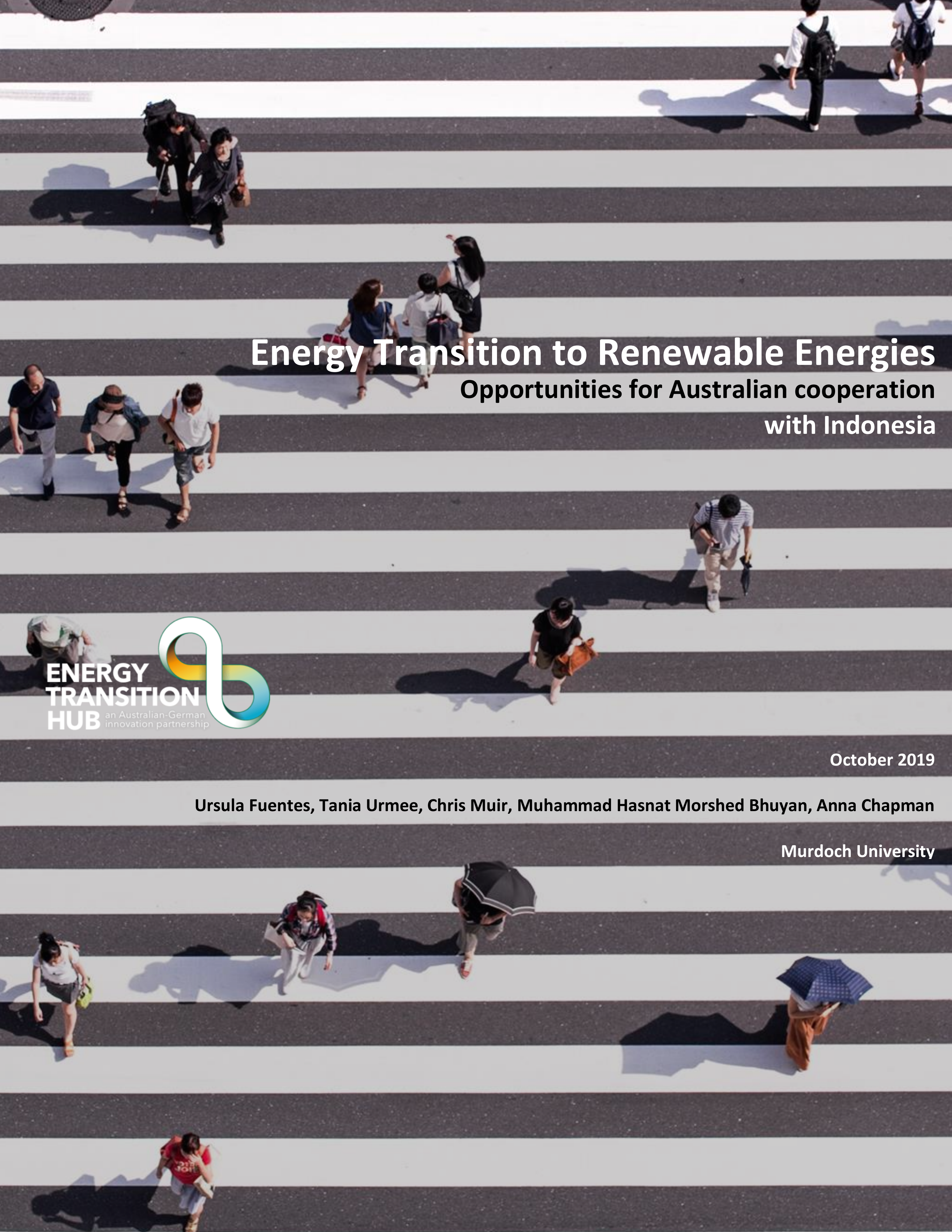

Energy Transition to Renewable Energies

Opportunities for Australian cooperation with Indonesia

ENERGY TRANSITION HUB an Australian-German innovation partnership

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Summary/Key messages

It is paramount for Indonesia to transition to renewable energy, to continue prospering from economic growth while meeting its commitment to the Paris Agreement, and achieving Sustainable Development Goals (SDGs). Indonesia has a target to achieve a share of 23% renewable energy by 2025 and 31% renewable energy by 2050 in the 2014 National Energy Policy. Currently, fossil fuels represent the majority of Indonesia's energy mix, and coal plays an increasing role in Indonesia's power plans. Fossil fuels dominate most projections of the country's energy future.

Current policies are not in line with Indonesia's renewable energy targets and there are challenges to overcome to meet the targets and create a secure and prosperous renewable energy future. Despite the targets, and against the Paris Agreement temperature goal, Indonesia continues to pursue plans for the expansion of coal power plants with a risk of locking in investments in fossil fuels for underutilised assets. The government subsidises coal power generation making it harder for renewable energy to compete, despite the multiple benefits of renewable energy.

This briefing paper looks at opportunities for Indonesia to embark on a transition towards zero emissions based on renewable energy, exploring the opportunities and benefits for sustainable development as well as for mutually beneficial cooperation between Australia and Indonesia. There is a huge untapped potential for expanding renewable energy in Indonesia, and Indonesia can, in addition, tap into the vast renewable energy resources in Australia, through regional cooperation and export of renewable energy from Australia to South-East Asia. Transitioning to renewable energy in Indonesia will help achieve the United Nations' Sustainable Development Goals and the Paris Agreement. This requires accelerated investments in renewable energy, shifting investment away from fossil fuels.

The analysis in this briefing paper highlights the following opportunities for collaboration between Australia and Indonesia to enhance renewable energy investment:

- Collaboration and exchange of best practice to support policy certainty and clear policy signals to investors, including through removing barriers.

- Further joint research and development of scenarios and pathways for a transition to 100% renewable energy in Indonesia and in Australia, including through sectoral integration and regional cooperation.
- Further research and development of joint renewable energy schemes between Australia and Indonesia as a potential extension to the ASEAN Power Grid.
- Further research into the possibility of renewable energy imports from Australia, such as green hydrogen.
- Collaboration and sharing of development of microgrid technology to provide enhanced access to clean energy in remote regions.

Contents

1. Introduction

How Indonesia, with 18,000 islands, the world's 4th largest population, and a strong G20 economy will fuel its ambitious economic growth is significant not only for achieving the Sustainable Development Goals (SDG), but also globally significant for the achievement of the objective of the Paris Agreement to limit global warming to 1.5dC.

Indonesia's energy policy is out of step with global energy markets including South East Asia. Coal investment is decreasing in most countries, but not in Indonesia. 27 GW of coal-fired power is to be added in the next ten years according to the energy plan released in 2018 – higher than Indonesia's planned capacity for renewable energy (Climate Action Tracker 2018).

With diminishing oil reserves and strong population and economic growth creating even larger domestic energy demands, Indonesia is moving into a position of becoming a net energy importer. With large untapped renewable energy resources, it is increasingly evident that a transition to renewable energy allows Indonesia not only to achieve its objective of energy independence and energy security, but also more broadly the SDGs and – closely linked – the important contribution to the Paris Agreement long-term temperature goal. This implies a radical move away from the current focus on relying on fossil fuels in particular from expansion of coal capacity.

Indonesia has a large and mostly untapped supply of renewable energy resources, in particular, significant geothermal and solar energy, as well as the opportunity to launch new local industries and jobs. Indonesia has identified its lack of energy independence in a predominately limited fossil fuel driven energy market, and targeted increasing its utilization of renewable energy with its 2006 and 2016 National Energy policies, to assist in diversifying its energy generation assets and regain its energy independence. Yet, Indonesia is not on track to achieve its renewable energy targets.

This paper investigates what opportunities exist for Indonesia to pursue a future in renewable energy to achieve its climate and sustainable development goals, including cooperation with Australia. Placing this in context we look at Indonesia's energy mix, current and future demands, greenhouse gas emissions and renewable goals and potentials as well as investment needs, and current policy gaps and barriers as well as opportunities for cooperation between Australia and Indonesia.

2. Indonesia's energy system at crossroads: Targets, investment needs, projections

Indonesia: a growing energy giant

Indonesia is among the world's fastest growing countries in terms of energy demand and the largest energy user in the Association of Southeast Asian Nations (ASEAN), accounting for nearly 40% of total energy use among ASEAN member States (ASEAN 2017, IRENA 2017). The total final energy consumption (TFEC) economy-wide has increased by about 36% from 120 million tonnes of oil equivalent (Mtoe) in 2000 to 163 Mtoe in 2015 (ESCAP 2017).

Oil was the dominating fuel in the overall energy mix in the primary energy supply (excluding traditional use of biomass) in 2016, accounting for about 40%, followed by coal 25% and gas 23% whereas renewable energy accounts for only 12% in Indonesia (excluding biomass) (IEA 2018). In terms of electricity generation by fuel type, in the same year coal represented 54%, gas 26%, hydro 8%, oil 6%, geothermal 4%, biofuels less than 1% and no wind power (IEA 2016).

On the basis that about 1 million motor vehicles and 7.5 million motorcycles are added to Indonesia's roads every year, the energy demand in the transport sector also expected to more than double (MEMR 2016). About half of all transport energy use in Indonesia in 2014 was in the form of gasoline used by road vehicles; another 40% was consumed in the form of diesel in road vehicles (IRENA 2017). Thus electric mobility presents a wealth of opportunities for greenhouse gas emission reduction from the transport sector.

Decarbonising the transport and electricity sectors creates large benefits for reducing air pollution in growing cities. While Indonesia is planning to introduce a ban on combustion engine vehicles from 2040 (Kimura, Suehiro et al. 2018), the lack of an enabling policy environment, however, limits the establishment of a market for electric vehicles although some companies are hoping that the market will take off in near future (Kimura, Suehiro et al. 2018).

While Indonesia is an archipelago of 18,000 islands, regionally just two islands account for the majority of energy use, Java accounted for the maximum share of TFEC at 56% in 2013 followed by Sumatra 25% (IRENA 2017).

Indonesia heavily relies on coal and to a lesser degree gas for electricity generation (IESR 2018), and is a net exporter of coal and also of natural gas (IEA 2018) (Figures 1 and 2).

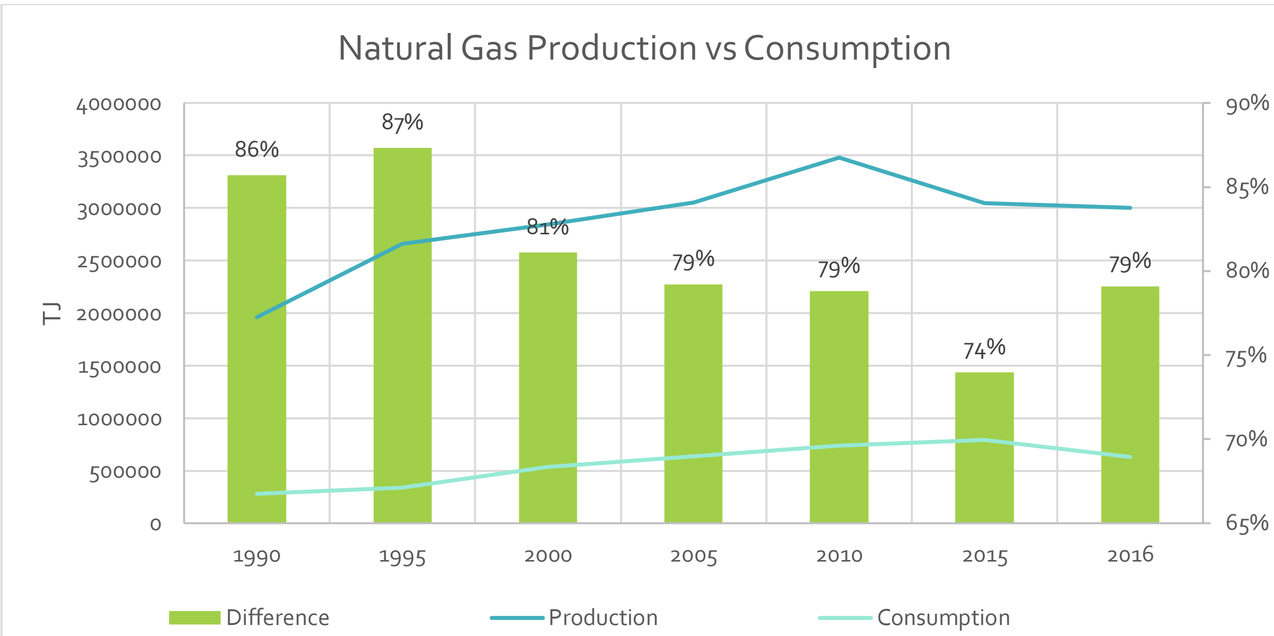

Figure 1 - Natural Gas Production vs Consumption (IEA 2018)

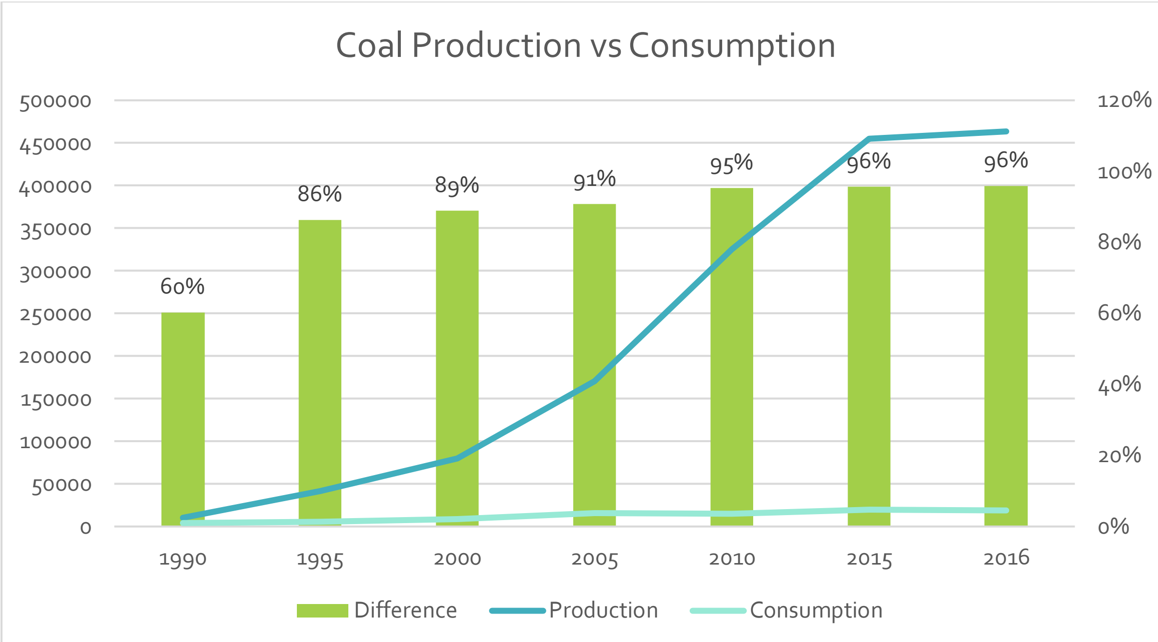

Figure 2 - Coal Production vs Consumption (IEA 2018)

Indonesia has coal resources at around 120.5 billion tons, proven oil resources at around 3.69 billion barrels, and proven natural gas reserves at around 101.54 trillion cubic feet (MEMR 2016). At current production rates, this implies 12 remaining years of oil reserves, 39 years of gas, and 146 years of coal (MEMR 2016).

Figure 3 shows that since 2006, Indonesia's domestic oil consumption exceeded its oil production and the difference in production and consumption is as high as 50% in 2013 (ADB 2014).

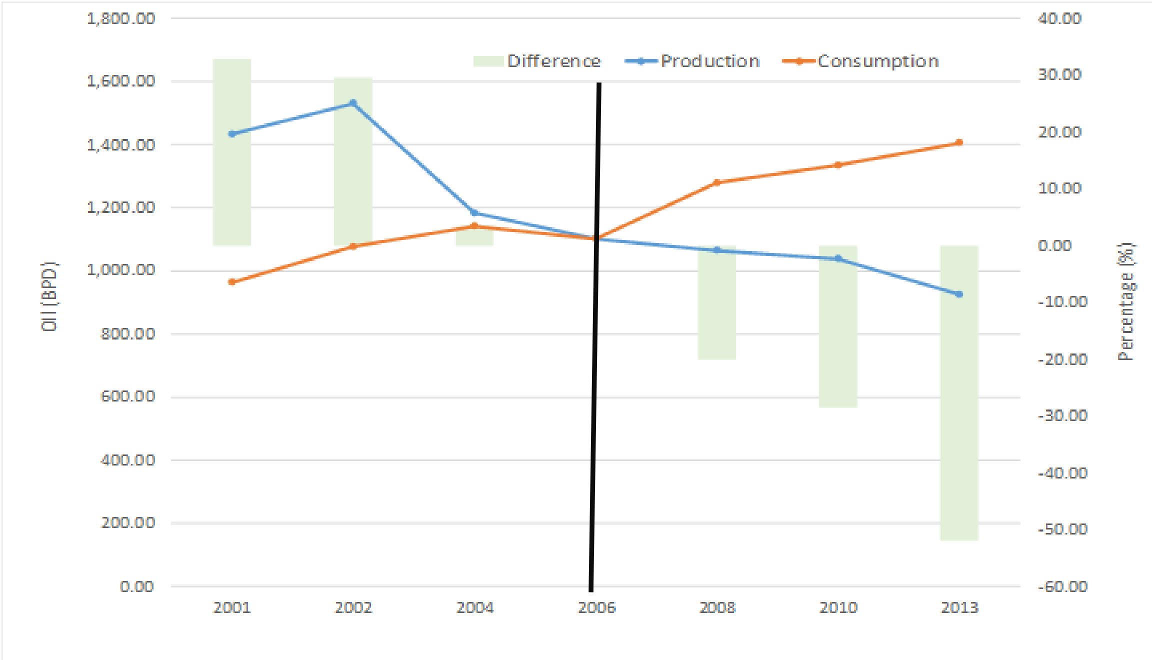

Figure 3 - Oil Production vs Consumption in Indonesia, Barrels per Day & Percentage Change (ADB 2014)

Indonesia's Agency for the Assessment and Application of Technology (locally known as Badan Pengkajian Dan Penerapan Teknologi or BPPT for short) predicts Indonesia will be a net importer of energy by 2032, and 40% of its energy mix will depend on imports by 2050 (BPPT 2018).

Energy outlooks project Indonesia will enjoy a gross domestic product (GDP) rise of between 4.5 to 6% annually to 2030 (compared to the current 5% per year), with a 13% population growth in the same timeframe (IEA 2017a, ASEAN 2017, IRENA 2017). As a result, the demand for electricity is projected to rise significantly to fuel Indonesia's ambitious economic growth.

Indonesia is the second largest coal exporter globally and a main coal supplier to Asian countries. Coal is a strategic export commodity providing a large share of the budget to some provinces such as East and South Kalimantan, and while revenues contribute only a small share of 1.5 to 2% to the national state budget (IESR 2019a).

Energy and climate targets

Specifically considering renewable energy and energy efficiency targets, in January 2014 Indonesia's parliament (IEA 2016) adopted a new National Energy Policy (NEP14) replacing an early 2006 plan. This plan dictates a goal of 23% renewable energy (excluding traditional uses of bioenergy) in the national energy mix by 2025 and a 31% renewables goal by 2050. For the 2025 goal, bioenergy represents 10%, hydro 3%, geothermal 7% and other renewables 3%. This is an increase from the current share of 6.5% renewables (Climate Action Tracker 2018).

Even if Indonesia were to achieve its targets for renewable energy, this would imply locking in fossil fuels inconsistent with the Paris Agreement (Fuentes et al., 2019). However, current policies are not even consistent with the targets, with coal expansion leading to locking in of fossil fuel infrastructure for decades to come (Climate Action Tracker 2018).

Category	Policies and targets	Reference
Efficiency	Reduce energy intensity by 1% per year and 17% reduction across sectors by 2025. Reducing Energy Consumption (TFEC) in 2025 by 17% industry, 20% transportation, 15% residential sector, 15% in commercial buildings compared to business-as-usual.	National Energy Plan (2017)
Electrification	Universal electricity access by 2020	Rural Electrification Regulation
Renewables	23% renewables share of total primary energy supply (TPES) by 2025, 31% by 2050 (excluding traditional uses of bioenergy) Approx. 92.2 Mtoe in 2025, consisting of 69,2 Mtoe (45.2 GW) for electricity and 23 Mtoe for non-electricity.	National Energy Policy (Govt Reg No. 79/2014)
GHG Emissions	Reduce GHG emissions 29% from BAU levels by 2030 (including forestry), and 41% by 2030 with international support	UNFCC INDC (2015)

Table 1 - Indonesian policy and targets, source: (IRENA 2017, 2018).

Further to this Indonesia has pursued plans for energy efficiency including most recently in its 2017 National Energy Plan (NEP17) pursuing energy efficiency gains/reductions across sectors (ADB 2016). NEP17 builds upon previous efforts as far back as the 2005 National

Energy Conservation Plan, which at the time identified a potential 15-30% of energy savings if energy efficiency measures were implemented in the industrial sector for example, and later updated to a broader 10-30% range. NEP17 put in place various reduction targets for different sectors such as 17% in the industrial sector, and approximately 17% across all sectors.

Indonesia's National Energy Policy (NEP) established in 2014 is referred to in its Nationally Determined Contribution (NDC) to the Paris Agreement in 2015. According to the analysis by the Climate Action Tracker (2018), Indonesia is on track to overachieve its NDC emissions reduction targets (both unconditional and conditional), and more so if it were to achieve its energy targets (listed in table 1). However, with current policies, Indonesia is not on track to achieve its renewable energy target.

Indonesia's National Energy Plan 2014 (PWC 2017) sets forth an aggressive growth in electricity generation capacity, starting from a basis of 59.7 GW in 2016, with a capacity of 115 GW by 2025 and 430 GW by 2050, a seven times increase (Figure 4).

The government aimed to expand power generation capacity through a 35 GW fast track program by 2019 (Enerdata 2015). This program was the third fast track development and a driver of power sector development. However, recently MEMR's minister announced substantial delays to half of the projected 35 GW of electricity projects, a non-trivial US$25 billion in projects (Eko 2018).

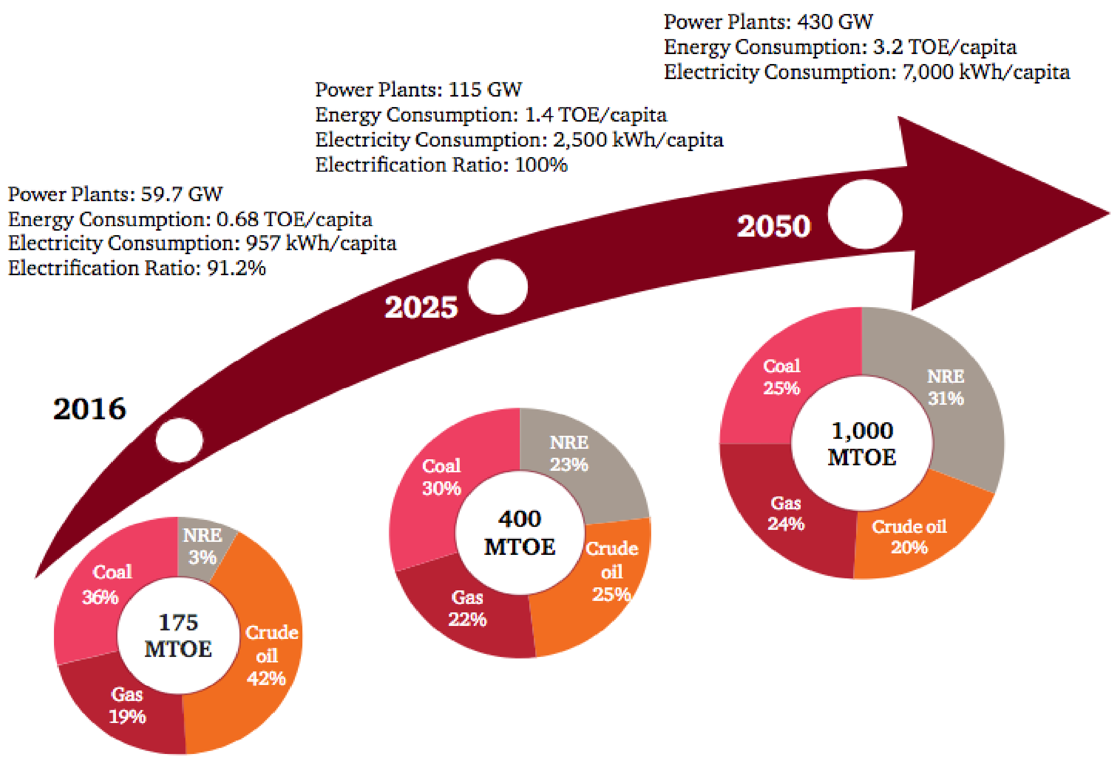

Figure 4. Indonesian National Energy Plan – Targets for 2025 and 2050 (National Energy Plan 2014) – Source (PWC 2017)

Indonesia's Electricity Supply Business Plan (MEMR 2019) for the state-owned utility PLN speaks to the government's own planning for renewable energy as a percentage of fuel mix, as demonstrated in Figure 5 for 2019-2028. It indicates that electricity generation would need to nearly double between now and 2028 – increasing from 245 TWh in 2016 to 433 TWh in 2028 (MEMR 2019). However, this is already lower than the previous growth projections.

There are discrepancies in the interpretation of the 23% primary energy mix target. In the Electricity Supply Business Plan, PLN interprets the target to 23% renewables in the electricity generation mix by 2025 (IESR 2019a). In comparison, in the General Planning of National Energy the target is converted into 45 GW of renewable capacity by 2025. Even so, the new Electricity Supply Business Plan sets out 27 GW of capacity of coal-fired power plants (IESR 2019a).

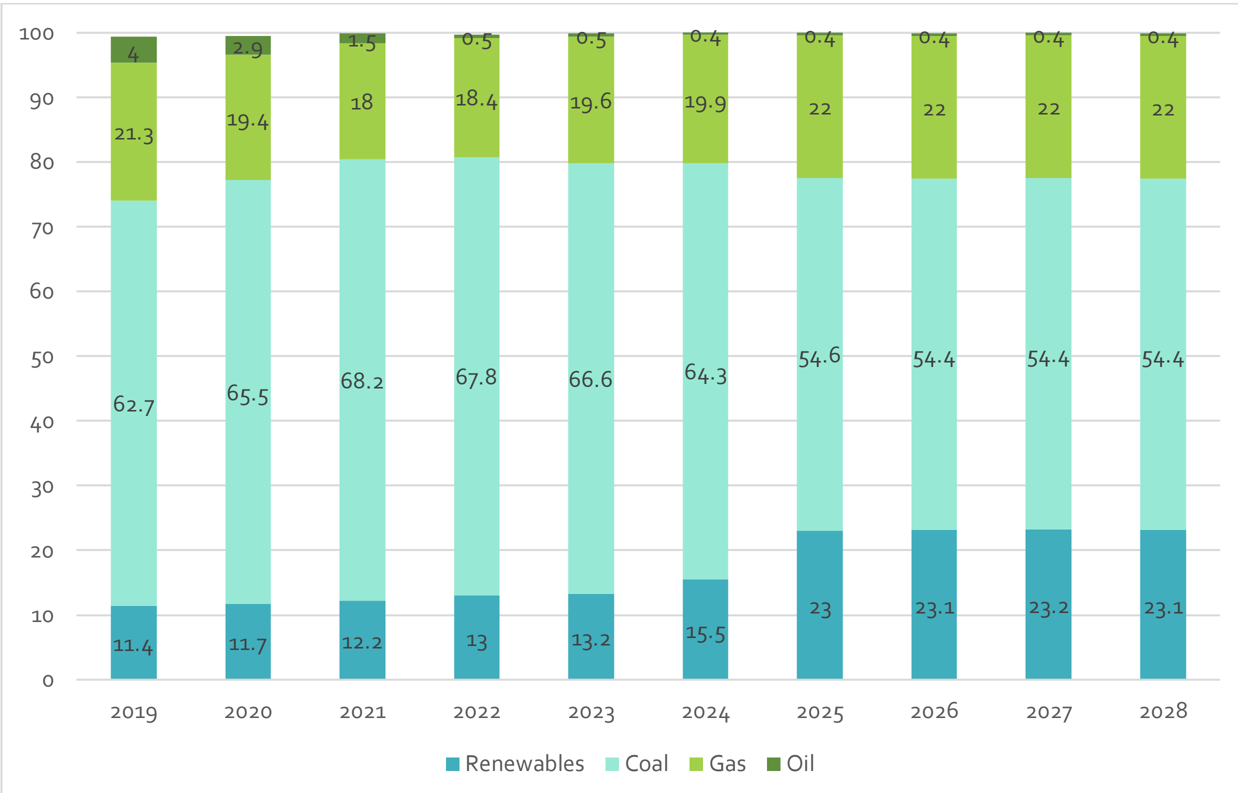

Figure 5 - Indonesia's Energy Mix for electricity generation by Fuel Type (MEMR 2019)

Projections and scenarios

The different scenarios considered in this paper have been taken from projections of Indonesia's National Energy Council (translated from Indonesian: Dewan Energi Nasional or DEN), APEC and IRENA. While the DEN projections include 2025 and 2050, APEC projects BAU to 2035, and IRENA until 2030.

These scenarios make the following assumptions:

- Indonesia National Energy Council (DEN) (Indonesian National Energy Council (DEN) 2016):
  - Business-As-Usual (BAU): assumes moderate GDP growth of 5.6% annually
  - Alternative 1 (ALT1): assumes moderate GDP growth of 5.6% annually and implementation of new renewable energy and energy saving technologies.
  - Alternative 2 (ALT2): assumes high GDP growth of 7.1% and implementation of new-renewable-energy and energy saving technologies.
- Asia Pacific Energy Cooperation (APEC) (APEC 2016):
  - Business-As-Usual (BAU): projects energy demand to grow 2.9% annually to 2035 across all sectors and fuel types except new renewable energy.
  - High Renewables Scenario: projects increasing penetration of variable renewable energy by doubling the use of renewable energy in the power and transport sector.
- IRENA (2017) Scenario:
  - Reference Case: IRENA develops this scenario based on planned policies and market development in technologies considering the Renewable Energy targets of Indonesia, inclusive of the Indonesian National Energy Plan (KEN) scenario of the Energy Outlook Indonesia 2014, and the National Electricity General Plan (RUKN) 2015-2034.
  - REMap: The REMap scenario is based on IRENA's analysis of replacing existing non-renewable energy technologies with renewable sources.

As per Figure 6, currently the energy mix within Indonesia is led by fossil fuels, with over a 90% share (when traditional biomass is not considered). Under 2025 business-as-usual (BAU) (Indonesian National Energy Council (DEN) 2016) scenarios energy use is set to grow by 1.6%, and fossil fuels are projected to drop to 84% of the overall mix with renewables growing its share. By 2050, the BAU scenario energy use is projected to grow by a staggering 5.3 times from 2015, but fossil fuels use will remain at a similar 86% of the total energy mix. Only in the ambitious ALT2 scenario does substantial progress start to reduce dependence on fossil fuels, with a drop to 77% fossil fuels by 2025, and 69% by 2050, consistent with the targets for "new and renewable energy" taking up a share of 23% by 2025 and 31% by 2050 (Figure 6). The share of 31% is already achieved in 2030 in the IRENA REmap scenario (above the 27% share in the reference scenario, while the APEC (2013) reference scenario shows only a share of 21% in 2035).

Markedly the APEC BAU scenario for 2035 shows considerably less growth in demand. Recent government announcements to delay up to half of Indonesia's 35 GW electricity projects worth US$25 billion (Eko 2018) provide an indication that the growth pipeline is already shrinking to more realistic levels.

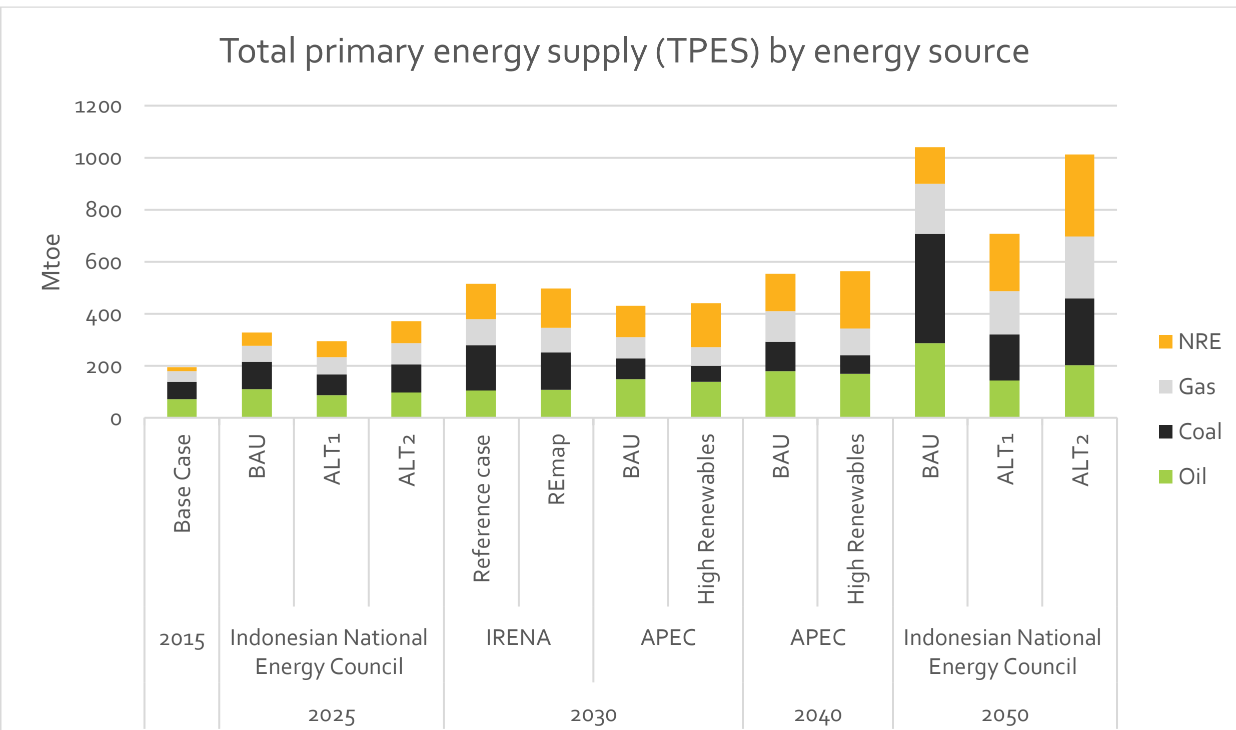

Figure 6 - Current and Projected Total Primary Energy Supply (TPES) by sources for the base case (IEA 2018), Indonesian National Energy Council (2016), IRENA (2017) and APEC (2016) Scenarios

In terms of electricity generation, Figure 7 tells much the same story across agency projections with fossil fuels dominating in all scenarios, even the most ambitious ones regarding renewable energy expansion.

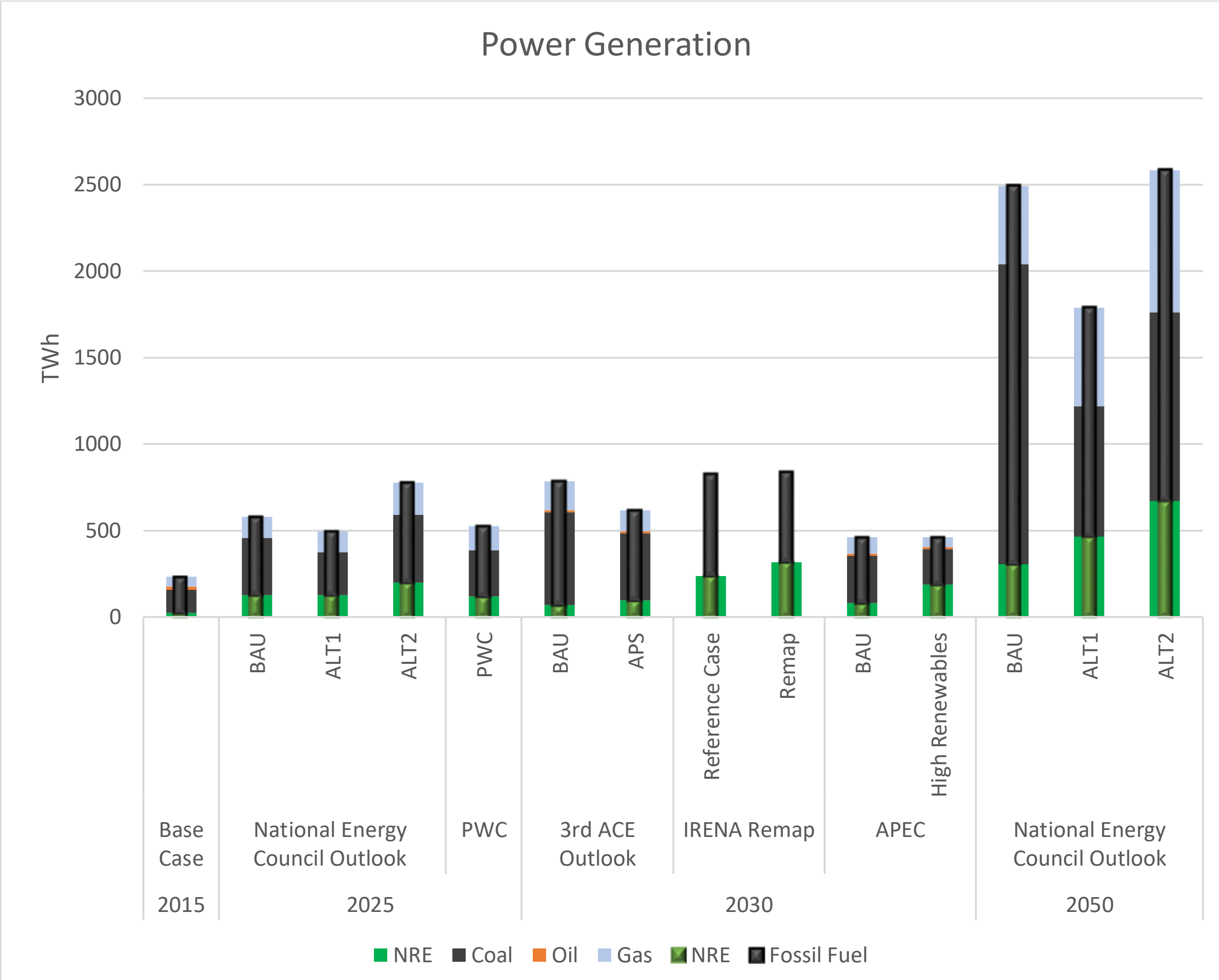

Figure 7 – Current and projected electricity generation by sources for the base case (IEA 2018), Indonesian National Energy Council (2016), PWC (2017), ACE (2017b), IRENA (2017) and APEC (2016) Scenarios (Note IRENA does provide a breakdown by fossil fuel type).

Complex Energy Sector responsibilities

At a national level, the Ministry of Energy and Mineral Resources (MEMR) is the governing body overseeing the Indonesian energy sector. MEMR is responsible for mandating Indonesia's energy goals. The Ministry of State Owned Enterprises manages the state-owned Perusahaan Listrik Negara (PLN) utilities and energy service company and

MEMR is the regulator for PLN. PLN is the prime energy generator and owner of transmission and distribution in Indonesia.

There is a wide range of actors at central, provincial, and local level, reflecting Indonesia's decentralised approach to government instigated in 2000. The previous system of centralized government and planning was passed from the national and provincial level down to regencies and local governments (Asian Development Bank Institute 2016). As a result, municipalities are often included in the process in particular for licencing.

Through PLN and MEMR the coal production industry enjoys a tight relationship with government, and continues to receive significant government financial support including an estimated US$664 million in 2015 (IISD-GSI, 2017; Ordonez et al., forthcoming). Subsidies offered to coal producers include loan guarantees, export tax exemptions, preferential VAT rates for coal mining companies, preferential corporate tax rates, tax allowances, preferential royalties rates, among others (IISD-GSI, 2017). Renewable energy is estimated to have received a mere US$133 million in subsidies in the same year (IISD-GSI, 2017). In addition, the government has capped domestic coal price for power generation at USD 70/ton to protect PLN from the risk of fluctuating price in the international market and maintain the status quo of coal as a cheap electricity source, which translates into a subsidy for the state-owned utility PLN. IESR (2019b) estimates this subsidy reaching USD 1.59 billion in just nine months in 2018. This leaves renewable energy competing with cheaper subsidized coal generation.

Beyond the coal industry, compromises exist within PLN itself. As the government's main generation agency, it is given broad remit and power to undertake its responsibilities. As both a fossil fuel supplier and owner of fossil fuel generation assets, under the current incentivised scheme PLN risks revenue streams and stranded assets if it swaps to renewable energy. With its broad powers, it is in the position to protect itself from such changes, effectively maintaining the status quo.

Even though Indonesia's predicted energy growth has been potentially slashed (Eko 2018), from a broader viewpoint Indonesia's Electricity Supply Business Plan 2018-2027 (RUPTL) still maps out an additional 27 GW of coal capacity (Climate Action Tracker 2018). This puts Indonesia at high risk of missing its renewable targets and locking Indonesia into a high carbon future with underutilised assets in particular with energy growth not meeting expectations (IEEFA 2017). The cost of overpayments and the risk of stranded assets will eventually be borne by the Indonesian government and consumers.

3. Renewable Energy potential and benefits for sustainable development

Indonesia has vast and currently mostly untapped renewable energy resources. Table 3 shows published estimates for the potential of renewable energy compared to currently installed capacity.

RE Resource	Installed Capacity (2015)	Max Reserves	Pipeline Total by 2019	Pipeline Total by 2025
Hydropower	5.025 GW	8.01 - 75.0 GW	5.332 GW	10.294 GW
Geothermal	1.403 GW	29.0 GW	2.264 GW	7.669 GW
Bioenergy	1.740 GW	32.4 GW	2.872 GW	2.872 GW
Solar PV	0.078 GW	207.8 GW (4.80 kWh/m2/day) to 500 GW[2]	0.260 GW	1.200 GW
Wind	0.003 GW	93 - 60.6 GW (3 – 6 m/s)	0.019 GW	0.019 GW
Ocean	<1 MW	17.9 GW	n/a	n/a
Totals	8.2 GW	355.7 - 422.7 355-422 GW	10.74 GW	22 GW

Table 3 - Indonesian Renewable Energy Capacity and Project Pipelines (Indonesian National Energy Council (DEN) 2016) (Bakhtyar, Sopian et al. 2013). Pipeline figures from (PWC 2017)

In fact, solar resources have a much more significant potential then suggested by PWC (2017) in Table 3. A report by the IEEFA suggests Indonesia has 500 GW of solar potential

1 8 GW estimate for additional hydro outside of protected areas. See (MEMR, PLN and JICA, 2011)
2 This figure is a different estimate from: (Hamdi 2019). The 207.8 GW figure is considered an underestimation of Indonesian solar resources, see discussion.
3 9GW IRENA estimate of potential for 2030

(Hamdi 2019). Another study found that covering 1.5% of Indonesia's territory with solar PV would generate 4.968 TWh, equating to 23 times the total electricity generation in 2017 (Fuentes et al., 2019). In short, available rooftops, land and water bodies can accommodate enough solar PV to supply a large multiple of current Indonesian electricity demand.

Significantly Indonesia holds 40% of the world's geothermal reserves at approximately 29 GW, and also has the potential for 60 GW with wind. The potential for expansion of hydro energy is limited if sustainability concerns are taken into account, for example excluding high value conservation forest areas (MEMR 2011). The MEMR (2011) study developed a 'realistic scenario' of hydro considering social and environmental impacts hindering potential projects. The 'realistic scenario' projected a capacity of 8 GW for 2027, which matches the lower end of the max reserves in Table 3.

The costs of renewable energy and battery technology is declining (particularly solar and wind) and in most parts of the world renewables offers the cheapest source of new generation (IRENA 2019). From 2017 to 2018, the price of all renewable decreased, for example, bioenergy -14%, solar PV and wind both declined -13% and hydro -11% (IRENA 2019). In Indonesia, the cost of renewables are also in decline, and by 2030, renewables will be less expensive than coal power plants, and wind power will match coal prices by 2050 (IESR 2019b). To date, Indonesia's energy storage has focused on pumped hydro. But a decline in hydro can be met with other storage technology such as batteries. Based on the IRENA (2017) Remap analysis, if renewable were to replace conventional fuels, it could save an estimated USD 1.7 billion per year in Indonesia's energy system.

Decarbonising the energy system: Scenarios towards 100% renewable energy

Several studies show that a 100% renewable energy scenario by 2050 is possible considering the renewable energy potentials of Indonesia (Ram, Bogdanov et al. 2017, Guenther 2018, Wang, Dargaville et al. 2018). Although meeting the electricity demand of Indonesia from locally available renewable resources could be challenging (Wang, Dargaville et al. 2018), pointing to a possible strategy of regional cooperation.

One of the options for 100% renewable energy integration in electricity system of Indonesia is developing solar energy as the main source of power generation with the help of long-term energy storage to meet the energy demand at any given time (Ram, Bogdanov et al.

2017, Guenther 2018). Table 5 shows the energy mix and annual supply for a 100% renewable option for Indonesia developed by Guenther (2018).

	Installed Capacity (MW)	**Annual Energy Supply (TWh)**	**Total Annual Energy Supply (%)**
Geothermal Power	5,500	41	6%
Hydropower	5,800	18	3%
Bioenergy	Not Determined	7	1%
Solar PV	Open Parameter	574	90%

Table 5 - Power Plant Mix and Annual Energy Supply for 100% Renewable Scenario by 2050 (Guenther 2018)

These scenarios will require a significant amount of storage capacity. Bioenergy can also be a key energy storage technology to support solar energy which would constitute 88% of the total energy mix by 2050 in the scenarios developed by Ram, Bogdanov et al. (2017). In addition, pumped hydro energy storage sites in Bali would give cumulative storage capacity of 2 TWh which is more than enough to provide 100% electricity from renewable sources in Indonesia according to some researchers (Guenther 2018, Wang, Dargaville et al. 2018). Guenther (2018) finds the necessity of complementation of short-term energy systems by a long-term storage system with lower storage capacity like gas storages.

The IESR (2019b) developed different transition scenarios, including a medium (30% renewables by 2027) and high (43% renewables by 2027) scenarios. The study found that the MEMR and PLN continuously overestimate energy demand, which will likely lead to stranded assets, where the costs are covered by the public (IESR 2019b). Whereas, if renewables doubled in the next decade, focusing on solar and wind, Java-Bali and Sumatra could reliably meet their electricity demand, reducing emissions by 36% and create job opportunities (IESR 2019b). The high renewable energy scenario found that realistic energy savings and resulting net cost savings would be feasible, in comparison to the Electricity Supply Business Plan (IESR 2019b).

A recently published scenario looks at the option of connecting Indonesia with Australia with submarine HVDC interconnection (Wang, Dargaville et al. 2018). It found importing renewable energy from the Australian National Electricity Market (NEM) via HVDC interconnectors is feasible and cost-effective option compared to meeting demand from locally available renewable energy sources for the 100% renewable energy scenario by 2050 (Wang, Dargaville et al. 2018). The provision of importing power from NEM reduces the overall systems costs of main Java-Bali power system of Indonesia from $AUD496B (billion) (without HVDC interconnection, discounted, $AUD2015) to $398B (with HVDC interconnection, discounted, $AUD2015) according to this study (Wang, Dargaville et al. 2018).

Further analysis is needed including for a connection from the much closer North West of Western Australia, which was considered through a project in the Pilbara with extremely high solar (2450 kWh/m2/day) and wind (8.2 m/s) resources (Dickson 2018). Other options would include connecting energy markets through export/import of green hydrogen produced from electricity generated with renewable energy.

Benefits of a transition to renewable energy

The following table provides the potential benefits of renewable energy on meeting sustainable development in Indonesia.

Potential Impacts of Renewable Energy Implementation	**SDGs**
New local business and employment opportunities	SDG 1: No poverty
Enhance food security through RE based irrigations, food drying, countering the drought	SDG 2: Zero Hunger
Powering health centres through RE, providing health services by powering vaccine refrigeration Electrification opens opportunities to move away from traditional biomass inside dwellings, and the associated indoor air pollution and health impacts.	SDG 3: Health and wellbeing

Transitioning away from fossil fuels will reduce outdoor air pollution levels, currently posing a serious health concern.	
Access to electricity through RE extend the study hours in remote areas, allows the use of advanced teaching aids e.g. internet & visual audio equipment, enables teaching of new technical skills in rural areas e.g. welding, electricals, electronics, etc.	SDG 4: Quality Education
Supply of fresh drinking water using RE based water treatment plant and desalination	SDG 6: Clean Water
Access to modern energy for electrification, cooking, and heating	SDG 7: Clean and affordable Energy
Increased incomes and new revenue streams. Enables use of equipment which improves jobs. Higher renewable energy uptake would reduce the total costs of the energy system and therefore, increase economic growth	SDG 8: Economic growth
Opportunities for small scale industries for semi-processing crops will increase by introducing RE thereby enhancing value addition Create new jobs in rural areas curbing rural-urban migration Increases economic potential/value of rural areas	SDG 9: Industry, Innovation & Infrastructure
About half of the targeted energy related emission reduction is possible by increasing RE share while meeting the NDC target	SDG 13: Climate action

Transition from use of kerosene and fuelwood for cooking and lighting reduces overall GHG emissions	
Use of preservation technologies can contribute to curbing overfishing by rural communities	SDG 14: Life below water
Switch to cooking with RE electricity can reduce demand for fuelwood and help preserve forests especially in rural areas, schools, hospitals, prisons, etc.	SDG 15: Life on Earth

Table 6 - Impacts of Rural Electrification on Meeting SDGs in Indonesia (McCollum et al. 2018, Brent 2017, IRENA 2017, Fuentes et al. 2019)

With current market developments and costs of renewable energy technologies – in particular wind and solar – as well as battery technologies falling fast and already making them competitive even without taking into account externalities (Fuentes et al., 2019), there is an opportunity to develop strategies and plans in line with an ambitious transition to 100% renewable energy and a corresponding acceleration of investment and faster uptake of renewable energy. Transitioning to renewables would reduce public expenditure on fossil fuel imports, opening opportunities in government to free funds for other avenues of investment (Fuentes et al., 2019) such as renewable energy.

4. Policy gaps and barriers

Policy gaps and barriers to Indonesia's uptake of renewable energy can be broken into a broad discussion of the political economy and influence of fossil fuel industry, and a more specific look at the challenges in the renewable energy sector landscape.

In considering the political landscape influenced by the fossil fuel industry:

- Political economy - At the top-level Indonesia's president has made cheap and reliable electricity, universal electricity access, as well as expanding public infrastructure a centrepiece of his last campaign, with the coal industry one of his key campaign backers (MCC 2018; Ordonez et al, forthcoming). The coal industry is also a significant contributor to national and in particular, provincial and municipality budgets (Atteridge et al 2018) and a key source of foreign exchange. Through the government, PLN, and MEMR the coal industry (both production/mining and power sector) enjoys a tight relationship with government (IESR, 2019b).

  The decentralization agenda has spurred the unstructured over production of coal. Changes in regulation have allowed local governments to issue licences for coal production (IESR 2019b). In 2001, 750 mining permits (including coal) were issued, but by 2014 it was closer to 11,000 (Atteridge et al 2018). Excessive coal production has led to a number of other issues such as deforestation, corruption, illegal mining, problems of land titles, and resource 'sterilisation' as small fragmented mines increase the difficultly of accessing deeper deposits (Atteridge et al 2018).

  A decline in the coal export market has incentivized the well-connected coal industry to tap into their government ties and lobby for coal fired plants to increase domestic demand for coal (Ordonez et al. forthcoming).

  Government rhetoric and regulations emphases the importance of coal production for domestic energy security, but 80% of coal is exported (IESR 2019b). Policymakers and industry perceive and portray coal as a cheap energy source to power the country, which sets a major obstacle for an energy transition (IESR, 2019b).

- Coal industry subsidies – The coal production industry continues to receive significant government financial support including an estimated US$664 million in 2015 (IISD 2018). This leaves renewable energy competing with cheaper subsidized coal generation (IESR 2018).
- PLN - as the government's main generation agency with a broad remit and power to undertake its responsibilities, PLN is perceived to have little incentive to move from fossil fuels, and a vested interest in protecting the status quo (IISD 2018). For example, as PLN supplies, owns and operates the majority of fossil fuel generation in Indonesia, it actively utilizes diesel generation in remote areas even though renewables may be a cheaper option as it risks losing a revenue stream. PLN has a history of over-estimating electricity and coal projections, resulting in revisions of Electricity Supply Business Plan (RUPTL) (2018-2027), where gas and renewables are reduced over coal, and the most recent RUPTL does not show a reduction in planned coal-fired power (IESR 2019b).
- Similarly, other state-owned oil and gas agencies such as PT Pertamina and PT Perusahaan Gas Begara (PGN) face similar positions, as they would also have revenue incentives to protect the status quo.
- Corruption – Corruption has persisted as an issue in Indonesia. Significantly, there are contemporary corruption investigations into the approval and funding of new plants (John 2018). The Clean and Clear program was introduced to certify miners who offer transparency over royalties, debts, permit issues and environmental commitments (IESR 2019b). In 2017, the East Kalimantan provincial board withdrew 400 licences, most relating the absence of a Clean and Clear approval (IESR 2919b). The Corruption Eradication Commission has recommended some 3,900 mining permits be revoked due to corruption infringements (IESR 2019b).

In focusing more closely on the renewable energy market itself, the following gaps and barriers have been identified:

- Renewable energy perception - At a more fundamental level in considering renewable energy, a frequent theme expressed in researching the lack of renewable energy in Indonesia is that it is perceived as costly, and as intermittent therefore risking grid stability (IESR 2018, IISD 2018), failing to consider environment externalities, and the rapid reduction of renewable energy costs, in particular solar and wind as well as storage technologies.

- Policy uncertainty - A commonly referred to barrier is the frequency the government changes its direction, policy and regulations, creating a large degree of uncertainty and risk to investing in building renewable energy projects (IESR 2018, IISD 2018). As an example, investments in geothermal projects are believed to have stalled thanks to a 2003 law decentralizing planning control from central to local governments (ADB 2016).
- Financial mechanisms - For renewable energy providers, the 2017 cap to renewable energy prices paid for generation has limited their ability to recoup costs, making projects unviable (IISD 2018).
- Tenders and approvals - At a project level, the government tender and approval process is impacting the ability for renewable energy projects to proceed. ADB (2016) gives several examples including:
    - A government geothermal tender process that places the entire risk of exploration on the winning bidder, where the supplied geothermal data in the tender process is considered highly variable sourced from departments with little financial and technical capacity (ADB 2016).
    - Extensive delays to environmental approvals for geothermal and hydropower sites in forested areas from the Ministry of Environment and Forestry (ADB 2016).
    - A failed solar PV bidding process constrained by poor site selection, poor solar availability data, grid interconnection issues, limited bid preparation times (ADB 2016).
- Operational barriers - For government-financed renewable power plant projects, the lack of formal handover by developers to district governments has left the authority stranded with no skills or resources in complying with national energy regulations and selling energy into the local energy market (Kumara et al. 2018). There is inadequate automation resulting in operator errors in small grids switching from solar PV to alternative power systems after daylight hours (ADB 2016). Scaling up renewable energy will have integration costs and planning will be needed to integrate renewables into the transmissions, and management of demand and response (IESR 2019b). Energy storage technology offers opportunities to complement renewable energy, particularly battery technology for smaller grids.

At the macro and micro policy level, IRENA (2017) identifies significant opportunities for Indonesia to tighten and enhance its policy relating to emissions targets and renewable energy:

- Look to align its NDC and renewable energy target policies.
- In addition, align these policies with those in MEMR & PLN.
- Improve planning and management of grid stability and dispatch strategies to better integrate variable renewable energy sources into the country's overall energy mix.
- Reform government energy procurement plans to not discount renewables.
- Investigate energy storage for grid stability.
- Devise improved renewables compensation for PLN to promote greater renewable uptake by the agency.
- Consider mini and micro grids in future expansion, and add funding into the PLN budget.
- Strengthen local renewable project financing, including providing large renewable project government loan guarantees, fund and guarantee loans on high upfront cost and risk geothermal projects.
- Tighten land tenure and use policies and legal frameworks for renewable projects.
- Simplify solar PV permits for ground mounted systems.
- Provide additional compensation for excess solar PV capacity.
- Reduce bioenergy permit procedures and costs.
- Increase the maximum size of bioenergy projects.
- Expand assessment of local marine energy resources and potential.
- Add wind power to the feed-in tariff program. (Although, this program has since had price caps imposed impacting the feasibility of renewables projects (IISD 2018)).
- Expand efforts to promote solar thermal systems.
- Utilize growing bioenergy feedstock on degraded land.
- Update domestic biofuel policies addressing barriers on both demand and supply.

5. Options for collaboration between Australia and Indonesia

Indonesia's interest in energy self-sufficiency to meet its projected high economic and population growth currently is focused on the use of domestic fossil fuel reserves predominately based on carbon-intensive coal. However, with renewable energy potential and current market developments of falling costs of renewable energy and storage technologies, there is a unique opportunity for Indonesia to fuel its rapid growth and modernise its economy with a transition to renewable energy.

With this in mind, from the Australian perspective, it is well placed to partner with Indonesia on helping deliver energy projects to meet this growth not just because it is a neighbouring country, but also because of its vast experience in renewable projects, including:

- Work together on development of strategies on transitioning towards 100% renewable energy, including intermediate plans, targets, and roadmaps for policies, and also developing joint research and scenario development.
- Work together on identification and removal of barriers, exchange on policy development, work jointly with stakeholders from industry and finance sector to remove barriers and attract enhanced investment into renewable energy.
- Work together on coal phase out strategies and just transition away from coal, including regional impacts in regions heavily dependent on coal.
- Regional cooperation through linking energy markets – either linking power grids or through export of green hydrogen – currently focus on Japan, Korea, but Indonesia would be an important potential partner, in particular if moving towards 100% RE, with some interest already in hydrogen.
- Australia is well placed to produce and supply green hydrogen from its vast wind and solar reserves, to help power Indonesia's increasing domestic industry and transport

sector and add flexibility through the use of hydrogen as an energy carrier. BPPT has shown interest in hydrogen, and has signed a memorandum of understanding with Toshiba (2018) for an off-grid hydrogen energy system, with an aim to install hydrogen for a distributed energy system by 2022.

- While the proposed Pilbara Asian Renewable Energy Hub (2019) focuses on Japan and South Korea as potential importers of green hydrogen, this and other similar projects present an excellent opportunity for a joint Indonesia-Australian renewable energy scheme in the long term. Utilizing vast renewable resources in Australia's north-west, coupled with 'green' hydrogen to export to Asia, the project presents a large opportunity for economic gain and collaboration between the two countries, with a focus on mutual benefits of a transition to renewable energy.
- As Indonesia and Asia as a whole are showing interest in hydrogen, other countries are already taking the opportunity to showcase their solutions (Holder 2018). Australia's geographic locality and renewable reserves are a perfect match to address this market.
- Indonesia's challenging geography as a large archipelago and in conjunction with a domestic policy of universal electrification, transmission & distribution of electricity has evolved into separate energy grids across the islands with 600 isolated grids and 8 major networks in operation in 2017 (PWC 2017). To date, Indonesia has yet to mature its ability to plan and manage grid stability and dispatch strategies to better integrate variable renewable energy supplies (IRENA 2017) but continues to explore micro-grids as an option to service areas with low electrification including Papua with assistance from the Asian Development Bank (Bellini 2018). Thanks to experience in building and perfecting its own renewable microgrid solutions, Australia's own energy companies like Horizon Power (2018) are well placed to provide microgrid technology and skills into the Indonesia market.

6. Conclusion

This briefing paper demonstrates the following opportunities for collaboration between Australia and Indonesia to enhance the investment in renewable energy in Indonesia to be explored:

- There is largely untapped potential for expanding renewable energy investment in Indonesia, which can be spurred by the support from the Indonesia government and its agencies through consistent renewable energy policy support and actions, in addition to a shift away from supporting the fossil fuel industry.
- There are several studies highlighting renewable energy opportunities for mutually beneficial cooperation between Australia and Indonesia. Further research is needed for analysis and scenarios for 100% renewable energy, and integration of energy markets, especially in relation to joint renewable energy schemes. In addition to the option of electricity transmission lines, there are opportunities for green hydrogen export from Australia and sharing of microgrid technology and skills.
- Further (joint) research and scenario analysis could inform a pathway towards the achievement of Sustainable Development Goals and the Paris Agreement Long-Term Temperature Goal through a transition to 100% renewable energy and electrification of end-use sectors as well as using green hydrogen to replace fossil fuels in industry and heavy-duty transport.
- Collaboration can also focus on jointly identifying opportunities for increasing investment in renewable energy by removing barriers and creating incentives, as well as developing a policy dialogue to share experiences and analysis for a transition to renewable energy, as well as a just transition away from coal.

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