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Decreasing costs of renewables – Implications for Indonesia's climate targets

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Abstract

The unconditional target of Indonesia's NDC foresees a reduction of GHG emissions of 29% relative to a Business-as-Usual (BAU) scenario, to reach 2034 $MtCO_2eq$ in 2030. It further specifies that the energy sector shall take a share of 37.6% of this mitigation effort to reduce emissions by 18.8% relative to BAU, reaching 1355 $MtCO_2eq$ emissions in 2030.

This study analyses how **falling cost projections of renewable energy technologies** (solar PV and wind energy) could inform energy sector and climate change mitigation plans of Indonesia.

- We show that cost projections valid for Indonesia for renewable energies have dramatically fallen over the past years. Costs projected for 2030 a couple of years ago are well undercut by more recent projections for 2030. **Recent cost projections for 2030 for wind energy are 31% lower than projections dating from 2015, solar PV cost projections have fallen by 49% on average.**
- If falling costs for renewables are considered, the renewable capacities given in RUEN (the National Energy Master Plan) could be revised at constant investments. **The overall renewable energy capacity given in RUEN for 2030 could be increased from 70 GW to 85 GW.** Solar PV would become the dominant source of renewable energy, wind energy would slightly surpass geothermal power generation.
- This increase in renewable capacities could inform the revision of Indonesia's NDC. If falling cost projections of renewables are considered, **the unconditional target could be reduced from 2034 $MtCO_2eq$ to 2005 $MtCO_2eq$ at constant costs**. This corresponds an increase from 29% to 30.1% reduction and **presents a 9.1% increase in the ambition of the energy sector**.

Further Reading

In a companion paper, Ordonez and Eckstein (2020) discuss the processes and assumptions underlying the current revision of the NDC in Indonesia. Based on interviews, they discuss the roles of the different institutions responsible for energy and climate mitigation plans, their policy and planning instruments and the relationship between these.

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

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1 Introduction

Each party signatory to the UNFCCC Paris Agreement of 2015 (UNFCCC 2015) is required to submit a document specifying the Nationally Determined Contribution (NDC) to reaching the target of limiting global temperature increase to well below 2°C and pursuing efforts to limit it to 1.5°C. The NDC's have been submitted in the months following the Paris Agreement, but need to be revised with a cycle of five years showing an increase in the ambition. The first revision is due in 2020.

This study investigates how falling cost projections for renewable energies could be considered in the revision of the NDC in Indonesia. National planning instruments are analysed in conjunction with current and past cost estimates and this shows a possible increase in renewable energy capacities. In turn, this can inform an increase in the ambition of the Indonesia's NDC by increasing the contribution of renewable energy to mitigation.

Indonesia submitted its NDC in 2015 (Government of Indonesia 2016). The NDC foresees an unconditional reduction of GHG emissions of 29% by 2030 relative to a Business-as-Usual (BAU) scenario and also establishes a conditional target of 38% reduction relative to BAU by 2030. The mitigation effort of the energy sector is second to that in the forestry sector. Nevertheless, renewable energies are one pillar to reduce emissions from electricity generation and are explicitly mentioned in the NDC.

Globally, renewable energies have seen dramatic reductions in costs. Wachsmuth et al. (2018) have performed an assessment of past and current costs and cost projections for the year 2030. They find that levelized costs of electricity projected for 2030 for solar PV and onshore wind energy have fallen by 20–50%. The authors then argue that this drop in costs could inform the current updates of NDCs, estimating that for each 1 MW of renewable energies foreseen in 2015, the same investment could now lead to an uptake of 1.9 MW.

This study applies the methodology developed by Wachsmuth et al. (2018) to Indonesia, estimating how specific cost reductions of solar PV and wind energy in the Indonesian context could be considered in the NDC revision of the country. The text continues by giving an overview of the NDC of Indonesia and the country's renewable energy plans. Section 3 presents cost estimates relevant for the time the NDC was designed and more recent figures. From these, a possible increase in power generation from renewable energies is calculated and discussed in Section 4. This section also presents results of emission saving estimates and relates these to the NDC. Section 5 gives a summary and concludes.

Annex A.1 discusses falling costs of batteries as a proxy of electric vehicles and their implications for a possible increase in the mitigation targets.

2 Renewables in Indonesia's climate commitments

2.1 NDC overview

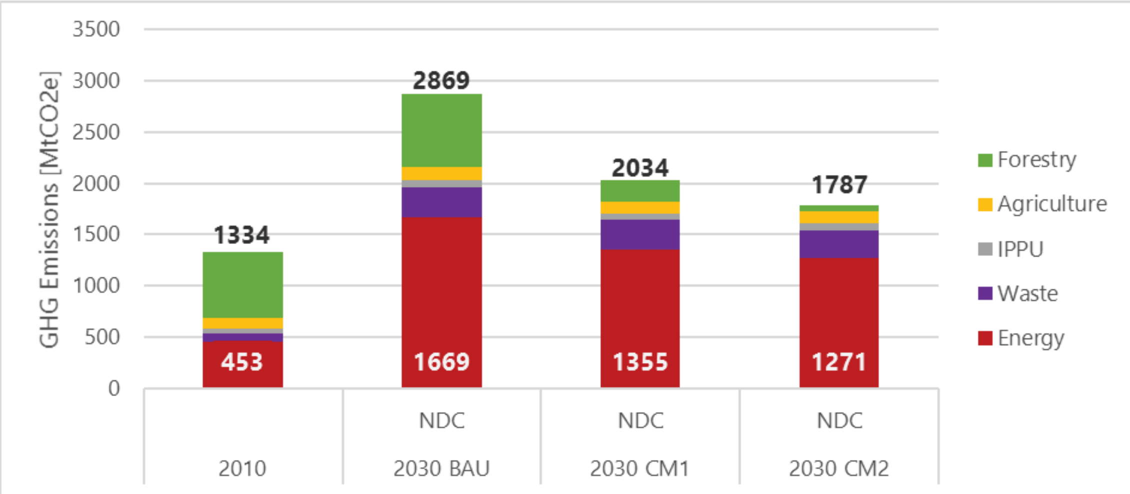
The Nationally Determined Contribution (NDC) of Indonesia (Government of Indonesia 2016) was submitted in 2016 following the UNFCCC conference in Paris. It specifies mitigation targets for GHG emissions relative to a Business-as-Usual (BAU) scenario. Figure 1 gives an overview of the targets: The NDC specifies that emissions following the BAU scenario would reach 2869 $MtCO_2eq$ in 2030. Two mitigation scenarios are defined, the unconditional scenario (counter measure 1 – CM1) corresponding to a decrease in GHG emissions of 29.1% (total of 2034 $MtCO_2eq$) and a conditional scenario (counter measure 2 – CM2) subject to international support and reaching 37.7% reduction[1] (total of 1787 $MtCO_2eq$). In the following, we focus on the unconditional scenario.

The NDC specifies mitigation targets in five sectors (Energy, Industrial processes and product use (IPPU), Agriculture, Waste and Forestry). The main share of mitigation is taken by the forestry sector, which sees a reduction of 69.6% of emissions, corresponding to a share of 59.5% of the total reduction. The energy sector sees a strong increase in emissions in the BAU scenario. In the unconditional scenario, it is foreseen to reduce emissions by 18.8% relative to BAU in this sector (37.6% of the total reduction). In 2030, the energy sector will be responsible for 66.6% of emissions.

1 The text in the NDC document speaks of a 41% reduction, but the emissions given for the unconditional scenario equal only 37.7%. This is also the value given in Table 1 of the NDC document (Government of Indonesia 2016).

Figure 1: NDC mitigation targets

GHG emission targets as specified in the Nationally Determined Contribution (NDC) of Indonesia with sectoral targets. The NDC gives an unconditional and a conditional scenario, denoted as CM1 and CM2 (countermeasure 1 and 2), respectively. Energy sector and total emissions are specified in numbers.



Source: Government of Indonesia (2016)

The measures specified in the NDC to reach the mitigation target of the energy sector are not very specific. The NDC specifies that clean coal technologies will be implemented, the gas infrastructure will be improved, and 30% biofuels will be implemented in 90% of use cases. In terms of renewable energies, 19.6% of electricity is specified to be generated from renewable sources. This target is referenced to the Electricity Supply Business Plan (*Rencana Usaha Penyediaan Tenaga Listrik*, RUPTL) of 2016[2], which gives targets up to 2025 (PLN 2016), but the text does not specify how the targets are related to the NDC or whether they are seen to be identical. Other reference documents given in the appendix are the National Energy Policy (*Kebijakan Energi Nasional*, KEN, Government of Indonesia, (2014)) and the National Energy Master Plan (*Rencana Umum Energi Nasional*, RUEN, Government of Indonesia (2014)), which will also be the basis of the following analysis. Again, the NDC does not specify how these documents provided input for the underlying calculations. For more details on the different energy planning documents in Indonesia and how they are related see Ordonez and Eckstein (2020), the companion report within this project.

2 RUPTL is issued on a yearly basis by the state-owned electric utility company PLN and gives plans for the following 10 years.

2.2 Projected renewables development

The reference document for all subjects related to energy planning in Indonesia is RUEN (the National Energy Master Plan), ratified as Presidential regulation. It was developed in 2014 by the National Energy Council (*Dewan Energi Nasional*, DEN) following the ratification of KEN (the National Energy Policy). RUEN gives very specific targets for the development of renewable energy capacities for the years up to 2050.

RUEN serves as reference for all energy planning and is also an important input to the yearly updates of RUPTL (the Electricity Supply Business Plan), which is also discussed below. We will therefore mainly refer to RUEN as the overarching document in the following. At the time when the NDC was developed, it was also a relatively recent document, so we assume that the plans figured in this document served as input to the NDC.

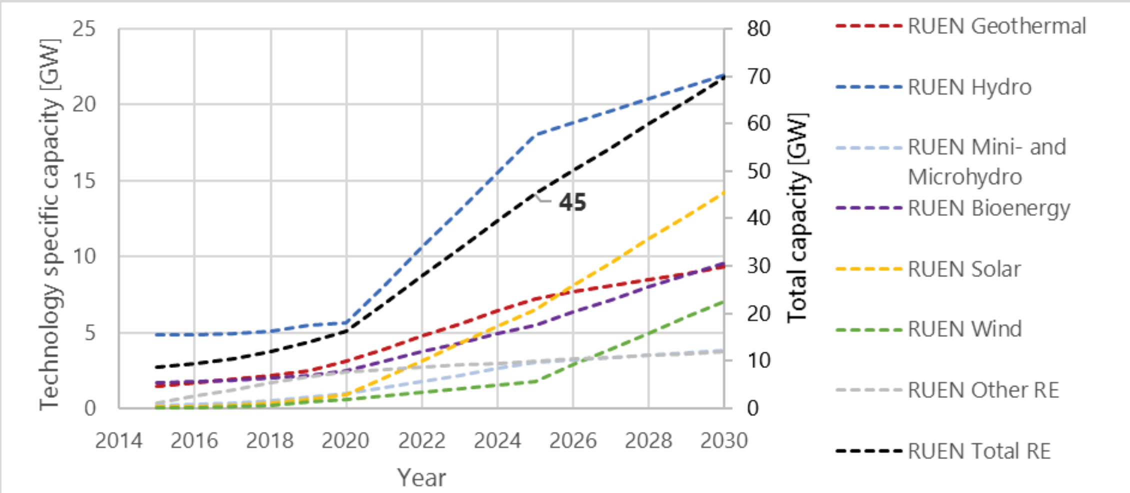
Figure 2 gives an overview of the renewable energy capacities given in RUEN. Specific targets are given for geothermal, hydro (separately for mini- and micro hydro), solar, wind and bio energy. 'Other RE' are technologies which harvest sources such as thermal or kinetic ocean energy. The total renewable capacities reach 45.2 MW in 2025 and 69.7 MW in 2030. It is worthwhile to note that within RUEN, the 2025 target corresponds to 23% of total primary energy consumed, which is arguably the most-cited renewable energy target in Indonesia, first set down in KEN. Solar and wind energy reach 14.2 MW and 7.0 MW capacity following RUEN respectively (20.4% and 10.1%). This is not as much as hydro energy (31.6%) but more than and close to geothermal energy (13.4%).

The targets of RUPTL of 2016 (PLN 2016) are given in Figure 3. RUPTL is the planning document of the state-owned electric utility company PLN and is issued on a yearly basis. Figure 3 also gives the values of the most recent RUPTL of 2019 (PLN 2019) as well as historic values taken from MEMR (2018). As becomes clear from the comparison with Figure 2, the capacities and the distribution between technologies is not aligned between RUEN and RUPTL. RUPTL plans less renewable energy capacities in total, but higher shares for geothermal (23.6%) and hydro energy (56.6%), while solar and wind both reach less than 2% (all values for 2025). Another interesting feature (persistent between editions of RUPTL) is the remarkable increase of capacities foreseen in 2025, with few additions following that year. Wind and solar take little part in this rise in either edition of RUPTL. Neither edition of RUPTL show figures up to 2030, the target year of the NDC, so it remains unclear how these are related.

Given these aspects, the main reference document for the following analysis will be RUEN, but RUPTL will also be discussed up again.

Figure 2: Renewable energy capacity plan as given in RUEN

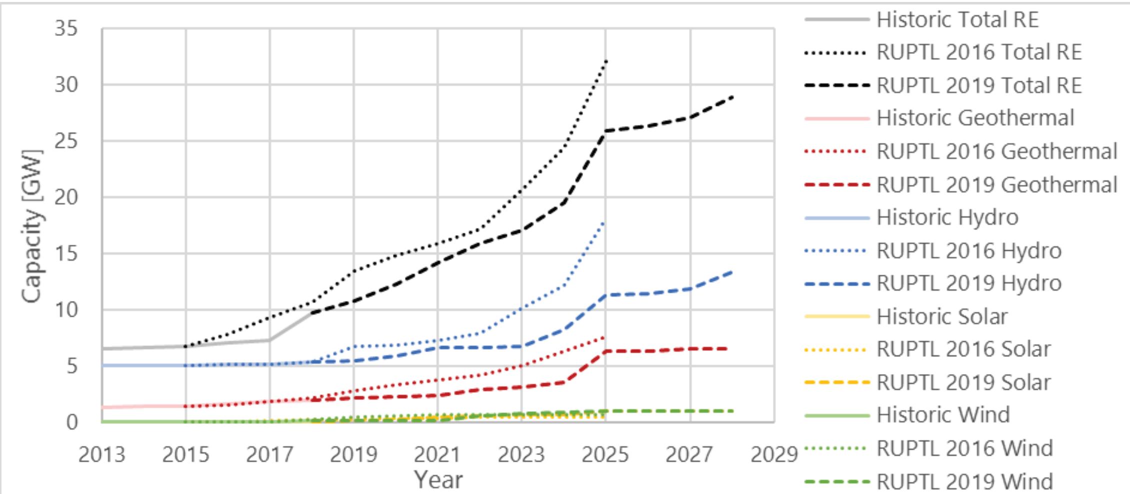
Renewable energy capacity plan as given in RUEN for the different technologies. Note that total renewable energy capacity is given on the right ordinate. The often cited target for 2025 is highlighted.



Source: Government of Indonesia (2014)

Figure 3: Renewable energy capacity plan as given in RUPTL

Renewable energy capacity plan as given in RUPTL of 2016 and 2019 for different technologies. RUPTL of 2016 is referenced in the NDC.



Source: PLN (2016), PLN (2019), MEMR (2018)

3 Cost progressions: Trends in Indonesia between 2015 and 2030

This study aims to estimate how the current revision of the NDC can be informed by using updated cost estimates for renewable energies to reach an increased ambition level. We use figures of levelized costs of electricity (LCOE) here as an indicator for costs. LCOEs reflect the upfront investment costs including costs of finance and all operating costs, such as maintenance as well as fuel costs, set in relation to the energy output of a given project. Technology specific LCOEs are available from different sources and comparable across time and regions.

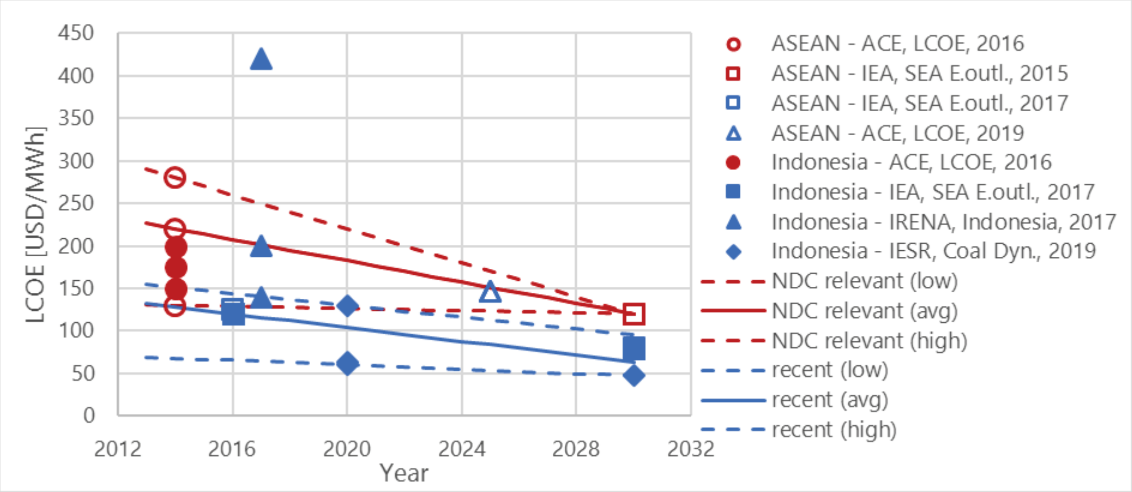
Figure 4 and Figure 5 provide estimates of the LCOEs for solar PV and wind energy for Indonesia in different years. In order to estimate reductions in cost projections, we initially require historic costs and 2030 estimates made at the time when the NDC was designed (denoted 'NDC relevant' in the following). In addition, current LCOEs and current 2030 estimates are necessary. By combining these, it is possible to estimate cost reductions for each year. Most sources give a range of values and this range has been used to derive a range in cost reductions as well.

The NDC relevant estimates are not specific to Indonesia, as sources were not available for both technologies. Instead, LCOE estimates for the ASEAN region are used (ACE (2016), IEA (2015)). For the more recent values and recent 2030 estimates, several publication with values specific to Indonesia were available (IRENA (2017), IEA (2017), Arinaldo and Adiatma (2019)). These were combined with values for 2050 by Arinaldo and Adiatma (2019). The values by IRENA (2017) for 2017 for Indonesia are not considered as they are higher than those already available at the time of the NDC from ACE (2016).

It is worthwhile to note that the projections for 2030 are partly already being undercut by current projects in Indonesia, which have settled at LCOE's just under 60 USD/MWh (Ordonez and Eckstein 2020). This indicates that the estimates used for 2030 are not overly optimistic even if the relatively recent values by IRENA (2017) are not considered.

Figure 4: Current and 2030 LCOE estimates for solar PV

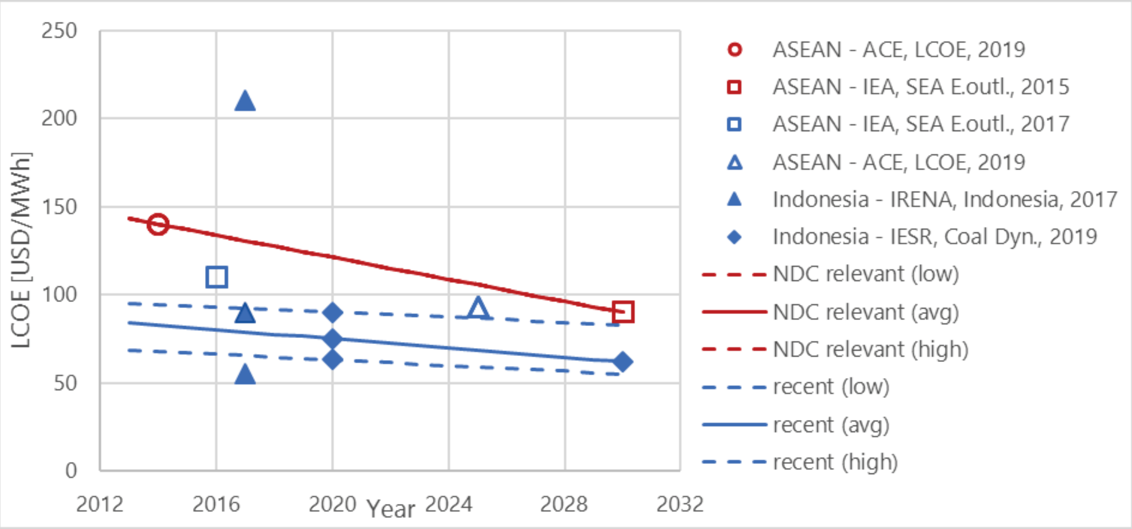
Estimates of the LCOE of solar PV for past and present as well as for 2030. Cost estimates from times of the NDC are indicated in red, more recent estimates in blue. Open symbols denote values valid for the ASEAN region, others are specific to Indonesia. Lines indicate those values used in the subsequent analysis.



Source: as given in the legend

Figure 5: Current and 2030 LCOE estimates for wind energy

As Figure 4, but for wind energy



Source: as given in the legend

A summary of the cost reductions is given in Table 1, again specifying values for each technology and cost range. Between the time when the NDC was composed and more recently, cost estimates for both, solar PV and wind energy, have fallen by approximately 47% (solar PV) and 31% (wind energy) for the year 2030. LCOE's of both technologies are projected to drop stronger than at the time the NDC was developed. Costs of wind energy (62 USD/MWh on average) remain higher than those of solar PV (47 USD/MWh on average) in terms of LCOE.

Table 1: Reduction of projected LCOEs between NDC relevant and recent projections

Reduction in projected LCOEs from NDC relevant estimates and recent estimates for solar PV and wind energy. Values given are for valid for the years specified.

	cost range	**2020**	**2025**	**2030**
Solar PV	Low	-52%	-57%	-61%
	Average	**-43%**	**-45%**	**-47%**
	High	-41%	-34%	-21%
Wind	Low	-48%	-44%	-39%
	Average	**-38%**	**-35%**	**-31%**
	High	-26%	-18%	-8%

Source: own compilation based on sources given in Figure 4 and Figure 5

4 Results: Impact of revised cost estimates on emissions

4.1 Revised renewable energy planning

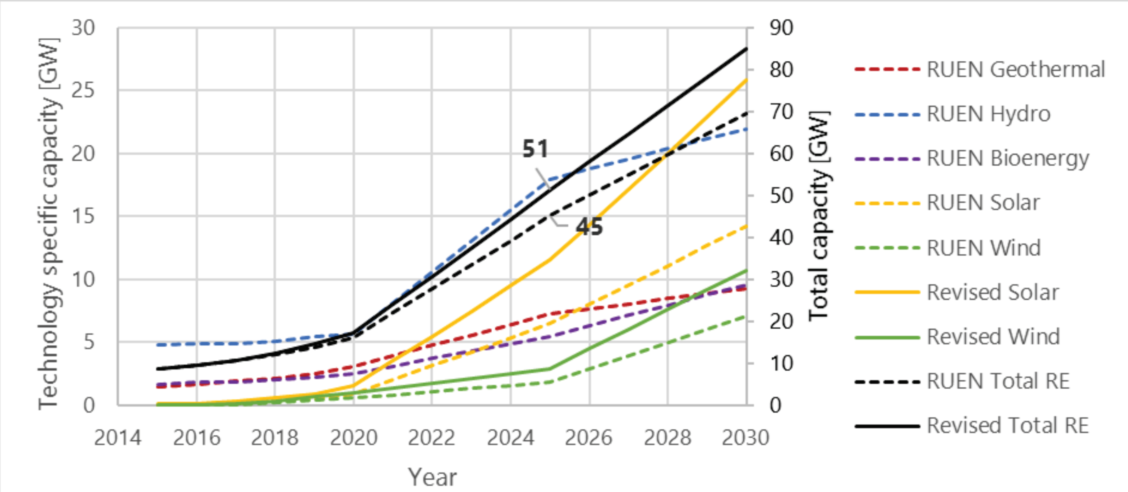
The updated cost figures and corresponding reductions given in Section 0 are used to estimate how these costs could be considered in a revision of renewable energy capacities in RUEN and RUPTL and then inform the ongoing NDC revision. In order to calculate the increase in capacity, the yearly ratio of costs (NDC relevant over recent) is used to estimate revised additions foreseen in each year in RUEN. The underlying assumption here and in the following is that the total required funds for investment are kept constant, investing the same total for an increased amount of renewables. We further assume that all capacities installed will remain in operation during the timeframe considered. This is realistic considering a lifetime of at least 20 years of operation for such technologies.

The resulting revised capacity plan for renewable energies based on RUEN is given in Figure 6. The total capacities in a certain year depend the combination of the increasing scaling factor as well as the size and the timing of the additions in the previous years. E.g. there are few capacity additions foreseen for wind energy in the years prior to 2025, so falling costs reaching a drop of 35% in 2025 have little influence on the capacity in 2025. In the years after, the increase in capacities is stronger, which results in a stronger increase in wind energy as well.

In 2030, the target year of this analysis, wind energy capacities could be increased from 7.0 GW to 10.7 GW while solar PV could be increased from 14.2 GW to 25.8 GW, both at constant investments. This sums up to an increase in total renewable capacities from 69.7 GW to 84.9 GW. Solar PV would then be the dominant renewable energy source, surpassing even hydro power, and wind energy would slightly surpass capacities of geothermal and bio energy.

Figure 6: Revised renewable energy capacities for RUEN based on recent cost estimates

Renewable capacities specified in RUEN as given in Figure 2. Revised solar and wind energy as well as revised total capacity is also indicated. Note that total capacity uses the right ordinate. Not all technologies are given for readability, please see Figure 2 for a full overview of RUEN.

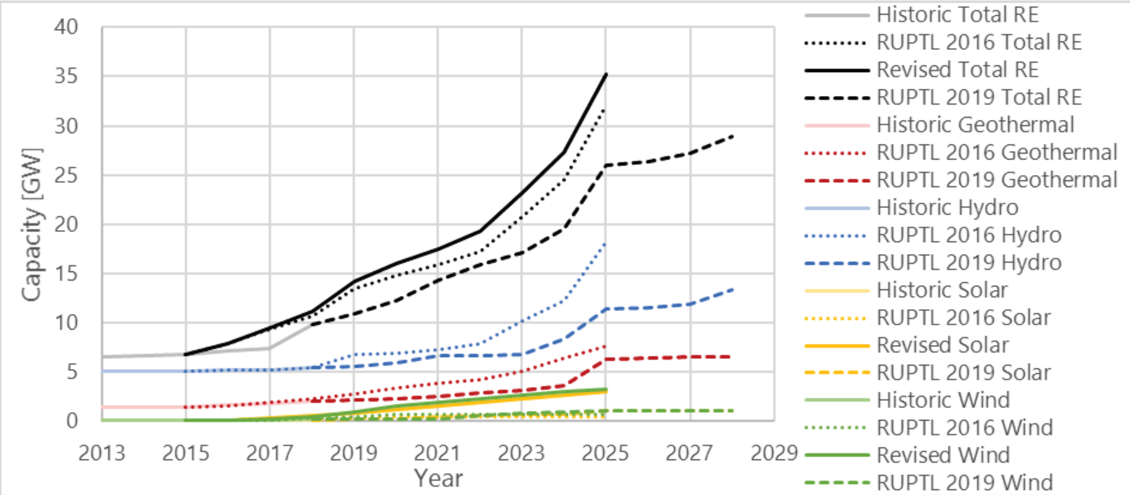


Source: Government of Indonesia (2014) combined with own analysis

The same methodology is applied to the renewable capacities given in RUPTL of 2016 (PLN 2016), which is also referenced in the NDC. Figure 7 gives the respective overview. The decreasing costs of renewables could lead to an increase of just under 10% in RUPTL 2016 (31.1 GW to 35.2 GW). As becomes obvious, subsequent editions of RUPTL – here exemplified by RUPTL 2019 – project less renewable energy capacity. This is due to a smaller total capacity. The share of renewables is larger in RUPTL 2019 than in RUPTL 2015, reaching 23% of generation in 2025 rather than 19% (not shown). Contrary to RUEN, the share of solar and wind energy capacities remains small (just under 10%) even in the revised version of RUPTL 2016.

Figure 7: Revised renewable energy capacities for RUPTL based on recent cost estimates

Renewable capacities specified in RUPTL as given in Figure 3. Revised solar and wind energy as well as revised total capacity is also indicated. Not all technologies are given for readability.



Source: PLN (2016), PLN (2019), MEMR (2018)

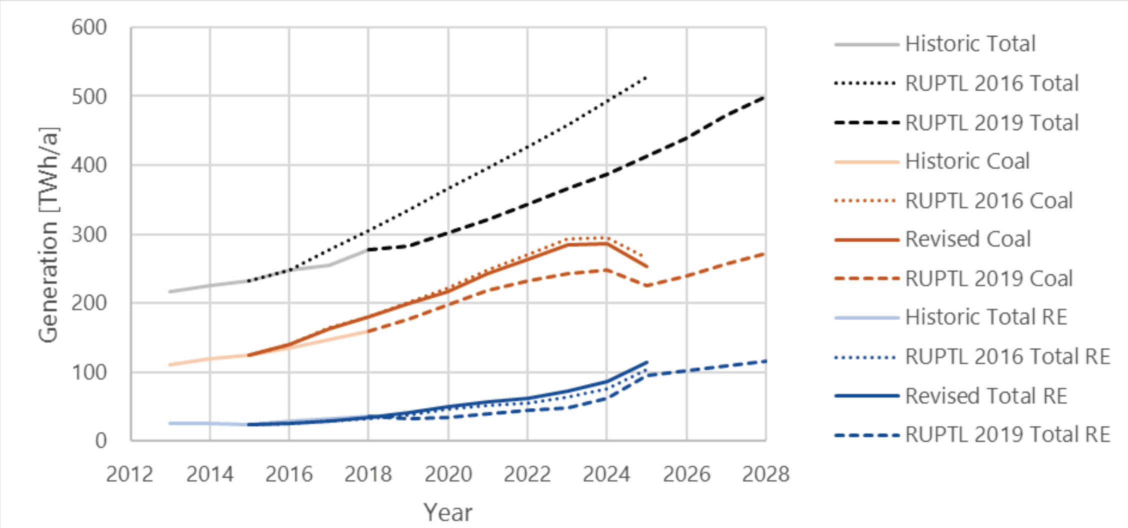
4.2 Impact on emissions

In order to move from a capacity increase to emissions savings, it is essential to first consider the corresponding electricity generation. In order to calculate generation, the yearly full load hours need to be considered. From historic values of generation and capacities given by IRENA (2019) for the years 2013 to 2016, we estimate full load hours of solar PV at 1745 h and that of wind energy at 2750 h. This allows to estimate the additional generation from the capacities as specified in Figure 6 and Figure 7.

Figure 8 shows the resulting generation plan for RUPTL 2016, assuming that coal fired power plants are replaced by the additional renewable capacity (total generation is kept constant). As is obvious from the figure, the total generation of RUPTL 2016 is overestimated with respect to RUPTL 2019 and this dominates the effect of additional renewable generation. Nevertheless, in the revised RUPTL 2016, approximately 11.5 TWh of electricity generated from coal fired power plants could be replaced with renewable energies in 2025. It cannot be assessed from this analysis alone whether this has been taken into account for the current edition of RUPTL, as other effects dominate and total generation is strongly decreased (115.1 GW or 21.8% less in 2025 in RUPTL 2019).

Figure 8: Revised renewable energy generation for RUPTL based on recent cost estimates

Electricity generation as specified in RUPTL 2016 and RUPTL 2019 and historic generation. RUPTL generation from renewables has been estimated using the capacities given in Figure 7. Full load hours are specified in the text. Additional renewable generation is subtracted from coal fired electricity generation for revised numbers.



Source: PLN (2016), PLN (2019), MEMR (2018), own estimates

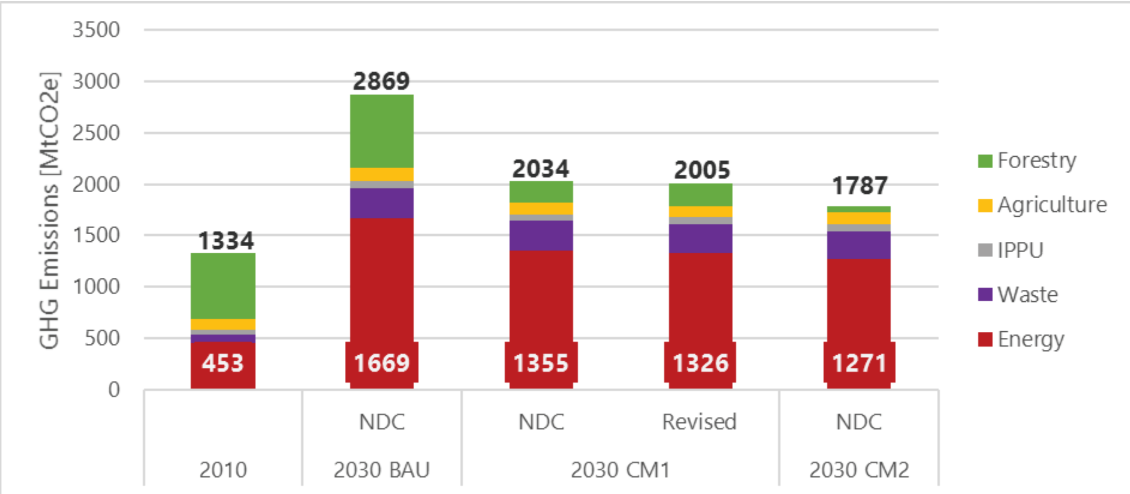
To estimate the emission savings that can be achieved by a capacity increase in renewable energies, we revert to RUEN. As discussed above, we assume this is the document which mainly informed the energy planning underlying the NDC. The revised capacity plan has been discussed in Section 4.1 and is given in Figure 6. This is the basis to estimate increased generation from renewable energies. We use the same full load hours as specified above – 1745 h for solar PV and 2750 h for wind energy. This results in 20.3 TWh and 6.3 TWh of additional generation respectively, or 26.5 TWh in total if the capacity increase in RUEN is used as the basis of the analysis.

We further assume that this additional renewable power generation would replace coal fired power plants, the most common form of electricity generation in Indonesia. PLN (2018) reports total generation and total emissions from coal fired power plants, from which the average emission intensity in the years 2018–2027 is calculated at 1078.5 gCO_2eq/kWh for coal fired power plants in Indonesia. Assuming that 26.5 TWh of coal fired power generation are replaced by additional renewable energy capacities, this results in emission savings of 28.7 $MtCO_2eq$ in the year 2030. This is the number that could be used in the revision of the NDC. Figure 8 gives an overview of the revised emission targets following this methodology.

The unconditional target of the NDC foresees a reduction of 29% relative to BAU to reach 2034 $MtCO_2eq$ in 2030, see Figure 8. The NDC further specifies that electricity generation contributes by reducing emissions by 18.8% to reach 1355 $MtCO_2eq$ in 2030. If the additional capacity of renewable energies is considered in the way described above, this number can be reduced to 1326.3 $MtCO_2eq$, which corresponds to 20.5% reduction. This presents a 9.1% increase in the ambition of the target for energy sector. In terms of total emissions, the ambition could be increased to a new total of 2005.3 $MtCO_2eq$ in 2030, which corresponds to a reduction of 30.1% instead of 29%.

Figure 9: Emission reduction in the INDC considering a revised plan of renewable energies

The sectoral and total mitigation targets as specified in the INDC of Indonesia for the year 2030 and updated values considering revised cost estimates for renewable energies. Also see Table 2 for details.



Source: Government of Indonesia (2016), own results

Again, it should be considered that this revision is based on the overarching assumption that investment funds remain constant. The increase in ambition is achieved only by considering falling cost projections in the revisions.

The values discussed above are valid for average costs. Table 2 specifies values for low and high cost estimates. As the spread between LCOE's for different cost estimates is rather high (see Section 0), the emission savings for high and low cost estimates are equally lower and higher, reaching roughly 50% more or less additional emission savings.

Table 2: Revised emission reduction targets for NDC

Revised emission reduction targets for NDC and the Energy sector in the INDC for low, average and high cost estimates in Table 1.

	Additional emission savings in 2030 [$MtCO_2eq$]			Revised target [$MtCO_2eq$]		Emission reduction [%]		Increase relative to original ambition [%]	
Cost estimate	**Solar PV**	**Wind energy**	**Total**	**NDC uncon-ditional**	**NDC Energy**	**NDC uncon-ditional**	**NDC Energy**	**NDC uncon-ditional**	**NDC Energy**
Low	-35.5	-9.9	**-45.4**	1988.6	1309.6	30.7%	21.5%	4.2%	14.5%
Average	**-21.9**	**-6.8**	**-28.7**	**2005.3**	**1326.3**	**30.1%**	**20.5%**	**2.7%**	**9.1%**
High	-12.7	-2.4	**-15.1**	2018.9	1339.9	29.6%	19.7%	1.4%	4.8%
Original targets				2034.0	1355.0	29.0%	18.8%		

Source: own compilation of results

5 Conclusions: Possible target revision based on reduction of cost estimates

This study analyses how falling cost projections of renewable energy technologies (solar PV and wind energy) could inform energy sector and climate change mitigation plans of Indonesia. The unconditional target of Indonesia's NDC foresees a reduction of GHG emissions of 29% relative to a Business-as-Usual (BAU) scenario, to reach 2034 $MtCO_2eq$ in 2030. It further specifies that electricity generation shall take a share of 37.6% of this mitigation effort to reduce emissions by 18.8% relative to BAU, reaching 1355 $MtCO_2eq$. In this study, we show that the overall ambition could be increased at constant investments to 30.1% savings or a target of 2005 $MtCO_2eq$ in the year 2030, if falling cost projections of renewable energies are considered to increase the share of mitigation of the energy sector.

This study shows that since the NDC has been designed, LCOE projections up to 2030 of solar PV and wind energy have significantly dropped. Current estimates of 2030 values are lower by 30–50% compared to estimates at the time when the NDC was composed.

In order to estimate the possible impact of these revised cost projections on the NDC, the study analyses how the National Energy Plan RUEN of 2014 could be revised if these costs were considered. The underlying assumption is that the available investment level remains the same. A scaling factor is calculated from the cost reductions to develop a revised capacity plan. In 2030, the renewable capacities can be increased from 70 GW to 85 GW, keeping investment expenditures unchanged. Considering the emission intensity of combined coal fired power plants, this translates to emission savings of 28.7 $MtCO_2eq$ for 2030. This corresponds to an increase in the ambition of the unconditional target of the NDC from 29% to 30.1% and presents a 9.1% increase in the ambition of the target for energy sector specified in the NDC.

While an increase of the ambition of only 1.1%-points presents only a small share, this would present an increase at constant investment. The numbers underline the importance to use recent cost estimates in the ongoing revision of the NDC. If trends continue, falling costs of renewables could undercut costs for generation based on fossil fuels, shifting investments and further cutting emissions.

Section A.1 takes a look at falling costs of batteries. These can be used as a proxy for an increase in the share of electric vehicles. The section discusses in how far electric vehicles can contribute to emission savings if the share of renewables is increased in the power sector.

Electricity generation is only one of the sectors that share the overall mitigation target, but it sees the strongest increase in emissions up to 2030 in Indonesia. Increasing the share of renewables is therefore of particularly important. This importance increases with under increased sector coupling. The decarbonisation of the electricity system is then a prerequisite for also cutting emissions in other sectors.

A.1 Falling costs of batteries and emissions from electric vehicles

In analogy to the study presented above, similar arguments hold true for batteries used in electric vehicles. Wachsmuth et al. (2018) also estimate their global decline in cost projections for 2030. They consider values at the time the NDC's were composed and compare these to more recent estimates. Similar to LCOE's, the levelized cost of storage (LCOS) are used an indicator. On a global level, Wachsmuth et al. (2018) estimate LCOS projections for 2030 to have fallen by 19–52%. They go on to argue that this could be an indicator for the increase in electric vehicles, as batteries are a main component determining the costs. Again assuming constant investment and considering the large uncertainty in these numbers, the possible increase of electric vehicles in the revision of a generic NDC is estimated. For each 1 million electric vehicles foreseen in an NDC, an additional 0.9 million could be considered at constant costs in a revision.

In the case of Indonesia, this argumentation is difficult to uphold for several reasons. First, the NDC does not mention any targets related to electric vehicles or more generally even the transport sector. Also, no plans or targets to electrify transport from the time of the first NDC are known to the authors. Only in the past years have electric vehicles been considered in Indonesia. This makes it difficult to estimate a revised increase as there is no initial target to scale.

The 2017 revision of RUEN gives targets for electric vehicles (2200 in 2025). In 2019, the Presidential Regulation 55/2019 was passed, which describes measures to support the development of battery powered electric vehicles in Indonesia, with a particular focus on developing a national industry. Adiatma and Marciano (2020) give an overview of other related planning documents in Indonesia.

In addition to the absence of targets from the time of the NDC, the argument to only consider falling cost projections is difficult to uphold because the electrification of road transport by itself does not lead to emission savings. In order to reduce total emissions, this needs to go hand in hand with an increase in renewable energies for electricity generation.

Renewable energies have taken a share of 11.2–13.3% between 2013 and 2018 (MEMR 2018). The most recent revision of RUPTL, the power supply plan by the utility company PLN, foresees a share of 23.2% electricity generation from renewable energies in 2028 (PLN 2019). This number is based on a strong increase foreseen in the coming years and a reduction of coal powered generation towards 2025. It is not trivial to estimate the emissions from electric vehicles, but this share would not suffice to significantly reduce emissions compared to conventional vehicles, discussed by Adiatma and Marciano (2020). This does not take into account aspects of local air pollution, which can also be reduced by the use of electric vehicles.

Adiatma and Marciano (2020) take a look at the impact of an increased share of electric vehicles on emission reduction targets. They consider two different scenarios for the development of electric vehicle shares ('moderate' at 4.2% and 'ambitious' at 57.4% in 2030, versus 0.4% in BAU) and discuss policies to support these developments. The authors combine the shares with different development plans for electricity generation to estimate emission savings relative to BAU. Savings reach only 0.3 $MtCO_2eq$ in the moderate scenario if renewable implementation follows RUEN and 0.6 $MtCO_2eq$ in the case of a hypothetical coal phase out (22% gas power, 78% renewable energies in 2050). These numbers increase to 8.4 $MtCO_2eq$ and 9.6 $MtCO_2eq$ in the case of the ambitious scenario of electric vehicle shares.

These estimates highlight the importance of first decarbonising the electricity supply in order to consider electric vehicles as a way to decarbonize the transport sector. This points back to the main text, which shows the direct effect of increasing the share of renewable energies in electricity generation. As pointed out above, this is an essential prerequisite to consider decarbonisation by sector coupling in general.

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