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This document will discuss the Financial and Ecnomic Analysis of Transjakarta's Plan for Electrification of bus fleets

Building a Regulatory and Financial Basis for Transjakarta First Phase E-bus Deployment

Task 4.4 & 4.5: Financial, Economic, and Cost Benefit Analysis of Transjakarta Electrification

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List of Abbreviations

AB	Articulated Bus
BAU	Business-As-Usual
BRT	Bus Rapid Transit
BTS	Buy The Service
BUMD	*Badan Usaha Milik Daerah* (Regional-Owned Company)
CAPEX	Capital Expenditure
CAPM	Capital Asset Pricing Model
CEF	Credit Enhancement Facility
CFF	Cities Finances Facility
CNG	Compressed Natural Gas
DKI	*Daerah Khusus Ibukota* (Special Capital Region of Jakarta)
E-bus	Electric Bus
EIRR	Economic Internal Rate of Return
EV	Electric Vehicle
GHG	Green House Gases
GoJ	Government of DKI Jakarta
HPS	owners' cost estimate (*Harga Perkiraan Sendiri)*
ICE	Internal Combustion Engine
IDR	Indonesian Rupiah
ITDP	Institute for Transportation and Development Policy
kg	kilogram
km	kilometre
kW	kilowatt
kWh	Kilowatt-hour
LE	Low Entry Bus
LSP	Litre Premium Equivalent
m	metre
MB	Medium Bus
NPV	Net Present Value
OEM	Original Equipment Manufacturer
OJK	Otoritas Jasa Keuangan/Financial Service Authority
OPEX	Operating Expense
p.a.	Per annum/per year
PLN	*Perusahaan Listrik Negara* (State Electricity Company)
PSO	Public Service Obligation
PT	*Perseoran Terbatas* (Limited Company)
PV	Photovoltaics
Rp	Rupiah
SB	Single Bus
SPV	Special Purpose Vehicle/Company/Entity
TCO	Total Cost Ownership

UK PACT	UK Partnering for Accelerated Climate Transitions
UMP	*Upah Minimum Provinsi* (Province Minimum Wage)
USD	United States Dollar
WACC	Weighted Average Cost of Capital

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Executive Summary

Transjakarta has been mandated by the Government to completely electrify its fleets of 10,047 buses by 2030 and to achieve at least 50% electrification by 2027. Accordingly, a roadmap has been prepared for gradual replacement of diesel/CNG buses and augmentation of fleet by procuring only electric buses from 2023 onwards. This report analyses the financial impact of the said roadmap considering various proposed business/financing models, the impact on the public service obligation (PSO) requirements and the social cost benefit of such transformation vis-à-vis the business-as-usual scenario.

This report relies on the findings of the previous reports namely (i) Report 3.2 and 3.3. on Transjakarta E-Bus Integrated Long-Term Implementation Phase (ii) Report 4.6 on Business models, Structured Financing Scheme, and Contractual framework of Transjakarta for first phase of large-scale electrification (iii) Report 4.1 on Detailed Technical Plan under the UK PACT EUM 124 - Phase II "Building a Regulatory and Financial Basis for Transjakarta's First Phase E-bus Deployment" Project.

The report evaluates the financial feasibility using Net Present Value of the difference of total pay-outs by Transjakarta between the Business as Usual (BAU) scenario and the following scenarios for deployment of electric buses:

- Option 1: E-buses are procured by Operators directly and deployed through BTS contract
- Option 2: E-buses are financed by Transjakarta/SPV and leased to operators
- Option 3: E-buses are procured by Transjakarta or the Operators through lease financing
- Option 4: This option uses a combination of the above options for different bus types i.e., Option 1 for Single/Low Entry and Medium buses, Option 2 for Articulated Buses and Option 3 for Microbus. Such an option divides the financing responsibility amongst the Government, Operators and Asset Aggregators/leasing companies and thus making the roadmap more implementable.

The total cash flow considered include the fees payable to operators, loan instalment/interest, insurance premium, lease rentals, asset management costs as applicable under each option but excludes the fare collection costs, cost of operation of the Transjakarta owned fleet under Options 1 and 3, and administrative and general overheads of Transjakarta as those expenses are likely to be same for diesel or electric buses. It should also be noted that the Maxi buses are assumed to be replaced by the Single buses and Royal Trans and tourism services are also excluded from the scope of this analysis based on the discussions with Transjakarta. The annual total pay-outs under the electrification options also include the payment of BTS fee with respect to the diesel fleet that are yet to be replaced with electric buses.

Accordingly, the summary of the financial feasibility analysis is presented below:

Table 1. Difference in NPV from BAU

Type of Bus/Option	Option 1	Option 2	Option 3	Option 4
Articulated Buses	-126	376	-188	376
Low Entry Buses	115	299	0	115
Single Buses	399	943	-358	399
Medium Buses	723	990	391	723
Microbus	3115	5583	5134	5134
Total	**4225**	**8191**	**4978**	**6747**
%age of BAU NPV	10.6%	20.6%	12.5%	16.9%

(Figures in Rp Billion)

The estimated year-wise increase (negative value) or decrease (positive value) in PSO requirements as compared to BAU scenario for various Options for electrification is shown in the table below.

Table 2. Reduction in Operating Subsidy

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Option 1	-11	-15	-23	-13	63	212	457	823	948	1073	1235
Option 2	-13	-11	6	58	172	391	754	1309	1602	1902	2112
Option 3	-32	-49	-63	-87	-31	112	394	811	1078	1352	1511
Option 4	-11	-13	-2	41	144	337	659	1143	1405	1674	1985

(Figures in Rp Billion)

In case the DKI Jakarta/Transjakarta decides to pursue Option 2, the net funding required is shown below.

Table 3. Net Funding Required from Transjakarta in Option 2

Yearly Funding Requirement	2023	2024	2025	2026	2027	2028	2029	2030	Total
Articulated Buses			889	1321	152	175	182	190	2909
Low Entry Buses	113					817	419	90	1439
Single Buses	435	651	134	969	1138	486	471	1600	5883
Medium Buses	193		96	391	476	482	495	760	2894
Microbus		45	87	176	267	485	777	935	2773
Total Investment Cost	**741**	**695**	**1207**	**2857**	**2033**	**2446**	**2345**	**3575**	**15899**

(Figures in Rp Billion)

Overall, all the four options considered are found to be financially feasible as compared to the Business-as-Usual scenario of using ICE buses. **However, it should be noted that the absolute amount of PSO requirement will still increase as compared to current levels due to expansion of the fleet by 2.5 times by 2030 and increase in cost of manpower etc. This analysis only confirms that the overall cost will be lower with electric buses than with ICE buses.**

Scenario analysis was carried out to ascertain the financial robustness of the various options considered. It is seen that, despite various adverse scenarios assumed, the NPV of electrification remains positive in all Options except when electric buses imported from Europe are considered. Option 2 remains the most favourable of all Options followed closely by Option 4. It is also seen that the financial feasibility is most sensitive to changes in Capex associated with the E-buses and is low to moderate sensitive towards changes in electricity prices, maintenance costs or cost of funds. Also, it is seen that the alternate roadmap which accelerates the e-bus deployment has a higher NPV as compared to the base case scenario.

The social cost benefits analysis shows that electrification of Transjakarta's fleet will result in reduction of GHG emissions, Noise and SOx/NOx/$PM_{2.5}$ emissions within the Jakarta city due to reduction in combustion of fossil fuels, foreign exchange outgo in importing motor fuels as well as reduction in public transport fuel subsidy burden on Government of Indonesia. However, these benefits are offset to an extent by the increased GHG and SOx/NOx/$PM_{2.5}$ emissions from electricity generating plants using fossil fuels. In order to maximise the benefit of electrification of the buses, there needs to be integration of renewable energy sources for charging of the buses. The Government of Indonesia also needs to bring down emissions from the coal-based power plants at least to the level of similar Asian countries like China or India.

The social cost/benefit of electrification is summarised in the table below.

Table 4. Social Cost-Benefit of Electrification

Parameter	Unit	2031	(2024-2034)
Reduction in GHG Emissions	‘000 Tons	288	1779
Reduction in SOx Emissions	Tons	(154)	(1160)
Reduction in NOx Emissions	Tons	2657	17,800
Reduction in $PM_{2.5}$ Emissions	Tons	(9.7)	(69.3)
Reduction in Foreign Exchange Outgo	USD Million	75	457
Reduction in Fuel Subsidy	IDR Billion	1089	6760
Economic IRR		34%	
Cost Benefit Ratio		2.41	

Overall, it is concluded that the electrification roadmap of Transjakarta is both financially and economically viable and needs to be implemented promptly to maximise the benefits. Integration of renewable energy in charging of e-buses and reduction of pollution from coal power plants will further increase the social benefits of this conversion. It is recommended that Transjakarta pursues different business/financing models for different types of buses as shown below:

Table 5. Financial models for different type of buses

Bus Type	Responsibility	Financial Model
Articulated Buses	Transjakarta	Self-financing through (Government Funding/Loans) or Leasing
Single/Low Entry Buses/Medium Buses	Operator (Loans/Leasing)	Own Equity + Bank Loans/Leasing
Microbus	Operator	Leasing (facilitated by Transjakarta)/Own Funds

1. Introduction

1.1. Background

Transjakarta has been mandated by the Government to completely electrify its fleets of 10,047 buses by 2030 and to achieve at least 50% electrification by 2027. Accordingly, a roadmap has been prepared for gradual replacement of diesel/CNG buses and augmentation of fleet by procuring only electric buses from 2023 onwards. This report will analyse the financial impact of the said roadmap considering various proposed business/financing models. The report will also estimate the impact on the public service obligation (PSO)/subsidy requirements considering the business as usual and the electrification scenarios. The social cost benefit analysis will consider the non-financial aspects of the project such as emissions, health affects etc.

1.2. Objectives of the Report

The objective of this report is to evaluate the financial and economic viability of the electrification roadmap prepared for Transjakarta under Task 3.2. & 3.3. (Report on Transjakarta E-Bus Integrated Long-Term Implementation Phase, "***The Roadmap***") and estimate the public service obligation (PSO)/Subsidy support needed for the same vis-à-vis the business-as-usual scenario. This report is a part of a series of reports under the UK PACT EUM 124 - Phase II "Building a Regulatory and Financial Basis for Transjakarta's First Phase E-bus Deployment" Project.

1.3. Scope of the Report

The scope of the report includes the evaluation of cost of funds of the fund channelling schemes. The fund channelling schemes are presented in Task 4.6: Business models, Structured Financing Scheme, and Contractual Framework of Transjakarta first-phase of large-scale electrification. Additionally, this report will also discuss the financial feasibility and social cost benefit analysis of the roadmap prepared for electrification of Transjakarta's ICE bus fleet. It encompasses estimation of the capital and operating expenditures associated with the electric buses over the life cycle/contract period of the assets based on the roadmap using different business models/fund channelling schemes and compared with the "business as usual" (BAU) i.e., operating diesel/CNG buses under the "buy the service scheme". It also enumerates various social benefits not captured in to the financial analysis and quantification of the same to the extent possible. Public transport projects which are otherwise not financially viable, are supported by the government based on their economic viability.

1.4. Evaluation Methodology

The evaluation methodology is based on comparison of Net Present Value of various options for the financial feasibility analysis and economic IRR and Benefit Cost Ratio for the social cost benefit analysis (SCBA). Further, this analysis is being carried out to ascertain financial feasibility of the project for Transjakarta. The cost elements for Transjakarta (e.g., lease fee or BTS Fee) are revenue elements of the service providers and while estimating the costs, the cost of funds/profit expectations are assumed to determine the fee that the service provider will charge to ensure financial viability based on present norms. Except in case of Option 2 (as explained later on in this report), no investments are made by Transjakarta and hence Financial IRR or project IRR cannot be calculated for Transjakarta.

1.5. Outline of the Report

The report begins by recapitulating the previous work done in Section 2 which forms the basis for this report. In Section 3, the cost of funds of each fund channelling schemes will be evaluated to inform the financial feasibility analysis that will be done in the subsequent sections. In Section 4, the total financial outgo for the period 2024-2034 for Transjakarta in the business as usual (BAU) scenario using ICE buses under the BTS scheme is estimated for comparison with the various Options for electrification of Transjakarta fleet. Similarly, the total cash outflow for Transjakarta is estimated under various business model options to replace the ICE buses with an electric bus fleet and compared with that in BAU.

Section 5 shows the effect of various scenarios on the financial feasibility of the project using conservative and pessimistic assumptions. In addition to financial feasibility, the social aspects of the electrification project also need to be evaluated. This is done in section 6. The following section enumerates various possible risks associated with the electrification of bus fleet and the report ends with conclusion and recommendations.

2. Recap of previous work

2.1. Implementation Roadmap

The Governor Decree has mandated a target of the 50% electrification of Transjakarta's bus fleet by 2027 and 100% electrification by 2030. Transjakarta's current business model is acquiring fleet through "buy the service" or BTS contracts. Its own fleet as well as contractual fleet are due for replacement in stages depending on the year of commencement/procurement and contract duration. Accordingly, **Report on Transjakarta E-Bus Integrated Long-Term Implementation Phase** (Report 3.2 & 3.3) has prepared two alternate electrification scenarios i.e., Scenario A (Base Case) and Scenario B (Alternative) as shown in Table 6 and Table 7 respectively. For simplicity, the Transcare buses are considered as Microbus. It should also be noted that, based on the discussions with Transjakarta, the Maxi buses (13.5 m) are to be replaced by the Single buses (12 m) and Royal Trans and tourism services are also excluded from the scope of this analysis.

Table 6. Scenario A (Base Case) : Number of Electric Buses Acquired

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Articulated Bus		0	0	111	165	19	22	23	24
Low Entry	74	26	0	0	0	0	190	98	21
Single Bus		100	150	31	224	264	113	110	375
Medium bus		100	0	50	204	250	253	260	401
Microbus		0	100	200	400	600	1129	1800	2160
Total e-buses added	**74**	**226**	**250**	**392**	**993**	**1133**	**1707**	**2291**	**2981**
Cumulative e-buses	74	300	550	942	1935	3068	4775	7066	10047
Total ICE and e-buses	**4,008**	**4,008**	**4,258**	**4,397**	**5,241**	**6,073**	**6,900**	**8,350**	**10,047**
Percent Electric	2%	7%	14%	24%	38%	51%	69%	85%	100%

The TCO analysis shows that the Electric microbus cost of operation is much lower than their gasoline counterparts and the investment per vehicle is also the lowest. If the electrification of this e-bus category is accelerated, Transjakarta can achieve higher electrification levels as a percentage of bus fleet or bus-kilometres and the expected financial and environmental gains can be maximised. Accordingly, Table 7 shows the alternate roadmap under Scenarios B.

Table 7 Scenario B (Alternate Case): Number of Electric Buses Acquired

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Articulated Bus		0	0	91	185	19	22	23	24
Low Entry	74	26	0	0	0	154	0	19	20
Single Bus		100	0	0	305	261	128	93	480
Medium bus		100	75	97	204	178	203	260	401
Microbus		50	450	585	793	977	1,129	1,186	1,219
Total e- buses added	**74**	**276**	**600**	**777**	**1,386**	**1,510**	**1,707**	**1,677**	**2,040**
Cumulative e-buses	**74**	**350**	**950**	**1,727**	**3,113**	**4,623**	**6,330**	**8,007**	**10,047**
Total ICE and e-buses	**4,008**	**4,058**	**4,658**	**5,182**	**6,419**	**7,628**	**8,455**	**9,291**	**10,047**

Percent Electric	**2%**	**9%**	**20%**	**33%**	**48%**	**60.6%**	**75%**	**86%**	**100%**

For conducting financial and economic feasibility analysis, we will be using the base case scenario (A) unless mentioned otherwise.

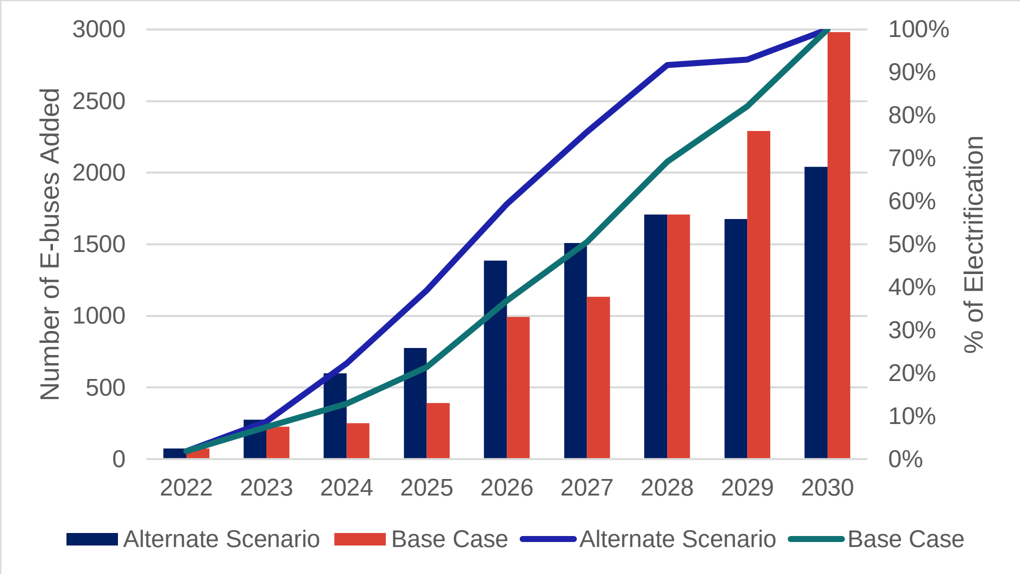

Figure 1 Comparison of progress of electrification of Transjakarta Fleet

2.2. TCO Analysis

The TCO analysis carried out in the Report on Transjakarta E-Bus Integrated Long-Term Implementation Phase (Task 3.2 & 3.3) shows that the cost of deployment of single electric buses (low entry and high deck) is 6% lower than the comparable diesel buses. Similarly, the electric articulated buses TCO is almost at par with their diesel counterparts and with a little more optimisation, TCO parity can be achieved. The retrofitted single buses, however, were not found to be as effective as the new (procured) single buses in terms of TCO, although some further analysis on the effectiveness of retrofitted single buses needs to be conducted due to lack of reliable data sources. However, for medium buses, the TCO for electric buses was still higher than the diesel buses and alternative models of medium buses with lighter weight and higher range needs to be explored for reduce the TCO below that of the diesel medium bus.

Since then, the prices of diesel, gasoline and CNG have been increased significantly by the Government of Indonesia and consequently, the TCO of electric buses are expected to further improve vis-à-vis their ICE counterparts.

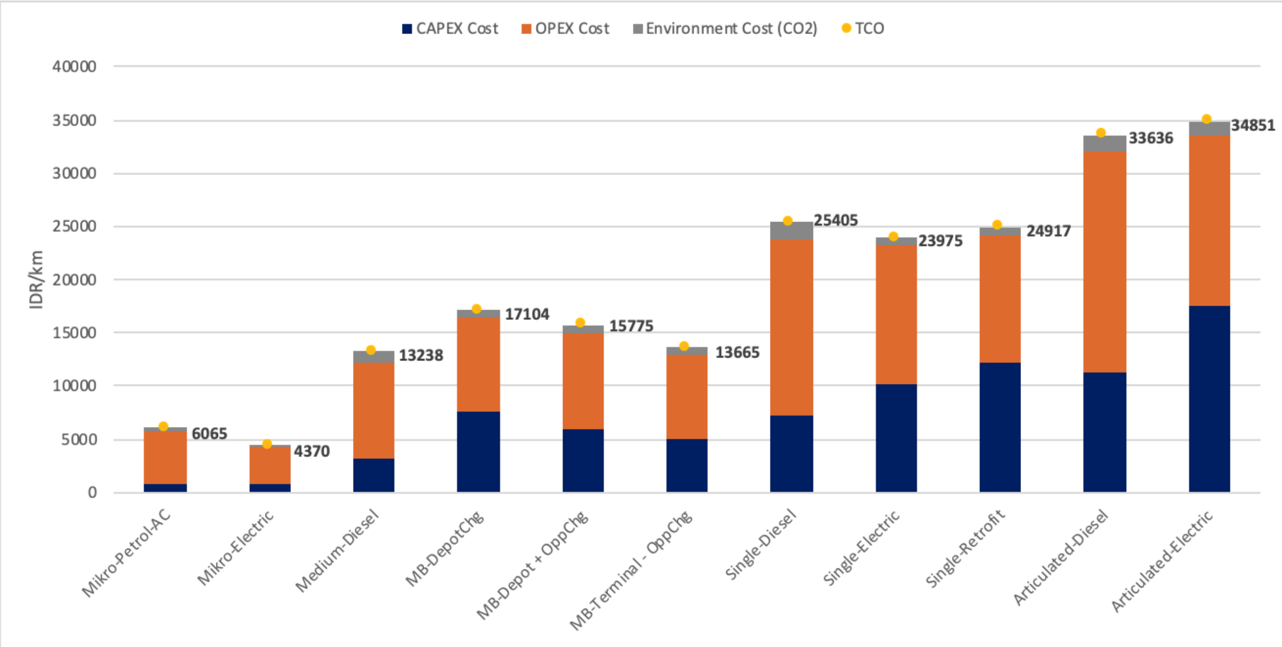

Figure 2 Results of TCO Analysis, September 2022

The TCO analysis, however has certain limitations. For example, it considers that all investments are made by user of the vehicle and does not cater to situations where the investment, operations and use are being done by different parties. Further, the TCO discounts all costs to a present value using real discount rate and ignores inflation. We have seen that the cost of energy and cost of maintenance of electric buses is much lower than those of diesel buses and the economic advantage of the electric buses will increase further over the years. Thus, the analysis in this report includes the above aspects and presents the estimated impact on year-wise cashflow of Transjakarta in BAU as well as various fleet electrification options.

2.3. Fund Channelling/Business Models

The report titled ***Business models, Structured Financing Scheme, and Contractual framework of Transjakarta*** **for first phase of large-scale electrification (Report 4.6)** has reviewed various possible business models and associated fund channelising schemes but essentially the following options emerge:

- Assets are procured by Operators directly and deployed through BTS contract
- Assets are procured and financed by Transjakarta
- Assets are procured by Transjakarta or the Operators directly under a lease financing mechanism

Various sources of fund have been discussed in the said report e.g., concessional finance from development financing institutions, foreign/ local commercial banks, use of credit enhancement facilities as well as using various financing instruments such as green bonds, limited participation mutual funds etc.

2.4. Detailed Technical Plan

This report analyses the various routes from the point of view of suitability of electrification, charging infrastructure, route lengths, etc. and recommends the most suitable routes that should be taken up for electrification in the first phase as well as impact of partial electrification which poses both challenges and opportunities.

The report also focuses on deciding the priority for the existing fleet and infrastructure requirements to be electrified between 2023 and 2025. Since the financial feasibility is being undertaken for complete fleet to be replaced till 2030, the output of this report is not readily usable for the financial feasibility analysis. The Report confirms that through optimal planning and provision of terminal charging, the replacement ratio for all bus types including medium buses can be restricted close to 1:1.

For the purpose of this report, the average route and use characteristics of the current fleet is considered to hold good for the augmented fleet as well.

3. Cost of Funds Evaluation

Channelling schemes and capital structure optimization analysis should be tailored to the project's unique characteristics. Relevant factors such as the size of the project, its risk profile, and the sources of capital should be taken into account.

Additionally, the analysis should consider the structure of the project's financial instruments, such as the debt-equity mix, the type of debt, the repayment terms, and the debt-service coverage. In order to ensure the success of the project, it is important to determine the most appropriate capital structure.

The following sub-sections below will discuss the cost of funds evaluation for the fund channelling schemes including the methodology and key inputs for calculation. It is to be noted that the cost of funds results below only act as a proof-of-concept to justify the viability of the fund channelling schemes itself. A comprehensive feasibility analysis should be conducted further on route level or project level for the purpose of financial transaction.

3.1. Financial Instruments

Different financial instruments may be used in E-bus Implementation. These include equity permanent capital, debt temporary capital, and mezzanine finance quasi-equity. Debt is often structured in the form of senior debt or subordinated debt. Senior debt has higher priority than all other claims on project cash flows and assets. Mezzanine finance refers to a kind of financial instruments that are primarily in the form of debt but also share some qualities of equity capital. It occupies an intermediate position between debt and common equity.

3.2. Capital Structure

The capital cost of E-bus implementation is the combined cost of various financial instruments that finance the project. Four dimension of capital structure:

1. types of financial instruments (equity, debt, and mezzanine finance);
2. the relative amounts of different financial instruments;
3. the sources of the financial instruments (e.g., international financial institutions, commercial banks, different types of equity participants, and the general public); and
4. the corresponding contractual conditions on these financial instruments (e.g., repayment period of debt, and government guarantee)

Each of the four dimensions can affect the total project cost.

The cost of equity is usually higher than that of debt because equity holders normally require a rate of return to their equity that is higher than the interest rate of debt as debt has a higher level of claim to the assets of the project companies. So, a lower level of equity reduces the total cost of the project. However, a lower equity level means higher risks to debt. Banks and other financial institutions may not be willing to finance a project that seems "un-bankable," or they may increase the risk premiums for a project with a low equity level.

There are also advantages and disadvantages in the use of bond and commercial debt. The interest rate of debt and its repayment period can be fixed or floated, while for bonds these are generally fixed. With flexible repayment period such as a grace period and floating interest rate bank debt allows more financial engineering flexibility. But debt is usually more expensive and has shorter maturity period than bonds.

3.3. Capital Structure Optimization for Each Scheme

The information available from published sources has limit comparability. Nevertheless, provide a broad picture of overall investment trends and current public infrastructure investment under each of the instrument.

Information is also presented, where available, on the potential drivers of the choices of financing instrument. This is influenced by the institutional arrangements, tax-effectiveness considerations, the type of infrastructure, the risks involved and the historical availability of capital. These factors are complex and interacting.

In a broad sense, efficient outcomes are dependent on efficient investment and policy decisions that generate the need for financing in the first place. Consequently, each financing instrument was also examined to determine the extent to which it enhances transparency and other incentives that promote accountability for efficient investment decisions.

A comparative assessment of the efficiency of the instrument used to finance and re-finance infrastructure was made on the basis of the disciplines imposed on the management of project risk and the resultant cost of finance, and the influence on the allocative efficiency of the investment.

In addition to the total cost of finance, there are many legal, institutional, market environment and project-specific factors that would have to be weighed up in selecting the financing instrument for project. These include:

1. broader economic policies concerning the desired level of infrastructure provision, and investment incentives for private service-providers
2. government responsibilities and taxing powers at different levels of government
3. the corporatization of government-owned providers and their governance arrangements that affect policies on pricing and the retention of earnings capital market infrastructure-related regulation.

Judgements are required to weigh up these factors in order to make an overall assessment. Moreover, the project-specific nature of investment affects against arriving at useful conclusions even for substantively similar infrastructure projects.

3.4. Methodology

The cost of funds is mainly estimated based on the nature of the source of capital i.e., equity and debt. The cost of funds is estimated in Indonesian Rupiah (IDR). In addition, capital sourced in other currencies e.g., U.S. Dollar (USD), cost of funds is estimated in IDR by incorporating currency risk premium.

Even though most of the key inputs for the estimation of cost of funds rely on market data, we also utilize some subjective inputs.

For instance, we assume that the investment manager will require at least 2% p.a. for management fee of limited participation fund (RDPT).

3.4.1. Cost of Equity

Cost of equity is estimated using the capital asset pricing model (CAPM). Risk-free in IDR is estimated based on Indonesian government bond spot rate reported by PT. Penilai Harga Efek Indonesia, a Securities Pricing Agencies (SPA). Sovereign credit risk is omitted by deducting with credit default swap (CDS) premium.

Equity risk premium is estimated using the systematic risk factor for transportation industry, developed market risk premium and Indonesian country risk premium.

3.4.2. Cost of Debt

Cost of debt is estimated based on the type of debt i.e., amortizing loan, bond, and lease payment. Both amortizing loan and lease payment assume monthly compounding. While in practice principal of bond paid at maturity, we assume that it is amortized in conjunction with coupon payment nevertheless maintaining equal bond equivalent yield (BEY).

3.5. Key Inputs

3.5.1. Cost of Equity

The main key inputs for the cost of funds modelling are cost of equity and cost of debt. Both are estimated in IDR term.

Cost of equity is estimated using CAPM with a risk-free rate of 5.33%[1], beta of 0.79[2] and market risk premium of 7.90%[3].

Table 8 Cost of Equity

[1] Calculated as 10-year Indonesian government bond's spot rate minus 10-year CDS premium.
[2] https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/Betas.html
[3] Calculated as the summation of developed market risk premium (4.55%) and Indonesian Country Risk Premium (3.35%).

Beta (Transportation)	1.05	ITDP estimate
10Y Government Bond Rate	7.01%	PHEI
ID-US 10Y USD Bond Spread	1.21%	ITDP estimate
Risk-Free Rate	5.80%	ITDP estimate
US Market Risk Premium	4.55%	Aswath Damodaran
ID Country Risk Premium	2.42%	ITDP estimate
Cost of Equity	**13.15%**	

Source: ITDP estimate, investing.com, otherwise stated

We assume that the above cost of equity is applicable to Transjakarta and its subsidiaries, while an additional 2% of premium will be required by the investors on equity investment made into private entities.

3.5.2. Cost of Debt

The cost of debt of fixed income instruments are estimated based on the yield to maturity given the credit risk associated. The cost of debt of bank loans on the other hand are estimated based on periodic payment of amortizing loan.

Cost of debt for different type of debts are estimated based on government bond's spot rate as the base rate and credit spread to incorporate default risk (based on rating).

Table 9 Cost of Debt Input

MATURITY	GOVT	CREDIT SPREAD MATRIX (bps)			
(YEAR)	SPOT RATE	AAA	AA	A	BBB
1	5.45%	26.2	97.0	217.1	430.3
2	5.92%	40.9	120.4	237.3	437.0
3	6.21%	50.3	134.7	245.3	445.6
4	6.41%	56.2	143.0	251.5	462.1
5	6.56%	60.3	147.9	258.9	483.7
6	6.69%	63.8	151.3	267.3	506.1
7	6.79%	67.4	154.3	275.9	526.6
8	6.88%	71.5	157.5	284.0	543.8
9	6.95%	76.1	161.0	291.2	557.4
10	7.01%	81.2	165.0	297.1	567.5

Source: ITDP estimate, investing.com, otherwise stated

A. Government Bond

The following table presents the yield to maturity of government bonds with distinct maturity.

Table 10 Yield to maturity of government bonds with distinct maturity

GOVERNMENT BOND YIELD	5	6	7	8	9	10
Spot Rate	6.56%	6.69%	6.79%	6.88%	6.95%	7.01%

PVIFA	4.18	4.86	5.49	6.08	6.63	7.13
Yield	6.27%	6.37%	6.46%	6.54%	6.61%	6.67%

Source: PHEI, ITDP estimate

B. Regional (Municipal) Loan

Interest rate applied on regional loan is regulated by Government Regulation 56/2018 with a fixed and effective rate equal to government bond yield plus 0.75%. The maturity authorized is 3 to 8 years. The following table exhibits the yield of regional loan with the associated maturity.

Table 11 Interest rate regional loan

REGIONAL LOAN	5	6	7	8	9	10
Govt. Yield + 0.75%	7.02%	7.12%	7.21%	7.29%	7.36%	7.42%

Source: PHEI, ITDP estimate

In addition to regional or municipal loan backed with government guarantee letter, PT SMI may raise fund from the capital market by issuing bond. Assuming its AAA rating, SMI's bond yield is expected as follows:

Table 12 SMI expected bond yield

BOND ISSUED BY SMI	5	6	7	8	9	10
AAA	7.09%	7.23%	7.35%	7.46%	7.55%	7.64%

Source: PHEI, ITDP estimate

We assume that SMI also requires 1% channelling fee on top of the issuance fee. The process will be passed through to the Provincial Government of DKI Jakarta.

C. Corporate Bond

Yield on corporate bond is estimated based on the government bond yield and taking credit spread into account. Credit spread used is provided by PHEI. We only provide yield on AAA and BBB-rated bond with the assumption of AAA rating for SPV using credit enhancement facility (CEF) and BBB rating for standalone creditworthiness.

Table 13 Yield on corporate bond

CORPORATE BOND	5	6	7	8	9	10
AAA	7.09%	7.23%	7.35%	7.46%	7.55%	7.64%
BBB	11.24%	11.51%	11.74%	11.93%	12.08%	12.19%

Source: PHEI, ITDP estimate

D. Bank Loans

Bank loan's interest rate is estimated based on AAA-rated corporate bond yield converted to amortizing loan rate. Currency risk premium is then calculated based on the average difference of Indonesian government bond in USD and in IDR.

Table 14 Currency risk premium

CURRENCY RISK PREMIUM	5	6	7	8	9	10
Government Bond Yield						
USD			4.99%	4.88%	4.94%	4.96%
IDR			6.69%	6.88%	6.95%	6.95%
Risk Premium			1.70%	1.99%	2.01%	1.99%

Source: Börse Frankfurt, PHEI, ITDP estimate

Table 15 Bank loan rate

BANK LOANS RATE	5	6	7	8	9	10
Yield AAA	7.17%	7.32%	7.46%	7.59%	7.71%	7.82%
PVIFA	4.124	4.779	5.383	5.940	6.452	6.923
Interest Rate (IDR EQ)	6.78%	6.92%	7.03%	7.14%	7.23%	7.31%
Currency Premium	1.92%	1.92%	1.92%	1.92%	1.92%	1.92%
Interest Rate (USD)	4.86%	4.99%	5.11%	5.21%	5.31%	5.39%

Source: ITDP estimate

The above interest rate is applicable to the Special Purpose Vehicle (SPV) established by Transjakarta. However, a private SPV is subject to additional premium (1%).

In addition to prevailing market rate, the cost of debt may include guarantee or credit enhancement premium. The two types of credit enhancement facility (CEF) discussed here are guarantee provided by UKEF and CEF provided by SMI.

E. Limited Participation Mutual Fund

In accordance with OJK's regulation number 34/POJK.04/2019 article 9 and 11, limited participation mutual fund can invest in more than one security:

1. Equities
2. Fixed Income Instruments
3. Hybrid Instruments
4. Currency or interest rate derivatives for hedging purposes.

The cost of funds is then estimated based on the securities managed in the fund. In addition, we assume that investors would expect their investment return will be able to cover the management fee (2%) charged by the investment management company.

3.6. Financing Schemes Considered

Based on the fund channelling schemes presented in Report 4.6, below is the financing scenarios that are considered for cost of funds evaluation accordingly.

Table 16. Fund Channeling Alternatives

Scheme Name	Description
Scheme A-1	PT. SMI Provides Regional Loan to The Government of Jakarta
Scheme A-2	The combination of Regional Loans and financing products issued by PT. SMI
Scheme A-3	Development Financial Institutions (DFIs) Loan to Government (2 Step Loan)
Scheme B-1	Loan from Commercial Foreign Banks to Private Sectors

Scheme B-1A	Loan from Local Commercial Banks to Private Operators - Business as usual (BAU)
Scheme B-2	Private Sectors Issue Financing Products to Finance the Project
Scheme B-2.1	An SPV owned by a RDPT (Closed ended Mutual Fund) will act as an asset aggregator
Scheme B-2.2	An SPV owned by a RDPT (Closed ended Mutual Fund) will act as an asset aggregator but obtains financing through a Leasing Company
Scheme B-2.3	Leasing Contract Between Operator and Leasing Company

3.7. Simulation-Based Input Data Modelling

WACC is used in financial modelling as the discount rate to calculate the net present value of a business. It is also used to evaluate investment opportunities, as it is considered to represent the firm's opportunity cost. Thus, it is used as a hurdle rate by companies. A company will commonly use its WACC as a hurdle rate for evaluating investment opportunity, as well as for financial modelling of internal investments. If an investment opportunity has a lower Internal Rate of Return (IRR) than its WACC, it should not be investing in the project.

$$WACC = We * ke + Wd + kd * (1 - T)$$

Where:

WACC = Weighted Average Cost of Capital

k_e = cost of equity

k_d = cost of debt

W_e = weight of equity in capital investment

k_d = weight of debt in capital investment

The simulation is structured based on the fund channelling scheme. Scheme A-1 will be full equity while others will be in combination of debt and equity financing. The base case scenario assumes that the down payment will be 30% of the fleet cost and sourced from the equity investor.

The output of the simulation will be in percentage of WACC. In addition, the output will include the operation and maintenance (O&M) fee in Rp/km per bus that will be borne by Transjakarta. Hence, the following assumptions on bus operation were made to perform the simulation:

1. Fleet cost : USD33,600 or IDR524,328,000 per unit
2. Daily kilo metres : 208 km
3. Number of days : 365 days per year
4. O&M margin : 10%
5. Contract period : 10 years
6. Loan/lease period : 7 years

7. Residual value : None

WACC resulted for each respected scheme is as follows. Based on the base scenario, the minimal WACC is in scheme A-3 and the maximum WACC is in scheme B-2.

Table 17 WACC resulted for each respected scheme

	A-1	A-2	A-3	B-1	B-1A	B-2	B-2.1	B-2.2	B-2.3
W_e	100.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%	30.0%
W_d	0.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%	70.0%
k_e	7.21%	8.35%	7.21%	15.15%	15.15%	15.15%	17.15%	17.15%	17.15%
k_d	0.00%	8.95%	8.61%	10.13%	10.31%	12.41%	8.70%	8.94%	9.88%
Weighted Average	7.21%	8.77%	8.19%	11.64%	11.76%	13.23%	11.23%	11.40%	12.06%
WACC	7.21%	7.39%	6.86%	10.08%	10.18%	11.32%	9.89%	10.03%	10.54%

Source: ITDP estimate

3.8. Further Consideration on Fund Channelling Schemes

Loan funding alone, either through market or concessional loans, has limited to no success regarding the purchase of electric vehicles. This is due to many factors already mentioned, such as predominance of CAPEX over operating and maintenance costs in investment decisions, limited knowledge of technology, poor financial conditions of operators, among others. Market maturity, reduced battery prices, increased knowledge and available charging and maintenance infrastructure will eventually make, in the medium- to long-term, loan-funding suitable for the purchase of electric buses.

The project structure is undeniably a complex problem because it involves changing the entire infrastructure of the transportation system, given limited operators with creditworthiness resulting access to cost of financing. Together with charging infrastructure, vehicle supply, and personnel training, complete with associated costs involved in transitioning to electric buses, such as the cost of purchasing and installing the buses, charging infrastructure, and maintenance. Nevertheless, there are social considerations to take into account, such as the impact on bus riders and the community at large. In order to successfully transition to an electric bus fleet, governments and other stakeholders must consider all of these factors and develop a comprehensive strategy for the procurement and actual implementation.

Fund channelling schemes and capital structure optimization analysis above encounters proof-of-concept characteristics. Still, it requires a thorough understanding of the underlying business, project feasibility analysis and financial models of E-bus deployment project under electrification transition program. This should be based on an analysis of the project's cash flows and its ability to generate sufficient returns to cover both the cost of capital and repayment terms. An analysis of the project's sensitivity to various market conditions can also be conducted to identify the optimal capital structure.

The ultimate goal of the analysis is to determine the most efficient capital structure to meet the company's financial objectives. In order to conduct a successful analysis, data collection and analysis of the company's financial data should be conducted. This includes a review of the company's financial statements (balance sheet, income statement, and cash flow statement), an evaluation of the financial risk associated with the company's existing capital structure, and an assessment of the company's current financial health.

It is important to consider the company's industry, the current market conditions, and the macroeconomic environment. Once the data has been collected and analysed, the analysis should be used to develop a model to evaluate the cost and benefits of the various capital structure options available to the company.

Finally, the results of the analysis should be used to develop an optimal capital structure for the company. This involves determining the most advantageous combination of debt and equity to maximize the company's return on investment, while minimizing its financial risk.

UK PACT

4. Business As Usual Scenario

It is evident from the previous chapters that the fund channelling scheme affects the cost of funds, which can be summarised as follow for the simplicity of evaluating the financial analysis:

Table 18. fund channelling scheme effect on cost of funds

Borrower	Cost of Funds
Government/Regionally owned Companies	Varies between 6.86% to 7.39% p.a.
Private Sector Company	Varies between 9.89% and 10.54% p.a.

This report uses the business models and fund channelling schemes developed in Report 4.6 to quantitatively evaluate various implementation options for Transjakarta.

The "Business as Usual" or BAU scenario considers that except for the pilot phase of 100 electric buses, no more electric buses will be deployed and remaining fleet will be continue to be replaced with diesel/ CNG buses as the case may be.

4.1. Assumptions

4.1.2. CAPEX Assumptions

Table 19 Capex Assumptions for Diesel Buses

Bus Types*	Articulated Bus	Single Bus**	Medium Bus	Microbus
Cost of ICE bus (Mio Rp) (2022)	4800	2341	958	345
Life of ICE bus (years)	10	10	7	7

** All bus* types analysed on this chapter is air-conditioned, including microbus

** includes both high-deck or low entry buses

Additionally, the following assumptions are also used:

a. Legal and Administrative fees is considered @ 3.5% on the amount of loan obtained (80%)

b. Residual value of the diesel bus is considered at 20% based on the owners' cost estimate (HPS, *Harga Perkiraan Sendiri*) from Transjakarta.

d. The diesel/CNG bus prices are expected to increase by 3.5% p.a. based on past trends on inflation for the manufacturing sector[10].

4.1.3. Operating Parameters and OPEX Assumptions

The per kilometre operating cost of a bus are estimated based on following assumptions:

a. <u>Distance travelled for variable operating costs such as tyres/tubes, and brake pads</u>.

The average distance travelled by various categories of buses is as follows:

Table 20. Average distance travelled of each bus categories

Bus Types	Articulated Bus	Single Bus	Medium Bus	Microbus
kms/day	205	192	188	196

These are average running by operating buses excluding the spare buses. 20 km of empty running is assumed to be included in this, based on the contracts between Transjakarta and bus operators.

b. Number of shifts operated

2 shifts of 7 hours steering duty are assumed for each operating bus (excluding spares/ replacement).

d. Cost of diesel/CNG

From September 3, 2022, the cost of diesel for public transportation fleets (Biosolar/CN48 – 30% bio diesel mixed with high-speed diesel) in Jakarta is Rp 6800/ litre[4]. The selling price of CNG (BBG) for the transportation sector is Rp 4,500 (USD 0.31) per litre of premium equivalent (LSP) with effect from May 1, 2022[5].

Trends in price of petroleum products

The price of diesel for non-public transport use in Indonesia has steadily increased from 0.07 US dollars per litre in 1998 growing at an average annual rate of 12% to 1.06 US dollars by 2022[6]. Further, IDR has depreciated by 2.7% during this period making the diesel prices increase effectively at about 15% p.a. However, such increase has not been passed on with respect to the diesel used for public-transport purposes and the gap has been met with increased subsidy. Hence what is relevant for Transjakarta is the price of bio-solar (CN48 grade) which is subsidised by the Government of Indonesia is available at a much lower price. The price of bio-solar has increased at a more modest rate of 4.5% i.e., Rp 5150 in April 2016 to Rp 6850 in September 2022 although the economic cost of the fuel was Rp 18150/litre[7].

Hence, conservatively, an annual increase in diesel/ CNG prices is considered @ 4.5% p.a.

e. Fuel Efficiency

The fuel efficiency of different categories of buses is considered as follows:

Table 21 Fuel efficiency of each bus categories

Bus Types	Articulated Bus	Single Bus	Medium Bus	Microbus
Diesel (km/litre)	--	2.03	3.2	8.5

[4] Price Update - MyPertamina (https://mypertamina.id/fuels-harga), March 1, 2023
[5] CNG price hike has no significant impact on businesses: officials – tanahair.net, May 11, 2022
[6] Indonesia Diesel price, 1960-2022 - knoema.com
[7] High World Oil Prices, Pertamina Keeps Fuel & LPG Stocks Sufficient | Pertamina, www.pertamina.com,July 8, 2022

CNG (km/LSP)	1.0	--	--	--

The above assumptions are based on discussions with operators and Transjakarta.

f. Maintenance Cost

The maintenance cost of different categories of buses is considered as follows:

Table 22 Maintenance cost of each bus category (2022)

Bus Types	Articulated Bus	Single Bus	Medium Bus	Microbus
Maintenance Cost (Rp/ km)[8] (2022)	9757	5643	3020	718

The above parameters are considered based on discussions with operators and Transjakarta.

g. The cost of fare collection is excluded as the same is in the scope of Transjakarta and is common for ICE as well as electric buses. Similarly, other overhead costs of managing the bus operations are also excluded from this analysis.

h. Manpower Costs

- Drivers per bus (net): 2.4 (2 shifts x 1.2).
- Driver Wage: The annual wage of a driver is considered at 200% of UMP (minimum wages) for large/ medium buses and at 100% of UMP for microbus plus one month bonus, retirement benefits and uniform costs. The UMP for 2023 was Rp 4.9 million increasing from 2.44 million Rp in 2014 i.e., 8% annually[8].
- Other administrative costs: 30% of driver costs for large/ medium buses and 10% for microbus since the buses are mostly operated by individual owners or drivers appointed by them[9].

Other Assumptions

a. Operator's margin – 10% of OPEX costs

b. Reserve fleet is assumed @ 10%

c. IDR/USD: 15,200, based on exchange rate on October 4, 2022, increasing annually by 5% p.a.

d. Insurance Cost: 1% of CAPEX (HPS)

[8] Indonesia Minimum Monthly Wages - 2022 Data - 2023 Forecast - 2012-2021 Historical (tradingeconomics.com)

[9] Based on discussions with operators, Transjakarta and Owners' estimate

4.2. Estimated Rp/km for different types of buses

Based on the assumptions above and using the methodology for estimation of Owner's Cost Estimate (HPS) for various types of vehicles, the estimated BTS fee for vehicles contracted in different years is presented in Table 24 and includes the following components:

i) Investment cost including interest on loans, depreciation, insurance, legal and administrative fee
ii) Salary of driver, checker
iii) Maintenance cost
iv) Fuel cost
v) Supervision/management costs
vi) Workshop staff costs
vii) Depot rent & maintenance
viii) Maintenance equipment – depreciation and maintenance costs
ix) Office operating costs, rates and taxes etc.

Table 23. Estimated Rp/km for ICE buses acquired in a given year

Year	Articulated	Single/LE	Medium	Microbus
2022	32,258	21,591	15,670	5,676
2023	33571	22488	16422	5947
2024	35062	23547	17352	6294
2025	36631	24667	18341	6663
2026	38281	25850	19394	7057
2027	40014	27097	20514	7478
2028	41838	28417	21708	7925
2029	43755	29810	22978	8402
2030	45774	31284	24332	8912
2031	47903	32847	25775	9454
2032	50145	34500	27314	10034
2033	52507	36250	28954	10653
2034	54997	38104	30705	11314

The cost of fuel, maintenance and manpower is indexed to the fuel price, inflation index and minimum wages (UMP) respectively and the Rp/km is revised annually assuming the following factors:

- Wages: 8% p.a. (UMP increase)
- Maintenance Cost: 4.11% (average general inflation over past 10 years)
- Fuel Prices: 4.5% (historical trends)

The estimated costs are compared with the actual rates contracted by Transjakarta with the operators as shown in Table 24. It is seen that the estimated values are within 2% of the contracted values adjusted for inflation. Further, it should be noted that the fuel prices were increase sharply during 2022 (Diesel – 33%, Petrol-30%, CNG – 45%) which accounts for the slight variation between the adjusted contracted rates and estimated rates.

Table 24. Comparison of BTS Fee between contracted rates and estimated rates

Type of Bus*	As per Contracts		Adjusted to 2023	As per Model	Difference
	Year of Contract	Rp/km	Rp/km	Rp/km	%
Articulated	2019	28761	33789	33568	0.6%
Single	2021	20315	22019	22485	2.1%
Medium	2021	15021	16281	16422	0.9%

* Data not available for airconditioned microbuses

4.3. Projected Cost of Operations of augmented fleet

Based on the Rp/km estimated above, the total cost of operations of Transjakarta assuming 100% contracted fleet in the BAU scenario is shown in Table 25.

Table 25. Estimated Total Cost of Operations (BAU)

Bus Type	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Articulated Buses	538	555	579	655	723	803	891	988	1019	1051	1084
Low Entry Buses	520	538	556	575	595	634	668	732	761	787	814
Single Buses	1230	1480	1578	1973	2064	2186	2278	2431	2542	2639	2777
Medium Buses	253	265	329	570	866	1219	1616	2067	2160	2264	2396
Microbuses	779	857	935	1165	1511	1924	2852	3708	3889	4085	4302
Total	**3320**	**3695**	**3977**	**4939**	**5759**	**6766**	**8305**	**9925**	**10371**	**10826**	**11373**

(Figures in Rp Billion)

It should be noted that the above cost of operation excludes any costs of Transjakarta operating its own (Swakelola) buses and the cost of fare collection and other overheads.

5. Electrification Scenario

5.1. Possible Business Models

The Task 4.6 (Business models, Structured Financing Scheme, and Contractual framework of Transjakarta first-phase of large-scale electrification) report has reviewed various possible business models and associated fund channelising schemes but essentially the following options emerge:

- Assets are procured by Operators directly and deployed through BTS contract
- Assets are procured and financed by Transjakarta/SPV and operated through operators
- Assets are procured by Transjakarta or the Operators under a lease financing mechanism

The report also analyses different fund channelling schemes including regional loan to Government of DKI/Transjakarta/SPV(BUMD), commercial loan to private operators, use of financial instruments such as green bonds, limited participation mutual funds etc. and estimates the cost of funds under each scenario. For the simplicity of analysis, we consider the cost of funds (WACC) for respective investing entity following combination of the business model/financing scheme:

Table 26. Cost of Capital for Various Business Models

Option Name	Assets Financed By	Source of Financing	Weighted Average Cost of Capital
Option 1	Private Operators	Equity from Investors and Debt from Local Commercial Banks	6.26% (flat) equivalent to about 10% p.a. (Source: HPS)
Option 2	Transjakarta or its SPV (Regionally owned entity)	Equity from DKI Jakarta and Debt from PT SMI, Commercial Banks, Financial Instruments	6.86% to 7.39% Average: 7.15%
Option 3	Asset Leasing Company (Private sector)	Equity from Investors and Debt from Financial Instruments	10.54% p.a.

5.2. Assumptions

5.2.1. CAPEX Costs

The capital cost for electric buses depends on:

a. Procurement cost of the e-bus depending on size of the bus as well as battery size

b. Taxes and duties

c. Charging infrastructure cost, including grid connectivity and charger installation costs.

d. Replacement ratio

f. Depot set up costs

It is seen in report 4.1 that through suitable sizing of the battery and arrangement of opportunity charging, the replacement ratio can be managed at 1:1 ratio i.e. one electric bus replaces one diesel bus. The allocation of capital cost under various Financing Options is summarised below:

Table 27. Allocation of Capital Cost Under Various Financing Options

Type of Expenditure	Option 1	Option 2	Option 3
Bus & Charger Cost	Operator	Transjakarta/SPV	Leasing Company
Depot Cost	Operator	Operator	Operator*
Grid Connectivity/ charger installation	Operator	Operator	Operator**
Down Payment	Operator		
Security Deposit* **	N/A	Operator	Operator
Terminal Charging	GoJ/ Transjakarta	GoJ/ Transjakarta	GoJ/ Transjakarta

** In case of Microbus, the space for night parking/charging will need to be arranged by leasing company*

*** In case of Microbus, the cost may need to be borne by the leasing company/charging service provider*

**** It is considered that the Operator will pay 10% of the bus capex as security deposit to ensure safety and care of the e-buses. This also reduce the financing burden on Transjakarta/Leasing Company*

The following assumptions have been made for various types of e-buses proposed to be deployed within the Transjakarta service. The cost included on the table below only assuming depot charging only. It is considered that in case terminal charging is provided, it will reduce the battery cost or increase the operating range and thus having beneficial impact on the overall cost to Transjakarta. Hence cost of terminal charging is ignored in this analysis.

Table 28. CAPEX assumptions for various types of E-buses (2022)

Bus Types*	Articulated Bus	Single Bus**	Medium Bus	Microbus
Battery Size (kWh)	450	324	135	42
Landed Cost of bus (USD)	550,000	297,000	130,000	30,240
Contract Period (years)	10	10	10	10
Residual Value	20%	20%	20%	20%
Grid Connectivity Cost/Bus (Rp mn)[10]	625	417	208	21

** All bus types analysed on this* chapter is air-conditioned, including microbus

**** Includes both high-deck or low entry electric bus

Further, over the years the cost of electric buses has been reducing due to rapid decrease in battery prices which constitutes the largest component of the e-bus price. The cost of electric

[10] Estimated based on Transjakarta Pilot E-bus project for Low Entry buses. Cost for other types has been considered proportionately based on the respective battery sizes and energy consumption/day.

buses in Indonesia are currently very high considering small purchase volumes, fully imported kits. As penetration of e-buses, procurement lots sizes and localisation components increase, the cost if likely to come down as already seen in countries such as India and China. In India, a 12 m low floor electric bus is available at costs around USD 200,000[11] (without subsidy) depending on manufacturer, battery size and lot size i.e., over 40% less than prices in Indonesia considered above and still falling. However, on a conservative basis, an annual reduction of 5% in electric bus costs is considered till 2030 in USD terms.

Based on discussions with operators, other CAPEX costs will include legal, admin and financing costs and is considered at 3.5% of the cost of the bus.

5.2.2. Operating Parameters and OPEX Assumptions

In addition to the assumptions common with operating ICE buses, the per kilometre operating cost of a bus are estimated based on following assumptions specific to e-buses.

a. Cost of energy (electricity)

Based on the special tariff negotiated by Transjakarta with PLN, the cost of electricity is assumed @ Rp 825/ kWh.

b. Fuel Efficiency

The fuel efficiency of different categories of buses is considered as follows:

Table 29. Fuel efficiency of each bus categories

Bus Types	Articulated Bus	Single Bus	Medium Bus	Microbus
Electricity (kWh/km)	1.80	1.20	1.00	0.18

The above assumptions are based on discussions with OEMs, operators, trials run done by Transjakarta, a 2020 report by Sustainable Bus[6].

c. Maintenance Cost

The maintenance cost of different categories of buses is considered as follows:

Table 30 Maintenance cost of each bus categories

Bus Types	Articulated Bus	Single Bus	Medium Bus	Microbus

[11] ITDP Team research

Electric (Rp/ km)[12]	4800	3200	2400	508

The above parameters are considered based on discussions with OEMs, operators, and e-bus Pilot project by Transjakarta.

5.3. Projected Cost of Operations of augmented fleet

5.3.1. Option 1: Fleet Procured by Private Operators

In this Option, the buses, charging infrastructure are procured by the operators and they offer services on a gross cost contract/buy the service model similar to the contracts under which Transjakarta has been procuring the diesel buses as well as the pilot e-bus services. The Rp/km is estimated for the electric buses acquired in different years as follows:

Table 31 Estimated BTS Fee (Rp/km) for Electric Buses acquired in a given year

Year	Articulated	Single/LE	Medium	Micro
2022	37723	23531	15867	5058
2023	38368	24041	16415	5242
2024	39134	24736	17144	5450
2025	40029	25493	17911	5731
2026	40925	26272	18720	6028
2027	41923	27124	19620	6278
2028	42929	28005	20572	6611
2029	44054	28970	21579	6966
2030	46042	30423	22846	7399
2031	48136	31963	24197	7862
2032	50345	33596	25639	8358
2033	52673	35328	27179	8890
2034	55130	37167	28822	9459

The BTS Fee estimated for single bus for 2022 is Rp 23,531/km which compares fairly well to the contracted value of 23,547.

A comparison of BTS fee for diesel and electric buses acquired in different years is shown in Figure 3. It is seen that in case of Articulated and single/low entry buses, the BTS Fee in initial years is higher for electric buses as compared to the ICE buses. The electric articulated bus in particular is

[12] Based on Transjakarta's Pilot E-bus HPS. For articulated buses and medium buses, a factor

not a standard product and especially, the high floor version needed for Transjakarta's BRT operations are not readily available. Hence the capex and operating parameters assumed are rather conservative. The cost of single buses assumed as per rates available in Indonesia are quite higher than comparable bus costs in China or India. The cost of acquiring and running these buses need to be ascertained with actual quotations from manufacturers for firm orders of minimum economic quantities. Further, possibility of replacement of these buses with higher number of single buses can be explored subject to operational feasibility as the carrying capacity of an Articulated bus is similar to that of 1.5 single buses but the BTS fee is estimated more than 1.5 times. This will also result in homogenisation of bus fleet and increase in number of single buses procured will further reduce the cost of acquisition/operation.

On the other hand, the BTS Fee estimated for the electric microbus is already lower than similar ICE Micro buses and can be considered for accelerated deployment.

The financial feasibility of Option 1 is evaluated by estimating the total BTS Fee payable to the operators in BAU scenario (diesel buses) and Option 1 (fleet comprising a mix of ICE buses which are not yet replaced and electric fleet replacing the retiring ICE bus fleet). The difference between the Rp./km for ICE buses under BAU and Electric buses shows the financial feasibility of electrification as shown below:

Table 32 Financial Feasibility of Operator Financing of Electric Buses

Option 1	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Articulated Buses	538	555	602	704	768	843	923	1011	1032	1053	1075
Low Entry Buses	522	540	558	577	596	631	657	710	734	754	781
Single Buses	1239	1499	1596	1994	2080	2189	2264	2368	2433	2500	2591
Medium Buses	253	264	327	559	840	1172	1540	1935	2012	2092	2192
Microbuses	779	852	916	1118	1413	1721	2464	3078	3213	3353	3500
Total	3331	3709	3999	4951	5696	6555	7848	9103	9424	9752	10138
Difference (BAU-Option 1)											
Articulated Buses			-24	-49	-45	-39	-32	-23	-13	-2	9
Low Entry Buses	-2	-2	-2	-2	-1	3	11	21	27	33	33
Single Buses	-9	-19	-18	-21	-15	-3	14	63	109	139	186
Medium Buses	0	1	2	11	26	48	76	132	148	173	204
Microbuses		6	18	47	98	203	388	630	676	731	802
Total	-11	-15	-23	-13	63	212	457	823	948	1073	1235

(Figures in Rp Billion)

It is seen that the overall cost of operating electric buses in this Option is slightly higher than operating ICE buses till 2027 but thereafter the cost of operating e-buses is much lower than that of ICE buses. Hence this Option is financially viable as compared to BAU.

Figure 3 Comparison of BTS Fee for ICE and Electric buses

5.3.2. Option 2: Fleet Procured by Transjakarta/Regionally Owned SPV

This scenario assumes that the cost of acquisition of the fleet and chargers is borne by Transjakarta or an SPV formed acquiring the fleet but the depot and grid connection is arranged by the operator. In this scenario, the operator is paid Rp/km fee for carrying out the operation and maintenance of the buses including cost of energy. Transjakarta secures debt and equity financing from DKI Jakarta and other sources and services them from the savings in payment of Rp/km as compared to the BAU scenario.

Table 33 Financial Feasibility of Transjakarta Financing of Electric Buses

Operating Costs + Instalments	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Articulated Buses	538	555	587	665	721	787	858	935	949	963	977
Low Entry Buses	522	539	557	575	594	628	650	698	715	729	771
Single Buses	1239	1498	1593	1988	2070	2173	2242	2330	2387	2446	2602
Medium Buses	255	265	327	561	841	1171	1536	1923	1988	2056	2181
Microbuses	779	849	907	1092	1361	1615	2265	2731	2731	2731	2731
Total Operating Cost	**3332**	**3706**	**3970**	**4881**	**5587**	**6375**	**7551**	**8617**	**8769**	**8924**	**9261**
Difference (BAU-Option 2)											
Articulated Buses			-8	-9	2	16	33	53	70	88	107
Low Entry Buses	-2	-2	-1	0	1	6	18	34	46	58	44
Single Buses	-9	-18	-15	-15	-5	13	36	101	155	193	175
Medium Buses	-1	0	2	9	25	48	80	144	172	209	215
Microbuses		8	28	73	150	308	587	978	1158	1354	1571
Total	**-13**	**-11**	**6**	**58**	**172**	**391**	**754**	**1309**	**1602**	**1902**	**2112**

(Figures in Rp Billion)

In this Option, the cost of operating ICE buses is lower until 2025 and thereafter operating electric buses is much cheaper as compared to the ICE buses. The Financial IRR for Transjakarta comparing the capital investments in the buses and the resultant savings in total BTS Fee paid works out to 14.9% p.a. which is much higher than estimated cost of funds for Transjakarta (7.15% p.a.). Hence this Option is also financially viable as compared to BAU.

5.3.3. Option 3: Fleet Procured by Third Party Asset Financiers /Lessors

In this Option, Transjakarta leases the buses/chargers from lessors and pays them lease fee on Rp/month/bus basis and pays Rp/km to operators for other operating/charging costs. The lease fee is determined considering the expected return on capital, insurance fees, administrative overheads, taxes etc. and resultant cashflow is summarised in Table 34.

Table 34 Financial feasibility of Leasing the Electric Buses

Option 3	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Leasing Charges and Operating Fee											

Articulated Buses	161	166	381	720	783	857	937	1024	1043	1061	1080
Low Entry Buses	246	253	260	268	276	537	684	738	757	773	821
Single Buses	718	975	1054	1454	1839	2052	2262	2510	2577	2645	2825
Medium Buses	182	189	250	490	798	1138	1514	2009	2078	2151	2287
Microbuses	457	514	602	781	1047	1517	2328	2834	2839	2843	2848
Total	1765	2097	2548	3712	4744	6102	7725	9114	9293	9474	9862
Difference (BAU-Option 3)											
Articulated Buses			-30	-65	-60	-54	-46	-37	-24	-11	3
Low Entry Buses	-5	-5	-4	-3	-3	-17	-17	-6	4	14	-7
Single Buses	-20	-45	-47	-72	-94	-93	-87	-79	-34	-6	-48
Medium Buses	-6	-5	-6	-8	-6	4	21	59	82	114	109
Microbuses		7	24	62	132	273	524	874	1051	1241	1454
Total	-32	-49	-63	-87	-31	112	394	811	1078	1352	1511

(Figures in Rp Billion)

In this Option also, the cost of operating ICE buses is lower until 2028 and thereafter operating electric buses is much cheaper as compared to the ICE buses.

5.4. Comparison of the various Financing Options

Given the difference in annual cashflows of each of the Options, it is best to evaluate each option in terms of the Net Present Value of the cashflows as presented below:

Table 35 Comparison of various Financing Options

	Difference in NPV from BAU		
Type of Bus/Option	**Option 1**	**Option 2**	**Option 3**
Articulated Buses	-126	376	-188
Low Entry Buses	115	299	0
Single Buses	399	943	-358
Medium Buses	723	990	391
Microbuses	3115	5583	5134
Total	**4225**	**8191**	**4978**
%age of BAU NPV	9.2%	17.9%	12.5%

(Figures in Rp Billion)

The NPV of operating electric buses overall as well as in most bus categories/Options is positive but Option 2 appears to be most feasible. There is scope for improving the NPV of electric articulated buses either by achieving better specs/ terms from OEMs or by replacing these buses with Single buses with equivalent carrying capacity.

From an implementation feasibility stand point, Option 3 seems to be most feasible considering fragile financial condition of most operators who are unlikely to be able to raise the requisite finances required in Option 1 and asset-lite approach of Transjakarta.

In order to optimise financial and implementation feasibility, and to reduce the financing burden on various stakeholders, it will be worthwhile to pursue different Financing Options for different types of buses (Option 4) as shown below:

Table 36 Option 4

Type of Bus	Financing Option	NPV
Articulated Buses	Option 2	376
Low Entry Buses	Option 1	115
Single Buses	Option 1	399
Medium Buses	Option 1	723
Microbuses	Option 3	5134
Total		6747

(Figures in Rp Billion)

The estimated year-wise increase (negative) or decrease (positive) in PSO requirements as compared to BAU scenario for various Options for electrification is shown in Table 37:

Table 37 Reduction in Operating Subsidy

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Option 1	-11	-15	-23	-13	63	212	457	823	948	1073	1235
Option 2	-13	-11	6	58	172	391	754	1309	1602	1902	2112
Option 3	-32	-49	-63	-87	-31	112	394	811	1078	1352	1511
Option 4	-11	-13	-2	41	144	337	659	1143	1405	1674	1985

(Figures in Rp Billion)

In case, the DKI Jakarta/Transjakarta decides to pursue Option 2, the net funding required is shown below

Table 38. Net Funding Required from Transjakarta in Option 2

Yearly Funding Requirement	2023	2024	2025	2026	2027	2028	2029	2030	Total
Articulated Buses			889	1321	152	175	182	190	2909
Low Entry Buses	113					817	419	90	1439
Single Buses	435	651	134	969	1138	486	471	1600	5883
Medium Buses	193		96	391	476	482	495	760	2894
Microbuses		45	87	176	267	485	777	935	2773
Total Investment Cost	**741**	**695**	**1207**	**2857**	**2033**	**2446**	**2345**	**3575**	**15899**

(Figures in Rp Billion)

6. Sensitivity Analysis

The financial analysis presented in section 4 is dependent on the assumptions made. There may be variations in actual realisation of these assumptions. The objective of this section is to check the sensitivity of various assumptions on the financial feasibility and to identify the key parameters which must be watched carefully to ensure the continued financial feasibility of the electrification of the fleet.

The following scenarios are considered:

Table 39. Parameters for Sensitivity Analysis

Parameter	Scenario Name	Assumptions
Energy Price	E1. Modest Fossil Fuel Price Increase	Diesel/Petrol/CNG prices and Electricity prices increase at the same rate of 3% p.a.
	E2. Higher Electricity price Rise	Diesel/Petrol/CNG prices and Electricity prices increase at the rate of 3% p.a. and 4.5% p.a.
Capex	C1. Over Supply in ICE Bus Market	Diesel Bus prices reduce by 5% p.a.
	C2. Rationalisation of E-bus prices in Indonesia	E-buses prices reduce by 15% p.a. for 3 years and then increase @ 3.5% p.a.
	C3. Considering E-buses imported from Europe	Cost of E-buses will be 67% more than in the base case.[13]
Cost of Funds	F1. Increase in cost of funds due to new technology	Cost of funds for each of the financing options increase by 1% p.a.
Maintenance Cost	M1. Higher Maintenance Cost for E-buses	Increase in Maintenance cost of e-buses by 10%
Accelerated Deployment	D1. Faster deployment of Microbuses	Using alternate deployment scenario B as shown in Table 7

The impact of the above sensitivity scenarios on the NPV of each of the options is shown:

Table 40. Sensitivity Analysis Results

Scenario/Option	A	B	C	D

[13] 12m E-buses in UK cost about USD 500,000 as compared to USD 300,000 assumed in base case.

Base Case	4,225	8,191	5,245	6,786
E1	3,170	7,127	4,181	5,713
E2	2,944	6,941	3,995	5,496
C1	766	4,491	1,661	3,274
C2	8,298	11,286	9,453	10,492
C3	-4,141	1,152	-3,771	-1,130
F1	3,343	6,860	4,040	5,650
M1	3,546	7,527	4,581	6,124
D1	4,319	8,603	5,602	7,143

(Figures in Rp Billion)

It is seen that, despite various adverse scenarios assumed, the NPV of electrification remains positive in all Options except C3 and Option 2 remains the most favourable of all Options followed closely by Option 4. It is seen that the financial feasibility is most sensitive to changes in Capex associated with the E-buses and is low to moderate sensitive towards changes in electricity prices, maintenance costs or cost of funds. Also, it is seen that the alternate roadmap which accelerates the e-bus deployment has a higher NPV as compared to the base case scenario.

7. Cost Benefit Analysis

7.1. Introduction

Public transport projects which are otherwise not financially viable, are supported by the Government based on their economic viability. Jakarta's bad air quality having an effect on the economic productivity and healthcare costs of the residents[14]. The Government of DKI Jakarta has initiated the electrification of Transjakarta fleet to curb the emissions arising from the public transport fleet. This section assesses various social costs and benefits of electrification of the fleet on account of various aspects of the operation of E-buses.

Societal benefits for EVs include better air quality and health, national security benefits, domestic economic development and other non-quantifiable benefits[15]. Some of the beneficial effects of electrification are monetarily quantifiable while some are non-quantifiable benefits. A recent Canadian study has found that converting all cars and SUVs in the Greater Toronto area to EVs would reduce air pollution-related deaths by 313 per year (0.005% of population), and deliver estimated monetary benefits of $2.4 billion[16] i.e., nearly $10,000 in social benefits shared by everyone, not just the people buying the cars[17].

7.2. Quantifiable benefits

7.2.1. GHG Emissions and Social Cost of Carbon

The use of electric vehicles leads to decrease in consumption of some types of fossil fuels (Diesel/Gasoline/CNG) in operating the vehicles but there is also an increase in consumption of other types of fossil fuel (coal, oil and natural gas) for generation of the electricity used for charging the E-buses. The net reduction in the GHG emission is socially relevant. Each litre of diesel burnt produces 2.67 Kg[18] of CO_2 without considering the upstream emissions in production, refining, transportation and storage of the fuels. Buses in Jakarta use 30% biodiesel as well. Considering average current fuel efficiency of single bus of 2.03 km/litre, the fleet produces 1.67 Kg of CO_2 per km including the indirect emissions related to extraction, production, transportation and storage of the fuel. Similarly, the carbon emissions for other bus types are also determined.

On the other hand, Indonesia's electric grid is primarily dependent on fossil fuel although the Government of Indonesia has ambitious plans of reducing the carbon load factor of the grid from

[14] Syuhada G, Akbar A, Hardiawan D, Pun V, Darmawan A, Heryati SHA, Siregar AYM, Kusuma RR, Driejana R, Ingole V, Kass D, Mehta S. Impacts of Air Pollution on Health and Cost of Illness in Jakarta, Indonesia. Int J Environ Res Public Health. 2023 Feb 7;20(4):2916. doi: 10.3390/ijerph20042916. PMID: 36833612; PMCID: PMC9963985..

[15] Ingrid Malmgren, "Quantifying the Societal Benefits of Electric Vehicles", World Electric Vehicle Journal Vol. 8 - ISSN 2032-6653, 2016

[16] CLEARING THE AIR: How Electric Vehicles and Cleaner Trucks Can Help Reduce Pollution, Improve Health and Save Lives in the Greater Toronto and Hamilton Area - Clearing The Air

[17] Study Suggests Each Electric Car Brings Nearly $10,000 In Social Benefits (insideevs.com)

[18] www.energuide.be, 2020

0.88 in 2018 to 0.67 by 2028 by aggressive addition of renewable sources of power as shown in Table below.

Table 41. Grid emission factor (combined margin – ex-post) kg CO2e /kWh

Description	2020	2022	2024	2026	2028
GHG emissions per kWh of electricity consumed	0.829	0.817	0.791	0.692	0.673

Source: KESDM 2019, RUPTL 2019

The saving in average GHG emission for E-Buses has been estimated after taking into account the transmission and distribution losses of 8.8%. By 2028, grid GHG emission factor is expected to reduce to 0.67. This can be further reduced with generation electricity using solar power at the bus depots, bus stations, parking areas, terminals and halts.

In order to assess the economic value of the GHG emission reduction, the Social Cost of Carbon (SCC) is estimated in Interim Report of Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, February, 2021[19] based on 3% discount rate as shown below:

Table 42. The social cost of carbon

Year	2020	2023*	2030
US$ @ 2020 Prices	51	54.1	62.0
Value of 1 US$ in current price	1.00	1.16	1.43
Value of 1 ton CO_2 in current price	51.0	62.7	84.5
Exchange Rate (IDR/USD)		15200	21388
Cost in Rp/Ton of CO_2		953,495	1807,280
Annual Increase		9.6%	

**Interpolated*

The social cost of carbon avoided by electrification of Transjakarta fleet is estimated as under:

[19] Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

Table 43. Estimated social cost of carbon avoided by electrification of Transjakarta fleet

		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
GHG Emission from Motor Fuels Avoided												
Petrol consumption avoided	Million litres		0.70	2.10	4.91	9.12	17.04	29.66	44.82	44.82	44.82	44.82
Diesel Consumption avoided	Miliion litres	5.41	9.73	11.51	21.60	33.67	46.91	57.54	76.10	76.10	76.10	76.10
CNG Consumption avoided (LSP)	Million LSP			6.92	17.21	18.40	19.77	21.20	22.70	22.70	22.70	22.70
GHG Emissions avoided	**000 tons**	**18.5**	**35.3**	**63.3**	**132.5**	**189.2**	**261.4**	**338.7**	**450.8**	**450.8**	**450.8**	**450.8**
GHG Emission from Electricity consumed												
%age of RE Consumed		5%	10%	15%	20%	20%	20%	20%	20%	20%	20%	20%
%age Grid Electricity Consumed		95%	90%	85%	80%	80%	80%	80%	80%	80%	80%	80%
Grid Emission Factor	kg CO2e/kWh	0.791	0.742	0.692	0.683	0.673	0.664	0.655	0.645	0.637	0.628	0.619
Electricity Consumed		**15.29**	**27.73**	**50.99**	**107.56**	**150.98**	**203.57**	**256.60**	**335.91**	**335.91**	**335.91**	**335.91**
GHG Emission from Electricity consumed	**000 tons**	**11.49**	**18.51**	**29.99**	**58.73**	**81.29**	**108.09**	**134.36**	**173.46**	**171.06**	**168.70**	**166.36**
GHG Emission Reduced	000 Tons	7.01	16.81	33.32	73.74	107.89	153.27	204.34	277.31	279.71	282.07	284.40
Cost of GHG Emission	IDR/Tons	1018985	1121099	1233446	1357052	1493045	1642665	1807280	1988391	2187651	2406879	2648077
GHG Emission reduction value	**Bn IDR**	**7.14**	**18.85**	**41.10**	**100.07**	**161.08**	**251.77**	**369.31**	**551.40**	**611.90**	**678.91**	**753.12**

7.2.2. Air Pollution (SOx/NOx/PPM) and Their Social Cost

The pollutants from gasoline powered vehicles include oxides of sulphur (SOx), and nitrogen (NOx) and other particulate matter (PM). The effect of reduction in these pollutants in the Jakarta air evaluated below.

SOx Emissions:

Sulphur dioxide can cause respiratory problems such as bronchitis, and can irritate the nose, throat and lungs. It may cause coughing, wheezing, phlegm and asthma attacks. Sulphur dioxide has been linked to cardiovascular disease as well.

Table 44. National Ambient Air Quality Standards vs. WHO guidelines

Air Pollutants	Average Time	NAAQS ($\mu g/m^3$)	WHO Guidelines($\mu g/m^3$)
SPM	24-hr	230	-
	1-yr	90	-
PM_{10}	24-hr	150	50
	1-yr	50	20
$PM_{2.5}$	24-hr	65	25
	1-yr	15	10
SO_2	1-hr	900	-
	24-hr	365	20
	1-yr	60	-
NO_2	1-hr	400	200
	24-hr	150	-
	1-yr	100	40
0_3	1-hr	235	-
	8-hr	-	100
	1-yr	50	-

According to a white paper published by ICCT in January 2021[20], 96.5% of the diesel fuel sold in Indonesia had a rated sulphur content of 2,500 parts per million (ppm). The Directorate General of Oil and Gas, GoI has set a 50-ppm fuel target for 2025, reduced from a 500-ppm target beginning in 2021[21]. Accordingly, SOx emission of 100 mg/Litre considering relative weights of Sulphur (S) and SO_2. Similarly, the SOx emission from gasoline ICEVs are estimated at 1000 mg/L[22] (with gasoline containing 500 ppm sulphur) based on Euro IV norms[23].

[20] Air quality impacts of palm biodiesel in Indonesia (theicct.org)
[21] Directorate General of Oil and Gas Decision No. 3674K/24/DJM/2006 and 3675K/24/DJM/2006
[22] Based on 500 ppm Sulphur
[23] Emission Standards: Europe: Cars and Light Trucks (dieselnet.com)

NOx Emissions:

Elevated levels of nitrogen dioxide can cause damage to the human respiratory tract and increase a person's vulnerability to, and the severity of, respiratory infections and asthma. Long-term exposure to high levels of nitrogen dioxide can cause chronic lung disease. A known deficiency of Euro IV/V heavy-duty vehicles is that they have extremely high NOx emissions in urban driving conditions. Further, low-sulphur fuels have also been found to exacerbate the NOx effect when blended with biodiesel[24].

According to a study conducted by The Real Urban Emissions (TRUE) Initiative established by the FIA Foundation and the International Council on Clean Transportation (ICCT) in November 2022[25], the actual emission of NOx in Jakarta was found as under:

Table 45. Emission of No_x in Jakarta

	Diesel Bus	CNG Bus	Gasoline Taxi
NOx emission (gms/kg)	45	2	1

7.2.1. Particulate Matter

According to the US Environmental Protection Agency (EPA), fine particle pollution found in vehicle tailpipe emissions causes cardiovascular harm, respiratory harm, cancer, reproductive and developmental harm etc., resulting in reduced quality of life, increased healthcare costs and premature death[26]. In 2019, Jakarta ranked first as the city with the worst air quality in Southeast Asia[3] and, according to the 2021 World Air Quality Report issued by AQ Air, Jakarta ranks 12th among capital cities worldwide in terms of average annual PM2.5 concentration (39.2 µg/m3), a level that far exceeds the World Health Organization Air Quality Guideline value of 5 µg/m3[25]. A study conducted by Vital Strategies in 2019 found that vehicle exhaust is the highest major source of PM2.5 pollution in both wet and dry seasons in Jakarta[27].

[24] Dana Lowell and Fanta Kamakaté, Urban Off-Cycle Emissions from Euro IV/V Trucks and Buses (ICCT: Washington DC, 2012). http://www.theicct.org/urban-cycle-nox-emissions-euro-ivv-trucks-and-buses

[25] true-jakarta-report-en.pdf (trueinitiative.org)

[26] U.S. Environmental Protection Agency, Integrated Science Assessment for Particulate Matter, EPA 600/R-08/139F, 2009.

[27] Vital Strategies, "Main Sources of Air Pollution in Jakarta," (2019), https://www.vitalstrategies.org/resources/identifying-the-main-sources-ofair-pollution-in-jakarta-a-source-apportionment-stu

Vehicular production of $PM_{2.5}$ can be classified into exhaust related and non-exhaust related caused by braking, from tires, fuel evaporation, oil and fuel leaks, and road dust. In regards to exhaust related $PM_{2.5}$, the difference between a Euro IV or higher standard vehicle or an electric vehicle is not so significant as shown in Figure 4. However, Jiang et al report that in real world driving conditions in Xi'an, China, the electric buses due to their higher weight, emit slightly higher (~2%) PM2.5 emissions as compared to their diesel counterparts[28]. However, the difference is small.

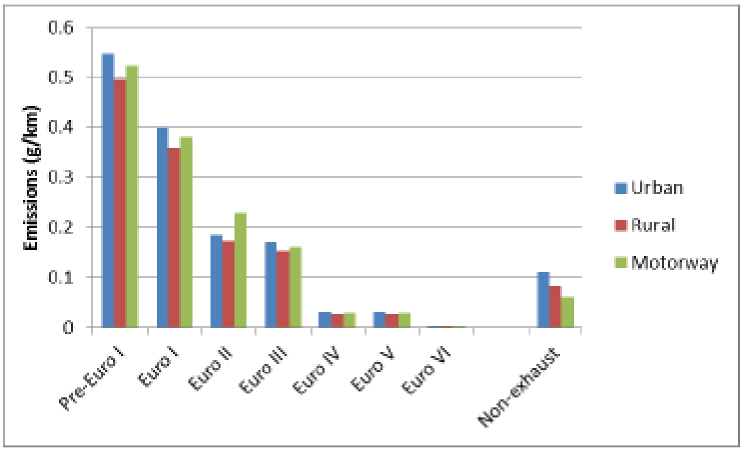

Figure 4. Exhaust and Non-Exhaust sources of PM2.5 in Transportation

On the other hand, Sang-Hee et al[29] report that the emission of $PM_{2.5}$ of the ICEVs (28.7-33.0 mg/V·km) were two times higher than those of the EV (13.9-17.4 mg/V·km). Accordingly, the reduction in PM2.5 emissions considered for various fuels is shown in Table .

Table 46 Reduction in PM2.5 emissions

	Diesel Bus	CNG Bus	Gasoline Taxi
$PM_{2.5}$ Emission increase (g/L)	0.13	0.010	-0.001

[28] Exhaust and non-exhaust airborne particles from diesel and electric buses in Xi'an: A comparative analysis - ScienceDirect

[29] Comparison of total PM emissions emitted from electric and internal combustion engine vehicles: An experimental analysisv

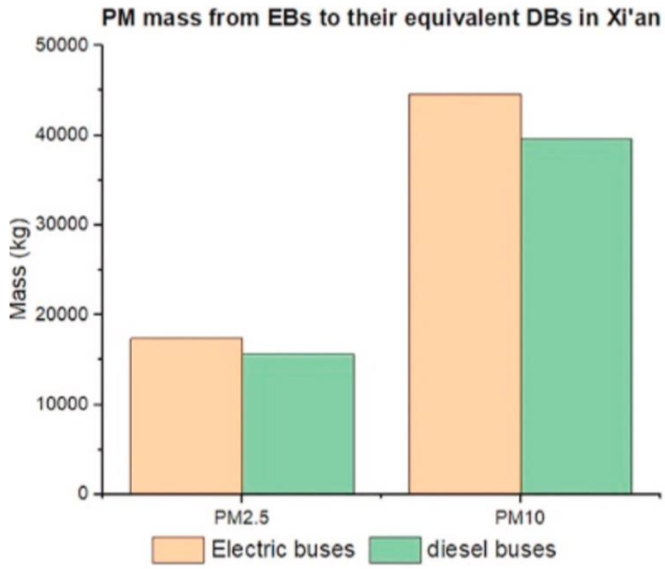

Figure 5 Comparison of PM emissions by Diesel and Electric Vehicles

Emissions from Electricity Production

The reduction in $PM_{2.5}$, SOx and NOx emissions from gasoline ICEVs is offset by the production of the same pollutants from electricity generation using fossil fuel. Indonesian emission norms are quite relaxed in respect of these pollutants as compared to other countries[30]. Although, Government of Indonesia has recently upgraded the norms[31], the allowed emission levels are still very high as compared to similar Asian countries. *The Ministry of Environment and Ministry of Energy and Mineral Resources need to take appropriate and urgent measures for measurement of emissions levels from the power plants and for the control of the same to mitigate adverse impacts from additional production of electricity for EV charging.*

Economic Cost of Air Pollution

The cost of the air pollution emitted as a result of transportation as well as electricity generation is estimated based on the cost per ton of respective emissions as estimated by the International Monetary Fund in "**Getting Energy Prices Right from Principle to Practice**", 2014 adjusted to current prices as follows.

Table 47 Social Cost of Emissions

Emission Cost (per Ton)	Sulphur Oxides			Nitrogen Oxides			Primary Fine Particulate Matters		
	Coal	Natural gas	Ground Level	Coal	Natural gas	Ground Level	Coal	Natural gas	Ground Level
USD (2010)	4,617	5,627	2,159	2,492	2,699	449	5,636	6,936	60,669
USD (2023)	6371	7765	2979	3439	3725	620	7778	9572	83723

30 Indonesia's coal power emission norms.indd (cseindia.org)

31 Paving way to new emission norms for thermal power plants in Indonesia (cseindia.org)

Emission Cost (per Ton)	Sulphur Oxides			Nitrogen Oxides			Primary Fine Particulate Matters		
	Coal	Natural gas	Ground Level	Coal	Natural gas	Ground Level	Coal	Natural gas	Ground Level
Rp (Million)	97	118	45	52	57	9	118	145	1273

Considering that nearly 50% of electricity in Indonesia is produced from coal and 36% from Natural gas and oil, weighted average values are considered.

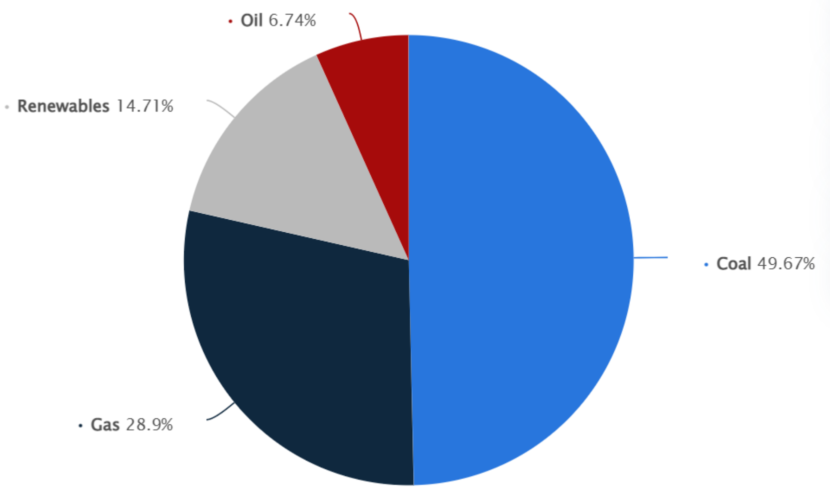

Figure 6 Source of energy for electricity generation in Indonesia (www.statista.com)

The estimated value of emission reductions due to electrification of Transjakarta fleet is shown below:

Table 48. Estimated value of emission reductions due to electrification of Transjakarta fleet

		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
SOx Emissions avoided												
From motor fuels	Tons	8	14	24	39	58	58	58	58	8	14	24
From electricity	Tons	83	114	149	184	231	222	212	203	83	114	149
Savings/(Cost)	Bn Rp	-4.0	-5.5	-7.2	-8.7	-10.8	-10.7	-10.4	-10.2	-4.0	-5.5	-7.2
NOx Emissions avoided												
From motor fuels	Tons	858	1,325	1,840	2,259	2,983	2,983	2,983	2,983	858	1,325	1,840
From electricity	Tons	82	112	146	180	226	216	207	197	82	112	146
Total Savings/(Cost)	**Bn Rp**	**8.6**	**14.0**	**20.3**	**26.0**	**35.8**	**37.4**	**39.1**	**40.9**	**8.6**	**14.0**	**20.3**
$PM_{2.5}$ Emissions avoided												
From motor fuels	Tons	(0.1)	0.0	0.2	0.5	0.9	1.9	3.6	5.6	5.6	5.6	5.6
From electricity	Tons	1.2	1.9	3.1	6.0	8.0	10.3	12.4	15.3	14.3	13.4	12.6
Savings/(Cost)	**Bn Rp**	-1.7	-2.6	-4.3	-8.2	-11.0	-13.6	-14.8	-17.1	-16.1	-15.0	-13.9

		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Total Savings	**Bn Rp**	-0.6	-0.2	-1.9	-3.7	-2.6	-0.5	2.4	7.9	10.7	13.7	16.8

It is seen that the emissions from electricity produced exceeds those from motor fuels saved in case of SOx and $PM_{2.5}$. Efforts are needed in regard to reducing emissions from power generation plants as well reducing EV battery weights in order to make the EVs better than their ICE counterparts in this regard.

7.2.2. Reduction in Public Service Obligations

Pertamina, the state-owned petroleum marketing company, supplies Pertalite (RON 90) at a price of Rp 10,000[32] as against a production cost of 14,450 i.e., with a subsidy of Rp 4,450. Similarly, diesel (Biosolar/ CN48) is sold at 6,800 rupiah per litre, compared with a production cost of 13,950 rupiah. As regards to the price of compressed natural gas used by articulated buses, the price was reduced in 2021 by Government of Indonesia by cutting the government profit's share from natural gas upstream[33]. Further, the price has been significantly increased in 2022 from Rp 3100 to Rp 4500 per litre premium equivalent (LSP)[5]. Hence it is assumed that there are no significant subsidies applicable to CNG.

On the other hand, electricity for e-bus charging is competitively priced. The government has decreed that the electricity for e vehicle charging will be determined by PLN between Rp 714 to 1625/kWh depending on the business prospects. This compares reasonably with the average electricity tariffs charged by PLN for various consumer groups which ranged between Rp 806 to 1447/kWh in 2021. Hence, it is reasonable to assume that the electricity for charging of e-buses is not subsidised. Thus, operating EVs would result in savings of to the government which it can deploy in other social benefit schemes as shown in Table .

Table 49. Economic Impact of Reduction in Fuel Subsidy

Fuel Type		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Diesel	Rp Billion	39	70	82	154	241	335	411	544	544	544	544
Gasoline			3	10	24	45	84	147	222	222	222	222
Total Reduction		**39**	**73**	**93**	**179**	**286**	**420**	**558**	**766**	**766**	**766**	**766**

(Figures in Rp Billion)

7.3. Non-quantifiable benefits

7.3.1. Noise Pollution

Due to fewer moving components, electric buses are decidedly quieter in operation than comparable ICE buses considering noise from propulsion system only. Other sources of noise due to movement of the bus is not differentiate between technologies. However, a comparison and

[32] Indonesia bites the bullet on fuel prices as subsidies soar | Reuters| September 3, 2022

[33] Why Indonesia Should Abandon its Natural Gas Pricing Regulation – The Diplomat

calculation of the economic effect similar to that made in atmospheric emissions cannot be made without calculating the decibel levels within the bus and surrounding areas which are contributed by factors other than the bus itself. Hence, the quantitative benefit from lower noise levels is kept outside the scope of this report.

7.3.2. Reduction in Foreign Exchange Outgo

Indonesia is a net importer of petroleum. Due to gradual decline in domestic production and increase in consumption, the import of petroleum reached 233,000 barrels/day in Dec 2020 as compared to 215,583 barrels/day in Dec 2019. Assuming no change in domestic production, the reduction in demand for motor fuels due to electrification of Transjakarta bus fleet will reduce the import of crude oil/derivatives to that extent. The saving in foreign exchange outgo due to electrification of the Transjakarta bus fleet is thus estimated in Table .

Table 50. Reduction in Forex Outgo

Forex Outgo Reduced		2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
No of Barrels ('000s)		34.0	66.1	87.1	170.2	275.5	414.1	569.2	791.8	791.8	791.8	791.8
Price per barrel (USD)		77.3	79.6	82.0	84.4	86.9	89.6	92.2	95.0	97.9	100.8	103.8
Foreign outgo saved	USD Mn	2.6	5.3	7.1	14.4	24.0	37.1	52.5	75.2	77.5	79.8	82.2
	Rp Billion	44	93	132	279	488	793	1,179	1,774	1,918	2,075	2,244

Due to the import dependency, a large portion of the money spent on fuel goes out of the Indonesian economy and consequently produces very little economic activity. In the United States e.g., it is estimated that the amount spent in other sectors can generate 16 times as many jobs per dollar spent as compared to the petroleum sector[34]. The effect of foreign exchange outgo on domestic economy is a very complex subject and beyond the scope of this report. Besides, the burden of this outgo is mostly borne by the customers with about 11.3% borne by the government of Indonesia by way of subsidies in 2021[35] (10.5% in 2020) and the impact of the subsidies has already been discussed in the previous section and hence not quantified again to avoid double-counting.

7.4. Economic Analysis (NPV, BCR)

7.4.1. Key Assumptions

[34] James J. Winebrake, Erin H. Green, and Edward Carr," Plug-In Electric Vehicles: Economic Impacts and Employment Growth", Energy and Environmental Research Associates, LLC October 2017

[35] Pertamina Financial Statement for 2021 (Unaudited)

Fiscal Correction Factor: A correction factor of 0.8 is used in the economic analysis to correct financial transfers (taxes, subsidies etc).

Discount Rate: 7.15% (nominal discount rate corresponding to Transjakarta/DKI Jakarta cost of funds)

For the purpose of Social Cost Benefit Analysis, the following has been considered:

Table 51. Social Cost Benefit Assumptions

Costs	Benefits
a) Incremental economic investment in acquiring the electric buses b) Cost of charging infrastructure	a) Saving in Operating Costs b) Saving in Social Cost of Carbon c) Savings in health costs due to reduction in SOx/NOx/$PM_{2.5}$ emissions d) Savings in subsidies on diesel/gasoline fuels

7.4.2. Results of Social Cost Benefit Analysis

Based on the analysis above, the summary of economic indicators are as follows:

Table 52. Social Cost Benefit Analysis Result

Parameter	Unit	2031	(2024-2034)
Reduction in GHG Emissions	'000 Tons	288	1779
Reduction in SOx Emissions	Tons	(154)	(1160)
Reduction in NOx Emissions	Tons	2657	17,800
Reduction in $PM_{2.5}$ Emissions	Tons	(9.7)	(69.3)
Reduction in Foreign Exchange Outgo	USD Mio	75	457

Reduction in Fuel Subsidy	IDR Bn	1089	6760
Economic IRR		34%	
PV of Benefits	IDR Bn	10,070	
PV of Costs	IDR Bn	4,179	
Cost Benefit Ratio		2.41	

8. Risk Factors and Mitigation

It is estimated that the electrification of Transjakarta's fleet is both financially and economically viable. However, during the implementation of the roadmap, Transjakarta will face risks and challenges in achieving the estimated savings and benefits. The main risks and possible mitigation strategies are mentioned below:

Table 53 Risk Identification and Mitigation

Risk	Description	Mitigation
Higher Capex	E Bus market is still evolving and is subject to supply constraints. Higher demand for rare minerals may also increase battery prices.	• Reduce contractual risks • Standardise bus models and consolidate orders to increase volume and achieve economies of scale • Increase localisation content • Place larger orders with OEMS with multi-year procurement plans • Reduce battery size by optimising routing/ scheduling and opportunity charging • Reduce cost of grid connectivity/instalment payment mechanism • Develop bigger pool of bus suppliers
Financing risk	Operators/Transjakarta/Leasing Company may not be able to arrange all the financing needed.	• Divide financing requirements amongst stakeholders. • Create more bankable contracts • Government subsidy to meet down-payment requirements which is repaid over initial 1-3 years and utilised for further procurement of buses. • Invite leasing companies to finance and own buses • Create financial instruments backed by Government/ Institutions • Involve OEMs as stakeholders in operating consortiums
Operating Risk	Availability of buses during operating hours Timely Maintenance within budgeted cost	• Long term spare parts and maintenance agreement with OEMs, guarantee for battery life/ performance • Proper planning, trials of E-buses to ensure adequacy of battery size/ charging infrastructure • Involve OEMs as stakeholders in operating consortiums
Utilisation Risk	E-buses not deployed for contracted kms	• E-bus involve very high fixed costs and much lower variable operating costs as compared to ICE buses. Hence to maximise the advantage of the E-buses,

Risk	Description	Mitigation
		there must be operated optimally and should be given preference over running ICE buses.
Asset/Technology Risk	Risk of E-buses not performing as per requirements	• Long term contract with OEM for maintenance/warranty • Involve OEMs as stakeholders in operating consortiums
Asset Life	Although E-buses are claimed to have a longer life as compared to ICE buses, the technology is new and there are hardly any examples of e-buses running for more than 10 years.	• Long term contract with OEM for maintenance/ warranty • Involve OEMs as stakeholders in operating consortiums
Residual Value/ Resale Risk	Asset cannot be sold at the end of contract period	• Since E-buses have zero tail-pipe emissions, these can be used for more than 10 years without any detriment to the environment. The regulation should be amended to allow E-buses to operate as long as they are road-worthy.
Safety Risk	E-buses are more prone to fire than ICE buses, especially during charging. E-buses move silently and pedestrians/other vehicles may not be aware of an E-bus approaching from behind.	• Installing effective charging and monitoring technology in depots • Enhancing the training of drivers, engineers, and technicians • Using additional vehicle inspection methods, including thermal imaging technology in depots • Install Electric vehicle warning sounds
Emission Risk	Emission from electricity produced may be more than emission reduced from ICE vehicles	• Utilise more green electricity for charging • Tighter norms and monitoring of emissions from power plants by Government of Indonesia
Bankruptcy Risk	Operator unable to pay loans/carry on operations	• Provision of appointment of substitute entity/transfer of quota
Grid Availability	Delay in providing grid connectivity and grid reliability	• Keep the utility company (PLN) informed about roadmap of electrification and requirement of connectivity at different locations well in advance.

Risk	Description	Mitigation
		• Terminal Charging facility can be used in case any of the depots do not have supply temporarily. • Redundancy in charging capacity to be built in.

9. Conclusion and Way Forwards

As per the directions received from The Transport Agency of Government of DKI Jakarta, Transjakarta has envisaged to replace all its current ICE vehicle fleet with electric vehicles by 2030. It also envisages a much larger scale of operations involving more than 10,000 buses as compared to current fleet of about 4000 buses. This will result in avoidance of significant amounts of GHG emissions that would have been emitted with ICE vehicles.

In addition, the feasibility study has also proven that the electrification roadmap will be financially beneficial as well as reduce overall social costs associated with public transportation using ICE vehicles such as SOx/NOx/$PM_{2.5}$ emission and noise pollution in the urban areas, subsidies on petrol/diesel, foreign exchange outgo in importing petroleum/derivatives.

Out of the various options of business/financing models analyses, Option 2 where Transjakarta finances the fleet appears to be the best for reducing the total operating cost of Transjakarta and consequently the subsidy burden on DKI, Jakarta. However, it is against the current operational philosophy of Transjakarta and many such public transport entities around the world who prefer an asset-lite approach where the burden of owning and operating the fleet is assigned to private sector.

The current financing models of Transjakarta for ICE /E-Buses is similar to Option 1. However, the lack of experience with electric buses and limited financing ability/solvency of the operators may prove a tumbling block in implementation of electrification roadmap.

Option 3 almost completely relieves both Transjakarta and the operators from the burden of financing the fleet but this is an untested model at present so far as Transjakarta is concerned although it is being used in other sectors in Indonesia and in financing E-buses in other parts of the world. Present regulations also prohibit third party ownership of fleet for Transjakarta operations.

Each of the options have their limitations too and Transjakarta should adopt more than one model/financing option for faster and more effective deployment of electric buses for reasons given below:

1. Approximately 20% of the present fleet are owned by Transjakarta and for strategic reasons it may make sense for Transjakarta to continue to own a part of the total fleet.
2. Not all private operators are financial capable of arranging the funds for making the investment in the electric buses, depot infrastructure etc. and those who can, have a limited capacity. Hence it will not be feasible to achieve the target of full electrification by 2030 using the private operator financing model only.
3. The third-party financing of electric buses is very common in most countries adopting electric buses but in Indonesia, a suitable legal and institutional framework needs to be developed to use lease financing options which may take some time as current regulations do not permit

third party ownership of buses as dealt with in detail in **Output 2: Regulatory Framework for Transjakarta's E-bus Deployment**.

Accordingly, the financing /business model recommended for various bus types is summarised below:

Table 54. Financing/business model recommended for various bus types

Bus Type	Responsibility	Financial Model
Articulated Buses	Transjakarta	Self-financing through (Government Funding/ Loans) or Leasing
Single/Low Entry Buses/Medium Buses	Operator (Loans/Leasing)	Own Equity + Bank Loans/ Leasing
Microbus	Operator	Leasing (facilitated by Transjakarta)/ Own Funds

It should be noted that the absolute amount of PSO requirement will still increase as compared to current levels due to expansion of the fleet by 2.5 times by 2030 and increase in cost of manpower etc. **This analysis only confirms that the overall cost will be lower with electric buses than with ICE buses.**

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