ENERGY STORAGE SYSTEM FOR MINI-GRID AND OFF-GRID ELECTRICITY ENERGY SOLUTION CONCEPT (INDONESIA CASE STUDY)

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BACKGROUND:

The up and down of electricity energy demand in a country will directly related to its economic growth. The impact in electricity energy demand could signify to the increase of carbon emission to the atmosphere especially if the electricity energy produced is done through fossil fuel power generation facilities that will significantly contribute to the climate change effect.

If in every 1MW of electricity energy saved is equal to 1MW electricity energy produced then we might have a simple solution to answer the need of energy demand but at the same time reducing the emission of carbon to the atmosphere. Today, we produce electricity through many means by using coal, diesel fuel, hydro, wind, solar ray and others as fuel to power the electric generator. A power plant such as hydro power plants usually will use a hydro turbine to power the generator that is designed to produce electricity by its maximum capacity, as the flow of water will be flowing continuously to the turbine. That means that during low demand of electricity supply, hydro power plant will produce a redundant electrical energy. Such waste of electricity energy must be able to be stored and release when the demand comes.

The idea of storing electricity energy is not new but utilising storage to work as it is a power plant to answer the rise of electricity demand without adding new power plant for peak time is something that must be tested and proven.

Today, there is more then one way to store energy. Many people use batteries but there are some other creative ideas being develop to store energy using other means such as compressed air, thermal storage and others.

This paper will discuss about the possibility of utilising energy storage system to store energy especially electricity energy based on the confirmed challenge of the Government of the Republic of Indonesia to provide additional 35GW of electricity power generation within the next 5 (five) years (2014 – 2019) to provide a possibility of above 7% GDP growth and has to be produced mostly by renewable energy.

Republic Indonesia is a fast economic growing country, an archipelago country that has about 17.000 islands during low tide that does not have a National Electricity Power Grid due to its geographic position. Indonesia has been enjoying an average of about 6% economic growth in the last 10 years that affect the increase of middle-income class. For the last 3 years, Indonesia affected by the slowing down world economy that slows down the grow to an average of 5% the most.

In order to avoid the economic middle-income class trap, the Government must be able to provide a steady grow of economy beyond 2020 by 7% and up. Unfortunately the ratio for Indonesia on GDP growth against electricity energy is 1:2. Means that to increase 100% of its GDP, Indonesia must produce 200% of its electricity capacity.

Unfortunately, installing power plant is not that simple and quick especially for the new and renewable energy power plants that could take at least some years of development. Indonesia which lies on the ring of fire has the largest reserved of the earth heat that should be develop as geothermal power plants however, the development may take 5 to 6 years. As a country that lies geographically in the middle of the equator, Indonesia gets two types of climate seasons, that is dry seasons and wet seasons. With plenty of rains and water flowing from its highlands, Indonesia enjoys a good stream of flowing rivers and natural dams to produce electricity through hydro power plants. But yet again, the development of a hydro power plant could also takes several years. On the other hand, plenty full of solar ray during dry seasons may only be useful during daylight and need a means of energy storage to preserve the electricity produced during day time to be used during night time.

Combining the use of energy storage system within the electrical grid system can be use to store electricity produce that maybe wasted during off-peak time especially from sources like the hydro power plants; in the time of electricity demand increase, those electricity energy stored can be released to add the increasing needs without any worries of additional carbon emission released to the atmosphere.

MINI-GRID and OFF-GRID ELECTRICITY SYSTEMS:

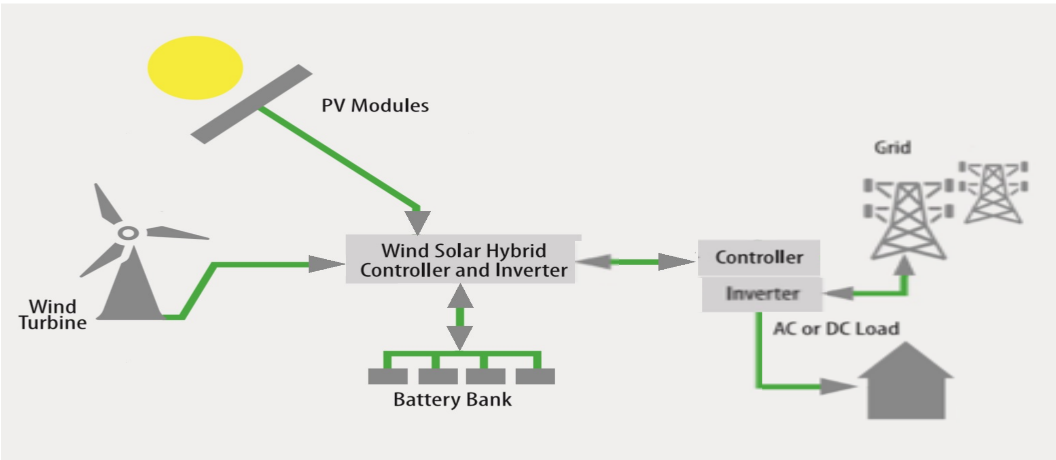
In electricity utilisation, off-the-grid electrical system is a system designed to function without the support of remote infrastructure like a single household usage whereas mini-grids system is designed typically to provide a smaller community. As a country that has no National Grid, the idea of developing electrical grid system will always goes back to either mini-grid or off-grid style.

Electrical power can be generated on-site from fossil fuel or from renewable energy sources that may include energy from solar ray, wind, mini and micro-hydro, or even from geothermal. By installing energy storage system such as batteries, energy produces maybe preserved until the time required to be released.

ENERGY STORAGE:

Electricity maybe generated by burning fossil fuel as the feedstock or also by the means of renewable energy. The electrical systems are divided into five parts; power generator, transmission, sub-station, distribution and last mile end-user. Electricity produced from a power generator streamed through the transmission line to high voltage sub-station then transformed to lowering down the voltage at the electricity sub-station before discharging through distribution channels to the last mile end user.

Electrical system may also utilise batteries to store electricity energy. Storage system often used to improve efficiency of energy utilisation and at the same time provides better voltage current stability of the electricity supplied. Electricity energy storage today not only done by building hydro dams or using batteries, high compression tanks too could be used to store compressed air. Some other means of energy storage that can be easily converted to produce electricity as examples are; the flywheel energy storage, gravitation energy storage and thermal storage.



Picture 1. Grid, Mini-Grid and Off-Grid Energy Storage System Illustration

INDONESIA ELECTRICITY LOAD:

Electricity load is divided by type of usage and time of usage. The load requires a power supply of a particular type of plant to meet the criteria of technical and economical supply of electricity supply. .

In Indonesia, electricity load is defined as;

1. Base Load, which forms an average load that occurs about 24 hours per day.

2. Medium Load is the shape of continues moderate changing loads. This type of load occurs approximately 14-18 hours per day.
3. Peak Load, is the type of load change with a sharp turn around. It occurs in about 6 hours per day. In the West Java region peak load could occurs around 12 hours a day considering the region's percentage of electricity consumption for industrial and commercial are relatively the highest in the Java-Bali electricity power grid.

<u>OBSERVATION AND DESK STUDY:</u>

An earlier observation and desk study were done to;

1) Calculate the fulfilment of peak load electricity with energy storage systems compared with Diesel Power Plant, Gas Fired Power Plant, and Gas Fired Combine Cycle Power Plant.
2) Determine the reduction of exhaust emissions from the energy storage system.
3) Prove that by combining power plant with energy storage system could meet the direct current increase of electricity demand.

The observation and desk study is limited on using battery as the main source of energy storage. The concept design economic of scale is only truly done.

<u>THE RESULT:</u>

2015-2025 Electricity Load Demand Analysis;

Energy storing mechanism (for the case of battery as storage; Battery Management System - BMS) is very important, as this will decide the success of storing the electricity energy wanted efficiently. The system controls the way electricity energy is stored and distributed to the grid and maintaining the balance of storing and releasing the energy to avoid an over-drain and overcharge off the battery.

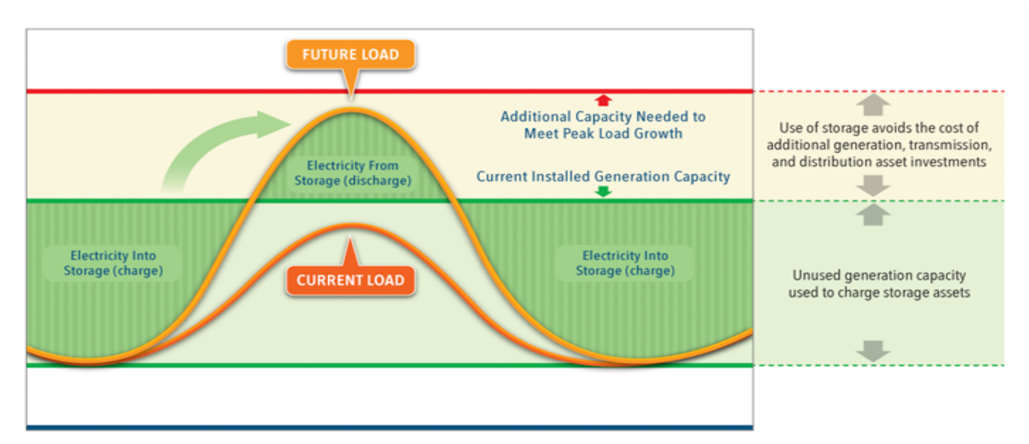
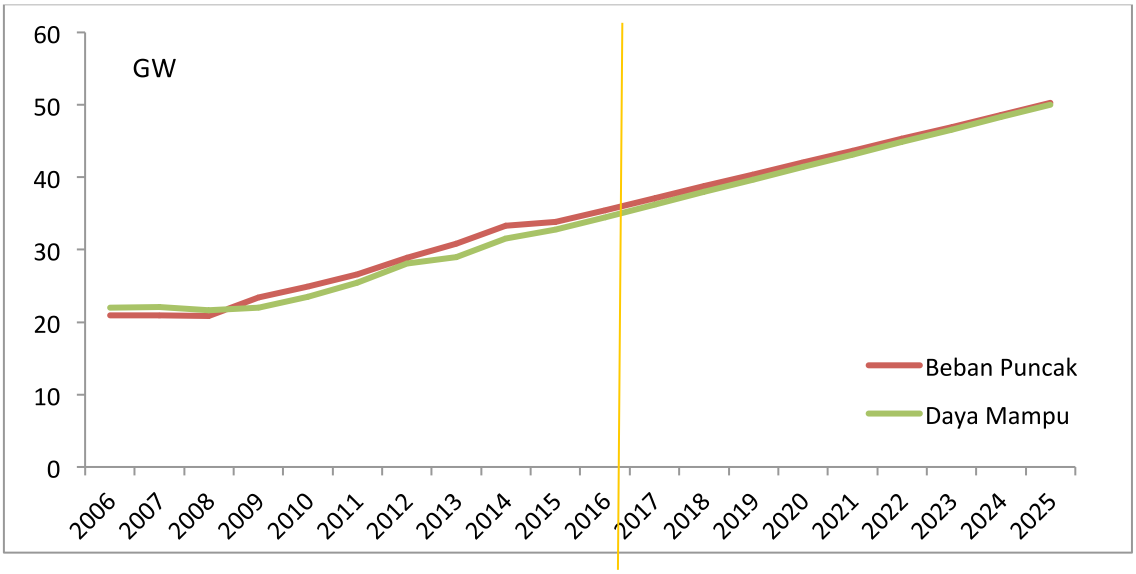


Figure 2. Energy Storage System Load Illustration

Based on PLN (Indonesia Power Company) peak load statistics, the electricity energy demand goes up to about 33.3 GW which has exceed the capability of electric power generator capacity of 31.5 GW that in many situation resulted in blackouts.

The current chosen solution of PLN is to supply the peak load demand with their standby diesel power generators, gas or steam power. The exercise has increased the carbon emission and the electricity production cost is not cheap.

Tabel 1. 2010-2025 Peak Load (red) vs Power Ability (green) Prediction



In 2006-2014, due to the economic growth in Indonesia, the average peak load is growing higher about 5%. That is about 1% higher then the true electricity supplied capacity every on going year.

To answer the increasing electricity peak load demand, the Indonesian Government has the ambition to establish the development of 99% electrification for the whole Indonesia by 2019. That will reduce the electricity deficit of 1.05GW to 0.22GW.

In the same target year, if Diesel Power Plant (DPP) is the choice of solution then Indonesia must have DPP with the capacity of 15,06 GW. An option to utilize energy storage system is seen. If Energy Storage System is used, it needs only an installation of 8,2 GW.

Table 2 shows the budget comparison for DPP, ESS, GFPP and GFCCPP development spending year 2015-2025.

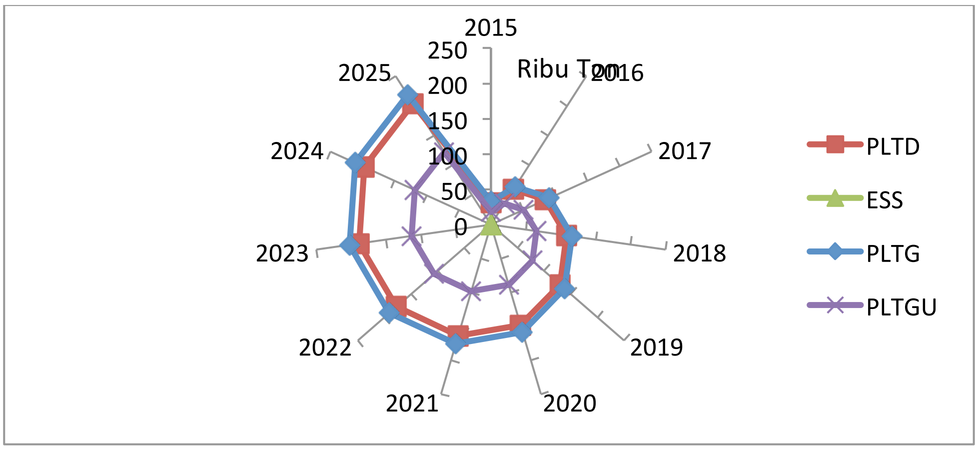
Table 2. 2015-2025 Power Plants Development Cost Illustration.

YEAR	DEVELOPMENT COST (USD$)			
	DPP	ESS	GFPP	GFCCPP
2015	1.404.232.804	743.417.367	1.316.468.254	2.106.349.206
2016	1.292.613.757	684.324.930	1.211.825.397	1.938.920.635
2017	1.180.994.709	625.232.493	1.107.182.540	1.771.492.063
2018	1.069.375.661	566.140.056	1.002.539.683	1.604.063.492
2019	957.756.614	507.047.619	897.896.825	1.436.634.921
2020	846.137.566	447.955.182	793.253.968	1.269.206.349
2021	734.518.519	388.862.745	688.611.111	1.101.777.778
2022	622.899.471	329.770.308	583.968.254	934.349.206
2023	511.280.423	270.677.871	479.325.397	766.920.635
2024	399.661.376	211.585.434	374.682.540	599.492.063
2025	288.042.328	152.492.997	270.039.683	432.063.492

Carbon Footprint

US Environmental Protection Agency (EPA) has made a threshold measurement for power plants, 500 kg CO_2 per MWH. Table 2 describe the anticipated carbon emission prediction produced by DPP (PLTD), ESS, GFPP (PLTG), GFCCPP (PLTGU) based on calculation of EPA threshold.

Table 2. Anticipated Carbon Emission Production



Based on EPA threshold assumption, for the similar MW produced, it is anticipated that the carbon emission produced in 2025 by DPP is 1.49MT, by GFPP is 1,59MT and by GFCCPP is 0,89MT. Those numbers are not small and may contribute to the increase of the earth temperature that might contribute to the climate change.

On the other hand, power storage system that will work like a power bank will release no extra carbon emission thus will help in providing better and greener world for the future generation to have much better living.

SUMMARY

- Indonesia would only need at least an extra 8,2GW as an example to cope with every increase of the energy demand today if Energy Storage System is chosen to compare with 15.6GW need to be produced by Diesel Power Plant.
- Based on the study exercise done, in long run, the Energy Storage System will help to prevent climate change.

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