Assessment of Commercial EV Demand in Argentina

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Abbreviations

AC	Air Conditioning
AFD	French Development Agency
BAU	Business As Usual
BEB	Battery Electric Buses
CAF	Development Bank of Latin America
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CF	Cash Flow
CNG	Compressed Natural Gas
EIRR	Economic Internal Rate of Return
EV	Electric Vehicle
FA	Financial Assistance
FI	Financial Intermediary
FIRR	the Financial Internal Rate of Return
GCF	Green Climate Fund
GHG	Greenhouse Gases
GIZ	German International Cooperation
IDB	Inter-American Development Bank
IEA	International Energy Agency
LCV	Light Commercial Vehicle
OPEX	Operational Expenditures
PTA	Public Transport Authority
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 Argentina from materializing the market potential.

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

Pilot tests with buses, taxis as well as LCVs are under realization. The Government of the Province of Mendoza has also implemented a project with 18 electric buses. As part of the Clean Mobility Plan 2035 by the City of Buenos Aires to improve public transportation in the city, a pilot test with alternative bus propulsion technologies was realized with support of CAF including 2 e-buses[1]. Andreani, a local logistics company, has conducted a pilot test using two Renault Kangoo ZE electric vehicles, monitored in collaboration with the Government of the City of Buenos Aires. The Government of the City of Buenos Aires also operates two such vehicles. Private electric vehicles are still very few in the country[2].

3. Commercial EV Market Potential in Argentina

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

[1] https://scioteca.caf.com/handle/123456789/1687

[2] For more information on pilots see Report 1, chapter 4

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[3].

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

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	1,300	9,400
Market share (% of stock)	4%	27%
Sales share (% of new registrations)	22%	100%

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

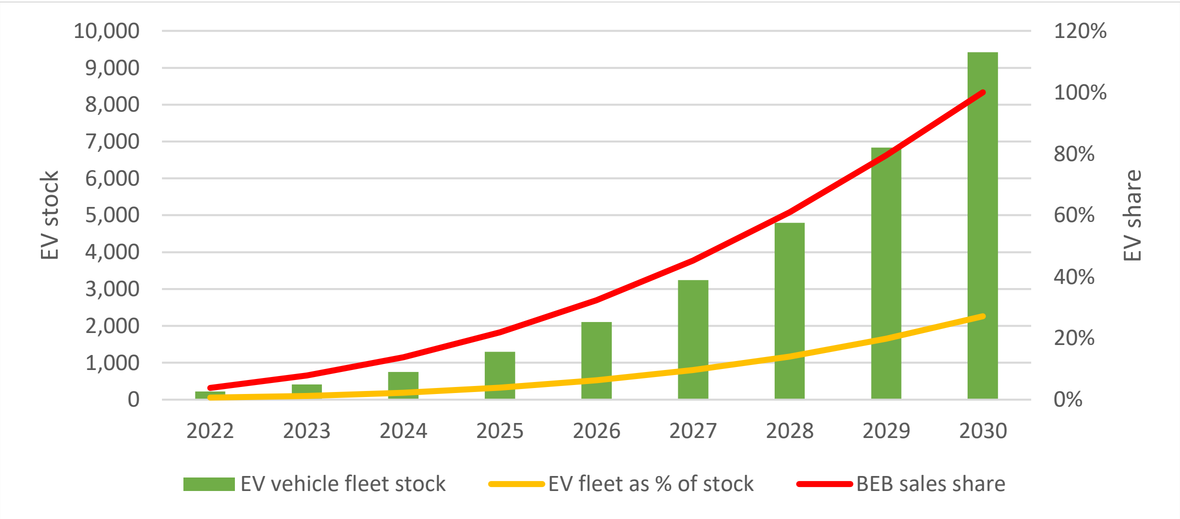
With a high growth scenario a market share of around 27% is targeted by 2030 equivalent to more than 9,000 electric buses operating in the country. The main parameters for the high growth market potential are outlined in the following table.

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

Parameter	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock buses	32,449	32,723	33,000	33,279	33,560	33,844	34,130	34,419	34,710
New registered BEBs	92	192	341	544	809	1,142	1,549	2,038	2,586
Stock BEBs	219	411	752	1,295	2,104	3,246	4,795	6,833	9,418
Share BEBs of stock	1%	1%	2%	4%	6%	10%	14%	20%	27%

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

Figure 1: Urban Electric Bus High Growth Scenario

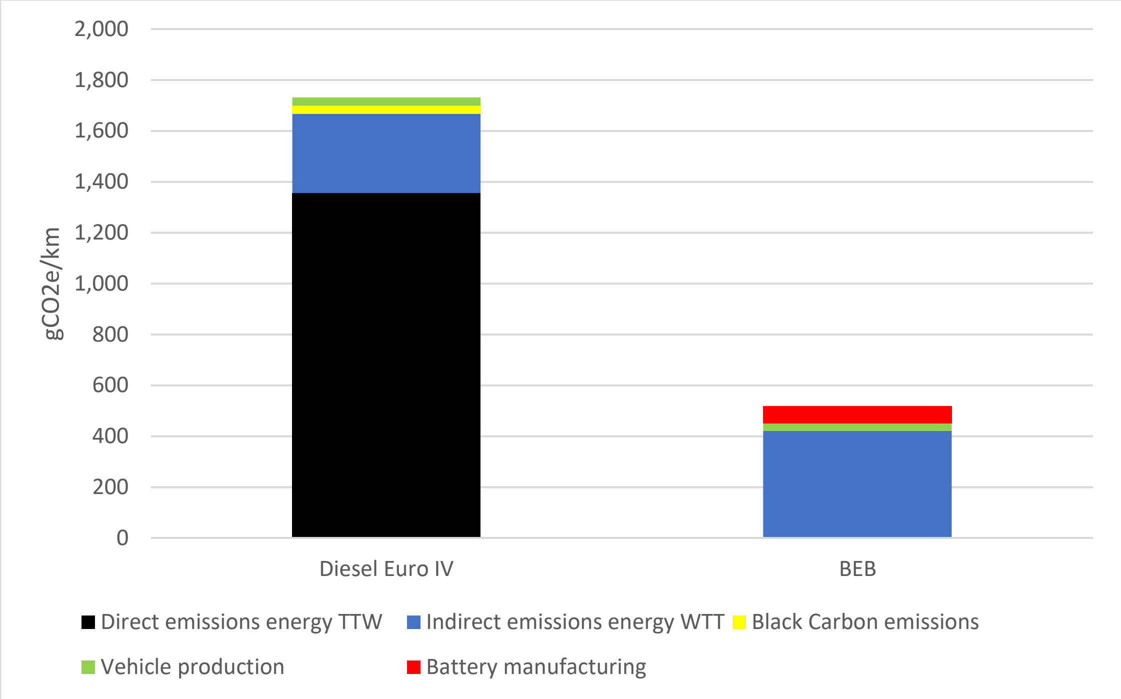


Source: Grutter Consulting

[3] For details on scenarios see Country Diagnostic Report Argentina

A BEB can reduce well-to-wheel (WTW) Greenhouse Gas (GHG) emissions in Argentina by 75% and cradle to grave emissions by 70% 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 Argentina

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	12,000	92,000
Market share (% of stock)	5%	39%
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.

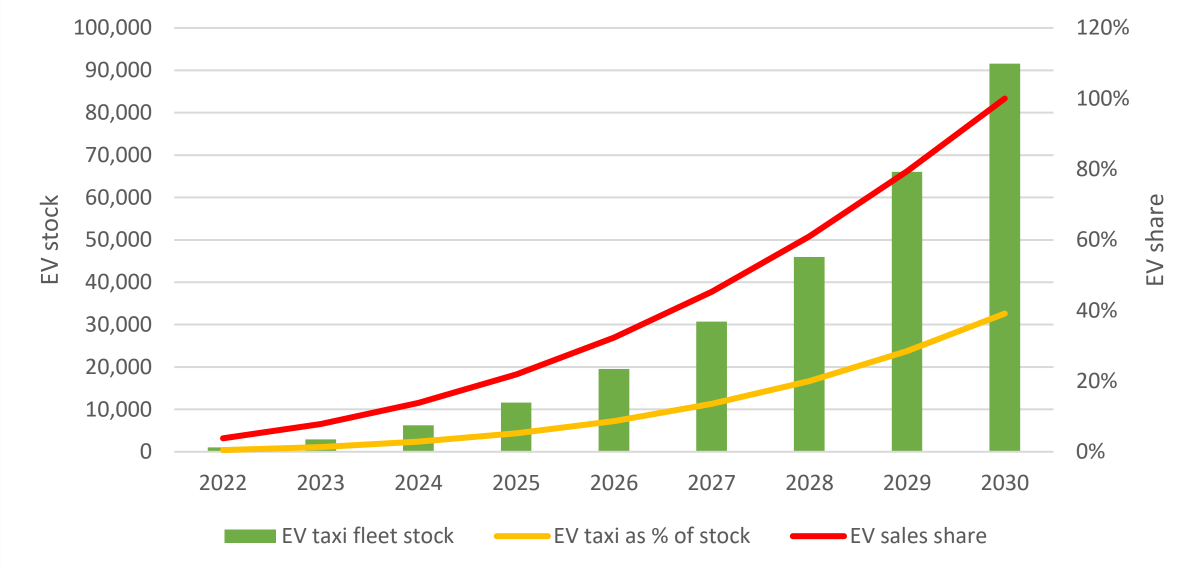
Table 4: High Growth Scenario Electric Taxis 2022-2030

Parameter	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock taxis	215,829	218,025	220,244	222,486	224,750	227,037	229,348	231,682	234,040
Sales e-taxis	900	1,878	3,328	5,323	7,930	11,215	15,244	20,082	25,526
Stock e-taxis	1,052	2,930	6,258	11,581	19,510	30,725	45,969	66,050	91,577
Share e-taxis of stock	0%	1%	3%	5%	9%	14%	20%	29%	39%

Source: Grutter Consulting

As of 2030 around 90,000 e-taxis would be electric with this scenario.

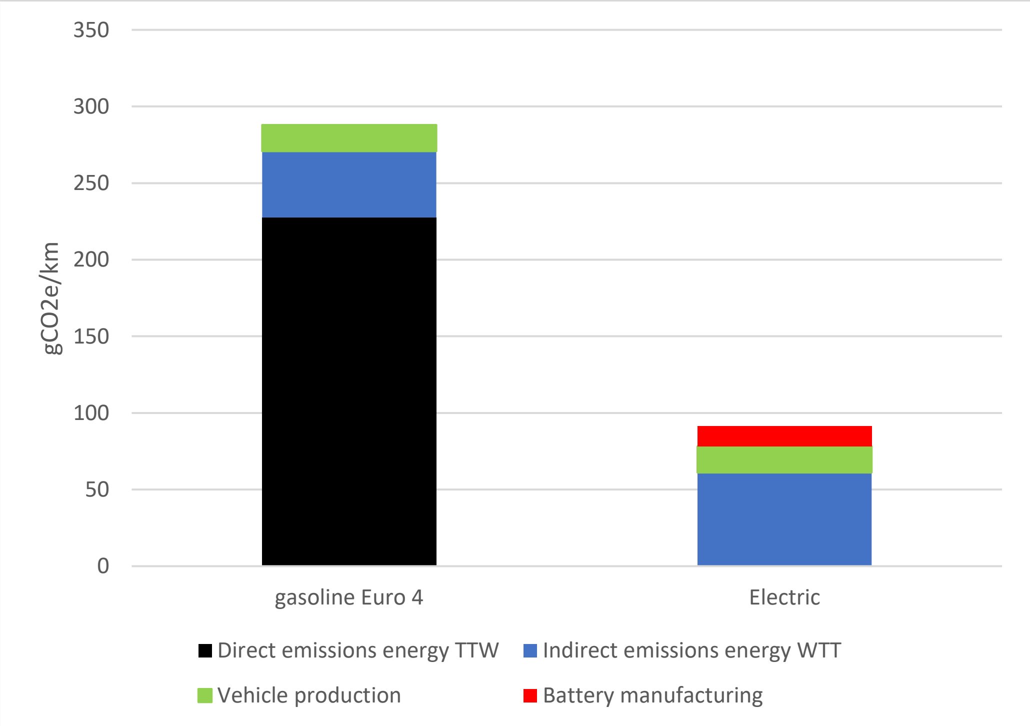
Figure 3: Electric Taxi High Growth Scenario



Source: Grutter Consulting

An electric taxi can reduce WTW emissions in Argentina by 77% and cradle to grave emissions by 68% (see figure below).

Figure 4: GHG Impact Electric Taxi



Source: Grutter Consulting; mileage and energy consumption based on values for Argentina

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	40,000	320,000
Market share (% of stock)	3%	21%
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.

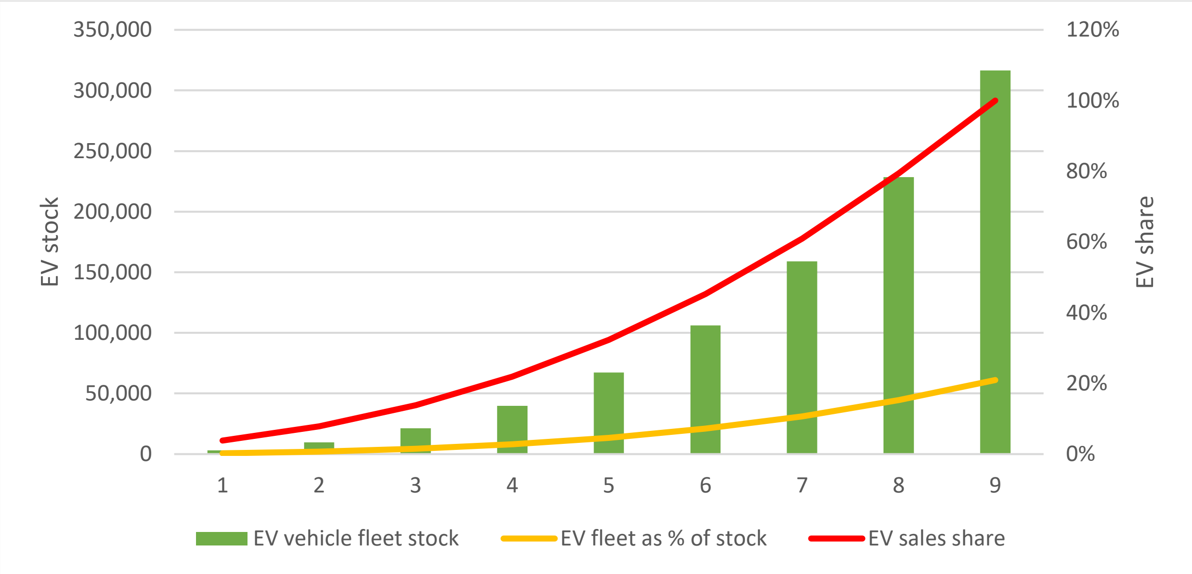
Table 6: High Growth Scenario Electric LCVs 2022-2030

Parameter	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stock LCVs	1,409,209	1,421,638	1,434,177	1,446,826	1,459,587	1,472,461	1,485,448	1,498,550	1,511,767
Sales e-LCVs	3,142	6,545	11,586	18,505	27,530	38,882	52,780	69,437	88,145
Stock e-LCVs	3,190	9,735	21,321	39,825	67,355	106,237	159,018	228,455	316,600
Share e-LCVs of stock	0%	1%	1%	3%	5%	7%	11%	15%	21%

Source: Grutter Consulting, report 1

As of 2030 more than 300,000 e-LCVs would operate in Argentina with this scenario.

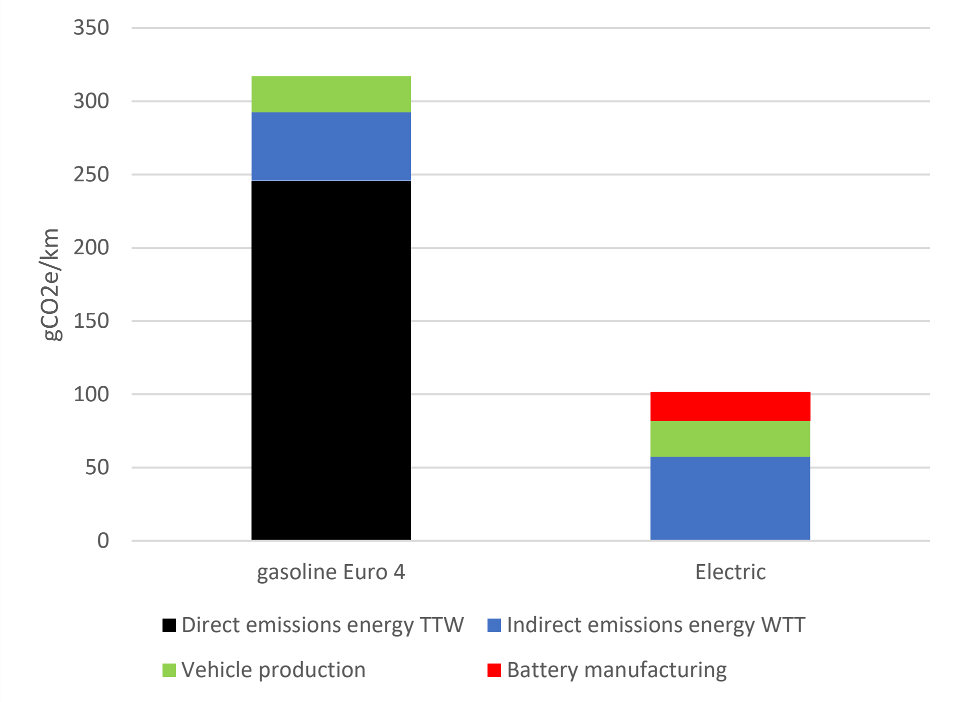
Figure 5: LCV High Growth Scenario



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 and as already tested in Argentina (Renault Kangoo) an electric LCV can reduce WTW emissions in Argentina by 80% and cradle to grave emissions by 68% (see figure below).

Figure 6: GHG Impact Electric LCV



Source: Grutter Consulting; mileage and energy consumption based on values for Argentina

4. Financial Assessment of Commercial EVs in Argentina

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 Argentina;
- 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. 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 Argentina for the transport sector.

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

Parameter	Value	Source
Cost of equity	16.2%	(UNFCCC, 2019); value for transport sector of Argentina
Share of equity financing	20%	Banks are willing to finance 80% with loans
Cost of debt	14%	Based on (Hinicio, 2020) Banco Provinicia
Share of debt financing	80%	Banks are willing to finance 80% with loans
Corporate tax rate	30%	Deloitte, 2020
WACC	11.1%	Calculated

4.2. Financial Analysis E-Buses

4.2.1. General Data

Calculations are realized for the standard bus as used in Argentina which is a 12m low-floor entry bus unit with 2 access doors. For the standard bus a diesel option is calculated. 2 options for BEBs have been included in the calculations:

- An overnight charged BEB with a battery set of 450 kWh[4];
- 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.

The following tables indicate the diesel bus specific values, the overnight BEB and the fast-charged BEB specific values. The annual mileage of the bus assumed for all technologies is 71,000 km[5].

Table 8: Baseline Fossil Bus Parameters

Parameter	Value	Source
Diesel usage	50 l/100km	(Hinicio, 2020)
Maintenance cost diesel bus	0.21 USD/km	(Hinicio, 2020)
Cost of diesel	0.75 USD/l	https://www.globalpetrolprices.com/
CAPEX diesel bus	160,000 USD	(Hinicio, 2020) incl. VAT of 10.5%
Lifespan fossil bus	14 years	1 million km standard value

Table 9: BEBs Common Parameters

Parameter	Value	Source
Specific electricity usage	1.1 kWh/km	Chinese average; (ADB, 2018); includes AC usage
Maintenance cost	0.20 USD/km	(ADB, 2018) based on 70% of diesel bus cost
Lifespan bus	16 years	2 years more than diesel
Lifespan battery @ 80% SOH	8 years	current guarantee levels of batteries
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

[4] 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.

[5] Source: Based on (Hinicio, 2020)

Table 10: BEB Overnight Charged Bus

Parameter	Value	Source
CAPEX bus	400,000 USD	Based on bus with 450 kWh battery set and sur-cost for battery size; includes 35% import tax (on 70% of sales value) and 10.5% VAT
CAPEX batteries	200 USD/kWh	LFP batteries
Battery capacity	450 kWh	Calculated based on workday range with sufficient
Charger power	60 kW	Calculated based on available charging time and daily average electricity usage

Table 11: BEB Fast Charged Bus

Parameter	Value	Source
CAPEX bus	340,000 USD	Based on standard fast-charged bus; includes 35% import tax (on 70% of sales value) and 10.5% VAT
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 12: TCO Calculations (USD of 2020)

Parameter	Diesel	BEB overnight	BEB fast
CAPEX bus	160,000	398,750	343,750
CAPEX charging infrastructure	0	9,700	12,113
CAPEX grid connection	0	30,000	30,000
CAPEX depot upgrade	0	7,500	7,500
Total CAPEX	**160,000**	**445,950**	**393,363**
Battery replacement yr 8	0	45,000	31,250
Energy cost yr 1	26,838	3,593	3,593
Maintenance cost bus yr 1	14,555	10,189	10,189
Maintenance cost infra yr 1	0	944	992
Finance cost average per year	10,683	26,623	22,951
Economic costs yr 1	6,852	1,194	1,194
TCO financial per km	**0.82**	**0.83**	**0.74**
TCO economic per km	**0.93**	**0.85**	**0.76**

Source: Grutter Consulting

Following conclusions are drawn:

- Comparing total costs over the bus lifetime BEBs have a comparable or even lower TCOs than diesel units;
- 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 13: Capital Demand (USD of 2020)

Capital investment BEB relative to CNG bus (per unit)	BEB overnight		BEB fast-charged	
	Absolute	%	Absolute	%
Additional capital investment	-285,950	179%	233,363	146%
Additional loan demand	-191,000	149%	147,000	115%
Additional equity requirement	-94,950	297%	86,363	270%

Source: Grutter Consulting

BEBs require a 2x higher capital investment than diesel buses[6]. Loans are currently only available for the bus component and limited to 80% of the capital. This means loans will increase by around factor 1.5. 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. 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.

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 5% and of fast-charged BEBs of 9% which is below the WACC of 11% i.e. BEBs are not profitable.
- The EIRR is 9% respectively 13%.

The investment in BEBs is thus not profitable enough to reach the WACC level 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.

[6] 2x higher capital investment is identical to incremental 100%

In both cases the discounted payback shows that the initial incremental investment is not recovered during the asset lifetime of 16 years.

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 for overnight charged units over the lifetime of the asset and for a fast-charged unit it only turns positive in year 15. This is also due to requiring re-investment in batteries in year 8 and in chargers in year 10.

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	Comparable for fossil and electric units	Non-discounted the cumulated lifetime costs for BEBs are comparable to fossil buses
Capital investment	2x of a conventional bus	Significantly higher capital requirement incl. higher loan demand; negative impact on debt to equity ratio
Equity investment	3x of a conventional bus	Significantly higher equity demand which might overstretch the capabilities of small and medium enterprises
Profitability	FIRR below WACC	Investment in e-buses is not profitable.
Discounted Payback	Incremental investment is not recovered with savings during asset lifetime	The investment in e-buses is not profitable and the payback time is 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 Argentina.

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	8 years	12 years
Interest rate	14%	4.6%
Lending rate	80% of bus investment	80% of total investment

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 CAF/co-financers at 6% 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	0.85	0.76
TCO financial new	0.73	0.67
FIRR old	5.0%	8.9%
FIRR new	5.0%	8.9%
Additional equity old	297%	270%
Additional equity new	179%	146%
Discounted Payback in years old	never	never
Discounted Payback in years new	never	13

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO reduces considerably is now clearly below that of diesel buses.
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 significantly. With fast-charged BEBs the investment can be recovered within 13 years.

It can be concluded that the concessional loan helps to resolve 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.

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	0.85	0.76
TCO financial new	0.65	0.60
FIRR old	5.0%	8.9%
FIRR new	11.8%	18.1%
Additional equity old	297%	270%
Additional equity new	none	none
Discounted Payback in years old	never	never
Discounted Payback in years new	10	7

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO reduces considerably with values now much lower than for diesel buses.
2. The FIRR increases significantly and is now above the WACC for all types of BEBs indicating a profitable investment.
3. Owners capital requirements are reduced significantly.
4. The risk and the capital exposure of the entrepreneur is reduced greatly. The incremental investment is recovered within 7-10 years which is considered to be a reasonable time-frame.

It can be concluded that the grant combined with the concessional loan resolves fully the profitability and risk issue.

4.3. Financial Analysis E-Taxis

4.3.1. General Data

Calculations are realized for the standard gasoline taxi as used in Argentina. The following tables indicate the general parameters, the fossil taxi specific values, and the e-taxi specific values. The average mileage assumed of taxis is 50,000 km.

Table 18: Baseline Gasoline Taxi Parameters

Parameter	Value	Source
Gasoline usage	10.0 l/100km	urban fuel consumption; https://autodata24.com/renault/logan/logan/16-i-90-hp/details
Maintenance cost	0.02 USD/km	Value for Renault Logan
CAPEX	15,500 USD	Renault Logan: https://www.renault.com.ar/automoviles/logan.html
Lifespan	10 years	500,000 km usage

Table 19: E-Taxi Parameters

Parameter	Value	Source
Specific electricity usage	0.16 kWh/km	Nissan LEAF or BAIC taxi
Maintenance cost	0.01 USD/km	40% below fossil
Lifespan	10 years	Idem fossil taxi
Lifespan battery @ 70% SOH	10 years	Idem lifespan taxi
Home charging share	70%	Assumption; only re-charge if above-average mileage or night shifts
Public fast-charging share	30%	
CAPEX e-taxi	37,500 USD	Nissan LEAF large battery or BAIC; includes import tax
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 20: TCO Calculations (USD of 2020)

Parameter	gasoline	e-taxi
CAPEX taxi	15,500	37,500
CAPEX charging infrastructure	0	2,000
Total CAPEX	**15,500**	**39,500**
Energy cost	4,150	732
Maintenance cost	1,000	600
Finance cost average p.a. during loan term	1,035	2,504
Economic costs of emissions year 1	323	122
Lifespan in years	10	10
TCO financial per km	**0.15**	**0.15**
TCO economic per km	**0.16**	**0.15**

Source: Grutter Consulting

Comparing total costs over the taxi lifetime 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	24,000	155%
Additional loan requirement	19,200	155%
Additional equity requirement	4,800	155%

Source: Grutter Consulting

E-taxis require a capital investment factor 2.5 of a gasoline unit. The required equity increases by the factor 2.5. This can place a serious problem for taxi owners. The investor could opt for purchasing 2 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 12% and above the WACC of 11%.
- The EIRR is 14%.

The investment in e-taxis is thus profitable but only marginally.

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 is only positive by year 10 i.e. at the end of the asset lifetime.

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	Comparable for e-taxis to gasoline units	Non-discounted the cumulated lifetime costs for e-taxis are comparable to 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	12%	Investment in e-taxis is profitable
Discounted Payback	Incremental investment is not recovered	This indicates a high risk profile of the investment.
Cash Flow	Negative cumulative CF up to year 10	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.

Summarized the investment in e-taxis with current financial conditions and business models is profitable but not sufficient concerning the involved risk and equity exposure and thus commercially not viable. 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. 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	8 years	8 years
Interest rate	14%	6.6%
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 CAF/co-financers at 6% 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	0.15
TCO financial new	0.12
FIRR old	12%
FIRR new	12%
Additional equity old	155%
Additional equity new	155%
Discounted Payback in years old	never
Discounted Payback in years new	9

Source: Grutter Consulting

The concessional loan improves the liquidity and is sufficient to make the investment financially attractive.

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.

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

Parameter	e-taxi
TCO financial old	0.15
TCO financial new	0.11
FIRR old	12%
FIRR new	28%
Additional equity old	155%
Additional equity new	0%
Discounted Payback in years old	never
Discounted Payback in years new	6

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO reduces significantly.
2. The FIRR increases significantly.
3. Owners capital requirements are 0.
4. The risk and the capital exposure of the entrepreneur is reduced significantly with a dynamic payback time discounted with the new WACC adjusted to the new loan conditions of 6 years.

It can be concluded that the grant resolves all problems except of potentially reduced income levels. It can be argued that grants are in fact not required for vehicles but could be used exclusively for an urban charging infrastructure.

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 calculation as based on a Renault Kangoo gasoline and electric version as already tested in Argentina. The annual assumed mileage is 23,000km based on DPEC.

Table 26: Baseline Gasoline LCV Parameters

Parameter	Value	Source
Gasoline consumption	10.8 l/100km	Urban usage: https://motoreu.com/renault-kangoo-1.6-16v-mpg-fuel-consumption-technical-specifications-9794
Maintenance	0.04 USD/km	excludes tyres and repairs
CAPEX	16,700 USD	Renault Kangoo; https://www.renault.com.ar/utilitarios.html
Lifespan	15 years	300,000 km lifespan mileage

Table 27: E-LCV Parameters

Parameter	Value	Source
Specific electricity usage	0.15 kWh/km	https://de.renault.ch/elektroautos/kangoo-ze/motoren.html
Maintenance	0.02 USD/km	50% of fossil version
Lifespan	15 years	Same as gasoline version; 1x exchange batteries
Lifespan battery @ 70% SOC	8 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	27,500USD	Renault e-Kangoo; price difference international 8,000 USD plus 35% import tax
CAPEX home charger 7.4kW	2,000 USD	Wall-box installation
Lifetime charger	15 years	Above guarantee level
Battery size	33 kWh	https://de.renault.ch/elektroautos/kangoo-ze/motoren.html
Drive range electric (maximum)	260 km	https://de.renault.ch/elektroautos/kangoo-ze/motoren.html

4.4.2. TCO

The following table shows the results of the TCO calculation.

Table 28: TCO Calculations (USD of 2020)

Parameter	Gasoline	e-LCV
CAPEX LCV	16,700	27,500
CAPEX charging infrastructure	0	2,000
Replacement battery cost in year 7		6,600
Total CAPEX	**16,700**	**29,500**
Energy cost	2,062	209
Maintenance cost	850	425
Finance cost average p.a. during loan term	1,115	1,970
Economic costs of emissions year 1	281	53
Lifespan in years	15	15
TCO financial per km	**0.19**	**0.18**
TCO economic per km	**0.20**	**0.18**

Source: Grutter Consulting

Comparing total costs over the LCV lifetime have comparable financial and economic TCOs to 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).

Table 29: Capital Demand (USD of 2020)

Comparison e-LCV to gasoline LCV	Absolute	%
Additional capital investment	12,800	77%
Additional loan	10,240	77%
Additional equity	2,560	77%

Source: Grutter Consulting

E-LCVs require nearly double the capital investment compared to gasoline 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 10% and slightly below the WACC.
- The EIRR is 14%.

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 gasoline unit. Only cash outflows are considered as revenues (cash inflows) are identical between an e-LCV and a gasoline unit. The cumulative CF is positive from year 9 onwards. This means that the company will have a positive liquidity impact from year 9 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 30: Summary Financial Assessment e-LCVs

Criteria	Result	Assessment
TCO	Comparable TCOs of e-LCVs	
Capital investment	80% higher than a conventional LCV	Higher capital requirement incl. higher loan demand
Equity investment	80% higher than a conventional LCV	Higher equity demand
Profitability	10%	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	Positive from year 9	The investment in e-LCVs has during a long period a cumulative negative liquidity impact

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	8 years	8 years
Interest rate	14%	6.6%
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 CAF/co-financers at 6% interest rate plus 2% spread of the national banking system

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	0.18
TCO financial new	0.15
FIRR old	10%
FIRR new	10%
Additional equity old	77%
Additional equity new	77%
Discounted Payback in years old	never
Discounted Payback in years new	8

Source: Grutter Consulting

The concessional loan improves the liquidity situation and the TCOs significantly. However the profitability is still below the WACC.

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.

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

Parameter	e-LCV
TCO financial old	0.18
TCO financial new	0.13
FIRR old	10%
FIRR new	40%
Additional equity old	77%
Additional equity new	no equity
Discounted Payback in years old	never
Discounted Payback in years new	4

Source: Grutter Consulting

Following impacts can be observed:

1. The TCO is now significantly lower than for gasoline units;
2. The FIRR is higher and above the WACC including concessional finance i.e. the investment is now profitable;
3. Owners capital requirements are lower than with a gasoline unit;
4. The risk and the capital exposure of the entrepreneur is reduced significantly with a dynamic payback time (discounted with the new WACC) at 4 years which is short.

It can be concluded that the grant resolves all commercial investment problems. The magnitude of the grant could however be reduced by factor 2 (10% instead of 20%).

5. Possible Business Models Investment Projects

5.1. Urban Buses

5.1.1. Barriers and Possible Business Models

Two main barriers to the implementation of electric buses are identified: i) the cost of the initial investment in the bus and its financing conditions; ii) the cost of the associated infrastructure (charging station). By having a reliance of 87% on fossil fuel and big CNG reserves to exploit, Argentina faces challenges on adding renewable sources to their electricity matrix. The Ministry of Transport also favours, at least in the short term, fostering of CNG buses.

The asset separation model could be an instrument to alleviate the financial investment barriers identified. Report 3 will also look at other alternative business and delivery models.

The asset separation model proposes to open the participation of new actors in the bus procurement and operation system to implement electric mobility projects. Traditionally, private participation is limited to the operators of the routes, but under this new business model it is possible to involve new actors that can invest in one or more components of the project: vehicle fleet, recharging infrastructure or even the adaptation of bus depots for electric mobility. The main advantage of this model is that capital costs are divided, which is one of the barriers identified for electromobility projects, and it also favors the reduction of capital access costs.

In this model there would be a shareholder or "fleet provider" that would purchase the project assets. The asset owners would lease or rent the assets to the operators, in exchange for a payment. This means that, unlike traditional fleet acquisition, in this model the operators would not make the fleet investment and would not own the equipment.

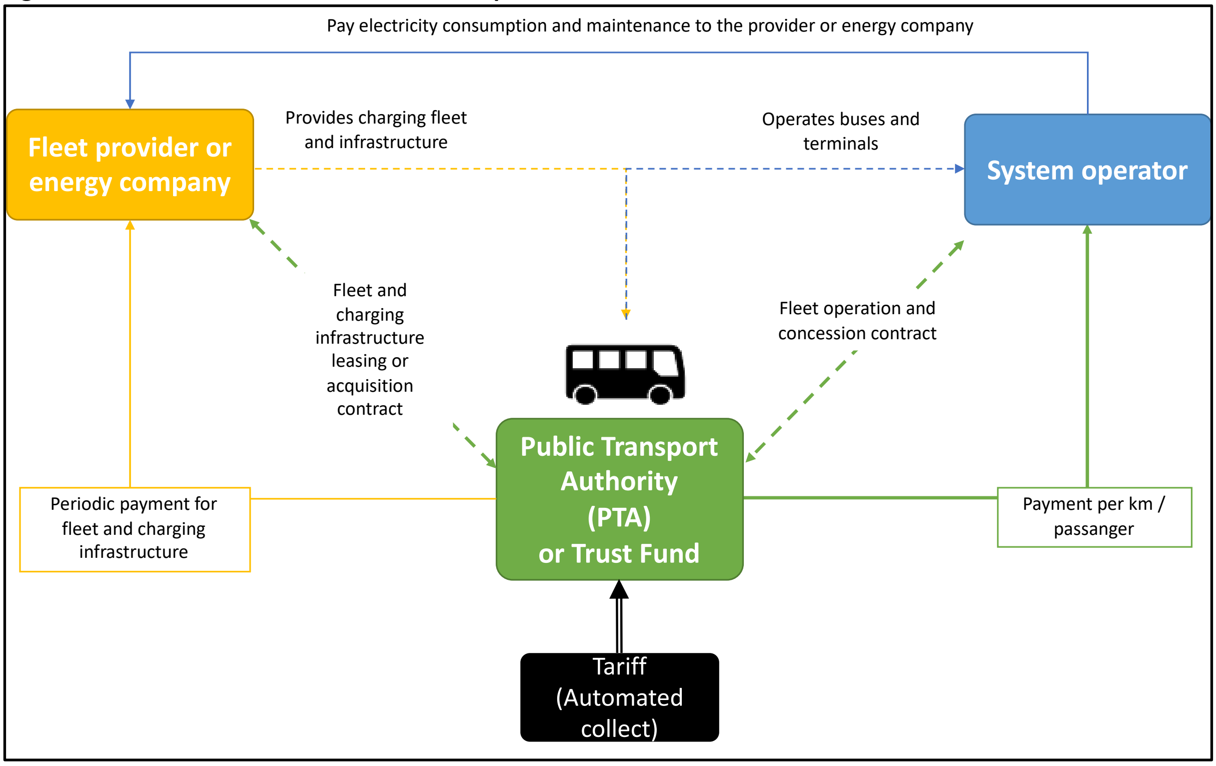
The following sections explain the roles of the actors according to the structure proposed as a business model.

1. **Fleet provider (for example energy company):** is responsible for acquiring the vehicle fleet, the charging infrastructure and its installation. The fleet provider may enter into a lease contract with the transport authority and, if necessary, an asset care and maintenance contract with the operator. This actor will finance the fleet through its own resources, as well as the acquisition of debt. The financing arrangements are their full responsibility.
   The fleet provider will receive a lease payment, which includes the acquisition value of the assets, finance charges and a profit margin. The payment of the lease payments will be the responsibility of the lessee, which in this case will be the management company or transport authority in the city where the project is implemented. The lease contract is expected to have an extension of 15 years, preferably in coordination with the concession period assigned to the operator of the units.

2. **Vehicle fleet operator:** is responsible for the operation of the service and will have a legal relationship with the transport authority, or managing company, through a service provision contract during the concession period, which could eventually be 15 years.
   The operator is responsible for paying other operating expenses such as personnel, energy consumption and other services associated with the operation. It is worth mentioning that in the asset separation model, the vehicle fleet operator could be remunerated through a payment per kilometer that covers its operating costs and a profit margin.

3. **Transport authority (PTA) or Trust Fund:** it is the one who signs the contracts with the project participants, makes the various payments according to the payment priorities and centralizes the collected fare resources. Depending on the type of contract established with the vehicle fleet provider, the transport authority could also be the owner of the assets.
   For this model to be attractive and successful, a secure source of payment is required, a situation that would attract new investors, especially for those interested in the vehicle fleet supply process. This could be achieved through the establishment of guarantees by national or local governments, which would generate lower risk conditions for investors in the face of possible unexpected variations in demand, for example.

Figure 7: Business Models Based on Asset Separation



Source: Grutter Consulting

5.1.2. Potential Investment Projects

The following table lists potential bus investment projects for Argentina.

Table 34: Potential Investment Projects e-Buses Argentina

ID	Ownership	Project	Nu. of units 2023 to 2027	Estimated CAPEX	Estimated GHG impact[7]	Timeline
1	Public	Transportation Company of Mendoza	36 12m buses	15 MUSD	68,000 tCO_{2e} reduced	2022 to 2025
2	Public	Municipal Automotive Transport State Society of Cordoba	40 18m buses	30 MUSD	75,000 tCO_{2e} reduced	2022-2025
3	Public	Low Emissions Program. Government of the City of Buenos Aires	300 12m units	126 MUSD	440,000 tCO_{2e} reduced	2022-2026
4	Public	Transportation Secretariat of the Municipality of Rosario	50 12m units	21 MUSD	73,000 tCO_{2e} reduced	2023-2027

Source: Grutter Consulting: Details see Excel sheet

Report 3 will list the potential investment projects suggested for investment with the fund including the GCF contribution part. The following financial intervention instruments are proposed for e-bus deployment in Argentina:

[7] Cumulative lifespan of units

- 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 CAF and co-finance, a long tenure and a high loan share (80% of total investment). This should be capable to cut interest rates by more than 60%.

5.2. Taxis and LCVs

5.2.1. Barriers and Intervention Options

The deployment of electric taxis and LCVs faces following major barriers:

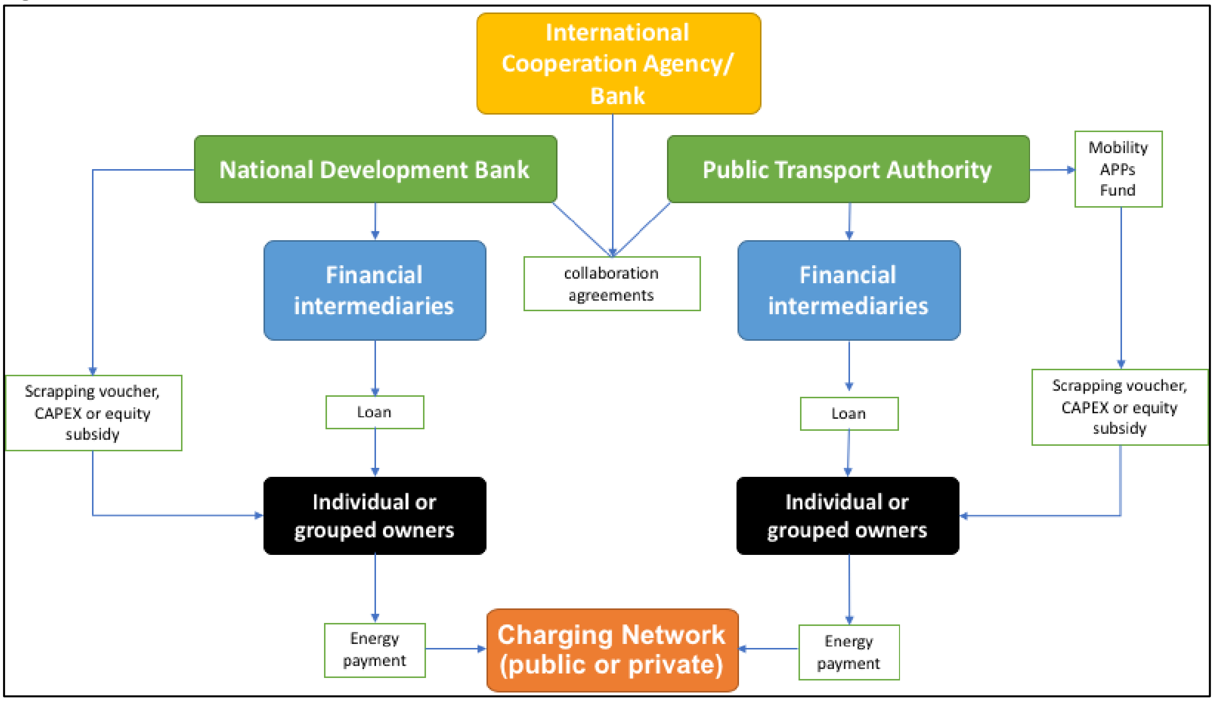
- E-taxis require a capital investment factor 2.5 of a gasoline unit. The investor could opt for purchasing 2 gasoline units instead of 1 electric one thus increasing considerably his revenue and profit base.
- Investments in e-LCVs are financially risky and not profitable.
- Lack of an urban fast-charging network in case of necessity. The same fast-charging network could be potentially used by taxis, cars as well as LCVs.
- For LCVs lack of information and know-how of options and possibilities of e-mobility in this area. Some 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 for electric LCVs as vehicles are owned by individual drivers and not by the logistics companies or by the cargo company.

5.2.2. Possible Business Model

The traditional model for the acquisition of Taxis and LCVs has been characterized as being entirely the responsibility of the individual owner or the entrepreneur grouping more than one vehicle. In this case, the traditional financial sector, or even vehicle sales agencies, are the ones who directly finance the owners. However, for the massification of electromobility in this market segment, additional incentives are needed to reduce the difference in the cost of gasoline or gas vehicles compared to electric vehicles.

The proposed model consists of the generation of Taxis or LCVs renewal programs with support to the owner to reduce the difference in CAPEX and stimulate the acquisition of electric vehicles. Here it is important the role that local development banks and transport authorities can play, as institutions that lead the structuring of this type of vehicle renewal programs, coordinating financing from banks or international cooperation agencies, and focusing the programs, in coordination with national and international development banks, to individual users or informal micro-entrepreneurs, who are usually considered by financial institutions as not creditworthy.

Figure 8: Possible Business Model for e-Taxis and LCVs



Source: Grutter Consulting

These would be the main roles played by each of the actors involved:

1. **International Cooperation Agency or Bank:** contributes with funding mechanisms or lines of credit to national development banks with favorable credit conditions compared to commercial banks. They can also collaborate in the design of vehicle fleet renewal programs (Taxis, LCVs, and even public transport) and in the identification of transport authorities that may be interested.

2. **National Development Bank:** creates lines of credit and establishes cooperation agreements with local transportation authorities to carry out the renovation programs. It is also in charge of selecting and contracting the intermediary financial entities that will operate the program and establish direct links with the atomized owners. Depending on the availability of resources, development banks may also offer direct incentives to vehicle owners through vouchers for scrapping or through subsidies for the payment of equity or CAPEX.

3. **Public Transport Authority:** creates lines of credit and establishes cooperation agreements with local transportation authorities to carry out the renovation programs and make the rules and credit conditions clear to individual operators. It is also in charge of selecting and contracting the intermediary financial entities that will operate the program, and of setting specific criteria on the users that can be part of the project.

4. **Financial intermediaries:** receive resources from both the development banks and the transportation authority, and place loans directly to the atomized owners. These intermediaries are directly responsible for the collection of loans.

This business model necessarily requires the creation of a public or taxi-preferential fast charging infrastructure network, so that individual owners have sufficient incentive to ensure continuous operation throughout the day without resorting to long empty trips to look for charging stations. This is mentioned because failed projects have already been identified in Latin America (Chile, Mexico), where the charging network was minimal and generated many inconveniences for Taxi drivers.

LCVs are very diverse with most operated by private entities but also many public or semi-public units such as for the postal service, utilities or municipal services. The financing structure above would be basically for the private sector. Whilst large companies not necessarily need loans, smaller companies and individual vehicle owners do require that.

The practical experience with LCVs is still very limited. Initial pilot projects with different vehicle categories and types will be required to eliminate the information barrier and know-how on EV possibilities. The design of complementary programs can contribute to accelerate the entry of electric vehicles in urban areas. For example, the creation of 0-Emissions zones, e.g. within historical centers, can encourage the purchase of LCVs by the private sector.

5.2.3. Potential Investment Projects

The following table lists potential taxi/LCV investment projects for Argentina.

Table 35: Potential Investment Projects e-Buses Argentina

ID	Ownership	Project	Nu. of units 2023 to 2027	Estimated CAPEX	Estimated GHG impact[8]	Timeline
1	Public	Transportation Secretariat of the Municipality of Rosario	30 taxis	1.1 MUSD of which 0.9 MUSD vehicles & 0.2 MUSD charging network MUSD	3,000 tCO_{2e} reduced	2023-2025
2	public	EPEC (Provincial Energy Company of Cordoba)	40 taxis	1.5 MUSD of which 1.2 MUSD vehicles & 0.3 MUSD charging network MUSD	4,000 tCO_{2e} reduced	2022-2024
3	public	Government of the Province of Mendoza	50 taxis	1.9 MUSD of which 1.5 MUSD vehicles & 0.4 MUSD charging network	5,000 tCO_{2e} reduced	2022-2026
4	public	DPEC (Provincial Energy Directorate of Corrientes)	25 LCVs	0.7 MUSD	2,000 tCO_{2e} reduced	2022-2025
5	public	EPEC (Provincial Energy Company of Cordoba)	100 LCVs	2.7 MUSD	8,000 tCO_{2e} reduced	2022-2025
6	public	Municipality of Cordoba	30 waste collection trucks	15 MUSD	59,000 tCO_{2e} reduced	2022-2026
7	public	Municipality of Rosario	30 waste collection trucks	15 MUSD	59,000 tCO_{2e} reduced	2022-2026

[8] Cumulative lifespan of units

In report 3 a taxi program will be structured around the pipeline project with concessional loans for taxis (no grants) and grants/concessional loan for the charging infrastructure. For LCVs a project will be structured also around a loan program combined with TA and pilot program activities.

The following financial intervention instruments are proposed for e-taxi and e-LCV deployment in Argentina:

- Grant facility covering up to 50% of the CAPEX of urban fast charging infrastructure designed for taxis and LCVs;
- Highly concessional loans for urban fast charging infrastructure with participation from the GCF blended with loans from CAF.
- For vehicles concessional loans from the GCF @ 0.75% which are blended with CAF and co-finance, a long tenure, and a high loan share (80% of total investment).
- For public commercial vehicles e.g. waste collection trucks grant facilities covering up to 20% of investment costs.

In report 3 the BAU price development of e-taxis and e-LCVs 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 EVs but a sustainable influx of this technology.

6. TA intervention Areas and Instruments

6.1. TA Actors in E-Mobility

Development Bank of Latin America (CAF)

Within the Clean Mobility Plan 2035 of the city of Buenos Aires, a pilot project of battery electric buses is being carried out, which will incorporate for a one-year period, eight units of different technologies on bus lines 12, 34, 39 and 59. This test seeks to evaluate the technical-economic and environmental feasibility of these buses in order to establish normative and economic frameworks that promote the inclusion of such vehicles in the public transport system. The evaluation of these vehicles has the support of CAF. The results will be key to decide whether to include more electric buses in the metropolitan area of Buenos Aires, which has more than 18,000 buses in operation and represents one of the largest fleets in Latin America.[9]

Another on-going initiative by the CAF, withing its project "LAIF Ciudades y Cambio Climático", is a pre-investment study for the implementation of sustainable transport in the cities of Santa Fe, Córdoba and Rosario.[10] The two main focus points are (i) possible optimization of the public transport system and (ii) calculating the CO_2 emissions with optimizations. The feasibility of incorporating electric buses is thereby considered.

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

[9] https://movelatam.org/wp-content/uploads/2019/06/MOVE-Regional-Report-2018-EN.pdf
[10] https://www.caf.com/media/2678922/laif-sei-transporte-ciudades-clean-10-07.pdf

initiative also gives a yearly overview about recent developments regarding e-mobility in every country in Latin America.[11]

Euroclima+

Euroclima+ is a European response for addressing climate change in Latin America. With the financial contributions from German Cooperation, Spanish Cooperation and French Cooperation they are committed to supporting environmental sustainability and climate resilient development. In Argentina their involvement has mainly been within legislative and regulatory frameworks. In 2018 Euroclima+ assisted in the creation of a national strategy for electric transportation.[12] They also supported in 2019 the formulation of a proposal for a national law for electric mobility.[13]

InterAmerican Development Bank (IDB)

Withing electric transportation sector, the IDB started supporting in April 2020 a pilot project by the company Voltu Motor Inc. in Buenos Aires, to test the conversion / retrofitting of fossil fuel buses, into electrical units. According to Voltu, the prototype is going to have a price tag comparable to conventional internal combustion busses with the same lifetime. The goal of this initiative it to prove the technical, economic and market feasibility of this business model.[14]

6.2. Possible TA Interventions within the E-Motion Program

The following technical assistance activities are deemed important to create favourable market conditions for mass deployment of e-buses[15]:

- 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 reduce barriers to initial investment 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.
- 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.
- Developing an information platform about e-mobility for Argentina.
- Roadmap for e-bus deployment which includes concrete steps and goes beyond just establishing targets.

For taxis and LCVs development of roadmaps plus design of charging infrastructure and business models such as leasing. For LCVs pilot projects are also suggested for different vehicle categories. A

[11] https://movelatam.org/
[12] http://euroclimaplus.org/estrategias-nacionales-de-movilidad-electrica-colombia-argentina-y-panama
[13] http://euroclimaplus.org/apoyo-en-el-desarrollo-de-marcos-legislativos-y-regulatorios-en-materia-de-movilidad-electrica
[14] https://www.iadb.org/en/project/AR-T1239
[15] Details will be elaborated in report 3

segment of interest for Argentina is also the usage of electric waste disposal vehicles which have a considerable GHG next to pollution and noise impact. This could be realized through a FA but supported previously with a TA which could include a pilot testing of such vehicles[16].

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[16] See for more details report 3

Annex: Calculation Details

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

Electricity Prices

Parameter	Value	Unit
Electricity price home charging	0.045	USD/kWh
Electricity price fast chargers	0.2	USD/kWh
Bus electricity cost	0.046	USD/kWh
Electricity price consumption buses or medium tension industry night off peak	0.046	USD/kWh
Power charge night per month	7	USD/kW
Power charge day off-peak per month	15	USD/kW

Calculation for buses

Average electricity price overnight charged buses	0.05	USD/kWh
Average electricity price fast charged buses	0.05	USD/kWh

Hinicio, 2020

TCO 12m Bus

Parameter	Value	Unit	Source
Distance driven per bus per annum	71,000	km	Hinicio, 2020
Workday distance driven daily	238	km	Default
Specific electicity usage	1.1	kWh/km	Chinese average; ADB, 2018; includes AC but not heating
Diesel usage	50	l/100km	Hinicio, 2020
Maintenance cost diesel bus incl. labor excl tyres	0.21	USD/km	Hinicio, 2020
Lifespan bus diesel	14	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	160,000	USD	Hinicio, incl. VAT of 10.5%
CAPEX overnight charged e-bus	398,750	USD	Based on bus with 350 kWh battery set and sur-cost for battery size; includes 35% import tax (based
CAPEX slow-charged batteries	200	USD/kWh	LFP batteries
CAPEX fast-charged BEB	343,750	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
Maintenance & repair cost of CNG buses relative to diesel incl. labour	120%		Based on CNG and diesel bus operators
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	238
Energy usage day	kWh	262
Risk ratio (higher energy consumption)		10%
Reserve ratio		20%
SOC loss year 8		20%
Battery size required year 8	**kWh**	**450**
Charging required at bus depot overnight		
Parameter	**Unit**	**Value**
Battery capacity	kWh	450
Average daily consumption workday	kWh	262
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	60

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	62
Average share of day electricity		24%
Fast-charger	kW	300
Power conversion efficiency of chargers		90%
Average required re-charge day with 300 kW charger	minutes	14
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	160,000	398,750	343,750
CAPEX charging infrastructure	0	9,700	12,113
CAPEX grid connection	0	30,000	30,000
CAPEX depot upgrade	0	7,500	7,500
Total CAPEX	160,000	445,950	393,363
Battery replacement yr 8	0	45,000	31,250
Energy cost yr 1	26,838	3,593	3,593
Maintenance cost bus yr 1	14,555	10,189	10,189
Maintenance cost infra yr 1	0	944	992
Finance cost average per year	10,683	26,623	22,951
Economic costs yr 1	6,852	1,194	1,194
TCO financial per km	0.82	0.83	0.74
TCO economic per km	0.93	0.85	0.76

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	50,000	km	average based on model
Daily mileage	161	km	Based on 310 working days
Charging at home average	70%		Assumption; only re-charge if above-average mileage or night shifts
Charging fast-chargers	30%		
CAPEX gasoline taxis	15,500		https://www.renault.com.ar/automoviles/logan.html
CAPEX e-taxi	37,500		Nissan LEAF large battery or BAIC incl. tax
Capex home charger 7.4kW	2,000	USD	Nissan LEAF large battery or BAIC
Gasoline consumption	10.0	l/100km	urban fuel consumption; https://autodata24.com/renault/logan/logan/16-i-90-hp/details
Electricity consumption	0.16	kWh/km	Nissan LEAF https://ev-database.org/car/1106/Nissan-Leaf
Charger lifespan	10	years	
Maintenance cost gasoline	0.02	USD/km	average rate exckl. Tyre and repairs
Maintenance cost total e-taxi	0.012	USD/km	40% lower than gasoline

gasoline versus e-taxi

Parameter	gasoline	e-taxi
CAPEX vehicle	15,500	37,500
CAPEX charger	0	2,000
Total CAPEX	15,500	39,500
Energy cost	4,150	732
Maintenance cost	1,000	600
Finance cost average per loan year	1,035	2,504
Economic costs yr 1	323	122
Lifespan in years	10	10
TCO financial per km	0.15	0.15
TCO economic per km	0.16	0.15

LCVs

1. Petrol Van

Parameter	Value	Unit	explanation
CAPEX van	16,700	USD	Renault Kangoo; https://www.renault.com.ar/utilitarios.html
Petrol fuel consumption	10.8	l/100km	urban: https://motoreu.com/renault-kangoo-1.6-16v-mpg-fuel-consumption-technical-specifications-9794
Maintenance cost	0.04	USD/km	excludes tyres and repairs;
Lifespan	15	years	Based on annual mileage
Daily distance driven	70	km	DPEC
Annual distance	23,000	km	DPEC

2. E-Van

Parameter	Value	Unit	explanation
CAPEX e-van	27,500	USD	Renault e-kangoo; preice difference international 8,000 USD plus 35%
Range WLTP	260	km	https://de.renault.ch/elektroautos/kangoo-ze/motoren.html
Battery size	33	kWh	
Cost battery	6,600	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	16,700	27,500
CAPEX charger	0	2,000
replacement cost batter		6,600
Total CAPEX	16,700	29,500
Energy cost	2,062	209
Maintenance cost	850	425
Finance cost average per year	1,115	1,970
Economic costs yr 1	281	53
Lifespan in years	15	15
TCO financial per km	0.19	0.18
TCO economic per km	0.20	0.18

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