grütter consulting

Assessment of Commercial EV Demand in Dominican Republic



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Abbreviations

AC	Air Conditioning
AFD	French Development Agency
BAU	Business As Usual
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
FI	Financial Intermediary
FIRR	the Financial Internal Rate of Return
GHG	Greenhouse Gases
GIZ	German International Cooperation
IEA	International Energy Agency
LCV	Light Commercial Vehicle
SOH	State of Health
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 Dominican Republic from materializing the market potential.

The focus is on assessing the 2030 potential market for commercial electric vehicles (EVs) in Dominican Republic 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 Dominican Republic

The Dominican Republic has initiated numerous activities to promote EVs. As of 2021 the EV market is however still very incipient with singular private EVs and no fleet of commercial EVs.

3. Commercial EV Market Potential in the Dominican Republic

3.1. Scenarios

The market potential can be assessed 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[1].

Report 3 will include also a Business as Usual (BAU) market development of EVs based on the decrease of EV prices until 2030.

[1] For details on scenarios see Country Diagnostic Report Dominican Republic

3.2. Urban Electric Buses

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

Table 1: Urban E-Buses: High Growth Scenario 2025 and 2030

Parameter	2025	2030
Cumulative e-buses	80	320
Market share (% of stock)	7%	24%
Sales share (% of new registrations)	22%	100%

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

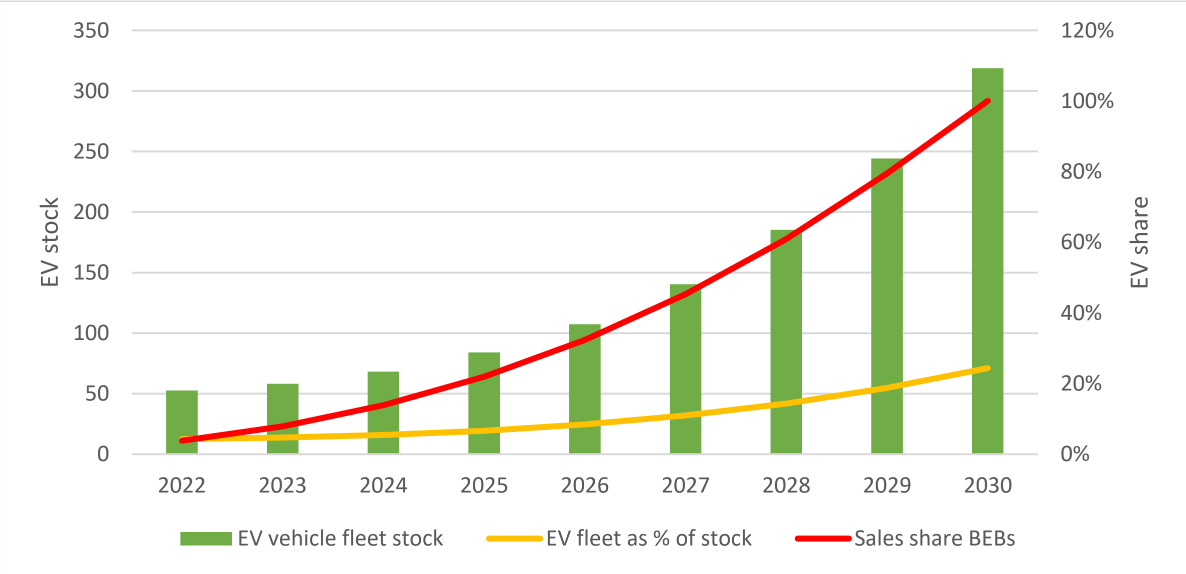
With a high growth scenario a market share of around 24% is targeted by 2030 equivalent to around 330 urban electric buses operating in the country. The main parameters for the high growth market potential are outlined in the following table.

Table 2: High Growth Scenario Electric Urban Buses 2022-2030

Parameter	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock buses	1,233	1,242	1,252	1,261	1,270	1,280	1,289	1,299	1,309
Sales BEBs	3	6	10	16	23	33	45	59	75
Stock BEBs	53	58	68	84	107	140	185	244	319
Share BEBs of stock	4%	5%	5%	7%	8%	11%	14%	19%	24%

BEBs: Battery Electric Buses
Source: Grutter Consulting; report 1

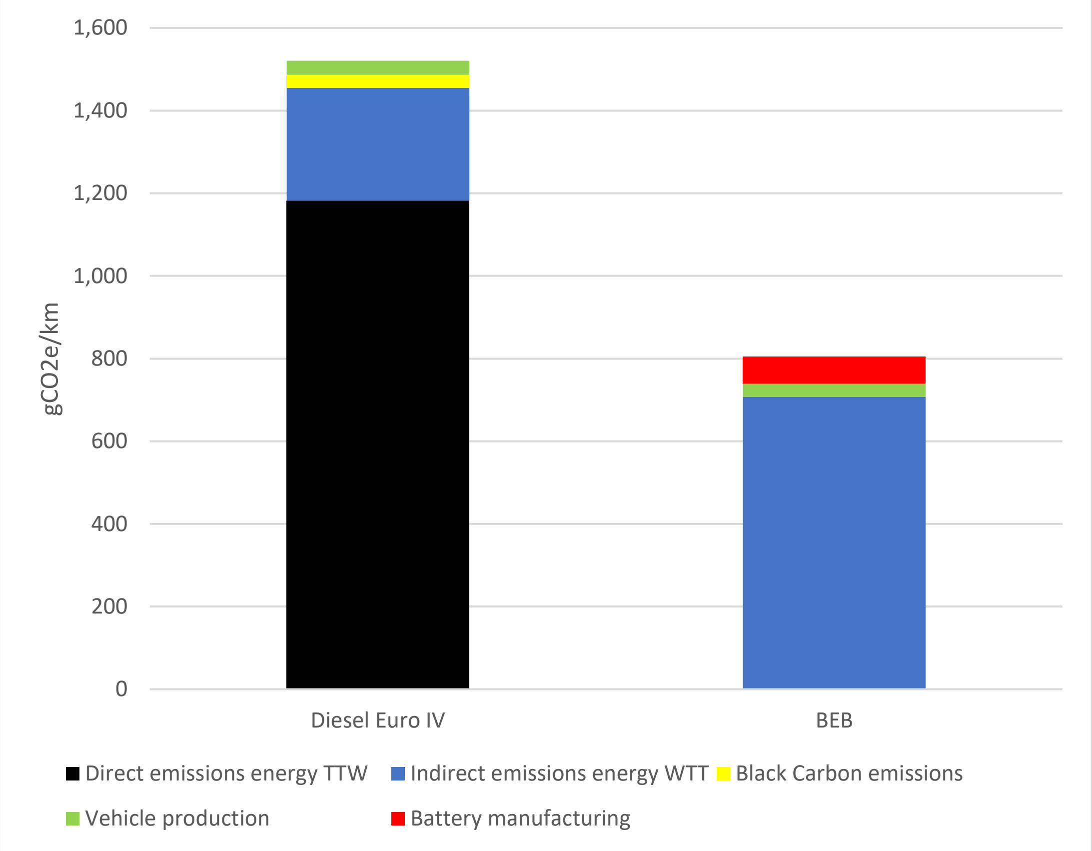
Figure 1: Urban Electric Bus High Growth Scenario



Source: Grutter Consulting

A BEB can reduce well-to-wheel (WTW) Greenhouse Gas (GHG) emissions in Dominican Republic by 52% and cradle to grave emissions by 47% compared to a diesel unit (see figure below).

Figure 2: GHG Impact Urban Bus (12m urban bus)



Source: Grutter Consulting; mileage and energy consumption based on values for Dominican Republic; major assumptions include 61,000km annual mileage; 44 l/100km diesel and 1.1 kWh/km BEB; 16 year lifespan bus; 8-year lifespan of battery; battery set of average 285 kWh; 110kg CO_2/kWh battery (ICCT, 2018); grid factor 0.643 kgCO_2/kWh

3.3. Electric Taxis

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

Table 3: Electric Taxis: High Growth Scenario 2025 and 2030

Parameter	2025	2030
Cumulative e-taxis	2,200	20,000
Market share (% of stock)	5%	35%
Sales share (% of new registrations)	22%	100%

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

The following table shows the main parameters for the high growth market potential of electric taxis.

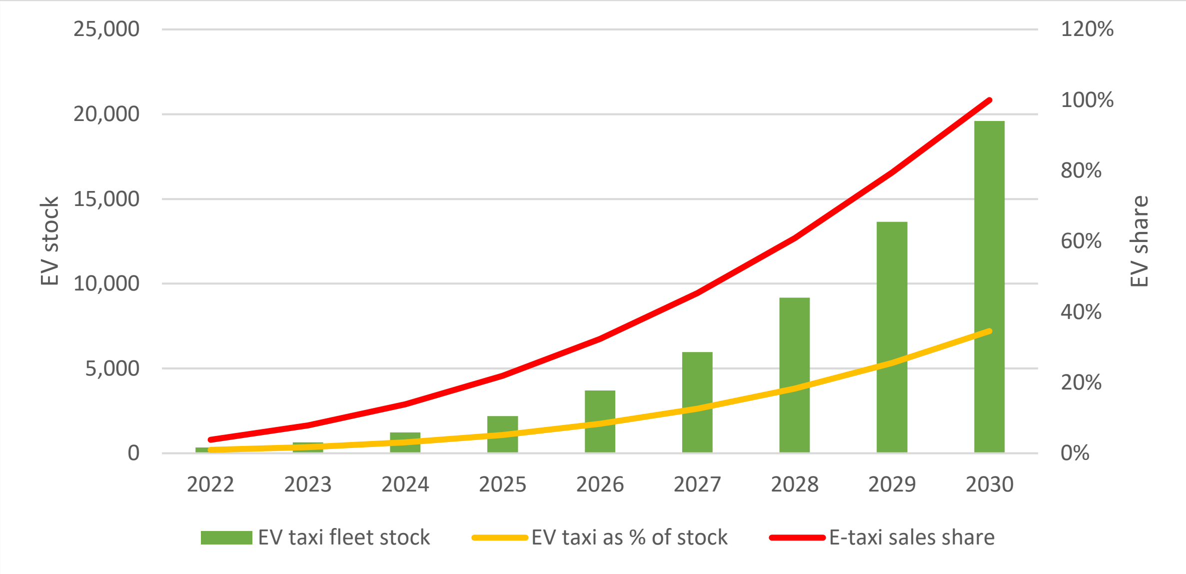
Table 4: High Growth Scenario Electric Taxis 2022-2030

Parameter	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock taxis	35,102	37,265	39,561	41,999	44,587	47,334	50,250	53,347	56,634
Sales e-taxis	141	309	576	969	1,516	2,254	3,220	4,457	5,954
Stock e-taxis	341	651	1,227	2,195	3,712	5,966	9,185	13,643	19,597
Share e-taxis of stock	1%	2%	3%	5%	8%	13%	18%	26%	35%

Source: Grutter Consulting, report 1

As of 2030 20,000 e-taxis would be electric with this scenario.

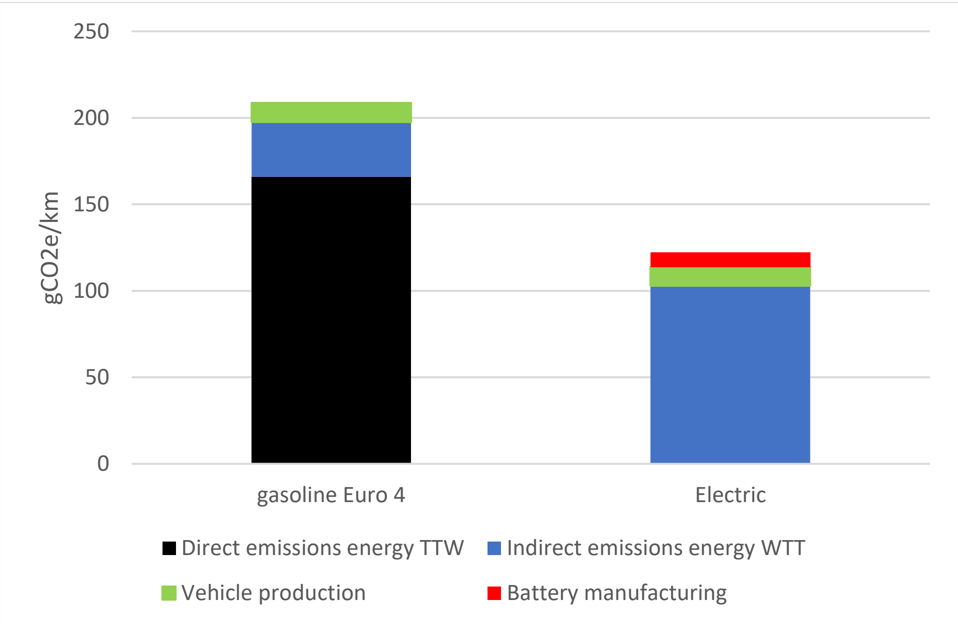
Figure 3: Electric Taxi High Growth Scenario



Source: Grutter Consulting

An electric taxi can reduce WTW emissions in Dominican Republic by 48% and cradle to grave emissions by 41% (see figure below).

Figure 4: GHG Impact Electric Taxi



Source: Grutter Consulting; mileage and energy consumption based on values for Dominican Republic; major assumptions include 78,000km annual mileage; 7.3 l/100km gasoline and 0.16 kWh/km e-taxi; 10 year lifespan vehicle; 10-year lifespan of battery; battery set of 60 kWh; 110kg CO_2/kWh battery (ICCT, 2018); grid factor 0.643 $kgCO_2$/kWh

3.4. Light Commercial Vehicles (LCVs)

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

Table 5: Electric LCVs: High Growth Scenario 2025 and 2030

Parameter	2025	2030
Cumulative e-LCVs	4,800	40,000
Market share (% of stock)	3%	24%
Sales share (% of new registrations)	22%	100%

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

The following table shows the main parameters for the high growth scenario of LCVs.

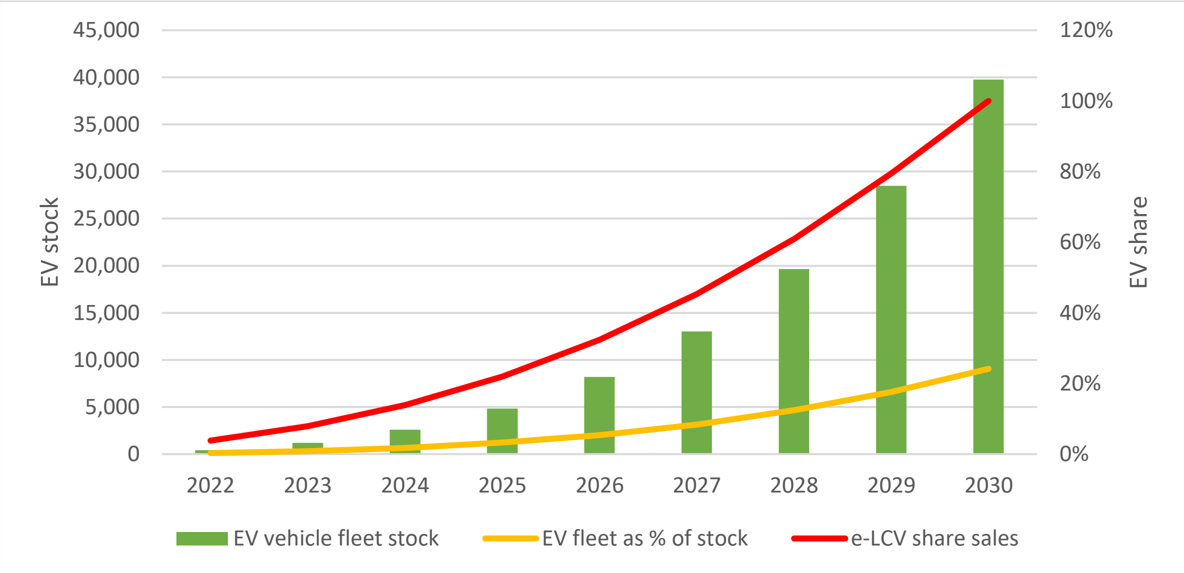
Table 6: High Growth Scenario Electric LCVs 2022-2030

Parameter	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock LCVs	140,593	143,405	146,273	149,198	152,182	155,226	158,330	161,497	164,727
Sales e-LCVs	369	777	1,391	2,246	3,378	4,825	6,622	8,808	11,305
Stock e-LCVs	419	1,196	2,587	4,833	8,211	13,036	19,658	28,466	39,770
Share e-LCVs of stock	0%	1%	2%	3%	5%	8%	12%	18%	24%

Source: Grutter Consulting, report 1

As of 2030 nearly 40,000 e-LCVs would operate in Dominican Republic with this scenario.

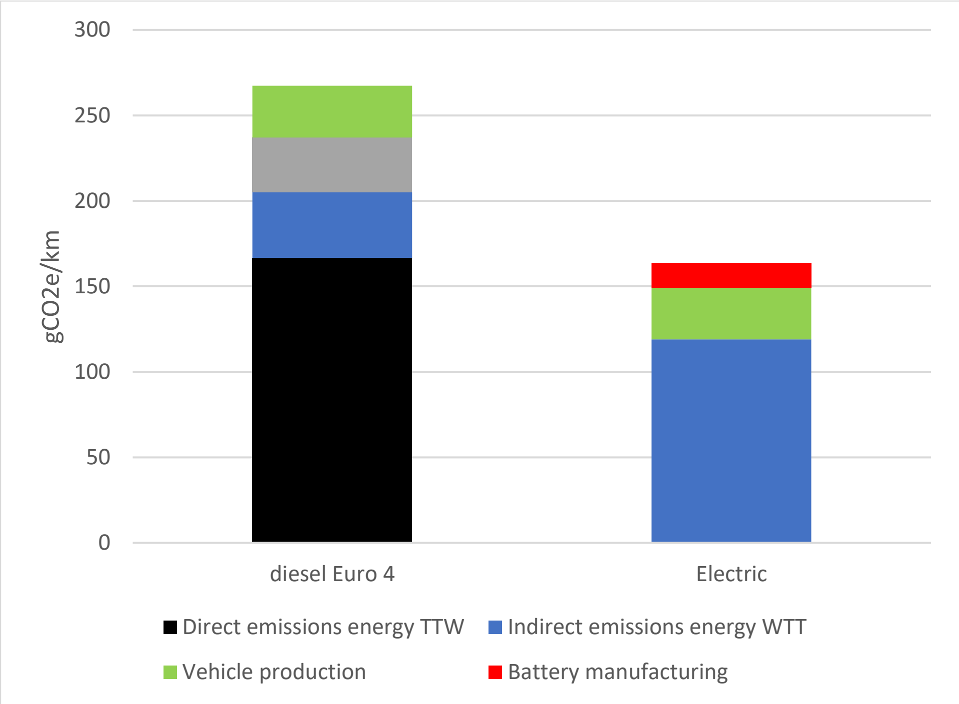
Figure 5: LCV High Growth Scenario



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 with a 2-ton capacity an electric LCV can reduce WTW emissions in Dominican Republic by 50% and cradle to grave emissions by 39% (see figure below).

Figure 6: GHG Impact Electric LCV



Source: Grutter Consulting; mileage and energy consumption based on values for Dominican Republic based on Peugeot Boxer diesel and electric version; major assumptions include 47,000 km annual mileage; 6.2 l/100km and 0.19 kWh/km e-LCV; 6 year lifespan; battery set of 37kWh; 110kg CO_2/kWh battery (ICCT, 2018); grid factor 0.643 kgCO_2/kWh

4. Financial Assessment of Commercial EVs in Dominican Republic

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 Dominican Republic;
- 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 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.

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 Dominican Republic for the transport sector.

Table 7: WACC Transport Sector Dominican Republic (all rates in USD)

Parameter	Value	Source
Cost of equity	13.6%	(UNFCCC, 2019); value for transport sector of Dominican Republic
Share of equity financing	20%	Banks are willing to finance 70-90% with loans
Cost of debt	12.5%	Current average rate of FIs for fossil units (IDB, 2020); see vehicle categories for special rates for EVs
Share of debt financing	80%	Banks are willing to finance 70-90%% with loans
Corporate tax rate	27%	Deloitte, 2020
WACC	10.0%	Calculated for fossil units

4.2. Financial Analysis E-Buses

4.2.1. General Data

Calculations are realized for the standard urban bus as used in Dominican Republic which is a 12m low-floor entry diesel bus with 2 access doors. Urban buses as first step are far easier to electrify than inter-urban (coach) units where less options are available on the market and which face difficulties of range, usage of space for batteries instead of luggage and limited energy savings (diesel units are very efficient for inter-urban usage whilst EVs are less efficient in higher speed operations). 2 options for BEBs have been included in the calculations:

- An overnight charged BEB with a battery set of 370 kWh[2];
- A BEB with batteries capable of fast-charging and a battery set of 200 kWh (C-rate of minimum 0.65) which allows to re-charge for additional 100km within around 20 minutes using a 300 kW charger.

The following tables indicate the diesel bus specific values, the overnight BEB and the fast-charged BEB specific values. The average annual bus distance driven is 61,000 km (based on OMSA urban bus operator).

Table 8: Baseline Fossil Bus Parameters

Parameter	Value	Source
Diesel usage	44 l/100km	Euro IV diesel bus based on EEA, 2020
Maintenance cost diesel bus	0.07 USD/km	Average value for Euro IV bus excl. repairs and tyres
Cost of diesel	0.94 USD/l	https://www.globalpetrolprices.com/
CAPEX diesel bus	130,000 USD	Standard Euro IV bus; see also Caribe tours
Lifespan fossil bus	16 years	1 million km usage which is standard in many countries
Loan conditions	12.5% interest rate 7 yr tenure	IDB, 2020

Table 9: BEBs Common Parameters

Parameter	Value	Source
Specific electricity usage	1.1 kWh/km	Chinese average; (ADB, 2018); includes AC usage
Maintenance cost	0.05 USD/km	(ADB, 2018), 70% of diesel bus
Lifespan bus	16 years	Same as diesel bus

[2] 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.

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[3];
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
Finance conditions	6.9% rate 80% coverage 7 years	Same conditions as for e-cars; Banco Popular; IDB, 2020

Table 10: BEB Overnight Charged Bus

Parameter	Value	Source
CAPEX bus	274,000 USD	Based on 350 kW standard bus; sur-cost for larger battery set
CAPEX batteries	200 USD/kWh	LFP batteries
Battery capacity	370 kWh	Calculated based on workday range with sufficient reserves (20% base reserve; reserve for higher than expected energy consumption due to traffic/climate/driver and 20% drop of SOH of batteries)
Charger power	50 kW	Calculated based on available charging time and daily average electricity usage

Table 11: BEB Fast Charged Bus

Parameter	Value	Source
CAPEX bus	240,000 USD	Standard fast-charged bus
CAPEX batteries	250 USD/kWh	NMC batteries
Battery size	200 kWh	Calculated based on workday range with sufficient margins and battery sets cum C-rates as offered in the market
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

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

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 12: TCO Calculations (USD of 2020)

Parameter	Diesel	BEB overnight	BEB fast
CAPEX bus	130,000	274,000	240,000
CAPEX charging infrastructure	0	8,500	12,113
CAPEX grid connection	0	30,000	30,000
CAPEX depot upgrade	0	7,500	7,500
Total CAPEX	**130,000**	**320,000**	**289,613**
Battery replacement yr 8	0	37,000	25,000
Energy cost yr 1	19,119	10,969	10,969
Maintenance cost bus yr 1	4,284	2,999	2,999
Maintenance cost infra yr 1	0	920	992
Finance cost average per year	7,509	8,257	7,232
Economic costs yr 1	4,747	1,731	1,731
TCO financial per km	**0.57**	**0.67**	**0.62**
TCO economic per km	**0.66**	**0.70**	**0.66**

Source: Grutter Consulting

Following conclusions are drawn:

- Comparing total costs over the bus lifetime of 16 years BEBs have a higher TCO than diesel buses;
- The TCO of fast-charged BEBs is slightly lower than of overnight charged BEBs whilst offering less operational risks.

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 13: Capital Demand (USD of 2020)

Capital investment BEB relative to Dieselbus (per unit)	BEB overnight		BEB fast-charged	
	Absolute	%	Absolute	%
Additional capital investment	-190,000	146%	159,613	123%
Additional loan demand	-115,200	111%	88,000	85%
Additional equity requirement	74,800	288%	71,613	275%

Source: Grutter Consulting

BEBs require a 2.5x higher capital investment than diesel buses[4]. Loans are currently only available for the bus component. 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 3-4. Equity is required for the additional investments as well as to par the loans. This places a serious problem for bus operators. With the same amount of equity the bus owner could opt to

[4] 2x higher capital investment is identical to incremental 100%

purchase 30 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 fossil 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 -7% and of fast-charged BEBs of -3%.
- The EIRR is -5% respectively 0%.

The investment in BEBs is thus 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).

4.2.5. Discounted Payback

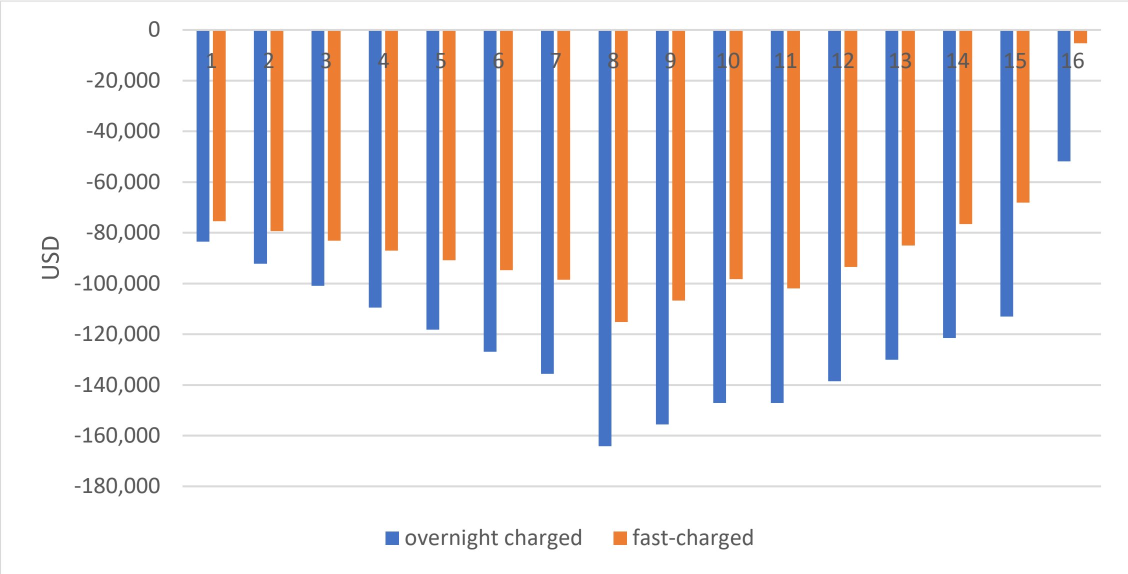
The discounted payback looks at the number of years required to recover the initial incremental investment from savings of BEBs relative to diesel buses. Annual incremental savings of using a BEB versus a diesel bus are discounted. The discounted payback gives a good indication of the risk the entrepreneur 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 cumulative CF remains negative during the lifetime of the asset (see figure below).

Figure 7: Cumulative Differential Cash Flow Electric versus Diesel Bus



Source: Grutter Consulting

The Cash Outflow relative to diesel buses increases initially due to loan interest rates and repayments.

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 14: Summary Financial Assessment BEBs

Criteria	Result	Assessment
TCO	15% higher for BEBs	Non-discounted the cumulated lifetime costs for BEBs are higher than for fossil 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 negative	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	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.

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. BEBs will require a different financial structuring and significant financial incentives to be a viable business proposal in Dominican Republic.

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 15: Concessional Loan Parameters

Parameter	Current conditions	Concessional conditions
Loan tenure	7 years	12 years
Interest rate	6.9%	3.9%
Lending rate	80% of bus investment	80% of total investment

The concessional interest rate is based on a 1.25% rate from the GCF (0.75% interest rate and 0.5% commissions fees factored into the interest rate) for 30% of the loan and 70% of the investment from AFD/co-financers at 5% interest rate

The following table compares the financial results with and without a concessional loan.

Table 16: Impact of Concessional Loan Conditions

Parameter	overnight charged BEB	fast charged BEB
TCO financial old	0.67	0.62
TCO financial new	0.68	0.61
FIRR old	-7.4%	-4.9%
FIRR new	-7.4%	-4.9%
Additional equity old	288%	275%
Additional equity new	246%	223%
Discounted Payback in years old	never	never
Discounted Payback in years new	never	never

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO does not change.
2. The concessional loan does not change the FIRR by logic (the FIRR is calculated without financial costs).
3. Owners capital requirements are reduced with the concessional loan (due to not only financing the bus but all investment components).
4. The risk and the capital exposure of the entrepreneur can be reduced but the investment is still not recovered during the asset lifespan.

It can be concluded that the concessional loan helps to resolve liquidity issues and results in an improvement of the investment profitability but risks very remain high with an unsatisfactory payback and a negative profit rate. 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.

Investment Grant

An upfront grant of 20% on the total initial investment combined with concessional finance is modelled. The following table shows the impact of an upfront grant combined with a concessional loan.

Table 17: Impact of 20% Upfront Grant + Concessional Loan Conditions

Parameter	overnight charged BEB	fast charged BEB
TCO financial old	0.67	0.62
TCO financial new	0.61	0.57
FIRR old	-7.4%	-4.9%
FIRR new	-3.3%	0.3%
Additional equity old	288%	275%
Additional equity new	none	none
Discounted Payback in years old	never	never
Discounted Payback in years new	never	never

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO reduces considerably – however values are still not lower than for diesel buses.
2. The FIRR increases but is still far below the WACC.
3. Owners capital requirements are reduced significantly.
4. The risk and the capital exposure of the entrepreneur is reduced. However, the incremental investment to a diesel bus is still not recovered during the lifespan of the asset.

It can be concluded that the grant resolves only partially the profitability and risk issue. The payback period is still to long i.e. additional incentives are required. With current electricity prices in Dominican Republic e-buses, even with significant incentives, remain unprofitable[5]. Diesel buses are also used for a long period (beyond the 10 years stipulated in the IDB, 2020) with a comparable lifespan of e-buses. Overall, additional incentives or regulations requiring the usage of e-buses will be required to make urban e-buses financially feasible in the Dominican Republic.

4.3. Financial Analysis E-Taxis

4.3.1. General Data

Calculations are realized for the standard taxi as used in Dominican Republic. The following tables indicate the general parameters, the gasoline taxi specific values, and the e-taxi specific values. The average mileage assumed of taxis is 78,000 km, based on daily 250km (data provided by Apolo taxi).

Table 18: Baseline Taxi Parameters

Parameter	Value	Source
Gasoline usage	7.3 l/100km	Average for Euro 4 unit based on EEA, 2019
Maintenance cost	0.01 USD/km	excludes tyres and repairs; Hyundai Elentra[6]
CAPEX	12,700 USD	Hyundai Elentra; https://www.supercarros.com/hyundai-elantra/1123656/
Lifespan	10 years	Apolo taxi

Table 19: E-Taxi Parameters

Parameter	Value	Source
Specific electricity usage	0.16 kWh/km	Nissan LEAF or BAIC taxi
Maintenance cost	0.004 USD/km	50% below fossil
Lifespan	10 years	Max. based on battery age

[5] The average electricity price is estimated at 0.16 USD/kWh which is based on medium tension consumption rates of 0.11 USD/kWh plus demand charge

[6] https://www.autocarindia.com/car-news/car-maintenance-cost-comparison--part-2-premium-and-executive-sedans-418738

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	35,700 USD	https://www.carrosrd.com/carros/Nissan/Leaf/SV/I-20994
CAPEX home charger 7.4kW	2,000 USD	Includes wall-box installation
Lifetime charger	10 years	standard value based on ABB
Loan conditions	7 year tenure 6.9% rate 80% coverage	Banco Popular

4.3.2. TCO

The following table shows the results of the TCO calculation.

Table 20: TCO Calculations (USD of 2020)

Parameter	Gasoline	e-taxi
CAPEX taxi	12,700	35,700
CAPEX charging infrastructure	0	2,000
Total CAPEX	**12,700**	**37,700**
Energy cost	5,313	2,573
Maintenance cost	775	310
Finance cost average p.a. during loan term	734	1,076
Economic costs of emissions year 1	637	319
Lifespan in years	10	10
TCO financial per km	**0.10**	**0.09**
TCO economic per km	**0.11**	**0.10**

Source: Grutter Consulting

Comparing total costs over the taxi lifetime of 10 years e-taxis have comparable financial and economic TCOs to gasoline units.

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 21: Capital Demand (USD of 2020)

Comparison e-taxi to gasoline taxis	Absolute	%
Additional capital investment	25,000	197%
Additional loan requirement	20,000	197%
Additional equity requirement	5,000	197%

Source: Grutter Consulting

E-taxis require a capital investment factor 2 of a gasoline unit. This can be a serious problem for taxi owners.

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 6% and comparable to the WACC.

- The EIRR is 9%.

The investment in e-taxis is thus profitable but not in line with the involved risk.

4.3.5. Discounted Payback

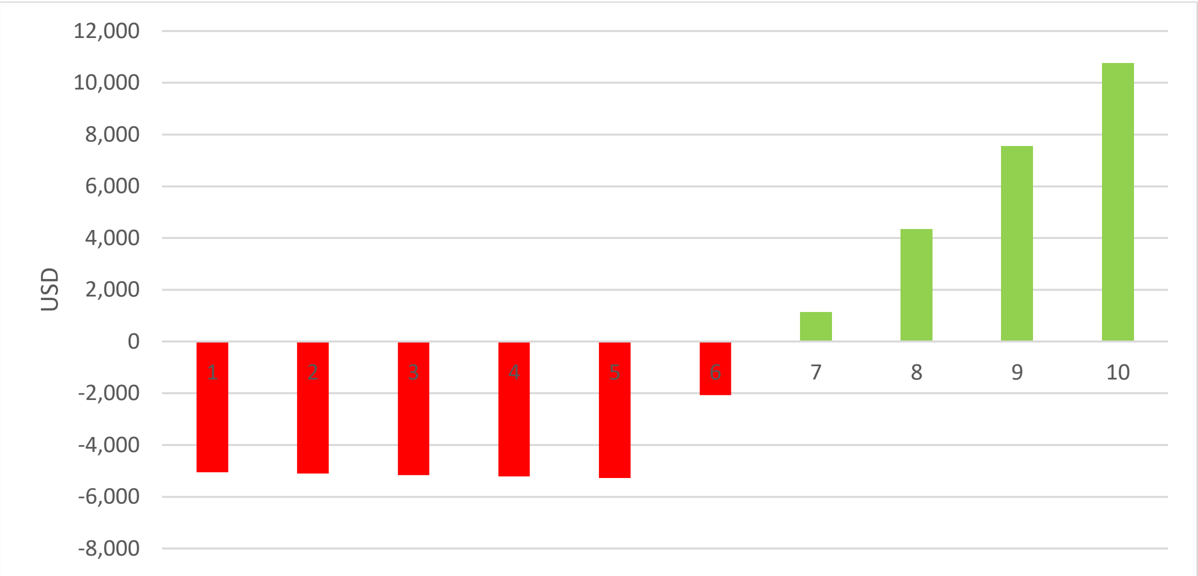
The discounted payback looks at the number of years required to recover the initial incremental investment from savings of e-taxis relative to gasoline units. Annual incremental savings of using an e-taxi versus a fossil taxi are discounted. The discounted payback gives a good indication of the risk 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 not recovered during the asset lifespan. This indicates that with current financial conditions the investment is risky.

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 cumulative CF turns positive in year 7.

Figure 8: Cumulative Cash Flow Differential Fossil versus E-Taxi



Source Grutter Consulting

Initially the cumulative CF of the e-taxi remains constant as loan repayments are heavier for an e-taxi than for a fossil unit and this cancels out the savings in the energy and maintenance field.

4.3.7. Summary Financial Assessment

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

Table 22: Summary Financial Assessment E-Taxis

Criteria	Result	Assessment
TCO	Similar values fossil and electric	Non-discounted the cumulated lifetime costs for e-taxis are comparable to gasoline units.
Capital investment	2x of a conventional taxi	Significantly higher capital requirement incl. higher loan demand
Equity investment	2x of a conventional taxi	Significantly higher equity demand which might overstretch the capabilities of taxi owners
Profitability	6%	Investment in e-taxis is idem to WACC
Discounted Payback	Incremental investment is not recovered	This indicates a high risk profile of the investment.
Cash Flow	Positive cumulative CF from year 7	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 the working capital ratio 6 years.

Summarized the investment in e-taxis with current financial conditions and business models is profitable but risky. Although gasoline prices are very low the low maintenance costs of e-taxis helps to make the investment profitable. A 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. 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 23: Concessional Loan Parameters

Parameter	Current conditions	Concessional conditions
Loan tenure	5 years	5 years
Interest rate	6.9%	5.9%
Lending rate	80% of CAPEX	80% of CAPEX

The concessional interest rate is based on a 1.25% rate from the GCF (commissions fees factored into the interest rate) for 30% of the loan and 70% of the investment from AFD/co-financers at 5% interest rate plus 2% spread of the national banking system

The following table compares the financial results with and without a concessional loan.

Table 24: Impact of Concessional Loan Conditions

Parameter	e-taxi
TCO financial old	0.09
TCO financial new	0.09
FIRR old	6%
FIRR new	6%
Additional equity old	197%
Additional equity new	197%
Discounted Payback in years old	never
Discounted Payback in years new	never

Source: Grutter Consulting

The concessional loan improves the liquidity but will not make a major change due to the fact also, that there is already a loan facility in place with favourable conditions.

Investment Grant

An upfront grant of 20% on the total initial investment with concessional finance is modelled. The following table shows the impact of an upfront grant.

Table 25: Impact of 20% Upfront Grant (incl. concessional financial conditions)

Parameter	e-taxi
TCO financial old	0.09
TCO financial new	0.08
FIRR old	6%
FIRR new	17%
Additional equity old	197%
Additional equity new	0%
Discounted Payback in years old	never
Discounted Payback in years new	8

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO reduces marginally.
2. The FIRR is with 17% now clearly above the WACC.
3. Owners capital requirements are 0.
4. The risk and the capital exposure of the entrepreneur is reduced significantly.

It can be concluded that the grant resolves all problems except of lost revenues.

4.4. Financial Analysis Electric LCVs

4.4.1. General Data

Calculations are realized for a standard LCV used for cargo purposes in urban settings. The following tables indicates the gasoline LCV specific values, and the e-LCV specific values. The annual assumed mileage is thereby 47,000 km (based on DHL). Multiple types and sizes of LCVs are available and used. The type of LCV assessed is shown in the photo below (this LCV is available since 2021 as diesel as well as e-version).

Photo 1: LCV Assessed

Source: Peugeot Boxer | Votre fourgon utilitaire polyvalent

Table 26: Baseline Fossil LCV Parameters

Parameter	Value	Source
Diesel consumption	6.2 l/100km	https://motoreu.com/peugeot-boxer-combi-2.0-bluehdi-mpg-fuel-consumption-technical-specifications-58411#:~:text=The%20engine%20has%20a%20Euro,8%2C6%20lt%2F100km.
Maintenance	0.02 USD/km	Vehicle manufacturer
CAPEX	39,900 USD	https://www.supercarros.com/peugeot-boxer/973849/
Lifespan	6 years	DHL

Table 27: E-LCV Parameters

Parameter	Value	Source
Specific electricity usage	0.15 kWh/km	Based on e-boxer version
Maintenance	0.01 USD/km	50% of fossil version
Lifespan	6 years	Same as fossil version
Lifespan battery @ 70% SOC	6 years	Same as vehicle 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	79,800 USD	https://commercialvehiclecontracts.co.uk/news/latest-vehicle-announcements/peugeot-e-boxer-revealed; small battery version
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 28: TCO Calculations (USD of 2020)

Parameter	Diesel	e-LCV
CAPEX LCV	39,900	79,800
CAPEX charging infrastructure	0	2,000
Total CAPEX	**39,900**	**81,800**
Energy cost	2,060	1,580
Maintenance cost	800	400
Finance cost average p.a. during loan term	2,305	2,405
Economic costs of emissions year 1	900	223
Lifespan in years	6	6
TCO financial per km	**0.24**	**0.38**
TCO economic per km	**0.26**	**0.38**

Source: Grutter Consulting

Comparing total costs over the LCV lifetime e-LCVs have higher financial and economic TCOs than diesel 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).

Table 29: Capital Demand (USD of 2020)

Comparison e-LCV to gasoline LCV	Absolute	%
Additional capital investment	41,900	105%
Additional loan	31,920	100%
Additional equity	9,980	125%

Source: Grutter Consulting

E-LCVs require 2 the capital investment than diesel units.

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 -46%.
- The EIRR is -37%.

The investment in e-LCVs is thus not profitable.

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 not recovered during the asset lifespan.

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 fossil unit. Only cash outflows are considered as revenues (cash inflows) are identical between an e-LCV and a diesel unit. The cumulative CF is negative during the entire asset lifetime.

Figure 9: Cumulative Differential CF e-LCV and Fossil Unit

Source: Grutter Consulting

4.4.7. Summary Financial Assessment

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

Table 30: Summary Financial Assessment e-LCVs

Criteria	Result	Assessment
TCO	50% higher TCO of e-LCV compared to diesel	
Capital investment	Factor 2 higher than a conventional LCV	Higher capital requirement incl. higher loan demand
Equity investment	Factor 2 higher than a conventional LCV	Higher equity demand
Profitability	Negative	Investment in e-LCVs is not profitable
Discounted Payback	Incremental investment is not recovered	The payback time is very long. This indicates a high risk profile of the investment.
Cash Flow	Negative all years (cumulative value)	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 not profitable, has a high risk and a very long payback time.

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 31: Concessional Loan Parameters

Parameter	Current conditions	Concessional conditions
Loan tenure	5 years	5 years
Interest rate	6.9%	5.9%
Lending rate	80% of CAPEX	80% of CAPEX

Idem to e-taxis

The following table compares the financial results with and without a concessional loan.

Table 32: Impact of Concessional Loan Conditions

Parameter	e-LCV
TCO financial old	0.38
TCO financial new	0.37
FIRR old	-46%
FIRR new	-46%
Additional equity old	125%
Additional equity new	105%
Discounted Payback in years old	never
Discounted Payback in years new	never

Source: Grutter Consulting

The concessional loan does not improve the situation which is not surprising given the fact that the current loan for EVs has comparable conditions.

Investment Grant

An upfront grant of 20% on the total initial investment with concessional finance is modelled. The following table shows the impact of an upfront grant.

Table 33: Impact of 20% Upfront Grant (concessional financial conditions)

Parameter	e-LCV
TCO financial old	0.38
TCO financial new	0.31
FIRR old	-46%
FIRR new	-39%
Additional equity old	125%
Additional equity new	None
Discounted Payback in years old	Never
Discounted Payback in years new	Never

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO is now lower but still above the level of diesel units;
2. The FIRR is still negative;
3. Owners capital requirements are 0;

4. The risk and the capital exposure of the entrepreneur is not reduced significantly.

It can be concluded that the grant does not resolve the major commercial investment problems. Diesel LCVs have very low operational costs and a high energy efficiency. Electric versions still have a very high CAPEX with prices however decreasing quickly. The differential CAPEX is however not recovered even with incentives levels as modelled. Report 3 will look at the market development of prices to assess at which stage commercial viability of e-LCVs might be closer.

5. Possible Investment Projects

5.1. Urban Buses

5.1.1. Barriers and Interventions Options

The Strategic Plan for E-Mobility states in Table 2 around five general barriers for the deployment of EVs (charging infrastructure, vehicle registration, power sub-sector, institutional, times required for administrative procedures when importing an EV). They do not apply specifically to the deployment of e-buses with exception of regulatory issues which is already being addressed currently in the country

Public transportation in Santo Domingo has been going through some important restructuration process, unifying individual operators into bigger consortiums that will operate on established bus lanes. Many of these, have significant fleets and will be replacing part of their fleet in the short term in order to be able to compete for the operation on some of the main bus corridors. One of the biggest barriers identified for the deployment of e-buses is the additional CAPEX. An option that could be used is the SPV under creation of FIMOVIT – Fideicomiso de Movilidad y Transporte,. This option has also been presented in the strategic plan.

Another barrier identified is the lack of capacities in the institutions and the operators when it comes to making decisions on which BEB would be more suitable for the routes. Since a series of BRT lanes are being structured, there is a window of opportunity to work together with INTRANT and the operators in order to find the optimal technology for each corridor (dimensioning of the battery pack, charging facilities, training of drivers and maintenance personal etc.)

As seen in the previous chapter, with the current prices for the electricity in the Dominican Republic, the TCO for e-buses remains higher than for diesel buses. Defining a preferential tariff for electricity for e-buses could be an important incentive to kick-start EV deployment.

5.1.2. Potential Investment Projects

The following table list identified potential investment project for Dominican Republic.

Table 34: Potential Investment Projects e-Buses Dominican Republic

ID	Ownership	Project	Nu. of units	Estimated CAPEX	Estimated GHG impact[7]	Timeline
1	Private	Caribe tours	150 9-11m buses	37 MUSD	110,000 tCO_{2e} reduced	2022
2	Public	OMSA (Metropolitan Bus Service Office)	38 18m buses and 112 13m buses	62 MUSD	120,000 tCO_{2e} reduced	2023

Source: Grutter Consulting: Details see Excel sheet

The following financial intervention instruments are proposed for e-bus deployment in Dominican Republic:

- 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/CAF finance, a long tenure (12 years or longer), and a high loan share (80% of total investment). This should be capable to cut interest rates by 50%.

The Dominican Republic uses a large number of mid-sized buses for inter-urban services which operate at a low to moderate mileage and which are used for a long time period. This results in low comparative costs of diesel units. E-buses for this segment are commercially not attractive yet and will require massive subsidies. The relatively high electricity costs, combined with low mileage, high average speed, and small units are all unfavourable conditions for a commercial electrification of bus services. In report 3 the BAU price development of e-buses will be matched with the financial profitability of units and the actions of the program to improve market access and reduce entry barriers related e.g. to performance risks. This will allow to identify the market potential and the appropriate timing for interventions to not only have a one-time batch of e-buses but a sustainable influx of this technology.

5.2. Taxis

5.2.1. Barriers and Intervention Options

The deployment of e-taxis faces two technology related barriers:

- Investments in e-taxis are financially risky and not profitable.
- 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.

The following table lists potential investment projects.

[7] Cumulative lifespan of units

Table 35: Potential Investment Projects e-Taxis Dominican Republic

ID	Ownership	Project	Nu. of units	Estimated CAPEX	Estimated GHG impact[8]	Timeline
1	Private	APOLO taxi	150 taxis	6 MUSD of which 1 MUSD for charging infrastructure	11,000 tCO_{2e} reduced	2022-2025
2	Private	Zero Emission RD	80 Uber vehicles	3 MUSD of which 0.5 MUSD for charging infrastructure	6,000 tCO_{2e} reduced	2023

Source: Grutter Consulting: Details see Excel sheet

Taxi projects can potentially be made commercially viable with incentives and with establishment of fast-charging infrastructure. This option will be further assessed in report 3.

5.3. LCVs

5.3.1. Barriers and Intervention Options

The deployment of e-LCVs faces following major barriers:

- Investments in e-LCVs are financially risky and not profitable.
- 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.
- Ownership structures are often a barrier as vehicles are owned by individual drivers and not by the logistics companies or by the cargo company.
- Diesel LCVs have very low operational costs and a high energy efficiency. Electric versions still have a very high CAPEX with prices however decreasing quickly. The differential CAPEX is in general not recovered even with incentives levels.
- Relatively high electricity prices in the country.

The following table lists potential investment projects.

Table 36: Potential Investment Projects e-LCVs Dominican Republic

ID	Ownership	Project	Nu. of units	Estimated CAPEX	Estimated GHG impact[9]	Timeline
1	Private	Energy Consulting and Solutions, ENCOS; Fleet of LCVs in Santo Domingo and Santiago	250	Investment and GHG impact are very much dependent on size of LCVs which has not yet been defined by the project		2022-2025
2	Private	DHL	30 (6 per year)	2 MUSD (based on 2t load vehicle)	1,000 tCO_{2e} reduced	2021-2026

Source: Grutter Consulting: Details see Excel sheet

Concessional finance and grants at levels potentially possible for the GCF do not resolve the major commercial investment problems of LCVs. Diesel LCVs have very low operational costs and a high energy efficiency. Electric versions still have a very high CAPEX with prices however decreasing quickly. Report 3 will look at the market development of prices to assess at which stage commercial viability of e-LCVs might be closer.

[8] Cumulative lifespan of units
[9] Cumulative lifespan of units

6. TA intervention Areas and Instruments

6.1. TA Actors in E-Mobility

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

AFD and European Union

AFD together with the European Union have been supporting the Greater Area of Santo Domingo in their peruse of reducing GHG emissions in the transport sector. In September 2020, they have committed to further support the implementation of the actions specified in the SUMP for Santo Domingo (also developed with AFD funding) with 10 Million Euros. Some actions include structuring the bus network, improving road connections, creating a pedestrian/cyclist network, road planning and traffic management. Likewise, organizing services and intermodality, establishing an integrated and social fare policy, managing demand and modernizing the vehicle fleet are among the objectives of the SUMP .

Feasibility studies are to be conducted for the establishment of bus lanes, capacity building as well as pilot projects. [10]

German Cooperation Agency GIZ

Through the project "Energetic Transition in the Dominican Republic", financed by the German Ministry of Environment, GIZ has been working together with the Dominican Government (specifically with the Ministry of Energy and Mines, as well as other 16 counterparts from the energetic sector, to implement measures that promote renewable energies and reduce CO_2 Emissions in the country.

The project focuses on four different components i) legal framework and communication, ii) financing of renewable energies, iii) Climate Change Policies and MRV iv) capacity building in grid integration and v) pilot projects.

Although there are no specific lines of action for e-mobility, it does lay the groundwork for the transition, since the diversification of the energy matrix with renewables plays out in more GHG reductions with EVs. Currently, the GIZ hired a consultancy to elaborate technical norms for e-mobility in the Dominican Republic and another one to establish differentiated tariffs for EV Charging. Both of them are expected to conclude within six months from now. [11]

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. [12]

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[10] https://intrant.gob.do/index.php/noticias/item/655-afd-y-union-europea-destinan-fondos-al-intrant-para-acciones-de-movilidad-sostenible
[11] https://transicionenergetica.do/lineas-de-trabajo/integracion-energias-renovables-variables/
[12] https://movelatam.org/

InterAmerican Development Bank (IDB)

IDB has been a strategic ally in the transition towards e-mobility. They financed and developed the “National Strategic Plan for e-Mobility” together with INTRANT and the Ministry of Energy and Mines. This plan describes in depth the current panorama for electric vehicles in the Dominican Republic, identifies barriers and enables and defines some of the next steps to be taken by several actors in the energy and the transport sector (one of them being, the regulation for the charging stations and the establishment of differentiated tariffs). The plan has added value in terms of the discussion around e-mobility.

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 Strategic Action Plan (INTRANT, 2020), specifies four areas of intervention with a total of 27 activities. The four areas are: 1. Legal Framework, 2. Capacity Building, 3. Charging Infrastructure and 4. Public and Private Vehicles. The activities have already widely been discussed with the stakeholders and are therefore a binding guideline to define the logical framework for the project to be executed by the GIZ. Some of the most important areas that have been discussed and will be developed further in report 3 are:

- 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 the public transport sector, and adaptation of bus concession contracts and bus tariff structures.
- Implementation of a pilot project with e-buses and LCVs in Santo Domingo.
- Information and knowledge dissemination as well as advisory services to companies and public entities interested in investing in LCVs.
- 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.

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Annexes

Electricity Prices

Parameter	Value	Unit
Electricity price home charging	0.17	USD/kWh
Electricity price fast chargers	0.30	USD/kWh
Electricity price consumption medium tension	0.11	USD/kWh
Electricity price consumption medium tension	0.11	USD/kWh
Power charge	5.4	USD/kW
Power charge	5.4	USD/kW

Tarifa MTD2; https://sie.gob.do/images/sie-documentos-pdf/marco-legal/resoluciones-sie/2017/SIE-004-2017-TF_-_Fijacion_TF_UR_EDESUR_EDEESTE_EDENORTE_FEB_2017.pdf

Calculation for buses

Average electricity price overnight charged buses	0.163	USD/kWh
Average electricity price fast charged buses	0.16	USD/kWh

Finance Costs

Parameter	Value	Unit
Loan term	7	years
Commercial interest rate	13%	
concessional interest rate	7%	
loan spread	2%	

in USD; see IDB, 2020, p.55 based on private cars Banco popular

General Parameters			
Parameter	**Value**	**Unit**	**Source**
NCV of diesel	43	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of diesel	74.1	gCO_2/MJ	IPCC, 2006, table 1.4
Density of diesel	0.844	kg/l	IEA, 2005
Well-to-tank mark-up factor diesel	23%		UNFCCC, 2014, Table 3
NCV of CNG	48	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of CNG	56.1	gCO_2/MJ	IPCC, 2006, table 1.4
Density of NG	0.714	kg/m^3	IGU, 2012
Well-to-tank mark-up factor CNG	18%		UNFCCC, 2014, Table 3
Methane slip as % of NG consumption TTW	1.1%		Average low and high value of ICCT, 2015, table 4 for crankcase and tailpipe
Methane slip as % of NG consumption WTW	3.4%		Average low and high value of ICCT, 2015, table 4 for well-to-pump and fuelling station plus TTW slip
NCV of gasoline	44.3	MJ/kg	IPCC, 2006, table 1.2
CO_2 emission factor of gasoline	69.3	gCO_2/MJ	IPCC, 2006, table 1.4
Density of gasoline	0.741	kg/l	IEA, 2005
Well-to-tank mark-up factor gasoline	19%		UNFCCC, 2014, Table 3
GWP_{100} of BC	900		Bond, 2013; see also IPCC, 2013, Table 8.A.6
GWP_{100} of CH_4	28		IPCC, 2013, Table 8.A.
BC fraction Euro 2 gasoline passenger car and LCV	25%		EEA, 2020, tabla 3-92
BC fraction Euro 4 gasoline passenger car and LCV	15%		
BC fraction Euro 2 diesel passenger car and LCV	80%		
BC fraction Euro 4 diesel passenger car and LCV	87%		
BC fraction Euro II HDV	65%		
BC fraction Euro IV HDV	75%		
BC fraction Euro 1 Motorcycle	25%		
BC fraction Euro 2 Mot	25%		
Conversion kWh to MJ	3.6	MJ per kWh	https://home.uni-leipzig.de/energy/energy-fundamentals/03.htm#:~:text=Power%20units%20can%20be%20converted,%3D%203.6%20MJ%20%5B
Battery manufacturing emissions	110	$kgCO_2/kWh$	ICCT, 2018, table 1 (per kWh battery set); average value not taking into account 2nd life usage of batteries

TCO 12m Bus

Parameter	Value	Unit	Source
Distance driven per bus per annum	61,200	km	OMSA urban bus operator (180km/d)
Workday distance driven daily	198	km	based on 10% more than average of 180km/d
Specific electicity usage	1.1	kWh/km	Chinese average; ADB, 2018; includes AC
Diesel usage	44	l/100km	default Euro IV Tier 3 COPERT with 15km/h
Maintenance cost diesel bus incl. labor and tyres	0.07	USD/km	Various operators
Lifespan bus diesel	16	years	default 1 million km
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	130,000	USD	Standard Euro IV bus; Caribe tours
CAPEX overnight charged e-bus	274,000	USD	Based on bus with 350 kWh battery set and sur-cost for battery size
CAPEX slow-charged batteries	200	USD/kWh	LFP batteries
CAPEX fast-charged BEB	240,000	USD	Based on standard fast-charged bus
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%20m
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 125 USD/m2 labour)
Cost grid connection of chargers	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
Maintenance & repair cost of e-buses relative to diesel incl. labour	70%		Based on experience in PR China; ADB, 2018; 10% higher tyre costs; 75% lower maintenance staff and general maintenance; 20% lower repair and spare parts
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	198
Energy usage day	kWh	218
Risk ratio (higher energy consumption)		10%
Reserve ratio		20%
SOC loss year 8		20%
Battery size required year 8	**kWh**	**370**

Charging required at bus depot overnight

Parameter	Unit	Value
Battery capacity	kWh	370
Average daily consumption workday	kWh	218
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	50

Option B: Fast Charging

Parameter	Unit	Value
Battery size	kWh	200
C-rate		0.65
Charging in 30 minutes	kWh	65
Average re-charge during day required with 20% reserve ratio	kWh	58
Average share of day electricity		27%
Fast-charger	kW	300
Power conversion efficiency of chargers		90%
Average required re-charge day with 300 kW charger	minutes	13
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

TCO Buses

12m standard bus, USD 2019

Parameter	Diesel	BEB overnight	BEB fast
CAPEX bus	130,000	274,000	240,000
CAPEX charging infrastructure	0	8,500	12,113
CAPEX grid connection	0	30,000	30,000
CAPEX depot upgrade	0	7,500	7,500
Total CAPEX	130,000	320,000	289,613
Battery replacement yr 8	0	37,000	25,000
Energy cost yr 1	19,119	10,969	10,969
Maintenance cost bus yr 1	4,284	2,999	2,999
Maintenance cost infra yr 1	0	920	992
Finance cost average per year	7,509	8,257	7,232
Economic costs yr 1	4,747	1,731	1,731
TCO financial per km	0.57	0.67	0.62
TCO economic per km	0.66	0.70	0.66

timespan of calculation: lifespan of e-buses with replacement investment for fossil buses; end of life value proportional to remaining lifespan

Finance costs based on concessional loan

TCO 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	77,500	km	310 wd
Daily mileage	250	km	apolo taxi
Charging at home average	70%		Assumption; only re-charge if above-average mileage or night shifts
Charging fast-chargers	30%		
CAPEX gasoline taxis	12,700		https://www.supercarros.com/hyundai-elantra/1123656/
CAPEX e-taxi	35,700		https://www.carrosrd.com/carros/Nissan/Leaf/SV/I-20994
Capex home charger 7.4kW	2,000	USD	Nissan LEAF large battery or BAIC
Gasoline consumption	7.3	l/100km	https://www.fueleconomy.gov/feg/PowerSearch.do?action=noform&path=1&year1=2019&year2=2019
Electricity consumption	0.16	kWh/km	Nissan LEAF https://ev-database.org/car/1106/Nissan-Leaf
Charger lifespan	10	years	
Maintenance cost gasoline	0.01	USD/km	https://www.autocarindia.com/car-news/car-maintenance-cost-comparison--part-2-premium-and-exec
Maintenance cost total e-taxi	0.004	USD/km	40% lower than gasoline
Loan tenure	7	years	Banco popular, see IDB, 202o, p.55
Loan share taxi	80%		
Interst rate fossil	13%		
interst rate electric	7%		

gasoline versus e-taxi

Parameter	gasoline	e-taxi
CAPEX vehicle	12,700	35,700
CAPEX charger	0	2,000
Total CAPEX	12,700	37,700
Energy cost	5,313	2,573
Maintenance cost	775	310
Finance cost average per loan year	734	1,076
Economic costs yr 1	637	319
Lifespan in years	10	10
TCO financial per km	0.10	0.09
TCO economic per km	0.11	0.10

LCVs

1. Diesel Van

Parameter	Value	Unit	explanation
CAPEX van	39,900	USD	https://www.supercarros.com/peugeot-boxer/973849/
Diesel fuel consumption	6.2	l/100km	https://motoreu.com/peugeot-boxer-combi-2.0-bluehdi-mpg-fuel-consumption-technical-specifications-58411#:~:te
Maintenance cost	0.02	USD/km	average price
Lifespan	6	years	DHL
Daily distance driven	142	km	DHL
Annual distance	46,800	km	DHL

2. E-Van

Parameter	Value	Unit	explanation
CAPEX e-van	79,800	USD	Peuegeot e-boxer
Range WLTP	180	km	https://commercialvehiclecontracts.co.uk/news/latest-vehicle-announcements/peugeot-e-boxer-revealed; small bat
Battery size	37	kWh	
Cost battery	7,400	USD	Based on 200 USD/kWh per battery
electricity consumption	0.19	kWh/km	WLTP
Maintenance cost	0.01	USD/m	50% of fossil (as only engine maintenance is included; no tyres, no repairs)
Lifespan van	6	years	assumed same as fossil
Lifespan battery	6	years	
Capex home charger 7.4kW	2,000	USD	
Lifespan charger	20	years	
Charging at home average	90%		Assumption
Charging fast-chargers	10%		Exceptional if long distances were made

fossil versus e-van

Parameter	diesel	e-van
CAPEX vehicle	39,900	79,800
CAPEX charger	0	2,000
Replacement battery cost	0	7,400
Total CAPEX	39,900	81,800
Energy cost	2,060	1,580
Maintenance cost	800	400
Finance cost average per year	2,305	2,405
Economic costs yr 1	900	223
Lifespan in years	6	6
TCO financial per km	0.24	0.38
TCO economic per km	0.26	0.38