Challenges of decarbonizing electricity in Indonesia: Barriers in the adoption of solar PV

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ABSTRACT

Around the world, there are increasing efforts underway to decarbonize the electricity generation system to mitigate the environmental impacts including climate change. While Indonesia has a huge potential for new and renewable energy, particularly solar photovoltaic, Indonesia has been largely dependent on fossil fuels. As of 2017, the installed capacity for solar photovoltaic in Indonesia was 78.5MW and this was only 0.04% of the theoretical solar potential, which is around 207.9GW(4.8kWh/m^2/day). With the case of solar photovoltaic, this paper examined the reasons of low adoption of the technology and the challenges of energy transition in Indonesia from the policy and institutional perspectives.

OVERVIEW AND ISSUES OF ELECTRIC POWER SYSTEM IN INDONESIA

As the fourth most populous country around the world, Indonesia generates and consumes around 1,021kWh/capita(in 2017) of electricity every year[1] and this electricity mainly comes from fossil fuels. In 2017, about 88% of the Indonesian electricity was generated from fossil fuels: 45% from coal, 30% from natural gas, 10% from diesel, and 3% from oil(Figure 1). Less than 12% was from new and renewable energy(NRE) sources, including 8% of hydro, 3% geothermal, and 0.26% of other renewable sources such as solar PV, wind power, biomass, biogas, waste, and tidal. Figure 2 shows a more detailed breakdown of the new and renewable energy sources of the electric power sector in Indonesia.

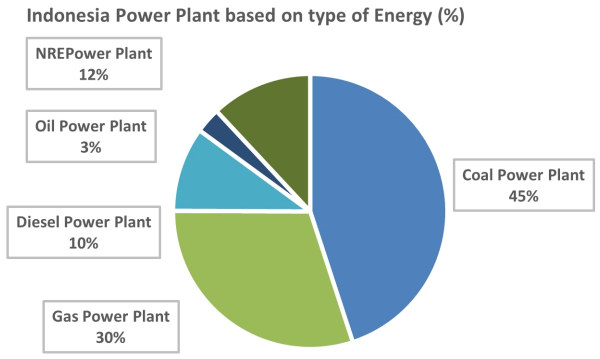

Figure 1. Electricity mix in Indonesia(Source: RUPTL PLN)

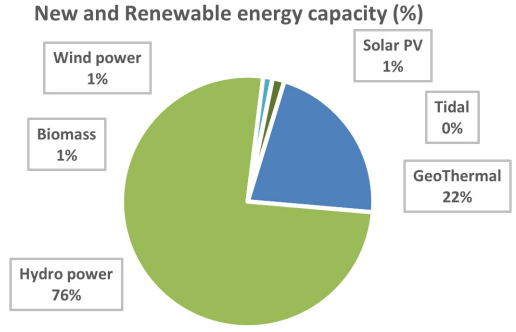

Figure 2. Installed capacity for electricity generation from new and renewable energy sources(Source: RUPTL PLN)

Decarbonizing the power sector is drawing more attentions from the national government of Indonesia. The Indonesia Constitution No. 30 of 2007[2] prescribed that one of the important goals of the energy system is to protect the national environment and ensure environmental sustainably. Indonesia ratified the Paris Agreement to the United Nations Framework Convention on Climate Change(COP 21 of UNFCCC) in 2016 on Constitution No 16 of 2016 and is committed to reduce 29% of the greenhouse gas emissions with its own efforts and 41% through international cooperation by 2030 compared to the business as usual scenario.[3] Detailed action plan on reducing greenhouse gas emissions can be seen on Constitution No. 61 of 2011.[4] More strategies and programs to reduce carbon emissions are in development.

Another issue of the Indonesia's electric power sector is in the form of electrification. Over the last 7 years, Indonesia has increased the electrification ratio significantly, through programs like Fast Track program(President regulation No. 7 of 2006, No. 4 of 2010) and electricity infrastructure program(President regulation No. 4 of 2016). In 2017, the electrification ratio reached 95.4%(Figure 3).[1] Despite this achievement at the national level, there are still populated areas and islands that do not have electric grids,

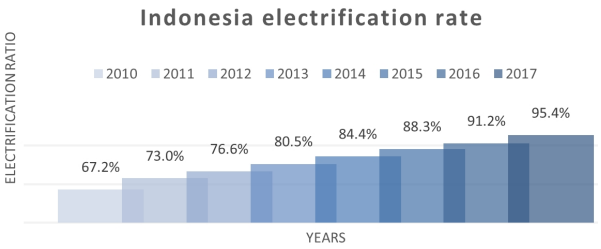

Figure 3. Increase of electrification rate in Indonesia between 2010–2017(Source: Lakin 2017)

because Indonesia has 17,000 islands as an archi-pelago country. Due to this geographical condition, Indonesia requires a distributed form of electrical system to achieve full electrification of the country.

RENEWABLE ENERGY AND SOLAR POTENTIAL IN INDONESIA

To reduce carbon emissions from the electric power systems and to increase the electrification further, new and renewable energy such as hydropower, geothermal, solar PV, and wind power can play a significant role. With surface are of more than 1,900,000km^2 and abundant natural resources, Indonesia has a high potential for renewable energy. The National Electric Company of Indonesia(PLN), from President Regulation No 22 of year 2017 on National Energy General Plan(RUEN),[5] estimated that about total 442.9GW of electric power could be generated from the renewable energy sources(RUPTL 2018-2027).[6] This includes 207.9GW of solar PV potential, 75GW of hydropower, 60.6GW of wind (>4m/s), 32.6GW of bioenergy, 29.5GW of geothermal, 19.5GW of mini/micro hydropower, and 17.9GW of tidal energy.

A report from the national energy general plan estimated that the average solar PV potential in Indonesia is 4.80kWh/m^2/day. Figure 4 shows the solar PV potential across geographical locations in

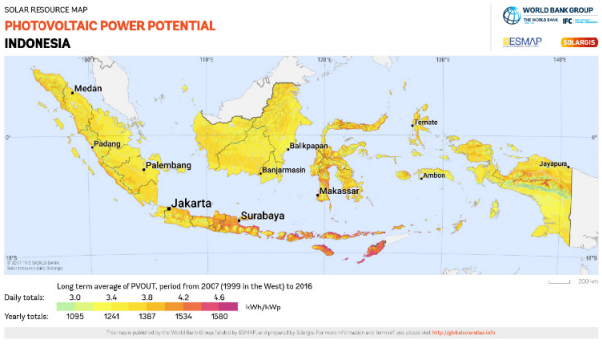

Figure 4. A map of solar potential in Indonesia(Source: Global Solar Atlas)

Table 1. Estimated solar potential across provinces of Indonesia

Provinces	Potential(MW)
West Borneo	20,113
South Sumatra	17,233
East Borneo	13,479
North Sumatra	11,851
East Java	10,335
West Nusa Tenggara	9,931
West Java	9,099
Jambi	8,847
Center Java	8,753
Center Borneo	8,459
DI Aceh	7,881
Riau Islands	7,783
South Sulawesi	7,588
East Nusa Tenggara	7,272
West Papua	6,307
Center Sulawesi	6,187
South Borneo	6,031
West Sumatra	5,898
North Borneo	4,643
South-west Sulawesi	3,917
Bengkulu	3,475
North Maluku	3,036
Bangka Belitung	2,810
Banten	2,461
Lampung	2,238
North Sulawesi	2,113
Papua	2,035
Maluku	2,020
West Sulawesi	1,677
Bali	1,254
Gorontalo	1,218
DI Yogyakarta	996
Riau	753
DKI Jakarta	225

Indonesia. Out of 34 provinces, West Borneo showed the highest solar PV potential, while Jakarta showed the lowest potential(Table 1).

The life-cycle greenhouse gas emissions from solar PV is estimated to be around 49.91g CO_2eq/kWh(Nugent et al. 2013), while the emissions from coal is around 1.127g CO_2eq/kWh(Agrawal et al, 2013). By substituting 1kWh of coal-based power with a power from solar PV, around 1.077g CO_2eq of greenhouse gas emissions would be avoided. Also, solar PV can be a solution to electrification in Indonesia by supporting off-grid electricity generation. Indonesia already had an experience with solar PV projects, such as in Sukatani village in West Java and Taratak village in Lombok. These solar PV systems successfully supplied electricity for public lighting in these rural areas.[7]

POLICY APPROACHES TO RENEWABLE ENERGY AND SOLAR PHOTOVOLTAIC

Indonesia's national energy policy, regulation No. 79 of 2014, specifies the aim of increasing the share of renewables.[8] By 2025, it targets to achieve more than 23% of the electricity should come from new and renewable energy sources. By 2050, it further envisioned to have more than 31% of energy is from new and renewable energy sources(Figure 5). To fulfill these target shares for new and renewable energy, the presidential regulation No. 22 of 2017 on the national energy plan further specified that estimated power plant installed capacity would be 135GW in 2025 and 443GW in 2050. It further specified that 45.2GW(33% of the capacity in 2025)

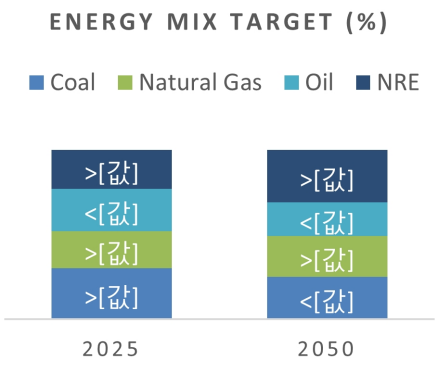

Figure 5. Electricity mix target by 2025 and 2050(Source: MEMR No 79 of 2014, National Energy Policy)

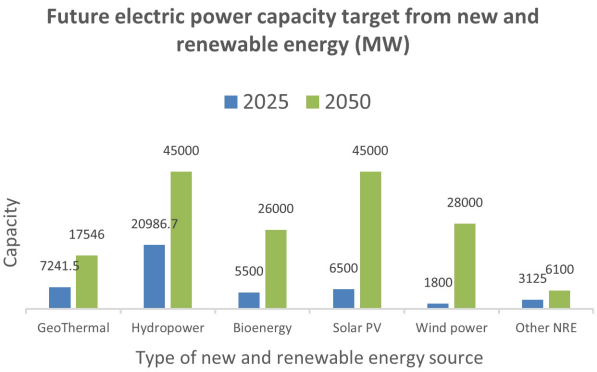

Figure 6. The target capacity for new and renewable energy in 2025, and 2050(Source: President regulation No 22 of year 2017 on RUEN)

and 167.7GW(38% of the capacity in 2050) should come from new and renewable energy installations.[5] The specific target capacity for solar PV is 6.5GW by 2025 and 45GW by 2050(Figure 6).

In August 2017, Indonesia Ministry of Energy and Mineral Resources(MEMR) adopted a flat-rate buy scheme for the new and renewable energy through MEMR Regulation No. 50 of 2017(Table 2). It uses a ceiling price based on the Power Generation Cost (BPP) in purchasing electric power from renewable energy sources. The purchase scheme of new and renewable energy electricity production can be seen in Table 3. BPP is a reference price determined by PLN every year, as a guidance for the electricity buy

Table 2. Main features of the MEMR Regulation No 50 of 2017

Features	Description
Key Features	• PLN is required to purchase electricity power from renewable energy sources [article II verse 2] • Purchasing of electricity power from renewable energy source done by PLN from direct election procurement mechanism based on capacity quota [article IV verse 1] • PLN required to operate renewable energy resources power plant up to 10MW and pay all power produced [article IV verse 3] • Grid connections done by contractor
Purchasing General Scheme	BOOT(Build, Own, Operate, and Transfer)
Local components	In procurements process, PLN will prioritize contractor with local components used as stated by regulations [article XV verse 1]. (Ministry of Industry Regulation No.54/2012 jo 5/2017)

Table 3. Financial scheme on new and renewable energy in MEMR Regulation No 50 of year 2017

Buy Scheme	Procurement	BPP Regional 〉 BPP National	BPP Regional 〈 BPP National
Solar PV	Direct selection based on capacity quota	85% BPP Regional	B2B negotiations
Wind Power	Direct selection based on capacity quota		
Biomass	Direct selection		
Biogas	Direct selection		
Ocean Energy	Direct selection		
Hydropower	Direct selection	BPP Regional	In Java, Sumatra, Bali, and other country where BPP Regional 〈 BPP National tariff based on B2B negotiations
Waste-to-energy	Based on law and regulations		
Geothermal	Based on law and regulations		

scheme. The MEMR regulation No. 50 of 2017 uses varying rates according to the location of power generation. For solar PV, wind, biomass, biogas, and ocean energy, when the regional BPP is higher than the national BPP, the maximum 85% of the BPP would be used, and when the regional BPP is lower than the national BPP, the price would be negotiated between parties. As of 2018, there are 11 provinces in Indonesia with total 225GW of estimated potential of new and renewable energy. Until April 2018, there are 70 power purchase agreements(PPA) with the new and renewable power producers for the total capacity of 1,214MW, including 45MW of solar PV in Gorontalo, West Nusa Tenggara, North Sulawesi, and Papua provinces.[9] Solar PV PPA comprised only about 4% of the total renewable energy power purchase agreements(Figure 7).

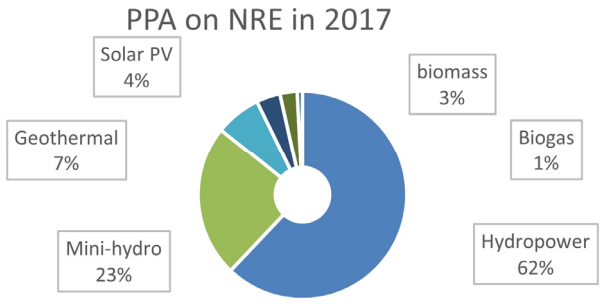

Figure 7. Power Purchase Agreement according to new and renewable energy sources(Source: NRE Directorate General of MEMR workshop presentation April 2018)

Another regulation that is also important in new and renewable energy investment is MEMR regulation No 10 of 2017, which was amended by the MEMR regulation No. 49 of 2017. This was amended again with No 10 of 2018 on Principle on Power Purchase Agreement. This regulation mainly covers the right and obligations between PLN and investors, and it also stated that the maximum duration for PPA is 30 years[10].

Through regulation No. 21/PMK.011/2010, the Ministry of Finance(MoF) of Indonesia provides incentives to promote the use of renewable energy for the generation of electricity. These incentives will be provided to the investors who fulfill certain criteria. These incentives include tax allowance and import tax collection exemption in income tax facility for investment in certain business fields(based on the government regulation No 18 of year 2015 and No 9 of year 2016 on tax allowance). Another incentive includes free value-added tax facilities, which is to provide free added-value tax on those who import equipment on new and renewable energy(government regulation no 81 year 2015), and exemption on customs fee, provided for those who import goods, machine, and material for new and renewable energy systems(MoF regulation No PMK176/2009 jo PMK 188/2015). The Government-certified tax facilities, which are regulated under the State Budget Revenue constitution, will be provided to investors on geothermal energy(MoF regulation No PMK179 of year 2013)[11].

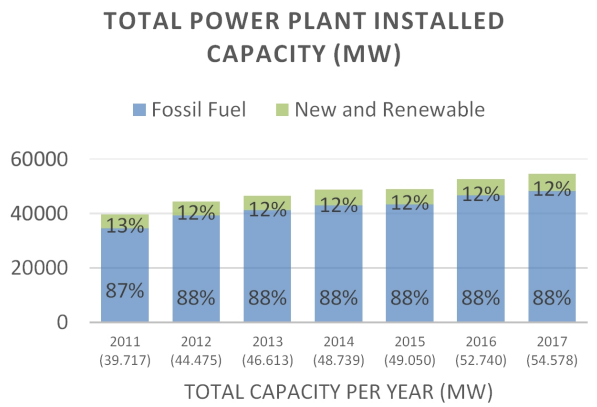

Figure 8. Total power plant installed capacity between 2011 and 2017(Source: RUPTL PLN)

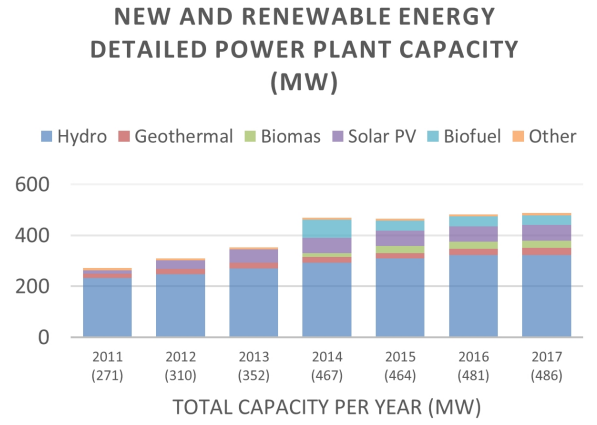

Figure 9. The power plant installed capacity from new and renewable sources(Source: RUPTL PLN)

CHALLENGES IN PROMOTING SOLAR PV IN INDONESIA

Although Indonesia is promoting the new and renewable energy, ongoing efforts do not seem to be significant enough to achieve sufficient energy transition. Figure 8 shows that the majority of the installed capacity for electric power still relies on fossil fuels. Between 2011 and 2017, the share of new and renewable energy did not increase despite the growth of total installed capacity: the share of new and renewable energy remained at around 12-13%, while the share of fossil fuels was around 87-88%. As shown in Figure 9, the new and renewable capacity was dominated by hydro and geothermal sources. This share of new and renewable energy largely falls behind the target share of 33% by 2025 or 38% by 2050, posing great challenges.

One of the reasons for the slow transition to renewable energy systems in Indonesia is because of the abundance of fossil fuels. In 2017, Indonesia was the second largest coal exporter, being in charge of 16% of world's coal exports.[12] Coal production can last 82 more years without any further exploration of reserves(Table 4).

Table 4. Indonesia's fossil fuel reserves(assumption no further exploration)[5]

Type resource	Resources	Energy Reserves	Production Capacity	Lifetime Expectation
Crude Oil	151 Billion Barrel	3.6 Billion Barrel	288 Million Barrel	12 years
Coal	120.5 Billion tons	32.4 Billion tons	393 Million tons	82 Years
Natural Gas	487 Trillion Cubic Feet	98.0 Trillion Cubic Feet	3.0 Trillion Cubic Feet	33 Years
Coal Bed Methane	453 Trillion Cubic Feet	–	–	–
Shale Gas	574 Trillion Cubic Feet	–	–	–

Notably, there are also barriers in the policy approaches to renewable energy and solar photo-voltaic. Although the solar PV development is yet in the nascent stage in Indonesia, frequent changes in policies impose uncertainties and risks in the solar industry. The MEMR regulation No. 17 of 2013 was revoked by MEMR regulation No. 19 of 2016 and it was revoked and replaced again with MEMR regulation No. 9 of 2018. In 2017, the MEMR regulation No. 12 of 2017 on the utilization of renewable energy sources for electric power supply came into effect, but this was replaced by MEMR regulation No. 43 of 2017 and then by MEMR regulation No 50 of 2017. All of these changes happened in the same year. The frequent changes in policy increase uncertainties and drop willingness to invest on new and renewable energy sector(Bridle et al, 2018)

Another barrier includes the BOOT(Build, Own, Operate, and Transfer) scheme. In the BOOT scheme, investors will first need to invest and build the power plant, which requires a great technical and financial resources. Investors will also need to control operation and maintenance, before they transfer the asset to the government by the end of PPA. This impose high cost and risk to the investors and therefore they are reluctant to invest under the BOOT scheme(Bashiri et al. 2011).

Furthermore, according to the MEMR No 50 of 2017, the price needs to be negotiated when the BPP is lower than the national BPP. The price negotiation with PLN can be another impedance in renewable energy project, as it may lead to long administrative processes. There will likely be conflicts as investors prefer higher ceiling price while the government would request the lowest price as best as possible.

To meet ambitious targets of new and renewable energy, especially the ones for solar PV, Indonesia needs a lot of investment from the private investors. But according to the renewables energy country attractiveness index(RECAI 2016) estimated by Ernst & Young(EY) in 2016,[13] Indonesia ranked at 38th(out of 40). Compared other emerging countries like Brazil, South Africa, Mexico, Indonesia does not offer favorable environment for overall private investment. One of the reasons may found in poor infrastructure.[14] This issue needs to be addressed in order to attract more private investment.

The minimum requirement of domestic component content in electricity infrastructure development(good and services) may pose another challenge. According to the Ministry of Industry(MoI) regulation No 54 of 2012 which amended with No 5 of 2017, minimum requirement of domestic component content in Solar PV electricity infrastructure development should be at least 40% of goods and 100% of services, or 46% of total goods and services in 2017.[15] In the near future, the minimum share of domestic component content for solar PV(total good and services) will increase to

50% in 2018 and 60% in 2019. The guidance and calculation procedure of domestic component content can refer to MoI regulations No 15 of 2011 and No 16 of 2011.[16] Considering that the solar PV sector in Indonesia is at the very early stage of its development, lacking technical expertise and know-how, this minimum requirement would likely to act as a burden in solar PV development unless there are appropriate policy and institutional support for the industry.

CONCLUSION

One of the ways to decarbonize electricity in the world is substituting fossil fuel based power with power from new and renewable energy source. Indonesia, with huge potential of solar PV and other renewable energy in general, can use this as an opportunity to develop solar PV industry to reduce greenhouse gas emissions and to achieve 100% of the electrification rate. When Indonesia meets its target of 45.2GW of solar PV capacity, it means that it would reduce about 45.2tons of CO2eq by substituting coal power with solar power.

But this study found that there are various challenges to overcome to promote solar PV in Indonesia. This particularly requires the establishment of favorable policy and institutional environment to attract private investment and to develop solar PV industry in the country. There is still time to develop new and renewable energy in the upcoming years. Indonesia should review, develop, and update its renewable energy policy and act now to move towards a sustainable future.

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