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Coal power and climate change in Indonesia

Final report

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SUMMARY AND RECOMMENDATIONS

Coal power will be an important contributor to power sector growth in Indonesia. It represents an abundant, low cost and domestic source of energy. This report explores the potential role of clean coal technology in Indonesia's energy future in relation to five domestic power sector policy drivers: 1) generation expansion, 2) energy diversification, 3) domestic coal consumption, 4) climate change mitigation and 5) electricity subsidy reduction. The study finds that:

- **Clean coal technology**: Available 'clean coal' technologies are cost neutral or slightly more economical than conventional technologies, in terms of delivered power costs. They are likely to provide modest improvements, of roughly 10 to 13 percent, in carbon emissions intensity versus traditional coal technologies. This is lower than previous estimates of GHG savings for clean coal technology in Indonesia and assumes that the country's lignite coal resources are exploited domestically as planned. The use of cleaner coal technology would be consistent with recent shifts in international financing guidelines for coal generation infrastructure from a number of OECD countries. It is possible that Indonesian clean coal generation may not be compatible with future financing guidelines, without the adoption of carbon capture and storage (CCS), due to the characteristics of the available lignite coal reserves.
- **Policy and planning**: There is a need to resolve apparent incompatibilities between domestic medium-term plans and strategies; most notably the National Energy Policy (*'KEN'*) and medium-term expansion plan of the Indonesian public utility ('*RUPTL'*). We estimate that under the medium-term expansion plan, the renewable energy contribution to the primary energy mix will be far lower than that required under the KEN, and the coal contribution substantially higher. Clean coal technology cannot resolve the observed differences between those two plans. There is also a need to reassess the realism of other targets, such as the level of domestic coal use set for 2019.
- **Climate Change:** The recent Intended Nationally Determined Contribution (INDC) submission of Indonesia to the United Nations Framework Convention on Climate Change (UNFCCC) proposes a 29% unconditional reduction in GHG emissions from business as usual levels in 2030. We estimate that the unconditional mitigation ambition described in the Indonesian INDC does not require additional effort beyond existing expansion plans for the power sector (i.e. the RUPTL). At the same time, we find that there may be opportunities to improve mitigation ambition in the sector in the future. Moving closer to the targets of the KEN would decrease emissions by increasing the share of renewable energy and reducing energy demand. We calculate that clean coal technology can play a small role in mitigation efforts, reducing total emissions in 2030 by between 1.2 and 2.0 percent from business as usual levels.

RECOMMENDATIONS

- Strategically set minimum regulatory standards for new coal power plants to lock in emissions intensity improvements and ensure financial viability with regards to international support, as well as to safeguard for the possibility of adopting CCS in the future where possible;
- Provide a roadmap to meet the National Energy Policy (KEN) 2025 energy diversification and renewable energy targets and ensure that this is reflected in national policy and investment planning. There is a need for a clear role for the public utility (*'PLN'*) with respect to the KEN and a strategy to ensure that sufficient renewable independent power production is stimulated. Aligning the RUPTL with the KEN would be a necessary first step
- Provide a clear signal to the private sector and investors regarding the domestic market obligation (DMO) for coal. A credible roadmap for how it can be met – whilst respecting other energy sector goals – will require a lower DMO target or a reduction in domestic coal production.
- Publish baseline data and assumptions related to the Indonesian INDC to improve transparency and more clearly establish the level of ambition in the power sector. Alignment of other policy objectives, such as the KEN and the medium-term expansion plan, may increase the mitigation contribution that is possible from the power sector.
- Carefully assess the role of clean coal technology in implementing Indonesia's INDC. The mitigation contribution from clean coal is estimated to be relatively modest and may be lower than previous studies would suggest. Options to fill this potential gap include a greater focus on energy conservation and an increased role for renewable energy. There is a large body of evidence detailing the benefits to the country for renewable energy and energy conservation, and they are closely aligned to the KEN.

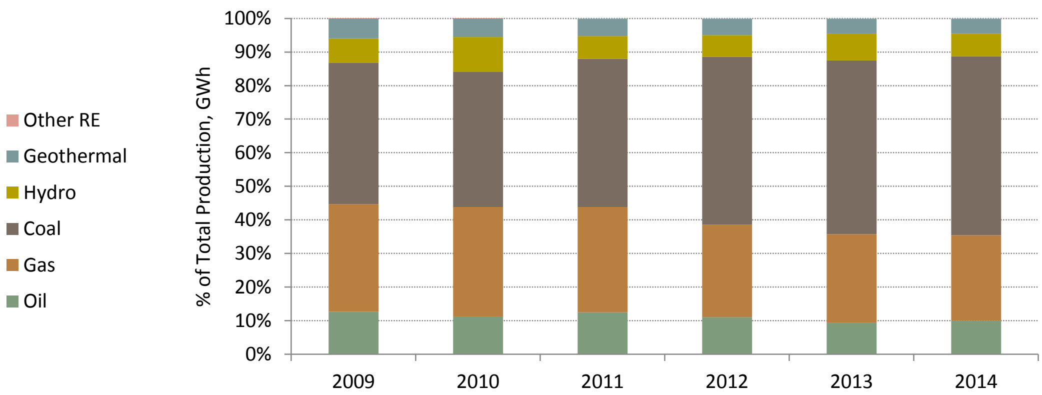
Background

Indonesia is the world's fourth most populous country and by far the largest country in Southeast Asia; the archipelago of more than 17,000 islands is home to 255 million people. The country has a rapidly growing demand for power, with the government proposing to grow the power sector by more than 60% (35 GW) in the coming five years, and annual demand growth is expected to continue at rates approaching 8% in the foreseeable future (Enerdata 2015; IEA 2015a).

The cornerstone of Indonesia's planned electricity generation expansion is a significant increase the installed capacity of coal power-fired power stations. This is a continuation of an existing trend, where the contribution of coal plants to electricity generation has increased from roughly 40%, to almost 55% in the last 5 years, corresponding to a significant decrease in the share of gas and oil based generation (see Figure 1). This report examines the potential role of coal and clean coal technology in the Indonesian power system over the coming ten to fifteen years.

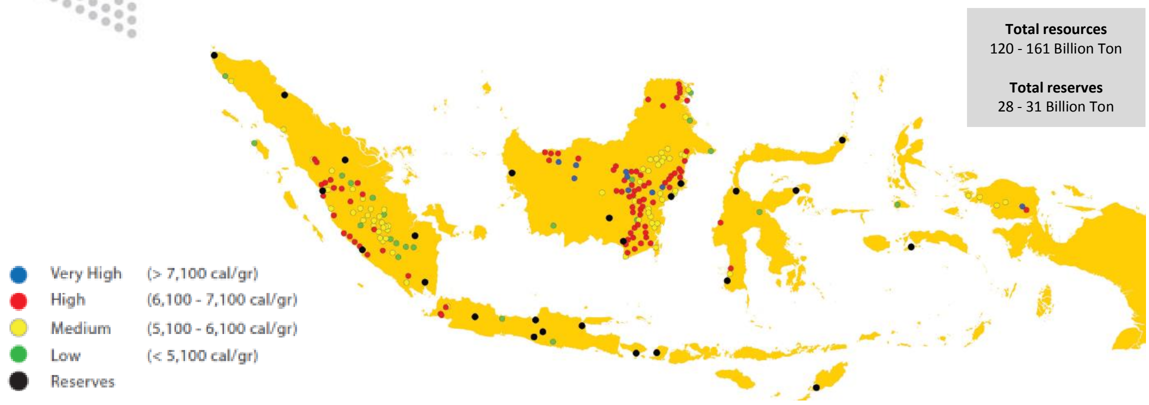
The research has been conducted in support of the Indonesian INDC process with a focus on clean coal as discussed with the Centre for Data and Information Technology (PUSDATIN), the focal point for the GHG inventory within the Ministry of Energy and Mineral Resources (ESDM).

Figure 1: Electricity generation by fuel/source in Indonesia in GWh (source: ESDM 2015)



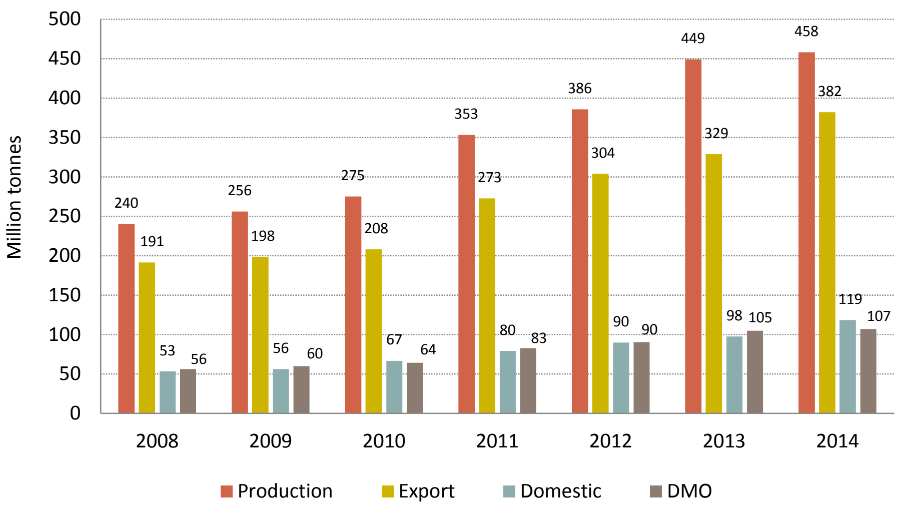
Indonesia is endowed with large coal resources, which are well suited to power generation and relatively inexpensive to exploit. Mining output has increased six-fold in the last 15 years, to well over 400 Mton per year in 2013 (Figure 3). In parallel, exports have grown just as rapidly to fuel power sector expansion in the region (e.g. China, India, Taiwan, and Japan). From a relatively minor producer in global rankings, Indonesia has emerged to become the world's largest exporter of steam coal for power generation. Exports now account for around 80% of mining production (IEA, 2015b). The largest reserves are of so-called non-bitumous coal or lignite (Figure 2). These types of coal have lower energy densities, are less attractive to export, are comparatively low cost, but produce more GHG emissions per useful unit of electricity produced. These reserves will be the dominant source of coal for Indonesia's planned electricity expansion.

Figure 2: Coal resources and reserves in Indonesia (source: DEN 2014; Geological Agency 2013)



The expansion of coal power takes place against a complex backdrop of domestic and international interests. There is a need to grow power production to meet Indonesia's economic and development plans while ensuring energy security through diversification and use of domestic resources. At the same time, Indonesia has pledged internationally to reduce GHG emissions by 29% in 2030 relative to the levels that it would emit under business as usual assumptions (GoI, 2015). The challenge will be to find the right balance between two different ambitions: coal expansion to power growth and reducing emissions to contribute to climate change mitigation.

Figure 3: Coal utilisation in Indonesia 2008 to 2014 (source: ESDM 2015)



Clean coal technology

The Indonesian government proposes to use 'clean coal' technology for future power generation as a possible answer to this challenge, or at least part of the potential solution. A number of technologies can (to varying degrees) reduce the level of CO_2

emitted from coal power production. The most feasible options until 2030 are: alternative combustion processes such as fluidized bed technology; higher temperature systems such as super-critical (SC) or ultra-super-critical (USC) combustion; and newer conversion processes such as integrated gasification with combined cycle steam turbines (IGCC)[1].

These advanced technologies are able to reach substantially higher thermal efficiencies compared to older pulverised coal power plants. However, overall efficiency not only depends on technology, but also on the type of coal used. Table 1 presents the results of an analysis of different coal generation technologies and coal types, with CO_2 emissions intensities as a close proxy for achieved efficiency. We find that **clean coal technologies can be expected to reduce CO_2 emissions by 10 to 13% using technology available today and the kind of coal available in Indonesia**. This could potentially increase to a 25% reduction, but only with additional heat recovery technology added to the most advanced IGCC systems, which do not (yet) see widespread commercial application.

Both SC and USC systems are already being constructed in Indonesia at commercial sites and sites being developed in cooperation with international development partners. However, there is no domestic regulation or standard that requires a certain technology or minimum level of thermal efficiency to be implemented and achieved over time. JICA (2012) have previously prepared a detailed study of technology readiness and an assessment of opportunities to deploy clean coal facilities. The roadmap developed under that project lists a number of specific plants to be built until 2025 and estimates that clean coal could save up to 26% of GHG emissions compared to traditional technology. This is approximately twice the savings that we calculate in emission factors, assuming low-grade Indonesian coal.

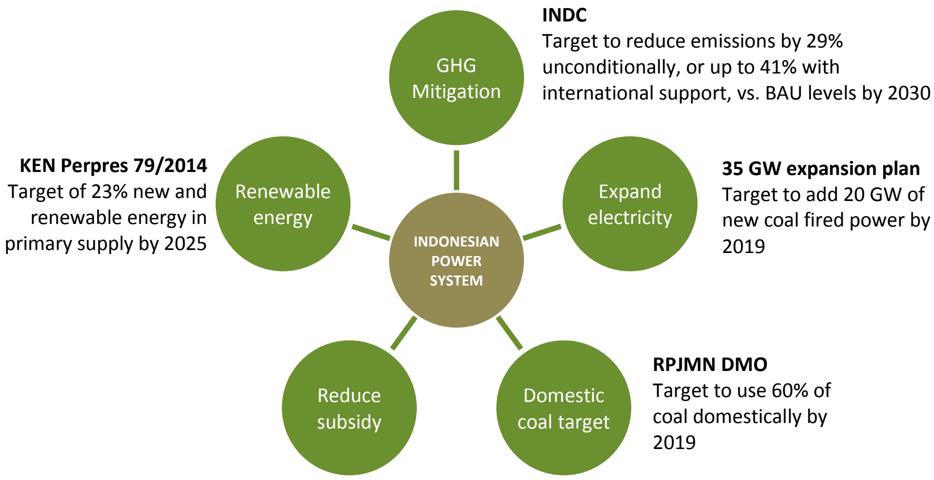
Table 1: Emissions factors for Indonesian coal power by technology and coal rank ($kgCO_2/kWh$) (source: authors' own estimates based on IPCC, 2006; JICA, 2012; Hashimoto et al. 2011 and Surunac et al. 2015)

	Emissions factors ($kgCO_2/kWh$)				
	PC	SC	USC	IGCC	IGCC (+heat recovery)
Bituminous	0.95	0.89	0.80	0.80	0.70
Sub-bituminous	0.99	0.91	0.83	0.83	0.75
Lignite	1.12	1.01	0.97	0.97	0.83

[1] This study did not include carbon capture and storage (CCS), as this technology is not considered by the Government of Indonesian before a 2030 timeframe.

To understand the potential role of coal and clean coal technology in the Indonesian power system we start by examining the existing targets and plans for the sector.

Figure 4: Five government priorities for the power sector in Indonesia (source: authors)



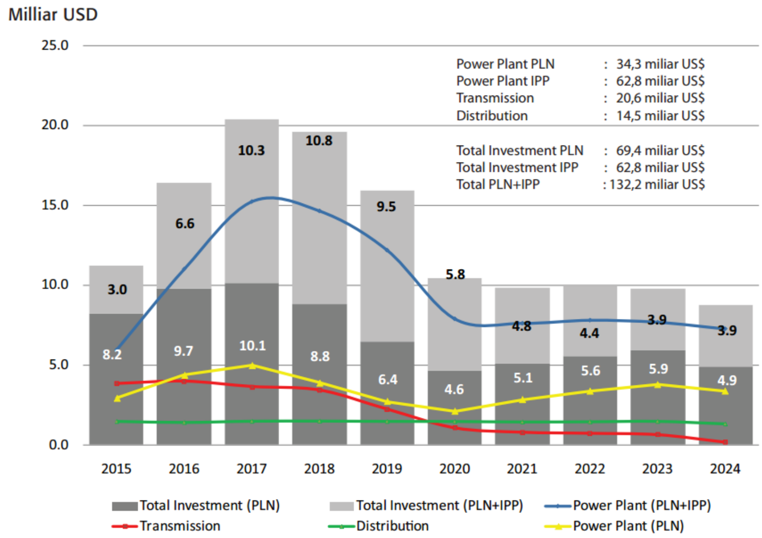
At the national level, there are at least 5 key government policies/strategies for the electricity sector. These relate to: 1) power sector expansion and electrification, 2) energy diversification and renewable energy, 3) domestic coal consumption/energy security, 4) climate change mitigation and 5) a push to reduce the subsidies provided to the public utility for electricity production (Figure 4). In the rest of this report we will explore the role of coal in Indonesia's energy future in relation to these five different and potentially opposing policy drivers. This forms the background to the findings and recommendations presented at the outset of this report.

Electricity Expansion

Growing the Indonesian power system, to provide both energy for a growing economy and a continued roll out of electrification, is a central objective in Indonesia for the coming years. The Government of Indonesia recently announced plans for 35 GW of capacity expansion by 2019 to cope with electricity shortages, meet growing demand and reduce oil-based generation. Coal-fired power plants make up 20 GW of the 35 GW planned and renewable energy sources slight less than 4 GW (Enerdata 2015). This expansion represents the first step in Indonesia's ambitions for the power sector. The National Energy Council projects that demand for electricity will more than triple by 2030, requiring an additional 150 GW of power generation capacity in the coming 15 years (DEN 2015). The public utility PLN estimates that 130 bln USD of investments are required over the coming ten years (Figure 5).

Coal power will be an important contributor to that growth; it represents an abundant, low cost and domestic source of energy. However the characteristics of power sector infrastructure financing in Indonesia mean that this growth is unlikely to be achieved without international support. The financial position of PLN has required it to look to donors in the past for significant lending support in order to build out its generation stock and transmission infrastructure. For example, Indonesia is estimated to have benefited significantly from coal export credits from OECD countries over the past decade, with more than 2.6 bln USD of loans for coal projects in the country (Bast *et al.* 2015). The arguments behind at least 1 bln USD of lending currently being considered by the WorldBank and ADB for the power sector strongly suggest that this situation will continue into the foreseeable future (Reuters, 2015).

Figure 5: Estimated power sector investment requirement until 2024 – where 'PLN' is investment by the national utility and 'IPP' is investment by private independent power producers (source: PLN 2015)



In this context, the political acceptance of coal fired power station financing outside of Indonesia becomes an important consideration. In November 2015 participants to the OECD Arrangement on Officially Supported Export Credits announced that they "will substantially limit official export credit support for new coal-fired power plants" by setting minimum technology requirements for different sized plants. Over two-thirds of the global coal-fired power projects receiving official export credit support from those same OECD participants between 2003 and 2013 would not have been eligible for such support under the new rules (OECD, 2015). These rules provide an important signal to Indonesia and its pursuit of clean coal technology. To be eligible for this type of financing support, large power plants will need to adopt at least USC technology. Assuming that USC technology will be adopted for new coal plants in Indonesia, they would be eligible for international support under the current OECD rules.

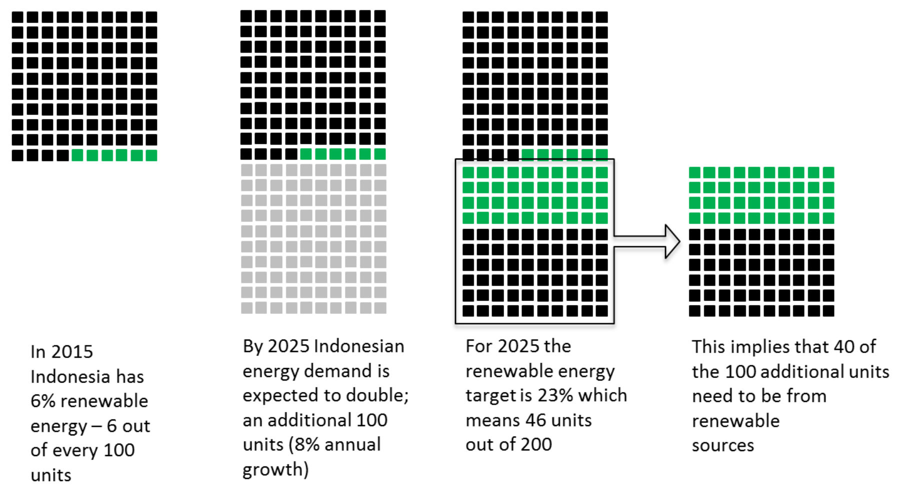
At the same OECD forum, quantitative CO_2 intensity rules were also considered. If these intensity guidelines were agreed at the levels considered (at that time proposed as 795 gCO_2/kWh), the quality of Indonesian coal for domestic power production could introduce a constraint. Lignite coal causes higher emissions and even USC (or IGCC) technology may not be able to meet eligibility requirements for export credit financing. We calculate (Table 1) that advanced clean coal technology may still deliver emission intensities above 795 gCO2/kWh using Indonesian lignite coal. Larger reductions in intensity would be possible through the application of technologies such as CCS. **Future strategies for financing power expansion in Indonesia will need to take into account potential technology limitations given a likely desire to work with international support.**

Energy diversification and renewables

The recent National Energy Policy (KEN; enacted in 2014 under regulation 79/2014) requires that the share of renewable energy in the primary energy consumption[2] increases to 23% in 2025 from an estimated 6% today. To reach the targets, the use of gas is expected to more than double, use of coal would triple, and renewables should grow more than eleven-fold within ten years. In the electricity sector, the projections released alongside the KEN suggest that renewables will need to grow to over 35% of electricity provided and coal should contribute slightly less than 50% (DEN, 2015).

However, the short to medium term planned expansion of coal presents some challenges to meeting the KEN. The medium term planning from PLN in their annually revised 'RUPTL' shows that, based on current planned power projects and growth, coal would grow to over 65% of electricity and renewables would contribute roughly 15% (PLN, 2015), far less than the KEN modelling requires. To meet the KEN two things are needed: an enormous increase in renewables over the coming decade plus significantly less coal consumption. Put very simply, **for every MW of new coal capacity built in the country, more than 2 MW of renewable generation should be built**. Based on planned projects, that ratio will be roughly inverted.

Figure 6: Simple illustration of KEN new and renewable energy expansion requirements (source: authors' own work)



Adopting clean coal technology instead of traditional coal can play a small role in getting closer to the KEN targets, by burning less coal for the same electrical output

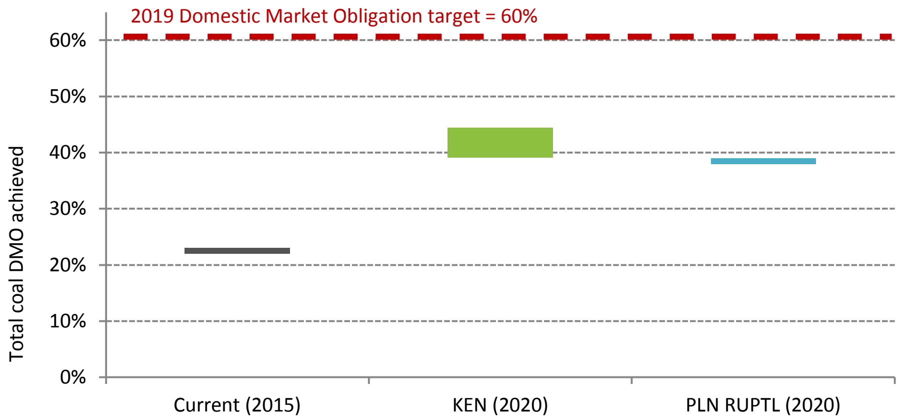
[2] Primary energy consumption measures the total energy demand of a country. It covers consumption of the energy sector itself, losses during transformation (for example, from oil or gas into electricity) and distribution of energy, and the final consumption by end users (Eurostat 2014).

(i.e. the share of coal in the primary energy mix is slightly lower, as coal is converted to electricity more efficiently). As a rule of thumb, for every 10 GW of modern USC clean coal built, 200 to 250 MW less renewables will need to be installed, at a saving of somewhere between 300 to 600 mln USD depending on what mix of technologies are considered. Clean coal technology therefore offers an incremental step towards meeting Indonesia's energy diversification targets in the KEN. However, even with clean coal technology, **the current medium term power sector plans reported by PLN in its RUPTL are incompatible with the KEN to a significant degree.**

Energy security and domestic use of mineral resources

In addition to a focus on renewable energy, the KEN also indicates that Indonesia should be "gradually reducing the export of fossil energy particularly gas and coal and fix the time limit to start stopping export". To that extent, Indonesia has aimed to tighten control over production, use, and pricing of mineral resources. One approach to regulating domestic energy sources used over the last years has been a Domestic Market Obligation (DMO), which requires that a specified percentage of Indonesian coal production is domestically consumed. In the 2015 medium term development plan (*'RPJMN'*) the DMO for 2019 is proposed to increase from its current value of less than 20% to more than 60%, or 240 Mt coal. To put this into context, it would require Indonesia to almost triple its domestic coal use in the coming 4 years, adding roughly 160 Mt to current levels of coal use (Figure 3).

Figure 7: Indonesian domestic coal use in 2015 and estimates for coal use under the KEN and RUPTL in 2020, compared to the 2019 DMO (source: authors' own work)



Even with the coal power planned as part of the 35 GW expansion under the RUPTL - which was found to be incompatible with the energy diversification targets of the KEN - it will not be possible to meet the DMO in 2019 (Figure 7). We estimate that the RUPTL would allow Indonesia to domestically consume roughly 38% of coal produced (at current levels) by 2020. The share of coal observed in Figure 7 for the KEN appears higher than the RUPTL, because both electricity demand and coal production levels are significantly lower under the KEN. The installed capacity of coal power installed under the RUPTL is substantially higher than the KEN and the renewables capacity correspondingly lower. Clean coal technology makes the achievement of the DMO more difficult by using lower volumes of coal.

The DMO target, therefore, requires Indonesia to use more coal than is possible under current plans in the sector. Doing so would move the energy system still further from the KEN targets and a 23% renewable energy mix. Based on these observations there are serious questions about Indonesia's ability to meet the DMO target, especially while meeting the KEN. A future in which both the DMO and KEN are achieved would require that current coal production levels are roughly halved over the coming years, a scenario that is not realistic. **A credible roadmap for how the DMO can be met – whilst respecting other energy sector goals – will require a lower target or a reduction in domestic coal production.**

Climate change

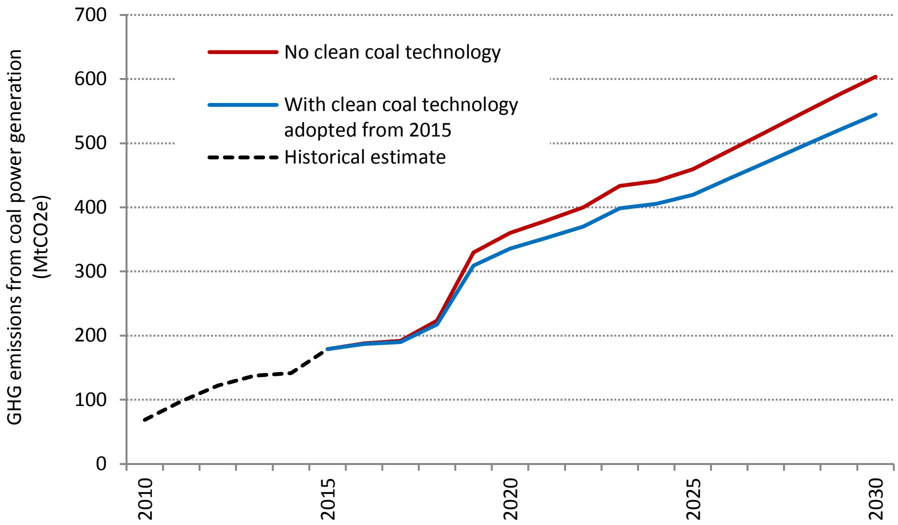
In 2009 Indonesia announced that it aimed to reduce its GHG emissions by 26% relative to business as usual levels by 2020, and possibly up to 41% with international support. This ambition was further elaborated in the National Action Plan for Mitigation (RAN-GRK). The RAN-GRK allocated the majority of emission reductions to the land-use sector, but included some relatively limited activities around renewables and energy efficiency. The precise role of coal in the baseline and the possibility for clean coal technology was not clear; however a number of development cooperation projects over the subsequent period did investigate this further. In September 2015, the government of Indonesia published its INDC, in which it announced the intention to reduce GHG emissions by 29% relative to business as usual in 2030 unconditionally, and possibly up to 41% with international support. This section of the report first looks at the INDC baseline and scenarios, before considering coal use and how that relates to the INDC.

The submitted INDC did not include precise actions and sector baselines , which makes it difficult to assess the contribution of individual technologies and fuels. It also makes it difficult to assess the level of mitigation ambition versus current plans and strategies. A background document on the RAN-GRK review, which served as the basis for the INDC, describes the Indonesian INDC mitigation scenarios in more detail, in particular some of the underlying assumptions for the Indonesian power sector (Bappenas, 2015).

Based on these scenarios we estimate that the Indonesian electricity baseline assumes very high levels of coal power production in the future, up to almost 80% in 2025. This would be considerably higher than the RUPTL projections. If true, this would mean that the INDC baseline power sector emissions are significantly higher than current power sector plans anticipate and **the 'unconditional' INDC scenario is no more ambitious than existing plans for the sector.** If the RUPTL were to be considered as the baseline for the power sector, any shift of expansion plans to more closely align with the KEN would represent mitigation effort beyond existing expansion plans. Such a framing of the baseline may allow Indonesia to increase absolute mitigation ambition in the power sector.

Clean coal technology can play a role in realising emissions reductions, yet the climate impacts of clean coal plants will be relatively modest compared to alternative approaches such as energy conservation and using sustainable energy sources. We estimate that savings up to 10-13 percent in GHG emissions can be expected from clean coal technology compared to using traditional pulverised technology, when Indonesian lignite coal resources are used. This is lower than estimates that we find in general literature or existing studies in Indonesia, but is considered to be realistic due to the relatively low energy and high water content of coal in the country.

Figure 8: GHG emissions from coal fired power generation in Indonesia based on the 2015-2024 RUTPL, extrapolated to 2030, with and without clean coal technology (source: authors' own work)



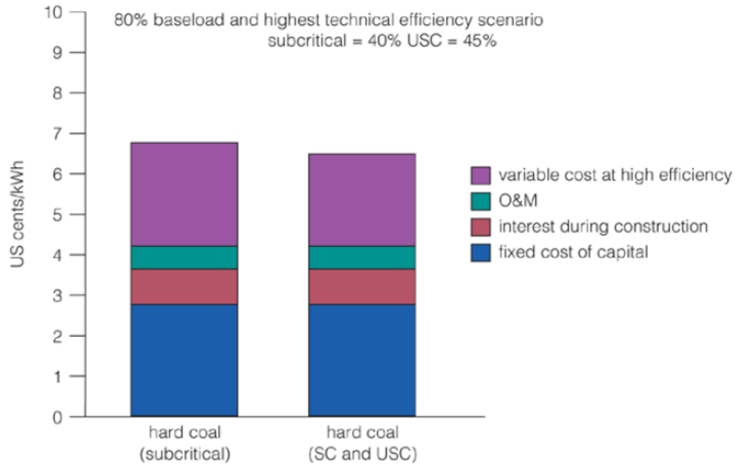
Based on current projections in the RUTPL extrapolated to 2030 we estimate that clean coal technology could, if applied as best available USC or IGCC, contribute roughly 60 $MtCO_2$ of savings by 2030 (Figure 8). However, as discussed earlier, the future outlined in the RUPTL is not compatible with the KEN (i.e. the KEN projects less coal use and hence less mitigation in this sector from clean coal technology). Should coal power be implemented at levels compatible with the KEN, then savings from clean coal are estimated as approximately 25 $MTCO_2$ by 2025 when the national energy policy should be met. To put these figures in perspective, if clean coal is built in accordance with the RUPTL, the attributable 60 $MtCO_2$ reduction represents approximately 7% of the total unconditional emissions reductions that Indonesia has proposed in its INDC. The INDC included an unconditional 29% reduction from a 2030 business as usual estimate of 2,881 $MtCO_2e$ for the entire country (or an absolute mitigation contribution of approximately 835 $MtCO_2e$). If coal is built at levels that allow the KEN to be reached, then attributable savings for clean coal technology will be commensurately less, approximately 4% of total emissions reductions in 2030 in Indonesia's NDC. **In conclusion, clean coal can play a small role in mitigation efforts, reducing total emissions in 2030 by between 1.2 and 2.0 percent**, as a fraction of economy-wide business as usual emissions. As noted earlier, shifting current power sector expansion plans closer to the targets of the KEN – by achieving a greater share of renewable energy and significant reductions in electricity demand – could make a greater overall mitigation contribution.

Subsidy reduction

Electricity prices paid by end-users are regulated under Presidential Decree No.8/2011. There are more than 30 tariff classes organised into six groups: social, household, business, industry, government and special services (PwC, 2013). The average selling price in 2014 was 818 Rp/kWh (approx. 6 US cents/kWh) while the cost of production was 1,297 Rp/kWh (0.5 US cents). The shortfall is funded through a government subsidy that amounted to approx. US$7.3 billion in 2014, or almost 34% of total operating revenue for the public utility PLN. There is therefore a strong focus from the Government of Indonesia to reduce generation costs and thereby subsidy. In that context, it is important to understand the potential cost impacts of clean coal technology as compared to conventional coal generation.

Coal prices are similarly regulated in Indonesia. Regulation No. 17/2010 stipulates that all coal produced by IUP/IUPK (Mining Business Permit /Special Mining Business Permit) holders must be sold at the regulated benchmark price, for both domestic or export sale (IEA, 2015c). The IEA has recently assessed the generation costs of different types of coal technologies in Indonesia using local generation characteristics and prices (Figure 9). They find that for coal plants that have moderately high full-load hours (as would be expected from a baseload generation unit), clean coal generation is equivalent to, or slightly lower cost, than convention generation.

Figure 9: Modelled average generation costs of coal-fired generation in Indonesia for a high load/high efficiency scenario (source: IEA, 2015c)



With no significant difference in levelised costs of energy, introduction of clean coal (USC, SC) should not affect subsidies, or may even lower them slightly when compared to what they would have been with pulverised coal technology. This was confirmed anecdotally in discussions with PLN staff who report that SC and USC technology tends to be favoured in responses to tenders for new coal independent power producers on the basis of cost.

References

Bappenas (2015) *Developing Indonesian Climate Mitigation Policy 2020 – 2030: through RAN-GRK review*, Ministry of National Development Planning/ BAPPENAS, Jakarta, November 2015

Bast, E., Godinot, S., Kretzmann, S. and Schmidt, J. (2015) *Under the Rug*, NRDC/Oil Change International/WWF, 2015

DEN (2014) *Executive reference data 2014 - National energy management*, National Energy Council, Jakarta, 2014

DEN (2015) *Indonesian Energy Outlook* 2015, National Energy Council, Jakarta, 2015

Enerdata (2015) *Indonesia releases its 35 GW power capacity addition plan*, Jakarta, May 2015 [**link**]

ESDM (2015) Handbook of Energy and Economics Statistic of Indonesia, Ministry of Energy and Mineral Resources, Jakarta

Eurostat (2014) Glossary: Primary energy consumption [**link**]

GoI (2015) *INDC Submission to the UNFCCC*, Jakarta, September 24th 2015

Hashimoto, T., K. Sakamoto, Y.Yamaguchi, K. Oura, K. Arima, and T. Suzuki (2011) *Overview of Integrated Coal Gasification Combined-cycle Technology Using Low-rank Coal*, Mitsubishi Heavy Industries Technical Review, Vol. 48, No. 3

IEA (2015a) *Energy Policies Beyond IEA Countries - Indonesia 2015*, International Energy Agency, Paris, 2015

IEA (2015b) *Key Coal Trends*, International Energy Agency, Paris, 2015

IEA (2015c) *Coal and gas competition in power generation in Asia*, International Energy Agency, Paris, 2015

IPCC (2006) *Guidelines for National Greenhouse Gas Inventories Volume 2 Energy*, Intergovernmental Panel on Climate Change, Paris

JICA (2012) *The Project for Promotion of Clean Coal Technology (CCT) in Indonesia*, Japan International Cooperation Agency

PLN (2015) *RUPTL 2015-2024, Electricity Supply Business Plan*, PT PLN Persero, Jakarta

PwC (2013) *Power in Indonesia: Investment and Taxation Guide*, 2nd edition, Jakarta

OECD (2015) *Statement from Participants to the Arrangement on Officially Supported Export Credits*, Paris, November 2015 [**link**]

Reuters (2015) *ADB commits up to $6 bln loan facility for Indonesia's power, energy sectors* [**link**]

Sarunac, Ness, and Bullinger (2015) *Improving the Efficiency of Power Plants Firing High-Moisture Coal*, Cornerstone Magazine, March 2015

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