Additional functions of Electric Vehicle on grid as storage support system

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Abstract. Indonesian grid electricity can be better with the contribution of electric vehicles (EV). EVs have electrical energy storage, which can store a load or electrical energy in a certain amount. EV already has a good charging system and charging type that requires a short amount of time. The vehicle to grid (V2G) charging system allows EV to be able to charge the battery as usual, and channel the energy in the EV battery to grid. The electricity grid has a system to keep the frequency at a nominal 50 Hz. EV functions in harmony with the connected reserve used in primary frequency regulation. Primary frequency regulation will be active with a frequency of ± 0.06% of the nominal frequency used. Utilization of EV can be used for load levelling in West Java grid load. Load levelling and peak cut threshold with the conditions made to get the smallest calculation amounted to 37.82MWh and 3182.30MW, with these two calculations EV has good potential to help the network.

1. Introduction
Electric vehicles (EV) are known as environmentally friendly vehicles, because EV has a hybrid system and full electric power that produces less emissions than conventional vehicles, EV also has a more flexible source of energy than fossil fuel vehicles [1,2]. EV can be a solution to maintain grid quality. V2G (Vehicle to Grid) technology that helps EVs to connect to the grid [3–5]. Indonesia’s electricity system now adopts an interconnection system [6]. Interconnection systems can combine electricity from one grid to another, for example, existing transmission grids with generator networks, or interconnection systems can unite one power source with another electricity source.

Habit of charging and discharging EV can affect the load on the grid, and can make the distance between the valley load and the peak load can be greater [7–9]. The V2G adoption in Indonesia can add the use of EV in addition to transportation needs as well as grid support systems. V2G capability allows EV to have ability to receive electrical energy from the grid and provide electrical energy to the grid, illustrated in figure 1 [10,11]. V2G regulates the charging time and EV battery usage [12,13].
Figure 1. Basic scheme of the V2G charging system.

2. Method of analysis

This study was simulation relationship between electric power grid and electric cars. This study aims to develop an EV function that can be used to maintain grid frequency quality. This study uses data of load, the data used is taken from PLN P3B project in the West Java Region.

EV will be assisted with a V2G charging system. EVs that are connected to the charging system will have the opportunity to channel energy to the grid. The filling and releasing activity can follow the grid dead band frequency ± 0.06%. Charging and discharging activities are affected by EV adoption and V2G participation. EV adoption and V2G participation have several needs to be used on the Indonesian electricity grid. EV adoption uses information from Indonesian vehicle data and assumptions to support the calculations made by the author, along with the assumptions used

| Number of vehicles       | 15924034 |
|-------------------------|----------|
| Average charge capacity (Kw) | 6       |
| Charger loss/pass       | 5%       |
| EV battery capacity (KWh) | 40      |
| Average charging and discharging | 50% |

2.1. Utilization of EV

The assumptions shown in table 1 can be used to find the amount of EV capacity, and the amount of electrical energy in EV. Total EV Capacity can be searched assuming the number of vehicles with an average charging capacity. The amount of electrical energy in an EV can be sought by the number of vehicles, battery capacity and average charging and discharging. The amount of EV capacity and the amount of electrical energy in EV can calculate load levelling and peak threshold. The initial peak threshold is used as a load threshold, and it is obtained from the load data 1 year earlier, then the load levelling is obtained from the load calculation, EV adoption, and V2G participation. This levelling threshold and peak threshold can indicate the potential use of EV as a support system [14].
3. Results and discussion

Indonesia's electricity system uses a 50 Hz frequency. Indonesia's electricity system is equipped with frequency regulation to maintain frequency conditions, primary frequency regulation will be active if there is a dead band ± 0.06% of the nominal frequency. Primary frequency regulation will use governor free and connected reserve. EV can help regulate primary frequency by being connected storage.

EV support system can be calculated by utilizing loading. The result data utilizes loading by calculating potential load levelling and peak cut threshold, to calculate load levelling and peak cut threshold must have the amount of EV capacity, and the amount of electrical energy in EV. Calculate the amount of EV capacity and the amount of electrical energy in EV obtained from processing assumption data.

3.1. Total EV capacity and amount of electric energy in EV

The assumptions listed in table 1 are used to find the amount of EV capacity and the amount of energy in EV. EV user conditions and battery depth that can be used for V2G participation need to be made, these conditions are made in table 2.

| EV Adoption | V2G Participation |
|-------------|--------------------|
| 5%          | 5%                 |
| 5%          | 20%                |
| 5%          | 35%                |
| 5%          | 50%                |
| 20%         | 5%                 |
| 20%         | 20%                |
| 20%         | 35%                |
| 20%         | 50%                |

Conditions for EV adoption and V2G participation are made from the total number of vehicles in West Java that are assumed to be EV, V2G participation uses the state of the EV battery used, the depth of participation is set according to conditions. Setting the number of EV adoptions and V2G participation is done to show the potential generated from several EVs, the depth of V2G charging and releasing needs to be regulated to show effective results. EV adoption is divided into 2, made into 5% and 20%, V2G participation is set to 4 conditions, this condition is 5%, 20%, 35%, and 50%, the maximum depth of V2G participation is 50% because it does not want to eliminate the EV function as a means of transportation. The biggest combination is 20% EV adoption and 50% V2G participation. Conditions can be used to show the potential comparison of each condition, this condition is also used to find the amount of EV capacity and the amount of electrical energy in EV [15].
The potential amount of EV capacity and the amount of electrical energy in EV is shown in table 3. EV storage is used to store grid power if it is connected to the V2G charging system. The V2G charging system can make energy direction from the EV battery to the grid, thereby helping the grid have a more stable load. Maintaining the stability of the grid load can affect the stability of the frequency, so EV can keep the frequency stable at 50 Hz [16].

The grid currently uses an interconnection system. Generations that enter the interconnection grid will be connected to a wider coverage area, as well as connected to each load that enters the interconnection grid. The wider interconnection grid area makes the load unequal to generation, EV connected to the V2G charging system can channel its energy to meet the load demand on the grid. EV helps the grid in accordance with the amount of electricity stored in the battery and the condition of the depth of V2G used, the results of the calculation of the amount of electrical energy in the EV can be used to calculate the amount of load levelling [17].

The amount of EV capacity and the amount of electricity in EV is strongly affected by the conditions of EV adoption and V2G participation written in table 2. The combination of the smallest conditions amounting to 5% EV adoption and 5% V2G participation, can produce a total EV capacity of 226.92 MW, and the amount of electrical energy on EV is 756.39 MWh. The biggest combination of EV adoption is 20% and V2G participation is 50%, then the total capacity of EV is 9076.7 MW and the amount of electrical energy in EV is 30255.66 MWh. The combination of EV adoption and V2G participation proved to greatly affect the results of the calculation of the amount of EV capacity and the amount of electrical energy in EV.

3.2. Load threshold
EV that is ready to help the grid will be installed with the V2G charging system. Threshold are important for charging and discharging energy, to avoid increasing the distance between the valley load and the peak load. The limit used for charging and releasing is the peak cut threshold. Peak cut threshold is defined as the amount of energy that has been purchased in the past and can be used as a limit. Peak cut threshold is obtained from load data 1 year ago with the same date. This study uses the peak cut threshold as a limit on the ability to do load levelling loads.
Table 4. Peak cut threshold.

| EV Adoption | V2G Participation | Peak Cut Threshold |
|-------------|-------------------|--------------------|
| 5%          | 5%                | 3182.30            |
| 5%          | 20%               | 3168.12            |
| 5%          | 35%               | 3153.94            |
| 5%          | 50%               | 3139.76            |
| 20%         | 5%                | 3168.12            |
| 20%         | 20%               | 3111.39            |
| 20%         | 35%               | 3054.66            |
| 20%         | 50%               | 2997.93            |

The amount of EV capacity can reduce the peak cut threshold, the peak cut threshold that originated from hierarchical data 1 year ago. Peak cut threshold with the smallest and largest combination of 3182.3 MW and 2997.93 MW, as written in table 4. The combination of the greater conditions makes the number of peak cut thresholds decreases. A reduced peak cut threshold explains the demand for electrical energy in the grid to be reduced [15].

3.3. Load levelling
The installed load for each region has a different daily load pattern. Load fluctuations can occur more than once a day, high load fluctuations result in distances between valley loads and high peak loads as well. This distance between peaks and valleys can be reduced by load levelling. Load levelling uses several EVs that are connected to the V2G charging system to store electrical energy, if the grid needs an additional source of electrical energy, EV can provide energy from the battery. Technically, load levelling is to fill the valley below the peak cut threshold and cut the peak at the top of the peak cut threshold. The depth of battery participation and the amount of electrical energy on the EV can affect the amount of load levelling. The amount of load levelling that can be seen is a comparison between conditions in table 5.

Table 5. Load levelling.

| EV Adoption | V2G Participation | Maximum Load Levelling |
|-------------|-------------------|------------------------|
| 5%          | 5%                | 37.82                  |
| 5%          | 20%               | 605.11                 |
| 5%          | 35%               | 1853.16                |
| 5%          | 50%               | 3781.96                |
| 20%         | 5%                | 151.28                 |
| 20%         | 20%               | 2420.45                |
| 20%         | 35%               | 7412.64                |
| 20%         | 50%               | 15127.83               |

Table 5 provides a comparison of load levelling between conditions. The condition of adoption of EV 5% and 5% V2G participation will get 37.82 MWh for load levelling. The amount of load levelling can be increased by increasing the EV adoption conditions and V2G participation. the greatest combination of conditions can get 15127.83 MWh [18].

4. Conclusion
Electric vehicles (EV) can help the electricity grid by regulating the load. EV uses batteries to absorb excess electrical energy, and to channel if the grid lacks electrical energy. vehicle to grid (V2G) charging system helps EV to charge and release electrical energy. EV connected to V2G can help the
grid in primary frequency regulation, which will be active if the frequency changes by ± 0.06% of the nominal frequency used.

EV potential can be seen by using load calculations. The load calculation involves the amount of EV, the average energy capacity of the EV battery, the average charging capacity, the average usage and charging capacity, along with the losses experienced during the charging and discharge process, the five factors can be used to calculate load levelling and peak cut threshold. The first combination of conditions can produce load levelling 35.63 MWh and can reduce peak cut threshold to 3724.41 MW. Increasing the combination can increase the amount of load levelling and reduce the number of peak cut thresholds. Both results of the calculation of the potential that can help the network.

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