Fraunhofer ISI

Preliminary Analysis

Decreasing cost projections of renewable energy and batteries and their implications for a revision of the NDC of Mexico

Preliminary analysis: Bringing climate policy up to date

Place: Karlsruhe, Germany

Date: May 15, 2020

Draft

Imprint

Decreasing cost projections of renewable energy and batteries and their implications for a revision of the NDC of Mexico

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Cover page: source example

Recommended citation

Eckstein, J.; Ordonez, J. A.; Wachsmuth, J. (2020): Decreasing cost projections of renewable energy and batteries and their implications for a revision of the NDC of Mexico. Draft report. Karlsruhe: Fraunhofer Institute for Systems and Innovation Research ISI

Published

Draft to be published after review

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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 were 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 Mexico. 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 could inform an increase in the ambition of the Mexico's NDC by increasing the share of renewable energies in mitigation.

Mexico submitted its NDC in 2015 (Government of Mexico 2015c). The NDC is based on the General Law on Climate Change (*Ley General de Cambio Climático*, LGCC, revised 2018; Government of Mexico (2018)). The LGCC sets a target of 50% reduction of GHG emissions relative to 2000 in 2050 and provides the legal framework for adaptation and mitigation in Mexico. The NDC foresees an unconditional reduction of GHG emissions of 22% by 2030 relative to a Business-as-Usual (BAU) scenario and also establishes a conditional target of 36% reduction relative to BAU by 2030. The energy sector and more specifically the electricity generation take a large share of the expected mitigation effort. Renewable energies are one pillar to reduce emissions from electricity generation.

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 Mexico, estimating how specific cost reductions of solar PV and wind energy in the Mexican context could be considered in the NDC revision of the country. The text continues by giving an overview of the Mexican NDC and renewable plans. Section 3 presents cost estimates relevant for the time the NDC was designed and more recent figures. From these, a possible increase in renewable energies is calculated and discussed in Sec. 4. This section also presents results of emission saving estimates and relates these to the NDC. Section 5 gives a summary and concludes.

A note on this version of the study

The current version of this study presents a draft of assumptions and results. The study team will collect stakeholder feedback to draw on Mexican expertise in order to reflect on the numbers presented here and better understand the processes underlying the ongoing revision of the NDC in Mexico.

Similar arguments as for renewable energies hold true for batteries as an indicator for prices of electric vehicles. This could also be considered in an increase of mitigation efforts. This part of the study is under development.

2 Renewables in Mexico's climate commitments

2.1 NDC overview

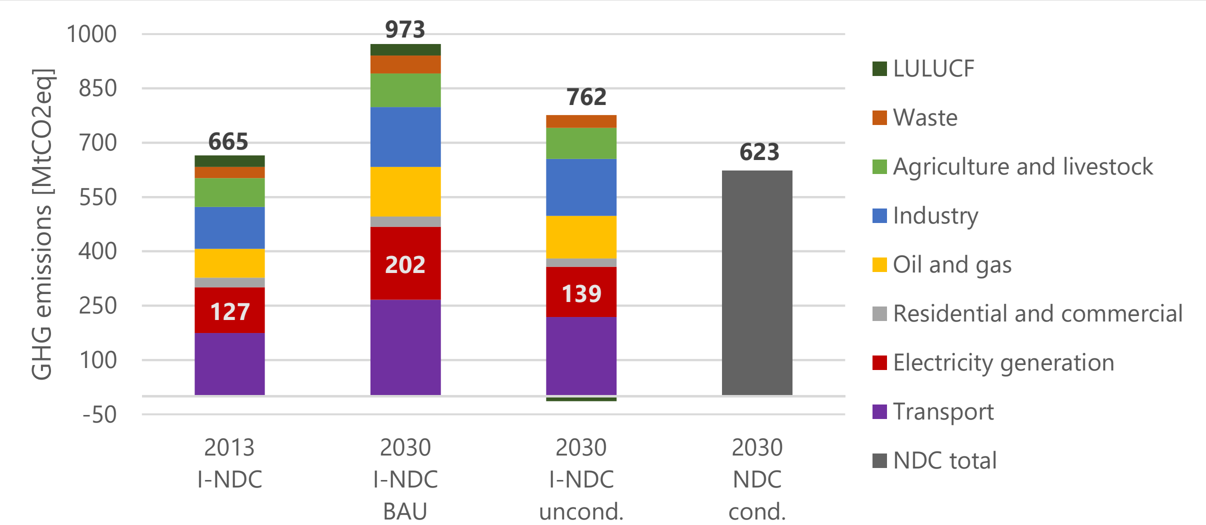
The Nationally Determined Contribution (NDC) of Mexico (Government of Mexico 2015c) was submitted in advance of the 2015 UNFCCC conference in Paris. It specifies mitigation targets for GHG emissions and black carbon. For both, the NDC gives targets relative to a Business-as-Usual (BAU) scenario. Here, we focus on GHG emissions. Figure 1 gives an overview of the targets: The NDC specifies that emissions following the BAU scenario would reach 973 MtCO2eq in 2030. Two mitigation scenarios are defined. The unconditional scenario corresponds to a decrease in GHG emissions of 22% (total of 762 MtCO2eq) compared to BAU by 2030. This could be increased to 36% (total of 623 MtCO2eq) in the conditional scenario subject to international support. The NDC covers five sectors: Energy; Industrial processes and product use; Agriculture; Waste; and Land use, land-use change and forestry (LULUCF)) with respective subsectors, but gives no split of the mitigation effort between sectors.

In terms of mitigation targets, the NDC available from the UNFCCC repository is less detailed than the Intended National Determined Contribution (abbreviated I-NDC for readability; Government of Mexico (2015)), which was submitted prior to the Paris agreement and is still available from the relevant authority in Mexico, SEMARNAT (*Secretaría de Medio Ambiente y Recursos Naturale*, Ministry of Environment and Natural Resources). The I-NDC specifies the same BAU target values and nearly the same values for the mitigation target. The I-NDC does not specify a conditional target. In the following, we assume that the I-NDC scenario and the unconditional scenario of the NDC are identical and build the analysis on the numbers given in the I-NDC document.

Contrary to the NDC, the I-NDC document specifies sectoral mitigation targets for the energy sector and seven other sectors and lists corresponding measures. For electricity generation, the I-NDC foresees a reduction of 31.2% from 202 MtCO2eq given as emissions following the BAU scenario to 139 MtCO2eq in the NDC (unconditional) scenario, see Figure 1. It further specifies as one measure of the energy sector that 43% of the energy generated in 2030 should come from 'renewable sources, efficient combined heat and power and thermoelectric plants with carbon capture and storage', summarized as clean energy (Government of Mexico 2015a).

Figure 1: NDC and I-NDC mitigation targets

Mitigation targets as specified in the Nationally Determined Contribution of Mexico (NDC, in grey bars) and Intended NDC (I-NDC), which provides sectoral targets for identical total ambition levels. The NDC gives an unconditional and a conditional scenario while the I-NDC specifies only one mitigation target.



Source: Government of Mexico (2015); Government of Mexico (2015)

2.2 Projected development of renewable energies

In Mexico, the energy transition is ruled by the Energy Transition Law (*Ley de Transición Energética*, LTE; Government of Mexico (2015)), which specifies that in 2024, 35% of electricity should be generated from clean energy sources. Clean energies include all forms of renewable energies, but also nuclear energies and efficient use of fossil fuels in co-generation facilities. One element of the LTE are renewable energy auctions, three of which have taken place in 2015-2017. The auction scheduled for 2018 had first been postponed but is now cancelled.

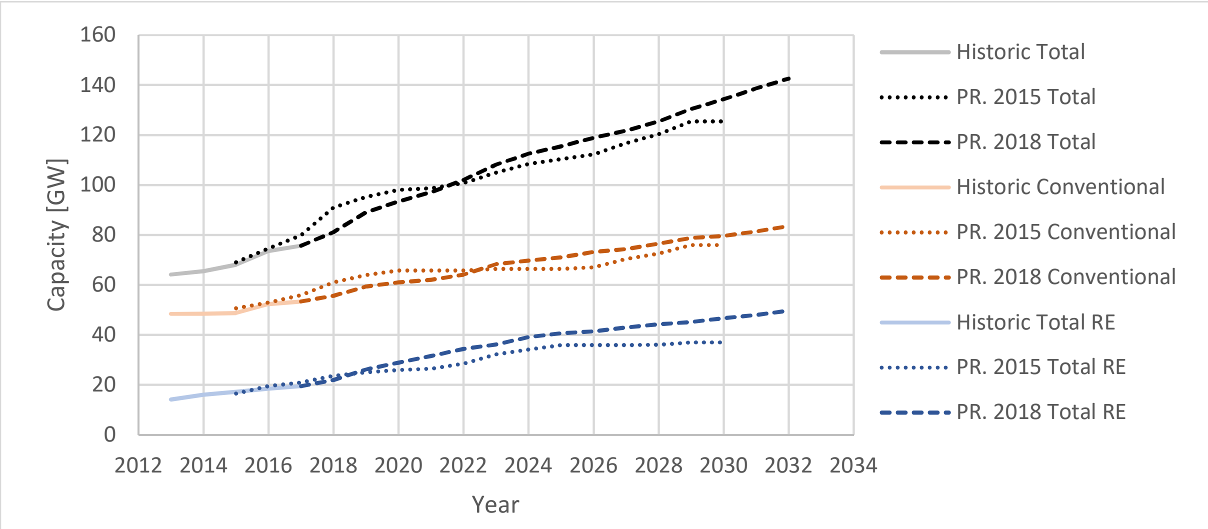
The reference document for planning electricity demand and supply in Mexico is PRODESEN (*Programa para el Desarrollo del Sistema Eléctrico Nacional*, Program for the Development of the National Electric System), issued on a yearly basis by SENER (*Secretaría de Energía*, Ministry of Energy). In the absence of more specific data underlying the NDC, we assume that PRODESEN of 2015 is aligned with the NDC and I-NDC targetsThis seems valid as both were established at the same time (*to be clarified*). .

Figure 2 gives an overview of the capacities for electricity generation in Mexico. It specifies the historic development, the plan as presented in the 2015 edition of PRODESEN (SENER 2015) and the edition of 2018 (SENER 2018). We refer to the 2018 edition here since the data underlying the 2019 publication (SENER 2019) is not available in the same format for relevant variables of the analysis. In PRODESEN, main renewable energy technologies are solar PV, wind, hydro and geothermal energy. We also add bioenergy to this list. In PRODESEN, nuclear energy and efficient co-generation are also considered as clean energy, but we do not account these technologies as renewable. The remainder is classified as conventional electricity generation. PRODESEN of 2015 estimates demand and supply only up to the year 2029, but we assume in the following that no renewable energy capacity is added in 2030, as in other years of the plan. In 2017, renewable energies provided a share of 25.7% to the total capacity, while PRODESEN of 2015 foresees a share of 29.5% in 2030 (34.8% in PRODESEN 2018).

Figure 3 shows the shares for the different technologies in 2030 for the 2015 and 2018 edition of PRODESEN. As apparent, the more recent edition foresees a dramatic increase of solar PV, reaching 22.7% of installed capacity (compared to 5.1% foreseen in PRODESEN 2015). It is the share of hydro energy that is reduced, the percentage foreseen for wind energy is at 37.8% for both editions.

Figure 2: Historic and planned capacities of electricity generation

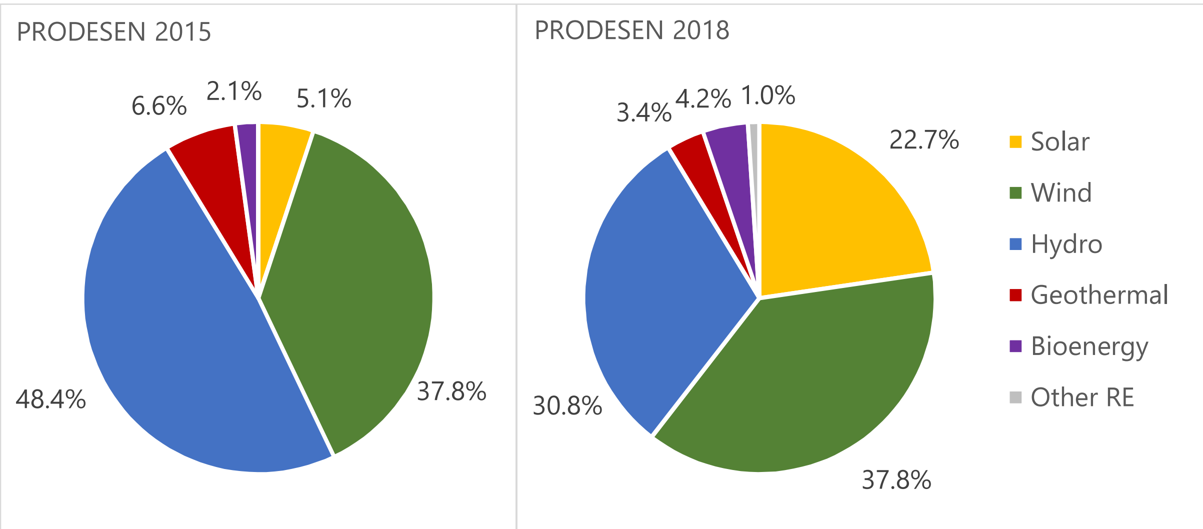
Historic (light full lines) and planned capacities given in PRODESEN 2015 (dotted lines, denoted by 'PR. 2015') and PRODESEN 2018 (dashed lines, denoted by 'PR. 2018') for the total capacity, conventional energy and renewable energies (including bioenergy).



Source: SENER (2015); SENER (2016); SENER (2017); SENER (2018)

Figure 3: Shares of renewable energy capacities by technology in 2030

Shares of capacities of renewable energy technologies foreseen for the year 2030 in PRODESEN 2015 and PRODESEN 2018.



Source: SENER (2015); SENER (2018)

3 Cost progressions: Trends in Mexico between 2015 and 2030

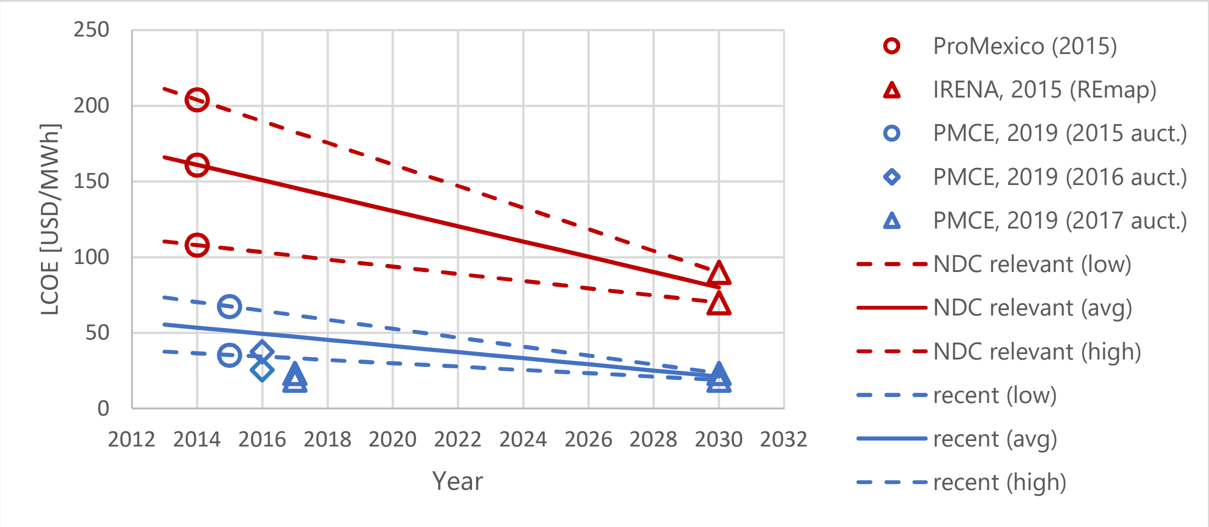
This study aims to estimate how the current revision of the NDC can be informed by using updated cost estimates for renewable energies to reach an increased ambition level. We use figures of levelized costs of electricity (LCOE) here as an indicator for costs. LCOEs reflect the upfront investment costs 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 Mexico 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 2015 estimates are taken from ProMéxico (2015), a document produced by SENER that cites values from Bloomberg Energy Finance. The NDC relevant 2030 estimates are taken from IRENA (2015), which provides specific values for Mexico.

The recent cost estimates are taken from the renewable energy auction outcomes as reported by PMCE (*Plataforma México, Clima y Energía*, PMCE (2019)). Auction outcomes are the results of a bidding process, which may not necessarily reflect costs, but the market situation at the time of the bid. Three renewable energy auctions have been held in Mexico since 2015, with a fourth officially cancelled in 2019. We use the outcomes of the first auction to estimate 2015 costs and the outcomes of the last auction in 2017 to estimate 2030 costs. Auction outcomes of 2017 will need to cover costs well ahead of 2030 already. As costs may further decrease, these numbers present a rough estimate and possibly only an upper limit. Considering that 2015 auction outcomes (for wind energy) only slightly undercut NDC relevant costs, but subsequent auctions have seen dramatic reductions in costs, the approach seems a valid compromise.

Figure 4: Current and 2030 LCOE estimates for solar PV

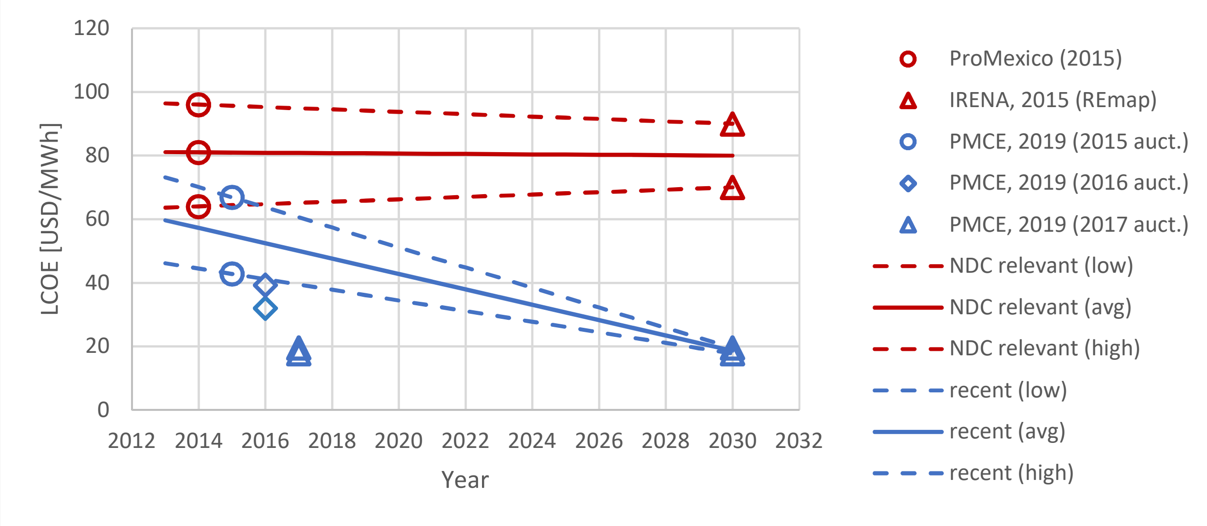
Estimates of the LCOE of solar PV for past and present as well as for 2030. Cost estimates from times of the NDC are indicated in red, more recent estimates in blue. Lines indicate those values used in the subsequent analysis. The most recent auction outcomes have been used as current 2030 estimates.



Source: ProMéxico (2015); IRENA (2015); PMCE (2019)

Figure 5: Current and 2030 LCOE estimates for wind energy

As Figure 4, but for wind energy.



Source: ProMéxico (2015); IRENA (2015); PMCE (2019)

A summary of the cost reductions[1] 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 75% for the year 2030 (74% in the case of solar PV and 77% in the case of wind energy). Cost estimates for recent years (e.g. 2020) of wind energy have not fallen as dramatically as for solar PV, but for 2030 they reach similar reduction rates and absolute values of just below 20 USD/MWh.

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.

	cost estimate	2020	2025	2030
Solar PV	Low	-68%	-70%	-73%
	Average	-68%	-70%	**-74%**
	High	-67%	-70%	-74%
Wind	Low	-48%	-62%	-75%
	Average	-47%	-62%	**-77%**
	High	-46%	-62%	-78%

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

[1] Cost reductions are estimated as the percentage of the difference in costs relative to the NDC relevant costs.

4 Results: Impact of revised cost estimates on emissions

4.1 Revised renewable energy capacities

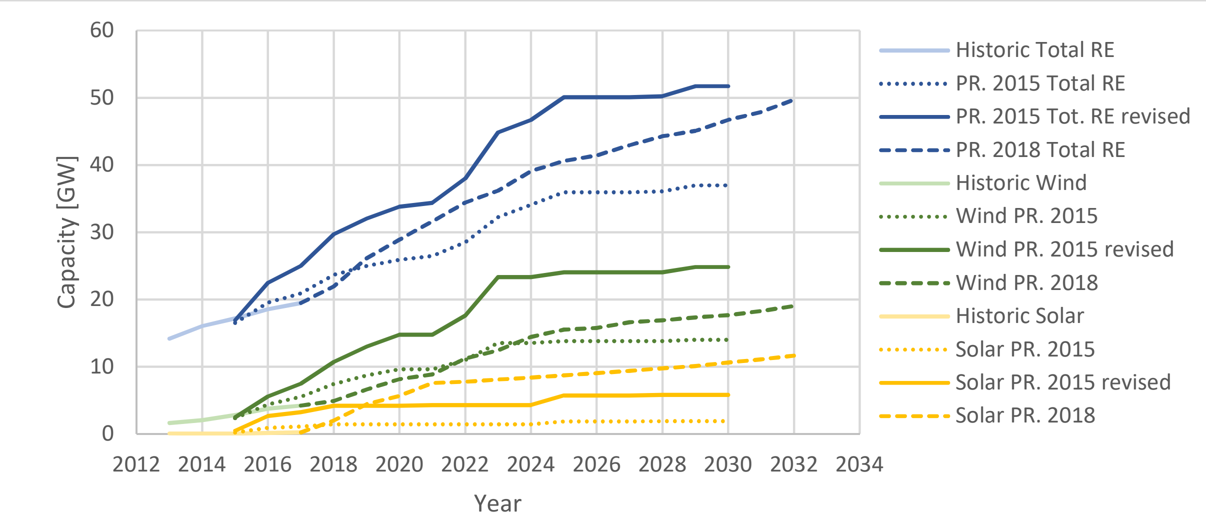
The updated cost figures and corresponding reductions given in Sec. 3 are used to estimate how these costs could be considered in a revision of PRODESEN 2015 (SENER 2015) and then inform the ongoing NDC revision. In order to calculate the increase in capacity, the yearly ratio of costs (NDC relevant over recent) is used to estimate revised additions foreseen in each year of PRODESEN 2015. 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 PRODESEN 2015, 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 after 2023, so falling costs reaching a drop of up to 77% have little influence on the final capacity in 2030.

In 2030, wind energy capacities could increase from 14.0 GW to 24.8 GW while solar PV could be increased from 1.9 GW to 5.8 GW. This sums up to an increase in total renewable capacities from 37.0 GW to 51.7 GW. It is worthwhile to note that in the recent PRODESEN 2018 (SENER 2018), solar PV capacities are already foreseen to reach 10.6 GW in 2030. But with a less pronounced increase of wind energy in PRODESEN 2018, total renewable capacities only reach 46.7 GW in 2030. Historic development of capacities did not reach targets set out in PRODESEN 2015. As shown, capacities given in PRODESEN 2018 therefore start from lower levels than previously foreseen. But this analysis alone cannot be used to assess whether the cost reductions have been considered for PRODESEN 2018.

Figure 6: Revised solar PV and wind energy planning based on recent cost estimates

Revised solar PV and wind energy capacities based on PRODESEN 2015 and reduced LCOE estimates given in Sec. 3 (average cost reductions given in Table 1). Plans of PRODESEN 2018 and values for total renewable energies are given for reference.



Source: SENER (2015); SENER (2016); SENER (2017); SENER (2018)

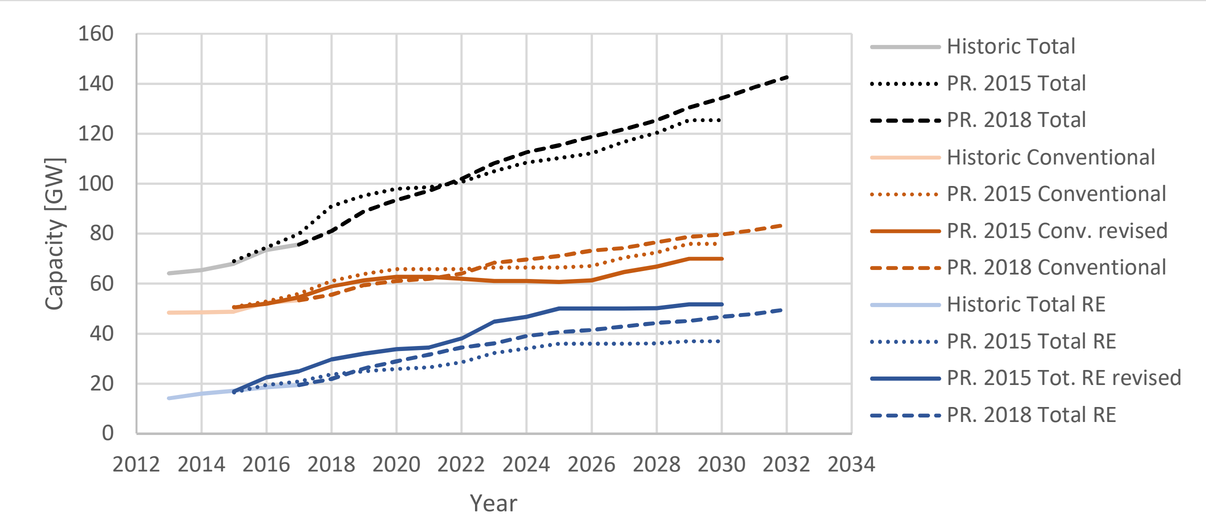
4.2 Impact on emissions

In order to move from 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 in PRODESEN 2015-2018 for the years 2014 to 2017, we estimate average full load hours per year of solar PV at 1406 h and those of wind energy at 2901 h. Using these numbers, the additional generation for 2030 is estimated at 36.9 TWh in total, of which 5.5 TWh are from an increase in solar PV and 31.4 TWh from an in increase in wind energy, both considering average costs.

We assume that the additional capacities could be used to replace combined cycle gas power plants. Combined cycle power plants are the most broadly used form of power generation in Mexico according to PRODESEN reports. Again using historic values, full load hours are estimated at 6160 h for combined cycle gas power plants in Mexico. Figure 7 indicates the revised renewable and conventional capacities (derived by dividing renewable generation by conventional full load hours). Following these arguments, conventional capacities could be reduced in 2030 from 76.0 GW to 70.0 GW, a reduction of 7.9%.

Figure 7: Revised renewable energy planning based on recent cost estimates

As Figure 2, now also indicating the revised capacity plan for renewable energies and a corresponding reduction for conventional generation capacities (scaled to consider the difference in full load hours, see text for details). Revised capacities shown here use average cost reductions given in Table 1.

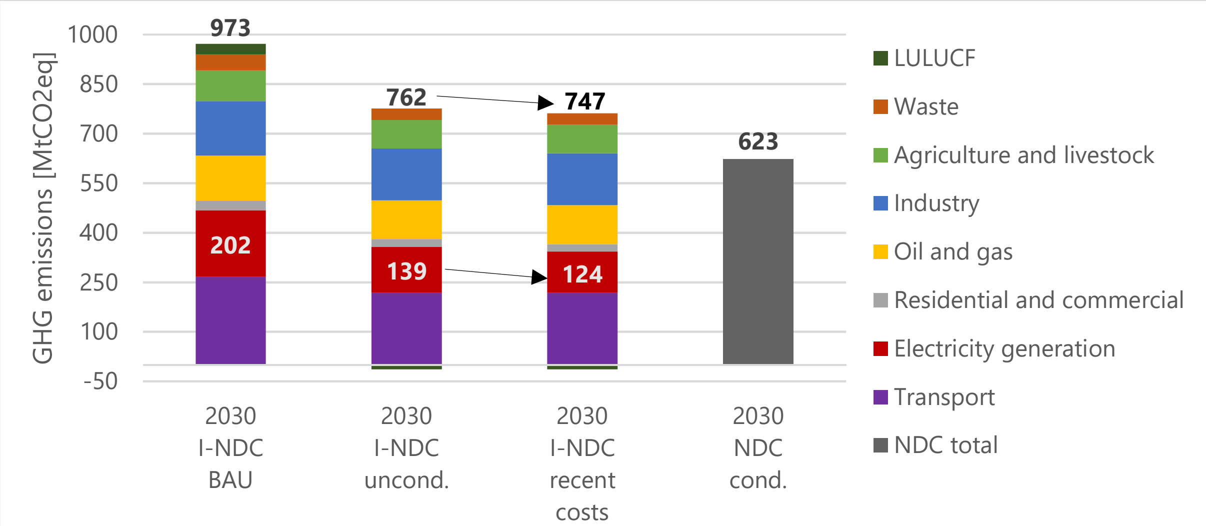


Source: own compilation, building on SENER (2015); SENER (2018) and other publications

To estimate emissions savings, we assume that the additional generation from renewable technologies of 31.4 TWh replaces combined cycle gas power plants.Considering an emission intensity of 400 gCO2/kWh for this technology, the avoided emissions from this increase in renewable energies results in 14.8 MtCO2eq in the year 2030. This number can be used to estimate the additional emission savings in the NDC.

Figure 8: Emission reduction in the I-NDC considering a revised plan of renewable energies

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



Source: Government of Mexico (2015); own estimate determined in this report

The unconditional target of the NDC foresees a reduction of 22% relative to BAU to reach 762 MtCO2eq in 2030, see Figure 8. The I-NDC specifies that electricity generation contributes by reducing emissions by 31.2% to reach 139 MtCO2eq in 2030. If the additional capacity of renewable energies is considered in the way described above, this number can be reduced to 124 MtCO2eq, which corresponds to 38.5% reduction. In terms of total emissions, the ambition could be increased to a new total of 747 MtCO2eq in 2030, which corresponds to a reduction of 23.5% instead of 22%.

Again, it should be considered that this revision is based on the overarching assumption that investment funds remain the same. The increase in ambition is achieved only by considering falling cost projections in the revisions. These values are relevant for average costs, Table 2 specifies values for low and high cost estimates, but resulting ambition levels remain very similar.

Table 2: Revised emission reduction targets for Mexico's NDC

Revised emission reduction targets for NDC and the Energy sector in the I-NDC for low, average and high cost estimates of solar PV and wind energy given in Table 1.

	Additional emission savings in 2030 [MtCO2eq]			Revised target [MtCO2eq]		Emission reduction [%]		Increase relative to original ambition [%]	
Cost estimate	**Solar PV**	**Wind energy**	**Total**	**NDC uncon-ditional**	**I-NDC Energy**	**NDC uncon-ditional**	**I-NDC Energy**	**NDC uncon-ditional**	**I-NDC Energy**
Low	-2.2	-12.9	**-15.1**	746.9	123.9	23.6%	38.7%	4.3%	24.0%
Average	**-2.2**	**-12.6**	**-14.8**	**747.2**	**124.2**	**23.5%**	**38.5%**	**4.2%**	**23.4%**
High	-2.1	-12.0	**-14.1**	747.9	124.9	23.4%	38.0%	4.0%	22.4%
Original targets				762.0	139.0	22.0%	31.2%		

Source: own compilation of results

5 Preliminary 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 Mexico. The unconditional target of Mexico's NDC foresees a reduction of GHG emissions of 22% relative to a Business-as-Usual (BAU) scenario, to reach 762 MtCO2eq in 2030. The Intended NDC (I-NDC) gives more details and specifies that electricity generation shall take a share of 30% of this mitigation effort to reduce emissions by 31.4% relative to BAU, reaching 139 MtCO2eq.

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 as much as 75% 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 electricity plan PRODESEN of 2015 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 40 GW to 51.7 GW, keeping investment expenditures unchanged. Considering the difference in full load hours, conventional capacities can be reduced from 76 GW to 70 GW. Due to the methodology, cost reductions in second half of the decade remain untapped in this analysis. Considering the emission intensity of combined cycle power generation, this translates to emission savings of 14.1 MtCO2eq for 2030. This corresponds to an increase in the ambition of the unconditional target of the NDC from 22% to 23.5% and presents a 23.4% increase in the ambition of the target for electricity generation specified in the I-NDC.

While an increase of the ambition of only 1.5%-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.

Electricity generation is only one of the sectors that share the overall mitigation target. Within the electricity sector, the 7%-point increase in ambition is significant. And with increasing sector coupling, the decarbonisation of the electricity system is of special importance, as it presents a prerequisite for also cutting emissions in other sectors.

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