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Designing Integrated EV Charging Station to Grid Platform

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ABSTRACT

The increasing fuel prices and global warming have received worldwide attention regarding the importance of environmental-friendly utilization. Indonesia enjoys the sustainable growth of 4-5% annually also supports the growth the transportation vehicles. The incremental of transportation vehicles poses danger to the national budgets, where high subsidy allocation in national budgets is paid for fuels subsidy. To address this issue, the government has introduced many incentives and supported the use of Electric Vehicles (EVs) nationwide. Supporting EVs nationwide is not an easy task since it involves collaborating with electricity suppliers, EV resellers, and maintenance tasks associated in supply chain management. The article takes case study of a state-own energy company, ICP, that is given mandate to support the EV adoption. The outcome of the article is expected to provide a guideline for a utility company to deliver electricity to charging stations nationwide.

Key words : Grid, Integrated, Electrical Vehicles, Nozzle, Hybrid System, Supply chain

1. INTRODUCTION

Indonesia has experienced consistent economic growth of 3-5% annually [1]. The consistent growth also supports the growth of vehicles. The trend of the vehicles in national statistics (BPS) in 2022 is illustrated as below in table 1:

Table 1: Growth of Vehicles.

Type of Vehicles	2019	2020	2021
Passenger Cars	15,592,419	15,797,746	16,413,348
Public Bus	231,569	233,261	237,566
Trucks/Pickups	5,021,888	5,083,405	5,299,361
Motor bikes	112,771,136	115,023,039	120,042,298
Total	**133,617,012**	**136,137,451**	**141,992,573**

The consistent growth of vehicles faces major challenges such as: major fuel prices are still subsided by government and limited public transportation. Limited public transportation has encouraged citizens to use private vehicles with fossil fuels. Recent years, the fuel price has increased significantly and make government to spend huge budgets for fuel subsidy [2] .

To address huge subsidies, the government has provided many incentives and encouraged vehicles migration from fossil-fuels to Electric Vehicles (EVs) [2]. The use of EVs has main objectives such as: (1) to reduce government subsidy for fossil-fuel prices; (2) to reduce gas emission (air pollution); (3) to promote the use of local abundant battery resources such as nickel and cobalt. Indonesia as a largest nickel producer has encouraged major cars and battery producers to produce EVs in Indonesia. To support EV growth, the government has given a mandate to ICP, a state-owned energy company to establish EV charging stations and support the distribution of electric charging stations around Indonesia area [3]. Applying electric charging stations on a wide scale is not an easy task since many preparations need to be taken. The article takes case study of ICP to support distributing charging stations in the retailers. The retailers are selected due to their wide coverage to a large population.

2. THEORETICAL FRAMEWORK

2.1. Energy Consumption.

Based on the data of Ministry of Energy and Minerals Resources (or known as ESDM) shows that Indonesian fossil-fuel reserves only can stand for less than 10 years. The use of fossil-fuels has reached 1.5 million barrels/day, with half of them needing to be imported [2] . The trend of fossil-fuels consumption increases along with economic growth. Recent fuel prices have increased significantly and make the government to reconsider of current fuel prices and needs to promote the alternative renewable energy [4].

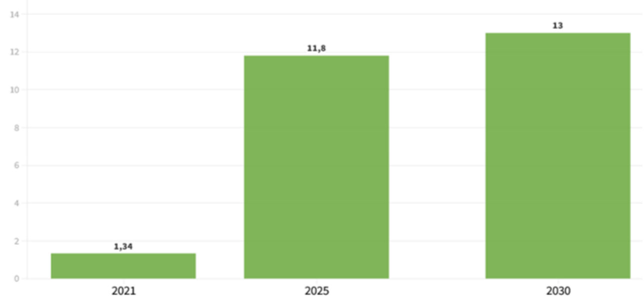

Figure 1: Projection Growth of EVs (millions) in Indonesia.

Major fuel consumption is spent in transportation, where government subsides around of 30% of fuel prices. The subsidy price may increase due to market fluctuations. For this purpose, the government has provided many incentives for EVs adoption such as major tax reduction for EVs along with their components and supporting facilities to establish EV ecosystems. Major incentives are also provided for customers that are willing to apply EVs.

In 2022, there are recorded: 22.671 EVs, comprised of 19.959 e-bikes, 2.654 e-cars, and 19.698 e-buses. Government expects the EV adoption may reach 13 million by year 2030 (Figure 1)..

2.2. Microgrid.

A Microgrid is a self-sufficient energy system (aggregator) that comprises of a group of interconnected loads and distributed energy resources. A microgrid acts as a single controllable entity that serves a discrete geographic area such as fleet model, college campus, hospital complex, business center, or household.

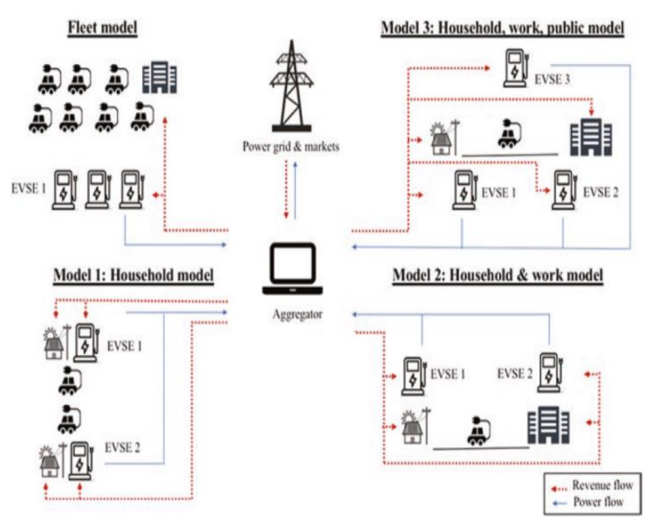

Figure 2. Potential Vehicle to Grid (V2G) revenue, pricing and power flow models [5].

Figure 2 illustrates the potential revenues, pricing, and power flow models from vehicles (charging points) to microgrid. Microgrid has three key characteristics such as:

a. A microgrid is local, means it delivers energy for nearby customers. ICP annual report shows until September 2023, the EV charging points has been established to the major cities in Indonesia such as: hotels, residentials, retailers, public transportation, banks, and government offices.
b. A microgrid is independent, means it can disconnect from central grid and operate independently. This feature suits with Indonesia area that has many remote areas and islands. Alternative electric generators can be added to microgrid to ensure smooth supply of electricity.
c. A microgrid is intelligent, means it enables to manages generators, batteries, and other sophisticated features.

2.3. Electrical Vehicles (EV)

EV has been widely promoted aggressively around the world. Although EVs have been promoted around the world; however, replacing fossil-fuel vehicles with EV needs to overcome with challenges such as [6]:

a. Lack of information. The type and quality of EVs can vary from one type to another type. There are a variety of EVs that have been introduced to the market with different batteries systems. The customer needs to have comprehensive information before deciding to buy.
b. Purchase cost. Currently, the purchase cost is still considered high compared to fossil vehicles. Customers need to make careful budget preparation to migrate to EVs.
c. Recharge station. A recharge station is an essential part to promote EVs. Currently, only major district areas are supported with recharge stations. The government has promoted the development of recharging stations in remote areas.
d. Electricity cost. Electricity supply is another factor that needs to be considered, especially with remote areas.
e. Maintenance. Although maintenance cost is relatively low for EV compared to fossil fuel station. However, the maintenance cost such as batteries recycling, and inventory can be a hidden cost for charging operator. Each operator should be equipped with enough knowledge to take care of the charging system and batteries life cycle.
f. Autonomy. Each operator microgrid and charging center should operate the station autonomously. Operator needs to make sure the uninterrupted electricity supply with several alternative sources.
g. Performance. The performance of charging stations may vary from one station to another. Microgrid operators need to ensure the stability of electricity supply and real-time data exchange between microgrids and smart grids (HQ).
h. Government incentive. Government incentive is an essential program to promote the use of EVs. Currently, the government has created an integrated supply chain from producer to end consumer, providing tax reductions for all producers, resellers, vendors, and consumers. More regulations have been introduced to ensure smooth transition from fossil vehicles to EVs.
i. Lack of models and brands. The EV industry is still in early stage, where there are few producers introduces their EV models in the market. Major car industry is still relied on fossil fuels. This condition will change in near soon, when there are many EV cars flooding the market with affordable prices.

The common specs of some EVs (Table 2)are illustrated as:

Table 2. Electrical specs of some electric vehicles [7].

Vehicle type	Manufacturer	Model	EV type	Electric range (km)	Battery size (kWh)
Motorbike	Zero	DS ZF8.5	All electric	City: 152 Highway: 92	8.5
	Harley Davidson	Lightwire		53	~10
	Brammo	Empulse		City: 206 Highway: 93	10.2
	Lito	Sora		City: 200 Highway: 100+	12
	Mission	Mission R		City: 370 Highway: 225	17
	Lightning	LS-218		275	20
Automobile	Toyota	Prius	PHEV	8	4
	Chevrolet	Volt	EREV	64	16
	BMW	i3	EV	160	18.8
	Nissan	LEAF	EV	160	24
	Toyota	RAV4 EV	EV	190	27
	Cooper	Mini E	EV	251	28
	Tesla	Roadster	EV	354	53

3. RESEARCH METHOD

3.1. EV and V2G adoption.

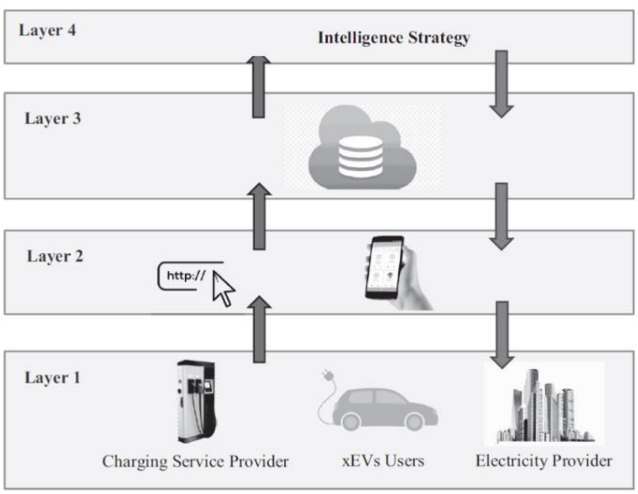

Figure 3. EV and V2G adoption framework.

The article proposes the adoption EV and microgrid or known as Vehicle to (Micro) Grid (V2G) that comprises of: (see Figure 3)

- Level 1: comprises of:
  - charging service provider. ICP targets the retailers acts as the nearest service provider to customers. ICP will build microgrids close to retailers. 1 microgrid can serve several nearest retailers (3-5 retailers).
  - xEVs users, can be motor-bikers and vehicle owners (private and public). ICP targets the major customers will be motor-bikes.
  - electricity provider, such microgrids and smartgrids (nearest trafo).
- Level 2: mobile application. ICP will integrate current corporate mobile application with microgrid and smartgrid management system (HQ).
- Level 3: cloud based access comprises of Infrastructure as a service (IaaS), Platform as a Service (PaaS), Software as a service (SaaS). Integrated cloud service has been established for integration management system: smartgrids, microgrids and charging station.
- Level 4: comprises of business case with the aims to apply intelligence strategy. This layer utilises the intelligence system that manages the integration service from grids to charging station, such as: supply and route of electricity, flow of information, and monitoring daily activity. It also supports decision making system for HQ and operator of charging station. Intelligent strategy supports maximizing business performance.

4. DESIGN

4.1. Layer 1. Charging Service Station, xEV users, and electricity providers.

The charging service station connects with microgrid computer system. Currently, there are 2 type of power supply such as: [8]

- Power 7 kW, suits with small retailers and premium residentials.
- Power 22 kW, suits with larger retailers and gas stations. It also commonly used in the malls and offices.
- Power fast charging DC 60 kW, suits with malls and offices.

The charging points are illustates below [8]:

Figure 4. Residential Home Charger Station (7 kW).

Figure 5. Medium Charging Point (22 kW).

Figure 6. Fast Charging Point DC 60 kW.

Currently, there are several services provided for customers such as:

a. Rental-buy Service.
Rental service is charged on monthly basis until 3 years.

Table 3: Rental-buy Service [8].

Manage Service	Fees/month
1 Nozzle AC 7kW	Rp. 954.000.-
2 Nozzle AC 7kW	Rp. 1.902.000.-
1 Nozzle AC 22 kW	Rp. 2.040.000.-
2 Nozzle AC 22 kW	Rp. 3.516.000.-
2 Nozzle AC Fast Charging 60 kW	Rp. 25.440.000.-

b. Purchase Service .

Table 4: Purchase Service [8].

Manage Service	Purchase price
1 Nozzle AC 7kW	Rp.14,400,000.-
2 Nozzle AC 7kW	Rp.28,800,000.-
1 Nozzle AC 22 kW	Rp.31.800.000.- (additional price for +CSMS)
2 Nozzle AC 22 kW	Rp.63.600.000.- (additional price for +CSMS)
2 Nozzle AC Fast Charging 60 kW	Rp. 534.000.000.-

The service in charging point includes:

- e-mobile platform (CSMS).
- Regular visitation and checks.
- 3 years warranty and extendable.
- Access card and RFID card (charging).
- Training service for operator.
- Helpdesk and data analysis through mobile app.
- Emergency team (24/7).

4.2. Layer 2. Mobile Application.

Currently, there are 3 schemes of charging process: offline system, hybrid system, and online system (See Figure 7).

Figure 7. Offine, Hybrid and Online System [8].

Those 3 systems are supported in the mobile application. Any business partner can apply to be an electricity charging reseller through mobile application. The process takes 3 days to complete.

4.3. Layer 3. Cloud Service.

The ICP mobile application is supported with integrated cloud services (IaaS, PaaS, and SaaS). The cloud service ensures smooth access for all stakeholders and end-to-end monitoring system to ensure the stability of electricity supply.

4.4. Layer 4. Intelligent Strategy.

The intelligent strategy is managed by HQ staff to minimize operation costs in each charging stations, provide data analysis to management, manage electricity and information routing in grids to ensure sustainability of electricity supplies, and maximize profits/revenue outputs through efficient programmes.

Table 5:. Business Case of Charging Station [8]

Assumption	**1 Charging Station Costs (Bundling EV)**
Financial model (return)	3 years
Depreciation (Fixed)	5 years
WACC-1	12.37
CapEx (Capital Expenditure)	
• EV batteries	Rp.89.500.000.-
• Charging apparatus (SPBKLU)	Rp.30.000.000.-
OpEx (Operation Expenditure)	
• Maintence tasks	7.59%
• Staffs Expenses	10.52%
• General Affairs	5.56%
• Marketing	0.94%
• Insurance	2%

Table 6:. Brief financial analysis for 1 charging station [9].

Total OpEx for 3 years	Rp.158.696.888.-
Total CapEx for 3 years	Rp.119.500.000.-
WACC	12.37%
NPV	13.799%
IRR	21.18%

The entire EV digital service that has established for the wide coverage as illustrated [9]: (See Figure 8)

Figure 8. EV Digital Service.

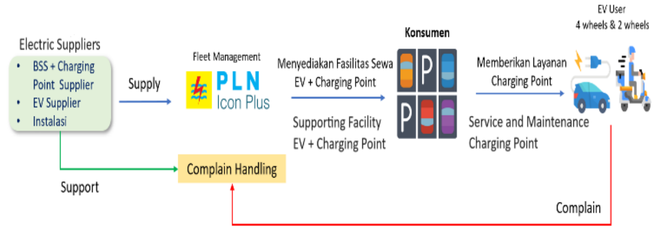

Figure 9. High Level Architecture EV Service Management [9].

Figure 9 show high level architecture EV service management as follows:

1. Electric suppliers provide electricity to ICP such as microgrid installation. Electric suppliers can come from multiple sources including renewable energy suppliers. All business arrangements are conducted through cloud service and HQ (Layer 3 cloud service and 4 intelligence strategy).
2. ICP operates and manages electricity delivery to each charging station. ICP installs charging stations on the customer premises. Customer premises can be retailers, residentials, gas stations, malls, and offices (Layer 2 mobile app and Layer 3 cloud services).
3. ICP through mobile app provides services to consumers including technical services (Layer 2 mobile app).
4. Whenever there is a complaint, customers can call through mobile app and is recorded as complain handling status in cloud service (Layer 1 charging premises, Layer 2 mobile app, and Layer 3 cloud service).
5. All reports will be submitted to HQ for further analysis and for further improvements (Layer 4 Intelligence Strategy).

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