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The optimal tax incentive and subsidy to promote electric trucks in Indonesia: Insight for government and industry

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ABSTRACT

This study aims to develop a mathematical model to encourage electric trucks and charging stations by providing tax incentives and subsidies in Indonesia. This study contributes to research on tax incentives and subsidies due to the need for more research on optimizing the optimal number of electric trucks and charging stations based on cost trade-offs for diesel and electric trucks. We consider carbon emission caps to limit the number of diesel trucks. This study examines the types of electric and diesel trucks consisting of multiple brands with these types of trucks. Total cost is formulated as the total investment cost of the electric truck and charging stations, the cost of operating and maintenance, diesel truck investment cost, carbon cost, and operation cost of charging stations. A numerical example and sensitivity analysis are illustrated to verify the proposed model and provide managerial insight for government and industry. The results show that a tax incentive of 36.0% without subsidies will not attract to purchase of electric trucks. In contrast, when incentives reach 36.5% to 40.0% and various subsidies ($1000 to $25,000), then electric truck skyrocket. In the year 2030, it is expected that about 477 trucks will be on the road in Indonesia and requiring the addition of 360 and 103 regular and fast charging stations, respectively.

1. Introduction

Governments in various countries and regions are looking for cleaner and more sustainable means of transportation to address the global problems of greenhouse gas (GHG) emissions, air pollution, and fossil fuel dependence. The U.S. Environmental Protection Agency (U.S. EPA, 2021) reported that the transportation sector now accounts for 29 % of the world's energy-related CO2 emissions and is constantly growing due to increased passenger and freight activity. Electric vehicles (EVs) have batteries instead of gasoline or diesel tanks and electric motors instead of internal combustion (IC) engines. EVs do not produce emissions from exhaust. Charging batteries can increase power generation, but the overall emissions associated with driving electric vehicles are typically lower than those of IC vehicles. They will generate even lower emissions when generating electricity from renewable energy sources such as wind power. A plug-in hybrid electric vehicle (PHEV) combines of fossil fuel and electricity, equipped with a battery, electric motor, fuel tank, and IC engine (The U.S. EPA, 2022; Holdway et al., 2010). The International Energy Agency (The IEA, 2021a) reported that 6.85 million EVs were sold in 2020, increasing to 30 million by 2025 and 45 million by 2030. In 2019, the market share of EV sales increased significantly to 7.2 million units, with a dominance of 46.5 % in China, Europe (24.3 %), the U.S. (20.1 %), and at least 20 countries (over 1 %). Global demand is forecasted with a market share of 17 % and 34 % in 2025 and 2030, respectively (The IEA, 2021b).

On August 18, 2019, Indonesian President Joko Widodo issued Presidential Decree No. 55 of 2019. It was first introduced to encourage and accelerate the implementation of various EV programs in Indonesia. This regulation has five key guidelines for accelerating EV, namely: i) development of the domestic industry, (ii) provide incentives, (iii) provide of electric charging stations and their regulations, (iv) compliance with technical requirements for EVs, and (v) environmental protection (Indonesian Legal Consultant SEEK, 2022). The program was designed to improve energy efficiency, energy security, and energy savings in Indonesia's transportation sector through clean energy, clean and environmentally friendly air quality, and reduction of carbon dioxide emissions. With the highest nickel ore production (30 %) and the largest nickel ore reserves (24 %) in the world, this material is an important component of EVs batteries (Pandyaswargo et al., 2021; The Ministry of Investment /BPKM of the Republic of Indonesia, 2022).

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Based on this potential, Indonesia is seeking to promote and expand sales of EVs and electric charging station infrastructure through the Ministry of Industry of the Republic of Indonesia to control air pollution. Among the measures the Republic of Indonesia government can offer to the industry are tax incentives and subsidies for the development of EVs and electric charging station systems. This policy requires the government to allocate an additional budget to make prices more affordable and closer to IC engines. Additional incentives include 0 % import tariffs on fully assembled electric vehicle imports and 0 % VAT and income tax (The Ministry of Industry of the Republic of Indonesia, 2022). These programs reflect the Indonesian government's efforts to encourage investment in EVs and electric charging stations. For example, EVs are exempt from luxury tax and are expected to be raised from 0 % to 5 %. One type of EV, the full and mild hybrid EVs, is taxed at a tax rate of 6 % to 12 %, up from the previous range of 2 % to 12 %. In addition, if an EV industry invests at least IDR 5 trillion (US$ 346.2 million), the government will allow tax deductions for up to 10 years (krAsia, 2022).

Developed and developing countries have recently focused on making EV sales more attractive through tax incentives, subsidy programs, and public charging infrastructure schemes. For example, the German federal government has a program to reach one million EVs and reduce CO_2 emissions by 2020. A mathematical model for the use of EVs to optimize electricity tax rates by providing subsidies granted by the German federal government (Hirte and Tscharaktschiew, 2013). Using market analysis, Jenn et al. (2013) analyzed the financial incentives for promoting the adoption of PHEV in the U.S. Financial incentives have increased the adoption rate for PHEV. The incentive is only effective if greater than US$1000. Local authorities in Spain setup a deduction on avenue tax for EVs to promote such cars or trucks as an opportunity solution for sustainable non-public mobility (Sánchez-Braza et al., 2014). Alhulail and Takeuchi (2014) analyzed the policy impacts of the Tonnage and Acquisition Tax Cut for schemes of Eco-friendly Vehicles and Eco-car Subsidies on the sales of eco-friendly vehicles in Japan. In their results, this scheme was influenced to promote sales more positively than the gasoline price policy. Chu and Gau (2015) developed a project with the aim of converting all diesel tricycles into e-trucks in the Xiluo production market. The Xiluo product market is expected to set an example for other wholesale markets in Taiwan. They developed e-trucks due to subsidies from the Taiwanese government. Bahamonde-Birke and Hanappi (2016) developed hybrid discrete choice modeling and estimation model to analyze the acceptance of electric vehicles by the Austrian population and the perspectives of electromobility in the country. The research provides functional models to analyze how different features of alternative-powered vehicles may impact their adoption in Austria and analyze the impact that different incentive policies may have on the acceptance of electric vehicles. Mersky et al. (2016) investigated the impacts of incentives on battery powered EVs sales in Norway. Yan (2018) studied the role of tax incentives in reducing the total cost of ownership (TCO) of battery-powered electric vehicles (BEVs), promoting BEVs, and achieving environmental benefits. He used cost-benefit analysis and ordinary least squares regression to compare results based on tax incentives in several European countries such as Norway, France, the United Kingdom, Italy, Hungary, Austria, Portugal, and Germany. Switching from conventional vehicles to EVs is particularly attractive in Iceland because renewable energy sources can power it. A dynamic simulation modeling approach utilizing the integrated energy and transportation systems to evaluate how the transition to electric vehicles can be achieved through tax incentives was studied by Shafiei et al. (2018). Agaton et al. (2019) studied the Philippine government's policy toward a more sustainable public transport system with introduced a public utility vehicle modernization program with e-jeepney. They see this potential to overcome problems related to air pollution, traffic congestion, dependence on imported fuels, and carbon emissions, transport groups. The obstacles in implementing government programs are the problem of investment costs and risks.

The previous literature review demonstrates that EV and electric charging station models have been widely discussed in the past, but there are no studies on optimal tax incentives and subsidies for comprehensively promoting electric trucks and electric charging stations, especially in Indonesia, based on cost minimization and including transport emissions. In order to address the research gap analysis, this study focuses on answering the following questions:

1. How many incentives and subsidies can be prepared by a government with a limited budget to optimize the number of electric trucks and electric charging stations?
2. How much carbon emissions of transport and total costs can be reduced?

To answer the questions above, this study aims to develop an integer linear programming (ILP) model. This research goals to determine the optimal number of electric trucks, diesel trucks, regular stations, fast charging stations, and the total carbon emission. This model considers the annual tax, operational, maintenance, and investment costs for the construction of electric charging stations. The primary purpose of this model is to minimize total costs and carbon emissions with budget constraints in providing tax incentives and subsidies. This proposed model involves the interests of government and industry. The contribution of this research are as follows: (1) a comprehensive ILP model was developed to optimize the optimal number of electric trucks, diesel trucks, and electric charging stations based on characteristics and conditions in Indonesia; and (2) this study will provide insight to the Indonesian government and industry.

The remainder of this paper is organized as follows in Section 2, a comprehensive literature review of the tax incentive and subsidies of electric truck models. Section 3 presents the existing financial and fiscal conditions in Indonesia to accelerate the electric tucks in Indonesia. Section 4 develops the proposed model using the ILP approach. Analysis of results for case studies and sensitivity analysis are presented in Section 5. Scenarios and insight into government and industry are discussed in Section 6. Finally, conclusions and future work from this study are discussed in Section 7.

2. Literature review

There are two standard policies for promoting EVs sales and infrastructure using the government's financial and fiscal approach, namely tax incentives and financial subsidies (Jenn et al., 2013; Sánchez-Braza et al., 2014; Mersky et al., 2016; Yan, 2018; Shafiei et al., 2018; Agaton et al., 2019). Recent research on financial fiscal has focused on optimizing and increasing the sales of EVs and electric charging stations. This study develops a mathematical model using the ILP approach. Previous studies have been published by using mathematical models to optimize EV sales and electric charging station infrastructure. Andrenacci et al. (2017) developed a simulation model and fuzzy approach to investigate the correct sizing for the charging infrastructure in an urban area based on the best service given to drivers. The results are used to determine the optimal number of charging stations based on the proposed scenario that guarantees a given level of service. The problem of optimal distribution system reconfiguration and charging management of PEVs is studied by Rahmani-Andebili and Fotuhi-Firuzabad (2017). They applied stochastic, adaptive, and dynamic predictive control of the stochastic model to solve and manage the variability and uncertainties associated with the PEVs charging pattern and using renewable energy sources power. Design an effective online auction scheme for EV bidding and charging, capable of allocating limited energy sources to EVs with multi-unit demands of electricity, and matching the EVs and geo-distributed charging stations, and gives protection to location privacy was developed by An et al. (2020). The authors have proven that LoPro schemes achieve incentive compatibility, individual rationality, and e-differential privacy. The authors demonstrate the effectiveness of LoPro in terms of EV utility, buyer satisfaction ratio, energy allocation efficiency, and EV State-of-Charge. Soleimani and Kezunovic (2020) formulated a model to find the economic benefit of postponing EV charging on transformer conditions. The model's objective is to determine the incentive that should be paid if the charging is postponed and compare it with the economic impact of transformer loss of life and failure hazard to find the global optimum. A critical review and analysis of several works on MicroGrids (MGs) topologies and components, energy management systems, and electric vehicles integration and its bidirectional energy management was reviewed by Ouramdane et al. (2021). The research gives an overview of MGs technology advancement in recent decades, taking into consideration distributed energy generation, energy storage systems, EVs, and loads. It reviews the main MGs architecture, operating modes, sizing, energy management systems, and integration of EVs. Danial et al. (2021) analyzed the feasibility of implementing an electrical charging station in the Bruneian market by performing life cycle cost analysis and comparing it with the Life Cycle Cost Analysis (LCCA) of a conventional filling station. Their research gives recommendations to the government, investors, and manufacturers: i) recommendation to the government on current subsidies for electricity cost and initial subsidy for the acquisition cost; ii) recommendation to an investor to find a suitable site for electric charging stations so that the acquisition cost can be minimized and iii) recommendation to manufactures is to reduce equipment and installation costs. The research also estimates the number of public electric charging stations required for Brunei to serve expected EVs by 2035. In addition, techno-economic and carbon emissions analysis for commercial EVs, IC vehicles, light-duty vehicles, and buses were also investigated by (Falcão et al., 2017; Abas et al., 2019; and Desreveaux et al., 2020). Table 1 shows the research gap analysis, including objective, method, parameters and variables, results and limitations, and future study research.

3. Indonesian government fiscal policies to accelerate electric vehicle

3.1. Current freight transportation conditions

Currently, goods transportation (freight logistics) in Indonesia is still dominated by land transportation (trucks and trailers). With the current conditions, which are dominated by land transportation, it will cause enormous economic losses due to congestion between these modes and is also not environmentally friendly due to increased carbon emissions. Based on data from BPS (2022), the Transportation and Logistics sector is a high priority in Indonesia because Indonesia is the largest archipelagic country in the world with a population of 240 million people, around 60 % of whom live on Java Island. Based on the New Normal conditions in Indonesia, post-COVID-19, there has been an increase of 15.79 % (year on year). It should be noted that in Indonesia, the transportation sector contributes 23 % of total national carbon emissions. This condition has increased in the capital region compared to small towns and rural areas. Land transportation emissions account for 89 % of the total transportation sector emissions. This was triggered by an increase in the number of fleets.

Therefore, through the Ministry of the Transportation Republic of Indonesia, the Government of Indonesia faces challenges and opportunities to create a sustainable and environmentally friendly freight transport sector in Indonesia (Green Freight Transport). The government hopes that cooperation between the government and the private sector, the role of the community, and international support can be carried out in developing environmentally friendly freight transportation.

3.2. Fiscal programs

In order to encourage the automobile industry is one of the efforts to increase sales of electric trucks in Indonesia. In this regard, some financial and fiscal policies and programs provided by the government are as follows, as shown in Fig. 1.

1) Electric trucks fiscal programs related to consumer
   a. Tax incentives for the sales or purchase of luxury trucks.
   b. Tax incentives for import duty on critical components. This program will be offered within a certain period to increase the local content.
   c. Incentive or subsidies for charging station equipment development.
   d. Internal market policies: d1) import tariff incentives for imports of machinery, goods, and materials as part of the investment, d2) professional competence certification, and d3) product certification and/or technical standards.
2) Electric trucks fiscal programs related to infrastructure
   a. Incentives for manufacturing charging station equipment.
   b. Funding support (subsidies) for expanding the charging station infrastructure.
   c. Free electricity charge at the charging station.
   d. Parking rates at locations are determined by the local government.
   e. Removal of fuel subsidies.

Based on these policies, this research model is a mathematical formula that includes electric trucks and infrastructure. This includes electric truck prices, operating costs, maintenance costs, investment taxes, investment costs, electric charging station installation costs, number of electric trucks, number of diesel trucks, and number of charging stations as well as total carbon emissions. The formula takes into account budget constraints imposed by the government. These results are expected to increase the number of electric trucks sold, and decrease the number of diesel trucks sold, reducing carbon emissions. This study considers several scenarios, which can be described in Table 2. The table explains that there are four criteria that will be optimized in this research. For example, Scenario 1 is an existing condition (business as usual) where there is no intervention by giving tax incentives and subsidies in the market. While Scenarios 2, 3, and 4 are the development of the proposed model by conducting government intervention in the provision of tax incentives and subsidies to stimulate sales of electric trucks and charging stations.

4. Mathematical model

To establish the mathematical model, the following assumptions, indices, parameters, decision variables, and objective functions are used.

4.1. Problem definition

In this study, the truck is divided into two types, namely the electric trucks and diesel trucks with the brand of each truck (index *i*; *j*). First, the government has projected sales of electric trucks and diesel trucks, in units, for a certain period (D). This study considers the government's financial incentives and subsidies based on budget allocations (GT, GS, γ) to optimize the optimal of number of electric trucks (units), the number of diesel trucks (units), the carbon emissions generated by diesel trucks and power plant for electric charging stations (kg.CO2-eq), the number of normal electric charging stations investments (stations), the number of fast electric charging stations investments (stations) and minimize overall costs. Furthermore, the government has set a basic tax for electric trucks (α_0). Practically, this basic tax for electric trucks is a higher than the tax for diesel trucks ($\alpha_0 > \beta$). Therefore, in order for electric trucks to compete with diesel trucks, the government can provide incentives or deductions from the basic tax to consumers so that sales of electric trucks can increase compared to sales of diesel trucks ($\alpha_0 \geq \alpha_1 \geq 0$). Along with the increase in sales of electric trucks, the number of diesel trucks sold can be reduced, which will affect the reduction of carbon emissions in transportation by diesel trucks with limited carbon caps by the government $\left(Y_j = G_j x Q_j \leq CAP\right)$. In addition,

Table 1
Research gap.

Author	Objective	Method	Parameters & Variables	Results	Limitation and Future Research
Andrenacci et al. (2017)	To investigate the correct sizing for the charging infrastructure in an urban area based on the best Level of Service (LoS) given to drivers.	Big data analysis, fuzzy modeling, and simulation.	Fuzzy logic:Waiting time (input)Distance (input)Station score (output) for the drivers to decide which station to charge Level of Service.	Determine the optimal size from CI (configuration of electric fast charging stations) by considering a scenario that guarantees a given LoS.	Taking into account the potential investor's point of view (business analysis). Hence, a solution can be presented those compromises between the demand side and the business side.
Rahmani-Andebili and Fotuhi-Firuzabad et al. (2017)	Studied by applying stochastic, adaptive, and dynamic predictive control of the stochastic model to solve.	Stochastic model predictive control, stochastic optimization, genetic algorithm.	Time horizon, value of incentive at each CHS, incentive at each time step of the optimization time horizon, and the status of switches for being open or closed at each time step of the optimization time horizon.	The proposed approach in the CHM of PEVs and DSR has remarkable potential for cost saving. It was proven that the application of MPC makes the problem outputs robust with respect to the value of prediction errors caused by the variable and uncertain power of RESs and accidental charging patterns of PEVs.	Several cost aspects were not considered in this study. For example: EV investment cost, carbon emission cost, and initial investment in electric charging stations.
An et al. (2020)	To design an effective online auction scheme for EV bidding and charging, capable of allocating limited energy sources to EVs with multi-unit demands of electricity, matching the EVs and geo-distributed charging stations, and giving protection to location privacy.	Theoretical analysis, simulation, MINLP.	*Online Scheme:* Allocation rule, payment rule, charging stations, and state of charge for the winning EV. *Desired Properties:* EV utility, individual rationality, incentive compatibility. *Differential Privacy:* Sensitivity, differential privacy, Laplace mechanism.	LoPro schemes achieve the desired properties of incentive compatibility, individual rationality, and e-differential privacy. The authors demonstrate the effectiveness of LoPro in terms of EV utility, buyer satisfaction ratio, energy allocation efficiency and EV SoC.	Considering the location and privacy of EV and the overall overhead cost calculation.
Soleimani, and Kezunovic et al. (2020)	To find the economic benefit of postponing EV charging on transformer condition. Determine the incentive that should be paid if the charging is postponed and compare it with the economic impact of transformer loss of life and failure hazard to find the global optimum.	Fuzzy logic, case study, simulation.	Fuzzy logic input: EV battery state of charge Required state of charge for next trip. Estimated time of EV departure. Customer comfort level. *Output*: EV participation factor. Incentive paid if the charging is postponed. Saving of postponing the EV demand.	It is found that a higher average load occurs when there is no management. The proposed management method, though with added incentive cost to the driver to participate in the postponement of charging, give lower total cost than without management. The EV load-related cost when using the approach is also much smaller.	Taking into account tax incentives on the cost of investing in EVs.
Danial et al. (2021)	To analyze the feasibility of implementing an electrical charging station in the Bruneian market by performing LCCA and comparing it with the LCCA of a conventional filling station. Identify the important parameters which strongly influence LCCs.	LCCA and sensitivity analysis.	Acquisition cost, operating cost, maintenance cost, selling revenue, vehicles served per day, charging efficiency, the average distance traveled.	With a low acquisition cost, the electrical charging station returns 1.47 times the investment while requiring comparatively less investment than the conventional filling station of 0.58 times. It is found that important parameters influencing the LCCs are acquisition cost, selling electricity prices and fossil fuel prices. Brunei required 646–3300 electrical charging stations to serve 273 K EVs by 2035.	Considering the total LCCA of an EV, for example: acquisition costs, operating costs and maintenance costs.
Falcão et al. (2017)	To assess the economics and the potential to minimize carbon emissions from medium duty urban EVs and compared to similar conventional diesel.	Simulation model, TCO, sensitivity analysis.	Economic parameters: Purchase cost, recharge equipment cost, battery cost, maintenance cost, energy cost. Environmental parameters: Diesel vehicles emissions and electric vehicle emissions	The total cost of ownership of an electric vehicle is 2.5 times higher than conventional vehicles with purchase price and the price of the battery as the main cost. Under the existing scenario, EV feasibility can only be achieved through government incentives or considering revenues from commercial activities. In the best-case scenario, the return of EV will only happen after 13 years of operation. EVs emit lower amounts of CO2eq with 4.6 lower than diesel vehicles.	The proposed model has not considered the optimal number of sales of diesel and electric vehicles and the trade-off between diesel vehicle and electric vehicle.
Abas et al. (2019)	To investigate the potential for introducing EVs to the Brunei	TCO, sensitivity analysis.	Economic parameters: acquisition cost, operating cost,	The government should consider both subsidies and	Future research could encourage EVs by offering

(*continued on next page*)

Table 1 (*continued*)

Author	Objective	Method	Parameters & Variables	Results	Limitation and Future Research
	market using LCCA and identify the key factors influencing its feasibility.		maintenance cost, and salvage cost. <u>Environmental parameters:</u> diesel vehicles emissions	raise current gasoline prices to encourage electric vehicles. Rising gasoline prices are effectively detrimental to ICEVs and HEVs. An initial subsidy of US $ 4103.25 will be proposed for EVs to compete with other vehicles for LCCs, raising the price of gasoline to US $ 0.6966 per liter. Coupled with the expected 69 % annual battery price drop by 2030, EVs should be able to compete with other vehicles without subsidies after 2030.	financial incentives such as tax/subsidies on fuel and electricity tariffs, duty vehicles, and infrastructure support to encourage adoption. The research may also improve the efficiency of power generation and transmission.
Desreveaux et al. (2020)	To propose a more realistic TCO comparison of EVs and diesel vehicles in the same segment. The focus of the work is on a combination of technical and economic models that can capture and compare the relevant factors of the two domains.	TCO, Net Present Value (NPV), sensitivity analysis.	Capital cost, salvage value, and energy cost.	The result highlights the benefits of the TCO of EVs in French, which is currently relatively strong, while relying on favorable tax bonuses. In general, economic variables have a greater impact on TCO than technical variables. Depreciation rates and government incentives are the main factors affecting the TCO of EVs.	The research could provide an accurate estimate of the TCO of vehicle options and calculate the amount of charging infrastructure required to charge a fleet of EVs for economic studies of a given region. The analysis can be extended by considering the impact of climate conditions and driver behavior on the TCO.
Yusof et al. (2021)	To analyze the feasibility of electric buses in Brunei by comparing LCCs with existing diesel buses commonly used in Brunei-Muara, Brunei's smallest and most populous area.	TCO, sensitivity analysis.	<u>Economic parameters:</u> acquisition cost, operating cost, maintenance cost, and disposal cost. <u>Environmental parameters:</u> diesel buses emissions	Brunei's government should consider introducing a combination of incentives and subsidies for electric buses purchases as well as infrastructure support, introducing taxes on diesel buses and diesel fuel purchases to make electric buses more economically viable, at least in the early stages.	Considering the total LCC of an electric charging station, for example: acquisition costs, operating costs, and maintenance costs. The proposed model could consider the optimal number of sales of diesel and electric buses.
Gan et al. (2021)	To assess the impact of PEV incentives on light-duty vehicle regulations and quantify the increase in carbon emissions caused by PEV incentives for vehicles sold in China, the United States, and the EU between 2012 and 2025.	Linear Programming (LP) and sensitivity analysis.	Tailpipe emissions of light-duty vehicles, electricity consumption rates, vehicles sales, annual travel of vehicles, and total amount of carbon emissions in China, the United States, and the EU.	Emissions due to the effects of PEV dilution and leaks are the highest in China. This is due to the large PEV market size, generous PEV super credits, and the high carbon emissions strength of China's electricity. China's automobile market continues to be the largest in the world due to increased greenhouse gas emissions from transportation.	Developing of a model that takes into account the impact of PEV dilution so that it can increase the progress of fuel-based technologies and low carbon emissions.

this study also considers the limits of investment in electric charging station development. This construction requires investment funds from the industry and the capacity for each electric charging station, for example, the speed of charging time; $\left[\frac{\sum_{i\in I}(F_i.Q_i)}{NC}; \frac{\sum_{i\in I}(F_i.Q_i)}{FC}\right]$.

4.2. Assumptions

The following assumptions are used in our model:

1. The model focused on the projected total sales of electric and diesel trucks.
2. The basic tax on an electric truck is greater than the tax on a diesel truck.
3. An electric truck's price is higher than a diesel truck's.
4. The government provides tax incentives and subsidies based on the allocated budget.
5. Carbon emissions are focused on transportation emissions and power plants for providing required electricity in the electric stations. The government has set a carbon cap limit.
6. Specifications for electric trucks, diesel trucks, regular electric charging stations, and fast electric charging stations are obtained from the manufacturer's specification data.

4.3. Indices

i	:	Types of electric trucks (ETs)	$i = 1, 2, \cdots, I$
j	:	Types of diesel trucks (DTs)	$j = 1, 2, \cdots, J$

4.4. Parameter

D	:	Projected total sales of electric and diesel trucks (units)
E_i	:	Price of unit electric truck i (\$/unit)
B_i	:	Price of electric truck battery i (\$/unit)
C_i	:	Price of electric truck charger i (\$/unit)
E_j	:	Price of unit diesel truck j (\$/unit)

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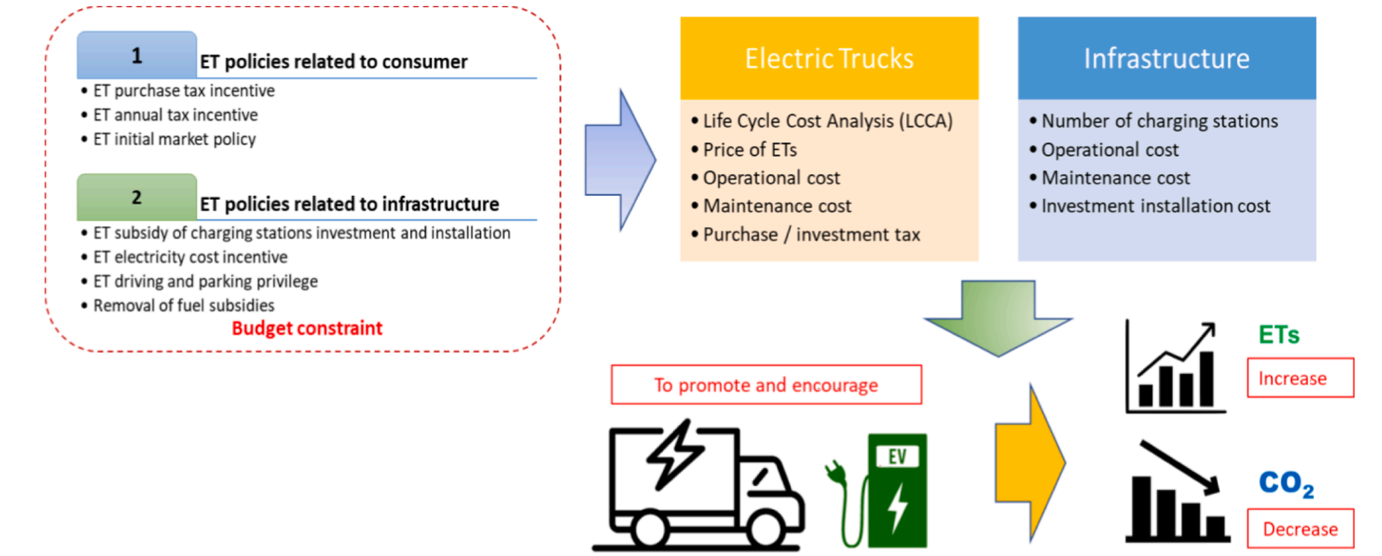


Fig. 1. Accelerate electric truck program based on government fiscal policies.

(*continued*)

α_0	:	Basic tax for electric trucks (%)
α_1	:	Tax incentives of electric truck price (%)
β	:	Diesel truck tax (%)
γ	:	Government subsidies for the construction of charging stations ($)
F_i	:	Battery capacity on electric trucks *i* (kWh/unit)
F_j	:	Fuel capacity on diesel trucks *j* (liter/unit)
G_j	:	Emission levels on diesel trucks *j* (kg.CO_2-eq/unit)
EC	:	Electricity cost ($/kWh)
DC	:	Diesel fuel cost ($/liter)
Δ	:	Percentage of fuel subsidy
ONC	:	Operational costs of normal charging stations ($/unit/station)
OFC	:	Operational costs of fast charging stations ($/unit/station)
MC_i	:	Maintenance costs of electric trucks *i*, including periodic maintenance fee, battery replacement, and tire replacement ($/unit), $MC_i = [(MR_i x\, d) + BR_i + TR_i]$ (Abas et al., 2019; Yusof et al., 2021)
MC_j	:	Maintenance costs of diesel trucks *j* ($/unit), including periodic maintenance fee, Accu replacement, and tire replacement ($/unit),$MC_j = [(MR_j x\, d) + BR_j + TR_j]$
MR_i	:	Maintenance rate of electric trucks *i* ($/unit/km)
MR_j	:	Maintenance rate of diesel trucks *j* ($/unit/km)
d	:	Distance between major cities (km)
BR_i	:	Battery replacement fee of electric trucks *i* ($/unit)
BR_j	:	Accu replacement fee of diesel trucks *j* ($/unit)
TR_i	:	Tire replacement fee of electric trucks *i* ($/unit)
TR_j	:	Tire replacement fee of diesel trucks *j* ($/unit)
MNC	:	Maintenance cost of normal charging stations ($/station)
MFC	:	Maintenance cost of fast charging stations ($/station)
INC	:	Investment and installation cost of normal charging stations ($/station)
IFC	:	Investment and installation cost of fast charging stations ($/station)
RC	:	Carbon emission costs ($/kg.$CO_2$-eq)
SC_i	:	Salvage value cost of electric trucks *i*. Salvage value includes scrap values of batteries during replacement and scrap values of the electric trucks *i* at the end of their lifetime ($/unit). According to Abas et al. (2019) and Yusof et al. (2021), salvage value cost is formulated by $SC_i = (SB_i + SV_i)$
SC_j	:	Salvage value of diesel trucks *j* ($/unit),$SC_j = (SB_j + SV_j)$
GT	:	Government budget for electric truck tax incentives ($)
GS	:	Company budget for the construction of an electric charging station ($)
ENC	:	Rate of carbon emission generated by the power plant for providing required electricity in the normal charging stations (kg.CO_2-eq/station)
EFC	:	Rate of carbon emission generated by the power plant for providing required electricity in the fast-charging stations (kg.CO_2-eq/station)
NC	:	The capacity of electric battery for regular charging stations (kWh/station)
FC	:	The capacity of electric battery for fast charging stations (kWh/station)
CAP	:	Carbon cap (kg.CO_2-eq)

Table 2
The meaning and explanation of the proposed scenario.

Scenario	Meaning and assumptions
1	Business as Usual (BAU), total sales grow generally without any intervention in electric trucks sales in the market
2	There is growth in sales of electric trucks with the provision of tax incentive Scenario 1 and subsidy Scenario 1
3	There is growth in sales of electric trucks with the provision of tax incentive Scenario 2 and subsidy Scenario 2
4	There is growth in sales of electric trucks with the provision of tax incentive Scenario 3 and subsidy Scenario 3

4.5. Decision variables

Q_i	:	Number of electric trucks *i* sold (units)
Q_j	:	Number of diesel trucks *j* sold (units)
Y_j	:	Total carbon emissions in diesel trucks *j* (kg.CO_2-eq),$Y_j = (G_j x Q_j)$
$CENC$	:	Total carbon emissions in regular charging stations (kg.CO_2-eq),$CENC = (ENCxS)$
$CEFC$	:	Total carbon emissions in fast charging stations (kg.CO_2-eq),$CFNC = (EFCxF)$
S	:	Number of normal charging stations (stations)
F	:	Number of fast charging stations (stations)

4.6. Objective function

The above problem can be formulated to minimize the total cost that consists of the electric trucks cost (Z_1), the diesel trucks cost (Z_2), the normal electric charging stations (Z_3), and the fast electric charging stations (Z_4). These formulas can be modeled as a single objective function; there are:

$$\mathbf{Minimize} Z = \mathbf{Z}_1 + \mathbf{Z}_2 + \mathbf{Z}_3 + \mathbf{Z}_4 \quad (1)$$

$$Z_1 = (\alpha_0 - \alpha_1).\sum_{i \in I}(E_i + B_i + C_i)Q_i + EC\sum_{i \in I}(F_i x Q_i) + \sum_{i \in I}(MC_i x Q_i) - \sum_{i \in I}(SC_i x Q_i) \quad (2)$$

$$Z_2 = \beta.\sum_{j \in J}(E_j x Q_j) + (1 - \Delta).DC\sum_{j \in J}(F_j x Q_j) + \sum_{j \in J}(MC_j x Q_j) + RC\sum_{j \in J} Y_j - \sum_{j \in J}(SC_j x Q_j) \quad (3)$$

$$Z_3 = [INC + ONC + MNC + (ENCxRC)]xS \quad (4)$$

$$Z_4 = [IFC + OFC + MFC + (EFCxRC)]xF \quad (5)$$

Subject to:

$$\sum_{i \in I} Q_i + \sum_{j \in J} Q_j = D \quad (6)$$

$$[\alpha_1.(E_i + B_i + C_i)Q_i] + [\Delta.DC(F_j x Q_j)] \leq GT \quad (7)$$

$$(INC.S) + (IFC.F) \leq GS + \gamma \quad (8)$$

$$Y_j + CENC + CEFC \leq CAP \quad (9)$$

$$\frac{\sum_{i \in I}(F_i x Q_i)}{NC} \leq S \quad (10)$$

$$\frac{\sum_{i \in I}(F_i x Q_i)}{FC} \leq F \quad (11)$$

$$\text{Tax incentive}: \alpha_0 \geq \alpha_1 \geq 0 \quad (12)$$

Eq. (1) is a single objective function of the proposed model. Eqs. (2)–(5) includes the electric truck prices, batteries, and chargers after taxing, electric trucks operating costs, electric truck maintenance costs, salvage cost of electric trucks, diesel truck prices after taxing, operating costs of diesel trucks, maintenance costs of diesel trucks, carbon emission cost from diesel trucks, diesel trucks' salvage cost, normal electric charging stations investment costs, operating and maintenance costs of normal charging stations, investment costs of fast charging stations, and operating and maintenance costs of fast electric charging stations. Eq. (6) represents a balance of projected total sales which is equal to the number of electric trucks sold and the number of diesel trucks sold. Eq. (7) means that the sum of tax incentives for all electric trucks sold, and fuel subsidy does not exceed the government budget. Eq. (8) shows that the total investment capital of the normal and fast charging stations cannot be more than the industry's budget and government subsidies. Constraint (9) ensures that the total carbon emissions cannot exceed the allocated carbon cap. Constraints (10–11) indicate that the normal and fast electric charging station's infrastructure requirements do not exceed the maximum capacity of normal and fast electric charging stations based on the manufacturer's data. Finally, constraint (12) represents the non-negative basic tax on electric trucks, which is higher than tax incentives.

5. Result and discussions

This section provides a numerical computation to illustrate the proposed model's application to several brands of diesel and electric trucks. In addition, some further analysis on sensitivity analysis is carried out to provide insights into government and industry.

5.1. Data requirement

This research is conducted in a case study of electric and diesel trucks with three brands for each type, $(i = 1, 2, 3)$ and $(j = 1, 2, 3)$. This study is conducted for three truck brands: Fuso, Volvo, and Toyota. These brands have specification data such as unit price, battery price, charger price, fuel or electric capacity, maintenance cost, and carbon rate of diesel trucks (Table 3). The type standard for the diesel truck engine is Euro 4. In this study, the distance between Surabaya city and Malang city is considered at 96 km (Fig. 2). Some other general data, such as estimated sales of trucks, that is, sales of 50,000 units based on Gaikindo data in 2021, the fiscal program for trucks, for example, basic tax for electric trucks of 40.0 %, tax incentives of 36.0 %, and normal tax of diesel truck 2 %. We assume the worldwide diesel fuel and electric prices are \$1.02/liter (Global Petrol Prices, 2022a) and \$0.10/kWh (Global Petrol Prices, 2022b), respectively, respectively the government gives a fuel subsidy with a factor, $\Delta = 0.60$. Therefore, the subsidized fuel price is $(1 - \Delta) \times \$1.02/\text{liter} = \$0.408/\text{liter}$. It is assumed that the government budget for tax incentives and fuel subsidies, and subsidies for charging stations are given \$2,000,000 and \$5,000, respectively. The corporate budget for the electric charging station is assumed to be \$250,000, and the carbon emission allocated by the government is 500,000 kg.CO2-eq and the other data (electricity and fuel cost) as shown in Table 4. Specifications for electrical station data are also presented in this study. These specification data of the electric charging station can be seen in Table 5.

5.2. Techno-economic analysis

Using the mathematical model developed in the previous section, the model was solved using the specified data for the parameters. In Fig. 3, the analysis starts with a tax incentive of 36.0 %, without subsidies, and with subsidies (range of \$1000–25,000). The results show that, in this case, there is no optimal for electric trucks and charging stations but still produced on diesel trucks. The total cost shown on the graph is still the total cost of diesel trucks. Then increasing the tax incentive from 0.5 % to 4.0 % with a variation of subsidies for charging stations will increase the sale of electric trucks and the construction of charging stations. This can be seen in Fig. 3 with shades of red (total cost electric truck), shades of green (normal charging station), and shades of blue (fast charging station). In addition, as shown in Figs. 4–6, the estimated number of electric trucks sold, the number of regular charging stations, and the number of fast charging stations with 36.5 % tax incentives with subsidies of \$0 to \$25,000.

Furthermore, the figures also show an important insight that a 40.0 % tax incentive (which means the government fully covers the tax) and a \$1000 to \$25,000 subsidy for electricity charging stations will be able to encourage sales of electric trucks and charging stations significantly. This is influenced by the decline in unit sales prices, batteries, and chargers on electric trucks so that the price of electric trucks can compete with the unit sales prices of diesel trucks. This can boost the electric truck industry, especially in Indonesia. Based on the above findings, using these scenarios, the Indonesian government will increase the number of electric trucks sold, the infrastructure of normal charging stations and fast charging stations by 53 units to 116 units (118.9 %), 40 stations to 93 stations (132.5 %), and 12 stations to 27 stations or 125.0

Table 3
Specification data of trucks.

Data	Electric Trucks			Diesel Trucks		
	Brand 1	Brand 2	Brand 3	Brand 1	Brand 2	Brand 3
Unit price	\$60,800	\$62,900	\$61,200	\$34,190	\$34,210	\$34,200
Battery price	\$1250	\$1000	\$1150			
Charger price	\$170	\$160	\$150			
Capacity	82.8 kWh	75.8 kWh	70.4 kWh	100 L	80 L	120 L
Maintenance cost	\$1383	\$1133	\$1283	\$843	\$932	\$959
Carbon rate				23.69 kg.CO_2	21.65 kg.CO_2	22.35 kg.CO_2
Salvage cost	\$745	\$831	\$873	\$171	\$274	\$239

Remarks: maintenance cost = periodic maintenance fee + battery replacement + tire replacement; salvage cost = scrap values of unit + scrap value of battery (Abas et al., 2019; Yusof et al., 2021).

Fig. 2. The distance between major cities for this study.

Table 4
General data.

Symbol	Parameter	Value	UoM (Remarks)
D	Projected total sales of electric and diesel trucks	50,000	unit (Gaikindo data, 2021)
α_0	Basic tax for electric truck	40.0	%
α_1	Tax incentives of electric truck price	36.0	%
β	Diesel truck tax	2.0	%
γ	Subsidies for charging stations' installation	5,000	$
EC	Electricity cost	0.10	$/kWh
DC	Diesel fuel cost	1.02	$/liter
Δ	Fuel subsidy factor	0.60	–
RC	Carbon emission costs ($/kg.$CO_2$-eq)	150	$/kg.$CO_2$-eq
GT	Government budget for electric truck tax incentives	2,000,000	$
GS	Company budget for an electric charging station	250,000	$
CAP	Carbon emission allocation	500,000	kg.CO_2-eq
d	Distance between major cities	96	km

Table 5
Specification data of electric stations.

Data	Normal Charging Station	Fast Charging Station
Initial investment fee	$2000	$3000
Capacity	100 kWh	350 kWh
Operational cost	$150	$250
Maintenance cost	$35	$65
Rate of carbon emission*	0.0050 kg.CO_2-eq	0.0030 kg.CO_2-eq

*) The value of the carbon emission rate refers to Thomas and Mishra (2022).

%, respectively. In addition, the total costs for electric trucks, normal charging stations, and fast charging stations are also shown in Figs. 3–6. Based on our results, the initial investment in electric trucks is the highest of the total component costs from $117,947.90 or 86.53 % of the total component total cost of electric trucks compared to other component costs such as operations cost, maintenance cost, and salvage value cost of 0.29 %; 45.88 %; and 32.701 %, respectively. The same analysis applies to the total cost of regular and fast charging stations. Therefore, as the number of charging stations increases, the capital investment of the two types of charging stations will increase by $80,000 to $186,000 and $36,000 to $81,000, respectively, or 91.50 % and 90.49 % of the total cost of other components. A detailed analysis and comprehensive calculation of component costs can be seen in Appendixes A and B.

Figs. 7-8 show the effect of tax incentives (α_1) and subsidies of charging stations (γ) on total cost, diesel trucks sold, and amount of carbon emissions. These figures indicate that increasing sales of electric trucks can reduce diesel trucks and carbon emissions. The decrease in the number of diesel trucks sold and carbon emissions range from -0.106 % to -0.126 % and -0.113 % to -0.135 %. Further analysis can be found in Appendixes A and B. By implementing the government's fiscal programs, the government can increase the number of electric trucks sold and reduce transport's carbon emissions.

The effect of the government's diesel fuel subsidy percentage (factor) (Δ) on the number of electric trucks and total amount of fuel subsidy ($) is shown in Fig. 9. The figure shows that with a 39.5 % tax incentive scenario, a subsidy for charging stations of $25,000, and a policy of reducing diesel fuel subsidies, the results can significantly increase electric trucks sales, thereby reducing diesel trucks and carbon emissions. Even if the subsidy is removed 100 % $(\Delta = 0)$, the shift from diesel trucks to electric trucks will be optimal. The increase in the number of electric trucks sold and the decrease in government fuel subsidies range from 1 % to 9 % and 8 % to 100 %, respectively. A detailed analysis can be seen in Appendix C. These results can provide insight to the government that by implementing a fuel subsidy regulation program, consumers can choose to switch from diesel trucks to electric trucks. Fig. 10 shows the impact of distance (d) between cities (km) on the number of electric trucks and the total cost ($). The figure shows that the total cost increases as the distance increases. The increase in grand total cost is due

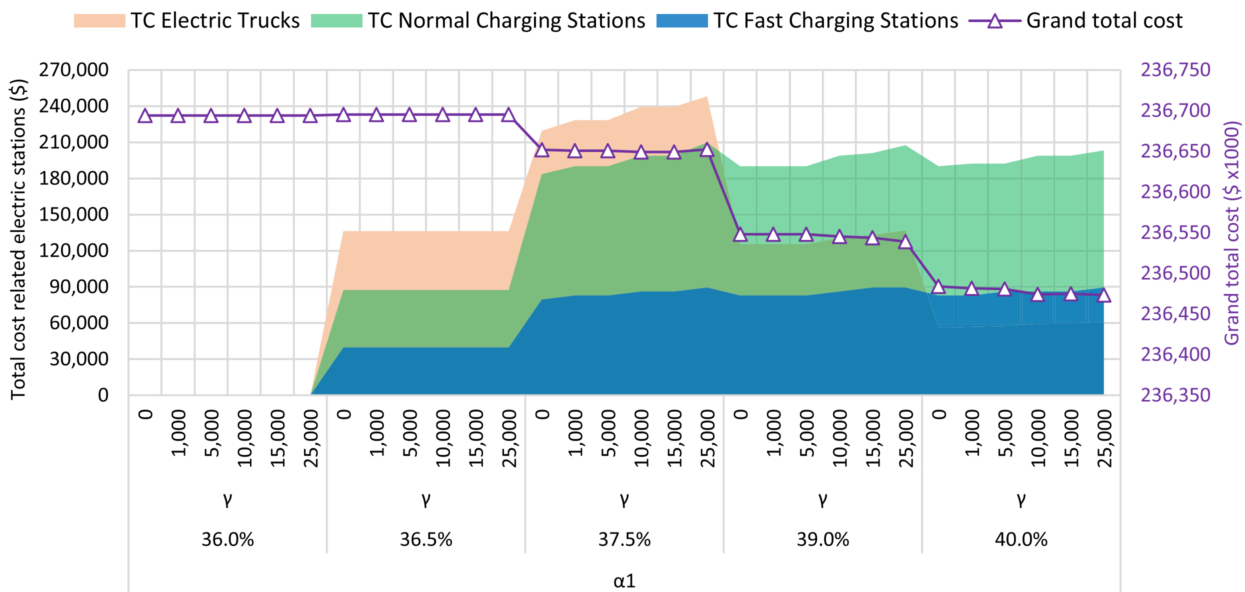


Fig. 3. Effect of tax incentives (α_1) and subsidies of charging stations (γ) on the overall total cost.

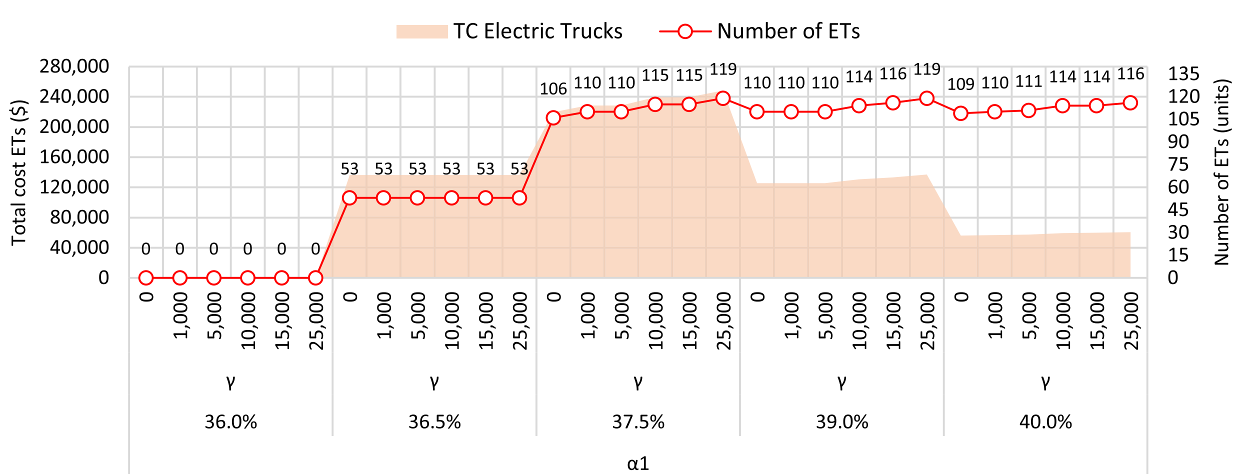


Fig. 4. Effect of tax incentives (α_1) and subsidies of charging stations (γ) on total cost and expected of electric trucks sold.

to an increase in operating and maintenance costs in both the total cost of diesel trucks and the electric truck's total cost. Meanwhile, the optimal number of electric trucks is insensitive as the distance increases. The computational results can be seen in Appendix D.

6. Scenarios for ten years: sensitivity analysis and insights for government and industry

In this section, sensitivity analyses are carried out to demonstrate the changes in the parameters of tax incentives (α_1) and subsidies (γ) in various scenarios over the 10-year period from 2021 to 2030. This analysis was performed using four scenarios: Scenario 0 with existing conditions or BAU with 37.0 % tax incentives and no subsidies. Second, in Scenario 1, there is a 38.0 % tax incentive and a $5,000 charging station subsidy. Scenario 2 also offers a 39.5 % tax incentive and a $15,000 subsidy to the charging station. In scenario 3, the tax incentive is 40.0 %, and the charging station subsidy is $30,000. In this scenario, we assume that the government has implemented a no-subsidy policy for consumers so that the price of fuel is higher than the price of electricity. These scenarios are shown in Table 6. These analyses consider tax incentives, subsidy scenarios, total projected sales of trucks (electric and diesel) (D), the government's budget for electric trucks (GT), construction budget for charging stations (GS), and carbon cap (CAP). Table 7 shows the estimated value of truck sales, some budget assumptions, and carbon caps.

From the calculation results, the average growth rate of electric trucks is expected to be 43.27 % in the BAU scenario from 2021 to 2030. A significant increase can be seen in 2028, from 52 units to 154 units (an increase of 102 units or 196.15 %). Scenario 1 grew from 3.31 % to 35.60 % or an average of 18.01 % per year, with a 38.0 % tax incentive and a $5,000 subsidy. Scenario 2 has a tax incentive of 39.5 % and a $15,000 subsidy, with growth rates ranging from 0.86 % to 39.59 % or an average of 17.59 % per year. Scenario 3 has a tax incentive of 40.0 % and a $ 30,000 subsidy, with growth rates ranging from 3.47 % to 45.64 % or an average of 17.91 % per year. Meanwhile, the total costs of Scenarios BAU and (1)-(3) show the same increase every year, ranging

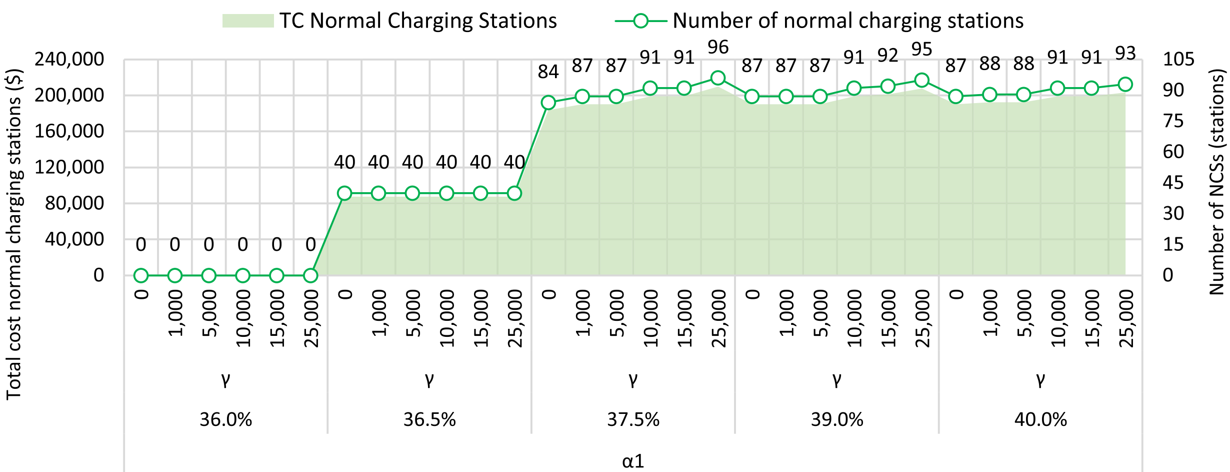


Fig. 5. Effect of tax incentives (α_1) and subsidies of charging stations (γ) on total cost and number of normal charging stations.

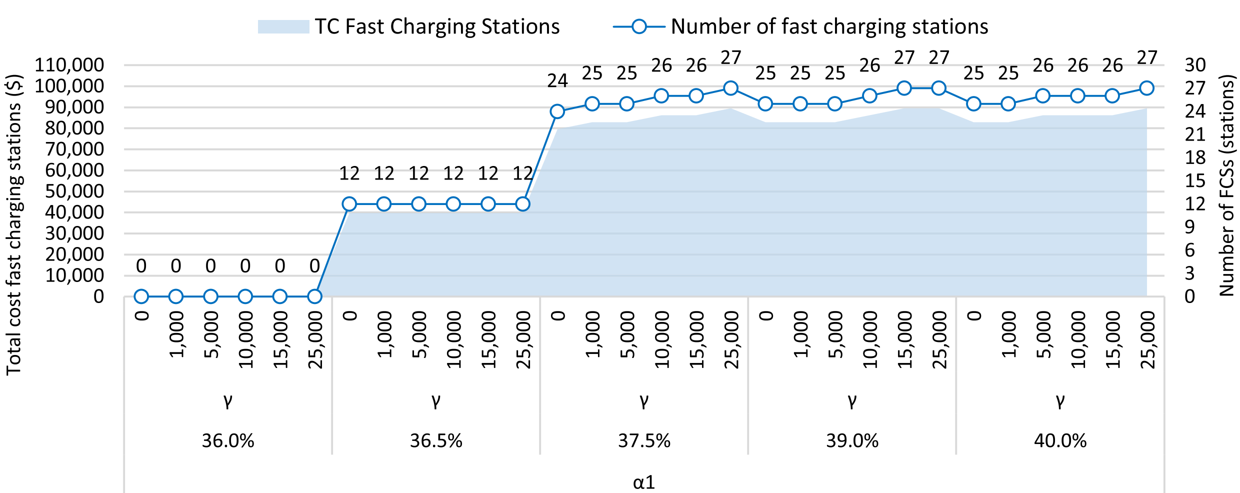


Fig. 6. Effect of tax incentives (α_1) and subsidies of charging stations (γ) on total cost and number of fast charging stations.

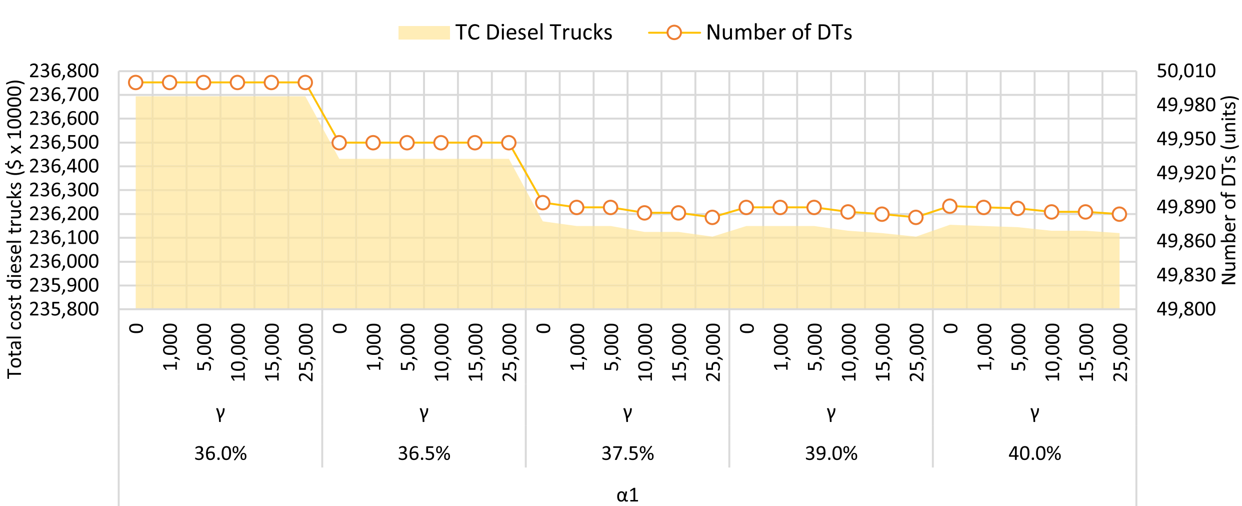


Fig. 7. Effect of tax incentives (α_1) and subsidies of charging stations (γ) on total cost and expected of diesel trucks sold.

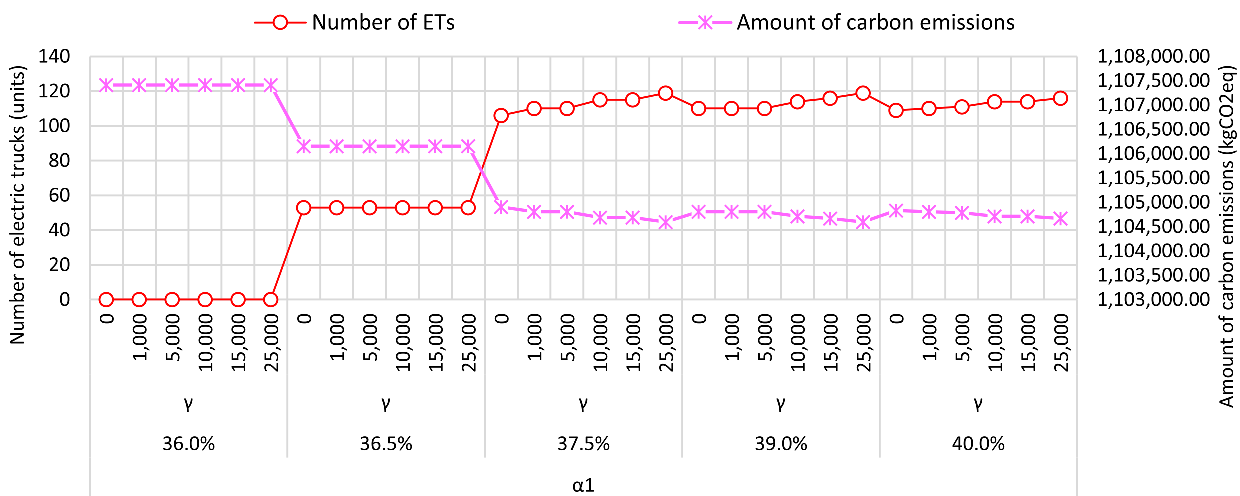


Fig. 8. Effect of tax incentives (α_1) and subsidies of charging stations (γ) on the number of electric trucks and total carbon emissions.

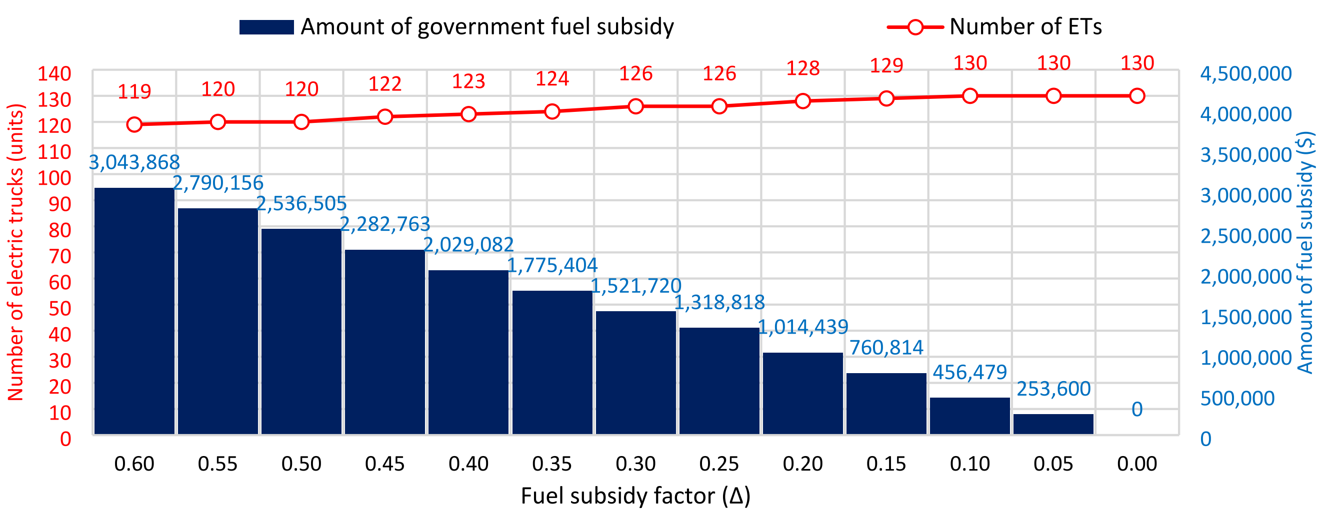


Fig. 9. Effect of fuel subsidy factor (Δ) on the number of electric trucks and amount of government fuel subsidy.

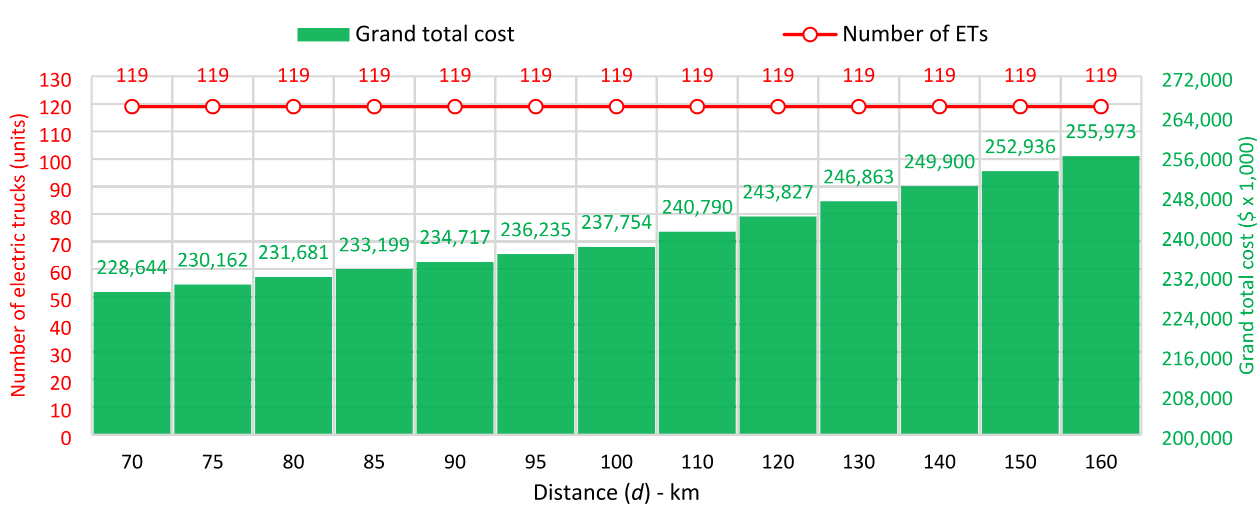


Fig. 10. Effect of distance (d) on the number of electric trucks and total cost ($).

Table 6
Scenarios for analysis.

Scenario to promote electric trucks	Value of tax incentives and subsidies from the Government
0	BAU (tax incentive = 37 %; subsidy for charging stations = $0)
1	Tax incentive = 38.0 %; subsidy for charging stations = $5,000
2	Tax incentive = 39.5 %; subsidy for charging stations = $15,000
3	Tax incentive = 40.0 %; subsidy for charging stations = $30,000

Table 7
Assumed data for 2021–2030.

Years of projection	Projected total sales (units)	The government budget for electric truck tax incentives ($)	Company budget for the construction of an electric charging station ($)	Carbon cap (kg.CO2-eq)
2021	50,000	2,000,000	250,000	500,000
2022	60,500	2,200,000	350,000	600,000
2023	73,205	2,500,000	400,000	750,000
2024	88,578	3,000,000	500,000	1,250,000
2025	107,179	3,500,000	550,000	1,500,000
2026	129,687	4,000,000	600,000	2,000,000
2027	156,921	5,000,000	650,000	3,000,000
2028	189,875	7,000,000	750,000	4,000,000
2029	229,749	9,000,000	850,000	4,500,000
2030	277,996	11,000,000	1,000,000	5,000,000

from 19.84 % to 21.09 % (average of 20.78 %). The results are shown in Figs. 11-12. In Figs. 13-14, it is clear that the changes in tax incentives and subsidies will affect the optimal number of normal charging stations and fast charging stations, which will increase from 93 stations to 360 stations (287.10 %) and 27 stations to 103 stations (281.48 %), respectively. The increase influences this in electric trucks, and subsidies to electric charging stations also increase the optimal number of charging stations.

Fig. 15 shows the growth of truck diesel from 2021 to 2030. However, year-over-year (YoY) growth in diesel is less significant than in electric trucks. Diesel truck growth ranges from 20.49 % to 21.45 %, or an average of 21.01 %. This is seen in the third scenario in 2022, which increased to 60,320 units from the previous year's 49,866 units, which means an increase of 10,454 units (20.96 %). Since then, the highest growth rate is 20.91 % in 2023, an increase of 12,685 units (from 60,320 units to 73,005 units). On the other hand, the following year will be around 21.03 %–21.45 %. Therefore, the government remains concerned about preventing the sale of diesel trucks by increasing the budget, raising the carbon cap, and offering some other tax programs, such as restricting the sale of diesel trucks or increasing the price of diesel fuel.

Fig. 16 shows that the third scenario can be used to minimize the allocation of remaining subsidies from the government. For example, in 2028, the subsidies provided in BAU Scenario, Scenarios 1 to 3 are $3,561,250; $8,031,140; $8,421,005; and $8,751,704, respectively, with a budget allocation of $7,000,000 per brand ($21,000,000 to all brands). The calculation results show that the remaining budget from the government is: $17,438,750; $12,968,860; $12,578,995; and $12,248,296. Another example in 2030, the subsidies given in the BAU Scenario and Scenarios 1 to 3, are $7,122,396; $11,073,268; $11,558,419; and $11,903,384, respectively. If the budget specified in 2030 for each brand is $11,000,000, it means that the budget for the three types of brands is given by $33,000,000, the remaining budget for all brands is $25,877,604; $21,926,732; $21,441,581; and $21,096,616, respectively. The results of this study indicate that the larger the budget allocated, the more budget can be absorbed to maximize the sales of electric trucks. This increase will also affect the development of electric charging stations. For further analysis, see Appendix E.

7. Conclusion and future works

This paper develops a mathematical model to increase electric truck sales and electric charging station construction by adopting the policy of providing tax incentives and subsidies from the Indonesian government. This model can also reduce diesel truck sales and carbon emissions. This model consists of a multi-brand type electric truck and a diesel truck. The purpose of this study is to minimize the total electric truck investment cost, operating cost, maintenance cost, diesel truck investment cost, operation, and maintenance cost, truck diesel carbon emission cost, investment cost, and total installation cost of electric charging station, operation, and maintenance of electric charging stations. The model was solved in Microsoft Excel and OpenSolver. This study shows that with a

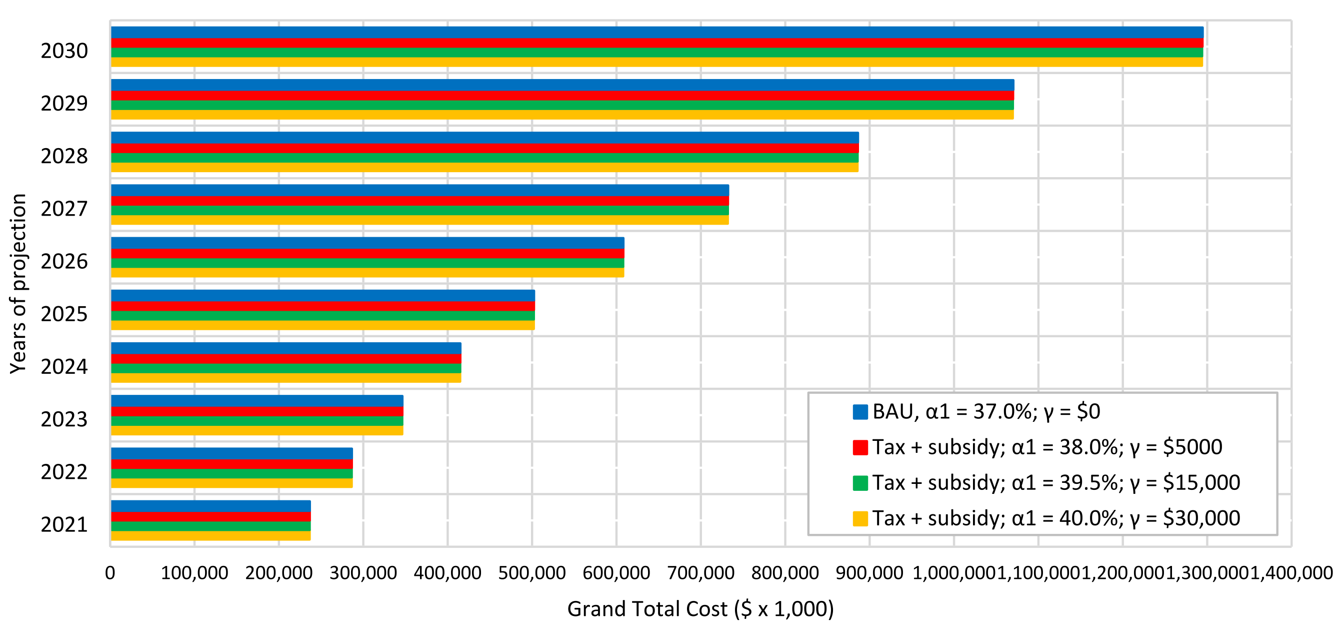


Fig. 11. Grand total costs projection of each scenario.

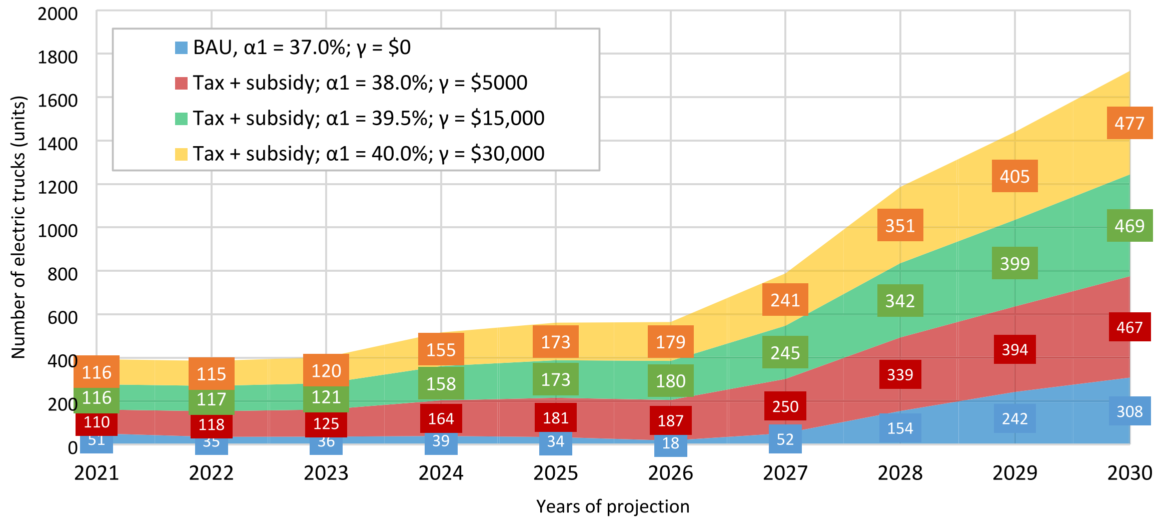


Fig. 12. Number of electric trucks projection of each scenario.

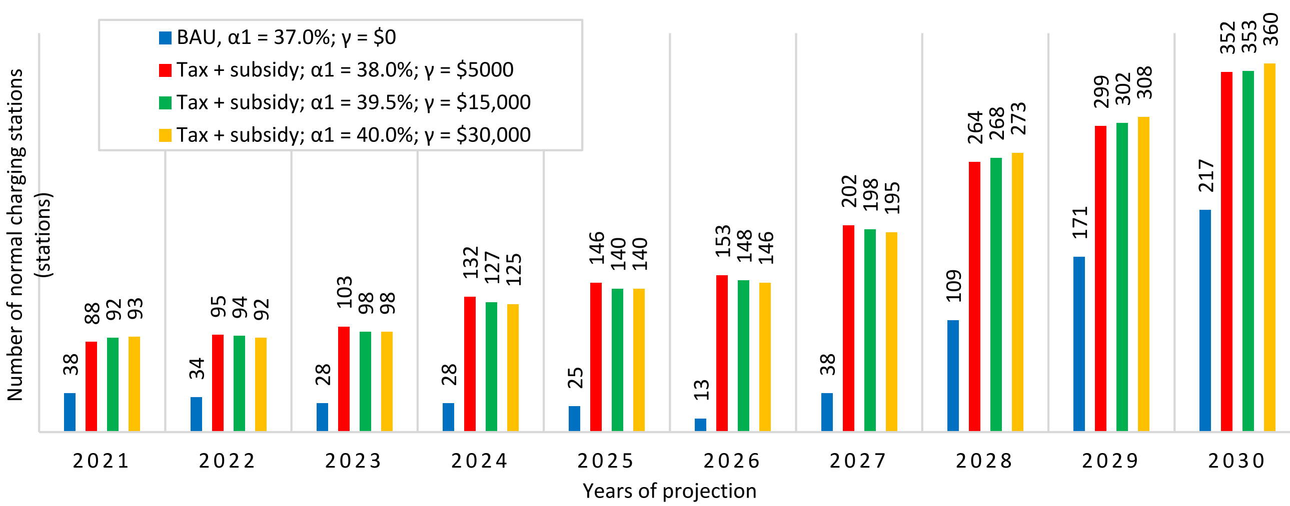


Fig. 13. Number of normal electric charging projections of each scenario.

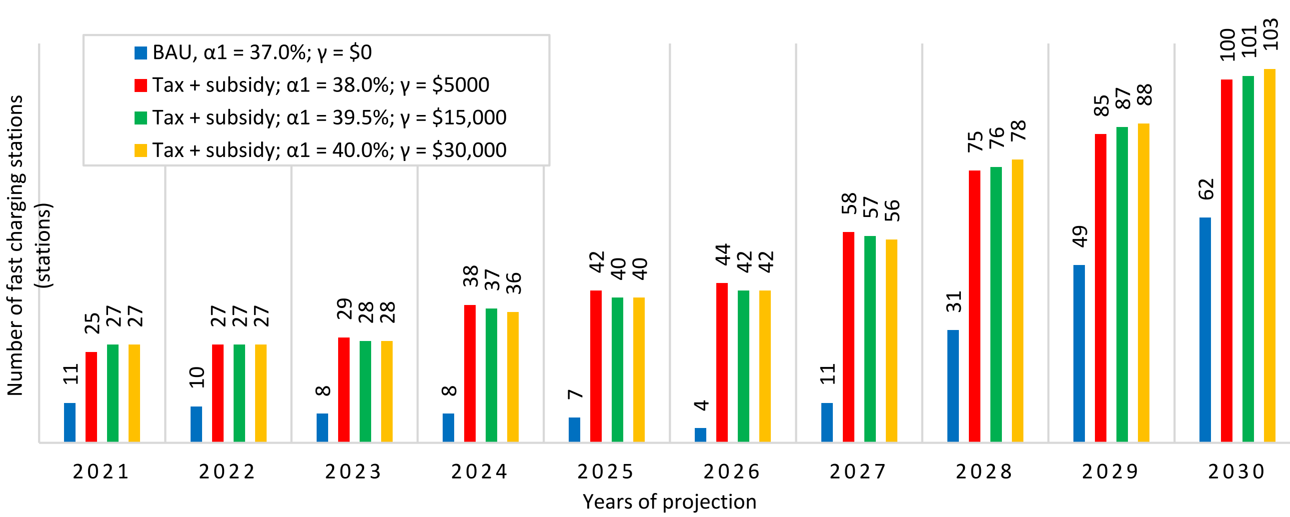


Fig. 14. Number of fast electric charging projection of each scenario.

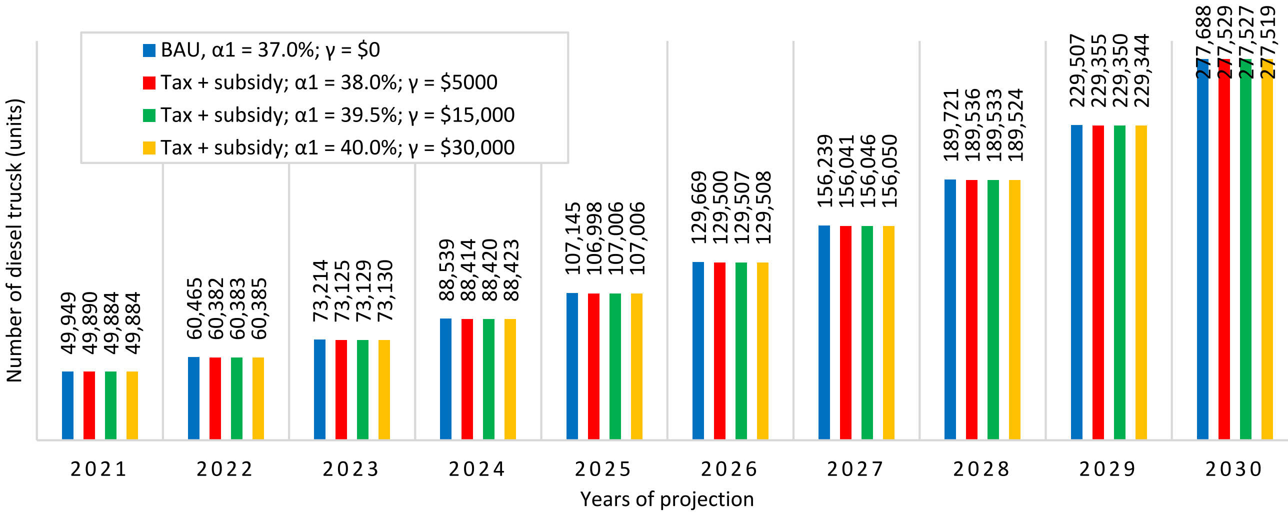


Fig. 15. Number of diesel trucks projection for each scenario.

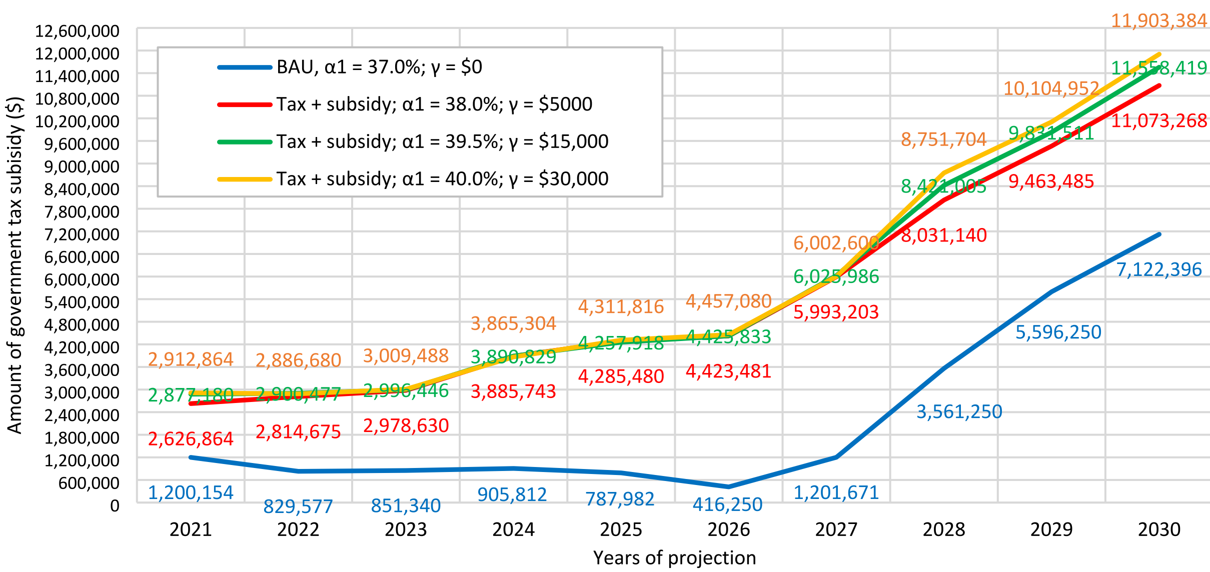


Fig. 16. Amount of government subsidies projection of each scenario.

tax incentive of 36.0 % and without subsidies, the sales of electric trucks are not obtained. This is due to the basic tax on electric trucks being higher than the tax on diesel trucks. Electric truck sales increase when tax incentives reach 36.5 %, with various subsidy incentives ranging from $1000 to $25,000 per brand. As a result, tax incentives minimize the investment price of electric trucks, which consist of unit prices, batteries, and chargers, thus making electric trucks more attractive than diesel trucks. Electric truck sales will increase significantly if the tax subsidy increases from 37.5 % to 40.0 % in the subsidy variation and the no-subsidy policy for diesel fuel. On the investor's side, constructing electric charging stations will also increase and be profitable.

This study also estimates the amount of truck electric and electric charging stations needed in Indonesia by the year 2030. Based on sensitivity analysis, it shows that the current policy (BAU scenario) does not significantly affect the increase in electric truck sales. In contrast to the third scenario, adding up to 40 % tax incentives and a subsidy of $30,000 could significantly increase electric truck sales and develop electric charging stations. In addition, by 2030, with a budget of $11,000,000 per brand, it will be possible to maximize a given budget and sales of electric trucks. It is estimated that Indonesia will have about 477 electric trucks on the roads by 2030. It will require between 360 regular charging stations and 103 fast charging stations.

The results of this study show that in order to promote the adoption of electric trucks in Indonesia, the government supports financial incentives such as taxes and subsidies to ensure the availability of appropriate infrastructures, such as charging stations. In addition, consideration of various opportunities and other fiscal policies such as incentives to the industry in import duty of materials, goods, and machinery, incentives for building factories of electric trucks, and incentives for the competent workforce to reduce the company's operational costs, should be taken into account in future studies. Finally, the heat or humid weather conditions may be considered to evaluate the performance of an electric truck.

CRediT authorship contribution statement

Ivan Darma Wangsa: Conceptualization, Methodology, Software, Validation, Investigation, Formal analysis, Writing – original draft, Writing – review & editing, Visualization. **Iwan Vanany:** Supervision, Conceptualization, Methodology, Formal analysis, Validation, Writing – original draft, Writing – review & editing, Visualization. **Nurhadi Siswanto:** Supervision, Conceptualization, Methodology, Formal analysis.

Declaration of Competing Interest

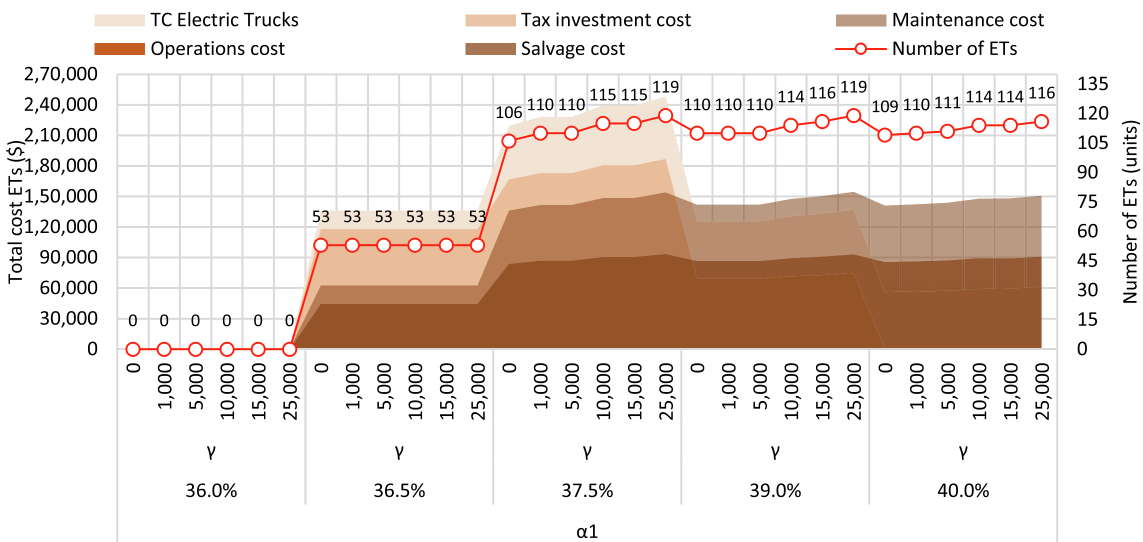
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

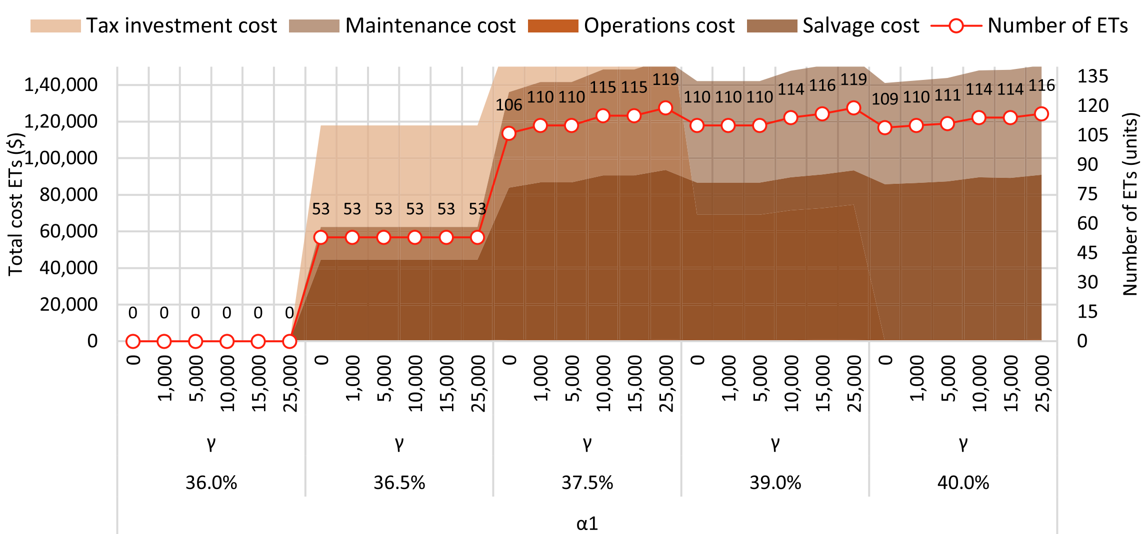
Appendix A

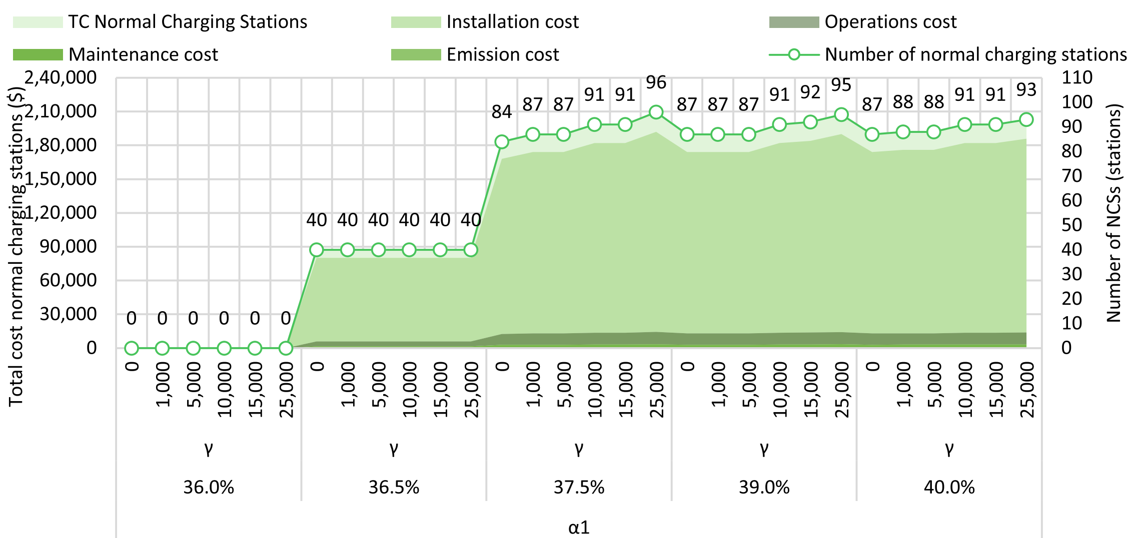
	α1																													
	36.0%						36.5%						37.5%						39.0%						40.0%					
	γ						γ						γ						γ						γ					
	0	1,000	5,000	10,000	15,000	25,000	0	1,000	5,000	10,000	15,000	25,000	0	1,000	5,000	10,000	15,000	25,000	0	1,000	5,000	10,000	15,000	25,000	0	1,000	5,000	10,000	15,000	25,000
Grand total cost	**236,694,018.75**	**236,694,018.75**	**236,694,018.75**	**236,694,018.75**	**236,694,018.75**	**236,694,018.75**	**236,695,177.44**	**236,695,177.44**	**236,695,177.44**	**236,695,177.44**	**236,695,177.44**	**236,695,177.44**	**236,652,068.83**	**236,650,948.40**	**236,650,948.40**	**236,649,265.55**	**236,649,265.55**	**236,652,516.62**	**236,548,092.34**	**236,548,092.34**	**236,548,092.34**	**236,545,424.46**	**236,543,562.27**	**236,539,075.11**	**236,483,953.70**	**236,481,508.09**	**236,480,664.51**	**236,474,165.66**	**236,474,732.00**	**236,473,244.82**
Tax investment cost	0.00	0.00	0.00	0.00	0.00	0.00	117,947.90	117,947.90	117,947.90	117,947.90	117,947.90	117,947.90	166,644.00	172,866.00	172,866.00	180,643.50	180,643.50	186,865.50	69,106.80	69,106.80	69,106.80	71,595.60	72,840.00	74,706.60	0.00	0.00	0.00	0.00	0.00	0.00
Operations cost	0.00	0.00	0.00	0.00	0.00	0.00	394.34	394.34	394.34	394.34	394.34	394.34	833.88	867.00	867.00	908.40	908.40	941.52	869.64	869.64	869.64	902.76	919.32	944.16	862.06	870.34	878.62	903.46	905.40	920.02
Maintenance cost	0.00	0.00	0.00	0.00	0.00	0.00	62,538.40	62,538.40	62,538.40	62,538.40	62,538.40	62,538.40	136,076.80	141,608.00	141,608.00	148,522.00	148,522.00	154,053.20	142,208.00	142,208.00	142,208.00	147,739.20	150,504.80	154,653.20	141,075.20	142,458.00	143,840.80	147,989.20	148,339.20	150,754.80
Salvage cost	0.00	0.00	0.00	0.00	0.00	0.00	44,574.00	44,574.00	44,574.00	44,574.00	44,574.00	44,574.00	83,951.70	86,930.10	86,930.10	90,653.10	90,653.10	93,631.50	86,629.60	86,629.60	86,629.60	89,608.00	91,097.20	93,331.00	85,798.90	86,543.50	87,288.10	89,521.90	89,307.50	91,011.10
TC Electric Trucks	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**136,306.64**	**136,306.64**	**136,306.64**	**136,306.64**	**136,306.64**	**136,306.64**	**219,602.98**	**228,410.90**	**228,410.90**	**239,420.80**	**239,420.80**	**248,228.72**	**125,554.84**	**125,554.84**	**125,554.84**	**130,629.56**	**133,166.92**	**136,972.96**	**56,138.36**	**56,784.84**	**57,431.32**	**59,370.76**	**59,937.10**	**60,663.72**
Tax investment cost	34,203,711.80	34,203,711.80	34,203,711.80	34,203,711.80	34,203,711.80	34,203,711.80	34,167,470.40	34,167,470.40	34,167,470.40	34,167,470.40	34,167,470.40	34,167,470.40	34,131,229.00	34,128,493.80	34,128,493.80	34,125,074.80	34,125,074.80	34,122,339.60	34,128,493.80	34,128,493.80	34,128,493.80	34,125,758.60	34,124,391.00	34,122,339.60	34,129,177.20	34,128,493.80	34,127,809.80	34,125,758.60	34,125,758.60	34,124,391.00
Operations cost	2,034,100.32	2,034,100.32	2,034,100.32	2,034,100.32	2,034,100.32	2,034,100.32	2,031,937.92	2,031,937.92	2,031,937.92	2,031,937.92	2,031,937.92	2,031,937.92	2,029,775.52	2,029,612.32	2,029,612.32	2,029,408.32	2,029,408.32	2,029,245.12	2,029,612.32	2,029,612.32	2,029,612.32	2,029,449.12	2,029,367.52	2,029,245.12	2,029,661.28	2,029,612.32	2,029,563.36	2,029,449.12	2,029,449.12	2,029,367.52
Maintenance cost	46,795,783.20	46,795,783.20	46,795,783.20	46,795,783.20	46,795,783.20	46,795,783.20	46,751,104.20	46,751,104.20	46,751,104.20	46,751,104.20	46,751,104.20	46,751,104.20	46,706,425.20	46,703,053.20	46,703,053.20	46,698,838.20	46,698,838.20	46,695,466.20	46,703,053.20	46,703,053.20	46,703,053.20	46,699,681.20	46,697,995.20	46,695,466.20	46,703,807.40	46,703,053.20	46,702,094.20	46,699,681.20	46,699,681.20	46,697,995.20
Carbon cost	166,111,665.00	166,111,665.00	166,111,665.00	166,111,665.00	166,111,665.00	166,111,665.00	165,923,329.50	165,923,329.50	165,923,329.50	165,923,329.50	165,923,329.50	165,923,329.50	165,734,994.00	165,720,780.00	165,720,780.00	165,703,012.50	165,703,012.50	165,688,798.50	165,720,780.00	165,720,780.00	165,720,780.00	165,706,566.00	165,699,459.00	165,688,798.50	165,724,639.50	165,720,780.00	165,717,427.50	165,706,566.00	165,706,566.00	165,699,459.00
Salvage cost	12,451,241.57	12,451,241.57	12,451,241.57	12,451,241.57	12,451,241.57	12,451,241.57	12,442,181.22	12,442,181.22	12,442,181.22	12,442,181.22	12,442,181.22	12,442,181.22	12,433,120.87	12,432,437.07	12,432,437.07	12,431,582.32	12,431,582.32	12,430,898.52	12,432,437.07	12,432,437.07	12,432,437.07	12,431,753.27	12,431,411.37	12,430,898.52	12,432,505.29	12,432,437.07	12,432,197.67	12,431,753.27	12,431,753.27	12,431,411.37
TC Diesel Trucks	**236,694,018.75**	**236,694,018.75**	**236,694,018.75**	**236,694,018.75**	**236,694,018.75**	**236,694,018.75**	**236,431,660.80**	**236,431,660.80**	**236,431,660.80**	**236,431,660.80**	**236,431,660.80**	**236,431,660.80**	**236,169,302.85**	**236,149,502.25**	**236,149,502.25**	**236,124,751.50**	**236,124,751.50**	**236,104,950.90**	**236,149,502.25**	**236,149,502.25**	**236,149,502.25**	**236,129,701.65**	**236,119,801.35**	**236,104,950.90**	**236,154,780.09**	**236,149,502.25**	**236,144,697.19**	**236,129,701.65**	**236,129,701.65**	**236,119,801.35**
Installation cost	0.00	0.00	0.00	0.00	0.00	0.00	80,000.00	80,000.00	80,000.00	80,000.00	80,000.00	80,000.00	168,000.00	174,000.00	174,000.00	182,000.00	182,000.00	192,000.00	174,000.00	174,000.00	174,000.00	182,000.00	184,000.00	190,000.00	174,000.00	176,000.00	176,000.00	182,000.00	182,000.00	186,000.00
Operations cost	0.00	0.00	0.00	0.00	0.00	0.00	6,000.00	6,000.00	6,000.00	6,000.00	6,000.00	6,000.00	12,600.00	13,050.00	13,050.00	13,650.00	13,650.00	14,400.00	13,050.00	13,050.00	13,050.00	13,650.00	13,800.00	14,250.00	13,050.00	13,200.00	13,200.00	13,650.00	13,650.00	13,950.00
Maintenance cost	0.00	0.00	0.00	0.00	0.00	0.00	1,400.00	1,400.00	1,400.00	1,400.00	1,400.00	1,400.00	2,940.00	3,045.00	3,045.00	3,185.00	3,185.00	3,360.00	3,045.00	3,045.00	3,045.00	3,185.00	3,220.00	3,325.00	3,045.00	3,080.00	3,080.00	3,185.00	3,185.00	3,255.00
Emission cost	0.00	0.00	0.00	0.00	0.00	0.00	30.00	30.00	30.00	30.00	30.00	30.00	63.00	65.25	65.25	68.25	68.25	72.00	65.25	65.25	65.25	68.25	69.00	71.25	65.25	66.00	66.00	68.25	68.25	69.75
TC Normal Charging Stations	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**87,430.00**	**87,430.00**	**87,430.00**	**87,430.00**	**87,430.00**	**87,430.00**	**183,603.00**	**190,160.25**	**190,160.25**	**198,903.25**	**198,903.25**	**209,832.00**	**190,160.25**	**190,160.25**	**190,160.25**	**198,903.25**	**201,089.00**	**207,646.25**	**190,160.25**	**192,346.00**	**192,346.00**	**198,903.25**	**198,903.25**	**203,274.75**
Installation cost	0.00	0.00	0.00	0.00	0.00	0.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	36,000.00	72,000.00	75,000.00	75,000.00	78,000.00	78,000.00	81,000.00	75,000.00	75,000.00	75,000.00	78,000.00	81,000.00	81,000.00	75,000.00	75,000.00	78,000.00	78,000.00	78,000.00	81,000.00

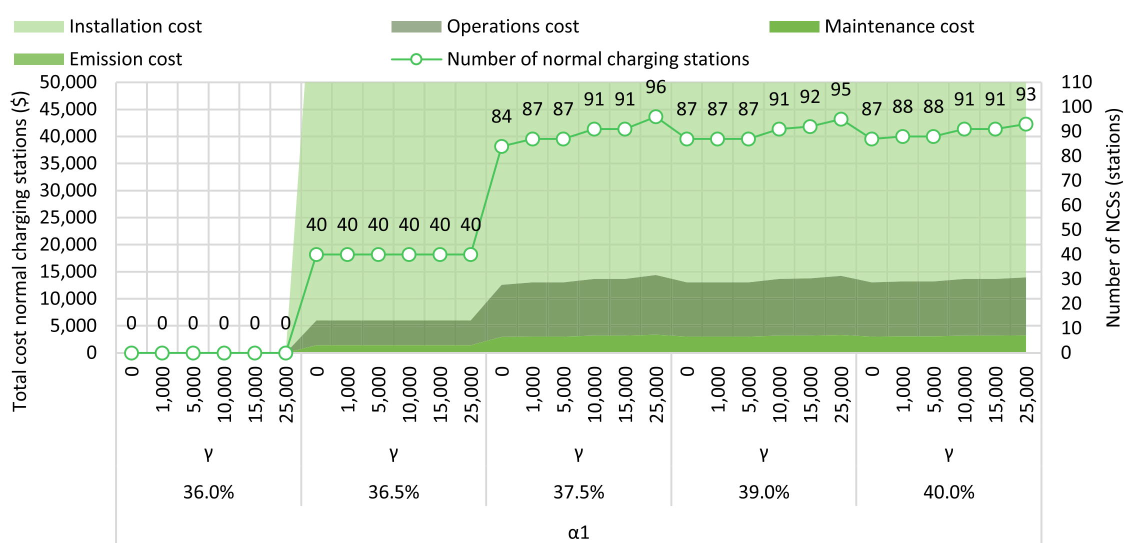
	α1																													
	36.0%						36.5%						37.5%						39.0%						40.0%					
	γ						γ						γ						γ						γ					
	0	1,000	5,000	10,000	15,000	25,000	0	1,000	5,000	10,000	15,000	25,000	0	1,000	5,000	10,000	15,000	25,000	0	1,000	5,000	10,000	15,000	25,000	0	1,000	5,000	10,000	15,000	25,000
Operations cost	0.00	0.00	0.00	0.00	0.00	0.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00	6,000.00	6,250.00	6,250.00	6,500.00	6,500.00	6,750.00	6,250.00	6,250.00	6,250.00	6,500.00	6,750.00	6,750.00	6,250.00	6,250.00	6,500.00	6,500.00	6,500.00	6,750.00
Maintenance cost	0.00	0.00	0.00	0.00	0.00	0.00	780.00	780.00	780.00	780.00	780.00	780.00	1,560.00	1,625.00	1,625.00	1,690.00	1,690.00	1,755.00	1,625.00	1,625.00	1,625.00	1,690.00	1,755.00	1,755.00	1,625.00	1,625.00	1,690.00	1,690.00	1,690.00	1,755.00
Emissions cost	0.00	0.00	0.00	0.00	0.00	0.00	5.40	5.40	5.40	5.40	5.40	5.40	10.80	11.25	11.25	11.70	11.70	12.15	11.25	11.25	11.25	11.70	12.15	12.15	11.25	11.25	11.70	11.70	11.70	12.15
TC Fast Charging Stations	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**39,780.00**	**39,780.00**	**39,780.00**	**39,780.00**	**39,780.00**	**39,780.00**	**79,560.00**	**82,875.00**	**82,875.00**	**86,190.00**	**86,190.00**	**89,505.00**	**82,875.00**	**82,875.00**	**82,875.00**	**86,190.00**	**89,505.00**	**89,505.00**	**82,875.00**	**82,875.00**	**86,190.00**	**86,190.00**	**86,190.00**	**89,505.00**
Type 1 of BETs	0	0	0	0	0	0	1	1	1	1	1	1	55	59	59	64	64	68	62	62	62	66	68	71	62	63	64	67	69	69
Type 2 of BETs	0	0	0	0	0	0	37	37	37	37	37	37	36	36	36	36	36	36	34	34	34	34	34	34	33	33	33	33	32	33
Type 3 of BETs	0	0	0	0	0	0	15	15	15	15	15	15	15	15	15	15	15	15	14	14	14	14	14	14	14	14	14	14	13	14
Type 1 of DTs	4,535	4,535	4,535	4,535	4,535	4,535	4,482	4,482	4,482	4,482	4,482	4,482	4,429	4,425	4,425	4,420	4,420	4,416	4,425	4,425	4,425	4,421	4,419	4,416	4,427	4,425	4,425	4,421	4,421	4,419
Type 2 of DTs	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,093	23,094	23,094	23,094	23,094	23,094
Type 3 of DTs	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,370	22,371	22,371	22,371
Yk = 1	107,434.15	107,434.15	107,434.15	107,434.15	107,434.15	107,434.15	106,178.82	106,178.82	106,178.82	106,178.82	106,178.82	106,178.82	104,923.50	104,828.76	104,828.76	104,710.33	104,710.33	104,615.60	104,828.76	104,828.76	104,828.76	104,734.02	104,686.65	104,615.60	104,876.14	104,828.77	104,828.77	104,734.02	104,734.02	104,686.66
Yk = 2	499,985.10	499,985.10	499,985.10	499,985.10	499,985.10	499,985.10	499,985.34	499,985.34	499,985.34	499,985.34	499,985.34	499,985.34	499,985.59	499,985.61	499,985.61	499,985.63	499,985.63	499,985.66	499,985.61	499,985.61	499,985.61	499,985.63	499,985.64	499,985.66	499,963.96	499,985.62	499,985.62	499,985.63	499,985.63	499,985.65
Yk = 3	499,991.85	499,991.85	499,991.85	499,991.85	499,991.85	499,991.85	499,992.09	499,992.09	499,992.09	499,992.09	499,992.09	499,992.09	499,992.34	499,992.36	499,992.36	499,992.38	499,992.38	499,992.41	499,992.36	499,992.36	499,992.36	499,992.38	499,992.39	499,992.41	499,992.36	499,992.37	499,970.02	499,992.38	499,992.38	499,992.40
αEiBiQi = 1	0	0	0	0	0	0	22,710	22,710	22,710	22,710	22,710	22,710	1,283,288	1,376,618	1,376,618	1,493,280	1,493,280	1,586,610	1,504,480	1,504,480	1,504,480	1,601,543	1,650,074	1,722,872	1,543,056	1,567,944	1,592,832	1,667,496	1,717,272	1,717,272
αEiBiQi = 2	0	0	0	0	0	0	865,130	865,130	865,130	865,130	865,130	865,130	864,810	864,810	864,810	864,810	864,810	864,810	849,436	849,436	849,436	849,436	849,436	849,436	845,592	845,592	845,592	845,592	819,968	845,592
αEiBiQi = 3	0	0	0	0	0	0	342,188	342,188	342,188	342,188	342,188	342,188	351,563	351,563	351,563	351,563	351,563	351,563	341,250	341,250	341,250	341,250	341,250	341,250	350,000	350,000	350,000	350,000	325,000	350,000
ΔDCQj = 1	277,542	277,542	277,542	277,542	277,542	277,542	274,298	274,298	274,298	274,298	274,298	274,298	271,055	270,810	270,810	270,504	270,504	270,259	270,810	270,810	270,810	270,565	270,443	270,259	270,932	270,810	270,810	270,565	270,565	270,443
ΔDCQj = 2	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,633	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682
ΔDCQj = 3	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,853	1,642,926	1,642,926	1,642,926
Normal charging stations	0	0	0	0	0	0	40	40	40	40	40	40	84	87	87	91	91	96	87	87	87	91	92	95	87	88	88	91	91	93
Fast charging stations	0	0	0	0	0	0	12	12	12	12	12	12	24	25	25	26	26	27	25	25	25	26	27	27	25	25	26	26	26	27

Appendix B


TC Electric Trucks
Tax investment cost
Maintenance cost
Operations cost
Salvage cost
Number of ETs
Total cost ETs ($)
Number of ETs (units)
γ
36.0%
36.5%
37.5%
39.0%
40.0%
α1


Tax investment cost
Maintenance cost
Operations cost
Salvage cost
Number of ETs
Total cost ETs ($)
Number of ETs (units)
γ
36.0%
36.5%
37.5%
39.0%
40.0%
α1


TC Normal Charging Stations
Installation cost
Operations cost
Maintenance cost
Emission cost
Number of normal charging stations
Total cost normal charging stations ($)
Number of NCSs (stations)
γ
36.0%
36.5%
37.5%
39.0%
40.0%
α1


Installation cost
Operations cost
Maintenance cost
Emission cost
Number of normal charging stations
Total cost normal charging stations ($)
Number of NCSs (stations)
γ
36.0%
36.5%
37.5%
39.0%
40.0%
α1

Appendix C

	Δ												
	0.60	**0.55**	**0.50**	**0.45**	**0.40**	**0.35**	**0.30**	**0.25**	**0.20**	**0.15**	**0.10**	**0.05**	**0.00**
Grand total cost	**236,539,075.11**	**236,788,595.89**	**237,035,467.63**	**237,279,090.59**	**237,526,713.42**	**237,778,745.88**	**238,022,177.85**	**238,223,349.80**	**238,517,568.65**	**238,765,772.18**	**239,067,725.07**	**239,269,933.75**	**239,521,255.88**
Tax investment cost	74,706.60	75,419.20	75,506.80	76,841.60	77,535.80	78,245.60	79,580.40	79,646.80	80,966.00	81,623.40	82,170.40	82,092.40	82,108.00
Operations cost	944.16	942.20	933.20	939.52	938.26	937.54	943.86	936.80	942.58	942.72	947.06	944.36	944.90
Maintenance cost	154,653.20	154,436.00	152,936.00	154,101.60	154,134.40	154,017.20	155,182.80	154,032.80	155,348.40	155,881.20	157,914.00	158,664.00	158,514.00
Salvage cost	93,331.00	95,189.80	96,175.70	98,779.10	100,551.80	102,282.30	104,885.70	105,657.20	108,302.80	109,903.30	110,987.20	111,198.20	111,156.00
TC Electric Trucks	**136,972.96**	**135,607.60**	**133,200.30**	**133,103.62**	**132,056.66**	**130,918.04**	**130,821.36**	**128,959.20**	**128,954.18**	**128,544.02**	**130,044.26**	**130,502.56**	**130,410.90**
Tax investment cost	34,122,339.60	34,121,655.80	34,121,655.80	34,120,288.20	34,119,604.40	34,118,920.40	34,117,553.00	34,117,552.80	34,116,185.40	34,115,501.60	34,114,817.80	34,114,817.80	34,114,817.80
Operations cost	2,029,245.12	2,282,854.86	2,536,505.40	2,790,043.74	3,043,622.88	3,297,178.56	3,550,679.16	3,753,560.02	4,057,755.84	4,311,278.88	4,615,511.63	4,818,391.26	5,071,990.80
Maintenance cost	46,695,466.20	46,694,623.20	46,694,623.20	46,692,937.20	46,692,094.20	46,691,135.20	46,689,565.20	46,689,449.20	46,687,879.20	46,687,036.20	46,686,193.20	46,686,193.20	46,686,193.20
Carbon cost	165,688,798.50	165,685,245.00	165,685,245.00	165,678,138.00	165,674,584.50	165,671,232.00	165,663,924.00	165,664,125.00	165,656,817.00	165,653,263.50	165,649,710.00	165,649,710.00	165,649,710.00
Salvage cost	12,430,898.52	12,430,727.57	12,430,727.57	12,430,385.67	12,430,214.72	12,429,975.32	12,429,701.87	12,429,633.42	12,429,359.97	12,429,189.02	12,429,018.07	12,429,018.07	12,429,018.07
TC Diesel Trucks	**236,104,950.90**	**236,353,651.29**	**236,607,301.83**	**236,851,021.47**	**237,099,691.26**	**237,348,490.84**	**237,592,019.49**	**237,795,053.60**	**238,089,277.47**	**238,337,891.16**	**238,637,214.56**	**238,840,094.19**	**239,093,693.73**
Installation cost	190,000.00	192,000.00	188,000.00	188,000.00	188,000.00	192,000.00	192,000.00	192,000.00	192,000.00	192,000.00	190,000.00	192,000.00	190,000.00
Operations cost	14,250.00	14,400.00	14,100.00	14,100.00	14,100.00	14,400.00	14,400.00	14,400.00	14,400.00	14,400.00	14,250.00	14,400.00	14,250.00
Maintenance cost	3,325.00	3,360.00	3,290.00	3,290.00	3,290.00	3,360.00	3,360.00	3,360.00	3,360.00	3,360.00	3,325.00	3,360.00	3,325.00
Emission cost	71.25	72.00	70.50	70.50	70.50	72.00	72.00	72.00	72.00	72.00	71.25	72.00	71.25
TC Normal Charging Stations	**207,646.25**	**209,832.00**	**205,460.50**	**205,460.50**	**205,460.50**	**209,832.00**	**209,832.00**	**209,832.00**	**209,832.00**	**209,832.00**	**207,646.25**	**209,832.00**	**207,646.25**
Installation cost	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	84,000.00	81,000.00	81,000.00
Operations cost	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	7,000.00	6,750.00	6,750.00
Maintenance cost	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,820.00	1,755.00	1,755.00
Emission cost	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.60	12.15	12.15
TC Fast Charging Stations	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**92,820.00**	**89,505.00**	**89,505.00**
Type 1 of BEVs	71	62	53	45	37	29	21	14	6	0	0	0	0
Type 2 of BEVs	34	38	42	46	49	53	57	60	63	64	59	54	55
Type 3 of BEVs	14	20	25	31	37	42	48	52	59	65	71	76	75
	Δ												
	0.60	**0.55**	**0.50**	**0.45**	**0.40**	**0.35**	**0.30**	**0.25**	**0.20**	**0.15**	**0.10**	**0.05**	**0.00**
Type 1 of DVs	4,416	4,415	4,415	4,413	4,412	4,412	4,409	4,410	4,407	4,406	4,405	4,405	4,405
Type 2 of DVs	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094
Type 3 of DVs	22,371	22,371	22,371	22,371	22,371	22,370	22,371	22,370	22,371	22,371	22,371	22,371	22,371
Yk = 1	104,615.60	104,591.91	104,591.90	104,544.52	104,520.83	104,520.84	104,449.77	104,473.46	104,402.39	104,378.70	104,355.01	104,355.01	104,355.01
Yk = 2	499,985.66	499,985.66	499,985.65	499,985.65	499,985.65	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66
Yk = 3	499,992.41	499,992.41	499,992.40	499,992.40	499,992.40	499,970.06	499,992.41	499,970.06	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41
αEiBiQi = 1	1,722,872	1,504,480	1,286,087	1,091,961	897,835	703,708	509,582	339,721	145,595	0	0	0	0
αEiBiQi = 2	849,436	949,369	1,049,303	1,149,236	1,224,187	1,324,120	1,424,054	1,499,004	1,573,954	1,598,938	1,474,021	1,349,104	1,374,087
αEiBiQi = 3	341,250	487,500	609,375	755,625	901,875	1,023,750	1,170,000	1,267,500	1,438,125	1,584,375	1,730,625	1,852,500	1,828,125
ΔDCQj = 1	270,259	247,682	225,165	202,557	180,010	157,508	134,915	116,953	89,903	67,412	40,438	22,466	0
ΔDCQj = 2	1,130,682	1,036,459	942,235	848,012	753,788	659,565	565,341	489,962	376,894	282,671	169,602	94,224	0
ΔDCQj = 3	1,642,926	1,506,016	1,369,105	1,232,195	1,095,284	958,331	821,463	711,903	547,642	410,732	246,439	136,911	0
Slow charging stations	95	96	94	94	94	96	96	96	96	96	95	96	95
Fast charging stations	27	27	27	27	27	27	27	27	27	27	28	27	27

Appendix D

	Distance												
	70	75	80	85	90	95	100	110	120	130	140	150	160
Grand total cost	**228,644,158.21**	**230,162,411.46**	**231,680,664.71**	**233,198,917.96**	**234,717,171.21**	**236,235,424.46**	**237,753,677.71**	**240,790,184.21**	**243,826,690.71**	**246,863,197.21**	**249,899,703.71**	**252,936,210.21**	**255,972,716.71**
Tax investment cost	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60	74,706.60
Operations cost	944.16	944.16	944.16	944.16	944.16	944.16	944.16	944.16	944.16	944.16	944.16	944.16	944.16
Maintenance cost	154,498.50	154,528.25	154,558.00	154,587.75	154,617.50	154,647.25	154,677.00	154,736.50	154,796.00	154,855.50	154,915.00	154,974.50	155,034.00
Salvage cost	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00	93,331.00
TC Electric Trucks	**136,818.26**	**136,848.01**	**136,877.76**	**136,907.51**	**136,937.26**	**136,967.01**	**136,996.76**	**137,056.26**	**137,115.76**	**137,175.26**	**137,234.76**	**137,294.26**	**137,353.76**
Tax investment cost	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60	34,122,339.60
Operations cost	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12	2,029,245.12
	Distance												
	70	75	80	85	90	95	100	110	120	130	140	150	160
Maintenance cost	38,800,704.00	40,318,927.50	41,837,151.00	43,355,374.50	44,873,598.00	46,391,821.50	47,910,045.00	50,946,492.00	53,982,939.00	57,019,386.00	60,055,833.00	63,092,280.00	66,128,727.00
Carbon cost	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50	165,688,798.50
Salvage cost	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52	12,430,898.52
TC Diesel Trucks	**228,210,188.70**	**229,728,412.20**	**231,246,635.70**	**232,764,859.20**	**234,283,082.70**	**235,801,306.20**	**237,319,529.70**	**240,355,976.70**	**243,392,423.70**	**246,428,870.70**	**249,465,317.70**	**252,501,764.70**	**255,538,211.70**
Installation cost	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00	190,000.00
Operations cost	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00	14,250.00
Maintenance cost	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00	3,325.00
Emission cost	71.25	71.25	71.25	71.25	71.25	71.25	71.25	71.25	71.25	71.25	71.25	71.25	71.25
TC Normal Charging Stations	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**	**207,646.25**
Installation cost	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00	81,000.00
Operations cost	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00	6,750.00
Maintenance cost	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00	1,755.00
Emission cost	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15
TC Fast Charging Stations	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**	**89,505.00**
Type 1 of BEVs	71	71	71	71	71	71	71	71	71	71	71	71	71
Type 2 of BEVs	34	34	34	34	34	34	34	34	34	34	34	34	34
Type 3 of BEVs	14	14	14	14	14	14	14	14	14	14	14	14	14
Type 1 of DVs	4,416	4,416	4,416	4,416	4,416	4,416	4,416	4,416	4,416	4,416	4,416	4,416	4,416
Type 2 of DVs	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094	23,094
Type 3 of DVs	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371	22,371
Yk = 1	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60	104,615.60
Yk = 2	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66	499,985.66
Yk = 3	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41	499,992.41
αEiBiQi = 1	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872	1,722,872
αEiBiQi = 2	849,436	849,436	849,436	849,436	849,436	849,436	849,436	849,436	849,436	849,436	849,436	849,436	849,436
αEiBiQi = 3	341,250	341,250	341,250	341,250	341,250	341,250	341,250	341,250	341,250	341,250	341,250	341,250	341,250
	Distance												
	70	75	80	85	90	95	100	110	120	130	140	150	160
ΔDCQj = 1	270,259	270,259	270,259	270,259	270,259	270,259	270,259	270,259	270,259	270,259	270,259	270,259	270,259
ΔDCQj = 2	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682	1,130,682
ΔDCQj = 3	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926	1,642,926
Slow charging stations	95	95	95	95	95	95	95	95	95	95	95	95	95
Fast charging stations	27	27	27	27	27	27	27	27	27	27	27	27	27

Appendix E

	2021				2022				2023				2024				2025			
	α1				α1				α1				α1				α1			
	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%
	γ				γ				γ				γ				γ			
	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000
Grand total cost	**236,675,796.98**	**236,618,860.95**	**236,507,142.27**	**236,473,244.82**	**286,520,173.03**	**286,431,802.91**	**286,322,831.73**	**286,294,606.90**	**346,368,337.93**	**346,306,599.95**	**346,191,404.18**	**346,157,778.15**	**415,069,518.32**	**415,007,532.42**	**414,867,317.03**	**414,819,312.47**	**502,348,879.63**	**502,278,344.86**	**502,115,331.84**	**502,061,434.14**
Tax cost	97,309.80	138,256.00	36,420.00	0.00	67,263.00	148,140.80	36,714.90	0.00	69,027.60	156,770.00	37,929.70	0.00	73,444.20	204,512.80	49,251.00	0.00	63,890.40	225,551.60	53,897.70	0.00
Ops. cost	378.48	867.70	919.32	920.02	265.30	942.08	934.50	918.64	273.74	1,010.66	978.94	970.66	279.58	1,314.58	1,266.84	1,243.24	240.98	1,458.68	1,393.68	1,393.68
Maint. cost	60,022.80	141,858.00	150,504.80	150,754.80	39,648.00	153,770.40	152,637.60	150,122.00	41,430.80	164,500.00	159,468.80	158,086.00	49,079.20	221,929.20	213,982.40	209,934.00	43,165.20	246,286.80	235,324.40	235,324.40
Salvage cost	42,998.70	86,844.00	91,097.20	91,011.10	29,074.50	91,944.90	91,114.20	89,538.90	29,775.20	96,044.60	92,894.00	92,149.40	33,619.40	126,694.40	122,012.40	119,650.30	29,552.00	138,966.00	132,880.90	132,880.90
TC Electric Trucks	**114,712.38**	**194,137.70**	**96,746.92**	**60,663.72**	**78,101.80**	**210,908.38**	**99,172.80**	**61,501.74**	**80,956.94**	**226,236.06**	**105,483.44**	**66,907.26**	**89,183.58**	**301,062.18**	**142,487.84**	**91,526.94**	**77,744.58**	**334,331.08**	**157,734.88**	**103,837.18**
Tax cost	34,168	34,128	34,124	34,124	41,362	41,305	41,306	41,307	50,084	50,023	50,026	50,026	60,572	60,486	60,490	60,492	73,301	73,200	73,205	73,205

	2026				2027				2028				2029				2030			
	α1				α1				α1				α1				α1			
	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%
	γ				γ				γ				γ				γ			
	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000
Grand total cost	**608,232,017.41**	**608,166,573.20**	**608,001,646.90**	**607,945,181.24**	**732,330,400.44**	**732,157,797.28**	**732,009,309.1**	**731,940,022.39**	**886,207,888.97**	**886,058,062.68**	**885,743,384.66**	**885,616,691.65**	**1,070,319,673.35**	**1,070,003,249.17**	**1,069,756,962.86**	**1,069,628,332.00**	**1,294,668,187.89**	**1,294,435,397.78**	**1,293,998,382.27**	**1,293,841,652.94**
Tax cost	33,750.00	232,814.80	56,023.20	0.00	97,432.80	233,501.40	76,278.3	0.00	288,750.00	422,691.60	106,595.00	0.00	453,750.00	368,707.20	124,449.50	0.00	577,491.60	582,803.60	146,309.10	0.00
Ops. cost	126.72	1,523.56	1,468.08	1,458.56	376.00	2,017.92	1,976.5	1,944.64	1,084.16	2,620.92	2,655.68	2,728.96	1,703.68	2,970.92	3,019.76	3,073.16	2,169.56	3,497.24	3,526.20	3,597.40
Maint. cost	23,090.40	256,583.60	247,104.00	245,621.20	67,505.60	341,500.00	334,586.0	329,154.80	197,551.20	453,769.20	458,717.60	471,062.80	310,437.60	521,323.20	528,837.20	537,434.00	395,202.40	615,967.60	619,733.20	631,195.60
Salvage cost	15,712.20	141,806.20	136,337.40	135,721.10	44,364.40	191,538.60	187,815.6	184,708.90	134,426.60	271,664.40	272,871.80	279,701.50	211,241.80	323,522.90	326,476.10	330,558.80	268,724.90	385,961.60	386,167.80	391,611.40
TC Electric Trucks	**41,254.92**	**349,115.76**	**168,257.88**	**111,358.66**	**120,950.00**	**385,480.72**	**225,025.2**	**146,390.54**	**352,958.76**	**607,417.32**	**295,096.48**	**194,090.26**	**554,649.48**	**569,478.42**	**329,830.36**	**209,948.36**	**706,138.66**	**816,306.84**	**383,400.70**	**243,181.60**
Tax cost	88,709	88,594	88,599	88,599	106,88	106,75	106,7	106,75	129,79	129,67	129,66	129,66	157,01	156,91	156,91	156,90	189,98	189,87	189,87	189,86

	2021				2022				2023				2024				2025			
	α1				α1				α1				α1				α1			
	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%
	γ				γ				γ				γ				γ			
	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000
	,838.00	,493.80	,391.00	,391.00	,421.20	,665.80	,349.60	,711.80	,301.40	,443.20	,178.40	,862.20	,223.20	,723.20	,822.00	,879.20	,029.80	,483.20	,960.80	,960.80
Ops. cost	2,032,019.52	2,029,612.32	2,029,367.52	2,029,367.52	2,459,889.12	2,456,502.72	2,456,543.52	2,456,404.80	2,978,277.60	2,974,646.40	2,974,809.60	2,974,850.40	3,392,617.92	3,386,497.92	3,386,579.52	3,386,938.56	4,115,675.52	4,108,364.16	4,108,298.88	4,108,298.88
Maint. cost	46,752,790.20	46,703,053.20	46,697,995.20	46,697,995.20	56,546,929.40	56,476,960.40	56,477,803.40	56,476,357.40	68,688,223.60	68,613,196.60	68,616,568.60	68,617,411.60	83,338,481.80	83,218,606.80	83,221,344.80	83,227,237.80	100,868,482.20	100,727,318.80	100,734,229.20	100,734,229.20
Carbon cost	165,930,436.50	165,720,780.00	165,699,459.00	165,699,459.00	200,986,354.50	200,691,414.00	200,694,967.50	200,707,501.50	242,820,540.00	242,504,278.50	242,518,492.50	242,522,046.00	290,764,717.50	290,345,655.00	290,370,996.00	290,375,827.50	351,932,467.50	351,438,915.00	351,462,795.00	351,462,795.00
Salvage cost	12,442,523.12	12,432,437.07	12,431,411.37	12,431,411.37	15,020,988.49	15,006,799.64	15,006,970.59	15,005,464.34	18,371,682.61	18,356,468.06	18,357,151.86	18,357,322.81	23,175,426.68	23,145,501.68	23,145,158.38	23,147,656.28	28,024,368.72	27,989,416.88	27,992,291.92	27,992,291.92
TC Diesel Trucks	**236,441,561.10**	**236,149,502.25**	**236,119,801.35**	**236,119,801.35**	**286,334,605.73**	**285,923,743.28**	**285,928,693.43**	**285,942,511.16**	**346,199,659.99**	**345,759,096.64**	**345,778,897.24**	**345,783,847.39**	**414,892,613.74**	**414,291,981.24**	**414,324,583.94**	**414,335,226.78**	**502,193,286.30**	**501,485,664.28**	**501,518,991.96**	**501,518,991.96**
Investment cost	76,000.00	176,000.00	184,000.00	186,000.00	68,000.00	190,000.00	188,000.00	184,000.00	56,000.00	206,000.00	196,000.00	196,000.00	56,000.00	264,000.00	254,000.00	250,000.00	50,000.00	292,000.00	280,000.00	280,000.00
Ops. cost	5,700.00	13,200.00	13,800.00	13,950.00	5,100.00	14,250.00	14,100.00	13,800.00	4,200.00	15,450.00	14,700.00	14,700.00	4,200.00	19,800.00	19,050.00	18,750.00	3,750.00	21,900.00	21,000.00	21,000.00
Maint. cost	1,330.00	3,080.00	3,220.00	3,255.00	1,190.00	3,325.00	3,290.00	3,220.00	980.00	3,605.00	3,430.00	3,430.00	980.00	4,620.00	4,445.00	4,375.00	875.00	5,110.00	4,900.00	4,900.00
Emission cost	28.50	66.00	69.00	69.75	25.50	71.25	70.50	69.00	21.00	77.25	73.50	73.50	21.00	99.00	95.25	93.75	18.75	109.50	105.00	105.00
TC Normal Charging	**83,058.50**	**192,346.00**	**201,089.00**	**203,274.75**	**74,315.50**	**207,646.25**	**205,460.50**	**201,089.00**	**61,201.00**	**225,132.25**	**214,203.50**	**214,203.50**	**61,201.00**	**288,519.00**	**277,590.25**	**273,218.75**	**54,643.75**	**319,119.50**	**306,005.00**	**306,005.00**

	2026				2027				2028				2029				2030			
	α1				α1				α1				α1				α1			
	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%	37.0%	38.0%	39.5%	40.0%
	γ				γ				γ				γ				γ			
	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000	0	5,000	15,000	30,000
	,935.80	,339.60	,127.80	,811.80	7,900.80	2,468.80	55,888.8	8,624.80	7,758.60	1,218.60	9,166.60	3,010.60	9,552.60	5,584.60	2,160.00	8,052.00	3,526.60	4,770.60	3,402.60	7,930.60
Ops. cost	5,015,266.56	5,006,984.16	5,007,335.04	5,007,384.00	5,982,797.76	5,973,103.68	5,973,348.5	5,973,544.32	6,955,420.80	6,946,363.20	6,946,216.32	6,945,775.68	8,236,671.36	8,229,229.44	8,229,360.00	8,229,392.64	9,928,941.12	9,921,156.48	9,921,058.56	9,920,666.88
Maint. cost	122,130,358.20	121,968,171.20	121,975,000.20	121,975,959.20	147,055,428.20	146,865,546.20	146,870,341.2	146,874,177.20	178,053,573.40	177,876,158.40	177,873,281.40	177,864,650.40	215,097,227.40	214,951,459.40	214,947,290.00	214,942,080.00	260,191,686.40	260,039,205.40	260,037,287.40	260,029,615.40
Carbon cost	426,136,927.50	425,570,556.00	425,593,822.50	425,597,175.00	513,068,227.50	512,404,432.50	512,421,195.0	512,434,605.00	621,027,487.50	620,407,275.00	620,397,217.50	620,367,045.00	750,120,802.50	749,611,222.50	749,596,875.00	749,578,860.00	907,358,355.00	906,825,307.50	906,818,602.50	906,791,782.50
Salvage cost	33,843,400.32	33,802,873.27	33,804,617.52	33,804,856.92	40,904,427.32	40,857,026.12	40,858,223.1	40,859,180.72	50,320,321.84	50,276,032.84	50,275,314.64	50,273,160.04	61,245,428.24	61,209,039.44	61,207,054.00	61,204,932.00	74,180,297.64	74,142,233.04	74,141,754.24	74,139,839.04
TC Diesel Trucks	**608,149,087.74**	**607,337,177.69**	**607,370,668.02**	**607,375,473.08**	**732,089,926.94**	**731,138,525.06**	**731,162,550.4**	**731,181,770.60**	**885,513,918.46**	**884,624,982.36**	**884,610,567.18**	**884,567,321.64**	**1,069,228,825.62**	**1,068,498,456.50**	**1,068,478,631.00**	**1,068,453,452.64**	**1,293,282,211.48**	**1,292,518,206.94**	**1,292,508,596.82**	**1,292,470,156.34**
Investment cost	26,000.00	306,000.00	296,000.00	292,000.00	76,000.00	404,000.00	396,000.0	390,000.00	218,000.00	528,000.00	536,000.00	546,000.00	342,000.00	598,000.00	604,000.00	616,000.00	434,000.00	704,000.00	706,000.00	720,000.00
Ops. cost	1,950.00	22,950.00	22,200.00	21,900.00	5,700.00	30,300.00	29,700.0	29,250.00	16,350.00	39,600.00	40,200.00	40,950.00	25,650.00	44,850.00	45,300.00	46,200.00	32,550.00	52,800.00	52,950.00	54,000.00
Maint. cost	455.00	5,355.00	5,180.00	5,110.00	1,330.00	7,070.00	6,930.0	6,825.00	3,815.00	9,240.00	9,380.00	9,555.00	5,985.00	10,465.00	10,570.00	10,780.00	7,595.00	12,320.00	12,355.00	12,600.00
Emission cost	9.75	114.75	111.00	109.50	28.50	151.50	148.5	146.25	81.75	198.00	201.00	204.75	128.25	224.25	226.50	231.00	162.75	264.00	264.75	270.00
TC Normal Charging	**28,414.75**	**334,419.75**	**323,491.00**	**319,119.50**	**83,058.50**	**441,521.50**	**432,778.5**	**426,221.25**	**238,246.75**	**577,038.00**	**585,781.00**	**596,709.75**	**373,763.25**	**653,539.25**	**660,096.50**	**673,211.00**	**474,307.75**	**769,384.00**	**771,569.75**	**786,870.00**

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	2021				2022				2023				2024				2025				2026				2027				2028				2029				2030			
	α1				α1				α1				α1				α1				α1				α1				α1				α1				α1			
	37.0%	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**
	γ				γ				γ				γ				γ				γ				γ				γ				γ				γ			
	0	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**
ng Stations																																								
Investment cost	33,000.00	75,000.00	81,000.00	81,000.00	30,000.00	81,000.00	81,000.00	81,000.00	24,000.00	87,000.00	84,000.00	84,000.00	24,000.00	114,000.00	111,000.00	108,000.00	21,000.00	126,000.00	120,000.00	120,000.00	12,000.00	132,000.00	126,000.00	126,000.00	33,000.00	174,000.00	171,000.0	168,000.00	93,000.00	225,000.00	228,000.00	234,000.00	147,000.00	255,000.00	261,000.00	264,000.00	186,000.00	300,000.00	303,000.00	309,000.00
Ops. cost	2,750.00	6,250.00	6,750.00	6,750.00	2,500.00	6,750.00	6,750.00	6,750.00	2,000.00	7,250.00	7,000.00	7,000.00	2,000.00	9,500.00	9,250.00	9,000.00	1,750.00	10,500.00	10,000.00	10,000.00	1,000.00	11,000.00	10,500.00	10,500.00	2,750.00	14,500.00	14,250.0	14,000.00	7,750.00	18,750.00	19,000.00	19,500.00	12,250.00	21,250.00	21,750.00	22,000.00	15,500.00	25,000.00	25,250.00	25,750.00
Maint. cost	715.00	1,625.00	1,755.00	1,755.00	650.00	1,755.00	1,755.00	1,755.00	520.00	1,885.00	1,820.00	1,820.00	520.00	2,470.00	2,405.00	2,340.00	455.00	2,730.00	2,600.00	2,600.00	260.00	2,860.00	2,730.00	2,730.00	715.00	3,770.00	3,705.0	3,640.00	2,015.00	4,875.00	4,940.00	5,070.00	3,185.00	5,525.00	5,655.00	5,720.00	4,030.00	6,500.00	6,565.00	6,695.00
Emission cost	4.95	11.25	12.15	12.15	4.50	12.15	12.15	12.15	3.60	13.05	12.60	12.60	3.60	17.10	16.65	16.20	3.15	18.90	18.00	18.00	1.80	19.80	18.90	18.90	4.95	26.10	25.7	25.20	13.95	33.75	34.20	35.10	22.05	38.25	39.15	39.60	27.90	45.00	45.45	46.35
TC Fast Charging Stations	**36,465.00**	**82,875.00**	**89,505.00**	**89,505.00**	**33,150.00**	**89,505.00**	**89,505.00**	**89,505.00**	**26,520.00**	**96,135.00**	**92,820.00**	**92,820.00**	**26,520.00**	**125,970.00**	**122,655.00**	**119,340.00**	**23,205.00**	**139,230.00**	**132,600.00**	**132,600.00**	**13,260.00**	**145,860.00**	**139,230.00**	**139,230.00**	**36,465.00**	**192,270.00**	**188,955.0**	**185,640.00**	**102,765.00**	**248,625.00**	**251,940.00**	**258,570.00**	**162,435.00**	**281,775.00**	**288,405.00**	**291,720.00**	**205,530.00**	**331,500.00**	**334,815.00**	**341,445.00**
Type 1 of BETs	0	60	68	69	0	75	75	74	2	91	89	88	1	126	122	120	0	147	140	140	0	167	162	160	8	208	203	200	0	189	200	208	0	159	170	179	1	169	181	193
Type 2 of BETs	36	35	34	33	35	34	33	32	33	33	31	31	7	7	6	6	3	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Type 3 of BETs	15	15	14	14	0	9	9	9	1	1	1	1	31	31	30	29	31	30	29	29	18	20	18	19	44	42	42	41	154	150	142	143	242	235	229	226	307	298	288	284
Type 1 of DTs	4,484	4,425	4,419	4,419	5,907	5,824	5,825	5,854	5,015	4,926	4,930	4,931	0	0	26	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Type 2 of DTs	23,094	23,094	23,094	23,094	27,713	27,713	27,713	27,713	34,642	34,642	34,642	34,642	57,736	57,736	57,736	57,736	69,249	69,256	69,284	69,284	81,699	81,699	81,699	81,699	102,124	102,124	102,124	102,124	142,973	142,973	142,973	142,973	183,823	183,823	183,800	183,780	224,673	224,673	224,673	224,673
Type 3 of DTs	22,371	22,371	22,371	22,371	26,845	26,845	26,845	26,818	33,557	33,557	33,557	33,557	30,803	30,678	30,658	30,687	37,896	37,742	37,722	37,722	47,970	47,800	47,808	47,809	54,115	53,917	53,922	53,926	46,748	46,563	46,560	46,551	45,684	45,532	45,550	45,564	53,015	52,856	52,854	52,846
Yk = 1	106,226.18	104,828.77	104,686.65	104,686.66	139,937.03	137,971.12	137,994.80	138,681.80	118,805.51	116,697.54	116,792.27	116,815.96	0.16	0.77	616.69	0.73	0.15	0.86	0.82	0.82	0.08	24.59	0.87	0.86	0.22	1.18	1	1.14	0.64	1.55	1.57	1.60	1.00	1.75	1.77	1.80	1.27	2.06	2.07	2.11
Yk = 2	499,98	499,98	499,98	499,98	599,98	599,98	599,98	599,98	749,99	749,99	749,99	749,99	1,249,	1,249,	1,249,	1,249,	1,499,	1,499,	1,499,	1,499,	1,768,	1,768,	1,768,	1,768,	2,210,	2,210,	2,210,	2,210,	3,095,	3,095,	3,095,	3,095,	3,979,	3,979,	3,979,	3,978,	4,864,	4,864,	4,864,	4,864,

	2021				2022				2023				2024				2025				2026				2027				2028				2029				2030			
	α1				α1				α1				α1				α1				α1				α1				α1				α1				α1			
	37.0%	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**	**37.0%**	**38.0%**	**39.5%**	**40.0%**
	γ				γ				γ				γ				γ				γ				γ				γ				γ				γ			
	0	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**	**0**	**5,000**	**15,000**	**30,000**
	5.32	5.62	5.64	5.65	6.65	7.01	7.00	6.99	9.46	9.90	9.87	9.87	984.56	985.17	985.15	985.13	241.00	393.26	999.42	999.42	783.43	784.25	784.22	784.21	984.82	985.78	986	985.74	366.09	367.00	367.02	367.05	768.95	769.70	271.77	838.80	171.72	172.51	172.52	172.56
Yk = 3	499,992.07	499,992.37	499,992.39	499,992.40	599,985.95	599,986.31	599,986.30	599,382.84	749,999.11	749,999.55	749,999.52	749,999.52	688,447.21	685,654.07	685,207.05	685,855.18	846,975.75	843,534.56	843,087.52	843,087.52	1,072,129.58	1,068,330.90	1,068,509.67	1,068,532.01	1,209,470.47	1,205,046.13	1,205,158	1,205,247.24	1,044,818.44	1,040,684.60	1,040,617.57	1,040,416.45	1,021,038.40	1,017,641.95	1,018,044.27	1,018,357.20	1,184,886.52	1,181,333.66	1,181,288.97	1,181,110.21
αEiBiQ i = 1	0	1,418,616	1,671,229	1,717,272	0	1,773,270	1,843,268	1,841,712	46,043	2,151,568	2,187,344	2,190,144	23,021	2,979,094	2,998,382	2,986,560	0	3,475,609	3,440,766	3,484,320	0	3,948,481	3,981,458	3,982,080	184,171	4,982,578	4,989,111	4,977,600	0	4,468,640	4,915,380	5,176,704	0	3,808,797	4,178,073	4,454,952	23,021	3,995,768	4,448,419	4,803,384
αEiBiQ i = 2	853,279	851,998	860,326	845,592	829,577	827,655	835,022	819,968	782,173	803,312	784,415	794,344	165,915	170,400	151,822	153,744	71,107	97,371	101,215	102,496	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
αEiBiQ i = 3	346,875	356,250	345,625	350,000	0	213,750	222,188	225,000	23,125	23,750	24,688	25,000	716,875	736,250	740,625	725,000	716,875	712,500	715,938	725,000	416,250	475,000	444,375	475,000	1,017,500	1,010,625	1,036,875	1,025,000	3,561,250	3,562,500	3,505,625	3,575,000	5,596,250	5,654,688	5,653,438	5,650,000	7,099,375	7,077,500	7,110,000	7,100,000
ΔDCQj = 1	274,421	270,810	270,443	270,443	361,508	356,429	356,490	358,265	306,918	301,471	301,716	301,777	0	0	1,591	0	0	0	0	0	0	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ΔDCQj = 2	1,130,682	1,130,682	1,130,682	1,130,682	1,356,828	1,356,828	1,356,828	1,356,828	1,696,072	1,696,072	1,696,072	1,696,072	2,826,755	2,826,755	2,826,755	2,826,755	3,390,431	3,390,774	3,392,145	3,392,145	3,999,983	3,999,983	3,999,983	3,999,983	4,999,991	4,999,991	4,999,991	4,999,991	6,999,958	6,999,958	6,999,958	6,999,958	8,999,974	8,999,974	8,998,848	8,997,869	10,999,990	10,999,990	10,999,990	10,999,990
ΔDCQj = 3	1,642,926	1,642,926	1,642,926	1,642,926	1,971,497	1,971,497	1,971,497	1,969,514	2,464,426	2,464,426	2,464,426	2,464,426	2,262,172	2,252,992	2,251,524	2,253,653	2,783,082	2,771,772	2,770,304	2,770,304	3,522,917	3,510,432	3,511,020	3,511,093	3,974,206	3,959,664	3,960,032	3,960,325	3,433,173	3,419,587	3,419,366	3,418,705	3,355,033	3,343,870	3,345,192	3,346,220	3,893,422	3,881,745	3,881,598	3,881,010
Normal charging stations	38	88	92	93	34	95	94	92	28	103	98	98	28	132	127	125	25	146	140	140	13	153	148	146	38	202	198	195	109	264	268	273	171	299	302	308	217	352	353	360
Fast charging stations	11	25	27	27	10	27	27	27	8	29	28	28	8	38	37	36	7	42	40	40	4	44	42	42	11	58	57	56	31	75	76	78	49	85	87	88	62	100	101	103

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