# A Concept of Developing Microgrid and Virtual Power Plant towards Grid Utility for the Better Electrification in Indonesia

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**Abstract**. In order to alleviate the stressful tension caused by the imbalanced power flow along the transmission and distribution feeders, the electric power utility in Indonesia may want to implement the trends of microgrid and VPP. As a result, the goal of this study is to develop a paradigm that captures the trend of implementing microgrid and virtual power plant (VPP) in order to improve the better electrification in Indonesia.

**Keywords:** microgrid; virtual power plant; electrification**.**

## 1 Introduction

Current power plants in Indonesia according to the report of Indonesia Energy Transition Outlook 2023, still dominated by coal [1]. Additionally, the grid utility is still very convinient while, the trend of distributed generators (DGs) such as solar PV system, wind power station, hydro-electric, and diesel/petrol generators are interconnected to the grid is booming. As the results, the power flow along the feeder from power plant to the consumer side become extremely imbalanced. The trend of microgrid and VPP are two options that can be considered to implement towards the electric power utility in Indonesia to overcome the hectic anxiety condition of imbalance power flow along the transmission and distribution feeders. As for this reason, this paper aims to generate a concept that describe a trend of impelemnting microgrid and VPP toward the better electrification in Indonesia.

Before the discussion regarding microgrids and virtual power plant (VPP) continue, let us firstly consider the distributed energy resources (DER). As commonly known, anything that can supply energy to the grid is considered as DER, as it simple, the installed of renewable energy generator in one household, has automatically become a DER. DER, which are built nearby users, seek to improve the efficiency and security of the energy supply. The mechanisms must be created with goals in mind for this to happen. Therefore, a complete understanding of the local demand for heat and power in


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relation to the central supply is necessary for an optimum supply model. Decentralized supply can take many different shapes and can serve any area, from a small town or village to a sizable metropolis. Power demand can be calculated using load profiles [2]. As it is observed, the features of DER that include its system, load and storage, say that it is conventional dispatchable (synchronous generators), non-dispatchable (renewables), and new dispatchable (renewable plus output power smoothing storage). While its loads are both non-controllable and controllable (demand management). Its storages are both response and capacity characteristically [3]. DER include the following types of embedded generators, namely, turbines-gas, wind, hydro-electric, photovoltaic (PV) system, diesel/petrol generators, energy storage system, vehicle to grid system, co-generation and other renewable energy generating system. DERs usually refers to smaller-size generation units or distributed mainly in distribution systems, and concentrated mainly closer to the loads [3].

However, for further development of DER, it comes the smartgrid. A microgrid is a small physical grid with interconnected loads and distributed energy resources within clearly defined electrical boundaries. The microgrid can connect or disconnect from the grid with a defined common point of coupling [4]. Though smartgrid is a collection of several power plants that connected through the line, the major investment in a microgrid is on its DERs. In other words, it cab be said that microgird is interconnected networks of loads and resources (DERs), and also high penetration of renewable energy resources [5].

The consideration of implementing Virtual Power Plant (VPP) through the exisisting utility system can be seen from these two examples. As it states on the website of Western Power, the developed program namely, Project Symphony. Project Symphony is an innovative pilot project designed to 'orchestrate' approximately 900 DER assets across 500 homes and businesses in the Southern River area s of Atwell, Harrisdale and Piara Waters into a VPP. The VPP then aggregate the electricity generated by the DER and dispatch excess supply to the network in the same way as a traditional power plant [5]. Another example of implementing VPP can be found on the website of Schneider Electric. There is a study case which has been developed namely, VPP: Solution to Utility Concerns on Integrating Distributed Residential Solar and Storage [6].

The rest of the paper is arranged as follow. Section II describes the proposed concepts of developing microgrid and VPP to the Indonesian's grid utility. The final section concludes the drawback of proposed concepts to the Indonesia's grid utility.

## 2 Proposed Concepts

### 2.1 Indonesia Current Grid Utility

Conventional grid utility in Indonesia are very common, consisting of power plant, transmission line, distribution line and consumer's side. Fig. 1 illustrates the current grid utility in Indonesia.

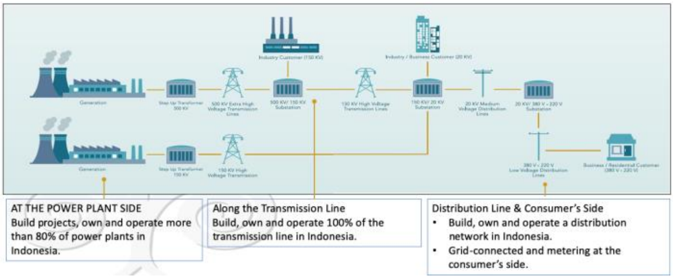


**Fig. 1** Current Electric System in Indonesia [7].

This kind of electricity system is applied to most of Indonesia's pronvince that lies within the archipilago. The ratio of the electrification of the installed capacity for each province as per December 2018 and until the second quarter of 2019 is 98.30%. and 98.50%, respectively. it means that most of the Indonesia's province has already been electrified. The electrification throughout the Indonesian archipelago and its ratio is illustrated in Fig. 2.

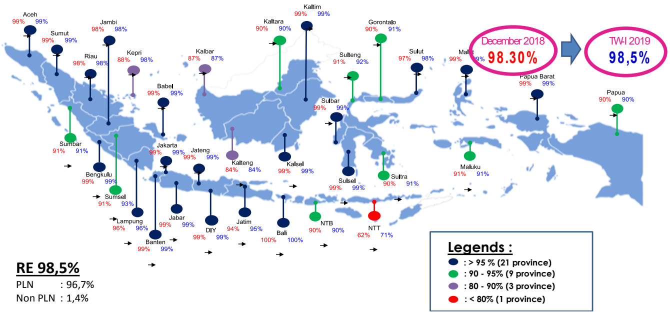


**Fig. 2** National Electrification Ratio per 2019 [7].

Along the transmission and distribution line, nowadays many DGs are connected. Since the use of renewable energy sources such as sun's irradiance, wind speed, river's debit and geothermal heat as functioned and produced clean and environmetal freandly electricity through such systems. Certainly these circumtances create imbalanced three-phase system. due to overcome such circumtances, the microgrid and VPP are best solutions.

## 2.2 Proposed Microgrid Concept

Indonesia is a country that has many natural resources such minerals, oil and gas that can be converted to electricity. Though those natural resources are mostly less, then the renewable energy resources are functioned as the sources of clean and environmentally friendly electricity. Both electricity systems, conventional, which is originally from natural resources and DGs-interconnected, which is originally from the renewable energy resources, can supply the consumer's electric energy and fulfill the proper voltage profile limit as the Indonesian standard of voltage profile limitation (±10%).

Fig. 3 illustrates the portion of renewable energy power plants in Indonesia. Fig. 4 illustrates the proposed concept of microgrid system throughout Indonesia grid utility.

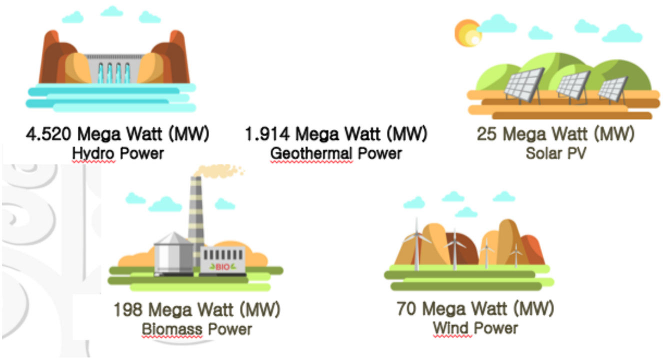


**Fig. 3** Various of Renewable Energy Power Plants in Indonesia [7].

To meet the electricity demands of its users, a microgrid must have a generation source.

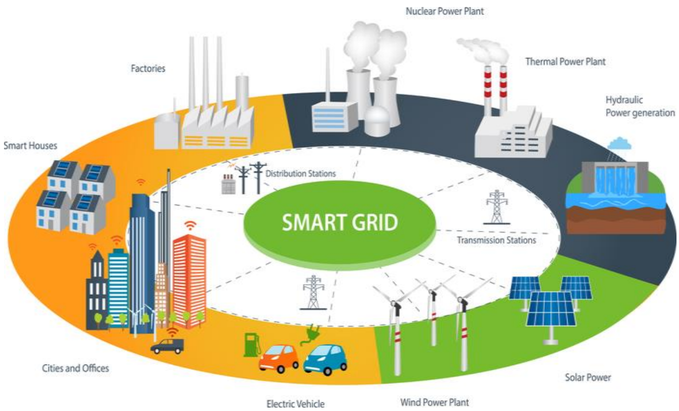


**Fig. 4** Proposed Concept of Smartgrid throughout Indonesia Grid Utility.

A microgrid generally operates while connected to the grid, but importantly, it can break off and operate on its own using local energy generation in times of crisis like storms or power outages, or for other reasons. Moreover, microgrid can be powered by distributed generators, batteries, and/or renewable resources like solar panels. Depending on how it's fueled and how its requirements are managed, a microgrid might run indefinitely.

A microgrid not only provides backup for the grid in case of emergencies, but can also be used to cut costs, or connect to a local resource that is too small or unreliable for traditional grid use. A microgrid allows communities to be more energy independent, in some cases, more environmentally friendly. Microgrids are capable of becoming electrically isolated from the grid in the event of an outage.

### 2.3 Mathematical model of VPP

Due to serve optimal operation, the feasibility analyzation the of implementing VPP, through a grid or even a large-scale grid, an algorithm, which consists of a mathematical model of decision process can be done by using competitive bidding strategy as mentioned in reference [8].

### 2.4 Proposed VPP Concept

A VPP gets its power from a pool of DERs spread across the network, usually solar panels and batteries connected to homes or businesses that generate and store energy from the sun. So, VPP is somehow a portfolio of DERs from multiple customers (known as aggregated DER) become available to provide services to the energy market when required.

Using smart cloud-based technology, a VPP can behave similar to a single traditional generator. As this kind of network is virtual, the system can quickly monitor, control and balance electricity demand, supply and storage in response to changing household needs. VPP is one of the best way one can integrate the grid with renewables, maximize grid efficiency and make energy more affordable for customers. Fig. 5 illustrates the proposed VPP into the Indonesia grid utility. This proposed concept is an adopted system that has already implemented in Australia [4].

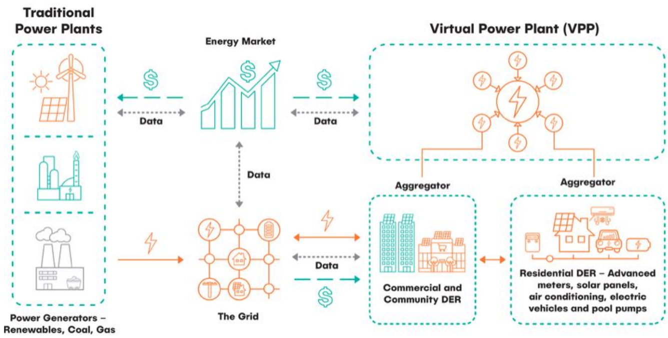


**Fig. 5** Proposed Concept of VPP.

## 3 VPP Through Indonesia Grid Utility Infrastructure

As VVPs are incorporated into the utility's infrastructure, they place more stress on an electrical infrastructure that, in many cases, is approaching the end of its design life and was not designed to meet today's needs for transmission and distribution reliability and efficiency. Given these problems, utilities are under pressure to discover cost-effective solutions to offset the effects of renewables and restructure their business models to capitalize on distributed production through better, faster, safer, and more profitable grid and asset management. To overcome these issues, forward-thinking utilities are increasingly embracing the concept of customer-sited integrated solar plus storage that can be aggregated and controlled by the utility. As the matter of fact, VPP itself could be one of the data acquisition tools for PV energy forecasting [9].

Considering several facts that are stated in [10], the utilization of VPP becomes crucial in Indonesia. Operational system of VPP is addressed to trade, energy balancer, and system-of-interests-based network (SoI). In other words, by utilizing a unit of available DER, a storage device, and regulated energy needs, this system is designed to serve as an energy balancer in the short, middle, and long terms. Using a rotating generator, a capacitor, and fast batteries, VPP is able to provide the primary control with the seconds of time it needs. The construction of a spare DER unit for few minutes and lowering demand to a more manageable power load for several hours during shaky electrical power recovery are two additional controls that the virtual power plant is good for. The simplify of VPP model that could be developed through the infrastructure of Indonesia grid utility is illustrated in Fig. 6.

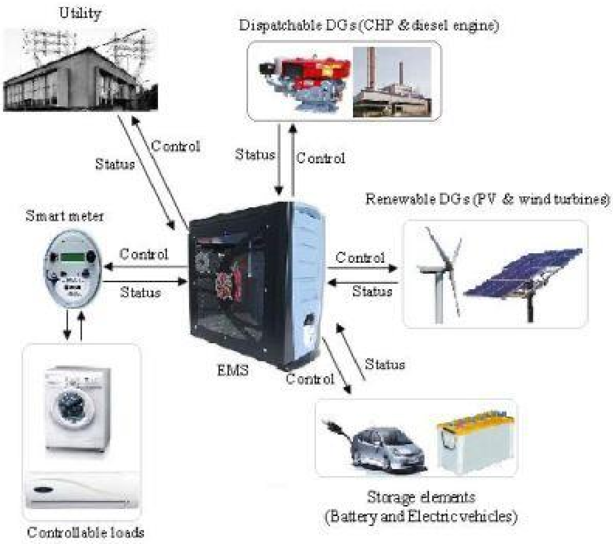


**Fig. 6** Simple VPP Concept through Infrastructure of Indonesia Grid Utility.

For the large scale of grid utility, and after conducting a feasibility analysis, VPP is able to interact using the bidding algorithm as follow.

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Comparing VPP internal electricity price with large grid
electricity price


Initialization

VPP internal electricity price = Pn

large grid electricity price = Pgrid
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Market principle price = Pclear

Large grid power purchase price = Ppurchase


If Pn < Pgrid, then Pn = Pgrid


Remaining power generation is sold to large grid in Large
grid purchase price

If Ppurchase < Pn < Pgrid,then

Pn = Pclear

If the load is insufficient, purchase electricity from
the big grid

If Pn > Ppurchase, Pn = Ppurchase.

If the load is insufficient, purchase electricity from
the big grid
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## 4 Conclusion

The microgrid and VPP trends are two approaches that can be explored for implementation towards the electric power utility in Indonesia to solve the stressful anxiety state of imbalanced power flow along the transmission and distribution feeders. As a result, the purpose of this article is to construct a concept that describes a trend of implementing microgrid and VPP to improve electrification in Indonesia. Overall, VPPs are a critical component of the future energy system, helping to improve efficiency, and integrate renewable energy sources.

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