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Turning a Liability into an Asset: How the Challenge of Powering Indonesia's Remote Grids is an Opportunity to Shape Cutting-Edge Energy Policy

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Abstract. President Jokowi has promised to add 35 GW of power to the national grid, while the Ministry of Energy and Mineral Resources wants to source 23% of its power from renewable sources by 2025. It will be difficult to reconcile these two goals as the majority of Indonesia's 35 GW is expected to come from high-capacity coal and gas-fired plants on Java and Sumatra. This runs the risk of both undershooting the renewables goal and neglecting the more remote provinces in eastern Indonesia that rely mainly on imported diesel fuel. With a shrewd policy aproach, this could pose an opportunity to begin developing small-scale renewable power sources – such as solar, wind, and biomass gasification – in more remote parts of Indonesia where natural resources are plentiful and large-scale fossil fuel plants are impractical. This would allow PLN to both boost the share of renewables in the energy mix and acquire experience running flexible micro-grids capable of managing diverse and decentralized energy sources. This would put Indonesia ahead of the curve, as efficient grids that can draw power from a wide range of sources will likely play a big role in the future of energy policy. If PLN continues to focus narrowly on high-capacity gas and coal plants, it will risk getting locked into an inflexible, high-carbon structure ill-suited for the needs of the 21st century. The limits of such a model are already showing in the United States.

Keywords: Infrastructure, energy policy, renewables, smart grid, PLN

1. Introduction

When President Joko Widodo unveiled his 5 Year Power Plan for Indonesia in 2015, one of the goals was to add 35 GW of capacity to the grid by 2019, the year in which he will come up for re-election (Jegho, 2015). This is an ambitious target and unlikely to be achieved in the given time frame. One of the main challenges is that it is expensive and difficult to deliver electricity to the remote eastern provinces of Indonesia. The challenge of remote electrification is further exacerbated by the fact that much of the planned development is already earmarked for the large and densely populated islands of Java and Sumatra which will mainly be served by new high-capacity coal-fired plants, and expansions of existing transmission grids (Deloitte, 2016).

The final challenge is that the Ministry of Energy and Mineral Resources recently set a goal of boosting renewables as a portion of the total energy mix from 10% to 23% by 2025 (Wulandari, 2017). This is an ambitious and perhaps unrealistic target given current economic and policy constraints, and is especially in danger of being neglected as the bulk of resources in Jokowi's Power Plan are going into coal-fired plants. Given these conditions, Indonesia runs the risk of getting locked into a high-carbon energy structure and missing out on the environmental and economic benefits of clean energy technologies (Jotzo, 2016). Such a structure would run the risk of concentrating

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investment and development on fossil fuels in Java and Sumatra, while neglecting remote grids in eastern Indonesia – and the opportunity they represent to develop a diverse renewable energy sector.

The research puzzle addressed in this paper is thus primarily a policy-oriented one. How can Indonesia increase overall generating capacity, while boosting the share of renewables and delivering power to remote grids in eastern Indonesia, especially given the existing policy bias toward high-capacity coal-fired plants? What policy steps can be taken to overcome these obstacles? While there is no magic bullet for these complex challenges, this paper argues that pursuing renewable energies and grid technologies in remote micro-grids in eastern Indonesia is one way to approach the problem, as it will both increase rural electrification and boost the percentage of renewables in the overall energy mix. It will also help Indonesia develop the technology and skills necessary to invest in alternatives to high-capacity coal-powered plants that are currently receiving the bulk of resources and political capital in Java and Sumatra. This will diversify its energy resources and prevent an overreliance on what may be an out-dated model of energy policy.

2. Background

Of the 35 GW of increased capacity Jokowi envisions, 28 of it is slated for Java and Sumatra - 18 GW in Java and 10 GW in Sumatra - relying primarily on high-capacity coal-fired plants capable of generating several hundred MW or more. That power will be distributed along unidirectional power transmission grids to large numbers of consumers concentrated in big urban centres like Jakarta, Medan and Surabaya. This orientation toward a fossil fuel-powered grid neglects the issue of powering Indonesia's more remote and isolated grids. The need for electricity in the eastern part of the Indonesian archipelago, in remote areas such as the Maluku Islands and Papua, cannot be adequately met with traditional one-way grids powered by high-capacity fossil fuel plants. This is reflected in the fact that the current plan only calls for a very moderate additional installed capacity in the Maluku Islands of 272 MW and in Papua of 220 MW (Deloitte, 2016).

It is difficult to build high-capacity power plants in remote areas of eastern Indonesia, where economic activity tends to be limited and infrastructure and access are poor. Research into this problem has found that low-emitting grid extensions are the most efficient means of providing rural electrification to remote areas, but even low-emitting grid extensions using coal are capital intensive and require an existing, reliably electrified grid, thereby posing significant barriers to entry (Y. Nagai, 2010). This in turn has driven up the cost of providing electricity in eastern Indonesia much higher than elsewhere in the country, and that cost is absorbed by the state-owned electricity company PLN - and ultimately the government. Many of these areas end up relying on expensive imported diesel fuel to run generators, or on biomass such as burning wood (SERIG, 2017).

This challenge of geography has bedevilled Indonesian energy policy for decades. Under the New Order, the distortion of energy prices was paved over to a degree through the application of generous subsidies, but in the reform era the government has tried to make the price of energy for consumers more accurately reflect its cost. PLN, the state electricity company, is responsible for covering any shortfalls in revenue and has historically incurred huge losses because of this system – thus a wave of legislation in recent years has tried to get retail prices more in line with costs (World Bank, 2008). As Indonesia democratized and increasingly devolved authority and responsibility to provincial and local levels, the energy needs of these far away provinces have become more obvious. This paper argues that what might appear at first blush to be a liability can actually be turned into an opportunity for Indonesian energy policy to adopt and pursue cutting edge grid technology and energy policy.

3. Conceptual Framework

Building one-way grids fed by high-capacity fossil fuel plants may be an appropriate strategy when seeking to power industrializing, developing urban areas in Java and Sumatra. Indeed, the needs of those markets are not too different from those of the United States in the 20^{th} century (steady economic growth, growing middle class, rising domestic consumption, rapid urbanization), and thus pursuing a similar model is both good policy and economically sustainable – as the paper will detail below. Coal, despite environmental concerns, makes economic sense in many parts of Indonesia, particularly in heavily populated areas where urbanization and industrialization are high (Cornot-Gandolphe, 2017).

But in remote areas of Indonesia, policy might be better served by aggressively embracing the potential of renewable energy sources – especially solar, wind and biogas – to power smaller, smarter and more nimble micro-grids. The unique environments in these remote areas, and the variety of natural energy resources available in each area, make them suitable candidates for developing renewable technologies that can capitalize on the natural advantages of far-flung places. Further, it would place Indonesia in an advantageous position in developing smaller and more efficient decentralized energy distribution systems that utilize a variety of energy sources. As the paper will argue below, it is probable that the future of energy policy will increasingly move in that direction, emphasizing smarter and more flexible grids that rely on efficiency gains in distribution. Policy-makers that are anticipating this trend will be ahead of the curve.

This argument is supported by a comparative analysis of energy policy in the United States and Indonesia, highlighting some important congruities as well as the limits of US experience for Indonesian policy. Drawing on media accounts, industry reports, government documents and contemporary scholarship the paper will first detail the historical contingencies that determined energy policy in the United States, comparing them favourably to the current energy needs in population-dense islands like Java and Sumatra. It will then argue that this model is reaching the limits of its utility in the United States because of the growing importance of distributed energy resources, smarter grid technologies and improvements in battery storage. This argument will then be extended to Indonesian energy policy, arguing that if the Indonesian government embraces the flexible, small-scale potential of micro-grids powered by a variety of renewable technologies it could craft a strategy for powering remote grids in eastern Indonesia that is both practical and economically sustainable. Moreover, it would provide an opportunity to proactively anticipate coming shifts in 21st century energy policy.

4. The United States and Its Vertically Integrated Monopolies – Still Viable?

The electric grid that currently serves the United States is a relic of 20th century American industrialization (Nye, 1992). At that time, it made sense to build big, powerful plants (fuelled by coal or oil) that fed one-way grids. Power was trafficked from these high-capacity plants great distances over AC transmission lines to electrify booming cities. As the United States industrialized in the 20th century and experienced rapid growth of densely populated urban centres, being able to transmit electricity over long distances to power cities was an important way to facilitate that growth. The regulatory architecture that evolved to serve that market – in which energy monopolies were allowed to exist as long as the rates they charged consumers, and returns they paid to investors, were carefully controlled by utility commissions – reflected those particular circumstances. The paramount need driving energy policy at that time was to build a large number of power plants to feed a growing, industrializing economy.

A report from America's Power Plan, a consortium of industry and academic leaders analysing America's energy transition away from fossil fuels, concludes that while that system reflected the requirements of last century's power needs, it is no longer in touch with the needs of the modern economy (Boyle, 2016). That kind of vertical consolidation made sense for the early 20th century American economy – where the government allowed utilities to maintain "natural monopolies" on generation and distribution as long as they continued building plants and investing in the grid. The regulatory architecture allowed the utilities to recover their costs, plus a rate of return on investment that was set by regulators. This was a policy that was both conducive to growth and made utility companies into attractive investments.

The energy sector in Indonesia partially reflects this model, and Jokowi's Power Plan borrows heavily from it. In the plan, capital is mainly being allocated to high-capacity coal and gas-fired plants feeding the large and relatively well-connected grids in Sumatra and Java. PLN has a monopoly on distribution and the retail price of energy is tightly regulated by the state using a cost-plus model, in which PLN recoups the cost for generation plus a margin, usually around 7% (Tharakan 2015). This arrangement is not an exact analogue of the US system, but the central strategy is similar enough to warrant comparison: it seeks to encourage investment in high-capacity fossil fuel plants while regulators keep an eye on prices and rates of return. In both cases domestic energy policy is geared toward capital-intensive, centralized schemes.

Indonesian policy-makers should note, however, that the limits of this model are now being tested in the US. Digital technologies, and in particular smart grid technologies, are eroding the traditional efficiency gains of vertically integrated monopolies where the utility generates and distributes power over one-way grids (Kiesling, 2015). Barriers to entry for alternative energy sources are getting lower – geothermal and wind are poised to become more cost effective than fossil fuels (Schilling 2009) and the levelized cost of solar is likely to be competitive within the next decade (Branker, et al. 2011). Battery storage is improving, requiring less reliance on traditional electricity producers to power grids and giving consumers greater options for storing power and utilizing it more efficiently, further contributing to the disruption of traditional utility models in the United States (Wagner, 2017).

The specific market and industry conditions of early 20th century America resulted in domestic energy policy that favoured "large-scale, high-technology, capital-intensive, integrated and centralized producers of energy from fossil fuels" in lieu of "alternatives such as small solar or wind farms" (Tomain, 1990). But 21st century market and industry conditions are increasingly favouring smarter grids that are more flexible and sectioned into micro-grids more suited to efficiently managing a variety of distributed energy resources (Hatziargyriou, et al, 2007). The economies of scale and efficiency gains that warranted the creation of vertical monopolies on generating and distributing power are likely to diminish as renewables provide a variety of cost effective sources of energy – such as solar, wind and biomass gasification – for the grid to draw upon. A study funded by the US Department of Energy found that by 2050, 80% of the United States' energy needs could be met by renewable energy sources that are commercially available today - but only if such technologies were combined with a more flexible grid (Wiedman 2013). Under such conditions, optimizing the distribution of diverse energy sources is likely to be a critical component of domestic energy policy. Policy-makers who acknowledge this will have a clear advantage in anticipating coming shifts in energy markets.

As it stands, United States energy policy is in some danger of missing this opportunity. The penetration of competitive renewable resources as a viable alternative to fossil fuels is often obscured and distorted by large fossil fuel subsidies, some of them over a century old that were originally designed to help the coal and oil industries in their infancies (Bridle 2014). Comparing public funding received in the initial 15 years of industry development, subsidies for the oil and gas industry were equal to .50% of the total national budget, while the renewable industry in a comparable 15 year period of its initial development received only .10% of the budget (Pfund 2011).

As further evidence of where the US government's current priorities in energy policy are, Secretary of Energy Rick Perry recently ordered the Federal Energy Regulatory Commission to guarantee payments to struggling coal plants (Nixon 2018). Federal regulators rejected the plan, but it nevertheless suggests that the United States is behind the curve on energy policy, with the executive branch aiming to prop up fossil fuel through subsidies that distort their actual economic viability. This in turn increases barriers to entry for renewable energy producers, and slows down the erosion of vertical monopoly power in the energy industry that is already underway.

The Federal Energy Regulatory Commission's ruling against Secretary Perry's plan could be interpreted as an indication that regulatory bodies are looking toward a future where America transitions away from fossil fuels and toward a more dynamic energy mix. Even so, it would likely take years to unwind and re-organize a complex regulatory structure where incentives are aligned to encourage investment in big power plants and large, one-way distribution grids. Indonesia, on the other hand, has an opportunity to channel investment and policy planning toward renewable energy sources feeding small micro-grids now. PLN, as the national distributor, is already tasked with managing a wide variety of energy producers, including a range of renewable sources, throughout the archipelago. Geographical challenges that seem like serious impediments to developing a nation-wide and sustainable energy policy could yet provide an opportunity to invest in technologies and develop skills necessary to anticipate coming changes in energy markets.

5. Indonesia, Renewables and Remote Grids – Liability or Asset?

Indonesia is spread across thousands of islands, with a wide range of natural resources and geological diversity. This has historically posed a challenge to electrifying remote grids in far-flung areas, but since policy-makers must come to terms with this obstacle of geography whether they want to or not it would be advantageous to re-frame this diversity not as an insurmountable obstacle but as an opportunity for developing a diverse and vibrant energy economy. PLN's largest grids are concentrated on the islands of Java and Sumatra while its remaining generating capacity is spread across 600 isolated systems throughout the rest of the archipelago (Tharakan, 2015). That means the needs of the energy market outside densely populated areas are already being served by micro-grids. Expanding the capacities of these 600 isolated grids by investing in grid expansion and fossil fuels would require prohibitively expensive investment in coal or gas-fired plants. Alternatively, capacity in some portion of those 600 isolated grids could be expanded by employing renewable technologies to capitalize on available natural resources – such as wind, solar or biogas – thus adding capacity at lower or equal cost without building out expensive and economically unfeasible plants or over-relying on imported diesel. As the national energy company, PLN is well positioned to begin investing in and developing these renewable resources, and in doing so to initiate development of smarter grid technologies to more efficiently manage them.

These remote eastern provinces represent a good opportunity to develop requisite technologies and skills because they offer a variety of energy sources and are already sectioned off from larger, capital-intensive grids. The options are therefore limited: to develop small-scale renewables to meet the modest energy demand in remote areas, or to continue shipping in expensive diesel fuel indefinitely. By pursuing the former, Indonesian energy policy can move toward diversifying its overall energy mix while developing renewable technologies and skills that will be important in crafting energy policy suited for the challenges of the 21st century. In the following section, this paper will analyse the results of several projects demonstrating the feasibility of harnessing available natural resources in remote parts of Indonesia. It will then discuss some policy steps PLN can take to incentivize the development of similar sites, while pushing for smarter grid management strategies.

In 2013 the US Department of Energy launched a program called Sustainable Energy for Remote Indonesian Grids (SERIG). SERIG's objective was to explore a variety of remote locations throughout Indonesia to determine what the most viable source of renewable energy in each location was. In Lamandau in central Kalimantan, the report found that it was possible to add 3.5 MW of installed capacity from biogas generated by palm oil waste, which could reduce the levelized cost of energy in the region from $.31/kWh to $.11/kwh. If PLN were to purchase power at that rate, the site could be developed with a capital investment of $8.78 million yielding a 50% internal rate of return while displacing 98% of existing diesel capacity.

The same report found that a site in Sabu Island in Nusa Tenggara could moderately reduce its levelized cost from $.38/kWh to $.35/kWh by installing 1 MW of solar power with battery storage. With a Feed-in-Tariff of $.25/kWh, the site could be developed at a cost of $6.26 million and yield a 14% internal rate of return. Alternatively, if PLN were to develop the site itself rather than purchase power from an independent source, it could realize a net present value of $475,000 according to SERIG's models (Burman, 2014). As the Sabu project would only displace 35% of existing diesel power, in order for PLN to maximize gains from this investment it would need to integrate it with the existing micro-grid in a way that optimized load distribution. This presents a good opportunity to begin developing smart grid management solutions on a modest scale.

A 5 MW solar plant that recently came online in Kupang in East Nusa Tenggara is another instructive example of how small-scale renewable solutions can be deployed to capitalize on the availability of natural resources in a cost effective manner. The plant, located in a remote eastern province of Indonesia, is able to operate in isolation while feeding a micro-grid serving the surrounding area (Pradipta, 2016). It was built by state-owned energy company PT Len Industri at a cost of $11.2 million, and operates under a 20-year Purchase Power Agreement with PLN at $.25/kWh. At these figures, the internal rate of return over 20 years is projected to be 18.40% with net positive cash flow expected after 9 years of operation (Mose 2016). A recent technical analysis of the plant estimates the monthly average output to be 623 MWh (Kumara et al). Assuming new diesel generation costs PLN $.39/kWh[1], the levelized cost of the plant can be expected to save PLN approximately $87,000 per month under current Feed-in-Tariff conditions. As the Kupang area is also supplied by a wide range of energy sources, including diesel, this presents further opportunity for PLN to develop and optimize its grid management capabilities.

These examples are not meant to be exhaustive, but seek to highlight the diversity of economically viable natural energy resources available in remote parts of the archipelago – solar in Nusa Tenggara and biogas in Sabu Island. The recent completion of a 70 MW wind turbine plant[2] by a consortium of energy companies in southern Sulawesi further highlights the wide diversity of renewable energy sources throughout the country (Domingo 2017). This brief analysis is meant to serve as a proof of concept that natural resources are available and can be developed at costs that are below that of building new diesel generating capacity, and under financial terms that are attractive to private investors.

This is important because as Jokowi's Power Plan allocates the bulk of its resources toward capital-intensive fossil fuel plants and expanded transmission systems in Java and Sumatra, it risks overlooking an opportunity to develop renewable energies in remote regions of eastern Indonesian. As the case of the United States suggests, investing too heavily in fossil fuel can lock energy policy into a high-carbon model and produce a lopsided energy mix driven by misaligned incentive structures. An over-reliance on capital-intensive fossil fuel-powered plants will likely place energy policy at a disadvantage as renewable energies continue to erode the traditional natural monopoly power of utilities, lower barriers to entry and create a decentralized network of distributed energy sources. Under such conditions, the large-scale production of energy in coal-fired plants is likely to cede its economic and competitive advantage to distributed power sources that are managed efficiently through smart grid technology. What policy steps can PLN and the Ministry of Energy take to anticipate these coming changes in energy markets? The final section will analyse that issue below.

6. Policy Impact

In a recent report, America's Power Plan made a series of recommendations for how US energy policy can encourage development of renewable resources and anticipate the emergence of decentralized grids drawing power from a variety of distributed sources (Wiedman 2013). The primary recommendations were: 1) establishing clear and transparent tariff structures 2) using long-term procurement contracts and 3) developing large-scale grid integration strategies. With regard to these three criteria, PLN tends to favour long-term contracts in its procurement process. However, it is unclear if PLN has a strategy for improved grid integration designed to handle distributed sources of energy generation, and recent changes to its tariff scheme have substantially altered the incentive structure for investment in renewable resources.

[1] This is the figure used by SERIG in its HOMER models.
[2] The capital cost of the project was $150 million, with a 30-year agreement from PLN to purchase power at $.11/kWh deemed to be economically viable by a consortium of power producers.

In contrast to utilities in the United States, which typically prefer market-based pricing mechanisms, PLN usually uses a Feed-in-Tariff scheme when purchasing power. Feed-in-Tariffs are much more common in Europe, where they successfully increased investment in solar power production (Jenner 2013). As a policy tool, Feed-in-Tariffs have the advantage of being relatively straightforward. PLN agrees to purchase power from a producer at a fixed price for a given period of time, usually 20 to 30 years. This makes it much easier for the producer to model their financial return and risk, as they are buffered from long-term market forces that may shift the cost of production.

Generous Feed-in-Tariffs for solar of between $.20-.25/kWh contributed to making the Kupang and Sabu projects discussed above attractive investments for energy producers, while tariffs of around $.11/kWh made the Lamandau biogas project and the Sidrap windfarm viable as well. Up until last year PLN's tariffs schemes were designed to encourage similar investments, especially in solar (by comparison, PLN typically purchases coal from IPPs for around $.05-.06/kWh). In this sense, PLN's policy approach to boosting investment in renewables appears to have an edge on US energy policy. Long-term contracts at fixed prices that are significantly higher than those paid for fossil fuels encourage power producers to invest in solar, wind and biogas and act as a disincentive to invest in coal and oil, especially in remote areas that are particularly suited for renewables and where coal and oil would be economically unviable anyway.

The downside of long-term Feed-in-Tariffs is that they expose PLN (and ultimately the government) to fluctuations in the retail cost of electricity over decades. In 2017 the Ministry of Energy introduced Regulation 50/2017 which changed the pricing scheme for purchasing renewable energies, pegging it to a national and regional cost of production benchmark (Wulandari 2017). As energy production is more expensive in eastern Indonesia than on Java and Sumatra, this scheme effectively makes it impossible for renewable energies to compete with fossil fuels on Indonesia's most heavily populated and economically active islands. However, it may still provide sufficient financial incentive to induce investment in solar, wind and biomass gasification outside of Java and Sumatra, in areas that would benefit the most from renewable technologies such as Sulawesi, Kalimantan and the Maluku Islands. It is too early to reach a definitive verdict on the effectiveness of this new policy, but even though it all but ensures coal and gas will continue to dominate in Java and Sumatra in the near-term, if may prove to be a shred compromise that jump-starts renewable investment in the outer islands.

As far as developing smarter grid technology that can optimize the management of distributed energy resources, PLN has room to grow in this area. This is a crucial area of forward-looking policy, because as energy generation becomes increasingly dispersed amongst a variety of sources, maximizing the efficiency of its distribution and transmission will be important for achieving the diversified energy mix the Ministry of Energy envisions. For now, efforts to develop smart grid technology appear to be mainly concentrated on the heavily developed island of Bali (Gustaman 2016). Few other provinces in Indonesia enjoy the same financial resources or friendly investment environment as Bali and PLN appears to currently lack a broader, comprehensive strategy for developing smarter grid management. This is an area that would benefit from more resources and attention from policy-makers, as energy policy that embraces smarter grid management is likely to yield significant upside in the coming decades. Moreover, as small grids in remote areas of Indonesia are already drawing power from a mix of diesel and renewables, they present a good opportunity to begin developing the technology and skills necessary for optimizing grid management on modest projects which can then be scaled up.

All of this suggests that Indonesian energy policy is at an interesting crossroads. The President is pushing to add 35 GW of installed capacity by 2019. The Ministry of Energy has set a separate goal of sourcing 23% of the overall energy mix from renewables by 2025. These are ambitious goals, further compounded by challenges of geography as remote provinces in eastern Indonesia are often difficult to electrify and must rely on expensive imported diesel. Given these conditions, it is sensible that the bulk of Jokowi's Power Plan is slated for coal-fired plants powering large grids in Java and Sumatra. However, the limits of over-investing in such a capital-intensive, high-capacity and centralized model is beginning to show in the United States, where a century of energy policy favouring vertically integrated monopolies and one-way grids powered by fossil fuel is impeding the transition to smarter and more efficient energy policy attuned to the management of diverse power sources.

As Indonesia seeks to diversify its energy mix, PLN and the Ministry of Energy should be wary of becoming overly reliant on a similarly outdated high-carbon model. This can be accomplished by paying above market prices to induce investment in renewable energy and focusing resources on developing better grid management technologies. Solar, wind and biogas are available and economically viable sources of energy in remote areas of Indonesia - If the government can dial in the appropriate policy mix. If it can, pursuing such a strategy would contribute toward the goal of adding overall capacity while boosting the percentage of renewables in the energy mix. Remote electrification poses many practical and economic obstacles – but with the right policy approach it can be re-cast as an opportunity for Indonesia to develop a proactive energy policy that anticipates the dynamic needs of the 21st century.

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