loans from the GCF @ 0.75% which are blended with AFD and co-finance, a long tenure (12 years or longer), a high loan share (80% of total investment) and the ability to take vehicles as loan guarantee[18]. Together with the entrance of financially stronger players this should be capable to cut interest rates by 1/3rd.

Market conditions are not yet given in Costa Rica for a mass deployment of e-buses. Next to this the pandemic has hit public transport operators hard. However, latter is also an opportunity to re-structure and consolidate the sector. Thus it is foreseen that initially TA will dominate and investment projects are not foreseen prior 2023/2024. Private investors such as Avolta Energy in Costa Rica have mentioned their interest in entering the market with equity capital to act as leasing company for buses under adequate market conditions.

## 5.2. Taxis

### 5.2.1. Barriers and Intervention Options

The deployment of e-taxis faces two technology related barriers and one generic barrier to the sector:

- Investments in e-taxis are financially risky. Whilst the profitability is fine, the payback period is long and taxi drivers need more than double of owners capital compared to a fossil unit.
- Lack of urban fast-charging network catering to the needs of taxi drivers. This makes the deployment of electric units a potential financial risk as drivers could loose considerable potential income and profit due to range limitations of e-taxis and lack of public fast-charging facilities.
- Serious financial problems of the sector: official taxis struggle under intense competition from ride-hailing services and latter are subject to legal intervention. The taxi sector is considered to be over-indebted and many loans have gone sour in this area. Not surprisingly bank managers ask for blanket guarantees which is an indicator that the sector is not creditworthy. Uber or related services lack a proper legal framework and operations are potentially financially not feasible if all costs are paid (e.g. appropriate vehicle and passenger insurance, tax and licence payments). It is expected that the market will undergo serious re-structuring.

[18] This will require vehicles to be insured against loss.

Investing in this area in the next few years thus entails a potential default risk which would need to be well managed.

To overcome the technical issues technical assistance is required to taxi operators as well as the government to prevent repeating the mistakes of other cities. Drivers need to be aware of range limitations and of charging speed of batteries and chargers. Average daily distances driven are thereby potentially a misleading figure as high-demand days like e.g. Friday/Saturday require longer ranges with less available charging time whilst constituting an important part of revenues and profits. Technical assistance is required to design an appropriate fast-charging infrastructure catering to the demands of taxis and ride-hailing vehicles. Cities like Amsterdam or London which have a clear e-taxi strategy fostering e-taxis whilst also establishing taxi-exclusive or taxi-preferential charging systems, show that the charging network needs not be established fully from the start. A minimum structure is however required with chargers located at strategic points where taxis often wait whilst also being distributed sufficiently over the urban area to avoid additional distances driven just for charging.

Financial assistance is required for the areas of concessional loans to taxis (vehicle subsidies are not deemed to be necessary). Basically loan conditions need to be softened in terms of more concessional interest rates and, potentially, an increase in loan tenure. Financial assistance in terms of a concessional loan plus grants is required for the establishment of a fast-charging network for taxis. Such a network will not be financially attractive and is not demanded by law. Thus no party will establish such a network. Once available and once a sufficiently large electric taxi fleet plus other EVs is available the network can be run potentially profitable but initial investments in charging systems will be required.

However, TA as well as FA will only make sense once the market conditions make investments financially sound i.e. a market re-structuring including legal clarity on ride-hailing services as well as potentially debt re-structuring of current taxi operators will be required.

### 5.2.2. Potential Investment Project

A longer-term (by 2025) potential investment project is the purchase of 200 electric taxis including the appropriate fast-charging network.

**Table 43: Potential E-Taxi Investment Project**

| Item | Description |
|---|---|
| Project contents | 200 e-taxis combined with a fast-charging network of 20 150 kW chargers in the GAM |
| Project owner | Charging network by electric utilities depending on location; taxis by individual taxi owners; national banks for loans to taxi operators |
| Financial mechanism | For taxis concessional loan through banks already involved in EV loans (e.g. subordinate concessional loan given to banks for on-lending); charging network concessional loan for installation costs; grant for equipment; municipality gives space / land free of charge |
| Total investment | 7.9 MUSD of which 6.4 MUSD taxis and 1.5 MUSD charging infrastructure including grid connection |
| Loan components | 5.1 MUSD loan for 80% of the total CAPEX e-taxis and 0.8 MUSD for 50% of the investment cost of chargers (equivalent to the installation costs) @ 4.6% interest rate for 8 years |
| Subsidy | 0.8 MUSD equivalent to 50% of total investment in fast-charging infrastructure |
| Financial indicators | FIRR of 17% (entire project i.e. taxis plus chargers); initial incremental investment is recovered in year 8 |

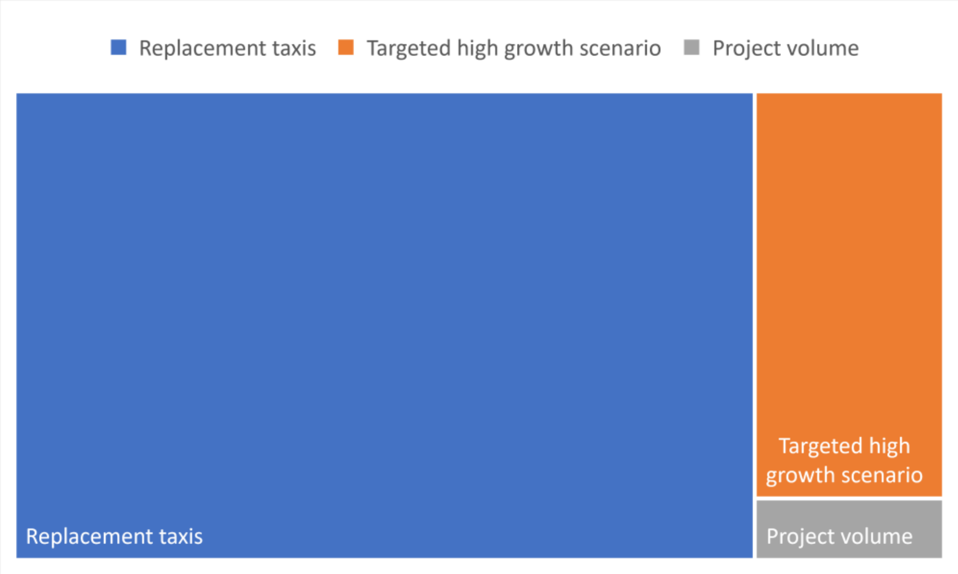
| | |
|---|---|
| Environmental impact (cumulative lifespan units) | Reduction of 24,000 $tCO_{2e}$, 0.2 tons $PM_{2.5}$ and 6 tons of $NO_x$ worth 1 MUSD economically |
| Cost of subsidy per $tCO_2$ | 31 USD/$tCO_{2e}$ |

Source: Grutter Consulting

### 5.2.3. From Market Potential to Market Volume

The following graph shows the stages from market potential to expected project volume by 2025.

**Figure 13: Market Potential to Project Volume Taxis (period 2022-2025)**




Source: Grutter Consulting

Between 2022 and 2025 some 6,000 taxis need to be purchased in Costa Rica. The high growth scenario would require around 1,300 of these to be electric (22% of total volume). The project under the Fund would purchase 200 electric taxis or 3% of the total market volume. This is considered to be achievable from a market share perspective.

The proposed project might seem small from the market potential. However, it would be an important intervention to kick start the process it will require substantial efforts as well as adequate intervention instruments from the technical and financial area to overcome the current market barriers. Under a Business as Usual Development (BAU) these barriers ill not be resolved and no fleets of e-taxis will operate in Costa Rica as the market conditions are not conducive towards adoption of e-taxis. Also, the project would allow to establish an initial fast-charging infrastructure for taxis critical for their deployment.

The following technical assistance activities are deemed important to create favourable market conditions for mass deployment of e-taxis:

- Assessment of optimal e-taxi technology and design of fast-charging infrastructure (for government for structuring whist investment vehicles are for charging infrastructure electric utilities and for vehicles leasing funds, investment funds or FIs).
- Roadmap for e-taxi deployment including public incentives for change towards electric units (for government).
- Assistance in developing a market structure with clear rules and regulations for ride-hailing services (for government).

The following financial intervention instruments are proposed for e-taxi deployment in Costa Rica:

- Grant facility covering up to 50% of the fast-charging infrastructure capital expenditure;
- Concessional loans with a long tenure (8 years or longer), a GCF concessional loan part with a GCF interest rate of 0.75%,and the ability to take vehicles as loan guarantee[19].

The current financial situation of the taxi sector is not apt for investments. A market and debt clearance will have to take place prior being able to invest with reasonable risk again into this sector. An investment project is thus not foreseen prior 2024/2025.

## 5.3. LCVs

### 5.3.1. Barriers and Intervention Options

The deployment of e-LCVs faces two major barriers:

- Investments in e-LCVs are financially risky. Whilst the profitability is fine, the payback period is long and the performance of units is unknown.
- Lack of an urban fast-charging network in case of necessity. The same fast-charging network could be potentially used by taxis, cars as well as LCVs.
- Lack of information and know-how of options and possibilities of e-mobility in this area. Companies are interested in EVs but do not have access to information on available models. Vehicle importers are not actively engaging in the business as they have higher profits selling fossil vehicles and their spare parts. In the urban cargo area also vehicles and customer demands vary widely.
- Ownership structures are often a barrier as vehicles are owned by individual drivers and not by the logistics companies or by the cargo company.

Currently companies are basically interested in pilots to test equipment and operations. Technical assistance would be basic at this point of time. This could be complemented by using the same concession loan instrument through banks as for taxis[20]. However, a demand for electric LCVs is not envisaged in the short term but rather in 3-5 years.

### 5.3.2. Potential Mid-Term Investment Project

A preliminary potential investment project for e-LCVs is described in the following table.

**Table 44: Potential E-LCV Investment Project**

| Item | Description |
|---|---|
| Project contents | 200 e-LCVs |
| Project owner | Logistics and distribution companies |
| Financial mechanism | Concessional loan through banks already involved in EV loans (e.g. subordinate concessional loan given to the three banks for on-lending) |
| Total investment | 6.6 MUSD excluding charging infrastructure |
| Loan components | 5.3 MUSD loan for 80% of the total CAPEX e-LCVs @ 4.6% interest rate for 10 yrs |
| Subsidy | None (potentially with charging network) |
| Financial indicators | FIRR of 0%; initial incremental investment is recovered in 7 years |

[19] This will require vehicles to be insured against loss.

[20] At first instance the national banks which are currently engaged in financing EVs (BN, the Banco Popular and the BCR) could be targeted.

| | |
|---|---|
| Environmental impact (cumulative lifespan units) | Reduction of 14,000 $tCO_{2e}$ and 4 tons of $NO_x$ worth 0.6 MUSD economically |

Source: Grutter Consulting

The following technical assistance activities are deemed important to create favourable market conditions for mass deployment of e-LCVs:

- Advisory service to interested companies in vehicle and technology available.
- Roadmap for e-LCV deployment including public incentives for switching towards electric units for public entity.
- Design of shared public fast-charging infrastructure for public entity.

The following financial intervention instruments are proposed for e-LCV deployment in Costa Rica:

- Grant facility covering up to 50% of the fast-charging infrastructure capital expenditure;
- Concessional loans with a long tenure (10 years), a GCF concessional loan for a part of the investment at 0.75% interest rate, and the ability to take vehicles as loan guarantee[21].

An investment project is foreseen in the medium to longer period 2024-2026 as electric LCVs are for companies still very much in the pilot stage currently with also very limited market offer.

# 6. TA intervention Areas and Instruments

## 6.1. TA Actors in E-Mobility

Various actors are engaged currently in electric mobility in Costa Rica. The coordination between each of these parts is crucial in order to not duplicate efforts.

**German Cooperation Agency GIZ**

Through the project MiTransporte, financed by the German Ministry of Environment, GIZ has been working together with the Costa-Rican government, as well as with private actors, to implement measures that reduce $CO_2$ Emissions in the country. Project advisory services are realized to the Costa Rican Government on (i) developing the necessary policies and regulations to improve public and private transport and freight transport services; (ii) the municipalities and local authorities on taking measures for improving public transport in the San José metropolitan area; (iii) on the electrification of local public transport; and (iv) on actively involving the public in the transition process and communicating Costa Rica's experiences at national, regional and international levels."[22]

The donation of three electric 12 m buses by the German Government in 2017, implied major logistic and administrative efforts which were coordinated by this project specifically. Currently, the three acquired BYD Buses are waiting to be deployed at an ICE deposit. They will operate on three commercial routes for a year. For this project several actors needed to be coordinated and the committee for the electrification of the public transport was consolidated. During the last year, several issues have been discussed in this space such as exploring different business models for public transport operators.

The MiTransporte project will end early 2022. In the remaining time, it will monitor the performance of the purchased e-buses. The project director has stated, that further TA is necessary in several areas

[21] This will require vehicles to be insured against loss.

[22] https://www.giz.de/en/worldwide/62687.html

such as insurances, training of firefighters, regulation of batteries in the second life and recycling, alternative business models for TP operators among others.

**UN Environment**

UN Environment has been implementing a series of regional projects that focus on capacity development in e-mobility. Through their platform "Move", funded by the European Union, they have imparted several webinars on various topics, as well as exchanges between different countries. This initiative also gives a yearly overview about recent developments regarding e-mobility in every country in Latin America. [23]

In Costa Rica, this cooperation partner has also been actively involved in the deployment of the e-bus pilot project, providing several webinars, workshops and conferences about the successful implementation of the transition to e-buses.

Currently UN Environment is implementing the GCF Readiness Program "advancing a regional approach to e-mobility in Latin America" in thirteen countries in the region including Costa Rica. The program focuses on enabling strategies and policies to scale up electric mobility and also submitting concept notes to different facilities like the GCF or the GEF in order to implement e-mobility projects. In this context a pilot project for electric taxis to the airport has been submitted to the GEF. Since the GEF cannot actually buy vehicles, the program would rent electric vehicles from a selected partnering car rental agency. Further, the project would keep on working on strengthening policies and building capacities for different actors.

The GCF Readiness Project is regional. It started in July 2020 and will end Mid 2022. Counterparts and specific deliverables for each country are defined on the go. The Logical Framework applies to all thirteen countries and consists of three main outcomes: (i) The first outcome focuses on information acquisition and exchange. This information shall be used to promote a regional online knowledge-sharing community. This first outcome concludes with technical experience exchange, promoting South-South cooperation; (ii) The second outcome centers on enabling policy and business models for the e-mobility scaleup. First the appropriate legal frameworks must be identified and if needed improved. This is followed by public and private development of business models with the help of regional consultation workshops and the establishment of an e-mobility task group. The result shall be a process for periodic reviews and progress updating of the readiness project; (iii) The third outcome aims to define the climate finance strategy, as well as the regional pipeline. This is achieved by developing regional consistent pipelines for the investments for e-mobility. The acquired information from the past outcomes shall be implemented. These concept notes are to be submitted to the GCF. For the two countries without a national electric mobility plan, one shall be developed.

**CRUSA Foundation**

The CRUSA Foundation actively supports the adoption of environmentally friendly public transport models by aiding the design of public policies, legal mechanisms and financial instruments. Currently they work together with GIZ and UN Environment on the implementation of the pilot e-bus project.

**InterAmerican Development Bank (IDB)**

IDB has been a strategic ally in the transition towards e-mobility. They financed ICEs 100 Hyundai Ioniq, and the fast-charging network being established by ICE. The Bank has also contracted some

[23] https://movelatam.org/

studies on business models for e-buses, and tariffs for charging among other. IDB is willing to grant technical assistance in 2021 for the MOPT, in order to achieve changes to concession contracts.

**Central American Bank for Economic Integration (BCIE)**

BCIE intends to support the Costa Rican government with technical assistance. The regional program for electric mobility (PRELEC), was meant to start this year. However, it has been undergoing some changes in order to make it more comprehensive and to include more countries. The program is on sustainable urban mobility and is currently in process of selecting a consulting firm to develop sustainable mobility plans in Central America.

**Others**

Other countries have directly supported Costa Rica in its goal to decarbonize the economy though the electrification of the transport sector. The Japan Cooperation Agency (JAICA) for example, donated some twenty Japanese electric cars to different ministries and public institutions. The Korean Government donated three electric chargers to ICE in 2016.

## 6.2. Possible TA Interventions within the E-Motion Program

Possible TA interventions include the area of policies, business models and concrete specialized TA. The major coordination would need to be with UN Environment. Latter is probably best posed to cover the area of TA for taxis as it will presumably implement an e-taxi project. In other areas GIZ could, due to its experience in the sector, take the lead and coordinate with the other involved institutions. Following areas are basically previewed for further TA:

- Policy advice including the establishment of concrete sub-sector specific roadmaps on electrification of urban public transport buses, electrification of LCVs and public charging infrastructure.
- Advice on business models and sector re-structuring basically for the bus sector including new business models separating bus ownership and bus operations, integration of other players with stronger financial background in tot eh public bus sector, and adaptation of bus concession contracts and bus tariff structures.
- Information and knowledge dissemination as well as advisory services to companies and public entities interested in investing in LCVs. This includes potentially the support for initial pilot projects.
- On-going TA on specific conditions to improve the enabling conditions for e-mobility deployment such as capacity building for insurance companies and firefighters allowing insurance companies to better assess the risk and costs of insuring an electric vehicle and by training specialized fire fighters and vehicle maintenance personnel (mechanics and depot managers) on how to cope with the particular hazards of EVs.
- Battery management (“second life” and disposal) policies and regulations.

# Annex

**E-Bus Data**

| Parameter | Value | Unit | Source |
|---|---|---|---|
| Distance driven per bus per annum | 60,000 | km | ARESEP |
| Workday distance driven daily | 201 | km | calculated based on 330 days and working days higher mileage |
| Specific electicity usage | 1 | kWh/km | Chinese average; ADB, 2018; includes AC |
| Diesel usage | 47 | l/100km | Aresep |
| Tyre usage diesel bus | 0.04 | USD/km | ARESEP data for tariff calculation |
| Maintenance engine and staff diesel bus | 0.07 | USD/km | ARESEP data for tariff calculation (55% liquids and materials and 45% staff) |
| Repair and spare parts diesel bus | 0.12 | USD/km | ARESEP data for tariff calculation |
| Tyre usage e-bus | 0.04 | USD/km | 10% more based on data China; ADB 2018 assuming slightly higher bus weight and regenerative braking |
| Maintenance engine and e-bus | 0.02 | USD/km | 75% reduction (90% reduction materials, 50% less staff cost (less staff but more qualified)) |
| Repair and spare parts e-bus | 0.10 | USD/km | 20% less (Less engine repairs but slightly more expensive spare parts; other repairs the same) |
| Lifespan bus diesel | 15 | years | standard Costa Rica |
| Lifespan bus electric | 16 | years | max based on battery age; can be 20% more than diesel |
| Lifespan battery @ 80% SOC | 8 | years | current guarantee levels |

**Financial defaults**

| Parameter | Value | Unit | Source |
|---|---|---|---|
| CAPEX diesel bus | 110,000 | USD | bus operators; Euro 4 coach style bus |
| CAPEX overnight charged e-bus | 262,000 | USD | based on coach bus offer Gold Dragon FOB*1.2 to get CIF plus 10k for lift |
| CAPEX slow-charged batteries | 200 | USD/kWh | LFP batteries |
| CAPEX fast-charged BEB | 226,000 | USD | Based on fast-charged bus coach bus style offers from Yutong, Foton, GD; FOB China *1.2 for CIF plus 10k for lift |
| CAPEX batteries fast-charged | 250 | USD/kWh | NMC batteries |
| Reduction battery cost in 8 years | 50% | | US DOE projections, 2017 have a decrease of 12% per annum; applied to 5 years; https://energy.gov/sites/prod/files/2017/02/f34/67089%20EERE%20LIB%20cost%20vs%20price%20metrics%20r |
| CAPEX charger excl. Installation per kW | 120 | USD/kW | Standard chinese chargers, 2 nozzles |
| CAPEX charger installations civil works | 2,500 | USD/bus | Civil works for chargers; 2 buses per charger; 5,000 USD per unit |
| Cost per bus depot upgrade | 7,500 | USD/bus | Coverage of bus and chargers with roof, no paving, includes labour (20m2 per bus, 250 USD/m2 material and 150 |
| Cost grid connection of chargers per bus | 30,000 | USD/bus | Compact sub-stations for groups of chargers; 20kV cables from connection substation to the compact substation, 400V cables from compact substation to chagers; costs not born by electric utility |
| Lifetime chargers | 10 | years | standard value |
| Lifetime bus depot upgrades | 20 | years | standard value |
| Lifetime grid connection | 20 | years | standard value |
| Maintenance chargers, grid connection, depot | 2% | | of investment |

**Option A: Overnight Charging**

**Battery Size Determination overnight charging**

| Parameter | Unit | Value |
|---|---|---|
| Daily range workday (max) | km | 201 |
| Energy usage day | kWh | 201 |
| Risk ratio (higher energy consumption) | | 10% |
| Reserve ratio | | 20% |
| SOC loss year 8 | | 20% |
| **Battery size required year 8** | **kWh** | **350** |

**Charging required at bus depot overnight**

| Parameter | Unit | Value |
|---|---|---|
| Battery capacity | kWh | 350 |
| Average daily consumption workday | kWh | 201 |
| Time available at depot night | hours | 6 |
| Power conversion efficiency of chargers | | 90% |
| Charging power required (incl. 1h reserve for slower charging last 20%) | kW | 40 |

**Option B: Fast Charging**

| Parameter | Unit | Value |
|---|---|---|
| Battery size | kWh | 250 |
| C-rate | | 0.65 |
| Charging in 30 minutes | kWh | 81 |
| Average re-charge during day required with 20% reserve ratio | kWh | 1 |
| Average share of day electricity | | 0% |
| Fast-charger | kW | 300 |
| Power conversion efficiency of chargers | | 90% |
| Average required re-charge day with 300 kW charger | minutes | 0 |
| Number of buses per fast-charger | buses / charger | 8 |
| Night charger power | | 40 |

Other options are possible e.g. smaller battery and higher C-rate, buses per fast-charger based on max 12 units or time*2 for charging and 3 hour slot

| **Bus price trend in real USD (average slow and fast charged** | |
|---|---|
| Cost 2020 | 244,000 |
| Projected e-bus cost 2025 | 188,100 |
| Projected e-bus cost 2030 | 156,600 |
| CAGR decrease | -4.3% |

Based on battery costs 2025 of 100 USD and 60 USD in 2030 based on BNEF (https://www.sustainable-bus.com/news/electric-vehicle-outlook-2020-bnef-electric-buses/#:~:text=With%20regards%20to%20electric%20bus,needed%20to%20keep%20prices%20falling%C2%BB.&text=But%20by%202030%20demand%20grows%20almost%2014%2Dfold%20to%201%2C755GWh.)

Additional 20% reduction in 2025 and 30% in 2030 due to larger manufacturing systems

| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual bus price projected | 244,000 | 233,416 | 223,290 | 213,605 | 204,339 | 195,475 | 186,995 | 178,884 | 171,124 | 163,701 | 156,600 |

**Financing terms**

| Parameter | Value | Unit | Source |
|---|---|---|---|
| Loan tenure | 7 | years | in line with coincession agreement |
| Loan share vehicle only | 80% | | BN, BCR, Banco popular |
| Interst rate loan E-bus | 7% | | BN, BCR, Banco popular |
| interst loan conventional | 8% | | BN, BCR, Banco popular |
| Discount rate | 6.9% | | WACC |
| Discount rate fossil | 7.5% | | WACC |

ARESEP regulations state that grid adjustments are to be paid by the prower provider. However, the connection from charger to the sub-station is in general not considered a grid adjustment.

## TCO Buses

*12m standard bus, USD 2020*

| Parameter | Diesel | BEB overnight | BEB fast |
|---|---|---|---|
| CAPEX bus | 110,000 | 262,000 | 226,000 |
| CAPEX charging infrastructure | 0 | 7,300 | 12,113 |
| CAPEX grid connection | 0 | 30,000 | 30,000 |
| CAPEX depot upgrade | 0 | 7,500 | 7,500 |
| Total CAPEX | 110,000 | 306,800 | 275,613 |
| Battery replacement yr 8 | 0 | 35,000 | 31,250 |
| Energy cost | 20,586 | 5,400 | 5,400 |
| Maintenance cost bus | 13,800 | 9,450 | 9,450 |
| Maintenance cost infra | 0 | 896 | 992 |
| Finance cost average p.a. during loan term | 3,888 | 8,018 | 6,917 |
| Economic costs yr 1 | 4,411 | 37 | 37 |
| Lifespan in years | 15 | 16 | 16 |
| TCO financial per km | 0.73 | 0.67 | 0.64 |
| TCO economic per km | 0.81 | 0.67 | 0.64 |

*timespan of calculation: lifespan of e-buses with replacement investment for fossil buses; end of life value proportional to remaining lifespan: all other costs incl. insurance same independent of technology;*

| Comparison Capital | Overnight charged | | fast charged | |
|---|---|---|---|---|
| | Absolute | % | Absolute | % |
| Additional Capital investment | 196,800 | 279% | 165,613 | 251% |
| Additional Loan | 121,600 | 238% | 116,000 | 205% |
| Additional equity | 75,200 | 442% | 72,813 | 431% |

**Impact concessional finance**

| | overnight charged | fast charged |
|---|---|---|
| TCO financial old | 0.67 | 0.64 |
| TCO financial new | 0.68 | 0.65 |
| FIRR old | 4.6% | 7.2% |
| FIRR new | 4.6% | 7.2% |
| Additional equity old | 442% | 431% |
| Additional equity new | 139% | 125% |
| Discounted Payback in years old | none | none |
| Discounted Payback in years new | year 16 | year 13 |
| positive differential CF old (year) | year 15 | year 13 |
| positive differential CF new (year) | positive from year 2; negative year 8 to 14 (investment chargers and replacement batteries) | positive from year 1; negative years 11-12 |

| Impact upfront investment plus concessional finance | | |
|---|---|---|
| | overnight charged | fast charged |
| TCO financial old | 0.67 | 0.64 |
| TCO financial new | 0.60 | 0.59 |
| FIRR old | 4.6% | 7.2% |
| FIRR new | 11.2% | 15.8% |
| Additional equity old | 442% | 431% |
| Additional equity new | 112% | 100% |
| Discounted Payback in years old | none | none |
| Discounted Payback in years new | year 10 | year 8 |
| positive differential CF old (year) | year 15 | year 13 |
| positive differential CF new (year) | positive from year 1 | positive from year 1 |
| absolute grant | 61,360 | 55,123 |
| cost per tCO2 (grant relative to GHG impact) | 41 | 37 |

**Taxis**

| Parameter | Value | Unit | Source |
|---|---|---|---|
| Average battery size | 60 | kWh | Nissan Leaf 2020; idem BAIC |
| Battery lifespan | 10 | years | idem to vehicle lifespan |
| Vehicle lifespan | 10 | years | |
| Annual mileage | 52,000 | km | ARESEP minimal value multiplied with 1.2 |
| Daily mileage | 168 | km | Based on 310 working days (ARESEP 26d/month) |
| Charging at home average | 70% | | Assumption; only re-charge if above-average mileage or night shifts |
| Charging fast-chargers | 30% | | |
| CAPEX gasoline taxis | 13,000 | | ARESEP based on Hyunday Accent (55% of taxis) |
| CAPEX e-taxi | 30,000 | | |
| Capex home charger 7.4kW | 2,000 | USD | Nissan LEAF large battery or BAIC |
| Gasoline consumption | 8.5 | l/100km | urban consumption hyundai Accent (https://www.adac.de/_ext/itr/tests/Autotest/AT797_Hyundai_Acc |
| Electricity consumption | 0.16 | kWh/km | Nissan LEAF https://ev-database.org/car/1106/Nissan-Leaf |
| Charger lifespan | 10 | years | |
| Repair cost per km gasoline | 0.13 | USD/km | ARESEP |
| Tyres gasoline | 0.01 | USD/km | ARESEP |
| Maintenance cost gasoline | 0.02 | USD/km | ARESEP |
| Maintenance cost total e-taxi | 0.121 | USD/km | 10% higher tyre cost; 70% lower maintenance; 20% lower repair cost |
| Loan tenure taxi | 5 | years | Bank conditions Costa Rica |
| Loan share taxi | 80% | | |

*gasoline versus e-taxi*

| Parameter | gasoline | e-taxi |
|---|---|---|
| CAPEX vehicle | 13,000 | 30,000 |
| CAPEX charger | 0 | 2,000 |
| Total CAPEX | 13,000 | 32,000 |
| Energy cost | 4,199 | 2,030 |
| Maintenance cost | 8,320 | 6,292 |
| Finance cost average per loan year | 450 | 963 |
| Economic costs yr 1 | 496 | 5 |
| Lifespan in years | 10 | 10 |
| TCO financial per km | 0.27 | 0.23 |
| TCO economic per km | 0.28 | 0.23 |

| Impact concessional finance | |
|---|---|
| | e-taxi |
| TCO financial old | 0.23 |
| TCO financial new | 0.23 |
| FIRR old | 24% |
| FIRR new | 24% |
| Additional equity old | 246% |
| Additional equity new | 123% |
| Discounted Payback in years old | 7 |
| Discounted Payback in years new | 5 |
| positive differential CF old (year) | 6 |
| positive differential CF new (year) | 1 |

| Impact upfront investment grant | |
|---|---|
| | **e-taxi** |
| TCO financial old | 0.23 |
| TCO financial new | 0.22 |
| FIRR old | 24% |
| FIRR new | 48.5% |
| Additional equity old | 246% |
| Additional equity new | no equity |
| Discounted Payback in years old | 7 |
| Discounted Payback in years new | 7 |
| positive differential CF old (year) | 6 |
| positive differential CF new (year) | 1 |
| absolute grant | 6,400 |
| cost per tCO2 (grant relative to GHG impact) | 64 |

**Investment cost other vehicle categories**

**Taxi relative to Nissan Sentra**

| **Category** | **Value** | **Source** |
|---|---|---|
| 2020 | 30,000 | Nissan Leaf or BAIC taxi 28-32,000 USD |
| 2025 | 19,000 | see McKinsey |
| 2030 | 15,000 | Assumes cost parity |
| CAGR | -7% | |

Expected price parity by 2030

Electric vehicle trends | Deloitte Insights

| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Taxi | 30,000 | 27,991 | 26,117 | 24,368 | 22,736 | 21,213 | 19,793 | 18,467 | 17,230 | 16,077 | 15,000 |

## LCVs

**1. Petrol Van**

| Parameter | Value | Unit | explanation |
|---|---|---|---|
| CAPEX van | 25,000 | USD | Suzuki APV |
| Petrol fuel consumption | 8.5 | l/100km | https://www.carsguide.com.au/suzuki/apv; Automercados indicates 9l/100km |
| Maintenance cost | 0.04 | USD/km | excludes tyres and repairs; data from Automercados |
| Lifespan | 15 | years | Based on annual mileage |
| Daily distance driven | 70 | km | Automercados; commensurate with annual mileage |
| Annual distance | 20,000 | km | 95% usage |

**2. E-Van**

| Parameter | Value | Unit | explanation |
|---|---|---|---|
| CAPEX e-van | 31,000 | USD | Maxus E-Deliver (see https://saicmaxus.co.uk/edeliver3/); 4.8 m3 cargo volume; short-wheel base; small battery |
| Range WLTP | 222 | km | https://saicmaxus.co.uk/edeliver3 |
| Battery size | 35 | kWh | |
| Cost battery | 7,000 | USD | Based on 200 USD/kWh per battery |
| electricity consumption | 0.15 | kWh/km | WLTP |
| Maintenance cost | 0.02 | USD/m | 50% of fossil (as only engine maintenance is included; no tyres, no repairs) |
| Lifespan van | 15 | years | assumed same as fossil |
| Lifespan battery | 8 | years | |
| Capex home charger 7.4kW | 2,000 | USD | |
| Lifespan charger | 10 | years | |
| Charging at home average | 90% | | Assumption |
| Charging fast-chargers | 10% | | Exceptional if long distances were made |

*fossil versus e-van*

| Parameter | petrol | e-van |
|---|---|---|
| CAPEX vehicle | 25,000 | 31,000 |
| CAPEX charger | 0 | 2,000 |
| Total CAPEX | 25,000 | 33,000 |
| Energy cost | 1,615 | 684 |
| Maintenance cost | 850 | 425 |
| Finance cost average 10 yrs | 787 | 1,038 |
| Economic costs yr 1 | 192 | 2 |
| Lifespan in years | 15 | 15 |
| TCO financial per km | 0.23 | 0.22 |
| TCO economic per km | 0.24 | 0.22 |

## Impact concessional finance

| | e-LCV |
|---|---|
| TCO financial old | 0.22 |
| TCO financial new | 0.20 |
| FIRR old | 12% |
| FIRR new | 12% |
| Additional equity old | 132% |
| Additional equity new | 66% |
| Discounted Payback in years old | 11 |
| Discounted Payback in years new | 6 |
| positive differential CF old (year) | 4 |
| positive differential CF new (year) | 1 |

| Impact upfront investment grant | |
|---|---|
| | e-LCV |
| TCO financial old | 0.22 |
| TCO financial new | 0.19 |
| FIRR old | 12% |
| FIRR new | 3081.8% |
| Additional equity old | 132% |
| Additional equity new | no equity |
| Discounted Payback in years old | 11 |
| Discounted Payback in years new | 11 |
| positive differential CF old (year) | 4 |
| positive differential CF new (year) | 1 |
| absolute grant | 6,600 |
| cost per tCO2 (grant relative to GH | 97 |

| LCVs | | |
|---|---|---|
| 2020 | 25,000 | BYD T3 is 19,000 USD and Nissan EVN is 30,000 USD |
| 2030 | 20,000 | cost parity with Nissan diesel |
| CAGR | -2% | |

| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LCV | 25,000 | 24,448 | 23,909 | 23,381 | 22,865 | 22,361 | 21,867 | 21,385 | 20,913 | 20,451 | 20,000 |

## Impact

GHG, PM2.5 and NOx impact per vehicle unit

Reductions in tons of EV versus fossil

| Parameter | urban bus | | taxi | | LCV | |
|---|---|---|---|---|---|---|
| | annual | lifespan | annual | lifespan | annual | lifespan |
| GHG TTW reduction | 95 | 1,521 | 10 | 101 | 4 | 58 |
| GHG WTW incl. BC reduction | 94 | 1,508 | 12 | 120 | 5 | 68 |
| Cradle to grave GHG reduction | 90 | 1,444 | 11 | 113 | 4 | 61 |
| PM2.5 reduction | 0.003 | 0.044 | 0.000 | 0.001 | 0.000 | 0.000 |
| NOx reduction | 0.325 | 5.203 | 0.003 | 0.029 | 0.001 | 0.019 |
| Economic value GHG(WTW), PM2.5 and Nox | 4,414 | 70,632 | 488 | 4,884 | 186 | 2,793 |

Lifespan based on EV lifespan

Default comparison: Euro IV unit; bus diesel

| Fleet Impact buses | year 2030 | Cumulative |
|---|---|---|
| **number -buses** | 1,998 | 1,993 |
| GHG WTW reduction | 188,284 | 3,031,786 |
| PM2.5 reduction | 6 | 88 |
| NOx reduction | 650 | 10,368 |
| Economic Benefits | 8,818,833 | 122,558,898 |

Cumulative is equivalent to all buses on the road by 2030 over their entire lifespan of 16 years

year 2030 includes 5 buses prior 2022

**Bus per km**

| Parameter | Diesel Euro IV | BEB |
|---|---|---|
| Direct emissions energy TTW | 1,264 | 0 |
| Indirect emissions energy WTT | 291 | 15 |
| Black Carbon emissions | 31 | 0 |
| Vehicle production | 37 | 34 |
| Battery manufacturing | 0 | 69 |
| Total lifecycle | 1,622 | 118 |

| | |
|---|---|
| WTW BEB versus diesel | 0.9% |
| cradle to grave BEB versus diesel | 7% |

**Taxi per km**

| Parameter | Gasoline | e-taxi |
|---|---|---|
| Direct emissions energy TTW | 193 | 0 |
| Indirect emissions energy WTT | 37 | 2 |
| Vehicle production | 16 | 16 |
| Battery manufacturing | 0 | 13 |
| Total lifecycle | 246 | 31 |

| | |
|---|---|
| WTW e-taxi versus gasoline | 1% |
| cradle to grave e-taxi versus gasoline | 13% |

| Fleet Impact taxis | year 2030 | Cumulative |
|---|---|---|
| **number e-taxis** | 8,437 | 8,337 |
| GHG WTW reduction | 100,951 | 1,009,510 |
| PM2.5 reduction | 0.5 | 5 |
| NOx reduction | 25 | 246 |
| Economic Benefits | 4,120,357 | 41,203,569 |

Cumulative is equivalent to all taxis on the road by 2030 over their entire lifespan of 10 years

year 2030 includes 100 taxis prior 2022

**LCV per km**

| Parameter | gasoline | electric |
|---|---|---|
| Direct emissions energy TTW | 193 | 0 |
| Indirect emissions energy WTT | 37 | 2 |
| Vehicle production | 28 | 28 |
| Battery manufacturing | 0 | 26 |
| Total lifecycle | 258 | 56 |

| | |
|---|---|
| WTW e-van versus gasoline | 1% |
| cradle to grave e-van versus gasoline | 22% |

| Fleet Impact LCVs | year 2030 | Cumulative |
|---|---|---|
| **number e-LCVs** | 57,879 | 57,879 |
| GHG WTW reduction | 263,759 | 3,956,378 |
| PM2.5 reduction | 1 | 19 |
| NOx reduction | 74 | 1,111 |
| Economic Benefits | 10,776,169 | 161,642,540 |

Cumulative is equivalent to all LCVs on the road by 2030 over their entire lifespan of 15 years