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Decreasing costs of renewables – Analysis of energy sector planning and climate policy in Indonesia

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Abstract

This study analyses the **processes and assumptions underlying the development of Indonesia's NDC** and its revision in 2020. The assumptions underlying the **related energy sector documents** (KEN, RUEN, RUKN, RUPTL) and their relationships are also assessed. The study is completed by giving a snapshot of the current state of discussion around constraints related to renewable energy.

The unconditional target of Indonesia's **NDC foresees a reduction of GHG emissions of 29%** relative to a Business-as-Usual (BAU) scenario (41% conditional to international support). It specifies that electricity generation shall reduce emissions by 18.8% relative to BAU.

- The overall target of a 29% and 41% **have been set by a non-public process**. The sectoral shares of GHG reductions are determined by the responsible ministries (ESDM in case of the energy sector), with modelling performed by academic institutions (e.g. BTI for energy).
- This modelling is partly based on existing plans of the energy sector. Data underlying this modelling is not public, but underlying socio-economic assumptions suggest that **the BAU scenario overestimates emissions**.
- The **NDC has no influence on planning in the energy sector** but should be considered a by-product of existing planning documents.
- The process underlying the current revision is repeated for the current revision of the NDC and likely also for creation of the LTS. **The ambition under the revised NDC will not be increased.**

The share of renewable energy in the NDC follows from a cascade of **energy planning documents** (KEN, RUEN, RUKN, RUPTL), which pass the target from the most overarching energy plans to the NDC.

- Arguably the most important target related to renewable energy planning in Indonesia set down by the countries' energy strategy KEN, to reach **23% renewable energy in each sector in total primary energy supply in 2025**. The assumptions underlying this target are not known and can therefore not be contested.
- The national energy plan RUEN makes this target more specific in terms of technology. The power sector plan by the ministry of energy RUKN and the power sector plan by the utility RUPTL all consider 23% renewable energy target. Besides that, these **plans remain largely disconnected from each other**.

- Nearly all energy planning documents regularly make use of **overestimated GDP growth assumptions for the future**, which has implications for the relevance of target set relative to this baseline. **Technological assumptions remain undisclosed**.
- There is no evidence costs play a role in any of these planning documents and **the underlying modelling is not cost-optimized.**

To understand the perspective of renewable energy in Indonesia, it is essential to consider factors that go beyond planning documents.

- Costs of renewable energy projects are higher in Indonesia than global averages. Project costs are especially determined by land permits, technology costs and an **elevated cost of finance.**
- The discussions often revolve around the impossibility to integrate renewable energy sources to the power system due to their variability. This line of argumentation claims **lacking grid stability, inflexible grid management** and points to difficulties in developing interconnections between islands.
- Implementation is not determined by following cost-optimized planning, but by a political agenda **serving vested interests in the energy sector, which leads to an increased use of fossil fuels, in particular coal-fired power capacities.**

Further Reading

In a companion paper, Ordonez and Eckstein (2020) discuss the potential to revise the NDC of Indonesia based on falling cost projections.

Within the same project, the team of authors has produced two more reports of the same structure for Mexico (Eckstein et al. 2020c, Eckstein et al. 2020a) and Argentina (Nascimento et al. 2020, Kurdziel et al. 2020).

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List of abbreviations

BAPPENAS	Ministry of National Development Planning	*Kementerian Perencanaan Pembangunan Nasional*
BAU	Business as Usual	
BTI	Bandung Technical Institute	
CM1	Counter measure 1	
CM2	Counter measure 2	
DEN	National Energy Council	*Dewan Energi Nasional*
ESDM	Ministry of Energy and Mineral Resources	*Kementarian Energi dan Sumber Daya Mineral*
IEA	International Energy Agency	
IEO	Indonesian Energy Outlook	
IPP	Independent Power Producer	
IPPU	Industrial Processes and Product Use	
KEN	National Energy Policy	*Kebijakan Energi Nasional*
KLHK	Ministry of Environment and Forestry	*Kementerian Lingkungan Hidup dan Kehutana*
LCDI	Low-Carbon-Development Initiative	
LTS	Long-Term Strategy	
NDC	Nationally Determined Contribution	
NRE	New and Renewable Energies	
PPA	Power Purchase Agreement	
PLN	Electric Utility Company	*Perusahaan Listrik Negara*
RE	Renewable Energy	
RPJMN	National Medium Term Development Plan	*Rencana Pembangunan Jangka Menengah Nasional*
RUEN	National Energy Master Plan	*Rencana Umum Energi Nasional*
RUKN	National Electricity Master Plan	*Rencana Umum Ketenagalistrikan Nasional*
RUPTL	Electricity Supply Master Plan	*Rencana Usaha Penyediaan Tenaga Listrik*
UNFCCC	United Nations Framework Convention on Climate Change	

1 Introduction

The Paris Agreement (UNFCCC 2015) aims to limit the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C (UNFCCC 2015). Article 4 of the Paris Agreement requires each signatory party to assess and submit their Nationally Determined Contribution (NDC) to achieving the goal of the Paris Agreement. The Paris Agreement foresees NDCs to be resubmitted with increased ambition every five years, with the first revision due in 2020. An integrated climate change mitigation and adaptation strategy document towards 2050, the Long-Term Strategy (LTS), is the second document set out by the Paris Agreement. The first submission of the LTS is due in 2020.

In this study, we assess to what degree the present and future costs of different power sector technologies are considered in the 2020 revision of Indonesia´s NDC and associated LTS. Further, we also address to what degree costs of power sector technologies are considered in energy planning strategies and plans issued by different authorities governing Indonesia´s energy sector. We thereby analyse the modelling tools applied and their underlying assumptions. The role of different government authorities is described in conjunction with the planning documents they issue, and the relationship between the authorities is documented. The report also reflects on the current discussion around renewable energy in Indonesia in general.

Indonesia´s parliament ratified the Paris Agreement (Law UU16/2016) and submitted its NDC to UNFCCC in 2016. Indonesia´s NDC (Government of Indonesia 2016) considers an unconditional reduction of GHG emissions of 29% by 2030 relative to a business as usual scenario (BAU). The main share of mitigation is in the forestry sector, followed by energy sector. To reach the contribution of the energy sector to the NDC, the use of renewable energy in the power sector plays an important role. In the unconditional scenario, the NDC states that 19.6% of electricity should be produced by renewable sources by the year 2030 (Annex, Government of Indonesia (2016)). This builds on the National Energy Plan (RUEN), which stipulates to reach a share of 23% new and renewable energy (NRE) by 2025 in primary energy supply.

Renewables have experienced massive cost reductions in recent years, a trend projected to continue in years to come: 2018 projections show future costs[1] of solar PV, wind energy and batteries to be 20-50% lower than 2015 projections (Wachsmuth et al. 2018). Renewable energy targets imply investment expenditures in order to deploy the corresponding technology. Cost reductions, on the other hand, enable foreseen investment expenditures to finance a higher capacity development of the corresponding technology. Wachsmuth et al. (2018) conclude from global figures, that for each MW of renewable capacity foreseen in 2015, the same investment volume could now be used to finance nearly double (1.9 MW) of the same technology. In a companion study to this publication (Eckstein et al. 2020b), we assess specific cost projections and renewable targets for Indonesia. While substantial cost reductions have been observed for solar-PV, wind energy and batteries in recent years, other renewable technologies such as hydro power or geothermal, show little cost reductions. Using recent cost projections, the renewable target of 45 GW by 2025, set down in Indonesia´s National Energy Master Plan (RUEN), could be increased to 51 MW (from 70 MW to 85 MW for 2030). This rather moderate increase reflects the comparably small share of solar PV and wind power currently envisioned in the 45 GW target. Cost reductions for key renewable technologies in the power sector also imply that the NDC could consider an increase in the share of mitigation taken by the energy sector (Eckstein et al. 2020b).

This study draws on publications of the different authorities, but equally on insights collected during 12 bilateral expert interviews and a stakeholder workshop. The interviews were conducted with key stakeholders from the different government bodies, academia, and other relevant institutions during a visit to Jakarta in February and March 2020. Whenever this report cites from one of the interviews, this is indicated by square brackets [as such]. An overview of the interview sample is given in Annex A.1.

This report is structured as follows. Section 2 continues by giving an overview of the current state of renewable energy in Indonesia. Section 3 then takes a detailed look at the current revision of the NDC and LTS of Indonesia. We assess the processes underlying the revision of the NDC and determine to what degree falling costs of renewable energy technology are considered in the NDC, e.g. by means of underlying energy sector modelling. As will become clear, the underlying renewable energy targets of Indonesia´s NDC are derived from national

[1] At a global level for 2030

goals as stipulated in other energy planning documents. This is the reason why Section 4 takes a look at these energy planning documents by the different authorities. The section analyses the different perspectives towards renewable energy, as well as the underlying modelling tools and the role of costs in this planning process. In particular, we provide insights to the National Energy Policy (KEN), the Energy Master Plan (RUEN), the Electricity Master Plan (RUKN) and Electricity Supply Business Plan (RUPTL). Section 5 highlights economic, technical and political constraints as by drawing from interviews with stakeholders and reflecting their views. Section 6 gives a summary and concludes.

In order to easy reading for those readers well aware of the background to each document described in this report, key insights are highlighted by a grey box.

2 Status quo of renewables in Indonesia

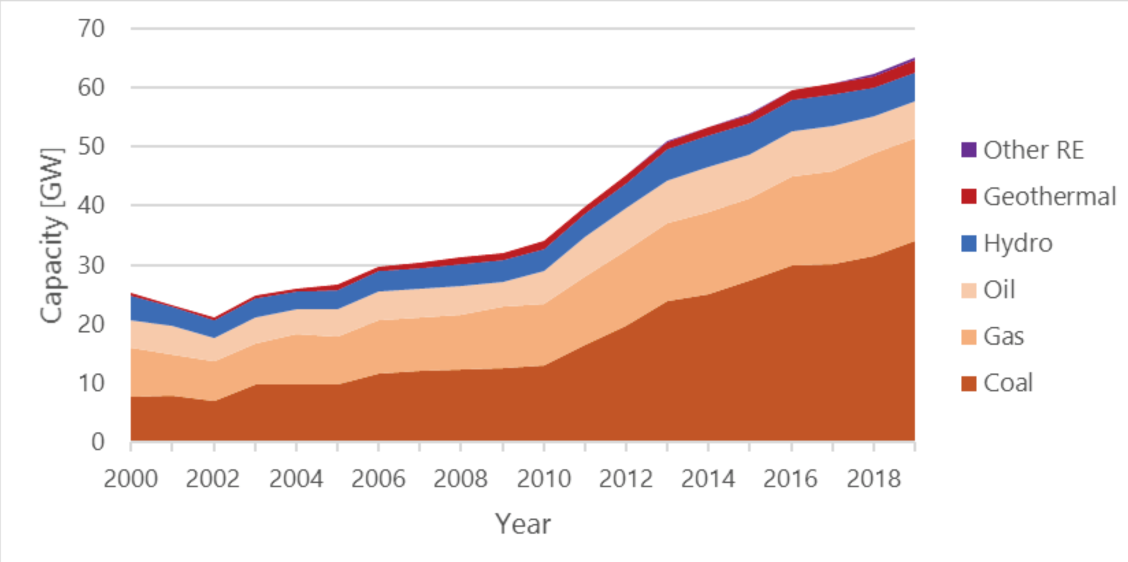
With a population of 265 million inhabitants and a GDP of just above USD 1 trillion, the energy demand of Indonesia, the largest economy in South East Asia, is projected to significantly increase in decades to come (DEN 2019). Indonesia´s per capita electricity consumption (0.8 MWh/cap) remains below that of many neighbouring South East Asian countries such as Vietnam (1.7 MWh/cap), Thailand (2.7 MWh/cap) and Malaysia (4.6 MWh/cap) (enerdata 2020). Indonesia's energy policy aims to increase per capita consumption by substantially expanding its power sector. Indonesia's total installed power capacity was 65 GW in 2018, largely determined by coal (52%), and followed by gas (27%) and oil (10%). Together, fossil fuels represent about 90% of installed capacities, while the remainder is determined by hydro (7%) and geothermal power (3%) (enerdata 2020). The country has substantial reserves of thermal coal, ranking as the largest coal exporter and 5th largest producer worldwide (IEA, 2019). The expansion of Indonesia´s power sector is mainly driven by the 35 GW fast track program, a program that aims to add 35 GW of power capacity in the coming years, the bulk (20 GW) of which is expected to come from coal (Ordonez et al. 2020).

Variable renewable energy, in particular solar PV and wind energy, still play a negligible role in Indonesia's power sector. Late capacity additions for wind power and solar PV remain low. Figure 1 displays a time series of the power sector composition in the timeframe 2000–2019. The largest share is taken by coal fired power plants, which have experienced a substantial increase in the last decade, followed by natural gas. Solar PV and wind energy together sum up to 0.1 GW.

Indonesia's first wind power plant in was inaugurated in the Sidenreng Rappang Regency in 2018, with a capacity of 75 MW (Nugraha 2018). Further, in the Jeneponto Regency of South Sulawesi, another new wind farm was built with a capacity of 72 MW (Tampubolon 2019). Indonesia's total installed wind capacity is currently around 150 MW. Similarly, the total installed solar PV capacity is around 160 MW, with the first larger utility scale projects coming online in recent years, following small scale PV installations across the country in the last decade.

Figure 1: Power sector composition of Indonesia

Electricity generation by technology in Indonesia in the timeframe 2000–2019



Source: enerdata (2020)

While the country has substantial reserves of fossil fuels, most importantly coal, it also has great potential for the development of renewable energy. Table 1 shows the potentials by technology as given in Indonesia´s National Energy Plan RUEN. Notably, solar PV has the largest potential with 208 GW, followed by hydro (75 GW) and wind energy (61 GW).

The global trend in falling costs of solar PV and wind power challenges Indonesia´s present and future power mix. Recent power purchase agreements (PPAs) for renewable projects between project developers and the utility company PLN still turn out at higher electricity purchase prices for PLN than new coal fired power plants. The South Sulawesi Wind Farm in Sindereng Rappang regency was agreed with a PPA of USD 11 cents/kWh. The PPA for the Cirata 145 MW floating solar PV power plant reached financial closure at USD 5.8 cents/kWh. New coal-fired power plants are reported to close PPAs around USD 4–5 cents/kWh (Maulidia et al. 2019).

Table 1: Renewable energy potentials of Indonesia

Potentials for the development of renewable energy in Indonesia according to the National Energy Plan RUEN

Technology	Potential
Large Hydro	75 GW
Mini and micro hydro	19 GW
Geothermal	30 GW
Wind	61 GW
Solar PV	208 GW

Source: Government of Indonesia (2014)

In a companion report, Eckstein et al. (2020b) look at the implications of falling costs for a revision of renewable energy planning and the revision of the NDC of Indonesia. They show that a cost optimal power sector could consider a stronger uptake of solar PV and wind energy projects. In this report, we elaborate on the administrative authorities responsible for planning of renewable energy and climate policy and disentangle the assumptions underlying the different plans and their interrelation.

3 The Nationally Determined Contribution and Long-Term-Strategy of Indonesia

This section describes the Nationally Determined Contribution (NDC) and the Long-Term Strategy (LTS) of Indonesia. Particular attention is given to the modelling of the energy sector. Thereby, the NDC and LTS are put into perspective with national energy planning.

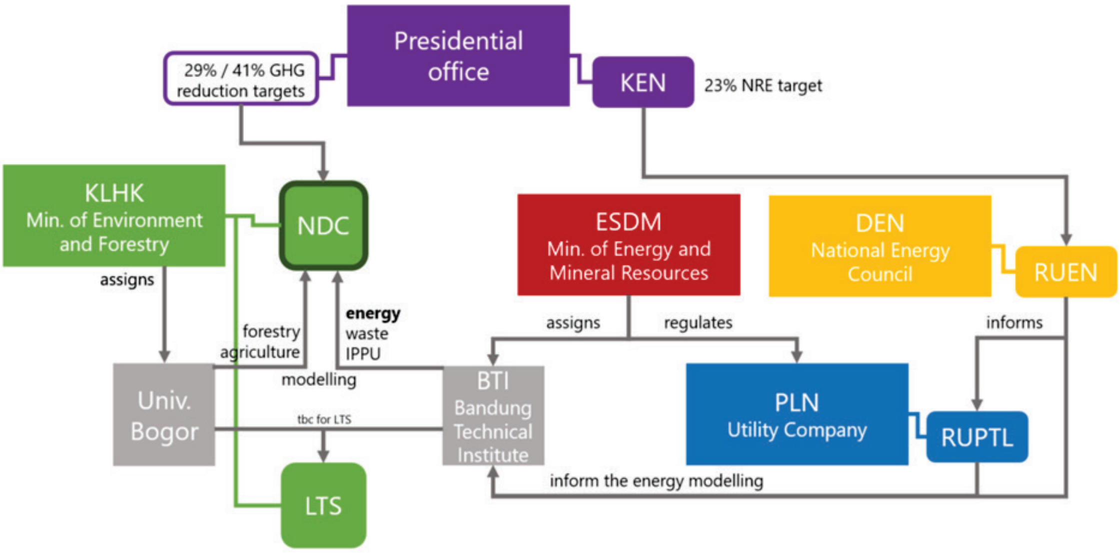
Figure 2 gives an overview of institutions and reference documents relevant for the NDC modelling and its revision. The main responsibility for NDC preparation is with the Ministry of Environment and Forestry (*Kementerian Lingkungan Hidup dan Kehutanan*, KLHK). KLHK is also in charge of the forestry sector, for which the University of Bogor is tasked with the modelling.

The energy sector targets are provided by Ministry of Energy and Mineral Resources (*Kementerian Energi dan Sumber Daya Mineral*, ESDM), who tasked Bandung Technical Institute (BTI) with the modelling work. This energy modelling in turn is partly determined by the existing planning documents RUEN (issued by the National Energy Council DEN) and RUPTL (developed by the utility PLN). The overarching document for the energy sector targets – which first sets down the 23% target in NRE by 2025 – is the National Energy Policy KEN, originally designed by the Presidential administration. The combined overall reduction targets of 29% and 41% have been set exogenously, supposedly again by the Presidential administration.

While this section focusses on the NDC, its 2020 revision and the underlying modelling, the Section 4 provides information the underlying energy planning documents themselves, with a particular focus on renewable energy.

Figure 2: Authorities and their planning documents for the NDC in Indonesia

Relationships of the different institutions (in boxes) and their regulations (with rounded corners) are each indicated in a separate colour. Academic institutions are shown in grey. Arrows indicate where an institution or document acts on another, which is labelled. The main focus is on the Energy and Forestry sectors. Not all relationships are shown. E.g., DEN consists of representatives of several ministries, including ESDM and KLHK, and the Presidential office also interacts with the ministries shown Details are provided in the text.



Source: own compilation

3.1 The Nationally Determined Contribution (NDC)

3.1.1 The NDC of Indonesia

Indonesia ratified the Paris Agreement within Law UU16/2016. The NDC of Indonesia (Government of Indonesia 2016), considers mitigation measures in five sectors: Forestry, Agriculture, Waste, Industrial Processes and Product Use (IPPU) and Energy. The mitigation targets are formulated relative to a baseline *Business as Usual* (BAU) case of development for the year 2030. Two different scenarios are presented: Counter Measure 1 (CM1) is the scenario underlying the unconditional target, while Counter Measure 2 (CM2) will only be targeted conditional to international support. The unconditional target foresees a reduction of emissions by 29% in 2030, while the conditional scenario aims at a reduction of 41%.

Figure 3 and Table 2 and provide an overview of the envisioned emission reductions by sector. The main burden of mitigation in both scenarios (CM1 and CM2) falls on the forestry sector. In the unconditional scenario CM1, the forestry sector contributes with a reduction of 69.6% of its sectoral emissions (e.g. relative to its BAU case). This represents a share of 60% of the overall mitigation effort. The energy sector contributes with a sectoral reduction of 18.8% relative to the BAU (314 MtCO_2eq, 38% of the total mitigation effort). Other sectors contribute with a reduction of less than 10% each relative to the BAU scenario (Table 2). In the baseline, as well as in both mitigation scenarios, the energy sector represents the largest share of emissions in 2030: In BAU, emissions from the energy sector increase by factor 3.7 between 2010 and 2030, in in CM1 by factor 3 and in CM2 by factor 2.8.

For the energy sector and particularly the electricity generation, the emission reduction is achieved by increasing the use of 'clean coal technologies' (0% of clean coal technologies for BAU, 75% for CM1 and 100% for CM2), as well as the use of renewables (19.6% RE generation for CM1 and 132.74TWh RE generation for CM2).

Table 2: Sectoral mitigation targets set down in Indonesia´s NDC

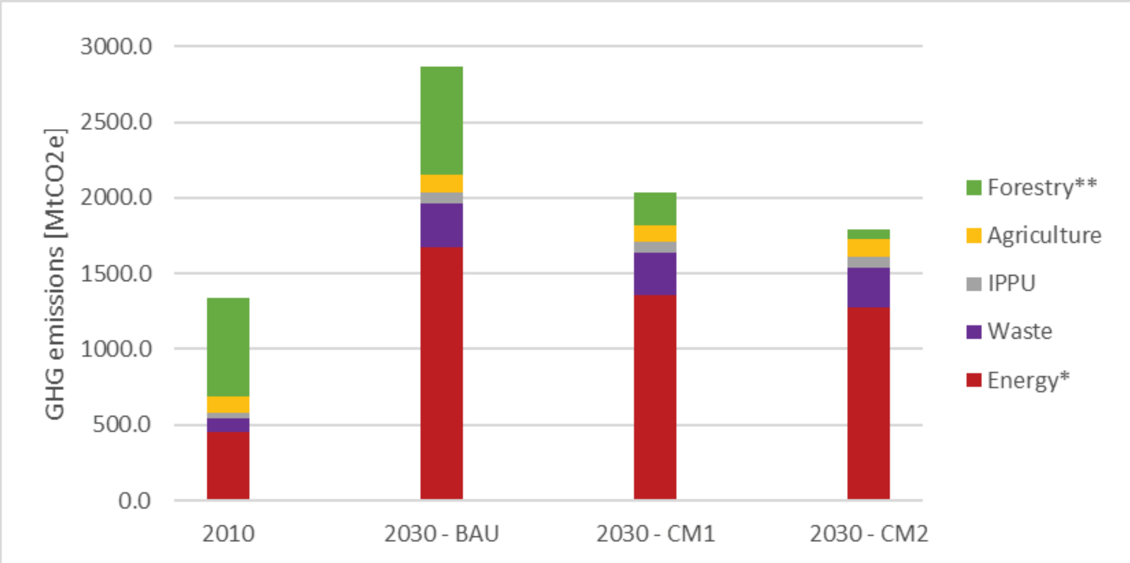
Targets for GHG emission reductions by sector and scenario as given in Indonesia´s NDC. Values are presented for the unconditional (CM1) and the conditional (CM2) scenario. IPPU: Industrial Processes and Product Use; *Including fugitive emissions; **Including peat fire

Sector	2010 [MtCO_2eq]	2030 BAU [MtCO_2eq]	2030 CM1 [MtCO_2eq]	2030 CM1 reduction	2030 CM2 [MtCO_2eq]	2030 CM2 reduction
Forestry**	647.0	714.0	217.0	69.6%	64.0	91.0%
Agriculture	110.5	119.7	110.4	7.7%	115.9	3.2%
IPPU	36.0	69.6	66.9	4.0%	66.4	4.7%
Waste	88.0	296.0	285.0	3.7%	270.0	8.8%
Energy*	453.2	1669.0	1355.0	18.8%	1271.0	23.8%
Total	**1334.0**	**2869.0**	**2034.0**	**29.1%**	**1787.0**	**37.7%**

Source: Government of Indonesia (2016)

Figure 3: Sectoral mitigation targets set down in the NDC of Indonesia

Targets for climate change mitigation of Indonesia as given in the NDC. Values are presented for the unconditional (CM1) and the conditional (CM2) scenario. IPPU: Industrial Processes and Product Use; *Including fugitive emissions; **Including peat fire. Also see Table 2 for values.



Source: Government of Indonesia (2016)

3.1.2 Setting up the NDC

In Indonesia, the Ministry of Environment and Forestry (*Kementerian Lingkungan Hidup dan Kehutanan*, KLHK) is responsible for the elaboration of the NDC. KLHK thereby coordinates the work across ministries, as mitigation efforts in each sector is the responsibility of a different ministry, e.g. the Ministry of Energy and Mineral Resources (*Kementerian Energi dan Sumber Daya Mineral*, ESDM) defines the contribution of the energy sector, while KLHK the contribution of the forestry sector. The ministries work with different research institutions to develop the underlying modelling scenarios that determine sector-specific potentials. In this context, the Bandung Technical Institute was tasked by ESDM with modelling the energy, waste and IPPU sectors, while KLHK worked with the Bogor Agricultural University for the forestry and agricultural sectors. The modelling results are passed on to KLHK, where sectoral results are combined for the NDC [IV03]. Exact assumptions for each sector and scenario are not publicly disclosed [IV05].

In the NDC elaboration process, the total emission reduction targets (29% and 41% reduction for CM1 and CM2) were not determined in a bottom-up manner, e.g. as a result of the sum of sectoral contributions. The exact process and underlying assumptions how these total emission reduction targets were defined is not transparent. Interviewees reported these targets were set by the presidential office [IV06, IV12]. The process was described as top-down, the presidential office providing reduction targets for CM1 and CM2 and the organisation responsible for each of the five sectors adapting or designing their contributions to fulfil these targets.

3.1.3 The 2020 revision of the NDC

The current revision of the NDC was initiated by KLHK in October 2019, and was foreseen to be finished by submitting the document to UNFCCC at the end of March 2020 [IV03]. The process was stated not to be substantially different to the initial NDC creation in 2015, yet it was stated to be less open to the general public [IV05].

The update of Indonesia´s NDC will not increase the ambition level of mitigation targets set out in the first NDC [IV03, IV05]. The revision is limited to adaptation measures, as well as monitoring, verification and reporting (MRV) elements [IV03, IV05]. To discuss in how far this is aligned with Art. 4 of the Paris Agreement is beyond the scope of this report[2]. The revision will consider the Ocean Dialogue, as key outcome of COP25 in 2019, yet it remains unclear in which way at the time of writing [IV03].

As the mitigation plans will not be updated, the main share of mitigation will remain with the forestry sector and in the jurisdiction of KLHK, which is currently in an internal process of specification of how to reach the ambitious mitigation targets [IV03]. This process also entails the determination of the conditions which should apply for switching to the conditional scenario and related targets under CM2, where one additional element could be the support to introduce carbon pricing [IV03]. It was stated that the Ministry of Finance is examining carbon pricing as one option to finance the measures required under the NDC [IV09].

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2 Paris Agreement, Art. 4.3 states that 'Each Party's successive nationally determined contribution will present a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.' UNFCCC 2015.

An increase in the ambition level of the energy sector is not foreseen, as the targets set down in the current NDC in 2015 are still seen as ambitious [IV02, IV03]. The revised NDC will specify more details on the technologies which will be considered to mitigate emissions in the energy sector [IV03, IV05].

Efficient coal ('ultra super critical' and coal gasification) and other technologies, such as nuclear and an increased share in biomass as energy source, will be specified as options [IV03, IV05]. Additionally, carbon capture and use (CCU) or carbon capture and storage (CCS) are considered to reduce emissions of the power sector [IV02, IV12], but high prices limit this option to be deployed only after 2030 without international support [IV12]. Interviewees reported that a dialogue between KLHK and ESDM (the Ministry of Energy) has taken place, with KLHK requesting ESDM to increase its ambition level. ESDM is reported to be reluctant to assume a higher mitigation share, in view of current difficulties to reach their current target of 23% new and renewable energy [IV01] (see Section 4 for more details).

3.1.4 Energy modelling underlying the NDC

Energy, including transport and buildings, is foreseen to be the sector with highest emissions in all scenarios underlying the NDC. It takes the second highest share of the overall mitigation effort, with a reduction of 18.8% of emissions relative to BAU in the unconditional scenario.

The responsible ministry for the energy sector of the NDC is ESDM, which also manages renewable energy policies and acts as the regulator of the electric utility company PLN. For modelling of the energy sector of the NDC, ESDM has tasked Bandung Technical Institute (BTI). BTI has been developing decarbonisation scenarios since 1997 and cooperates closely with international organizations, such as IDDRI (Institute for Sustainable Development and International Relations). BTI is involved in all NDC related modelling activities, e.g. also in the biennial update report [IV12].

To develop the mitigation scenarios underlying the NDC, a stakeholder dialogue with key stakeholder of energy policy was carried out, including PLN, DG Electricity of ESDM [IV12]. The current and future penetration of different technologies were analysed, as well as their mitigation potentials [IV12]. 'Clean coal technologies', such as 'super critical coal' or 'ultra super critical coal' were determined to be a feasible option. This refers high-efficiency coal power plants, increasing their efficiency from currently approx. 30% to close to 50% [IV02]. This can be increased to 55% with integrated gasification, but implies high costs

[IV12, IV04]. The NDC itself gives renewable energy targets for 2030 for CM1 (19.6% in electricity generation) and CM2 (132.74 TWh). The target for CM1 cites the annual 10-year electricity planning document (RUPTL) of 2015 by the utility PLN, while the introductory text cites the targets of the National Energy Plan RUEN, particularly the target to reach a share of 23% new and renewable energy (NRE) by 2025 in primary energy supply.

These documents (RUPTL and RUEN) inform the energy modelling underlying the NDC, but details on how they link to the NDC generation targets are not provided (e.g. the RUPTL (issued on a yearly basis) cited in the NDC only covers the period 2015–2024, RUEN does not entail electricity generation targets). Section 4 discusses both documents, as well as their relation to the NDC and one another.

In terms of overall modelling, basic assumptions driving the BAU are the economic growth and population development. The NDC states that 'ExSS (Extended Snap Shot) using GAMS (General Algebraic Modeling System) and CGE (Dynamic CGE)' were used as modelling tools in the energy sector (Government of Indonesia 2016). The exact GDP and population growth rates are not reported in the NDC itself, but a study by BTI (Siagian et al. 2017) claiming to use the same values specifies GDP growth rate of 5.5% and an increase in the population by a factor of 1.3 (from 2005 to 2030). Siagian et al. (2017)state: '*Despite using the same assumptions for economic development and population growth, the INDC*[3] *estimates larger baseline emissions [than the study by BTI]*'. The authors however cannot analyse the underlying reasons for this difference, *'because the corresponding energy level and energy mix in 2030 are not provided in the INDC document'* (Siagian et al. 2017).

This study (Siagian et al. 2017) and discussions with stakeholders hint at a possibly overestimated baseline. If the BAU scenario overestimates economic and population growth, a reduction relative to BAU could in theory be achieved even without any change of current business. This directly influences the efforts that are necessary to reach the targets of either one of the mitigation scenarios in all sectors, but particularly the energy sector.

Another important parameter to consider in modelling the composition of the energy supply is the efficiency to transform primary energy into electricity. For coal, the numbers have been specified above (30% to 55% in the case of gasi-

3 The Intended Nationally Determined Contribution (INDC) is identical in its scenarios to the NDC in the case of Indonesia.

fication). For renewables, the IEA gives international guidelines to use an efficiency of 100% for solar and wind energy. If this parameter is set to values lower than 100%, and all else is equal, this artificially increases the share of renewables in the primary energy mix. Different statements were made about the values used in the modelling of renewables in the NDC of Indonesia [IV12]. The fact that this is not clearly defined and being discussed shows that this efficiency may be used as a tuning parameter to adjust the results to exogenous requirements.

As has become clear from these considerations, costs do not play a role in determining the targets of the NDC. The share of mitigation between sectors is not determined in a transparent process and certainly does not follow a least cost approach. Similarly, targets within the energy sector do not consider costs or cost progressions.

3.2 The Long-Term Strategy (LTS)

In Indonesia, the process to develop the LTS is coordinated by KLHK [IV03]. It was initiated in October, 2019, but further action was postponed due to the work required on the NDC [IV03, IV12]. Still, it is planned to be finished in 2020 [IV03]. It is the aim to align key assumptions on macro-economic parameters such as population and GDP growth with the Low-Carbon Development Initiative (LCDI) of BAPPENAS (addressed below), but the process has not been formalized [IV03]. The overall emission savings target has also not been specified. It was stated that the LTS will consider aspects of a fair share for Indonesia of the total remaining total carbon budget [IV12].

The modelling work behind the LTS will likely be performed by BTI and Bogor Agricultural University and may involve international partners such as IDDRI [IV12]. If BTI is tasked with developing the LTS, an important input will likely be the study by Siagian et al. (2017) in which the AIM/CGE model was used to estimate pathways and impacts of two scenarios, reaching values of emission reduction close to those in CM1 and CM2 of the NDC.

4 Targets and plans for renewable energy

As discussed in the preceding section, the role of the NDC (and the LTS) for national planning is limited, particularly for the energy sector. In fact, the energy planning in the NDC can be seen as a by-product of the different planning documents specific to that sector. Therefore, the following sections present and discuss the different institutions particularly relevant to the energy sector and their planning instruments along with their perspective on renewable energy planning

In Indonesia, three institutions share the main responsibility of power sector planning: the National Energy Council (*Dewan Energi Nasional*, DEN), which issues the National Energy Master Plan (RUEN) and the Indonesia Energy Outlook (IEO), the Ministry for Energy and Mineral Resources (*Kementarian Energi dan Sumber Daya* Mineral, ESDM), which issues the National Electricity Master Plan (RUKN) and the utility PLN (*Perusahaan Listrik Negara*), a state-owned enterprise, which issues the Electricity Supply Master Plan (RUPTL). Table 3 gives an overview of the different planning documents, including their time horizon.

Table 3: Overview of energy planning documents for Indonesia

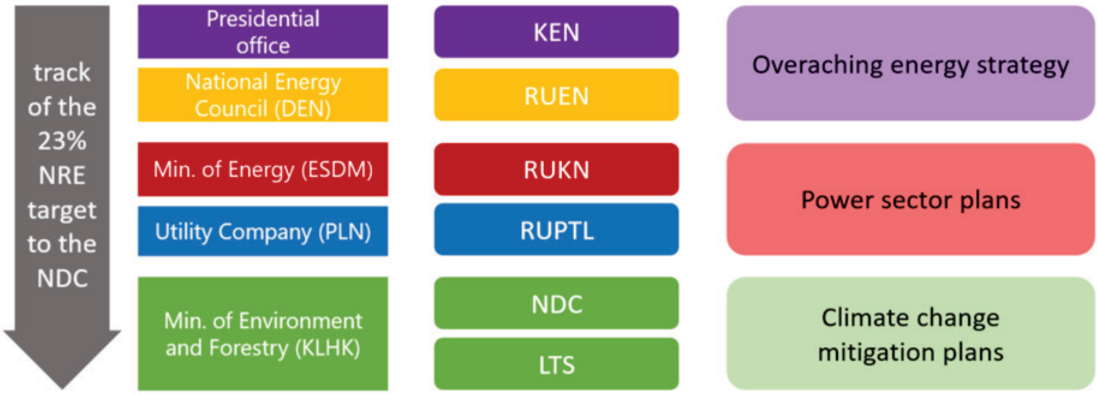
List of documents related the energy planning in Indonesia which are discussed in this study

Document	Full name Indonesian	Full name English	Issued by	Scope	Time of issuance	Time horizon
KEN	*Kebijakan Energi Nasional*	National Energy Policy		Energy	2014	2025; 2050
RUEN	*Rencana Umum Energi Nasional*	National Energy Master Plan	DEN	Energy	2014/ 2017	2025; 2050
IEO	-	Indonesia Energy Outlook	DEN	Energy	Yearly	2050
RUKN	*Rencana Umum Ketenagalistrikan Nasional*	National Electricity Master Plan	ESDM	Electricity	2008, 2019	20 years
RUPTL	*Rencana Usaha Penyediaan Tenaga Listrik*	Electricity Supply Business Plan	PLN	Electricity	Yearly	10 years
NDC		Nationally Determined Contribution	KLHK	All sectors	2015, revised 2020	2030
LTS		Long-Term Strategy	KLHK	All sectors	Expected 2020	2050

Source: own compilation

Figure 4: Track of the 23% new and renewable energy target to the NDC

The cascade of documents that pass on the target of 23% new and renewable energy by 2025 in primary energy. See Table 3 for a list of abbreviations. Details are given in the text.



Source: own compilation

Figure 4 presents the different energy and climate plans to provide orientation for the following sections. The most prominent target for renewable energy in Indonesia is to reach 23% NRE in primary energy in 2025. This target has been set down in the National Energy Policy KEN and is picked by the National Energy Master Plan RUEN, which gives specific technology targets, also for electricity generation. For planning, RUEN informs all other documents. These two documents can be classified as overarching energy strategy.

KEN and particularly RUEN are further interpreted by power sector plans. On the one hand, this is the National Electricity Master Plan RUKN by ESDM, which is mostly related to policies and has no influence on further planning and implementation. The Electricity Supply Business Plan RUPTL is the 10-year planning document issued on a yearly basis by the utility PLN. It is informed by RUEN, but only the latest editions reach a target of 23% NRE in 2025. In practice, RUPTL has little importance when it comes to implementation.

RUEN and RUPTL are cited in the NDC and will likely also determine the LTS. Discussed in more detail in Section 3, the climate change mitigation plans within the responsibility of KLHK (NDC and LTS) have no influence on setting targets for the energy sector. Rather, the share of the energy sector set down in climate change mitigation targets are determined by plans defined in other documents. The economic growth rates underlying all documents including the NDC (and probably the LTS) are taken from different studies by the Ministry of National

Planning (BAPPENAS). BAPPENAS has limited power, but is often approached by international organizations.

4.1 The National Energy Policy (KEN)

The National Energy Policy (*Kebijakan Energi Nasional*, KEN) was passed under the Yudhoyono administration (2004–2014) in 2014 (Government Regulation 79/2014). It has since been followed and adopted by the different authorities and institutions and reflected in their planning instruments. Article 28 of KEN specifies that DEN oversees the implementation of KEN, while Article 30 specifies that KEN governs RUEN and RUKN.

KEN specifies targets for the primary energy mix for the years 2025 and 2030 (Article 9). Together with values of total primary energy supply stated in Article 8, this translates to specific values for the utilization of renewable energy. Table 4 lists the target values given in KEN for the different energy sources. The target mainly referred to is a share of 23% NRE in total primary energy supply by the year 2025. This is the table also described in the NDC.

It should be noted that the values presented in Table 4 are valid for all sectors, one of which is the supply with electricity. Renewable energy sources are specified in KEN to be geothermal, wind, bioenergy, sunlight, water flow and water fall, hydrokinetic ocean and ocean thermal energy. New energy sources are from 'new technolog[ies], coming from both renewable energy and non-renewable energy sources, among others nuclear, hydrogen, coal bed methane, liquefied coal, and gasified coal' (Government of Indonesia, 2014b).

Table 4: Targets related to the composition of the primary energy mix specified in KEN

Values for 2025 and 2030 specify Total Primary Energy Supply (TPES)

Energy source	2025 share	2030 share	2025 TPES [Mtoe]	2030 TPES [Mtoe]
New and Renewable Energy (NRE)	23% (min.)	31% (min.)	92	310
Oil	25% (max.)	20% (max.)	100	200
Coal	30% (min.)	25% (min.)	120	250
Natural Gas	22% (min.)	24% (min.)	88	240
Total	**100%**	**100%**	**400**	**1000**

Source: Government of Indonesia, (2014)

Targets are only one part of KEN, which gives many details of the objectives and framework of the energy supply in Indonesia. E.g. Article 12 mentions that solar energy should maximise and oblige to use components produced in the country, which points to the local content requirement for renewable energy systems. KEN also spends several articles on the requirements to electricity pricing, subsidies and support mechanisms. A possible review five years following its implementation in 2014 is foreseen, but this has not taken place.

Assumptions underlying KEN

In bilateral discussions, several stakeholders highlighted that the process under which the targets in KEN were derived was not public. If there was some form of analysis – considering technology costs or not – the underlying assumptions and estimates are not known [IV06, IV05]. This is an important insight when it comes to the implementation of KEN by the different authorities and institutions. While KEN sets the overarching targets, the underlying logic remains undisclosed. This induces difficulties when it comes to working with the target as it is not fit for discussion as long as the base remains unknown. This also explains why the different targets and plans are not coherent in all details, as will be shown, and there is no common basis to assess future planning other than the target itself.

4.2 The National Energy Master Plan (RUEN) and IEO

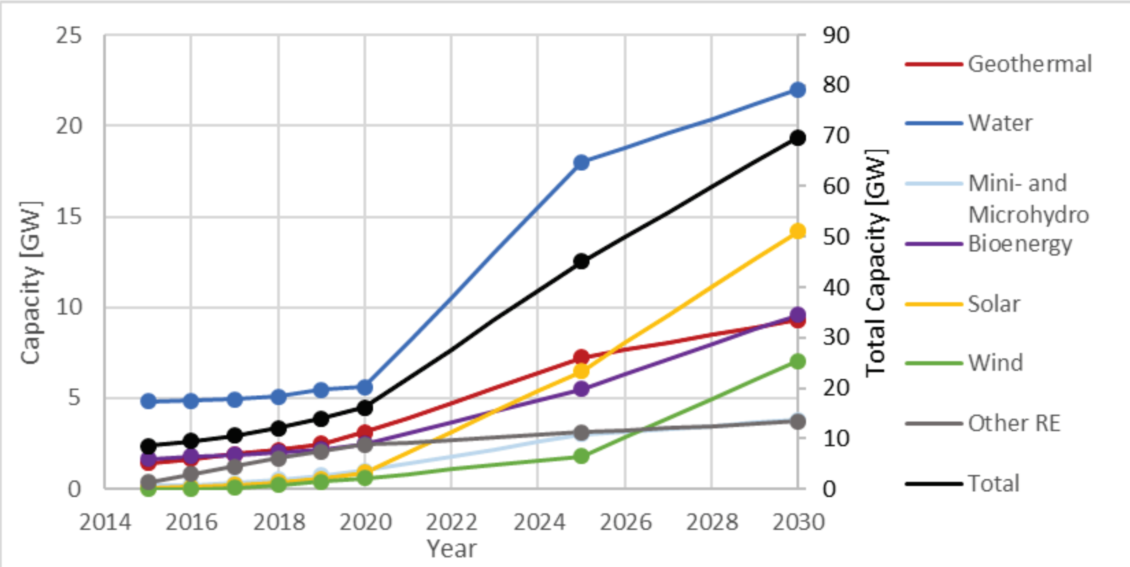
The National Energy Master Plan (*Rencana Umum Energi Nasional*, RUEN) was approved and published as Presidential Regulation 22/2017 (Government of Indonesia 2014a). It is a plan for the energy supply and demand prepared DEN (the National Energy Council). RUEN is more detailed than the governing KEN and remains one of the main reference documents for energy planning of Indonesia. In addition and on a yearly basis, DEN issues a study on the future energy supply and demand, the Indonesia Energy Outlook (IEO).

Renewable Energy in RUEN

Several sections of the RUEN are devoted to renewable energy. The section on total primary energy supply (Section 4.2.1 of RUEN), specifies the total energy from renewable sources (23% of 400 Mtoe as specified in KEN) to be 92.2 Mtoe in 2025. For the electricity supply, this is set to correspond to a capacity of 45.2 GW. This is further broken down to different technologies, which results in a timeline of capacities as given in Figure 5. For other sectors than electricity supply (transport and industry applications), an increased share of biomass and biologically derived fuels is foreseen.

Figure 5: RUEN capacity plan for renewable energy

Capacity plan given in the National Energy Master Plan (RUEN, issued by DEN) for the different technologies. RUEN specifies values up to 2050, these are not shown here to retain consistency with the other documents.



Source: Government of Indonesia (2014)

Assumptions and methods underlying RUEN

It is not transparent in RUEN how figures on total primary energy are transformed to power sector capacities. This requires efficiency values to determine how renewable electricity generation links to primary energy and load hours of operation to transform generation to capacities. As mentioned in Section 3.1, the conversion degree recommended by IEA for solar and wind energy is 100%, while the international standard for geothermal energy is 10%. RUEN specifies that 33% is used for geothermal energy (Section 2.3.b of RUEN), but it remains undisclosed for the other technologies. The full load hours assumed are not specified for any technology.

Basic assumptions underlying the modelling of RUEN are laid out in the document. Main drivers are given in Table 10 of the RUEN document, being GDP growth, population growth, the urban population ratio and the number of households. GDP growth for the modelling underlying RUEN was assumed to reach values between 4.8% and 8% between 2015 and 2030. Historic values between 2009 and 2018 have only reached more than 6% between 2010 and 2012, while average GDP growth was 5.5%. (enerdata 2020). Concerning electricity demand, it is interesting to note that a demand of 2.5 MWh per capita in 2025 was assumed, chosen to match the demand in developed countries [IV04]. The modelling tool is not specified.

Since the renewable energy target itself is given by KEN, the split between technologies could be informed by modelling that considers costs. Whether this has been considered is unknown, the reasoning for the specific split between technologies in RUEN remains undisclosed.

The role of RUEN

RUEN can be understood as the ex-post modelling of KEN. The assumptions are more explicit, though not all tools are clearly defined and not all values provided. The results do not contest KEN; the aim of RUEN is rather to provide a path of how to meet the targets laid down in KEN. The 400 Mtoe total supply are a value taken from KEN. As has been noted above, the targets set down in KEN have no publicly available economic or modelling basis, so the high GDP growth to meet this target in supply can be considered to be of secondary importance.

RUEN is seen as the highest-level document for energy planning in Indonesia. As has been noted above, KEN could be revised every five years. Similarly, a revision of RUEN is possible. In bilateral stakeholder meetings, a possible revision was said to be ongoing [IV01]. Others stated that it is possible but improbable [IV02]. In a case of revision, it was stated that the modelling tools would be those applied for the IEO (LEAP, Balmorel) and cost could be taken into account [IV02].

The Indonesia Energy Outlook (IEO)

Next to RUEN, DEN issues on a yearly basis a study of energy demand and supply until 2050, the Indonesia Energy Outlook (IEO). It is more detailed as RUEN, but has no role in official planning processes. In the last version issued in 2019 (DEN 2019), the LEAP model[4] is used for the overall energy system, while Balmorel[5] is applied for the electricity supply sector. In the latest IEO, GDP growth is limited to a more moderate 5.6% growth rate per year. Another essential input to the modelling behind IEO are relevant targets, one of which is KEN (the 23% target), but also other regulations and RUPTL (see Section 4.4). Within the boundary of these policy constraints, the model results are cost-optimized (DEN 2019).

In national planning, the IEO plays only the informing role of an in dependent study. RUEN is the reference document for energy planning and RUPTL is more relevant when it comes to actual implementation.

4 https://leap.sei.org/default.asp, last accessed October 13, 2020

5 http://www.balmorel.com/, last accessed October 13, 2020

4.3 The National Electricity Master Plan (RUKN)

The Ministry for Energy and Mineral Resources (*Kementarian Energi dan Sumber Daya Mineral*, ESDM), is charged with overseeing and developing the energy system of Indonesia. In this role, ESDM is the official regulator of the utility PLN. The Directorate General for Electricity and more specifically the Directorate General for Renewable Energy deals with questions related to the role of renewables in the electricity system. ESDM produces its own planning document, the National Electricity Master Plan (*Rencana Umum Ketenagalistrikan Nasional*, RUKN).

The RUKN has been issued twice, the document published in 2019 being an update of that in 2008 (ministerial decrees 2682 K/21/MEM/2008 and 143 K/20/MEM/2019). The current RUKN (MEMR 2019) describes policies that determine the energy supply, but also presents projections of the demand and supply on a provincial level. The demand is projected in two scenarios, which are mainly determined by the difference economic growth rates (6.7% and 5.2%, taken from planning documents of BAPPENAS). For renewable energy supply, the targets of KEN are fulfilled in the national average (23% NRE by 2025). Geothermal, and hydro power are listed separately along with the category 'other new and renewable energy'. The assumptions underlying the split between technologies remain undisclosed.

RUKN covers the full electricity supply, which includes PLN and its subsidiaries (different to RUPTL, which is the planning document of PLN itself, see Section 4.4). As such, the scope is larger, but the role for planning is limited. RUKN does not set targets as these are taken from KEN and RUEN. It specifies a technology mix for each province, but on aggregated terms for renewable energy. While ESDM is the regulator of PLN, the actual implementation is with the utility. In view of these issues, RUKN should be considered a document mostly relevant for policies related to electricity and not for generation planning.

4.4 The Electricity Supply Business Plan (RUPTL)

The Electricity Supply Business Plan (*Rencana Usaha Penyediaan Tenaga Listrik*, RUPTL) is the 10-year planning document that has been issued on a yearly basis by the utility PLN since 2015 (PLN (2015), PLN (2016), PLN (2017), PLN (2018), PLN (2019)). Each edition is published as Ministerial Decree by ESDM. PLN (*PT Perusahaan Listrik Negara (Persero)*) is a state-owned enterprise, and as such owned and managed by Ministry of State-Owned Enterprises (MSOE). In its role as energy supplier, it is formally regulated by the Ministry of Energy and Mineral Resources, ESDM. PLN owns and procures the majority of Indonesia's power generation capacity, it also owns and operates all electricity grids, giving it a quasi-monopolistic role (Cornot-Gandolphe 2017)[6].

Renewable energy in RUPTL

RUPTL has specific plans for implementation of different renewable energy technologies on the national level. This is reflected in the generation plan, which is published in each edition of RUPTL. The total generation given in Figure 6 shows that in general, the generation foreseen for the following decade repeatedly overestimates the demand. This is reflected in the fact that subsequent editions of RUPTL start at similar values and show similar total growth rates. The same is true for the electricity generation from coal, as this is the main energy carrier, but also for the combined category 'new and renewable energy' (NRE). For coal, it is also worthwhile to note the dip in electricity generation in the year 2025, to which the growth of NRE forms a counterpart. After 2025, the generation from coal and NRE continue to rise at a similar growth rate. The 23% target of NRE by the year 2025 set down in KEN and RUEN is interpreted as a target in generation by PLN[7]. Only the latest two editions of RUPTL reach the target and only the latest edition retains the target after 2025.

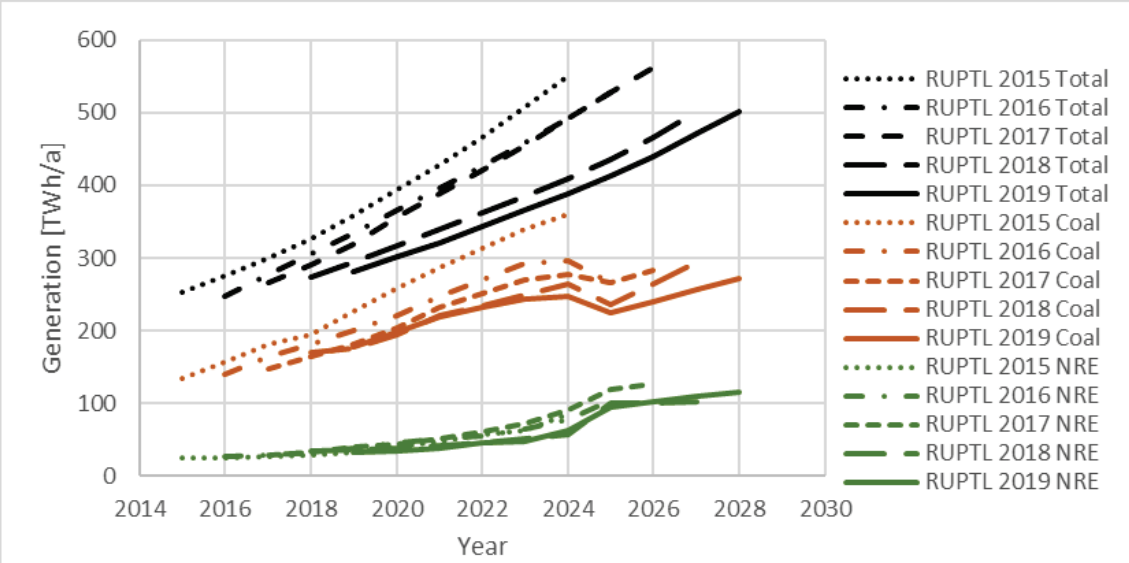
In terms of generation, RUPTL splits NRE into hydro, geothermal and 'Other NRE', see Figure 7. While hydro and geothermal are both associated with similar pathways towards increasing their shares, 'Other NRE', which includes solar, wind, mini- and micro-hydro as well as biomass power plants only reaches roughly 20% to 30% of the total NRE. In particular, these technologies do not play a large role in the growth foreseen prior to and in 2025. As for the total generation, the actual growth of 'Other NRE' is much slower than planned in each RUPTL, as different editions start from similarly low values.

6 It was stated that there have recently been high-level discussions to unbundle PLN [IV01]. This had been attempted previously in Law UU 20/2002, but was then cancelled by the constitutional court [IV01].

7 This implies differences hidden in the conversion efficiency.

Figure 6: Electricity generation plan specified by RUPTL

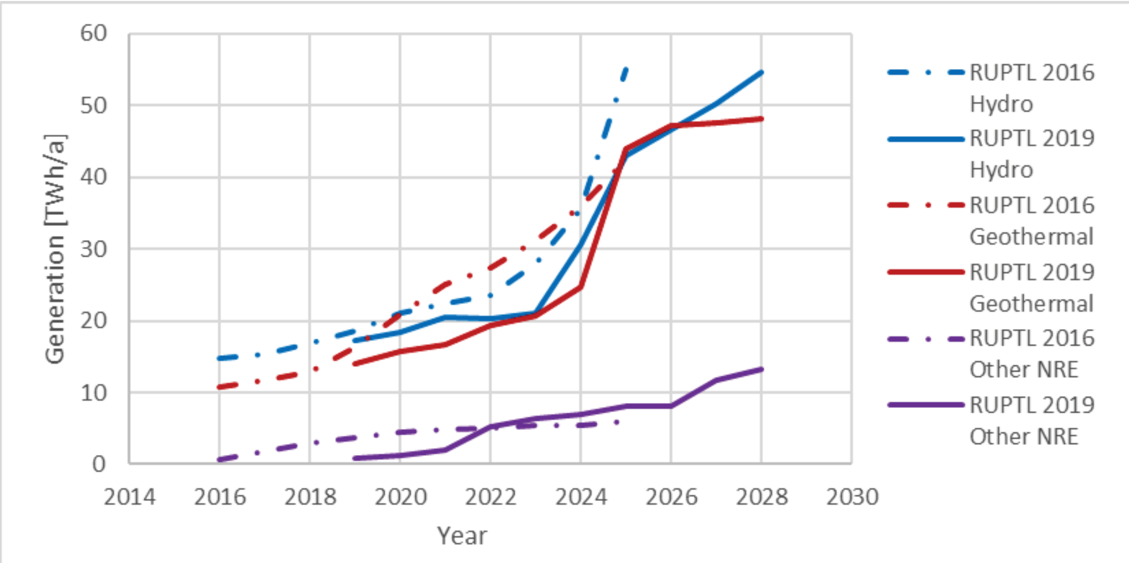
Generation plans of five subsequent editions of the Electricity Supply Business Plan (RUPTL) issued by PLN. Only coal, NRE and total are shown, other technologies are listed in the different documents.



Source: PLN (2015), PLN (2016), PLN (2017), PLN (2018), PLN (2019)

Figure 7: NRE electricity generation specified by RUPTL

Generation plans of two editions of the Electricity Supply Business Plan (RUPTL) issued by PLN for renewable energy. Only hydro and geothermal are specified separately while other technologies are summarized as 'Other NRE'. Values of only two editions are shown here to retain readability.



Source: PLN (2016), PLN (2019)

Modelling and assumptions underlying RUPTL

RUPTL describes part of the modelling underlying the projection. As is specified in Section 5.3 of PLN (2019), the main factors driving the overall energy demand are the economic growth, population growth, electricity tariffs and electrification programs, including special industrial or economic site development plans. The regression model Simple-E is then used to estimate future demand. The economic growth rate and population growth rate are taken from studies by the Ministry of National Development Planning (BAPPENAS). For economic growth, an annual increase of 6.45% on average is assumed, taken from the high scenario of BAPPENAS, which is higher than in the previous years (except 2011). Starting in 2020, an electrification ratio of 100% is assumed.

While the assumptions underlying the overall demand are made explicit in RUPTL, the same is not true about the split between technologies. Section 5.6 of PLN (2019) simply specifies that coal and gas are assumed to be always available and that the government target of 23% renewable energy is adopted. In order to reach this target, the potentials of each technology are said to have been analysed, which leads to the outcome described above. Tools and assumptions remain undisclosed.

The role of RUPTL

RUPTL is the planning document of PLN, the sole grid operator and utility and is therefore much closer to implementation of actual capacities than other documents. If subsequent plans of RUPTL, which reflect historic values of their starting point are compared, it becomes apparent that the plans are not followed stringently, particularly for renewables other than hydro and geothermal (see Figure 7). The targets of previous years are not achieved and the growth rate between initial years in each plan is much slower than the increase in generation projected in each document. This is in part due to the modelling assumptions, which lead to overestimating the demand. The split between different technologies is not motivated by modelling.

RUPTL should be seen as an indicative plan of PLN. RUPTL is a plan to meet the 23% target of NRE by 2025 but not a plan of actual projects. This weak role of RUPTL has also been indicated by stakeholders, who stated that the target of 23% NRE in generation will hardly be reached by PLN [IV08]. It was stated that of the 16 GW capacity in NRE foreseen to be implemented in the latest RUPTL, only 10 GW will actually be implemented [IV08]. Technological and regulatory constraints that influence the planning of PLN and partly determine costs of renewable energy projects are therefore discussed in Section 5.

4.5 The role of BAPPENAS

The Ministry of National Development Planning (*Kementerian Perencanaan Pembangunan Nasional*, commonly abbreviated as BAPPENAS) is the ministry in charge of strategic planning. Therefore, it is often one of the first contact points of donors and international institutions [IV11].

The most recent planning document by BAPPENAS is the National Medium Term Development Plan (*Rencana Pembangunan Jangka Menengah Nasional*, RPJMN, BAPPENAS (2019b)). Another strategic document specifically with regard to climate change mitigation is the Low-Carbon Development Initiative (LCDI, BAPPENAS (2019a)). This is a study that considers development pathways with strong mitigation and adaptation plans up to 2045 (to commemorate 100 years of independence of Indonesia [IV12]).

Though supported internationally, the practical role for planning of the LCDI is very limited. BAPPENAS does not have a financial budget of its own to implement plans and ministries that are affected by the plans of BAPPENAS can refuse to implement these, limiting the influence of BAPPENAS [IV11, IV05].

The macroeconomic parameters determined by BAPPENAS are often considered by other ministries as reference in their own documents [IV11]. Previous publications of BAPPENAS have informed assumptions of economic growth in the studies and planning documents discussed above. However, the economic growth rate used in the assessments of BAPPENAS have repeatedly been too high and this is again true for the GDP growth rate of 6% underlying the current RPJMN. As has been discussed above, this has strong implications for the NDC and the energy planning documents discussed above.

5 Constraints on renewable energy

The following section gives a summary of those points of the bilateral discussions related to economic, technical and political constraints related to renewable energy. This section is not a comprehensive compendium of all aspects related to renewable energy. Rather, it reflects the main line of argumentations of key governmental and non-governmental stakeholders of energy policy about increasing the share of renewable energy in Indonesia´s power mix across Indonesian.

5.1 Economic constraints: Determining project costs and tariffs

One stakeholder [IV09] has summarized that costs of renewable energy projects are determined by three factors: technology costs, land permits and interest rates.

Technology costs are partly determined by the 'local content requirement': Indonesian regulations require that in renewable energy projects, at least 60% of the technology is produced locally [IV08]. This has been noted is a chicken-and-egg problem: as long as there is no local industry, no local market can form, which is required to support a local industry [IV11, BTI]. Due to the local content requirement, the decline in technology costs seen worldwide is not necessarily reflected in Indonesia. Nevertheless, as technology costs fall, some consumers have already started to operate their own solar rooftop of containerized PV plant, disconnected from the grid of PLN [IV09, IV10].

Land permits are difficult to obtain, especially in densely populated Java and Bali [IV09], which is also the region with 70% of electricity demand [IV01]. Land acquisition is seen as one of the main drivers of local costs [IV08, IV02].

Interest rates for loans given to renewable energy projects are double digit, opposed to general interest rates, which are around 5–6% [IV09]. An alternative stakeholder has stated that the interest rate for renewable energy projects is at 10% and has specified this is also an estimate used by PLN [IV11]. It is hard to disentangle what causes these high interest rates as they are determined separately for each project [IV09]. Local banks generally do not associate renewable energy projects with easy return, which is why international financing is often required [IV04].

As described in more detail in Section 2, electricity generation costs are currently at around 6–7 cents/kWh for coal fired power plants [IV01]. Current auctions for renewable energy projects (solar PV projects in Sumatra and a floating solar PV park on Java) are reaching just below 6 cents/kWh [IV04]. Due to the different conditions on the islands of Indonesia, the costs of electricity generation vary widely from one region to another. The tariffs are, however, are equal across the whole territory [IV09]. In order to limit costs, PLN uses the cheapest technology, which currently are coal fired power plants in many parts of Indonesia [IV01, IV09].

Levelised Costs of Electricity (LCOE) reflect the total costs of an energy project, but are not considered in planning. Current regulations support IPPs (Independent Power Producer, supplying to PLN as grid operator).

IPPs are seen as a first step towards increasing the share of renewables [IV11], but the specific regulations do not always lead to cost optimal supply [IV08]. The feed-in tariff currently paid by PLN is based on the so-called BPP (*Biaya Pokok Penyediaan*, Cost of Provision) scheme [IV09]. In this scheme, the feed-in tariffs are determined based on the local costs of electricity production [IV09]. This leads to most renewable energy projects being set up in remote areas, where costs for PLN and therefore revenues for renewable energy projects are high [IV09]. After past reforms of the rregulations to push for higher shares of renewables had been blocked by PLN [IV01], a new law to support the development of renewables is currently being discussed between parliament and government [IV01, IV05]. The new law is based on a study by ESDM, which considers LCOEs [IV01], but little details are known to the general public yet [IV05]. Some technical details have been provided by relevant local stakeholders[8] stating the regulation should create the environment for projects to pay back investments. A bidding process was foreseen for solar PV and wind energy projects, while hydro and geothermal projects would be appointed directly [IV01]. A new rooftop PV regulation is also planned for 2020 [IV11].

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8 Projects with a capacity below 20 MW will receive a feed-in tariff, with higher prices in the first ten years of operation and lower prices afterwards. This should give projects enough time to pay back investments. Projects above 20 MW will receive a 30 year contract. PPAs based a bidding process will be implemented for solar and wind energy projects. Hydro energy projects will be directly appointed. Geothermal energy projects are of second priority as exploration costs remain high. Biomass and biogas projects above 10MW are foreseen to receive a 20 year contract. The law will also implement a new institution responsible for renewable energies, which would replace some of the responsibilities of DEN and ESDM. As stated above, passing this law can take a long time and the proposal may see changes during the process.

5.2 Technical constraints: Variability and grid stability

A regular argument when discussing renewables is their variable power supply[9]. This variability is a physical property of wind and solar power generation but can be managed by either increasing energy storage, balancing the variability by interconnections between (island) grids or demand-side management. All solutions require a modern transmission grid that allows fast response while maintaining grid stability.

Variability of renewable energy

When discussing renewables in Indonesia, these are often split into technologies that can provide baseload supply (hydro, geothermal, biomass) and those that are variable in their supply (solar PV, wind) [IV08, IV02, IV01]. The variability of solar PV and wind energy is seen as problematic by PLN [IV11, IV08].

It is difficult for PLN to provide the necessary flexibility in coal fired power plants [IV11] and PLN is trying to compensate this by increasing the share of hydro power [IV11] or planning to use batteries for this purpose [IV08]. The unmanaged variability is also the reason why solar and wind energy do not play a large role on remote islands [IV08]. Biomass is seen as the most feasible source of renewable electricity. In the area of the Java-Bali grid, where 70% of electricity demand is located [IV01], problems of land acquisition make it difficult to install higher shares of solar PV or wind energy plants [IV09].

In discussions with Indonesian stakeholders, energy storage is the most common solution cited in order to increase the share of solar PV and wind energy and generate a baseload supply [IV02, IV04]. It has been stated that each MW of solar PV or wind energy needs one MW of balancing power, e.g. by battery or natural gas power plants [IV02]. For this reason, it was stated that battery prices need to drop equally to enable a higher share of solar PV or wind energy [IV02]. Pumped storage is seen as an alternative, but the potential is limited [IV02].

Interconnections between island grids could be another option to prepare increasing shares of solar PV or wind energy. Currently, the only international interconnection is a link to Malaysia on the island of Kalimantan (140 MW ca-

9 The preferred term with Indonesian stakeholders is 'intermittency'. We use variability here to reflect that power supply is not on or off but variable in general.

pacity) [IV08, IV01]. The grids of Java and Bali are also linked and form the largest grid in terms of demand (70% [IV01]). A memorandum of understanding has been signed to explore a possible interconnection between mainland Malaysia and the island of Sumatra [IV08]. A feasibility study has been done for an interconnection between Sumatra and Java [IV08], and this link is also foreseen by the 2019 edition of RUKN (MEMR 2019). Generally, interlinkages are seen as difficult due to the many islands[10] and deep geological fault lines [IV02].

Grid stability and grid management

Several stakeholders state that the electricity grid is not in a condition to deal with variable renewables, considering either their variable supply or the necessary demand-side management [IV01, IV05, IV09].

Some renewable energy projects apparently cannot supply electricity due to limitations of the grid, with technical problems such as the transformation of AC/DC power or the stability of frequency [IV05, IV09]. These technical problems extend to managing the supply and demand. It has been said that dispatch planning is done on a 'manual basis' and daily resolution, which is not high enough to consider solar PV and wind energy [IV05, IV09, IV11].

These problems of connecting and integrating renewables point to necessary investments into the grid and grid management. If PLN is required to finance the necessary investments, this would increase the overall system costs associated with a higher share of renewables. PLN is not free to set the electricity tariffs, but these need to be approved by the government and have in the past therefore been an element of election programs [IV05] (also seeOrdonez et al. 2020).

PLN is now in discussion with the President to increase tariffs [IV08], but current electricity tariffs have been frozen at 10 cents/kWh since 2017, which does not necessarily reflect costs [IV08]. This points to a direct link from the presidential administration to the funds available to PLN for investing into renewable energy systems and the transmission grid.

Another player is the coal industry, an important sector of Indonesian economy, providing state income through royalties, supplying a major export product. The companies in the coal sector have limited interest in an increasing share of renewables in the Indonesian electricity system and are powerful players in Indo-

10 This is summarized by Indonesian stakeholders as the 'archipelago condition'.

nesian politics [IV05, IV09, IV12]. Some parts of the Omnibus Law currently discussed in parliament could further strengthen the position of the coal industry [IV05].

These points explain the claim that the reluctance of PLN to invest into the grid is linked to corporate as well as political will [IV09].

5.3 Political constraints: Implementation disconnected from planning

Despite the 23% NRE target being stipulated at the overarching energy strategies of the country and also within Indonesia´s NDC, the bulk of power capacity added to Indonesia´s power system is fossil based.

Coal represented 64% of new capacity additions between 2008 and 2018, gas 24% and oil 4%. Together, fossil fuel capacity additions of the last decade sum up to 92%, with the remainder being hydropower (3%) and geothermal (3%). The current share of renewables among total installed capacity is close to 10%, while its share in generation is around 8%. This leads to question if Indonesia is on track to reach its target of 23% RE in the power generation mix by 2025.

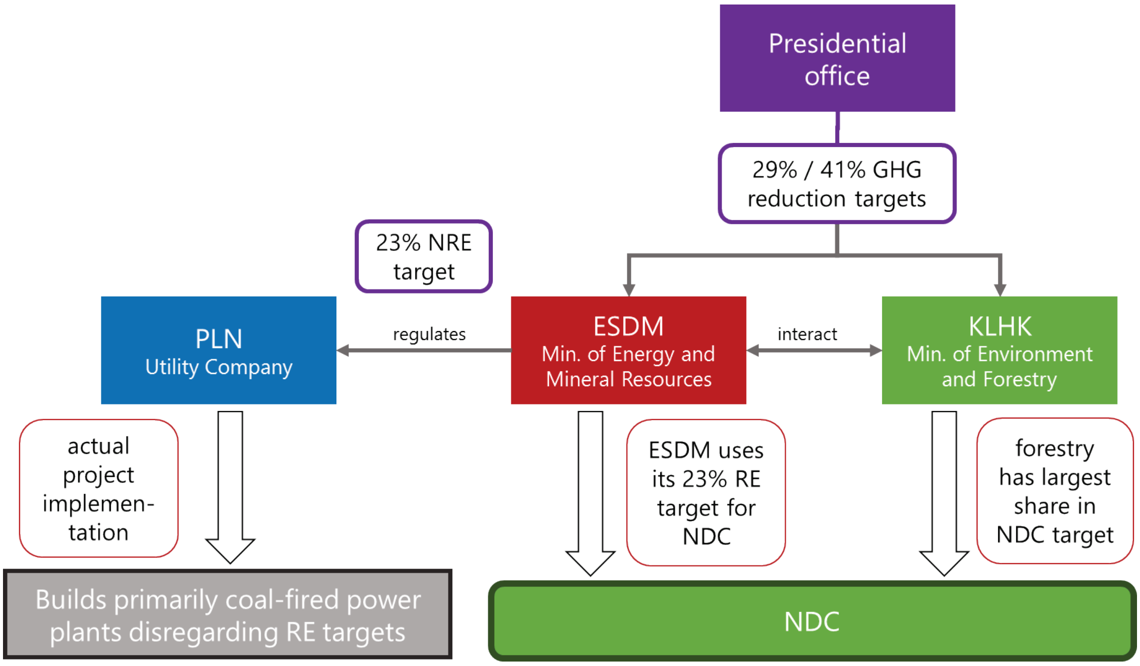
(Bridle et al. 2018) PLN as in the midst of an energy trilemma, with three conflicting goals, namely to increase the share of renewable energy, to reduce energy subsidies and to maintain low electricity prices. In practice, PLN sacrifices the goal of incrementing the share of renewable energy in favour of the others. Further, groups that are supportive to RE in Indonesia are less influential than supporters of fossil fuels (Bridle et al. 2018). Indeed, the massive development of coal-fired power plants in previous years is projected to continue in the future (Shearer et al. 2020). The underlying reasons are related to a variety of country specific drivers, such as the large reserves of the country with coal, the presence of a long established and highly influential coal industry, the contribution of coal mining towards economic growth and public budgets, and the institutional organization around PLN, among others (Ordonez et al. 2020).

It becomes evident that a wide number of economic and non-economic considerations besides costs and respective future cost reductions of renewables determine the uptake of these technologies in the energy system. While falling costs of solar PV and wind energy suggest an increase of their share in the energy system in order to reach the NDC target, the NDC remains disconnected from these purely economic considerations.

Figure 8 illustrates the most relevant institutions and targets determining the ambition level of renewables in the NDC, while contrasting it with reality in recent years. The overall NDC is driven by the target to reduce 29% of GHG emissions by 2030 relative to the baseline, a target stated to have been determined by the presidential office [IV05, IV06]. This target has to be jointly met by the contribution of the different sectors, most importantly the energy sector, coordinated by ESDM, and the forestry sector, coordinated by KLHK. ESDM, already under pressure to reach the 23% renewable energy target by 2025, is officially stipulated to contribute with this share to reach the NDC mitigation targets. In reality, the 23% NRE target is neglected by PLN, whose actual project implementation is nearly totally composed of coal-fired power plants (see above and Section 4). Of note, several stakeholder referred to high efficiency coal fired power plants ('super critical' or 'ultra super critical') as the measure considered in the NDC to reduce GHG emissions. Instead of fostering a system that allows to integrate higher shares of renewables, this further stabilizes the existing coal-based power system.

Figure 8: Implementation of renewables disconnected from the NDC process

A sketch of main targets (round corners) and institutions (in boxes) involved in the NDC process and their role in implementation of renewable energy projects.



Source: own compilation

6 Conclusions

In the past years, renewables, most importantly solar PV and wind, have experienced massive cost reductions. In a companion report, Eckstein et al. (2020b) show that by considering these falling costs in the revision of Indonesia´s NDC, renewable energy capacities planned for 2030 could be increased from 70 GW to 85 GW at constant investments, leading to substantial emission savings in the power sector. In this report, we discuss the process of the NDC revision and its relation to the different planning documents in the energy sector, as well how they relate to the renewable energy targets and the actual implementation of renewable energy projects.

Indonesia´s NDC foresees an unconditional reduction of GHG emissions by 29% relative to BAU in 2030. The energy sector, being the biggest contributor in 2030, is envisioned to reduce emissions by 18.8% (second to forestry). It remains unclear how the baseline modelling is precisely developed, Siagian et al. (2017) suggest that the BAU scenario overestimates key socio-economic assumptions and thereby baseline emissions. With regard to mitigation efforts, the target-setting process for the NDC was reported as being a top-down approach, where the 29% overall emission reduction target was first defined, and sectoral contributions were designed to match this overall target, taking into account existing targets stipulated in planning documents.

For the energy sector, the National Energy Policy KEN first defines a 23% RE target in total primary energy supply by 2025. The National Energy Master Plan RUEN translates this target to the power sector and gives a distinct technology split for electricity generation. The assumptions underlying the determination of the technology split remain undisclosed and evidence suggests that power sector plans do not consider cost-optimized planning. This partially explains why, despite large potentials, solar PV and wind power still play a minor role in Indonesia´s RE targets. The 23% RE target also determines the contribution of the energy sector to climate protection in the NDC, and thus solar PV and wind energy only play a marginal role in Indonesia´s efforts to reduce GHG emissions.

The different plans to increase the share of renewables remain largely disconnected from one another. The NDC is yet another document that has little influence in target setting and implementation and is rather the by-product of the other energy sector plans. The assumptions underlying many plans remain undisclosed, which challenges an in-depth evaluation of existing targets. Most importantly, the relevance of planning documents for actual implementation of renewable energy projects and power sector composition is limited, as PLN continues to expand the power sector unattached from plans, building mostly coal-fired power plants.

In Indonesia, high costs for renewable energy projects are related to high financing costs due among others to difficulties in obtaining land permits and the local content requirement. The variability of solar PV and wind energy projects is seen as a problem that can only be dealt by developing energy storage, as grid interconnections are not considered feasible. Grid management is a problem, which leads to technical problems of integrating renewables. These factors maintain an unfavourable environment for wind and solar PV project development. Overall, the development of Indonesia´s power sector strongly relies on the deployment of coal-fired power plants, a trend observed in the last decade and projected to continue in the near future. Indonesia's climate protection plans stipulate the development of higher efficiency coal-fired power plants as a mitigation measure in the energy sector.

To improve the position of renewables, policies should be streamlined. Assumptions and modelling tools should be made explicit so they can be adapted and revised. Targets should be re-evaluated considering cost-optimization. To actually increase the share of renewable energy projects, a clear political commitment and associated policies seem essential. Increasing the share of renewable energy requires investments into the electricity grid infrastructure that will pay back in lowering future generation costs. Indonesia is not only lagging behind world energy markets, but risks locking itself into high energy costs and maintaining a large carbon footprint of its industrial products.

A.1 List of interviews

Interview	Stakeholder	Date
IV01	Government	February 25, 2020
IV02	Government	February 25, 2020
IV03	Government	February 25, 2020
IV04	Government	February 27, 2020
IV05	Non-government	February 26, 2020
IV06	Non-government	February 27, 2020
IV07	Non-government	March 2, 2020
IV08	Business	February 28, 2020
IV09	Business	March 5, 2020
IV10	Association	March 2, 2020
IV11	Scientific	February 24, 2020
IV12	Scientific	February 26, 2020

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Disclaimer

The views expressed within the report solely lie with the authors.

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