IISD International Institute for Sustainable Development

Global Subsidies Initiative

Case Study: What is the true cost of coal in Central Java?

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October 2017

This case study was written before the Minister of Energy and Mineral Resources Ignasius Jonan announced that they "will not approve any coal-fired power plants in Java, (…), any more" (Jensen, 2017). The announcement follows Indonesia's commitment to achieve 23 per cent of renewable energy by 2025.

The conclusions of this case study support the minister's decision, bringing in additional arguments to support the need to reduce coal capacity and support renewable power instead.

Introduction and Context

As the world's fourth most populated country and the largest economy in Southeast Asia (Organisation for Economic Co-operation and Development, n.d.), Indonesia's needs for energy are rapidly increasing. The Government of Indonesia expects to add 35 GW of coal power capacity by 2026, as stated in the Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) (Ministry of Energy and Mineral Resources [MEMR], 2017a), the procurement business plan of PLN (the state-owned electricity generation company). Most of the new developments will take place in the island of Java, which will host half of the new capacity.

Java is the economic centre of the country (see Figure 1). It has two major development areas: Jakarta and Surabaya, which define the "Java Economic Corridor," known as the "driver for national industries and services provision" (MEMR, 2012). The development of the region strongly depends on the availability of reliable and affordable electricity able to meet the demand. The Government of Indonesia is expecting a significant electricity demand increase in Java, planning expansions of transmission and power generation capacity. The national electric grid traverses Java from west to east and links with Bali, enabling electricity exchanges within the region. The capacity of this electric corridor is being increased and is expected to be completed by 2026 (Global Energy Network Institute, n.d.).

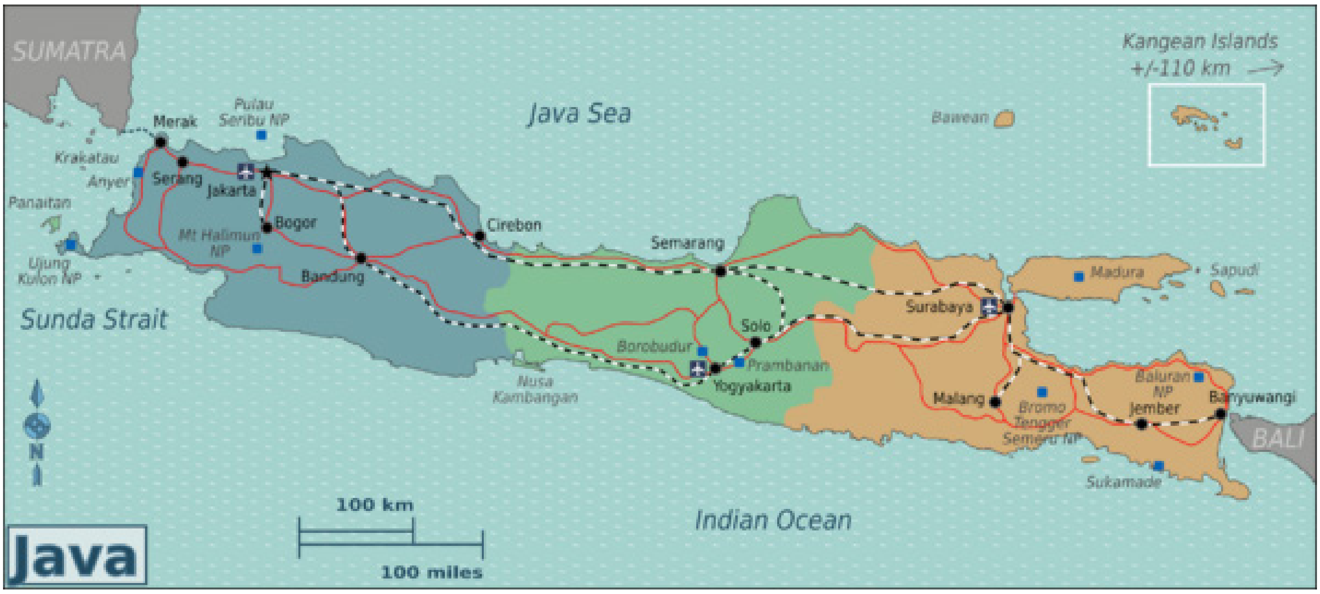

Figure 1. Map of Java island, including the Central Java region (green).

Source: Wikitravel, n.d.

Central Java is a major actor in Indonesia's electricity expansion plans. The region is already producing more electricity than it requires, feeding the excess to the Java–Bali grid to be consumed in other major cities and industrial areas. The new plans include Central Java as the host of around half of the new coal power capacity expected in Java by 2020.

But are these plans realistic and what will this cost—not just the cost to rate-payers, but also in terms of impacts on climate change and air pollution? Are there alternatives to these developments?

Coal Generation and Consumption in Central Java

Central Java is the third most populated province in Indonesia, with almost 34 million inhabitants and a density of population of around 1,000 inhabitants per square kilometre (Asian Development Bank, 2016), which is among the world's highest (Indexmundi, 2014). By the end of 2015, the electrification rate in Central Java was 91.36 per cent (MEMR, 2016a), one of the highest in the country.

Central Java has almost no coal reserves, but coal electricity generation in the region plays a very important role, with several coal power plants spread around its coast. As of 2016, Central Java has a coal-based power capacity of 5.1 GW from operating plants (Petromindo, 2016; MEMR, 2017a), which can produce up to 36,000 GWh per year (see Table 2), or 17 per cent of Indonesia's total electricity consumption in 2015 (PT PLN, 2016).

Electricity consumption in the Java–Bali grid is growing at an average rate of 5 per cent compound annual growth rate (CAGR), and the demand is expected to keep going up between 2016 and 2020 at a rate of 6 per cent CAGR. Industrial development and increased electricity access will be the main drivers of this growth (MEMR, 2017a).

The most recent revision of PLN's RUPTL estimates that the Java area will add 13 GW of new coal capacity by 2020 (Sundaryani, 2017), increasing capacity by more than a third. With this increase, PLN aims to improve the reserve margins[1] of the electricity system—that is, to assure that there is enough additional power capacity to respond to demand peaks. PLN's objective is to reach a reserve margin of 25–30 per cent in Java–Bali. However, considering the current plan for new power plants, the reserve margin will surpass 40 per cent by 2026 (Chung, 2017). An IISD study of electricity systems in the world finds that global average reserve margins are generally between 10 and 20 per cent (Nguyen, Bridle, & Wooders, 2014). This indicates that current capacity expansion plans in Java might be unnecessarily large.

[1] Reserve margin is the difference between capacity and peak demand.

Around half of the new capacity planned for Java will come from Central Java. In 2015, Central Java produced 40 per cent more electricity that it needed for its own consumption, feeding the excess to the Java–Bali grid to support its appetite for electricity. Despite some project revisions by the latest RUPTL, Central Java is still planning six new coal power plants with a total capacity of almost 6 GW (see Table 1). Most of the new capacity will be developed by independent power producers (IPPs), who will sell the produced electricity to PLN to feed into the grid.

Table 1. Existing and ongoing/proposed coal power plants in Central Java

Existing Coal-Fired Power Plants	Proposed Coal-Fired Power Plants
• PLTU Cilacap 1-2, 2 x 300 MW (2006, PLN) • PLTU Tanjung Jati B 1-2, 2 x 660 MW (PLN) • PLTU Tanjung jati B 3-4, 2 x 660 MW (PLN) • PLTU 1 Rembang, 2 x 315 MW (PLN 2013) • PLTU 2 Jateng (Adipala) (PLN 2015), 1 x 660 MW • PLTU Cilacap exp, 1 x 614 MW (IPP, 2015	• PLTU Jawa-4 (FTP2, Tanjung Jati B 5-6), 2 x 1,000 MW (IPP, 2019) • PLTU Jawa-8, 1,000 MW (IPP 2019) • PLTU Jawa Tengah (PPP), 2 x 950 MW (IPP 2019-2020) • PLTU Jawa-10, 1 x 1,000 MW (unallocated)
Total existing: 5,144 MW **Calculated generation per year*: 36 TWh**	**Total proposed: 5,900 MW** **Calculated generation per year: 41.4 TWh**
Total MW combined: 10,014 MW **Calculated generation per year: 77.4 TWh**	

Source: Petromindo, 2016; MEMR, 2017a; and author's calculation
** The calculation considers a load factor of 0.8 (Petromindo, 2016). Load factor is the ratio of the actual produced electricity to the maximum production possible, based on the capacity with no loses.*

The True Cost of Coal-Fired Power in Central Java

Burning coal to generate electricity has significant negative impacts on climate change and on health, due to carbon dioxide emissions and other greenhouse gasses, as well as fine particles that are associated to respiratory and cardiovascular diseases (Petrofsky, 2017; World Health Organization, 2016). In their Global Subsidies Initiative report, Attwood et al. (2017) estimate that the cost of air pollution associated with coal electricity generation is USD 19 per MWh, and the corresponding cost of climate change is USD 42 per MWh.[2] These costs add to the actual cost of generating electricity and more than double it. In addition, the report analyzes the subsidies provided to coal power generation in the country, and estimates the additional cost of these subsidies at USD 5 per MWh in 2015. Considering these subsidies and externalities, the total cost of coal electricity generation in 2015 was close to USD 116 per MWh. Figure 2 summarizes these different components.

In Central Java, where coal plants extend across the region, the cost of externalities is significant and needs to be taken into account when policy-makers decide on the future of the region's electricity sector. By subsidizing coal power, the government is actually creating greater economic costs for health and climate change, and these costs have to be fully considered in investment decisions, particularly compared to renewable forms of energy that do not have these same externalities.

[2] This is based on a summary of international estimates from organizations such as the World Health Organization, the International Monetary Fund, the U.S. government and others, as outlined in detail in Attwood et al. (2017).

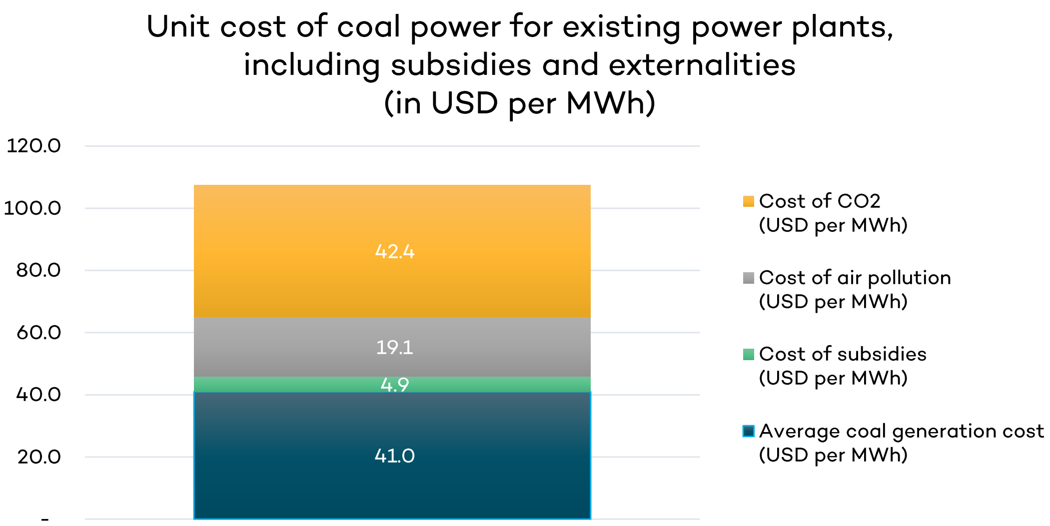

Figure 2. Unit cost of the different components of coal generation in Indonesia for existing power plants.

Source: PT PLN, 2016; Attwood et al., 2017

Table 2 represents the total costs of coal power generation in Central Java, including subsidies and externalities. The generation cost of existing coal power plants is defined by the latest value available for PLN's cost of coal electricity, at USD 41 per MWh (PT PLN, 2016). The unit cost of the power generated by new coal power plants is based on the average PLN generation cost, as determined per the Ministerial Decree 19/2017 (MEMR, 2017b). The most recent value of PLN's average generation cost is USD 65.2 per MWh (MEMR, 2017c), and is higher than the cost for the previous plants because it includes a mix of all the technologies used to generate electricity.

The calculations estimate that the total cost (including subsidies and externalities, as per Attwood et al., 2017) of existing power plants is almost USD 4 billion a year. New coal power plants will cost an additional USD 5.4 billion every year. Central Java will face a total cost of almost USD 9.3 billion as of 2020, when all the new power generation will be in place. Around half of it (USD 4.7 billion) will be in the form of health and climate change externalities. This is equivalent to the cost of health insurance for two thirds of Indonesians (Blend, 2014) or the annual salary of 2 million Indonesians (based on average salary from Bank of Indonesia, 2017).

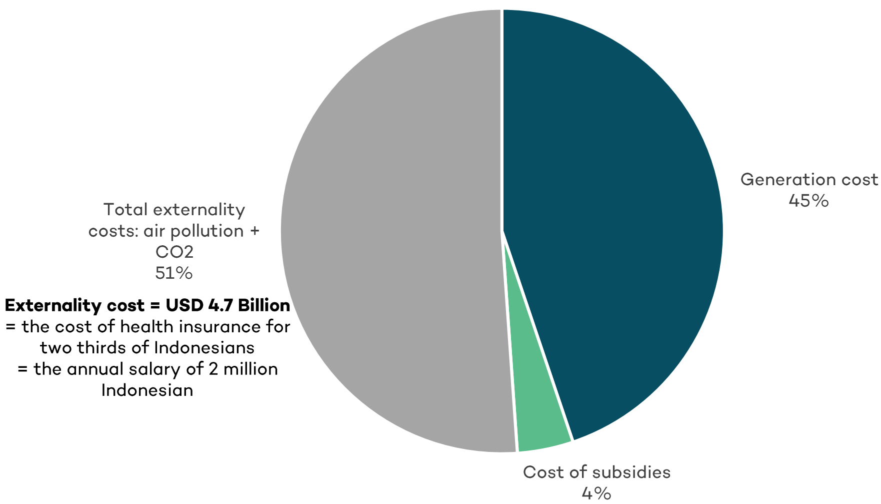

Figure 3. Distribution of cost of coal power generation in Indonesia, including subsidies and externalities

Source: Attwood et al., 2017; MEMR, 2017a; and author's calculation

Table 2. Total cost of coal generation from Central Java coal power plants.

	Generation (GWh)	Generation cost (MUSD)	Cost of subsidies (MUSD)	Cost of air pollution (MUSD)	Cost of CO2 (MUSD)	*Total externality costs: air pollution + CO2 (M USD)*	**Total cost of coal power generation (M USD)**
Existing Coal Plants	36,049	1,478	177	689	1,528	*2,217*	**3,872**
Proposed Coal Plants	41,347	2,696	203	790	1,753	*2,543*	**5,441**
Total	**77,396**	**4,174**	**379**	**1,478**	**3,282**	*4,760*	**9,313**

Source: Attwood et al., 2017; MEMR, 2017a; and author's calculation
Note: as generation cost, the average generation cost for existing coal plants is USD 41 per MWh and for proposed coal plants is USD 65.20 per MWh.

New coal power plants in Indonesia will be built using supercritical and ultra-supercritical technologies (MEMR, 2017a). The International Energy Agency considers that ultra-supercritical coal power plants are around 10 per cent more efficient than conventional ones (Ito, 2011). However, due to a lack of specific data for Indonesia, new and old coal power plant emissions, the same value proposed in the report by Attwood et al. (2017), are used for old and new coal power plants.

Furthermore, a study by Chung (2017) identified an additional cost of USD 3.16 billion per GW of installed capacity in the form of capacity payments to coal power producers for the availability of additional capacity, even if it is not used. These capacity payments are part of current power purchase agreements between PLN and IPPs. As a consequence, the new 6 GW of coal capacity in Central Java would have an additional cost of USD 19 billion over the duration of the 25-year power purchase agreements.

Although the need to increase electricity access is of utmost importance in Indonesia, the costs of expanding electricity access through coal may be much higher than policy-makers realize, especially when the full cost, as described above, is considered. The following section considers the cost of producing electricity with renewable energy technologies. Electricity produced by renewable technologies has much lower climate and health impacts, and the cost of these technologies is falling, creating a significant gap between the true cost of coal and renewables.

Renewables Potential in Central Java

The potential of renewable energy sources in Central Java is significant. The region counts of geothermal and hydropower resources and the conditions to develop solar and wind are favourable. However, the electricity generation mix is dominated by coal and other fossil fuels, as represented in Figure 4. Renewable energy represents only 6 per cent of total generation capacity of Central Java, including 5 per cent of hydro and 1 per cent of geothermal. Both geothermal and hydropower are renewable sources that deliver constant electricity, as coal-based thermal power plants do.

This section presents the current potential of each renewable technology, in order to assess the possible electricity generation and compare it with the targets for coal power.

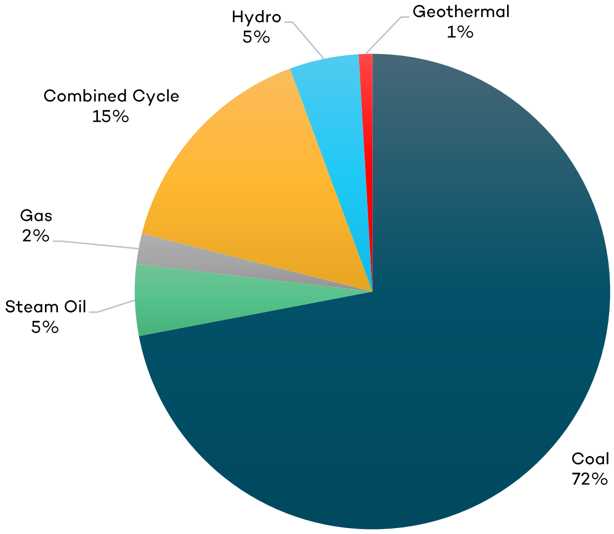

Figure 4. Electricity capacity mix Central Java in 2015

Source: PT PLN, 2016

Geothermal Power

Currently, geothermal capacity in Central Java is 60 MW, representing 1 per cent of total installed capacity, and 1.2 GW in Java Island, or 3 per cent of the total (PT PLN, 2016). Geothermal power is a reliable source of energy, with a high load factor comparable to coal. The Indonesian government estimates a total of 387 MW hypothetical geothermal resources in Central Java, and 1,739 MW of hypothetical resources in total on Java island. Possible reserves are around three times higher (MEMR, 2016b).

Hydropower

The potential for hydropower is also considerable in the region. In 2014, 2.6 GW of hydropower capacity was connected to the Java–Bali grid, with Central Java hosting 0.3 GW (International Renewable Energy Agency [IRENA], 2017a). Indonesia's MEMR (2016b) estimates that Central Java has 1,044 MW of total potential capacity for micro and mini-hydro (less than 10 MW) and 2,833 MW in all of Java. Other estimates for the island of Java consider a potential of 12,272 GW for large-scale hydropower capacity (larger than 10 MW) (Angel, 2017). This is almost five times more than the currently installed capacity. The MERM's estimate will be used in this analysis.

Wind Power

There is currently no installed wind electricity in Java, but the potential of wind power in the region is significant, and there are several studies evaluating the resources. The MEMR (2016b) considers a potential capacity of 813 MW in Central Java and 4,300 MW in all of Java. A study completed by the Wind Hybrid Power Generation Project (2013) identified up to 115 MW of wind power potential in Central Java and Yogykarta and 465 MW for all of Java island. IRENA (2017a) foresees a theoretical potential of 3,900 MW of wind power in the Java–Bali region. This paper will consider the MEMR estimates.

Solar Photovoltaic Power

The island of Java does not have solar power installations feeding the electric grid. Estimating the potential of solar photovoltaic (PV) power is harder than for other technologies, given its versatility and flexibility. Solar PV modules can be installed on rooftops but can also be part of large-scale solar plants. Indonesia's MEMR (2016b) includes potential capacities of 8,730 MW in Central Java and 28,187 MW in total Java. The study completed by the UNDP DTU Partnership (2016) considers a potential of 540 MW for rooftop solar PV in the Java–Bali system. IRENA (2017a) estimates a total potential of 38,700 MW in the Java–Bali system. This analysis will consider the MEMR's values.

Table 3 summarizes the potential of each previous technology as estimated by the Indonesian MEMR (2016b) for Central Java. It shows that, if all that capacity is developed, the region can have access to almost 18 GWh of electricity, which is equivalent to 43 per cent of the generation expected from the new coal power plants in Central Java. Indeed, this would respond to the most conservative needs for additional power capacity, considering that current plans risk leading to a significant overcapacity, as discussed in the first section.

Table 3. Renewable energy potential and generation in Java, according to government estimates

Renewable Energy Technology	Potential Capacity MW	Load Factor	Potential Generation (GWh)
Mini- and Microhydro	1044	35%	3,201
Solar	8753	14%	10,735
Wind	813	13%	926
Geothermal	387	81%	2,746
TOTAL	**12,881**		**17,607**

Source: MEMR, 2016b

The Cost of Renewable Power in Central Java

Determining the real cost of renewable power in Central Java is not an easy task. The cost of renewable energy technologies has decreased significantly, and the year 2017 has so far seen record low prices for renewable energy technologies such as solar. Recent solar projects developed in India are selling the electricity produced at USD 40 per MWh (Safi, 2017). In Chile, solar PV is reaching prices as low as USD 29 per MWh (Dezem, 2016).

Figure 5 shows the levelized cost of electricity from different renewable energy sources in the years 2010 and 2016. As demonstrated by the examples in Chile and India mentioned before, 2017 values have proved to be lower. In Indonesia, the cost of renewable electricity is determined by Regulation No. 12 of 2017 (MEMR, 2017d). This regulation defines the price to pay to renewable electricity generators based on the average regional price or on tendering schemes, depending on the technology and local conditions.

In this study, to simplify the calculations, the average regional tariff[3] is applied to all the technologies, which will result in a conservative estimate of the total cost (tenders might lead to lower prices).

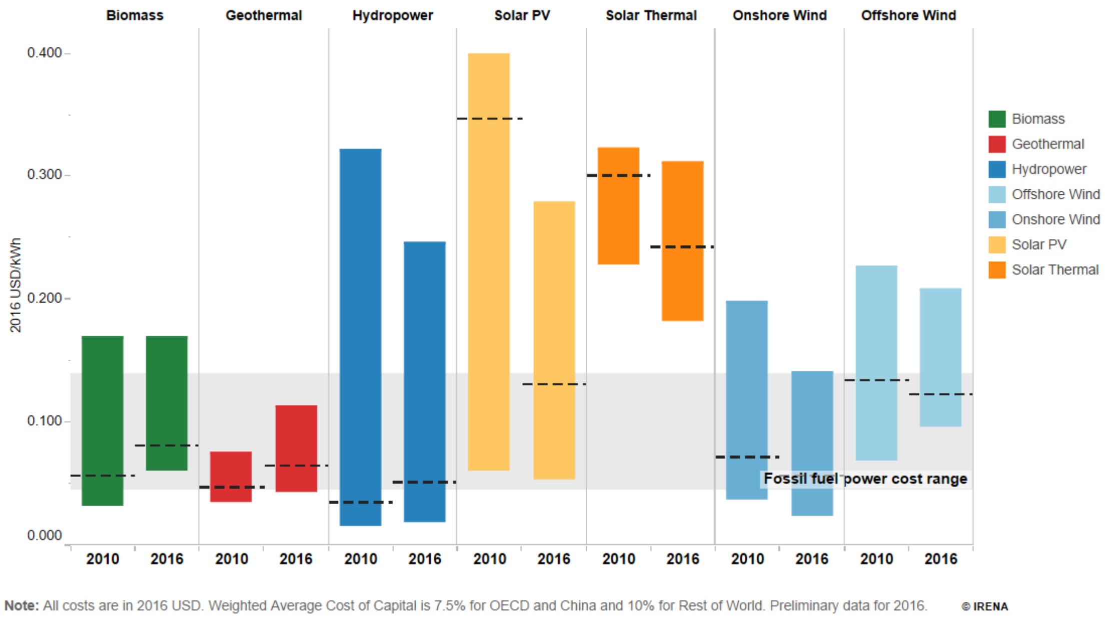

Figure 5. Global Levelized Cost of Electricity 2010–2016 for renewable energy sources.

Source: IRENA, 2017b

[3] According to regulation 12/2017, if the average regional power generation cost is lower than the national one (as it is the case of Central Java), the regional value applies. In 2016, Java–Bali's average power generation cost was USD 6.52 cent/kWh (MEMR, 2017d)

Renewable energy technologies have associated externality costs, determined by the life-cycle assessment of the respective technologies. However, since these costs are associated with the equipment and the corresponding estimation has not been included in the coal power generation analysis, the externalities cost for renewable energy technologies will not be considered.

Table 4 summarizes the total cost of generating the identified renewable energy potential at the current rates, determined by PLN's average regional power generation cost in 2016. This renewable energy would cost PLN USD 1.15 billion per year. This is much lower than the USD 2.3 billion[4] that the equivalent coal electricity would cost, once subsidies and externalities are included.

Table 4. Estimation of cost to PLN of renewable energy capacity deployment, according to MEMR estimates and current PLN tariff for renewable energy

Renewable energy Technology	Potential Capacity MW	Potential Generation (GWh)	PLN renewable energy tariff USD per MWh (2016)	Total price of generation Million USD (2015)
Mini- and Microhydro	1044	3,201	65.20	209
Solar PV	8753	10,735	65.20	700
Wind	813	926	65.20	60
Geothermal	387	2,746	65.20	179
TOTAL	**12,881**	**17,607**	**65.20**	**1,148**

Source: MEMR, 2016b; MEMR, 2017d

Comparison and Conclusions

When subsidies to coal and externalities are included, renewable power generation is cheaper. If the identified renewable energy potential were developed in the Java region, these sources could generate enough electricity to replace a significant part of the new coal capacity expected in Central Java. When including all the costs, the renewable energy would be around USD 1.3 billion cheaper, every year. Figure 6 compares the unit cost for each option. In addition and as highlighted in the first section, the additional coal capacity might not even be fully used, but PLN would still have to pay in the form of capacity payments (Chung, 2017)

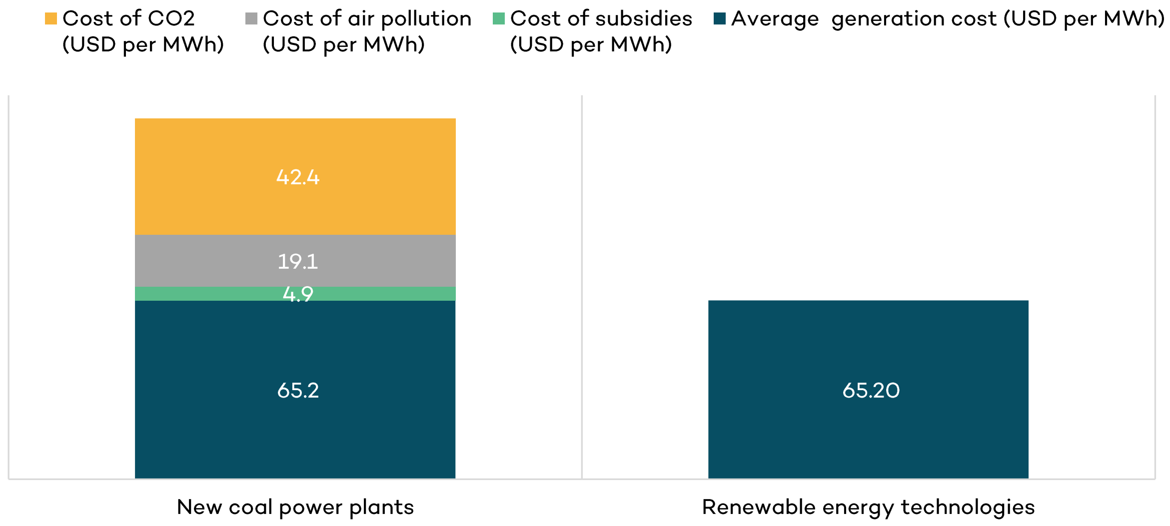

Figure 6. Comparison of unit cost of coal and renewable power generation

Source: Attwood et al., 2017; MEMR, 2017d

[4] This value is calculated considering 17,607 GWh of new coal power generation, including subsidies and externalities as per Table 2.

With these numbers in mind, it is clear that policy-makers in Central Java should strongly consider how they wish to pursue the need for additional power capacity. Indonesia aims to supply affordable and reliable electricity. Currently, coal is the favoured choice, mainly on fiscal grounds, as policy-makers do not consider the costs of externalities like air pollution and greenhouse gas emissions when planning the electricity sector expansion. But when externalities are accounted for, the true cost of coal increases significantly, especially compared to renewables.

In addition, in the case of electricity generation for remote areas, solar PV and wind can offer a cheaper option for electrification than grid extension. A study commissioned by the Asian Development Bank (2016) to evaluate the most cost-efficient option to electrify the island of Sumba in Indonesia concluded that, with an electrification target of 95 per cent, off -grid solutions would represent the least-cost choice for 30 per cent of most remote households. Off-grid renewable energy solutions avoid costly investments in transmission lines, which would not pay off for a small number of customers. Off-grid renewable technologies are also considered cheaper than diesel generators for the supply of remote areas (Jennings et al., 2017).

4.1 Getting the Prices Right

In order to offer a viable alternative to coal power, it is also very important to get the selling price of renewable electricity right. The most effective way to determine the actual cost of renewables is to establish a reverse auction mechanism for all renewable energy technologies. Recent reverse auctions for solar PV are returning lower costs than the USD 65.20 per MWh used in this study. Figure 5 shows that recent prices for renewable energy technologies can be under the threshold defined by Indonesia's regulations. This means that, in the near future, the gap between coal and renewables may become even bigger as the cost of renewable energy falls and is reflected in the prices. Reverse auctions select the lowest bidders, and thus automatically adjust the cost decrease of renewable energy sources. This would have a positive impact on PLN's average generation cost.

For policy-makers in Central Java, where coal-fired electricity is on track to multiply in the coming years, it poses an important question about whether coal is the best and most economical choice for generating electricity. With externalities in mind, choosing coal today might seem like a way to save money, but it will come back more expensive in the form of air pollution and carbon dioxide emissions. At the same time, renewable power could be cheaper if the current price regulation was replaced for an open auctioning system. Indonesian policy-makers face a very important task that will affect the country's long-term future.

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