ELECTRIC VEHICLES

INDONESIA

Jan VAN DEN AKKER

2022

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LIST OF ACRONYMS AND ABBREVIATIONS

Agency for the Assessment and Application of Technology	Badan Pengkajian dan Penerapan Teknologi (BBPT)
Center for Research and Technology Development on Electricity, New and Renewable Energy and Energy Conservation, MEMR	Pusat Penelitian dan Pengembangan Teknologi Ketenagalistrikan, Energi Baru, Terbarukan dan Konservasi Energi (P3TEK-EBTKE), KESDM
Ministry of Energy and Mineral Resources (MEMR)	Kementerian Energi dan Sumber Daya Mineral (KESDM)
Ministry of Environment and Forestry (MoEF)	Kementerian Lingkungan Hidup dan Kehutanan (KLHK)
Ministry of Industry (MoI)	Kementerian Perindustrian
Ministry of National Development Planning - National Development Planning Agency	Kementerian Perencanaan Pembangunan Nasional - Badan Perencanaan Pembangunan Nasional (Bappenas)
Ministry of Research and Technology - National Research and Innovation Agency	Kementerian Riset dan Teknologi/Badan Riset dan Inovasi Nasional
Ministry of Transportation (MoT)	Kementerian Perhubungan
National Electricity General Plan	Rencana Umum Kelistrikan Nasional (RUKN)
Electricity Supply Business Plan	Rencana Usaha Penyediaan Tenaga Listrik (RUPTL)
National Energy General Plan	Rencana Umum Energi Nasional (RUEN)
National Energy Policy	Kebijakan Energi iNasional (KEN)
Public charging station (EC)	Stasiun Pengisian Kendaraan Listrik Umum (SPKLU)
Public battery exchange station	Stasiun Penukaran Baterai Kendaraan Listrik Umum (SPBKLU)
Sales Tax on Luxury Goods	Pajak Penjualan atas Barang Mewah (PPnBM)
Special Capital Region of Jakarta	Daerah Khusus Ibu (DKI) Kota Jakarta
Statistics Indonesia	Badan Pusat Statisik (BPS)
State Electricity Company	PT Perusahaan Listrik Negara (PLN)
Transfer of Motor Vehicle Title Fee	Bea Balik Nama Kendaraan Bermotor (BBNKB)
Vehicle Tax	Pajak Kendaraan Bermotor (PKB)

µg	Microgram
ASEAN	Association of South-East Asian Nations
BaU	Business as Usual
BCG	Boston Consulting Group
BEV	Battery Electric Vehicle
BOE	Barrels of Oil Equivalent
BSS	Battery Swap Station
BUR	Biennial Update Report
CO_2	Carbon Dioxide
CSO	Civil Society Organization
CS	Charging Station
dB	Decibel
DGE	Directorate-General of Electricity
EV	Electric Vehicle
EVCS	Electric Vehicle Charging Station
FCEV	Fuel-Cell Electric Vehicle
GAIKINDO	Association of Indonesia Automotive Industries
GDP	Gross Domestic Product
GEF	Global Environment Facility

GHG	Greenhouse Gas
GoI	Government of Indonesia
$GtCO_2$	Gigaton of carbon dioxide (Giga = billion)
HEV	Hybrid Electric Vehicle
km	kilometer
kWh	Kilowatt-hour
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
IDR	Indonesian Rupiah (USD 1 = 14,500 IDR
ITDP	Institute for Transportation and Development Policy
LCEV	Low-Carbon Emission Vehicle
LCGC	Low-Cost Green Car
MJ	Megajoule (one million Joules)
NC	National Communication
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organisation
PHEV	Plug-in Hybrid Electric Vehicle
PLN	Perusahaan Listrik Negara
Rp	Indonesia Rupiah
RAN-GRK	National Action Plan of GHG Emission Reduction
ROE	Regional-government Owned Enterprise
RON	Research Octane Number
SDG	Sustainable Development Goal
SOE	State-Owned Enterprise (by central government)
TCO	Total Cost of Ownership
TVET	Technical Vocational and Educational Training
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
V2G	Vehicle-to-Grid

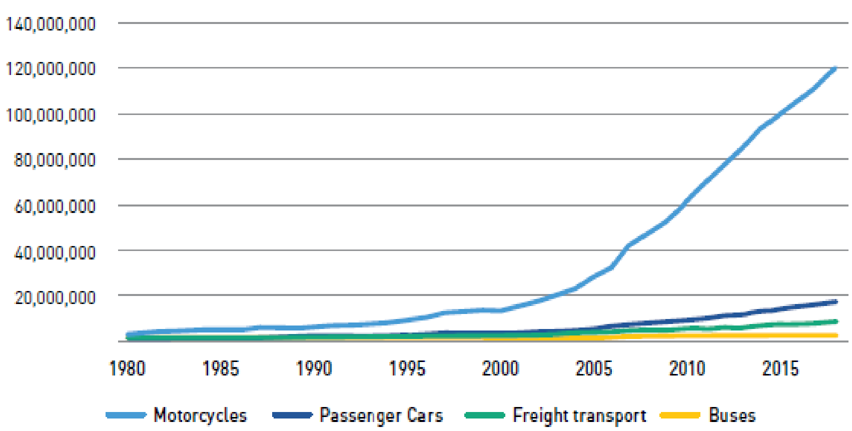
1. CONTEXT

1.1 Energy and climate change mitigation in Indonesia

Road transport and fuel consumption

Indonesia is an archipelago with a land territory of 190 million hectares, containing five big islands (Sumatera, Java, Kalimantan, Sulawesi, and Papua), and about 17,504 other small islands[1]. The total population of this country was an estimated 270 million peoples in 2020 making it the fourth largest populous country. Between 2000 and 2010, Indonesia experienced an average annual population growth rate of 1.49% and between 2010-2020 of 1.25%. The population is projected to reach 296.4 million by 2030 with an average annual growth rate of 0.96% between 2020-2030. The country had a Gross Domestic Product (GDP) of IDR 15,435 trillion in 2020. During 2000-2020, GDP grew at an average of 4.9% annually. Following the successful recovery from the social and economic crisis in 1998-1999, Indonesia has been showing a steadily increasing trend in alleviating poverty. In 2005, the number of people living in absolute poverty has declined from 48.0 million people in 1999 to 35.1 million people and further declined to 27.5 million in 2020. The number of people living in relative poverty has declined from 23.4% in 1999 to 16.0% in 2005 and 10.2% in 2020. [2]

Box 1 Number of registered 2-wheel and 4-wheel vehicles in Indonesia



Source: IESR (2020), based on data provided by BPS

According to the Central Statistical Agency (BPS), there were 133.6 million vehicles in 2019, the largest number being motorcycles with a total of 112.8 million units, followed by passenger cars (15.6 million) and good cars and bus of 5 million and 0.2 million, respectively. Between 2008-2018, the vehicle fleet grew dramatically with almost 10% annually; there were 68 million units more vehicles in 2019 compared to in 2008 (see Box 1). For more information on the vehicle sector in Indonesia, the reader is referred to Annex F.

Not surprisingly, energy consumption in the transport sector grew by 7.6% annually from 2008-2019. The share of transport in Indonesia's final energy consumption was 41% (up from 31% in 2008). In absolute terms, energy consumption was 414 million barrels of oil equivalent (BOE), up from 186 million BOE in 2008[3].

Almost all the energy consumed in the transport sector is in the form of petroleum products, mainly diesel (147 million BOE in 2018) and gasoline (95 million BOE), only about 6% comes from other sources (biofuel, natural gas, electricity). About 90% of the consumption is in land transportation (reflecting the 90% modal share of road transport in overall transport). In passenger transport, most energy is consumed by motorcycles (49%), passenger cars (44%), minibus (3%) and other (4%).

Indonesia became a net importer of petroleum products by 2004 after domestic demand exceeded production. In 2018, Indonesia imported around 50% of the total domestic demand of petroleum products which reach around 74 billion liters.

1 BPS (2021)

2 Ibid.

3 *2020 Handbook of Energy & Economic Statistics of Indonesia*

Transport and greenhouse gas emissions

Indonesia is among the world's top ten emitters of GHG emissions. Indonesia GHG emissions in 2016 were estimated at 1.45 gigatons of CO_2 (including LULUCF and peat-fire) Approximately 34% of Indonesia's GHG emissions come from the energy sector (0.54 $GtCO_2$), of which 0.14 $GtCO_2$ from transport (0.12 $GtCO_2$ from road transport), about 25% of total GHG emissions in the energy sector. The road transport system is the main emitter within land transport, comprising cars (11%), motorcycles (82%), buses (1.7%), and freight transport (5.3%)

Box 2 Greenhouse gas emissions, Indonesia

No.	Sectors	Year		Percentage	
		2000	2016	2000	2016
1	Energy	317,609	538,025	30.97	36.91
2	IPPU	42,610	55,260	4.15	3.79
3	AFOLU (incl. peat fire)	600,570	752,138	58.56	51.59
4	Waste	64,832	112,351	6.32	7.71
Total without FOLU & peat fire		520,253	822,326	100	100
Total with AFOLU & peat fire		1,025,621	1,457,774		

Source: Second BUR. IPPU: industrial processes and product use; AFOLU: agriculture, forestry and other land use

Indonesia's greenhouse gas emissions are projected to reach 2.87 $GtCO_2$ in 2030 (business-as-usual, BaU). Energy is forecasted to become the main contributor to Indonesia's GHG emissions in the near future. Based on the National Communication's BaU scenario, the energy sector will start to dominate Indonesia's GHG emission, surpassing the land-based sector, by 2024 and are projected to reach 1.67 $GtCO_2$ by 2030. The power generation sector will be the main contributor of GHG emissions in the 2030 BaU with a 48.6% GHG emissions share, followed by manufacturing industries, , household, and commercial with 14.5%, 3.12%, and 0.8% GHG emissions share, respectively (Indonesia NC3, 2016; BUR2, 2018) and the transportation sector with a share of 31.4% (524 $MtCO_2$). The Government of Indonesia (GoI) submitted the First Nationally Determined Contribution (NDC) and submitted in November 2016 (along with the ratification of the Paris Agreement through Act 16/2016 in October 2016). The NDC set the unconditional reduction target of 29% below business-as-usual scenarios (base year 2010) by 2030 and the conditional reduction target (i.e., with international support) of up to 41%. Particularly, 11% (about 314 Mt CO_2e) to 14% (398 Mt CO_2) emission reduction from the total BAU in 2030 is expected to stem from the energy sector including transport (Indonesia NDC, 2016). The GoI has formulated an NDC Mitigation Road Map as a guideline for both Party stakeholder and non-Party stakeholders to contribute to the achievement of NDC targets through the provision of information on physical targets, timelines, and indications of potential locations for mitigation and adaptation actions.

Local air and noise pollution

Air pollution is a problem in big cities, including Jakarta province, the capital of the Republic of Indonesia. The pollution is due to increased human activities, population growth, the increasing number of industries, and transportation. Monitoring of ambient air quality parameters, such as total suspended particles (TSP), sulfur dioxide, nitrogen oxide, carbon monoxide, hydrocarbons, and lead, in Jakarta indicates that the condition is concerning. Transportation is the main source of ambient air pollution in big cities, such as Jakarta. A recent report by ICCT describes the air quality and health impacts of transportation tailpipe emissions in 2015 in a number of countries. Regarding Indonesia, the report mentions that death in 2015 due to particulate matter ($PM_{2.5}$) and ozone were an estimated 54,000 of which 13% attributable to transport[4]. The PM emissions are associated with transport and periodic biomass burning. A recent study shows that the majority of the average annual PM_{25} concentrations[5] measured at the Java sites (Bandung, Jakarta, Semarang, and Surabaya) exceeded the Indonesian annual ambient air quality standard (15 μg/m^3) and $PM_{2.5}$ in urban areas varies between 11-28 μg/m^3.

4 $PM_{2.5:}$ (< 2.5 μm in aerodynamic diameter), of which of about 2/3 attributable to vehicles. Source: *A global snapshot of the air pollution-related health impacts of transportation sector emissions in 2010 and 2015*, International Council on Clean Transportation (ICCT, 2019)

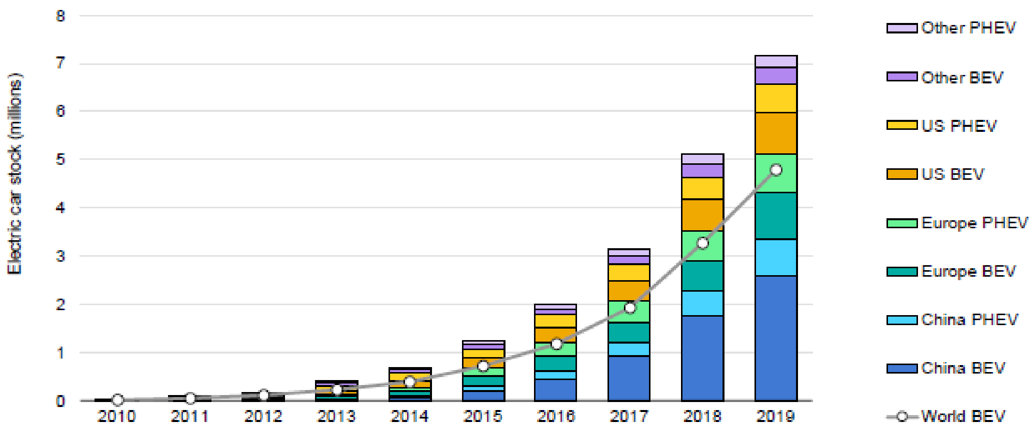
5 *Assessment of Urban Air Quality in Indonesia*, in "Aerosol and Air Quality Research", 20: 2142–2158, 2020. *Ambient Air Polllution*, WHO (2016)

Indonesian cities are noisy. Daily sounds in Indonesian cities include the engines of motorized traffic and car horns. Noise levels are limited and need to be monitored according to the Ministerial Decree KEP-48/MENLH/11/1996. The Decree regulates standard noise levels in residential areas at 55 dB and office areas at 65 dB, but measurements of noise levels from motor vehicle activity in Jakarta areas have yielded higher levels[6].

1.2 Global trends in electric vehicles

According to IEA statistics[7], global sales of electric cars topped 2.1 million globally in 2019 to boost the stock to 7.2 million electric cars. These numbers refer to passenger electric vehicles (EV) that use batteries for energy storage and must be plugged in to be recharged (BEV) and plug-in hybrid electric vehicles (PHEV) that have both batteries and liquid-fuel storage and refueling systems (see Box 17).

Box 3 Global electric car stock (2019)



The in global stock (see Box 15) has increased rapidly, led by China, the US, Japan and several European countries. This rise is the result of several factors, including strong technological progress, cost reductions (especially batteries), and policy support, including purchase incentives, driving and parking access advantages, and increased public charging infrastructure availability.

Global production volume of PHEVs and BEVs in 2019 was about 2.8 million vehicles still a small share of global car sales. EVs still face obstacles. One is battery cost, which make EV cost much more than the drive systems of today's internal combustion engine vehicles[8]. Thus, investment cost is higher, although fuel savings will help pay this back, especially for high-mileage drivers. To achieve a tipping point in sales, EVs will likely need to achieve near- parity on a first cost basis with ICE vehicles, and provide sufficient driving range and recharging convenience. The infrastructure for electric-vehicle charging continues to expand. In 2019, there were about 7.3 million chargers worldwide, of which about 6.5 million were private[9].

6 Noise levels of 67-71 dB (Semanggi, Sudarman areas). *Model of Noise Propagation in Urban Area A Case Study in Jakarta;* Prasetyo et al./ OIDA International Journal of Sustainable Development 09:02 (2016)

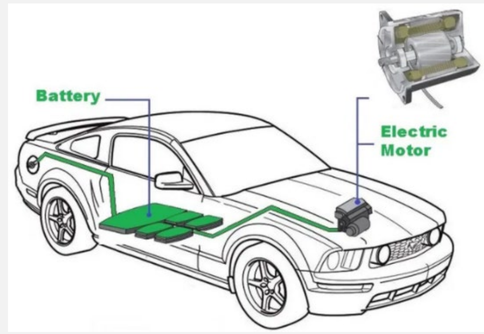
7 IEA Global EV Outlook 2020

8 Battery improvements will bring cost down from levels of around USD 350/ kWh to USD 15/ kWh in the future (IRENA, 2017)

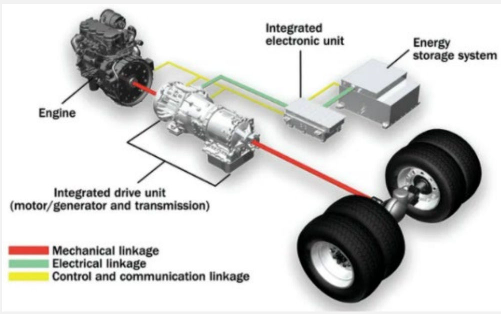
9 Publicly accessible chargers accounted for 12% of global light-duty vehicle chargers in 2019, most of which are slow chargers. Globally, the number of publicly accessible chargers (slow and fast) increased by 60% in 2019 compared with the previous year, higher than the electric light-duty vehicle stock growth. China leads in the rollout of publicly accessible chargers, particularly fast chargers, which are suited to dense urban areas with less opportunity for private charging at home (IEA, 2020)

Box 4 Electric cars

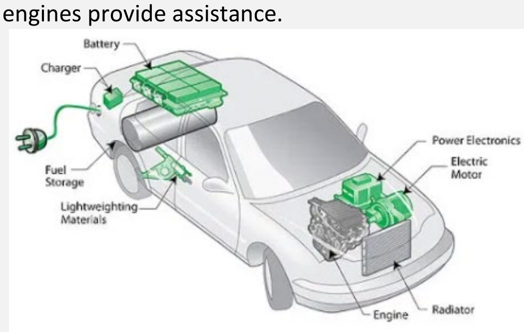
The *internal combustion engine vehicles* (ICEV) run on gasoline or diesel. There are three main types of electric vehicles (EVs), classified by the degree that electricity is used as their energy source.



- BEVs, or *battery electric vehicles*, are fully-electric vehicles (EVs) with rechargeable batteries and no gasoline engine. Battery electric vehicles store electricity onboard with high-capacity battery packs. Their battery power is used to run the electric motor and all onboard electronics. BEVs do not emit any harmful emissions that come out of the exhaust pipe of traditional gasoline-powered vehicles. BEVs are charged by electricity from an external source.

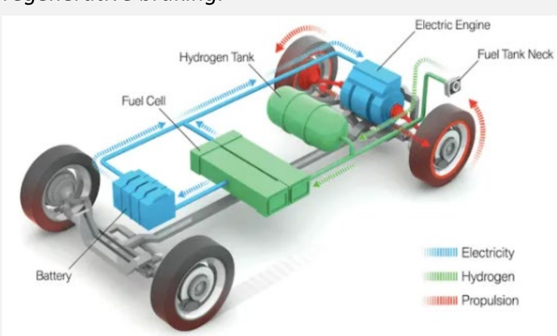


- *Range extension electric vehicles* (REx) feature both combustion engine & electric motor but most of the driving is done by the electric motor only. The internal combustion engine is only there to charge the battery if in case it gets low.
- PHEVs of *plug-in hybrid electric vehicles* can recharge the battery through both regenerative braking and "plugging in" to an external source of electrical power. The newer PHEV models can go anywhere from 10-40 miles before their gas engines provide assistance.



- HEVs, *hybrid electric vehicles*, are powered by both gasoline and electricity. The electric energy is generated by the car's own braking system to recharge the battery. This is called 'regenerative braking', a process where the electric motor helps to slow the vehicle and uses some of the energy normally converted to heat by the brakes. You cannot plug the car in to charge the battery. HEVs start off using the electric motor, then the gasoline engine cuts in as load or speed rises. The two motors are controlled by an internal computer, which ensures the best economy for the driving conditions.

Fuel economy for regular engines is measured by the number of litres consumer per 100 kilometres travelled, abbreviated to the commonly seen L/100 km. In the case of EVs, a "litre equivalent" is used taking the electric energy consumption of kilowatt hours per 100 kilometres and converting to a conventional format, where one litre of gasoline is equals 8.9 kilowatt-hours of electricity. When a regular car decelerates, kinetic energy is lost through heat dissipation in the act of friction braking, as the pads come in contact with the rotors. On an EV, pressing the brake pedal causes the electric motor to run in reverse that consequently slows down the wheels, and at the same time recaptures that kinetic energy and sends it back into the battery, a process called *regenerative braking.*

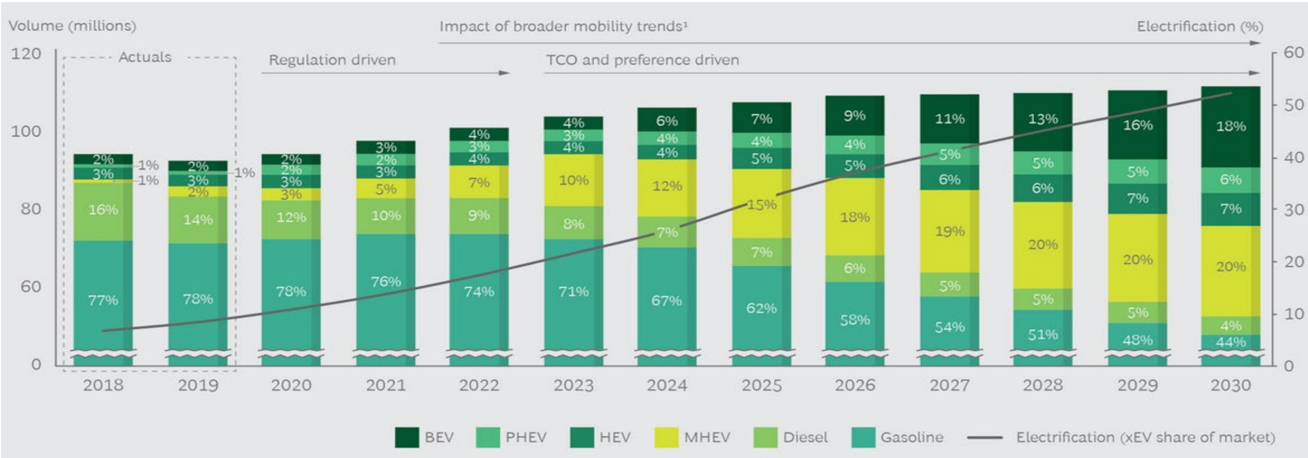


A *fuel cell car* (FCV) is a vehicle powered by a fuel cell, which is a device that produces electricity when fed with oxygen and a suitable fuel. The fuel is often hydrogen and then the car is sometimes referred to as a hydrogen fuel cell car (HFCV). Like the BEVs, it does not contain tailpipe and the byproduct is only water. There is no need to plug-in as the fuel cells are recharged by refilling the hydrogen.

*Hydrogen infrastructur*e is far from reality as of now, which is not the case with EV charging infrastructure as it is getting worldwide momentum.

Electric Vehicle (EV) chargers are classified according to the speed with which they recharge an EVs battery. Level 1 EV charging uses a standard household outlet (at the house or office) to plug into the electric vehicle and takes over 6-8 hours to charge an EV for approximately 90-120 km. Level 1 chargers have the capability to charge most EVs on the market. Level 2 charging requires a specialized station, typically found at office buildings, shopping malls and public charging stations and will take about 2-4 hours to charge a battery to 80-120 miles of range. Level 3 charging (DC fast charging) is currently the fastest charging solution in the EV market. Fast chargers can be found at dedicated EV charging stations (along highways or in transportation hubs) and charge a battery up to 140-280 km range in approximately 30 minutes.

Box 5 Global car sales projection up to 2030

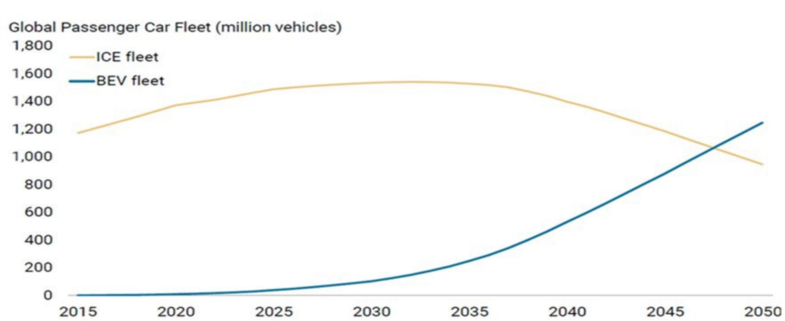


Source: Boston Consulting Group (2020). MHEV: mild hybrid electric vehicle.

However, more and more people are considering purchasing an electric vehicle and an analysis carried out by BCG (see Box 5) estimates that by 2030 the sale of EVs could overtake the sale of conventional vehicles, while in terms of the car fleet, this could happen between 2045 and 2050 (see Box 6). This could happen if governments continue to support electrification with financial and non-financial incentives and, in some regions, by tightening regulations during the next few years. HEV sales will likely see steady high-single-digit growth rates throughout the decade. In the near term, HEV economics are favorable for ridesharing until BEV costs come down. PHEVs appeal to consumers who regularly drive long distances and to single-car owners.

An important factor is the total cost of ownership (see Box 3). Once the car is purchased, electricity is cheaper than gasoline, by the kilometer traveled, depending on the prices of electricity and gasoline/diesel in the country. Section 2.5 gives a calculation example for two electric car models in Indonesia. EVs can provide fuel efficiencies (in final energy terms) that are two to four times higher than a comparable ICE vehicle. The favorable economics of EVs for ridesharing (taxis and ride-hailing services) will contribute to the additional growth of EVs. TCO of EVs is falling because the prices of batteries are decreasing steeply. The BCG analysis expects that, between 2014 and 2030, battery pack prices will have slid more than 80%, from USD 540 to USD 100 per kWh. On a global basis, falling battery prices to lead to a tipping point for BEV TCO by 2022 or 2023.

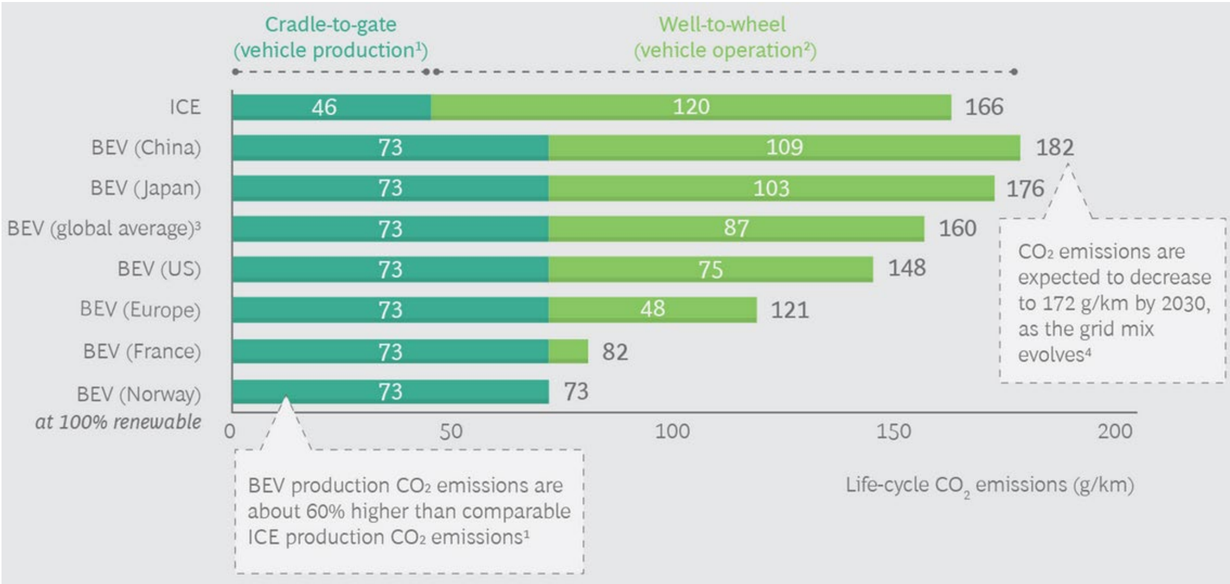
Box 6 Global passenger car stock projections



Source: Morgan Stanley Reseach 2017

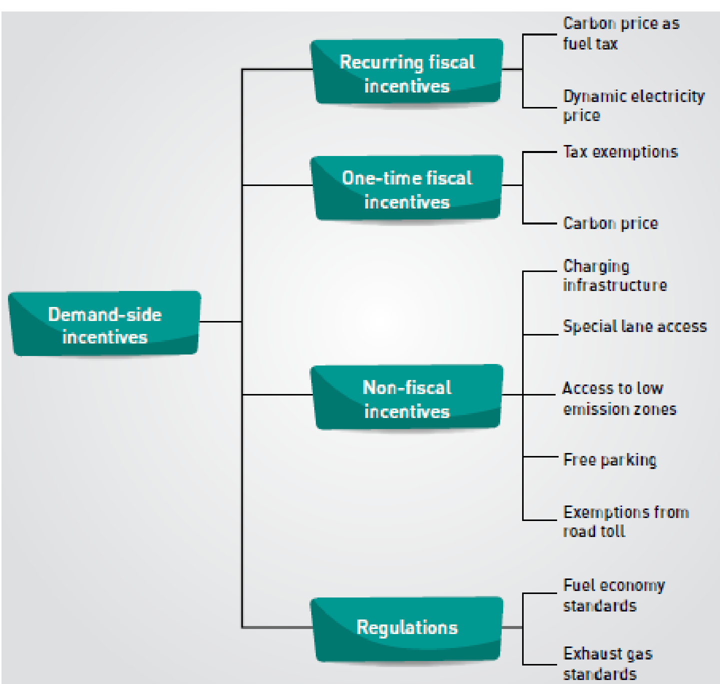
Battery-electric vehicles provide zero-vehicle emissions driving for both tailpipe CO_2 emission and pollutants. EVs also reduce noise pollution in cities. However, the 'upstream' CO_2 emission can be considerable in countries that have electricity grids that are not sufficiently decarbonized. BEVs provide better well-to-wheel emissions. In operation, the average ICE will produce around 120 g/km of CO_2 emissions over its life cycle. At one end of the spectrum, a BEV in Norway produces as little as 0 g/km (assuming 100% use of renewables) while at the other, a BEV in China produces as much as 109 g/km (see Box 7). Also, depending on the vehicle's region of manufacture and its battery size, producing a BEV can generate up to 60% more CO_2 emissions than producing a comparable ICE. The life-cycle emissions advantage of an EV thus depends on the vehicle's location, with the country's degree of reliance on fossil fuels in energy production being the main driver of CO_2 emissions.

Box 7 Global car sales projection up to 2030



Source: Boston Consulting Group (2020); IEA Tracking Power (2019); ICCT; MDPI Sustainability Journal (2019)
Notes:
1) Average global estimate. Differences between countries will occur depending on manufacturing technque and energy sources used
2) Calculations asssume an electric efficiency of 5.6 km/kWh and include emissions from fuel production and combustion or electricity generation and CO_2 emissions from maintenance (replacement fluids; tires; batteries)
3) At an average carbon intensity of 478 gCO_2/kWh
4) Carbon intensity in China's grid expected to fall from 605 gCO_2/kWh to 550 gCO_2/kWh

Box 8 Demand-side incentives and other policy instruments



At the national level, the shift to electrification has ramifications for jobs, skills, tax revenues, infrastructure, and the environment. Financial and non-financial incentives remain critical for maintaining the rising sales momentum established in the past several years, until market forces can support EVs on their own Tightening emissions regulations is a second critical issue. Many countries have legislative barriers, such as laws that restrict or regulate installation of charging stations (public and private) or levy and removing such roadblocks will be necessary. Other countries may want to consider measures to promote development of their own battery industries.

Source: *The Role of Electric Vehicles in Decarbonizing Indonesia's Road Transport Sector* (IESR, 2020)

2. ELECTRIC VEHICLES IN INDONESIA

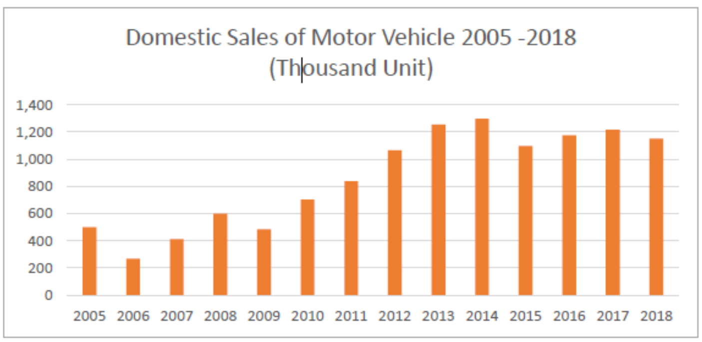
2.1 Vehicle transport in Indonesia

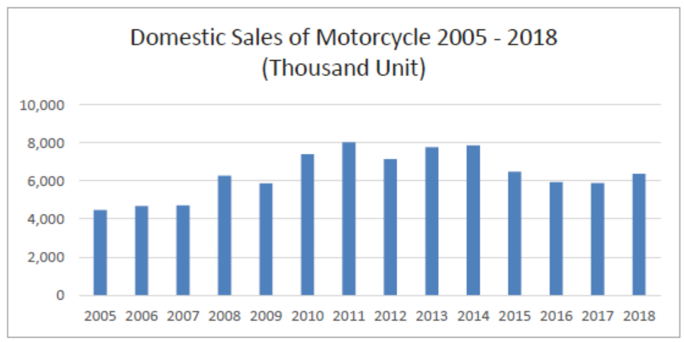
Automotive and two-wheeler industry

In the period 2013-2019, the country produced about 1.2 million vehicles per year on average, which makes the country the largest producer in ASEAN (about 4 million annually on average) after Thailand (producing about half of ASEAN's). Domestic sales in the same period were about 1.1 million on average per year, and exports about 0.3 million annually[10]. Indonesia predominantly produces mini or compact passenger vehicles (52%), SUVs, and light pickup trucks under one ton. Most of the vehicles built in Indonesia are from foreign brands, notably Japanese, and produced in the country through a joint venture plant with a local partner or a fully owned plant[11]. Top-selling companies have a large number of sales outlets; in total about 1,500 of which 60% are located in Java and 20% in Jakarta[12].

Most automobile manufacturers in Indonesia (including passenger car manufacturers and commercial truck manufacturers) are a member of the non-governmental Association of Indonesia Automotive Industries (*Gabungan Industri Kendaraan Bermotor Indonesia*, GAIKINDO).

Box 9 Sales of 4-wheelers and 2-wheelers in Indonesia





Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Motor Vehicle	501	269	412	599	486	703	838	1,065	1,254	1,299	1,099	1,177	1,216	1,151
Motorcycle	4,470	4,688	4,713	6,280	5,881	7,398	8,043	7,141	7,771	7,867	6,480	5,931	5,886	6,383

Source: Kementerian Perindustrian, *Roadmap of Low Carbon Emission Vehicle,* PowerPoint, Indonesia-Japan Automotive Seminar (Jan 2019)

The automotive industry in Indonesia plays an important role in the economic growth of the nation, contributing about 10% percent of the GDP and providing employment to some 1.5 million people.

Indonesia produced 7.8 million two-wheelers in 2014, mainly for domestic use. Honda and Yamaha account for 90% of the market. Scooters accounted for the largest market share in Indonesia's two-wheeler market. With higher ownership (about

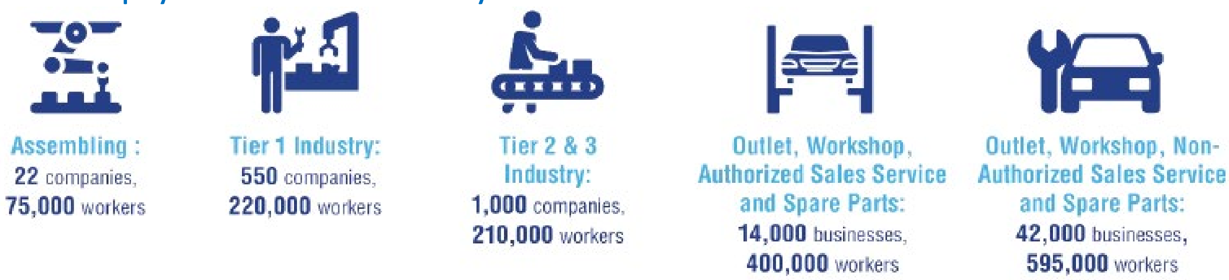
10 Hidayat, Ali Akhmad Noor (2018-03-29). "Menperin: Industri Otomotif Sumbang 10,16 Persen ke PDB". Tempo (2020) and "Indonesian Automobile Industry Data". files.gaikindo.or.id (2019). In 2018, exports were 264,000 units (CBU, completely built up, i.e. imported as fully finished assembled unit) and 82,000 CKD (completely knocked own, i.e. imported in parts and assembled locally) and 87 million component pieces.

11 Main car manufacturers are Toyota, Daihatsu, Suzuki, Mitsubishi, Honda, Nissan

12 Apart from these brands, Kia, Mazda, GM, Ford, Hyundai, Mercedes-Benz, BMW, Fuji Industries and VW have a presence in Indonesia. Source: *The Automobile & Motorcycle Industry in Indonesia,* MUFG (2015)

3.3 people per unit), the domestic demand is saturated at about 6.4 million annually, but exports grow. In 2019, 7.2 million units were produced, of which 0.8 million for export. In 2019, there were about 106 million two-wheelers in use. The industry in Indonesia employs around 1.5 million workers in various jobs ranging from the assembly industry, first, second, and third-tier component industries, up to employees at the workshop, sales, service, and spare parts.[13]

Box 10 Employment in automotive industry



Source: *The Indonesian Automotive Industry: An Update* (2020), GAIKINDO

Relevant energy and transport policies

Given the growth of the transport sector, there is an opportunity to build cleaner and more sustainable road transport systems to avoid a significant amount of future GHG emissions. This will help Indonesia to meet its targets of the NDC. The Government seeks to promote the use of low-carbon vehicles, including fuel-efficient gasoline and diesel vehicles (LCGC, low-cost green car) and a range of electric vehicles (HEV, PHEV, BEV, FCEV[14] (see Box 4 for a description of the electric vehicle types). Under the Automotive Industry Roadmap (see Box 11), low-emission[15] four-wheel vehicles are expected to reach 400,000 (20% of the vehicle market) by 2025 and 1,200,000 by 2035 (30% of the market) and 2-wheelers will have reached 2 million (20% of the market) by 2025 and 4.5 million in 2035 (30% of the market). This is linked with Indonesia's industrial development strategies. The Government seeks the development of a domestic electric vehicle (EV) manufacturing industry for both domestic sales and exportation. The efforts will leverage the country's rich supplies of nickel laterite ore, the primary input in the lithium-ion batteries, enabling Indonesia to become the leader of EV manufacturing within ASEAN.

A set of policies has been issued by the GoI relevant for the implementation of climate mitigations activities in transport:

- Law No 32/2009 on Protection and Management of Environment sets the basis for management of greenhouse gas emission and pollution, while Government Regulation No.41/1999 concerns Control of Air Pollution. Minister of Environment and Forestry Regulation No.12/2010 on Implementation of Air Pollution quality in the regions sets the threshold for the vehicle emission level.
- New Government Regulation No. 30 (2021) on Implementation of road traffic and transportation, in response to Job Creation Law (Omnibus Law), this regulation is the government's effort to encourage the implementation of activities related to Road Traffic and Transportation by providing business facilities to increase investment and include traffic impact analysis, testing, and design of motorized vehicles, operation of terminals, business licensing and subsidies for transportation operations.
- Ministry of Transportation Decree No. 201/2013 aims to mitigate emissions in the transportation sector through a complete "avoid, shift and improve" approach, including fuel substitution from oil to gas and encouragement of using non-motorized vehicles.
- MEMR Regulation No. 12/2015 regulates the provision, utilization, and administration of biofuels.

[13] https://www.statista.com/statistics/978944/indonesia-number-of-motorcycles-use/; https://www.trade-off.id/2020/01/29/motorcycle-sales-stagnant-in-local-market-hike-in-export/

[14] Hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), battery electric vehicle (BEV), fuel cell electric vehicle (FCEV)

[15] Including HEV, PHEV, full electric vehicles (BEV and FCEV) and flexy engine cars (running on ethanol or biofuel blends)

- Government Regulation No. 41 (2013) differentiates level of taxation for various type of cars, including for low-cost green cars (LCGC), to support fuel conversion, and to increase the domestic production of motor vehicles. Government Regulation No. 14/2015 on National Industrial Development Master Plan Year 2015-2035 prioritizes hybrid and fuel cell technology development in the transport sector

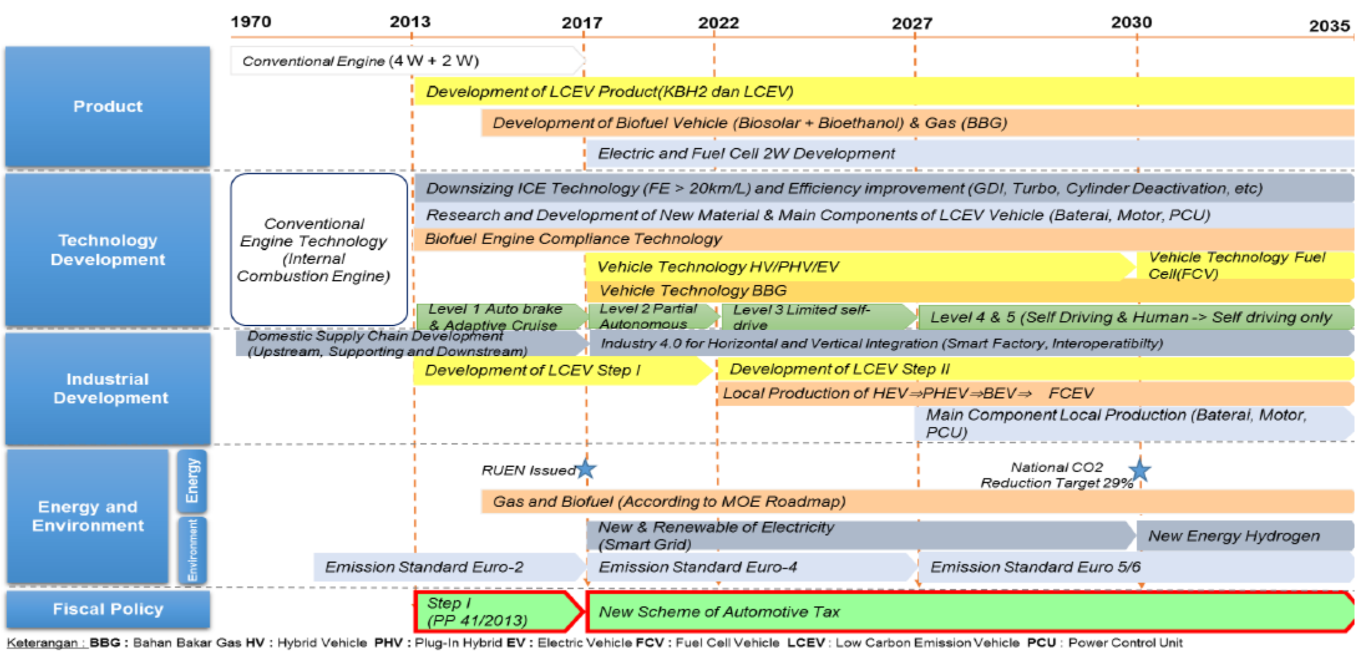
2.2 Electric vehicles in Indonesia

Electric vehicle (EV) road map

The Government seeks to promote the use of low-carbon vehicles, including fuel-efficient gasoline and diesel vehicles (LCGC, low-cost green cars) and a range of electric vehicles (HEV, PHEV, BEV, FCEV). This is linked with Indonesia's industrial development strategies. The government's Making Indonesia 4.0 strategy was launched in 2018 and outlines steps to enable the country to capitalize on the evolving trends of manufacturing provided by the Fourth Industrial Revolution. These include the application of new digital and automated technologies to improve production processes and service delivery. Key priorities of the roadmap include the development of a domestic electric vehicle (EV) manufacturing industry. Efforts to develop Indonesia's EV industry center on leveraging the country's rich supplies of nickel laterite ore, the primary input in the lithium-ion batteries that are used to power EVs. Under the government's strategy, EVs are expected to comprise 20% of the vehicle market by 2025. Officials have stated that the country's vast resources of lithium could enable Indonesia to become the leader of EV manufacturing within ASEAN.

The high number of cars and motorcycles in the road transport sector justifies the need to address passenger vehicles as one of the main contributors to carbon emissions in Indonesia's transport system. For four-wheel passenger cars, the alternatives are formed by hybrid cars (HEV), plug-in hybrid cars, (PHEV), and battery electric cars (BEV). For two-wheelers (motorcycles, scooters), the alternative is formed by electric motorcycles. Indonesia has set ambitious targets that are summarised in Box 12.

Box 11 Automotive industry roadmap



Source: Source: KP, *Roadmap of Low Carbon Emission Vehicle*, PowerPoint, Indonesia-Japan Automotive Seminar (Jan 2019)

Policies and regulations

The **Presidential Regulation 55/2019 on the Acceleration of Battery Electric Vehicles for Road Transportation Program ("PR 55")** supports EV development and market diffusion in Indonesia (see Box 13). The Regulation acts as an umbrella legal framework for BEVs, EV battery production, local content requirements, charging stations and possible tax incentives with more derivative regulations to be enacted thereafter

As of December 2019, the Indonesian government has issued various derivative regulations related to the EV industry and industrial and services sectors. For example, MEMR issued **Regulation No. 13 (2020)** on the "Provision of Charging Infrastructure for Battery Electric Vehicles". Reg 13 one of the implementing regulations for PR 55 and sets out who can engage in the charging infrastructure business, the different charging infrastructure business models; the applicable electricity tariff; and technical and safety requirements and charging plug standardization. The Ministry of Industry (*Permenperin*) **Regulation Number 27 (2020)** concerns "Specifications, Development Roadmap, and Provisions for Calculating Domestic Component Levels of Domestic Motor Vehicles for BEV". **F**inally, ***Permenperin* No. 8 (2020)** concerns allows EV to be partially dismantled (in IKD Incompletely Knock Down) state or in a Completely Knock Down (CKD) as long as the domestic industry cannot produce the required components. Moreover, until local companies are able to ramp up their production, complete electric vehicles CBU, Completely Built-Up) should be (temporarily) imported. Transport Ministry **(*Permenhub*)** Regulation **No. 45 (2020)** on the "Physical Type Testing of Electric-Powered Motorized Vehicles" lays out all the requirements an electric vehicle must have before it can be sold in Indonesia, including additional testing that does not exist for conventional vehicles such as electric recharging capabilities, insulation, functional safety, and hydrogen emission.

Box 12 Quantitative vehicle targets, automotive industry roadmap

ITEM			2020	2025	2030	2035
MOTOR VEHICLE	Production	Total (Unit)	1.500.000	2.000.000	3.000.000	4.000.000
		Percentage LCEV(%)	10	20	25	30
		Percentage LCGC (%)	25	20	20	20
	Sales	Total (unit)	1.250.000	1.690.000	2.100.000	2.500.000
	Export	Total (unit)	250.000	310.000	900.000	1.500.000
MOTOR CYCLE	Production	Total (unit)	8.000.000	10.000.000	12.500.000	15.000.000
		Percentage Electric Motorcycle (%)	10	20	25	30
	Sales	Total (unit)	7.500.000	9.000.000	11.000.000	13.000.000
	Export	Total (unit)	500.000	1.000.000	1.500.000	2.000.000

Source: KP, *Roadmap of Low Carbon Emission Vehicle* (2019)
LCEV: low-carbon emission vehicle, LCGC: low-carbon green car (run of diesel or gasoline). LCEVs include HEV, PHEB, BEV/FCEV and flexy-engine cars (run on gasoline ort diesel blended with ethanol (E100) or biofuel (B100)

Until recently, a 40% luxury goods tax was imposed on passenger cars (including electric vehicles), while import duties could be as high as 40 percent. This is one reason that electric vehicles were costing about three times as much as a comparable ICEV (an EV in Indonesia would have been more expensive than in the USA). Government Regulation **No. 73 (2019)** on Taxable Goods classified as luxury items in the form of motorized vehicles that are subject to the Sales Tax on Luxury Goods (LST, or *PPnBM, Pajak Penjualan atas Barang Mewah*) which took effect in October 2021 to further encourage the use of energy-saving and environmentally-friendly vehicles. As part of the Regulation, the government regulated the PPnBM rate for four-wheeled electric vehicles (PHEV, BEV, FCV) by setting a tariff of 15% with 0% tax imposition on the selling price (see Box 14).

The Ministry of Home Affairs' Regulation (***Permendagri*) No. 8 of 2020** concerns the "Reduction of Ownership Transfer of Motor Vehicle Fee (BBNKB)" and Vehicle Tax (PKB). However, it needs further implementing regulations from local governments. For example, the Governor of Jakarta Reg.No. 3/2020, makes battery electric vehicles exempted from vehicle title transfer fee (BBNKB).

Other fiscal incentives will include the reduction and exemption of corporate income tax for a certain period (for the EV and related battery and electric motor industries)[16], exemption of fees for electricity installation for charging stations, exemptions of parking fee charges for EVs, relief of electricity charging fees at charging stations, funding support for charging station infrastructure development, incentive for charging station equipment production, and fiscal incentives for research, development and technological innovation EV-related and battery-based activities as well as industrial vocations of battery-based components. Non-fiscal incentives include a) ease of import for export purposes and export financing facilities, b) professional competency certification for battery-based, and electric vehicle industry human resources, c) product certification and/or technical standards for battery-based electric vehicle industrial companies and battery-based

Box 13 Acceleration of battery electric vehicle program for road transportation, PR55/2019

Based on PR 55/2019:

- An "EV" is defined as a vehicle moved by an electric motor using electricity power from battery directly in the vehicle or from outside the vehicle. "Electric motor" itself is defined as an electromechanics equipment which consumes electricity to produce mechanical energy as its driving force. Whereas, "battery" is defined as the source of electricity used to supply electricity in an electric motor. PR 55/2019 divides EV into 2 (two) main categories, a) two wheeled and/or three wheeled EV, and b) four wheeled and/or more EV.
- There are 2 (types) of "EV manufacturers" acknowledged under PR 55/2019, namely 1) EV manufacturing company (EV Industry) and 2) EV components manufacturing company (EV Components Industry).
- EV "charging facilities" consist of "charging stations" having electric power supply, control facilities for current, voltage and communication, and safety and protection system and/or "battery exchange stations" (BEX). Charging activity through charging stations may be done through private electricity installation (for own use) or through "public charging stations (SPKLU). SPKLU will be located in, for example, petrol stations, central and regional government offices, malls, and roadside public parking lots. "Public electricity battery exchange stations" (S*tasiun Penukaran Baterai Kendaraan Listrik Umum*, SPBKLU), enable members of the public to rent batteries and exchange them when they run out. Other than PLN, Battery Exchange Stations/SPBKLU may also be provided by private business entities.
- A company selling electricity through a 'charging station' shall hold an "electricity supply business license" (*Izin Usaha Penyediaan Tenaga Listrik* or IUPTL) and shall own an "electricity working are" (*Wilayah Usaha Penyediaan Tenaga Listrik*, WUPTL).
- The electricity tariff imposed by the "charging stations" shall be determined by the Minister of Energy and Mineral Resources. For IUPTL holders the applicable tariff will be the electricity tariff for bulk sales (*penjualan curah*) multiplied by a 'Q' multiplier factor (ranging from 0.8 to two) determined by the Integrated IUPTL holders. For electricity from Integrated IUPTL holders to "private electricity installations" (for non-public transportation), the applicable tariff will be PLN's standard electricity tariff depending on the category (e.g., residential area with certain installed capacity). For electricity from SPKLU to BEV owners, the applicable tariff will be the electricity tariff for special services multiplied by an 'N' multiplier factor (up to 1.5) determined by the IUPTL holders operating the SPKLU.
- Considering the current domestic capability for EV production, the Indonesian Government obliges local content requirement (*Tingkat Komponen Dalam Negeri* or "local content") fulfilment for the EV industry or components industry gradually (two-wheeled EVs from 40% in 2019 to 80% after 2026; four-wheeled EVs from 35% to 80% after 2030)
- The above-mentioned entities (EV industry and components industry, charging stations, BEX) as well as R&D institutions, EV transportation companies and individuals may receive "fiscal and non-fiscal incentives", such as a) exemption of customs duty for import of EV, b) reduction or exemption of 'sale tax on luxurious goods', c) reduction or exemption of taxes imposed by the regional or central government, d) exemption of customs duty for (import of) machines, capital goods and equipment for EV investments, e) incentives for the production of equipment for charging stations, f) incentives for parking tariffs determined by the regional government. In addition, the Government also provides non-fiscal incentives for entities and individuals, such as (1) the exemption on the restriction to use certain roads in Indonesia.

[16] For example, the government has announced a tax holiday that allowed 100% corporate income tax exemption for 5 to 20 years, based on the investment value and an additional 50% tax discount for two years beyond the expiration of the above tax holiday. https://www.globenewswire.com/news-release/2020/09/18/2095767/0/en/Indonesian-Electric-Vehicle-EV-Market-Analysis-Growth-Opportunities-Fuel-the-Growth-Pipeline-Engine.html

component industries[17]. **MoT Reg. No. 65/2020** legalizes the conversion of conventional motorcycles to electric in public repair shop that is authorized by the government

Electric vehicles market and sales targets

The country has just begun to enter the field of electric vehicles. There are about 24 types of electric motorcycles, 29 types of electric cars, and 3 types of electric buses (see Box 15). The Indonesian electric vehicle market is highly concentrated at its early growth stage.

As of April 2020, there were less than 2000 BEVs sold in Indonesia and 15,500 units of electric two-wheelers. Currently, the two dominant brands are BYD and Hyundai. In 2019, 101 battery-electric cars were sold in the country (compared to just a couple sold in 2018) with Tesla (model-3) 38 units, BYD 27 units, and Hyundai-Ioniq 22 units. Total market size (based on Jakarta sales) in 2019 for e motorcycle 1947 units, with 1747 e-motor scooters and 200 units e-motorcycles. Dominant brands in electric motorcycles are GESITS (selling 856 units in 2019) and VIAR (selling 617). Mitsubishi is leading in PHEV cars.

Before 55/2019 were issued, the National Energy Planning / RUEN (Presidential Regulation No 22/2017) set targets by 2025 to apply 2,200 electric vehicles, 2.1 million electric motorbikes, and to build 1000 electric vehicle charging stations. Apart from accelerating the use of electric vehicles, the Ministry of Energy & Mineral Resources (MEMR) will also focus on prioritizing the market of two-wheeled electric vehicles (motorbikes and e-scooters). This policy is decided in consideration to (i) the large population of two-wheeled vehicles (the number of two-wheeled vehicles already being over 120 million units in 2020, and is predicted to reach 150 million units by 2025), (ii) the price of electric motorbikes being competitive

Box 14 Sales tax rates for four-wheel vehicles

Type of vehicle	Luxury-Goods Sales Tax (LST)	Tax base (of selling price)
Low-cost green car (LCGC	15%	20%
HEV (engine capacity up to 3000 cc)	15%	13.33-80%*
HEV (capacity 3000-4000 cc)	20-30%	13.33-80%*
Flex engine technology (biofuel)	15%	53.3%
PHEV, BEV, FCEV		

* depending on type of fuel, fuel efficiency and emission level

Motor vehicles for carrying less than 10 persons have 15-40% LST for < 3000 cc and 40-70% LST for vehicles 3000-4000 cc (depending on fuel efficiency and emission levels). Motor vehicles for carrying 10-15 persons have 15-20% LST for < 3000 cc and 25-30% LST for vehicles 3000-4000 cc (depending on fuel efficiency and emission levels). Vehicles with engine capacity > 4000 cc have 95% LST

Source:
https://www2.deloitte.com/content/dam/Deloitte/id/Documents/tax/id-tax-info-nov2019.pdf

Box 15 Electric car and buses models and manufacturers

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[17] *Contribution of the automotive industry on national income growth*. PowerPoint, Ministry of Finance, 14th Gaikindo Automotive Conference (July 2019);

Box 16 Electric two-wheelers models and manufacturers

with combustion engine (ICE) motorbikes, as well as (iii) the ease of developing infrastructure to support electric motorbikes (battery swaps) compared to the supporting infrastructure of charging stations for electric cars.
To that end, MEMR will encourage the penetration of the electric motorcycle market and the escalation of electric motorbikes usage through the conversion program from conventional motorbikes to BEV motorbikes, targeting to reach 100 million units by 2025. In doing this, Indonesia aims to follow the example set by China and India (see Box 30) The Ministry of Industry (MoI) has targeted 20% or about 400,000 units of Electrified Vehicles (Including HEV, PHEV, and BEV) and 2 million electric motorbikes produced and available in the domestic market by 2025. *Kemenperin* will provide regulations/standards (with BSN) for domestic Industrial development of main EV components and supply chain.

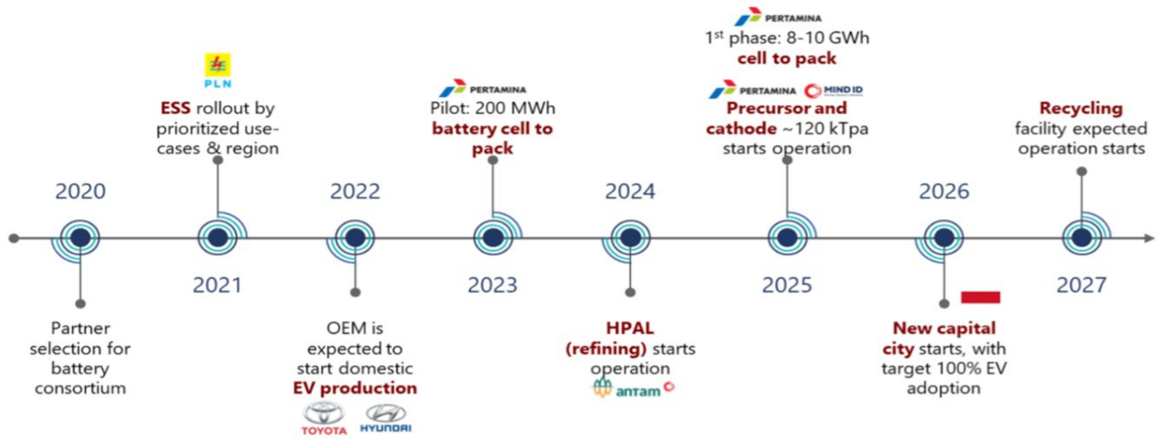
Battery industry

The development of the EV battery industry ecosystem is very important for the EV program. It can also have a very large economic impact for Indonesia, including a contribution to the national GDP of up to USD 8.5 billion a year, absorbing a workforce of up to 8,000 - 16,000 people, and with potential tax revenue of up to USD 1 billion a year. To realize an integrated EV Battery industrial ecosystem from upstream to downstream, at least an investment of USD 4-6 billion is needed. Industry reports show that sales-weighted battery pack prices in 2019 were an average of USD 156 per kilowatt-hour (kWh), down from more than USD 1,100/kWh in 2010. Some predictions show that in the next 5 years the price of batteries pack will be below 170 USD per kWh and in the next 10 years, it will be below 100 USD per kWh.

For the future trend of lithium battery technology which contains more nickel components (NCM 811) where Indonesia has large nickel reserves, the potential for Indonesia to enter the global battery industry supply chain network will be very strategic. Two industrial estates in Indonesia are designated to facilitate battery-grade mineral processing and nickel production: Morowali Industrial Area (IMIP) in Morowali, Central Sulawesi and Weda Bay Industrial Area (IWIP) in Halmahera, North Maluku. Both locations are strategic for nickel production due to their abundance of nickel deposits, having a total of around 23% of global laterite nickel ore deposit. Pertamina is developing a battery value chain with other state-owned enterprises (SOEs) to enhance the value of nickel upstream and also other raw materials. To achieve economies of scale that can compete, cooperation of these SOEs with global players is urgently needed. Several companies in both areas are to produce nickel sulphate and cobalt sulphate as inputs for battery cell production. Two companies in IMIP plan to start production in 2021, one company in IWIP aims for 2023. A domestic company, PT International Chemical Industry, plans to start battery cells production of 256 MWh/year by early 2021. A consortium of SOEs, including MIND ID, Antam, Pertamina and PLN, is also being formed with a target to produce 33 GWh/year of battery cells[18]

[18] *Indonesia Energy Transition Outlook (2021)*

Box 17 Timeframe with milestones for battery industry



Source: taken from ….

2.3 Electric vehicle charging

Charging infrastructure

By the end of 2019, the country had built a total of 20 charging stations for electric vehicles which increased to 62 in 2020 and 122 in 83 different locations. Of the 62 charging facilities, 27 were public and 35 were private (blue Bird, Mitsubushi, BMW, Mercedes). The public EV charging infrastructure is led by PT Perusahaan Listrik Negara (PLN), which is a state-owned

Box 18 Experience with electric motorcycles in China and India

China leads the electric motorcycles market with the largest fleet and annual sales. In late 2019, the stock of electric motorcycles in China was close to 300 million units (Xinhua News, 2019a). Recent data suggests that the annual production of electric motorcycles rose from approximately 33 million in 2018 to 36 million units in 2019 (China Bicycle Association, 2019). 35 Regulations and modest prices have played a major role in the high demand for electric motorcycles. The growth of electric motorcycles has been spurred by two notable policies from the central government. First, in 1999, the government designated electric two-wheelers possessing a low speed and weight as bicycles. This exempted them from registration requirements and permitted them to be driven on bicycle lanes. Second, several urban areas have banned gasoline powered motorcycles from city centres (Cherry, 2010).

The sales of electric motorcycles in India rose from 54 800 units in 2018 to 126 000 units in 2019 (Wadhwa, 2019). India had an estimated fleet size of 0.6 million electric motorcycles in fiscal year36 2018-19 (IEA, 2019b). About 20% of the CO2 emissions and 30% of particulate emissions in India are estimated to be caused by motorcycles (Viswanathan and Sripad, 2019). Recent government policies have taken into consideration the need to electrify the motorcycles fleet. In 2019, the national government proposed a plan to make all motorcycles sales electric ones (up to 150 cubic centimetres) as from March 2025 (Vardhini, 2019). Under the first phase of the Faster Adoption and Manufacturing of Hybrid & Electric Vehicles (FAME I) scheme, 88 models of electric motorcycles were eligible for a subsidy. Until September 2018, around 90% of the beneficiaries under FAME I were lead-acid powered electric scooters. From October 2018, subsidies for lead-acid battery vehicles were discontinued, but incentives for lithium-ion battery vehicles remained. Information has not been obtained regarding the percentage level of annual sales of electric motorcycles that have been achieved by the two countries.

Sources: Mini-Study on EV Vehicles and Manufacturers, by Agus Purwadi (2020); own analysis (also the largest) electricity corporation in the country[19]. PLN conducted three trial runs in Jakarta with the bus operator TransJakarta and had installed about 21 charging units by the end of 2020[20]. The PLN Roadmap aims at 3,851 by 2025. These can cater to about 114,000 vehicles, so the the planned SPLUs will not be enough to service MoI's EV Roadmap target of 400,000 electric cars by 2025. More fast and superfast SPLUs will be set up in several locations[21].

PLN has signed memorandums of understanding with 20 companies to push EV adoption in Indonesia. Thirteen companies are set to provide support with installing charging stations, including the ride-hailing rivals Go-Jek and Grab, toll road operator Jasa Marga, energy company Pertamina, bus operator Transjakarta[22] and Indonesia's largest private lender, BCA. For example, TransJakarta has announced an ambitious plan to expand its electric bus (e-bus) fleet to 10,000 units over the decade (about 83% of its bus fleet in 2030 would be electric), starting with 100 new electric buses in 2021[23]. The second group, tasked with building electric vehicles, is made up of six international automakers, including China's DFSK, Japan's Mitsubishi, Germany's BMW, and Indonesia's Gesits[24]. Research is promoted through an agreement with state-owned electronics manufacturer LEN, which will be backed by the Agency for the Assessment and Application of Technology (BPPT) state-owned electronics manufacturer LEN, which will be backed by the Agency for the Assessment and Application of Technology (BPPT).

The taxi operator Blue Bird has put 30 electric taxis into operation and set up 14 charging stations in the taxi pool and 1 at the Soekarno Hatta Airport. The plan was to buy an additional 200 BEV in 2020 as the second phase of this trial, but the trial was postponed due to the COVID-19 situation. Blue Bird has its own ambitious road map for EV introduction (see Box 32).

The right business model still needs to be developed, based on these trials. The price of BEV is still very expensive[25], although will drop when Government Regulation Number 73 (on PPnBM) becomes effective in 2021. It is still unclear how durable electric cars are and whether a second-hand BEV car market will exist in the future (ICEV cars are sold after 5 years in operation). Bluebird's BEV is now operating at 450 km (with two charging). In the future, to reduce operational cost, additional EVCSs outside of the pool are required to accommodate the operation of BEV up to 500 km with multiple charging.

Box 19 Bluebird's roadmap for electric vehicles

Year	2019	2020	2021	2022	2023	2024	2025	2026
Number of EV adopted	*100*	*2,500*	*5,000*	*7,500*	*10,000*	*12,500*	*15,000*	*17,500*
Year	2027	2028	2029	2030	2031	2032	2032	2034
Number of EV adopted	*20,000*	*22,500*	*25,000*	*25,000*	*25,000*	*25,000*	*25,000*	*25,000*

Source: Bluebird presentation at ADB, Indonesia Resident Mission Workshop, 19 February 2019.

19 *Growth Opportunity Analysis of the Indonesian Electric Vehicle (EV) Market* (1019) https://www.globenewswire.com/news-release/2020/09/18/2095767/0/en/Indonesian-Electric-Vehicle-EV-Market-Analysis-Growth-Opportunities-Fuel-the-Growth-Pipeline-Engine.html

20 *Indonesia Energy Transition Outlook 2021* (IESR, 2021). Examples: Jakarta: PLN Disjaya, Senayan City, Aeon Mall and PLN Pusat; Denpasar (Bali): PLN UID; and in Bandung. Source: PowerPoint, Electrifying Road Transportation in Indonesia, PLN (Nov 2019)

21 The charging time at a regular SPLU takes 4-6 hours. As for the fast SPLU, it takes 2 hours, while superfast SPLU only takes 15-45 minutes. Source: https://indonesiaexpat.biz/featured/pln-to-develop-charging-stations-for-electric-buses-in-jakarta/

22 The C40 Cities Finance Facility is supporting Jakarta to implement an operational trial fleet of 100 e-buses in the network of TransJakarta, which will contribute to Jakarta's target of promoting public transport mode share to 60% as well as to 100% electrify TransJakarta's fleet in 2030. See https://www.c40cff.org/projects/jakarta-electric-bus

23 https://www.thejakartapost.com/news/2020/12/29/transjakarta-wants-10000-electric-buses-in-service-by-2030.html

24 https://www.electrive.com/2019/10/22/indonesia-moves-on-ev-development-and-infrastructure/

25 25 units of BYD e6 and 4 units of Tesla Model X 75 D. Pricing is an issue. The BEV taxis mentioned costed about USD 40-50,000. More towards the lower end, a BEV would be about USD 32,000. With the incentives of about 33% (PB 73/202, *Permendagri* No 8/2020 as well as *Pergub* DKI Jakarta No 3/2020) the cost would be about USD 25,000, while a comparable ICEV model would be available at USD 15,000.

The ride-hailing company Grab launched its first fleet of electric vehicles in early 2020, with a pilot testing 20 out of 500 electric taxis. Grab has now built EVCS at two locations, namely in Tangerang City Mall and Aeon Mall. Another EVCS was built at the Soekarno-Hatta International Airport for a pilot with 50 EV cars. Grab also provides monthly EV rental services for government and private institutions.

In 2020, Grab tested 20 e-motorbikes for grab bike services[26]. Pertamina and Go-Jek are planning to launch a trial on a local brand electric motorcycle and battery swap station in Jakarta[27]. The PLN Roadmap calls for 14,000 battery swap stations in Indonesia and 52,125 by 2035[28]

National-level regulations are supplemented by local-level actions. The Government of DKI Jakarta has planned to electrify the BRT system with a fleet of 11,511 buses by 2025 and gradually all of the BRT fleet will use electrical buses by 2030. *Kemenperin* together with NEDO Japan has initiated the pilot deployment of 270 electric motorbikes with about 1000 batteries at 40 battery swap stations in Bandung and Denpasar, including piloting utilization of second-life batteries for household electrification. E-bikes can be leased at about USD 80 per month[29]. The Government of DKI Jakarta has exempted BBNKB[30] for BEV with DKI Jakarta Governor Regulation No. 3 of 2020. Meanwhile, Bali Provincial Government through the Governor of Bali Regulation No. 48 of 2019 concerning the Use of Battery-Based Electric Motorized Vehicles will provide incentives through BBNKB and PKB instruments and will implement restrictions on vehicle use fossil fuel motorized.

Electric vehicles and the power grid

The emission reduction benefit of EV transition depends on the total emission arise from the whole value chain, from material mining, battery, and vehicle manufacturing process, electricity production, to the end user's EV technology (see Box 21. The current high dependency on coal power plants could hamper the emission reduction goal by developing EV.

In the energy sector, Indonesia has embarked on the development of clean energy sources as a national policy. In Regulation No. 79/2014 on National Energy Policy, the Government has set out the ambition to transform, by 2025 and 2050, the primary energy supply mix with shares as follows: a) new and renewable energy at least 23% in 2025 and at least 31% in 2050; b. oil should be less than 25% in 2025 and less than 20% in 2050; c. coal should be a minimum of 30% in 2025 and a minimum of 25% in 2050; and d. gas should be a minimum of 22% in 2025 and a minimum of 24% in 2050[31].

The development of clean power generation has been advancing slowly. Renewable energy only accounted for about 12% of the power generation mix until 2018. The Indonesian government has set a target of a high portion of renewable energy, of approximately 27% by 2030, including geothermal, wind, biomass, and solar energies. However, at the same time, the government has also accelerated the construction of coal-based power plants to match fast-growing economic growth. Currently, the coal power plant accounts for 60% of Indonesia's power generation mix. In the General Plan of Electricity Provision (RUPTL) 2019-2028, coal will still dominate with 48% until 2028. The vision is to have a high share of renewable energy of 27% by 2030.

T he peak of daily electricity demand still occurs at a certain time (evening to midnight), causing a large gap between peak and valley in the load profile. The difference between peak and off-peak becomes an oversupply problem that can threaten

[26] As part of the pilot, users were interviewed on what they see as obstacles. 54% of 4-wheel users feel that the current EVCS network is not yet sufficient; 43% of twee-wheel users are concerned about vehicle quality and limited mileage and 7% are concerned regarding the issues of battery charging/swapping network availability.

[27] Reportedly, Singapore-based Grab Holdings Inc. and ride-hailing and payment operator PT Go-Jek Indonesia are having merger discussions (Dec 2020); https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/tesla-open-to-buying-a-legacy-carmaker-grab-gojek-said-to-near-merger-61545834

[28] *Indonesia Energy Transition 2021,* Institute for Essential Services Reform (IESR)

[29] NNA Business News, https://english.nna.jp/articles/1370 (Augusr 2019)

[30] *Bea Balik Nama Kendaraan Bermotor* (Transfer of Motor Vehicle Title Fee)

[31] Source: First Nationally Determined Contribution (NDC), 2016

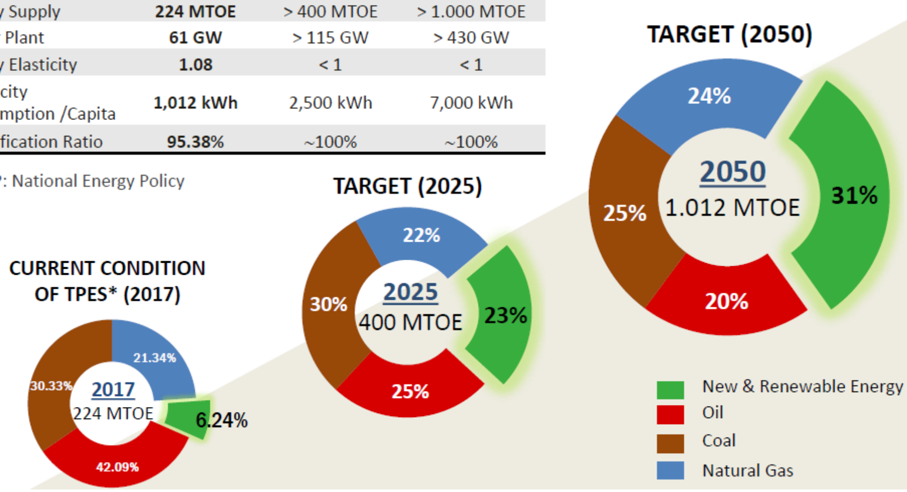
Box 20 NEP and NDC targets

National Energy Policy (NEP)

NEP* TARGET	2017	2025	2050
Energy Role	National Capital Development		
NRE on Energy Mix	**6.24%**	23%	31%
Energy Supply	**224 MTOE**	> 400 MTOE	> 1.000 MTOE
Power Plant	**61 GW**	> 115 GW	> 430 GW
Energy Elasticity	**1.08**	< 1	< 1
Electricity Consumption /Capita	**1,012 kWh**	2,500 kWh	7,000 kWh
Electrification Ratio	**95.38%**	~100%	~100%

*) NEP: National Energy Policy

Note
MTOE: Million Ton Oil Equivalent
NRE: New-Renewable Energy



NDC target:

Share of NDC Targets in Indonesia per sector based on **unconditional** mitigation scenario are:

1. Forestry (17.2%)
2. **Energy (11%) = 314 $MtCO_2e$**
3. Agriculture (0.32%)
4. Industry (0.10%)
5. Waste (0.38%)

Reduce **Green House Gas Emission in Energy Sector** in year 2030 **around 314 $MtCO_2e$** (unconditional mitigation scenario) **or 398 $MtCO_2e$** (conditional mitigation scenario)

Energy Policy:

The reduction target of National GHG emissions from energy sector in 2025 is 34.8% (476 $MtCO_2e$) and in 2050 is 58.3% (2,726 $MtCO_2e$)

Source: PowerPoint by MEMR "National Energy Policy Indonesia", Workshop NEXTEP – UNESCAP (Bangkok, 2019)

the electricity market between power producers and transmission system operators. The utilization of EVs together with the adoption of renewable energy and feed-in tariffs (FIT) in power grid management are estimated to increase the popularity of the vehicle-to-grid (V2G) concept. In the V2G concept, electric vehicles communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate. Batteries represent excellent energy storage, having high energy efficiency and a fast response time. BEVs have generally a significantly larger battery capacity than other EVs. Thus, EVs can provide power to help balance loads by "valley filling" (charging at night when demand is low) and "peak-shaving" (sending power back to the grid when demand is high), making use of the battery storage capacity of the EVs.

The adoption of renewable energy in power grids has had a positive impact on emissions reduction. However, it also potentially leads to a significant problem due to instability, as most renewable energies have unpredictable fluctuations. In the V2G concept, the large-scale use of electric vehicles could buffer renewable power sources (such as solar or wind power for example) by storing excess energy produced during sunny or windy periods and providing it back to the grid during high load periods, thus effectively stabilizing the intermittency of wind power. Some see this application of vehicle-to-grid technology as an approach to help renewable energy become a baseload electricity technology and thus allowing a higher penetration of RE into the power grid system.

2.4 Barriers to the introduction of electric vehicles

The implementation of this long-term solution is hindered by several **barriers** in technical, regulation, financial, awareness, and knowledge development that are briefly discussed below

- *BEV's price and total cost of ownership (TCO) more expensive than ICEV*

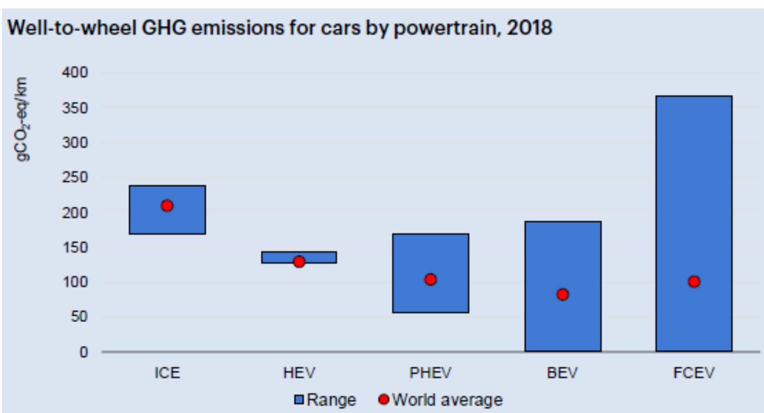
One of the biggest hurdles for the introduction of EVs is currently the upfront cost. BEV and TCO prices for four-wheeled vehicles are still relatively higher than ICEV. The cheapest HEV is about USD 37,000, the cheapest PHEV about USD 86,000,

Box 21 CO_2 emissions of ICE and electric vehicles

BEV are often hailed in the press as 'zero-emission' vehicles, but that depends on what emissions one is talking about. *Well-to-wheel (WTW*) emissions include:

- *Tailpipe* (or *tank-to-wheel*, *TTW*) emissions result from the rest products off of internal combustion engines (ICE) that leave the tailpipe and from leakage of hydrocarbons in the fuel tank. Per definition, these are zero for full electric vehicles (BEV and FCEV).
- To these must be added, the *upstream* (or *well-to-tank, WTW)* emissions. For oil products these are extraction, refining and distribution. For biofuels, they include the emissions that come from growing the biofuels feedstock, transforming it into a biofuel and transporting it to the fuel pump (and account for other co-products made in the process). For electricity, they comprise the emissions incurred in generating the electricity, including line losses, as well as in charging the vehicle. In the case of hydrogen, WTT emissions are incurred by producing, transporting and dispensing the hydrogen to the vehicle.

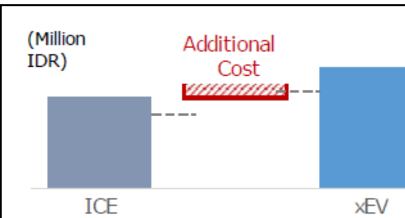
Life-cycle emissions not only take into account the well-to-wheel emissions, but add the emissions also come from sourcing, altering and incorporating materials into the final product (i.e., the car, its engine and drivetrain, or battery and/or fuel cell), as well as from the end-of-life (i.e., disposal, reuse and/or recycling). A recent IEA publication mentions that, based on global average energy intensity, BEV had the lowest specific WTW GHG emissions (i.e., on a per kilometre basis) among the cars evaluated, at around 95 grammes of CO2-eq per kilometre (g $CO2_{-eq}$/km). The average battery electric car emits about 60% less $CO_{2\text{-}eq}$ per kilometre than gasoline ICE vehicles and 40% less than the average hybrid cas. However, due to the large variability in the carbon intensity of electricity generation in electricity systems and across countries, the GHG mitigation potential of BEVs can vary considerably, as is indicated in the figure below.



The range indicates the variability of WTW GHG emissions for each car at the country level. For ICE vehicles, HEVs and PHEVs, the range is determined considering the minimum and maximum fuel-economy values across countries. PHEVs are assumed to drive 60% of their annual mileage on electric drivetrain and 40% on gasoline engine. For PHEVs and BEVs, the 2018 carbon intensities of electricity generation at country level correspond at minimum to a vehicle charging in Iceland (0.1 g $CO_{2\text{-}eq}$/kWh) and at maximum to a vehicle in South Africa (1 002 $gCO_{2\text{-}eq}$/kWh). FCEVs, the minimum is calculated considering production of hydrogen from dedicated renewables, the maximum corresponds to hydrogen production from electrolysis considering electrolysis in China (the country with the most FCEVs in operation and with the highest carbon intensity of electricity generation) and the world average is based on steam methane reforming (8.8 kg $CO_{2\text{-}eq}$/kg hydrogen).

Note that the accounting of GHG emissions measure not only CO2 emissions, but also other greenhouse gases and normalise these to a global warming potential of 100 years (GWP100), to report on a $CO_{2\text{-equivalent}}$ basis. Source: *Global EV Outlook 2020* (IEA)

and the cheapest BEV about USD 40,000, at least some USD 7000 pricier than gasoline or diesel vehicles. Electric motorcycles cost 1.3-1.35 times as much as fossil fuel-powered counterparts[32]. BEV's price is not the only thing they consider; consumers also consider the total cost of ownership (TCO) of the cars they purchase (see Box 3). A recent LPEM FEB UI study (2019) shows the price of BEV is still much more expensive than ICEV but with the right incentives (such as PPnBm, BBNKB, and reduction of PKB) the TCO of BEV will become more competitive with or even lower than ICEV when used for high-frequency usage (in public transportation such as buses or taxis), although it may not reach competitive in terms of price or TCO for electric vehicles for personal use



Electric vehicles (xEV) have higher sales price than ICE vehicles:

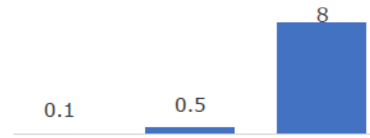
- HEV: 1.2 times more
- PHEV, BEV: at least 1.5 times more

Source: Institut Otomotif Indonesia (IOI), *Prospects and penetration outlook of electric vehicles in Indonesia*

[32] *The Indonesia Automotive Manufacturing: An Update* (June 2020), Gaikindo); *Indonesia Energy Transition 2021* (IESR)

- *Lack of EV ecosystem and limited charging infrastructure*

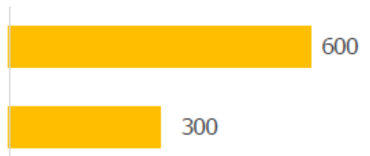
Private and semi-public charging points refer to charging points installed at home or workplace while public charging points are installed in public places including highways, traffic hotspots, shopping malls, airports, etc. Public charging points are important to extend the range for limited range BEV drivers to allow long-distance drivers. A private charging point is a necessity for BEV owners given that the vehicle is typically parked at the residence for the longest portion of the day; it can also be an alternative for BEV owners for those who don't have access to a home charging point. By the end of 2020, there were 67 public charging points installed in 37 locations and 9 battery swap stations in 9 locations[33]. Acceleration of the deployment of semi-public and public charging points is a necessary condition for people to use BEV. Range anxiety is important for consumers given the current limited public charging stations.



Charging time

- ICE/HEV: refilling takes minutes
- Rapid charging: 0.5 hours
- Normal charging: 8 hours

Source: Institut Otomotif Indonesia



Driving distance range:

- ICE/HEV: 500-600 km per refill
- PHEV/BEV: 300 km per charge

Source: Institut Otomotif Indonesia

The state-owned electricity firm PLN has estimated that private and public players would need to invest IDR 54.6 trillion (USD 3.7 billion) to install more than 31,000 commercial charging stations by 2030[34] to reach the government's EV goals. Charging infrastructure with appropriate tariffs[35] form part of the EV ecosystem.

Box 22 Total cost of ownership

The **total cost of ownership** (TCO) can be derived by using the formula: TCO = D + FC + ICB + IC + MR + (T-S), where
- D: depreciation = purchasing price minus resell price of the vehicle
- ICB: interest paid on borrowing (vehicle loan, bank loan) if paid for with loan
- FC: fuel cost = fuel consumption (unit per km) * fuel price (per unit) * total km driven (during ownership period)
- OC: other operating cost, such as parking fees, toll, road fees
- IC: insurance cost
- MR: maintenance and repair cost (incl. battery substitution) in the ownership period
- T: government taxes (e.g., import duty, PPnBM)
- S: government subsidy

This gives the consumer TCO. A social TCO can be calculate by adding social or environmental cost, such as the cost of GHG emissions. The Institute for Economic and Social Research, Faculty of Economics and Business, Universitas Indonesia (LPEM-FEB UI) has done a study on *Estimating the Total Cost of Ownership (TCO) of Electrified Vehicle in Indonesia* (2020). The calculation starts with assuming that purchasing prices of HEVs is about 1.2 and of PHEV and BEV about 1.5 times higher than of ICEVs. EVs become more economical depending on the annual mileage. At 10,000 km per year, the TCO of xEVs are relatively high, but at 18,000 km, HEVs become compatible with ICEV. At 25,000 km, BEVs become more competitive. Of course, the numbers shift in favor of BEVs if fuel cost increase. The analysis also shows that the TCO is very dependent on battery replacement cost and the recycle or reuse from the batteries. Lowering taxes (e.g., PPnBM) in combination with some subsidy and higher fuels can shift the TCO of PHEV and BEV towards competitiveness with ICEV.

[33] Source: MEMR presentation, draft of BEV public Launching, 3 December 2020. Until April 2021, a total of 122 charging stations have been built in 83 locations such as public oil-fuels stations, public natural gas stations, offices, hotels, shopping centers, parking areas, and rest areas along the toll roads (https://www.esdm.go.id/en/media-center/news-archives/indonesia-to-accelerate-ecosystem-of-battery-electric-vehicles-says-energy-minister)

[34] https://www.thejakartapost.com/news/2020/10/15/consumers-concerns-hamper-electric-vehicle-adoption-in-indonesia-experts.html.

[35] The charging tariff of SPKLU is included in the special service category, with rates ranging from IDR 1,644.52 to IDR 2,466.78 per kWh. Source: https://www.esdm.go.id/en/media-center/news-archives/indonesia-to-accelerate-ecosystem-of-battery-electric-vehicles-says-energy-minister

The ecosystem does not just mean the charging station and battery switching outlets, but establishes a whole local supply chain for the EV industry, from the manufacturing industry, sales outlets, and maintenance businesses as well as the environmentally friendly recycling and disposal of batteries.

On the raw material side, Indonesia holds a big opportunity by having the largest global nickel reserves (see Annex K for more details on battery production). Nickel is a crucial material for EV's batteries to increase their energy density. The battery will hold not only an important role in the EV industry but also for renewable energy development. Thus, investment in the battery industry is crucial for promoting an EV industry.

In March 2021, the Ministry of State Owned Enterprises (SOE) established Indonesia Battery Corporation (IBC), a joint venture company consist of four SOEs namely PT Aneka Tambang Tbk (IDX: ANTM), PT Indonesia Asahan Aluminium (MIND ID), PT Pertamina, and PT PLN. It is expected that IBC will synergise with various global companies in the future to operate lithium battery plant for EV. IBC has a plan to pilot and develop the battery swap mechanism in Indonesia. In 2021, IBC plans to pilot battery swap stations that would service about 500 two-wheeled BEVs.

- *Production of electric vehicles is limited*

Despite the existing ambitious EV Roadmaps, there is no serious local production yet of four-wheel BEV and limited availability of models in the market. Local producers are still struggling as the overall demand is still low, thus hindering sales improvement. However, several ride-hailing platforms have established cooperation with electric two-wheelers companies: Grab with Kymco, and Gojek with Gesits and Viar. There are no domestic facilities to produce 4-wheeled electric cars as of now. Several plans for investments have been announced by several car companies. Two major companies, Hyundai (South Korea) and Toyota (Japan), have committed to invest approximately USD 2 billion and USD 2.8 billion, respectively, to build factories and do production in Indonesia.

- *Lack of evidence to support the implementation of policies and plans*

The policy regarding the acceleration of the battery-based electric motor vehicle program is a recent policy that has been enacted as of August 2020. Under the policy a number of regulations are planned. Recently, the policy on charging station standard have been issued under MEMR Ministry Regulation 13/2020. Plug-ins for BEV in charging station has adopted international standards: Type 2 AC Charging (AC Slow), DC Charging CHAdeMO (DC Fast), and DC Charging Combo Type CCS2 (Combo Slow AC & Fast DC). However, various stakeholders, both within the government (central and local government), producers (industry), and consumers still are not fully aware of or do not fully comprehend these regulations which may hinder the actual implementation of the policy and regulations aiming to support development of the electric car ecosystem and encouragement of the BEV market.

- *Lack of knowledge, awareness, and demonstration*

A vehicle is considered as one of the most expensive purchases by individuals or households, often equal to months or years of income, and will last for many years. In general, the consumer wants a vehicle that is affordable, safe, comfortable, and reliable for travel and meets many practical needs. For all these reasons, consumers generally will undertake lengthy research and take safe decisions to choose a vehicle. In general, there is lack of customer awareness and knowledge about BEV advantages, existing incentives, and features which pose barriers to BEV adoption. There is a lack of demonstration and pilot projects with EVs (like taxis) and EV public charging, combined with campaigning and promotion stressing benefits.

- *Issues in sustainable battery production, waste management and recycling*

Battery electric vehicles are predicted to be the future driving solution, especially in cities because they do not produce air pollution and have the potential to reduce greenhouse gases. However, battery production and disposal has environmental impacts that need to be carefully managed. When the battery life has run out (usually between 6-10 years, depending on the number of charging cycles it undergoes), the used battery will become waste. Battery waste is dangerous and damages the environment. Battery waste contains heavy metals and hazardous substances such as mercury, manganese, lead, nickel, and lithium which can pollute water and soil and can harm the human body. Globally, lithium-ion batteries (LIBs) are the dominant electricity storage technology for applications requiring high energy density. There are two main options for extending the useful life of Li battery materials. One approach is to reuse or recondition used battery packs for use in "second life" applications. At the end of their first (EV) life, many batteries will still retain over 75–80% of their original capacity and could, therefore, be used in less demanding applications. The other option is recycling. However, the recycling of larger EV Li-batteries is at an infant stage. There are only a limited number of recycling factories worldwide. Right now, there is one large battery recycling company in Indonesia, PT Indonesia Puqing Recycling Technology (in Morowali, Sulawesi) that can produce battery-grade materials through the recycling process of used batteries.

More regulation is needed and a good monitoring, verification and enforcement (MVE) system to be established, so that the waste of lithium batteries from electric cars does not become a new problem, following the bad example set by lead-acid battery recycling. Maybe up to 70% of used lead acid batteries are recycled in the informal sector. In Indonesia, more than 200 illegal used lead acid battery (ULAB) smelters are currently operating that emit lead and other metal particulates into the air which can be carried downwind and deposited in soil and surface water, potentially causing severe health problems.

2.5 Business cases: examples of EV charging and battery swap

Case A) – fast charging of 4-wheeled vehicles in hybrid grid-solar systems

The fuel consumption specification for ICE taxis is 0.0896 liters per km, while the electricity consumption specification for BEV taxis is 0.123 kWh per km[36]. ICE and BEV taxi vehicles are considered to operate with an annual mileage of 98,550 km, while other service vehicles run 18,000 km per year. The type of gasoline consumed by ICE taxis has Research Octane Number 92 (RON-92) with an emission factor of 2.153 kg of CO2/liter, while the emission factor from the electricity network in the Java-Bali system (Jamali) is 870 kg CO2/kWh with transmission and distribution losses of 9%, giving an emission factor of 956 kgCO2/kWh. It should be noted that the calculation in the Box does not only take into account the emissions associated with driving (tank-to-wheel), but also but also well-to-tank (GHG emissions associated with the production and transport to the filling station of the gasoline consumed) and the GHG emissions in battery manufacturing (in case of EVs), as explained in Box 21. Thus, one can calculate that a typical taxi will reduce 7.18 tCO_2 per year and a service vehicle 1.74 tCO_2 per year.

Part of the energy in one EV charging station (at MEMR, for official cars) in Jakarta can partly be provided by solar energy, for example, by rooftop solar at adjacent buildings. It is assumed in the case that energy supply is by solar is about 20%, as indicated in Box 23. Thus, the emission reduction will be higher. In this case, a vehicle will reduce 1.74 tCO_2 per year (compared to 1.26 tCO_2 per year for a BEV fully powered by grid electricity). More details on the solar component io is presented in Box 25.

Box 23 gives the details of a modern fast-charging station for the 4-wheelers. One superfast charging station will be able to charge 30 vehicles a day (depending on their daily mileage, this implies in the calculation that 37 different taxi vehicles or 201 service cars visit the station). In the end, the emission reduction per station is the same, namely 185 tCO_2 per year (this depends on the station's capacity to charge = expected GHG emission reduction per car per mileage * times mileage of the car) in the case of grid-charged stations. In the case of the official vehicles in the project, the energy needed is 20% generated by solar, the emission reduction is 244 tCO_2 per year. **Thus, the total emission of the two charging stations (one with solar; one without) over their lifetime (of 10 years) is (1,848+2,445=) 4,293 tCO_2.**

Case B) Battery swap stations with 2-wheelers

Calculations of the potential reduction in GHG emissions are also carried out for two-wheeled vehicles. The millage for long-distance motorcycles (ride-hailing) is assumed 150 km a day with a 90% availability factor (or 135 km/day) or 49,275 km annually. The fuel consumption specification for ICE motorcycles is 0.033 liters per km, while the electricity consumption specification for BEV is 0.033 kWh per km. Similar to the 4-wheeled vehicles, the 2-wheeled vehicles are also assumed to use gasoline with RON-92 and using the Jamali system for the electricity supply of the BEVs. With the same calculation approach as for 4-wheeled vehicles, the potential for GHG mitigation on the utilization of 2-wheeled BEV is 2.47 tCO_2 tons

[36] Boxes 33 and 34 provide information on the sources of information and/or way of calculation

of CO_2 per year (ride-hailing). The CO_2 emission reduction per year (0.40 tCO_2) for other 2-wheelers is lower because the mileage is assumed to be less (22 km a day or 8,000 per year)

Box 23 CO_2 emissions reduction and cost estimates of reduction with charging 4-wheeled vehicles in hybrid grid-solar charging stations

	Assumptions 4-wheeler (personal car)						
a	Lifetime km car	160000		km	Viva (Indonesia)		
b	Battery manufacturing	82		$kgCO_2/kWh$	ICCT (2018)		
c	Battery size	38		kWh	Gridoto		
c1	Available energy	29		kWh	75% (degradation, battery reserve; operational flexibility)		
d	Range of battery	232		km	=c1/i		
e	Battery replacement	1.25			Assumption		
f	Battery emissions	3116		$kgCO_2$	= b*c		
g	Car manufacturing (powertrain, glider)	9000		$kgCO_2$	TNO (2014); T&E (2016); Verkade (2017)		
h	Java-Bali grid emission factor	870		gCO_2/kWh	Electricity System GHG Factor (MEMR, 2019)		
	(including T&D losses)	956			=h*(1-9%)		
i	Energy consumption (MWh/km)	0.123		kWh/km	Light-weight car; various sources		
	Emissions 4-wheel personal car						
j	Emissions (gCO2/km)	Gasoline	BEV			TTW gasoline	
k	- Car manufacturing	56	56		= g/a	2.153	$kgCO_2/L$
l	- Battery		24		= e*f/b	0.0830	L/km
m	- Tank-to-wheel (TTW) emissions	179	118		Diesel/gasoline: GEF. BEV = h*i		
n	- Well-to-tank emissions (20% of TTW)	36			18-22% of (TTW); see Hoekstra (2020)		
o	*Tota emissions (gCO2/km)*	*270*	*198*		= j+k+l+m+n		
p	Difference gasoline-BEV	73		gCO_2/km			
	Difference with solar added	96	20%		of energy needed		
	Direct emission reduction						
		Taxi	Official (average) car				
q	Daily distance travelled	270	49.32	km/day	PPG Team; MEMR data		
s	Annual mileage	98,550	18,000	km/yr	PPG Team; MEMR data		
t	Annual GHG emission reduction	7,179	1,735	$kgCO_2/yr$	=s*p/1000		
u	Lifetime emission reduction - car	11,655	15,418	$kgCO_2$	=t*a/s		
v	**Number of (different) cars (BEV), all stations**	**26**	**141**	per year	=ad		
w	Annual reduction per stations	185	244	tCO_2/yr	=x/af		
x	Annual reduction, all stations	185	244	tCO2/yr	=t*v/1000		
y	**GHG reduction over lifetime all stations**	**1,848**	**2,445**	tCO_2	=x*z		
z	Lifetime station	10	10				
	Charging station	**Superfast (taxi)**	**Superfast (car)**				
aa	Capacity	120	120	kW	Assumed		
ab	Batter charge time	0.3	0.3	hrs			
ac	Cars per day	30	30		Assumed		
ad	Number of different cars per station	26	141		=ac*d/q		
ae	*% BEV cars*	100%	100%				
af	**Number of stations**	**1**	**1**				
ag	Cost per station	80,000	80,000	USD	PPG Team		
ah	Cost per electric vehicle	44,000	44,000	USD	PPG Team		
	Emission reduction (direct - pilot/demos, w/solar)		**4,293**	**tCO_2**			
	Number of cars served over the station's life		**317**				
	Number of charging stations		**2**				

The technical data related to specific energy consumption, emission factor, transmission, and distribution network losses are the same for both short and long-distance vehicles as is the lifetime in terms of mileage (45,000 km). Thus, this leads to the result that the lifetime emission reduction for short-distance and long-distance 2-wheeled BEVs is the same, namely 2.25 tCO_2.

Box 24 CO_2 emissions reduction and cost estimates of reduction with charging 2-wheeled vehicles in battery swap stations

	Assumptions, 2-wheelers					
a	Lifetime km 2-wheeler	45,000	km	Otomotif net		
b	Battery manufacturing	82.5	$kgCO_2/kWh$	ICCT (2018)		
c	Battery size	1.40	kWh	Otomotiof net Gridoto		
d	Range of battery	32	km	Aim2 (2020)		
	Available energy	1.05	kWh	75% (degradation, battery reserve; operational flexibility)		
e	Battery replacement	2		Assumption		
f	Battery emissions	116	$kgCO_2$	= b*c		
g	E-bike/e-scooter manufacturing	284	$kgCO_2$	ADB (2009)		
h	Java-Bali grid emission factor (imcl. losses)	956	gCO_2/kWh	Electricity System GHG Factor (MEMR, 2019)		
i	Energy consumption (MWh/km)	0.033	kWh/km	Indonesia data; ADB e-bikes in China (2009)		
	Emissions 2-wheelers					
j	Emissions (gCO_2/km)	Gasoline	BEV		TTW gasoline	
k	- Manufacturing	6.00	6.00	= g/a	2.153	$kgCO_2/L$
l	- Battery		5	= e*f/b	0.0330	L/km
m	- Tank-to-wheel (TTW) emissions	71	32	Diesel/gasoline: GEF; Indonesia data. BEV = h*i		
n	- Well-to-tank emissions (20% of TTW)	16		18-22% of (TTW); see Hoekstra (2020)		
o	*Total emissions (gCO2/km)*	*93*	*43*	= j+k+l+m+n		
p	Difference e-scooter/e-motorcycle	50		gCO_2/km		
	Difference with solar added	58	25%	of energy		
	Direct emission reduction, 2-wheelers					
		Ride hailing	Other			
q	Daily distance travelled	135	22	km/day	Grab	
s	Annual mileage	49,275	8,000	km/yr	MEMR; PPG Team	
t	Annual GHG emission reduction	2,467	401	$kgCO_2/yr$	=s*p/1000	
u	Lifetime emission reduction	2,253	2,253	$kgCO_2$	=t*a/s	
v	**Number of (different) e-bikes, all stations**	**204**	**1,254**	per year	=ae*af	
w	Reduction per station	28	28	tCO_2/yr		
x	Annual reduction all station	502	502	tCO2/yr	=t*v/1000	
y	**Total reduction (tCO2) - life all stations**	**5,024**	**5,024**	tCO_2		
z	Lifetime station	**10**	**10**			
	Charging station, BSS	**Ride hailing**	**Other 2-wheelers**			
aa	Capacity	5.6	5.6	kW	Assumed	
ab	Number of batteries	12	12	hrs	Assumed	
ac	Batter charge time	3.0	3.0			
ad	E-bikes/scooters per day	48	48		Assumed	
ae	Number of different vehicles per station	11	70		=ad*d/q	
af	**Number of BSS stations**	**18**	**18**			
ag	Cost per station (cabinets of 12 batteries)	6500	6500	USD		
ah	Average price of EV 2-wheeler	1240	1240	USD		
		Direct emission reduction (pilot/demos, BSS)	**10,048**	**tCO2**		
		Number of e-bikes/scooters served over the station's life	**4460**			
		Number of charging stations	**36**			

Box 24 gives the details of possible emission reduction and cost calculation for a SPBKLU (public battery swap station), assuming it will exclusively serve electric motorcycles. One cabinet unit of SPBKLU contains 12 batteries. So, one battery swap station will be able to charge 48 electric 2-wheelers a day (depending on their daily mileage, this implies in the calculation that 11 different ride-hailing e-motorcycles/scooters or 70 other 2-wheelers visit the station). In the end, the emission reduction per station is the same, namely 28 tCO2 per year (this depends on the station's capacity to charge = expected GHG emission reduction per car per mileage * times mileage of the car) in the case of grid-charged stations. **Thus, the total emission of the 36 battery charging stations over their lifetime (of 10 years) is 10,048 tCO_2.**

Cost estimate of solar-powered fast charging station

It is assumed that one of the demonstration fast-charger facility is powered by solar PV. The solar PV is already installed as rooftop in the building, but it is instructive to see what the additional cost would have been, based on the assumption that the solar PV provides 20% of the energy for an 18 kW superfast charger needed during the day (when the sun shines, eliminating the need for an expensive battery pack).

Box 25 Estimate of cost of hybrid solar-grid fast charging station

	Investment costs - solar charging station (fast charger)			Assumptions	Solar PV details		
	(i) Charging station	80,000	USD		Sunshine (peak) hours	5.45	hrs/day
	Solar - base data				Module	160	W/m2
al	Percentage energy provided by solar	20%			(Jakarta)	1,990	kWh/yr/m2
am	Needed	1,140	kWh/day	=al*af	https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#PVP		
an		83,220	kWh/yr	=am*365	Area	338	m2
ao	Watt	54	kWp	=am/0.85/ak	Irradiation	671,784	kWh/yr
	Investment cost				Efficiency PV panel	16.0%	
ap	- solar panels	34,000	USD	PPG Team	Production	107,485	kWh/yr
aq	- inverter + DC breaker	1,030	USD	PPG Team	Available energy (incl. losses)	87,332	kWh/yr
ar	- civil works, rack and cables	8,000	USD	PPG Team	Size and costs		
as	- battery pack	0	USD	Assumption	Battery (130 Ah, 12 V)	200	USD per battery
	(ii) Cost solar - subtotal	43,030	USD	=ap+aq+ar+as	Solar panel	200	USD/module
	(iii) Installation, design	3,500	USD	PPG Team		320	Wp
	(Iv) Misc	150	USD	=(i)+(ii)+(iii)+(iv)		170	modules
at	**Investment cost**	**126,680**	**USD**			0.625	USD/Wp
					Losses and derating	19%	

Total cost of ownership of 2-wheeled and 4-wheeled electric vehicles vs ICE alternative

Another instructive analysis is the comparison of the lifetime cost of electric 2-wheelers and 4-wheelers (personal cars) versus the conventional vehicle (powered by an ICE, fueled by gasoline. The results are given in **Box 25.** The 'back-of-the-envelope' analysis concludes that over their lifetime an electric e-motorcycle/scooter is already competitive, in large part due to the higher maintenance cost of the gasoline bike. In the case of electric personal cars, the higher purchase price (at least 1.5 times more) still makes these more expensive in terms of lifetime cost.

Box 26 Cost of ownership and operation of electric vehicles versus ICE

Social discount rate	12%				
Fuel	0.66	USD/litre			
Electricity	0.072	USD/kWh			
Lifetime	5.6		yrs	8.9	
Battery replacement	100	USD/kWh			
TCO calculations	Electric 2-wh		ICE 2-wheel	Electric 4-wh	ICE 4-wheel
Investment cost	1,240		1,034	44,000	24,000
Resale price	-207		-34		
Battery replacement	140			3,040	
Maintenance			11		252
Annualised investment and periodic cost	299		257	11,975	6,110
Annual operating cost					
- fuel	19		175	159	992
- maintenance			32	1,100	752
Total cost (annualised over the lifetime)	**318**		**465**	**13,235**	**7,854**

Note:
The analysis is based on info provided in websites:

- http://b2tke.bppt.go.id/index.php/en/258-motor-listrik-vs-motor-skutik-eng
- https://www.globalpetrolprices.com/Indonesia/gasoline_prices/
- https://www.globalpetrolprices.com/Indonesia/electricity_prices/

and reports:

- *Total cost of ownership and its potential implications for battery electric vehicle diffusion*, by Hagman et.al in Research in Transportation Business & Management 18 (2016) 11–17
- *Estimating the total cost of ownership (TCO) of electrified vehicle in Indonesia,* LPEM-FEBUI Working Paper – 043, by Riyanto et.al. (January 2020)

Annex A. IMPORTANT STAKEHOLDERS

Stakeholder	**General role regarding energy and transport**
Ministry of Energy and Mineral Resources (MEMR)	Develop energy planning and supply, including for the transport sector
Ministry of Industry (MoI)	Developing planning for the industrial sector, including automotive manufacturing of vehicles and vehicle components, including batteries
Ministry of Transport (MoT)	Construct national transport policy and manage public transport operation and transport infrastructure
Ministry for the Environment and Forestry (MoEF)	Preparation of national policy for pollution control and environmental impact management of transport sector
Ministry of National Development Planning / BAPPENAS	Construct national development planning, including transport sector
Coordinating Ministry of Maritime and Investment	Coordinating several technical ministries, including MEMR and MoEF
Local governments	Regulate development and regional-level planning, including local transport
PT PLN	PT Perusahaan Listrik Negara is an Indonesian government-owned corporation that has a monopoly on electricity distribution in Indonesia and generates the majority of the country's electrical power
PT Pertamina	PT Pertamina (Persero) is a national state enterprise that manages oil and gas mining in Indonesia. Pertamina once had a monopoly on the establishment of gas stations in Indonesia, but this monopoly was abolished by the government in 2001.
PT IBC	PT Indonesia Battery Company, established in 2021, is expected that IBC will synergize with various global companies in the future to operate lithium battery plant for EV.
Private enterprises (i.e. BlueBird, Grab, Gojek)	Bluebird is a private taxi company Grab is a Singaporean ride-hailing company. Gojek is an Indonesian on-demand multi-service platform and digital payment technology group based in Jakarta that works with a million motorbike driver partners. Blue Bird collaborated with transportation technology company Gojek to deliver Go-Blue Bird which enables customers to request Blue Bird taxis directly in Gojek app
Ezyfast	Ezyfast is a private company for operating battery swap stations and renting out batteries.
PT Jakarta Utilitas Propertindo (JUP)	PT JUP is a subsidiary business of PT Jakarta Propertindo (an enterprise owned by the DKI Jakarta government)
BPPT	BPPT is the government's research institute on technology
P3TEK KESDM	P3TEK KESDM is the Ministry of Energy's research center for renewable energy technology