1.5°C
NATIONAL
PATHWAY
EXPLORER

CLIMATE ANALYTICS

NATIONAL 1.5°C COMPATIBLE EMISSIONS PATHWAYS AND CONSISTENT POWER SECTOR BENCHMARKS

Indonesia, Viet Nam, Philippines, India and Japan

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SUPPLEMENTARY MATERIAL

Supplementary material and background data can be consulted on the dedicated webtool:
1p5ndc-pathways.climateanalytics.org/

A digital copy of this report along with supporting appendices is available at:
www.climateanalytics.org/publications

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SUMMARY

To date, governments have submitted inadequate and unambitious NDCs, that are not sufficient to meet the Paris Agreement long term temperature goal.

This report presents domestic emissions pathways required to keep to the Paris Agreement's 1.5°C limit for five countries: Viet Nam, Philippines, India, Indonesia and Japan and assesses if current 2030 climate targets are in line with these pathways. Pathways are derived from the pathways assessed in the IPCC Special Report 1.5°C. Key decarbonisation benchmarks for the power sector consistent with 1.5°C emissions pathways are also provided.

Among the countries analysed here, applying equity principles for Viet Nam, Philippines, India and Indonesia mean that they would receive international support to implement their 1.5°C domestic emissions pathways, while Japan would need to provide support to developing countries' emissions reduction efforts.

COUNTRY KEY MESSAGES

Viet Nam's 1.5°C compatible pathway requires emissions reductions of 35%-50% from 2015 levels, by 2030, this equates to a domestic reduction of 183-237 MtCO2e/yr. **Viet Nam** has huge renewables potential, and could become a regional leader in solar and offshore wind. Our analysis suggests that renewable energy can represent 100% of the power sector by 2040.

Our analysis indicates that the **Philippines**' current Nationally Determined Contribution (NDC)* is Paris compatible. However, current policy projections show that the **Philippines** is not on track to meet its NDC, with emissions expected to increase by 34-41% above 2015 levels. The power sector analysis shows that renewables can make up to 85% of the power mix by 2030.

For **India's** domestic emissions to be in line with the 1.5°C limit, they would need to peak soon and reduce emissions as early as possible, aiming for a 2030 emissions level of 1.6 (1.5–1.9) GtCO2e, equivalent to 16% below 2005 levels (23-1% below 2005 levels). The decarbonisation of its power sector would require the phasing out of both coal and gas before 2040, and renewable energy share would simultaneously need to reach 90-100%.

Indonesia's Paris compatible pathway requires it to reach emissions reductions of 30-48% below 2015 levels by 2030. Achieving such an emissions trajectory will be made possible with considerable increase in renewables in its power mix – up to around 74% by 2030 from 13% in 2017.

Japan's Paris compatible pathway would require a rapid decline in domestic emissions, to reach 65% below 2013 levels by 2030. Reducing its emissions to a 1.5°C compatible emissions pathway would require a coal phase out roughly by 2031, and a fully decarbonised power sector by 2040 at the latest. This would also require a high uptake of renewables – at least 60% by 2030. Additionally, like all developed countries, in order for **Japan** to make a fair contribution to the Paris Agreement's goals, it will need to also provide support to developing countries to reduce their emissions.

It is important to note that fair share considerations embedded in the Paris Agreement would imply that the gap between Viet Nam, Philippines, Indonesia and India's current policy projections and their 'fair share' range would be closed by each country's own action. Then, the remaining gap between the 'fair share' range and Paris compatible domestic emissions pathways should, and would need to, be closed with support from developed countries.

* Analysis prior to Philippines' submission of its updated NDC on April 15, 2021

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1 Introduction

As part of the Paris Agreement, 184 governments have put forward targets (NDCs) to limit the global average temperature increase to 1.5ºC with the aim to '*significantly reduce the risks and impacts of climate change'*. To date, their combined effect is not sufficient to achieve this limit. At the moment they put the world on a path to approximately 3°C of warming (Climate Action Tracker 2020e) – double the agreed limit.

In their successive NDCs, governments are required to put forward more ambitious emissions reduction targets, that should align with the Paris Agreement. The Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C showed not only why governments must act urgently to prevent higher levels of warming, but also how emissions need to, and can be reduced, by at least 45% by 2030 compared to 2010. By mid-century emissions will need to be brought to net zero by to limit global warming to 1.5°C. To meet the urgent need to translate these global trajectories to action in line with the Paris Agreement, developing countries will require support.

This analysis aims to be a resource to empower a broad range of national stakeholders, including civil society, in understanding decarbonisation pathways in line with the 1.5°C limit. These pathways, assessed with other lines of scientific evidence, show how a selection of five countries can update their 2030 targets (NDCs) and develop long-term low carbon development strategies in line with the Paris Agreement, living up to their promises to prevent dangerous climate change.

The analysis is framed around two timelines: the medium term (by 2030), and the long term (by mid-century). Sectoral benchmarks consistent with the analysed emissions pathways will be updated and provided through an online tool throughout 2021. This report provides those for the power sector.

2 Global Mitigation Pathways consistent with the 1.5°C temperature limit

2.1 Domestic action

In 2015, countries adopted the Paris Agreement, and agreed to *"[…] strengthen the global response to the threat of climate change[…], including by holding the increase in the global average temperature to well below 2°C […] and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels"* (UNFCCC, 2015).

Article 4.1 of the Paris Agreement outlines key operational steps to be taken to enable the achievement of the long-term temperature goal:

- To reach *"global peaking of greenhouse gas emissions as soon as possible"*
- *"To undertake rapid reductions thereafter in accordance with best available science"*
- *"To achieve a balance between anthropogenic emissions by sources and removals by sinks in the second half of this century"*

This establishes a mandatory requirement for all parties to take domestic action to reduce emissions in their countries. The Agreement further affirms that action taken for implementation should "*reflect equity and the principle of common but differentiated responsibilities and respective capabilities* (*CBDR)".*

This implies that in order to make a fair contribution to meeting the Paris Agreement's goals, developed countries need to both take domestic emissions reduction action and assist developing countries to reduce their emissions. This means that a developed country's total NDC "fair share" action range is the total sum of domestic reductions plus support for emission reductions action overseas which can be in the form of climate finance, or other support for mitigation consistent with the Paris agreement (Climate Action Tracker 2018).

For developing countries, the 1.5°C compatible pathways are not their own domestic emission reduction targets to be achieved without support. The fair share and equity considerations embedded in the Paris Agreement imply that without support a developing country would only reduce its emissions to its "fair share" range, and the gap between this fair share range and the 1.5°C compatible domestic pathway could only likely be bridged with support from developed countries in one form or another. If a developing country's current policy pathway lies above its fair share range then it should take further action domestically to bring its emissions to at least this range.

While there are several equity principles, pathways considered here are not aligned with a given equity principle, but are however aligned with the notion of "highest plausible ambition": pathways that are technically and economically feasible. These pathways take into account present day characteristics, such as the current infrastructure (e.g., emissions intensity of the economy), of individual countries.

2.2 How are global Paris Agreement compatible pathways defined?

Paris Agreement compatible pathways used in the analysis are defined in the IPCC Special Report on 1.5°C (IPCC SR1.5) as those that limit warming to 1.5°C with no or limited overshoot (<0.1°C). In these pathways, the increase of global average temperature above its pre-industrial level is limited to below 1.6°C for the whole twenty-first century and below 1.5°C by 2100 (typically 1.3°C) (IPCC 2018a).

Each country is provided with illustrative pathways as well as a 1.5°C compatible range derived from the full set of Paris Agreement compatible pathways from the IPCC SR1.5, considering sustainability limits as defined by the IPCC SR1.5 (Fuss et al. 2018; IPCC 2018b).

While any one global pathway as defined above is internally consistent with the 1.5°C limit, an assessment of multiple pathways is not. As an example, consider the archetypal pathways described above. Following a constructed emissions scenario at the higher end of this range, i.e., resulting from the delayed pathway in the near term and the immediate pathway in the long term, would not necessarily limit warming to 1.5°C as either individual pathway achieved. Therefore, from the full set of 1.5°C pathways, we highlight a number of 'illustrative' pathways per country to further interrogate technological and sectoral specific transformations that enable reaching this climate goal.

2.3 Global Emissions Pathways assessed and their differences

Illustrative emissions pathways are provided for each country. The provision of these pathways, in addition to the broader (IPCC) scenario range, is essential for three reasons.

First, the selection of illustrative pathways guarantee compatibility with the Paris Agreement when assuming that all countries follow a specific illustrative pathway - that is, each scenario presents an internally consistent trajectory to arrive at 1.5°C. Integrated assessment models allocate global emissions reductions across regions differently, and, as a consequence, the scenario which has the highest emission budget varies per country. If all countries would follow the scenario with their highest emission budget, this would lead in total to an exceedance of the 1.5°C temperature limit.

Only a single, illustrative, up-to-date global pathway is guaranteed to provide a consistent estimate of all national emissions levels in line with the Paris Agreement. Any national level of emissions above/under this pathway (within the "IPCC range") will imply other countries must do more/less than their respective illustrative levels. When assessing this distribution at the global level and implied national level, we therefore measure the median of the range and below in order to provide a high-confidence estimate that the derived emissions still achieve the global temperature goal when aggregated together across all assessed countries.

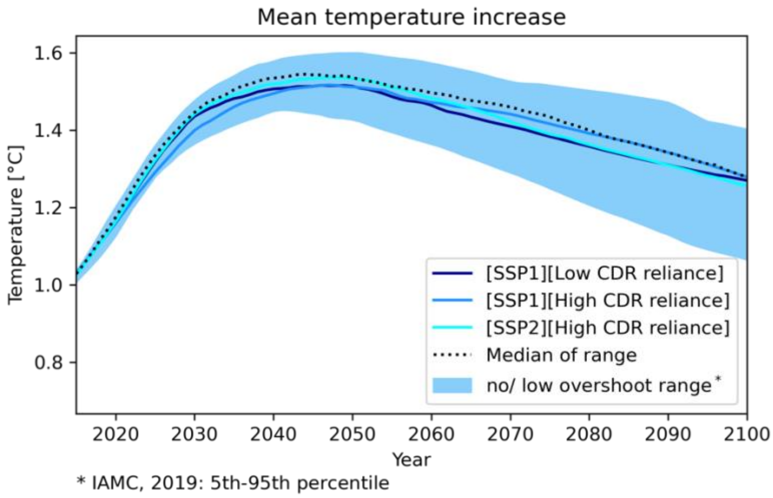

Figure 1: Selected illustrative pathways and their behaviour with regards to mean temperature increase compared to the overall global-least costs pathways assessed in the IPCC Special Report on 1.5°C. The selected illustrative pathways are below the median.

Providing a deep dive into what it means to be Paris Agreement compatible is the second motivation behind providing illustrative pathways. These pathways are assessed in detail, investigating not only the aspect of nation-wide emissions, but also unravelling sectoral emissions and providing energy consumption on the primary, secondary and final energy level.

Lastly, some of the Paris Agreement compatible pathways rely heavily on carbon dioxide removal, especially late in the century. Providing illustrative pathways allows the option for identifying sustainable emission reduction pathways contrasting them to other pathways more dependent on long-term carbon removals.

These illustrative pathways are selected based on the following criteria:

- **Minimising global warming:** throughout the 21^{st} century, including limiting peak 21^{st} century warming to 1.5°C, minimising warming reached by the end of the century and minimising the number of years mid-century peak warming exceeds 1.5°C.

- **Minimising the reliance on Carbon Dioxide Removal (CDR):** such as large-scale afforestation and reforestation (AR), the use of bioenergy and carbon capture and storage (BECCS) or direct air capture combined with CCS (DACCS). All modelled pathways that limit warming to 1.5 °C rely on CDR mostly to offset harder-to-abate sectors (such as agriculture, industry processes or aviation).

  However, the amount of CDR required will depend on the pace of global progress in reducing emissions; early action to rapidly decarbonise and reduce the overall need for CDR will be essential. If deployed at a large scale, CDR technologies would entail negative side-effects across different dimensions of sustainable development objectives, their technological and economic viability has not been proven yet, and limited progress has been observed in planning and deploying them at national level (Fyson et al. 2020).

In this context, sustainability limits are considered**:** the IPCC SR1.5 finds limits for a sustainable use of both CDR options globally by 2050 to be below 5 $GtCO_2$ p.a. for Bioenergy with Carbon Capture and Storage (BECCS) and below 3.6 $GtCO_2$ p.a. for sequestration through AR, while noting uncertainty in the assessment of sustainable use and economic and technical potential in the latter half of the century (Fuss et al. 2018; IPCC 2018b).

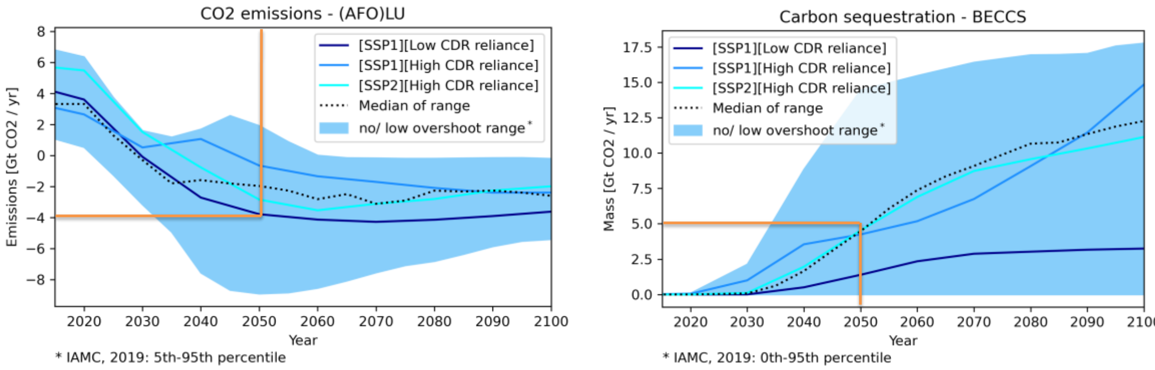

Figure 2: Selected illustrative pathways compared to the sustainailbity criteria as defined in the IPCC SR1.5 for a sustainable use of land-based Carbon Dioxide Removal (CDR) options.

- **Minimising the reliance on fossil fuel combined with CCS**: while these technologies have lower emissions than unabated fossil fuels, they do not allow a full decarbonisation of the plant. Additionally, they require high investments upfront and the risk of locking the countries into stranded assets making it harder to decarbonise in the long term. Furthermore, studies show that forecasted costs of fossil with CCS are not competitive with renewable energy costs (Climate Action Tracker 2020h; Sgouridis et al. 2019).

- **Immediate action in line with 'highest plausible ambition':** countries have a limited carbon budget to reach the temperature limit compatible with the Paris Agreement. The sooner action is taken the less risk there is of running out of time to decarbonise and remain within that carbon budget. It allows countries to take into account needed investments in long-lasting energy infrastructure and the required time to turn over specific end-use sectors such as transport (fleet turn over).

- **Data availability**: not all pathways are provided with a granularity and availability of data suitable to downscale their energy system from regional to national level. Thus, this criterion is key in the selection of the pathways as well.

Table 1 shows the selected illustrative pathways and their global relative behaviour based on the above-mentioned criteria i.e., allowing less or more carbon sequestration compared one to another or relying less on CDR through reduced primary energy demand compared to one another.

Table 1: Selected illustrative pathways, their underlying models and their application in this analysis. Further details on these. Models are available at the following sources: (Van Vuuren et al. 2018), (Fujimori et al. 2017; Rogelj et al. 2018), (Grubler et al. 2018), (Ram et al. 2019).

Illustrative Pathways Selected	Model	Primary Energy Demand	Carbon Sequestration (BECCS)	Carbon Sequestration (AFOLU)	Reliance on fossil-fuel with CCS	Scope of analysis
[SSP1] [High CDR reliance]	IMAGE SSP1	→	↑	↑	↑	Full sectoral investigation
[SSP1] [Low CDR reliance]	AIM SSP1-19	→	↓	↓	↓	
[SSP2] [High CDR reliance]	AIM SSP2-19	↑	↑	→	↑	
[High energy demand] [Low CDR reliance]	REMIND_1.7 CEMICS-1.5	↑	↓	↓	X	Energy mix discussion only
Low Energy Demand	MESSAGE LED	↓	X	X	X	
100% RE	EWG LUT Global100RE				X	

2.4 Limitations and outlook towards updated global pathways

While global emissions pathways assessed in IPCC reports are essential for the broad scientific setting and underpinning of the guidance on long-term energy system transformation, these pathways were published in the scientific literature well ahead of the release of the IPCC SR15, and were therefore often developed in 2017, or before. They do not necessarily keep track of current developments in energy markets, disruptive technological developments, consumer choices and policy trajectories. Furthermore, sustainability constraints identified by the IPCC and others and the plausibility of future large-scale deployment of key technologies, such as BECCS, nuclear power plants, fossil fuel with CCS and land-use options are often not captured in these pathways.

A parallel workstream to this analysis, together with the global energy-economic modelling community, aims at developing an additional illustrative set of 1.5°C compatible pathway variants, on an annual basis, taking into account both IPCC assessments and the latest data and analyses on policies, technology markets and costs, as well as other identified areas of evolution. This will allow the annual refinement of the presented benchmarks as well as the addition of further models and other lines of evidence to empower stakeholders in understanding and making informed choices about the necessary transformative changes.

3 National mitigation pathways consistent with the 1.5°C temperature limit

3.1 Regional context

Driven by its high reliance on fossil fuels as well as growth in energy demand, the Asian region contributes significantly to the increase in global greenhouse gas emissions (Climate Analytics 2021). Of the five countries analysed in this report, India is the most emitting country followed by Japan and Indonesia (Gütschow et al. 2019).

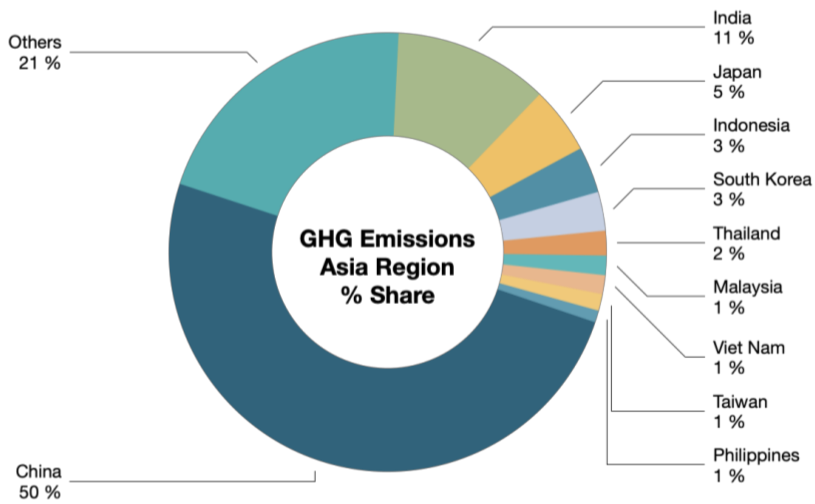

Figure 3: GHG emissions excluding LULUCF per country in the Asia region the year 2017. Source : (Gütschow et al. 2019).

When considering the absolute size and relative share in power generation of coal power plants, Asia is the region with highest risk of stranded assets, (Climate Analytics 2019). The five countries analysed here are among the top 10 countries which account for 91% of the total global coal pipeline with India at 12%, Indonesia (6%), Viet Nam (6%), the Philippines (2%) and Japan (2%).

This is not in line with the Paris Agreement benchmarks (figure 4), which require non-OECD Asia to phase out coal by 2037 and OECD countries, including Japan, by 2031 (Climate Analytics 2019). Regional 1.5°C compatible benchmarks indicate that non-OECD Asia needs to decrease coal generation by 63% compared to 2010 levels by 2030 (Climate Analytics 2019).

While gas represents a significantly lower share than coal in 2017, recent analysis suggests that for the Asian-Pacific region it will play a marginal role in 2030 with renewables energy uptake of around 74%.

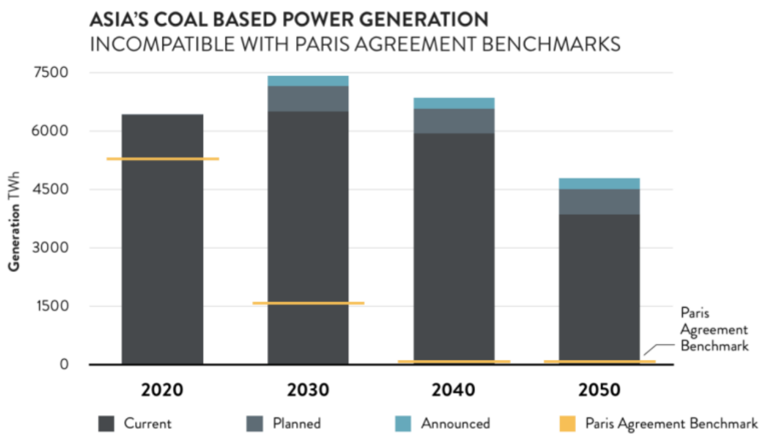

Figure 4: Planned coal expansion in non-OECD Asia against Paris Agreement compatible benchmarks. Source:(Climate Analytics 2019)

3.2 Indonesia's domestic transition pathways:

3.2.1 National Context and current targets

Indonesia is developing economically and seeing a concomitant rise in energy demand. The high and slowly increasing carbon intensity of this energy demand has led to more than doubling its energy related emissions between 1990 and 2017, which are expected to continue to rise until 2030 under current policies (Climate Action Tracker 2020b; Climate Transparency 2020a).

Within the energy sector the largest share of emissions comes from the rapidly growing electricity supply. This sector has seen emissions increase almost ten-fold from 1990 to 2017 and is now responsible for around a third of all energy related emissions. Indonesian power is highly carbon-intensive and set to become more so, with coal dominating (60%) and new coal power additions far outpacing renewables.

The second largest sector is transport, responsible for around a quarter of energy-related emissions and also displaying strong growth.

Indonesia is one of the few countries in the world for which energy related emissions, and their growth, are matched by emissions in the LULUCF sector. In the total greenhouse gas balance, energy and LULUCF each contribute around 40% of the total. Deforestation, peat degradation and peat fires have contributed to a three-fold increase in emissions from this sector and Indonesia now leads the world in LULUCF emissions.

In addition to energy and LULUCF, waste and agriculture are responsible for generating a significant amount of greenhouse gases – around 10% each, making up roughly a third of all GHG emissions (when including LULUCF). Of these two, the waste sector has seen emissions jump by a factor of 20 in the last three decades, the largest increase of any sector in Indonesia.

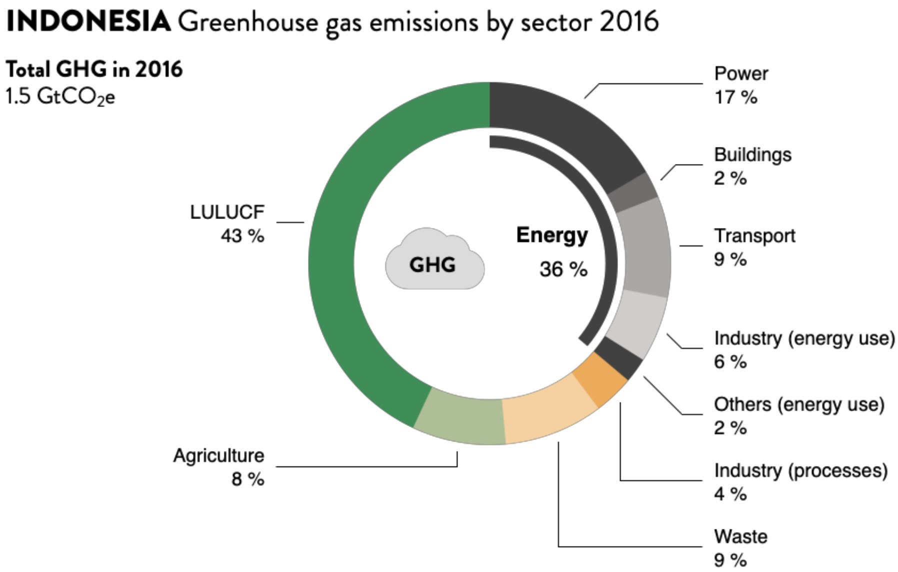

Figure 4: Historical emissions by sector. Sources: (Climate Action Tracker 2020b; Gütschow et al. 2019)

Indonesia's economy is fossil fuel intensive; coal, oil and natural gas supply three quarters of primary energy. Indonesia has significant indigenous coal resources and is the world's fifth largest producer of coal. Together with palm oil, which has historically been a major driver of deforestation, coal is

Indonesia's biggest export product ((OEC) 2019). The use of coal is also encouraged domestically with subsidies on coal (and oil) use and a cap on the price of coal.

The focus on coal as foundation for the country's growing power system is set to continue given current government expansion plans: Indonesia operates 33 GW of coal-fired power plants and plans to double this capacity in the next decade. Coal has already doubled its share of the power sector between 1990 and 2017, from ~30% to ~60%.

Meanwhile, Indonesia's vast renewable electricity energy potential remains largely untapped. Government plans to reach renewable power capacity of over 15 GW by 2019 were not reached but renewables support has recently been strengthened in response, with improvements to feed-in tariffs, net metering rules and easing the administrative process for rooftop solar installations. However, these policies are not expected to bring Indonesia closer to meeting its renewables targets as renewables cannot compete with highly subsidised coal.

Indonesia also has a target to increase the share of biofuels in all fuels across all sectors by 30% by 2025. Given the historical connection between biofuel production from palm oil plantations and deforestation, it is unclear whether this would drive real emission reductions in the country. Another decarbonisation effort comes from the 2017 Electric Vehicles Development Plan, driven by concerns about air pollution. The plan projected 3 million electric or hybrid two-wheelers and cars on Indonesia's roads by 2025 but it is unclear whether existing incentives will achieve these objectives. Indonesia is also strengthening public mass transit systems which would enable the shift from private to public transport (Climate Action Tracker 2019, 2020b).

3.2.2 Emissions Pathways and adequacy of domestic targets

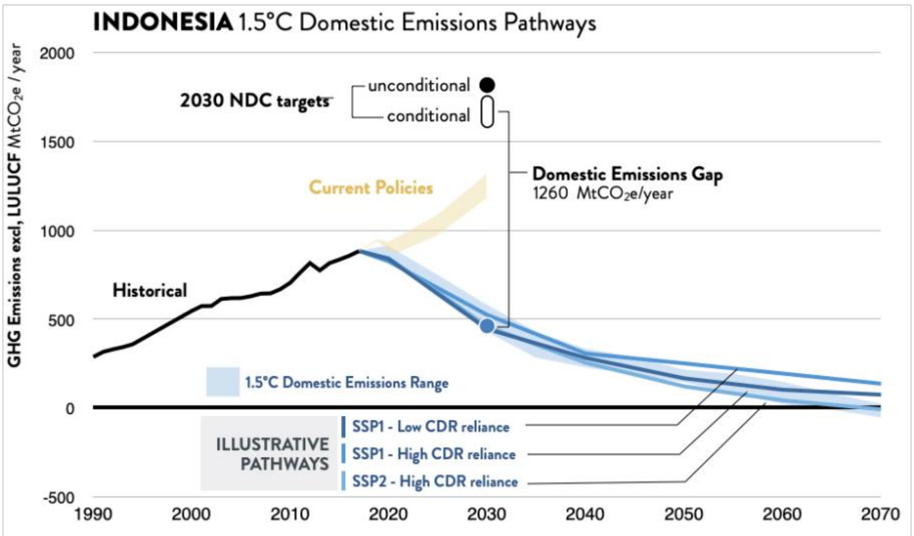

Figure 5: The figure shows national 1.5°C compatible pathways. This is presented through a set of illustrative pathways (blue lines) as well as a 1.5°C compatible range (blue shaded area) for total greenhouse gases (GHG) emissions, excluding LULUCF. The 1.5°C compatible range is based on the full range of resulting Paris Agreement compatible Pathways from the IPCC SR1.5 filtered with sustainability criteria and are represented here the median (higher bound) to 5th percentile (lower bound) and middle of the range which defines the benchmarks. Values are rounded. NDC and Current policy projections are provided by the Climate Action Tracker, Update 2020.

Indonesia's climate commitment under the Paris Agreement (NDC) sets an unconditional emissions target below a baseline for 2030. This target would result in GHG emissions excluding land-use, land-use change and forestry (LULUCF) increasing 118% above 2015 levels by 2030.

Indonesia NDC would allow emissions far above those that would result from its current policy projections with these emissions lying far above the "fair share" range for Indonesia assessed by the Climate Action Tracker (Climate Action Tracker 2019, 2020b). Indonesia is responsible for bringing its domestic emissions to the "fair share" level.

Paris Agreement compatible pathways for Indonesia require domestic GHG emissions, excluding LULUCF, to peak and decline immediately, and reach 30-48% reductions below 2015 by 2030. The total gap between Indonesia's NDC and Paris Agreement compatible domestic pathways is close to 1.3GtCO_2e.

The gap between the NDC level (and its current policy) and the "fair share" level needs to be closed domestically, and the remainder of the gap, from "fair share" level to **Paris Agreement compatible pathway closed** with and through international support.

Under the Paris Agreement's enabling decisions Indonesia would have been expected to strengthen its target in its updated NDC during the 2020/21 submission round. Instead, Indonesia has indicated its intention to stick with the existing target, which it is expected to easily achieve without any additional policy effort.

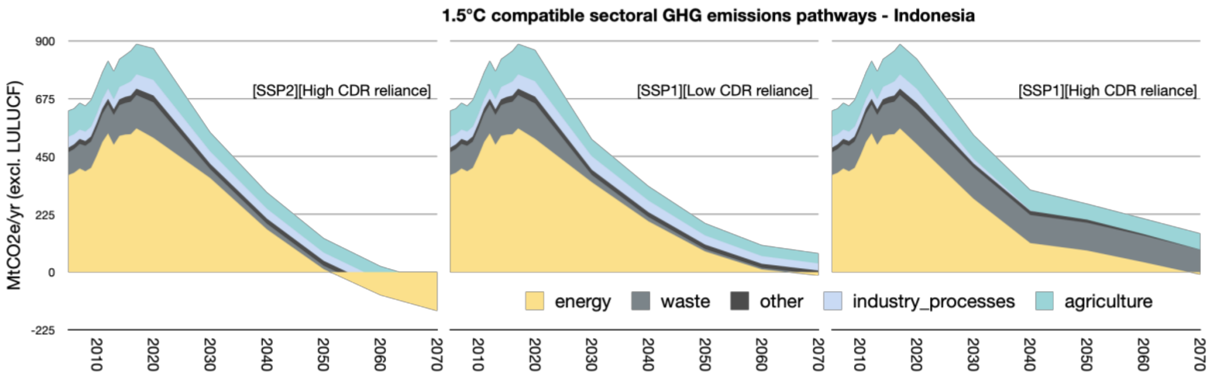

Figure 6: 1.5°C compatible pathways, GHG emissions excluding LULUCF.

Indonesia has not yet published a long-term strategy or mid-century emissions target. In a Paris Agreement compatible emissions pathway, Indonesia would reach net zero GHG emissions excluding LULUCF by around 2070, and net zero CO_2 by around 2055. The power sector would be the first sector to reach net zero CO_2 from around 2035.

By 2050, GHG emissions excluding LULUCF would have reduced to 150-215 Mt$CO_{2e/yr}$, from 835 Mt$CO_{2e/yr}$ in 2015, driven primarily through emissions reductions in the energy sector, but also in waste and agriculture.

In these model pathways the power sector would need to be contributing negative emissions of up to -40 MtCO_2 at this point, to balance remaining emissions from other energy sectors as well as waste and agriculture, while renewables would provide all of Indonesia's electricity.

Avoiding the need for negative emissions at this scale would need faster decarbonisation in the other energy-using sectors. In addition, reaching larger shares of renewables earlier would reduce Indonesia's reliance on negative emissions technologies in the second half of the century under a 1.5°C domestic emissions pathway. The land use sector is important in Indonesia, and emissions from

LULUCF could be brought to zero by around 2030 and become an emission sink thereafter. These negative emissions could lead to net zero GHG including LULUCF being achieved from around 2040 (Climate Action Tracker 2019).

3.2.3 Decarbonising the power sector and policy implications

Indonesia's emissions have been increasing rapidly since 2015 due to two developments: emissions in the land-use and forestry sector due to deforestation and peat land degradation, and largely unmitigated energy sector emissions growth due to high and increasing emissions intensity, especially in the power and transport sectors, along with economic growth.
Coal dominates the power sector and will continue to do so given the government's expansion plans and ongoing subsidies. Meanwhile, even modest targets for renewables build-out have been missed.

To bring Indonesia's emissions in line with Paris Agreement compatible pathways, the share of renewables in the power sector, as the most viable and beneficial zero carbon technologies, would need to increase from 13% to up to around 74% by 2030, requiring roughly a fourteen-fold increase in generation. Higher shares of renewable energy would avoid reliance on negative emissions technologies starting in the 2020s. Reaching this renewables deployment level means that Indonesia would avoid having to introduce nuclear power or fossil fuel-based generation with CCS as assumed in some models. Indonesia does not have nuclear power today and is not expected to given the costs and risks. Fossil fuels with CCS are not expected to become commercially viable in the power sector anywhere globally.

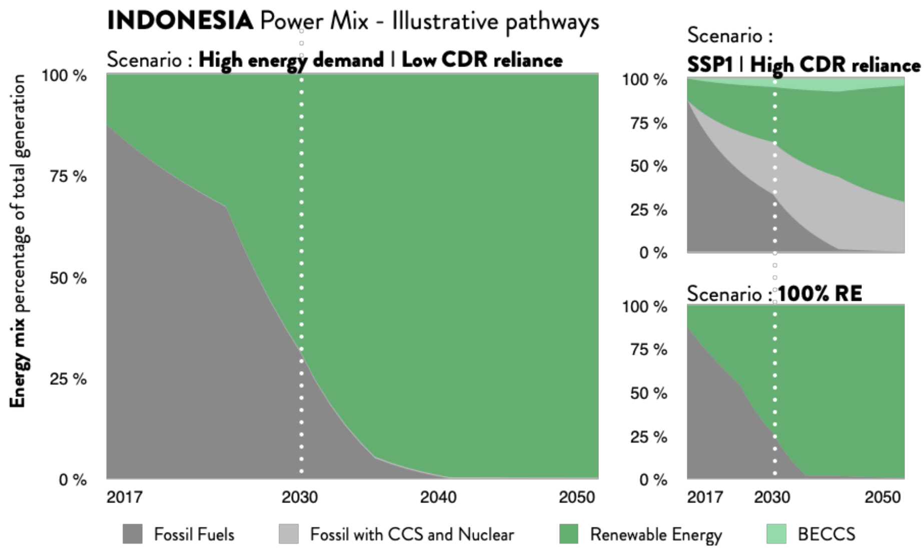

Figure 7: Share of technologies in the power mix consistent with 1.5°C compatible emissions pathways.[1]

Carbon neutrality (i.e. CO_2 net zero) in the power sector is achieved in Paris Agreement compatible pathways for Indonesia from as early as 2035 through a complete phase out of unabated coal by 2030 and a near complete phase out of unabated gas by 2035. Gas use in power without CCS peaks in 2030 in all marker pathways and sees declines thereafter with complete phase-out reached in almost all analysed pathways by 2050. Unabated oil is phased out between 2025 and 2040 in most pathways.

3.2.4 Key characteristics on Indonesia's 1.5°C compatible pathways

[1] A selection of illustrative pathways is presented here. Please refer to pathways http://1p5ndc-pathways.climateanalytics.org/ for further illustrative pathways power mix.

	Unit	Historic		1.5°C compatible benchmarks			Net zero years	Country targets	
		2015	2017	2030	2040	2050		2020	2030
Total GHG (excl. LULUCF)	$MtCO_{2e/yr}$	835	883	461 (434 / 581)	266 (234 / 334)	191 (150 / 215)	2070 (2065/2075)	-	1723 to 1817
	% (below 2015)		-	−45% (−48% / −30%)	−68% (−72% / −60%)	−77% (−82% / −74%)		-	+106% to +118%
Total CO2 (excl. LULUCF)	$MtCO_{2e/yr}$	557	591	307 (278 / 361)	154 (47 / 175)	30 (11 / 46)	2055 (2050/2060)		-
	% (below 2015)		-	−45% (−50% / −35%)	−72% (−91% / −69%)	−95% (−98% / −92%)			-
Power Emissions intensity	gCO2e/kWh		770	110–270	-70 to –80	-40 to 10	2035 (2035/2055)	-	-
Share of renewable power	%		13	54–74	90–98	99 –100	-	23%	-
Share of unabated fossil fuel in power	%		87	26–33	1–2	0–0	2030-2035	-	-

3.3 Viet Nam's domestic transition pathways:

3.3.1 National Circumstances

The main emitting sector is energy, including transport and other end use sectors, comprising 55% of emissions (excluding LULUCF). The energy sector has grown by 73% over the past decade. Industry, which has grown 129% over the past decade, is responsible for 11% of total emissions (excluding LULUCF). Industrial process emissions come mainly from cement production, followed by steel and ammonia production (MNRE 2019). These emissions are harder-to-abate but to peak emissions by 2020 and decline following a Paris Agreement compatible pathway, industry and energy are key sectors to focus decarbonisation efforts in Viet Nam.

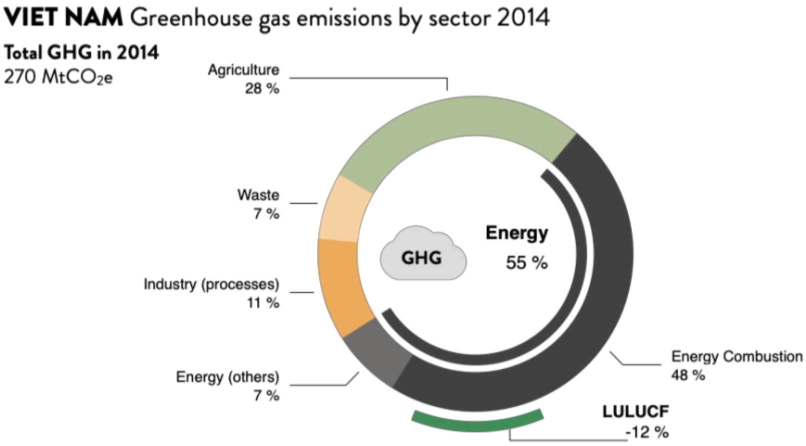

Figure 8: Historical emissions by sector. Sources: (Climate Action Tracker 2020i; Gütschow et al. 2019)

Viet Nam's energy sector is dominated by fossil fuels, which contribute more than half of its emissions. Economic growth and universal electrification have led to a rising energy demand, which is being met by an overreliance on fossil fuels, in particular coal (Chapman et al. 2019). Viet Nam became a net energy importer in 2014 (IEA 2020a). Net energy imports incur risks to energy security, whereas Viet

Nam has large untapped potential for renewable energy, especially solar and offshore wind resources (Chapman et al. 2019).

3.3.2 Emissions pathways and adequacy of domestic targets

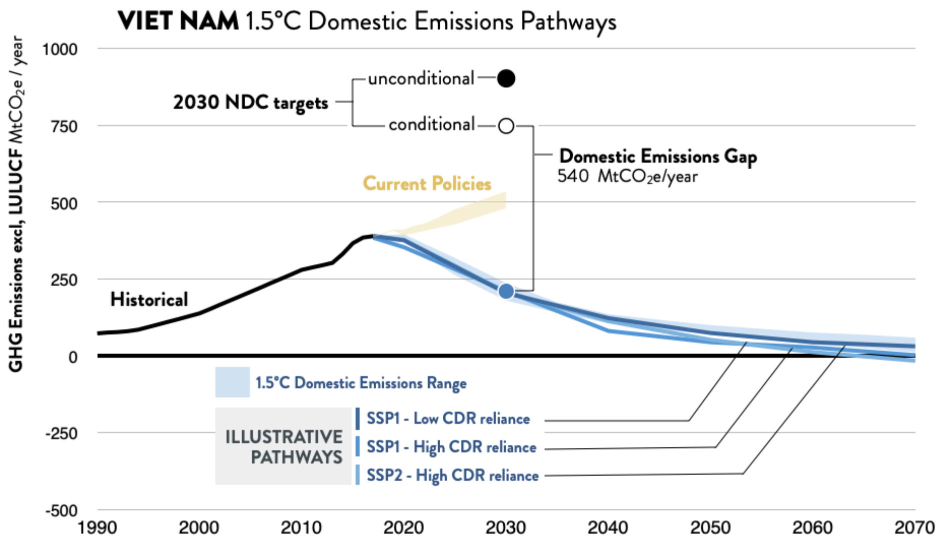

Figure 9: The figure shows national 1.5ºC compatible pathways. This is presented through a set of illustrative pathways (blue lines) as well as a 1.5°C compatible range (blue shaded area) for total greenhouse gases (GHG) emissions, excluding LULUCF. The 1.5°C compatible range is based on the full range of resulting Paris Agreement compatible Pathways from the IPCC SR1.5 filtered with sustainability criteria and are represented here the median (higher bound) to 5th percentile (lower bound) and middle of the range which defines the benchmarks. NDC and Current policy projections are provided by the Climate Action Tracker, Update 2020.

Viet Nam updated its NDC in September 2020, unconditionally pledging a 9% reduction in greenhouse gas (GHG) emissions below business-as-usual (BAU) levels by 2030. The NDC is equivalent to 903 $MtCO_{2e/yr}$, a 146% increase on 2015 emission levels.

Viet Nam also has a conditional target, 27% below BAU by 2030 with international support, equivalent to 748 $MtCO_{2e/yr}$ excluding LULUCF, an increase by 104% on 2015 by 2030.

Under current policies, Viet Nam is on track to overachieve its weak NDC by a wide margin and would result in a substantial increase in emissions, lying far above the 'fair share' level as assessed by the Climate Action Tracker (Climate Action Tracker 2020i).

The Paris Agreement 1.5°C compatible pathway is 35-50% lower than 2015 levels, requiring a domestic reduction to 183-237 $MtCO_{2e/yr}$ by 2030. Viet Nam is responsible for closing the gap from the NDC level (and its current policy projections) to the 'fair share' level while the remainder of the gap, from the 'fair share' to the Paris Agreement compatible pathway would need to be achieved through international support.

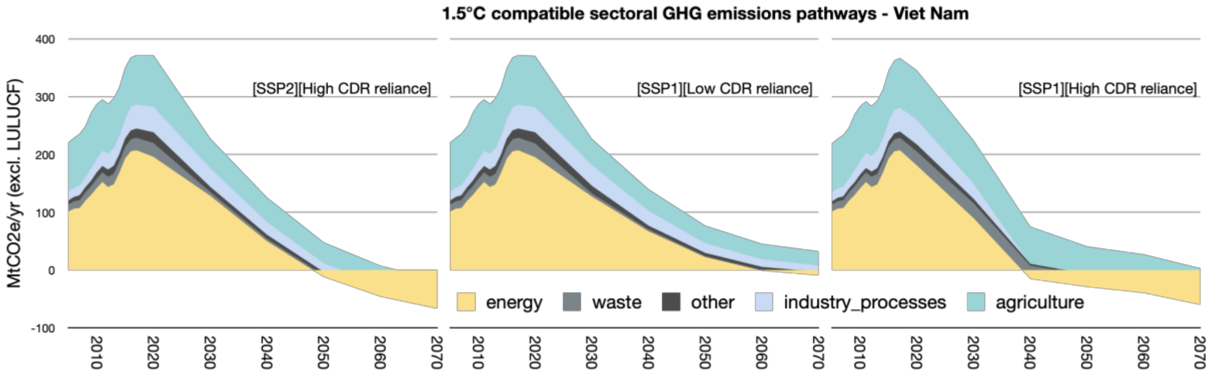

Figure 10: 1.5°C compatible GHG emissions pathways by sector.

Viet Nam does not have a net zero GHG target. The Paris Agreement compatible analysis suggests that Viet Nam could reach net zero GHGs by as early as 2080, and net zero CO_2 by 2060, excluding LULUCF. Viet Nam could reach net zero GHG and net zero CO2 even sooner when including LULUCF, and expanding on the current LULUCF sink.

The pathways analysed show that the energy sector will require the largest share of emissions reductions, as this sector is responsible for most emissions at present. In all pathways, emissions in the agriculture and waste sectors will decline but they will not be eliminated. Carbon dioxide removal (CDR) technologies will be required to balance emissions to reach net zero GHGs (IEA 2020a).

3.3.3 Decarbonising the power sector and policy implications

To be Paris Agreement consistent, **Viet Nam would need to reduce GHG emissions by about 35-50% below 2015 levels by 2030**. Meeting this pathway would require accelerated decarbonisation efforts as the current policy pathway is far from Paris Agreement compatible. In 2014, the energy sector was responsible for the largest share (55%) of emissions, followed by agriculture (28%), industrial processes (11%) and waste (7%) (excluding LULUCF).

Paris Agreement compatible analysis indicates that unabated fossil fuels can be reduced to 34% by 2030 and to 9% by 2050, compared to 72% in 2017 in the primary energy supply. Renewable energy can be ramped up from 28% in 2017 to 66% in 2030 and 91% - 100% in 2050.(Climate Action Tracker 2020i)

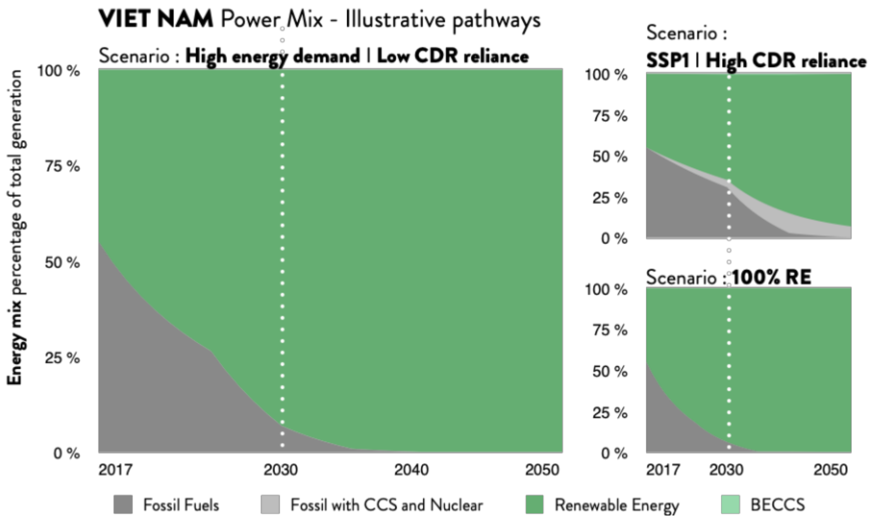

Figure 11: Power mix per technology consistent with 1.5°C compatible emissions pathways presented in figure 1. The shaded area represents the different scenarios analysed here.

Viet Nam can **reduce the carbon intensity of its power sector by 91% by 2030, and by 100% by 2040, and reach 95% share of renewables in 2030 and 100% in 2040.** Paris Agreement compatibility would require phasing out **coal and gas from the power sector by 2030 - 2035.** Despite draft plans to cancel some coal fired power generation, Viet Nam has a vast coal project pipeline. It is also on a trajectory to ramping up natural gas, which would lock in a carbon intensive energy system and risk expensive stranded assets. There are only a few transport policies aimed at reducing emissions.

Viet Nam would need to implement further policies to reduce emissions from the transport sector, to reduce dependence on oil, and transition to electric vehicles as well as support a modal switch to low or zero emissions transport. The industry sector requires substantial decarbonisation efforts as emissions have increased 129% over the past decade.

3.3.4 Key characteristics on Viet Nam's 1.5°C compatible pathways

	Unit	Historic	1.5°C compatible benchmarks			Net zero years	Country targets	
		2017	2030	2040	2050		2020	2030
Total GHG (excl. LULUCF)	MtCO2e/yr	389	210 (183 / 237)	129 (110 / 136)	82 (74 / 100)	2085 (2080 /2095)	-	748 to 903
	% (below 2015)	6%	−43% (−50% / −35%)	−65% (−70% / −63%)	−78% (−80% / −73%)		-	+114% to +158%
Total CO2 (excl. LULUCF)	MtCO2e/yr	235	112 (106 / 135)	54 (21 / 65)	13 (7 / 19)	2060 (2055 /2065)	-	-
	% (below 2015)	9%	−48% (−51% / −38%)	−75% (−90% / −70%)	−94% (−97% / −91%)		-	-
Power Emissions intensity	gCO2e/kWh	360	40 - 220	0 - 20	0	(2035 /2050)	-	-
Share of renewable power	%	45	94-95	100	100	-	7	10
Share of unabated fossil fuel in power	%	55	5-6	0	0	(2029 /2034)	-	-

3.4 Philippines’[2] domestic transition pathway

3.4.1 National Circumstances

The Philippines has ramped up coal in the power supply, which it needs to import, and has a strong dependence on oil imports for its growing transport sector. More than half of the total primary energy supply is imported coal and oil, posing risks to energy security (Department of Energy 2020b). Net energy imports have increased 121% over the past decade (IEA 2020b).

Energy, the key emitting sector, accounted for nearly 60% of emissions in 2017. Renewable energy plays a role in the current energy mix, representing 25% of the power supply and 32% of primary energy in 2017. Agriculture is the second largest contributor to emissions at 27%, waste represents 9% of emissions and industry 5%.

The Philippines’ current NDC is a 70% reduction in GHG emissions below business-as-usual projections by 2030, or 43-49% below 2015 emission levels, conditional on financial, technological and capacity building support. The Philippines is currently revising its NDC and has no long-term target. The Philippines has a 100% electrification target for 2022 (for targeted households based on 2015 census) (Department of Energy 2020c). There is also a target for 24% energy savings across all sectors by 2040 (Republic of the Philippines 2017).

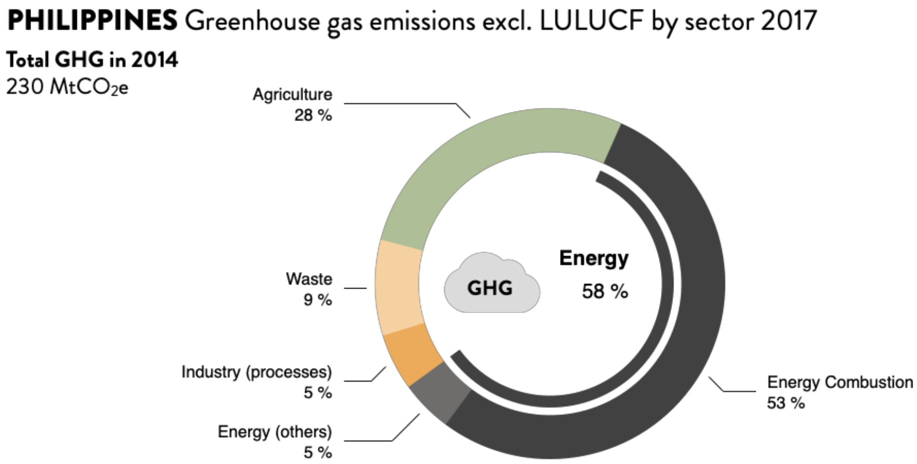

Figure 12: Historical emissions by sector. Sources: (Climate Action Tracker 2020f; Gütschow et al. 2019)

Fossil fuels accounted for 68% of the primary energy mix in 2017, with the power and transport sectors taking largest shares.

The Philippines has seen some renewable energy developments, but this is outweighed by coal and gas plans. Renewables can increase energy security by reducing import dependence and decarbonising the power and transport sectors. The National Renewable Energy Program (NREP) aims to triple renewable energy capacity level from 4.8 GW in 2010 to 15.3 GW by 2030 (Department of Energy of the Philippines 2011). The NREP was updated with a target for 20 GW of renewables by 2040, whereas the new draft NREP (2020 to 2040) scales up ambition for the installed renewables capacity to reach 30 GW by 2040 (Department of Energy 2020c). The Philippines is undergoing a number of electricity market reforms allowing for a competitive power market favouring renewable energy, including the Green Energy Option, renewable auctions, the Renewable Portfolio Standard, and a carveout clause for utilities to curtail coal generation (Climate Action Tracker 2020g).

[2] Philippines submitted an updated NDC on April 15th, 2021 after the finalisation of this analysis.

The Philippines is highly dependent on coal, and the announcement of the coal moratorium indicates a political shift. The moratorium places up to 10 GW of the coal pipeline under a question mark (Ahmed and Brown 2020; Department of Energy 2020a). Projects covered under the moratorium are unclear, but it is likely to generate policy spill-over effects leading to the acceleration of renewables (Climate Action Tracker 2020g). It needs to be complemented with a plan to phase out existing capacity by 2040.

The Department of Energy (DOE) has approved four LNG regasification terminal projects for 2022 to 2025 worth PHP 64,632 million, with more investment expected in future (Department of Energy 2020c). The recent expansion plans for LNG terminals will continue import dependence, and lock in fossil fuels in the energy mix or risk expensive stranded assets.

Given the dependence on oil, the Philippines lacks targets and policies for the transport sector. The transport sector is dominated by fossil fuels and there are no policies to electrify this sector, nor plans to phase out heavy duty vehicles or to support a modal shift in transport (Climate Transparency 2020b). This is a missed opportunity for decarbonisation, electrification, flexible grid management, and energy security (if powered by renewables).

3.4.2 Emissions Pathways and adequacy of domestic targets

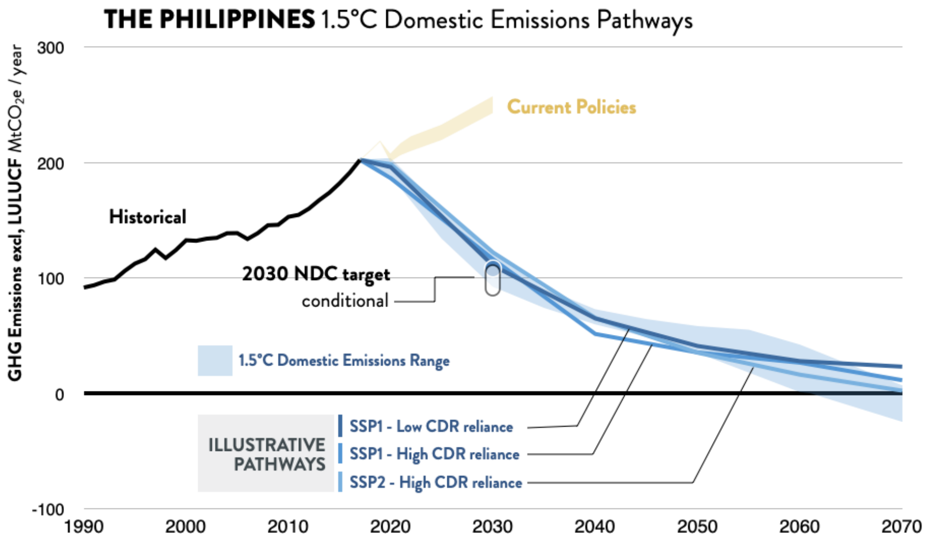

Figure 13: The figure shows national 1.5°C compatible pathways. This is presented through a set of illustrative pathways (blue lines) as well as a 1.5°C compatible range (blue shaded area) for total greenhouse gases (GHG) emissions, excluding LULUCF. The 1.5°C compatible range is based on the full range of resulting Paris Agreement compatible Pathways from the IPCC SR1.5 filtered with sustainability criteria and are represented here the median (higher bound) to 5th percentile (lower bound) and middle of the range which defines the benchmarks. Values are rounded. NDC and Current policy projections are provided by the Climate Action Tracker, Update 2020.[3]

The Philippines is in the process of updating its climate commitment under the Paris Agreement (NDC). The current NDC is a 70% reduction in GHG emissions below business-as-usual (BAU) projections by 2030, conditional on international support. The current NDC translates[4], in a reduction of 92-104

[3] Philippines submitted an updated NDC on April 15th, 2021 after the finalisation of this analysis.
[4] The NDC does not provide a business-as-usual (BAU) pathway. Our analysis calculates the BAU based on emissions data from the Climate Action Tracker's current policy emissions pathway (excluding LULUCF), published in the 2015 assessment, harmonised with the latest PRIMAP historical data from 2010.

$MtCO_{2e/yr}$ by 2030, which translates to 43-49% below 2015 levels (excluding LULUCF) (Climate Action Tracker 2020f; Gütschow et al. 2019).

Modelling indicates that Philippines' current NDC is consistent with Paris Agreement compatible pathways. However, current policy projections show the Philippines is not on track to meet its NDC, with emissions expected to increase by 34-41% above 2015 levels and lies above the 'fair share' assessed by the Climate Action Tracker (Climate Action Tracker 2020f; Gütschow et al. 2019).

The Philippines is responsible to close the gap between the current policy projections and the 'fair share' level, while the remainder of the gap, from 'fair share' level to Paris Agreement compatible pathway will be closed with and through international support.

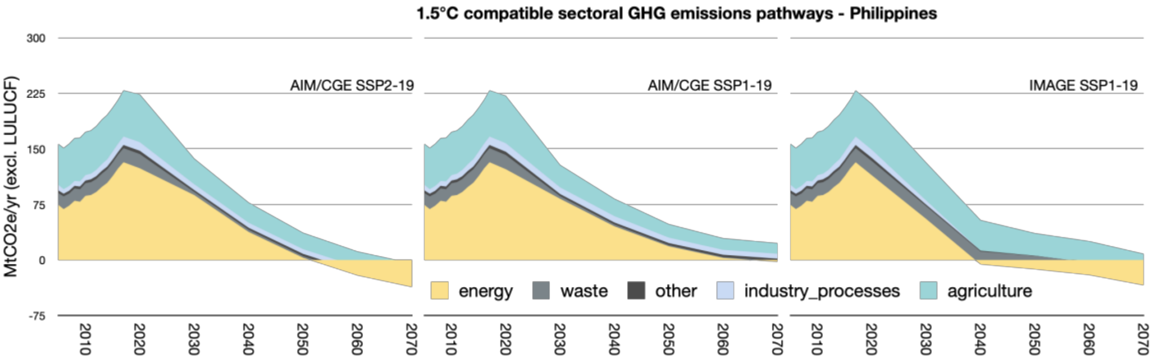

Figure 14: 1.5°C compatible GHG emissions pathways by sector.

The Philippines does not have a net zero greenhouse gases (GHGs) target, although our analysis indicates that net zero GHGs excluding LULUCF is possible by around 2055 in line with Paris Agreement compatible pathways. Net zero CO_2, excluding LULUCF, is possible by around 2040. Including LULUCF can move this forward, depending on the size of the sink that would be achieved.

Across all pathways, emissions reductions will largely be driven by the energy sector, as this sector contributes the largest share of emissions. By 2050, there is a potential to decrease fossil fuels to 10% and increase renewables to 90% in primary energy. 100% renewable energy electricity generation can be achieved by 2050. Considering the declining prices of renewable and the unfeasibility of CCS at present, plans or investment in fossil fuels relying on CCS to reduce emissions would place the Philippines in danger of increasing stranded assets. A high renewable energy pathway will prove more feasible and provide more benefits for sustainable development.

Negative emissions approaches, such as CDR, may play a role in bringing emissions to net zero. However, LULUCF emissions remains highly uncertain. CDR can balance out the remaining emissions from other sectors, particularly agriculture, which is expected to take the largest share of emissions in all scenarios from 2050. Favouring climate friendly agricultural methods will reduce the need for CDR.

3.4.3 Decarbonising the power sector and policy implications

A Paris Agreement consistent pathway requires about a 41% reduction below 2015 emission levels by 2030. Modelling indicates rapid decarbonisation of the energy sector is crucial to align the current policy pathway with 1.5°C pathway. The energy sector was responsible for 58% of emissions in 2017. Coal utilisation in power generation, and oil in the transport sector have been large contributors to the Philippines' GHG emissions. (Department of Energy 2020c)

Our analysis suggests fossil fuels in the primary energy mix can be reduced from 68% in 2017 to 58% by 2030, and renewables increased by up to 54%. Renewables can make up to 85% of the power mix by 2030. The Philippines could reduce the carbon intensity in the power sector by 84% by 2030 compared to 2017 levels. A potential for high penetration of renewables indicates that nuclear energy need not play a role in decarbonisation. The Philippines' nuclear energy program roadmap places huge unnecessary risk of catastrophic damage to a country prone to earthquakes.

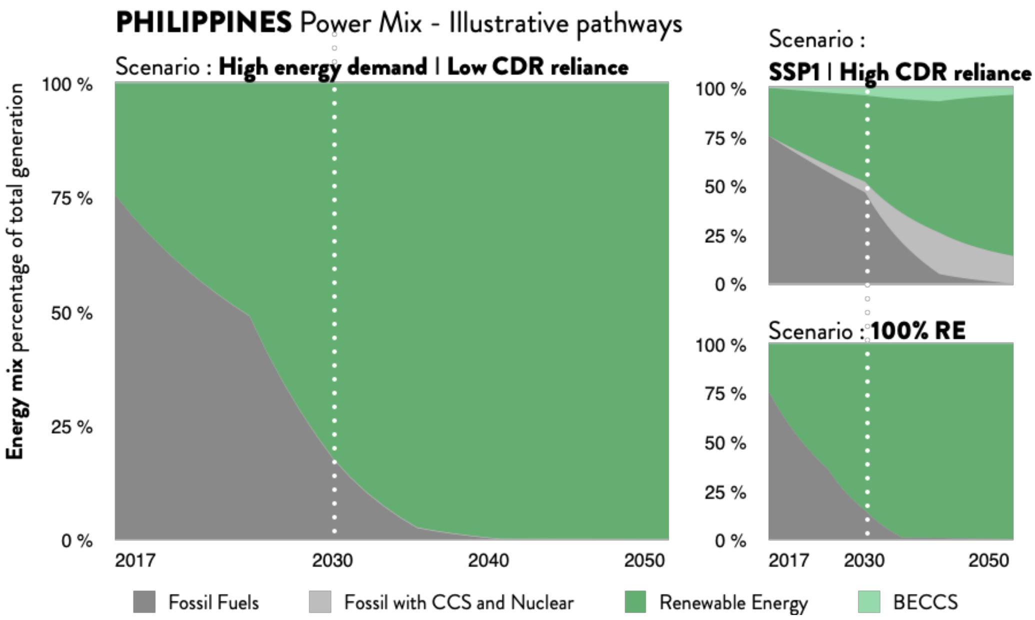

Figure 15: Power mix per technology consistent with 1.5°C compatible emissions pathways presented in figure 1. The shaded area represents the different scenarios analysed here.

The electricity and transport sectors have the potential to play a major role in decarbonising the country's economy, given the dominant role of coal and oil. The Energy Secretary has announced a coal moratorium, which could halt emissions growth and curb emissions by up to 9% below 2015 levels (Climate Action Tracker 2020g). The Philippines has an opportunity to accelerate the transition to renewables by integrating the coal moratorium into policy, and applying it to all new coal fired power plants in the pipeline, as well as developing a plan to phase out coal before 2040 for existing capacity. The move to reverse energy auctions in 2021 will speed up the deployment of renewables. However, the expansion of gas infrastructure is a barrier to low emissions power, and does not set the country on course for energy independence while also risking expensive stranded assets (Ahmed 2020; Climate Action Tracker 2020g).

3.4.4 *Key characteristics of 1.5°C compatible trajectories*

	Unit	Historic	1.5°C compatible benchmarks			Net zero years	Country targets	
		2017	2030	2040	2050		2020	2030
Total GHG (excl. LULUCF)	$MtCO_{2e/yr}$	202	108 (93 / 122)	66 (60 / 73)	51 (36 / 58)	2070 (2060 / 2075)	-	748 to 903
	% (below 2015)	-	−41% (−49% / −33%)	−64% (−67% / −60%)	−72% (−80% / −68%)		-	+114% to +158%
Total CO2 (excl. LULUCF)	$MtCO_{2e/yr}$	118	56 (50 / 64)	24 (9 / 30)	3 (0 / 7)	2050 (2050 / 2055)	-	-
	% (below 2015)	-	−45% (−51% / −38%)	−76% (−92% / −71%)	−97% (−100% / −93%)		-	-
Power Emissions intensity	gCO2e/kWh	670	100 (100 / 310)	−40 (−40 / 40)	−40 (−40 / 0)	2040 (2040 / 2050)	-	-
Share of renewable power	%	25	72 / 85	96 / 99	100	-	-	-
Share of unabated fossil fuel in power	%	75	15 / 28	1 / 4	0	2034	-	-

3.5 India's domestic transition pathway:

3.5.1 *National Circumstances*

India is the second most populous country in the world and undergoing rapid development with GHG emissions tripling in the last three decades to reach 3 $GtCO_2e$. Three quarters of these emissions come from the combustion of fossil fuels in the energy sector, around 20% from agriculture, and the remainder from industrial process emissions and waste.

Within the energy sector, electricity generation and industry are responsible for around 45% and 30% of emissions respectively, and transport for ~15%. The remaining ~10% are generated mostly in buildings (6%), agriculture (3%).

Per capita emissions had increased to 2 $tCO2_e$ by 2017, still far below the global average of over 6 $tCO2_e$/capita, but are growing at around 3–4% per year.(Climate Action Tracker 2017; Climate Transparency 2020a)

A small but slowly growing emissions sink (-0.3 $GtCO_2$) comes from LULUCF.

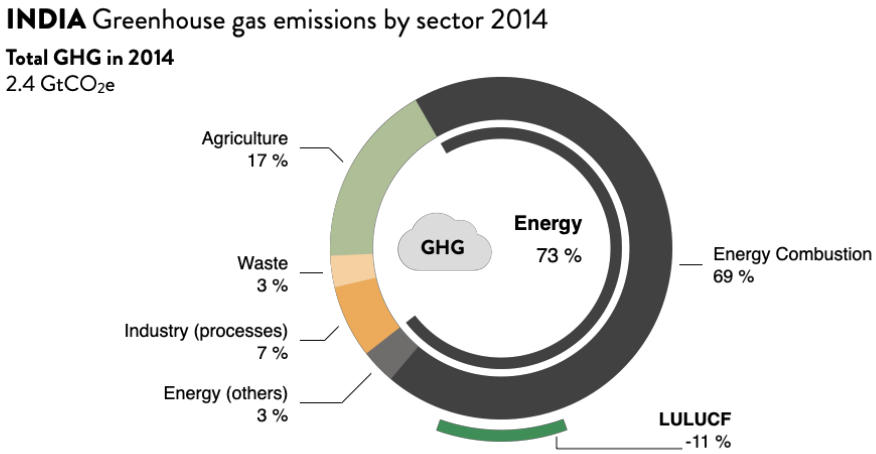

Figure 16: Historical emissions by sector. Sources: (Climate Action Tracker 2020a; Gütschow et al. 2019)

Combustion of coal dominates emissions in industry, power generation and the commercial and public services sectors, while oil is the main driver of emissions in transport, residential buildings and agriculture.
Refined petroleum is India's single largest export product. (Observatory of Economic Complexity 2019)

Because coal is more abundant than gas domestically, coal use has been prioritised. This includes (consumption) subsidies of around 10 billion USD, which hamper the transition to renewable energy. India has a total of 200 GW of coal power plants installed today and is planning to increase this by another ~100 GW in coming years.

Renewable capacity is to increase from the current ~90 GW to 175 GW by 2022 and 450 GW by 2030. A phasing out of fossil fuel subsidies and clear prioritisation for renewables paired with phase-out targets for unabated fossils before 2040 would open up a transition to a 1.5°C pathway for India.

On the demand side, India has an efficiency programme for industry which resulted in a modest 0.03 $GtCO_2e$ savings between 2012 and 2015.(Climate Action Tracker 2020a)

India downscaled its earlier vision of a fully electric car market to a 30% share of sales of electric vehicles by 2030. This would lock in a significant share of the estimated half a gigatonne of carbon dioxide emissions from transport until at least 2050 or longer if the share is not increased to 100% by 2035 in line with international benchmarks (Kuramochi et al. 2017). Indian rail transport, which accounts for less than 10% of India's transport emissions, is planned to be net zero by 2030, achieved through full electrification.

3.5.2 Emissions Pathways and adequacy of domestic targets

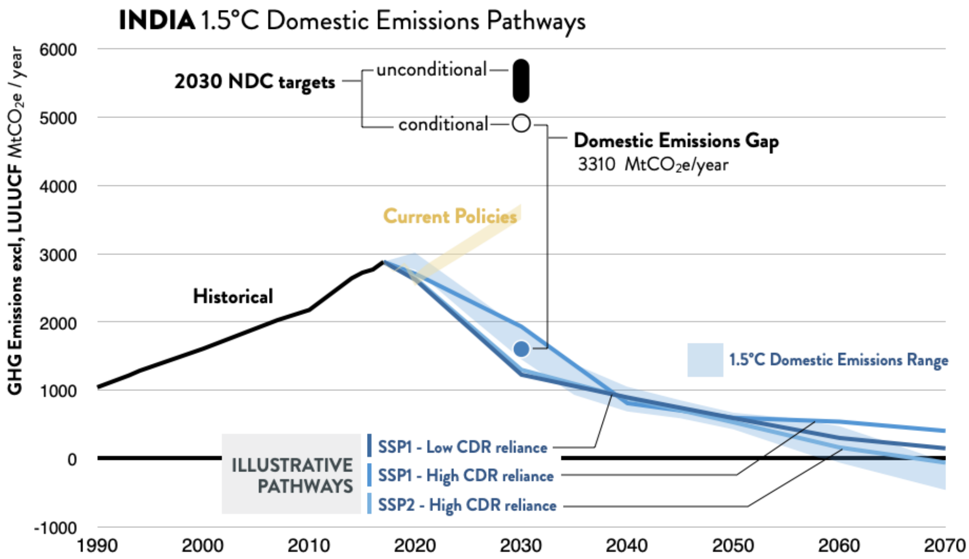

Figure 17: The figure shows national 1.5ºC compatible pathways. This is presented through a set of illustrative pathways (blue lines) as well as a 1.5°C compatible range (blue shaded area) for total greenhouse gases (GHG) emissions, excluding LULUCF. The 1.5°C compatible range is based on the full range of resulting Paris Agreement compatible Pathways from the IPCC SR1.5 filtered with sustainability criteria and are represented here the median (higher bound) to 5th percentile (lower bound) and middle of the range which defines the benchmarks. Values are rounded. NDC and Current policy projections are provided by the Climate Action Tracker, Update 2020.

Both India's conditional and unconditional NDC would result in emissions far above the current policy projections for India, and also lie above India's "fair share" range assessed by the Climate Action Tracker emissions (Climate Action Tracker 2020a).

India's NDC sets a GDP emissions intensity target of 33–35% below 2005 levels. This would result in an increase in GHG emissions excluding LULUCF of 180–200% above 2005 levels. By contrast, current policies, already taking into account the dip due to the pandemic, are expected to lead to an increase of emissions of around 100-110% above 2005 levels, substantially below the NDC target range.

India's NDC includes an additional target to reach a share of non-fossil capacity in the power sector of 40% by 2030, subject to international support. Achieving this target implies even lower total emissions than the intensity target but is expected to be achieved with current policies a decade earlier, with a share of non-fossil power generation capacity expected to reach 60–65% in 2030 (Climate Action Tracker 2020a).

India has not yet communicated an updated, more ambitious NDC, which was expected in 2020 under the Paris Agreement.

India's current policy projections lie above the fair share range for India calculated by the Climate Action Tracker, which means that both its NDC and its current level of action are not yet compatible with its fair share contribution to global efforts to reduce emissions (Climate Action Tracker 2020a).

For India's domestic emissions to be in line with the 1.5°C limit in the Paris Agreement, they would need to peak soon and reduce emissions as early as possible, aiming for a 2030 emissions level of 1.6 (range of 1.5–1.9) GtCO2e, equivalent to 16% below 2005 levels (range of 23% to 1% below 2005 levels). It needs to be emphasised that the gap between India's current policy projections and 1.5°C compatible domestic emission pathways for India can likely only be largely closed with support from developed countries.

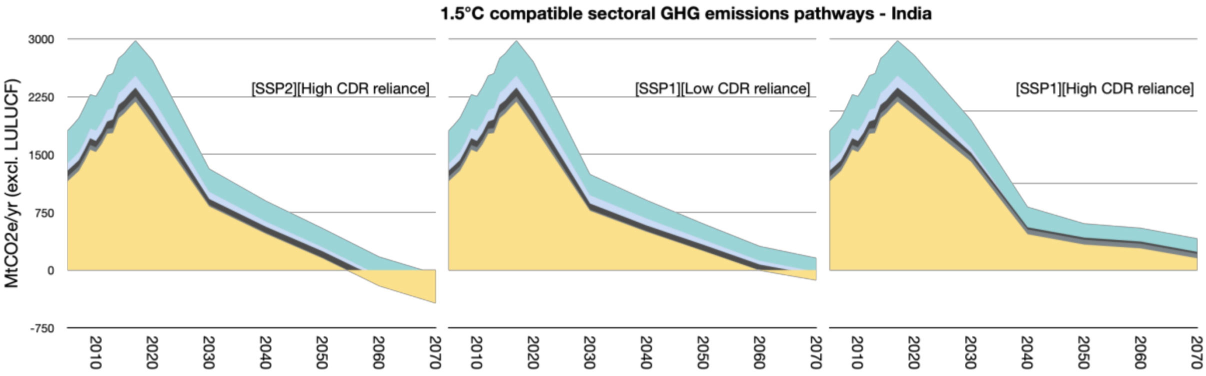

Figure 18: 1.5°C compatible GHG emissions pathways by sector.

Paris Agreement compatible pathways see India reaching net zero GHG emissions by 2065 and net zero CO_2 by 2055 (excluding LULUCF).

By 2050 GHG emissions excluding LULUCF would have to be reduced to 0.5–0.6 $GtCO_2e$ or ~70% below 2005 levels. The power sector would contribute up to 0.2 $GtCO_2$ negative emissions at this point, depending on the speed with which zero-carbon technologies can be adopted before 2050. Pathways with renewable electricity shares near 80% in 2030 achieve the required emissions reductions without negative emissions technologies.

3.5.3 Decarbonising the power sector and policy implications

Three quarters of India's primary energy come from fossil fuels and a similar share of all electricity is generated from coal, the most emission intensive fossil fuel. To bring emissions levels in line with 1.5°C compatible domestic pathways, India would need to draw down its unabated fossil fuel use both in power generation and other sectors along with scaling up renewable sources.

To bring emissions levels in line with 1.5°C compatible domestic pathways, India would need to transition to a fully renewable energy system by 2050, which would also avoid reliance on carbon capture and storage technologies. To reach this point primary energy from renewables would need to double by 2030 and renewable electricity generation would need to increase by a factor 2 to 8 and reach a share of 70–80% in 2030.

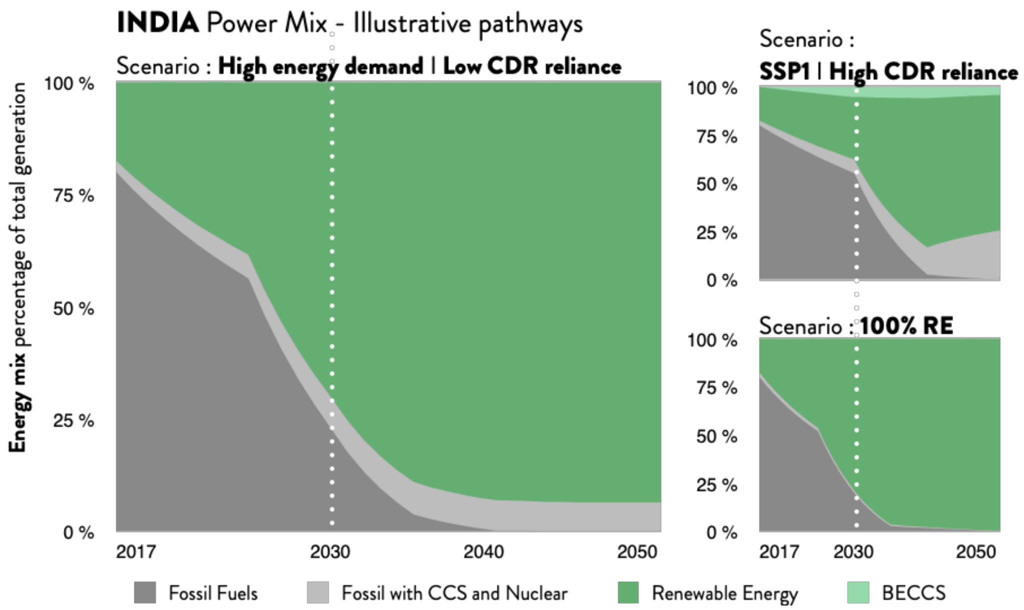

Figure 19: Power mix per technology consistent with 1.5°C compatible emissions pathways presented in figure 1. The shaded area represents the different scenarios analysed here.

Both coal and gas would need to be phased out before 2040, with a renewable share of 90–100% achieved by then. A clear prioritisation for renewables over coal and a phase out of fossil subsidies as well as a managed transition with a planned phase out fossil fuels from power generation would be essential elements of this transition.

3.5.4 Key characteristics of 1.5°C compatible trajectories

	Unit	Historic	1.5°C compatible benchmarks			Net zero years	Country targets	
		2017	2030	2040	2050		2019	2030
Total GHG (excl. LULUCF)	$MtCO_{2e/yr}$	2880	1602 (1470 / 1891)	914 (704 / 1050)	550 (442 / 670)	2065 (2060 / 2070)	-	
	% (below 2005)	51%	−16% (−23% / −1%)	−52% (−63% / −45%)	−71% (−77% / −65%)		-	
Total CO2 (excl. LULUCF)	$MtCO_{2e/yr}$	2222	1176 (1046 / 1368)	581 (162 / 681)	122 (23 / 177)	2055 (2050 / 2055)	-	-
	% (below 2005)	74%	−8% (−18% / 7%)	−54% (−87% / −47%)	−90% (−98% / −86%)		-	-
Power Emissions intensity	gCO2e/kWh	730	150 (150 / 330)	−50 (−50 / 50)	−60 (−60 / 0)	2040 (2040 / 2050)	-	-
Share of renewable power	%	18	69 / 79	89 / 98	87 / 100		8%	-
Share of unabated fossil fuel in power	%	80	20	2	0	2035 - 2036	-	-

3.6 Japan's domestic transition pathway:

3.6.1 National Circumstances

Japan's GHG emissions (excluding LULUCF) amounted to around 1.2 $GtCO_2e$ in 2018 and stem primarily from fuel combustion in the energy sector (~90%) with emissions from the power sector dominating (~50%), followed by industry and transport (~20% each), and buildings and industrial process emissions (~10% each). Much smaller shares come from agriculture and waste. Japan's land use and forestry sector contributes a small emissions sink of ~0.05 $GtCO_2e$. (Climate Action Tracker 2020d)

Japan's emissions were stagnant for decades with little change in energy demand and emissions intensity but started decreasing from 2013 by an average 2.5% per year, including 3.9% in 2018. This means Japan's per capita emissions decreased by an average of ~7% annually in the last five years, reaching just below 10 tCO_2e/cap in 2018, which is comparable to the EU average and about half the US average.(Climate Action Tracker 2017, 2020d)

Emissions from most sectors have been slowly decreasing, most notably industry, emissions from power grew by around a third over the last three decades. This was primarily due to an increase in coal power production following the 2011 Fukushima accident. However, emissions from power have also started decreasing since 2013, a trend buoyed by a burgeoning renewables sector and helped by the gradual re-introduction of nuclear power.

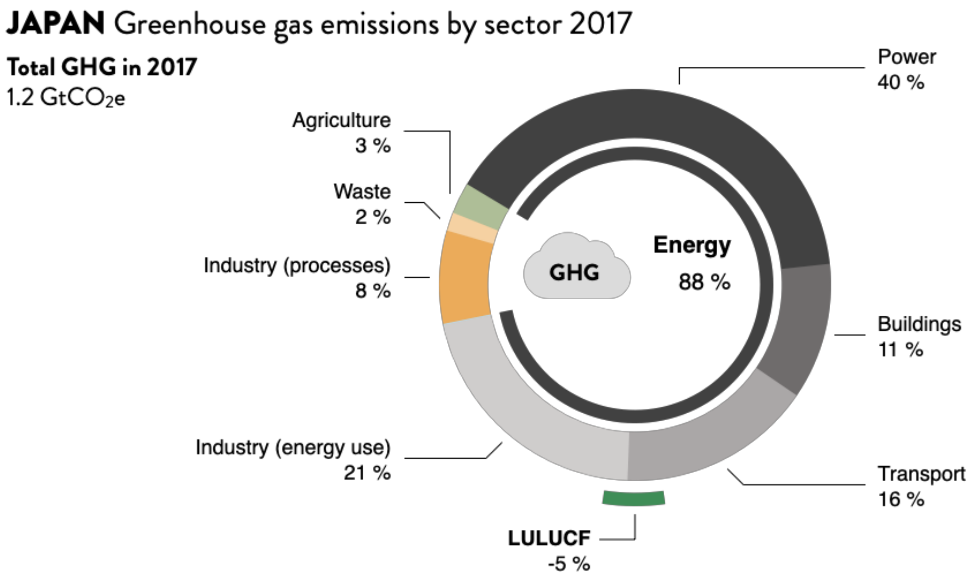

Figure 20 : Historical emissions by sector. Sources: (Climate Action Tracker 2020d; Gütschow et al. 2019)

Japan's economy is highly dependent on fossil fuels which accounted for around 90% of primary energy supply in 2019 with renewables at less than 10%. The largest contribution, around a third, is from oil, primary fuel in the transport sector, but also in power, industry and buildings. Coal and natural gas each contribute around a quarter across the power and industry sectors.

In the power sector, coal has steadily expanded, driven by the country's recent liberalisation of the power market without effective policies in place to reflect the external cost of fossil fuels: Japan's carbon price is set at 2–3 USD/tCO_2 making it difficult for low carbon sources to compete.(Parra et al. 2018; World Bank 2020) Although the government has announced plans to phase out inefficient coal plants, its energy strategy still sees coal providing a quarter of the country's power a decade from now.

Nuclear energy used to provide a quarter of the country's energy mix, but all plants were suspended after the 2011 Fukushima nuclear accident. They are now being brought back online slowly, but it is unclear whether the government's NDC target of ~ 20% will be achievable given public opinion.

Renewables have started to make inroads into Japan's electricity sector, primarily spurred by support for solar PV, one of the biggest potential renewable sources in Japan.(Deng et al. 2015) Of the total renewable share of ~19% in 2019, hydropower and solar PV accounted for about a third each, followed by biomass.(Climate Transparency 2020a; IEA 2020c) The NDC target of 22–24% renewable share is set to be (over) achieved without additional effort and recent regulatory improvements should speed up adoption of solar energy.(Climate Action Tracker 2017) Japan is also formulating a plan to develop its largely untapped offshore wind potential.(Climate Action Tracker 2020d; Deng et al. 2015)

Cars are Japan's second largest export after nuclear technology and Japan is in the process of setting emission reduction targets for new vehicles of up to 90% by 2050.

Japan has no binding targets or emission reduction policies for the industry sector, relying on voluntary commitments instead. Nevertheless, industrial emissions have seen the largest decreases, dropping by a third in the last three decades, due to a combination of reduced activity and reduced emissions per output. The strongest reductions have come from the cement sector.

3.6.2 Emissions Pathways and adequacy of domestic targets

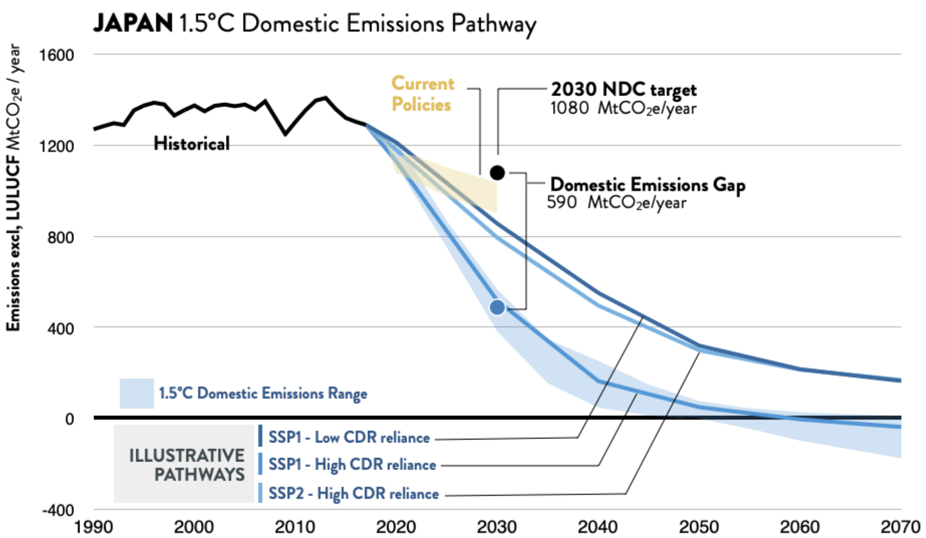

Figure 21: The figure shows national 1.5°C compatible pathways. This is presented through a set of illustrative pathways (blue lines) as well as a 1.5°C compatible range (blue shaded area) for total greenhouse gases (GHG) emissions, excluding LULUCF. The 1.5°C compatible range is based on the full range of resulting Paris Agreement compatible Pathways from the IPCC SR1.5 filtered with sustainability criteria and are represented here the median (higher bound) to 5th percentile (lower bound) and middle of the range which defines the benchmarks. Values are rounded. NDC and Current policy projections are provided by the Climate Action Tracker, Update 2020.

Japan's NDC sets a 2030 emissions level of ~1,040 $MtCO_{2e/yr}$ including its forestry sink, equivalent to around 1,080 $MtCO_{2e/yr}$ excluding land-use, land-use change and forestry (LULUCF). This is equivalent to a 24% reduction below 2013 levels by 2030, excluding LULUCF. By contrast, Paris Agreement compatible pathways for Japan require a rapid decline in domestic **GHG emissions (excluding LULUCF), reaching about 65% below 2013 levels by 2030 which translates to around 487 $MtCO_{2e/yr}$ by 2030 (corresponding to 63% below 2010 levels)**.

Japan's domestic emissions reductions compatible with the Paris Agreement lies above the "fair share" level as assessed by the Climate Action Tracker and thus requires Japan to further reduce emissions overseas by providing support to other countries (Climate Action Tracker 2020d).

Under the Paris Agreement's enabling decisions governments were expected to strengthen their targets and submit updated NDCs in 2020. Japan has resubmitted its existing target while working on a revised NDC for submission ahead of the 2021 climate summit, also as part of the discussion about implementing the recently announced 2050 net zero GHG goal. Japan is expected to easily achieve this restated NDC target without additional policy effort.

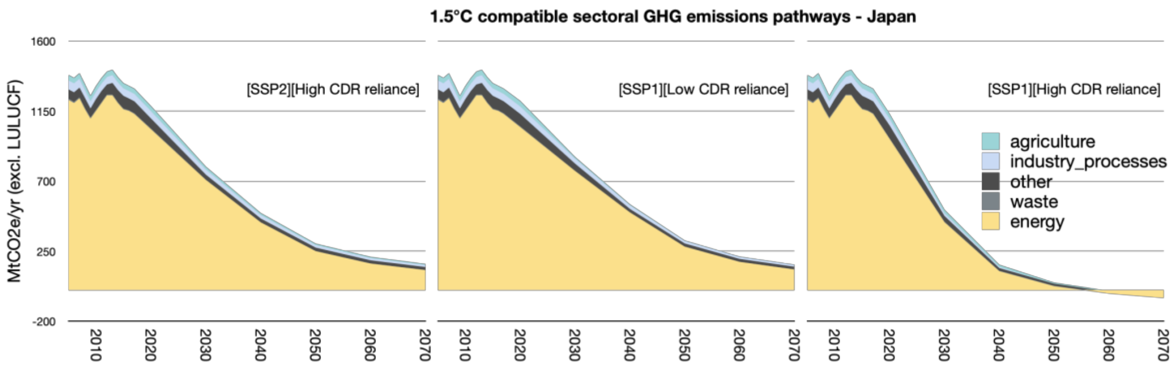

Figure 22: 1.5°C compatible GHG emissions pathways by sector.

In its long-term strategy under the Paris Agreement, Japan committed to an 80% emissions reduction by 2050, albeit with an uncertain baseline. In October 2020, the prime minister announced that **Japan would aim to reach net zero GHG emissions and carbon neutrality by 2050**.(Climate Action Tracker 2020c)

Japan would need to achieve net zero GHG emissions by 2060 at the latest, excluding LULUCF, while including LULUCF sinks in the range of the current levels would result in net zero GHG emissions by around 2050. This will require a full commitment to decarbonisation in next year's energy strategy revision to inspire new and strengthened regulations in all sectors and a strengthened 2030 emissions reduction target. **Net zero CO_2 would likely be achieved a few years before net zero GHG emissions.**

3.6.3 Decarbonising the power sector and policy implications

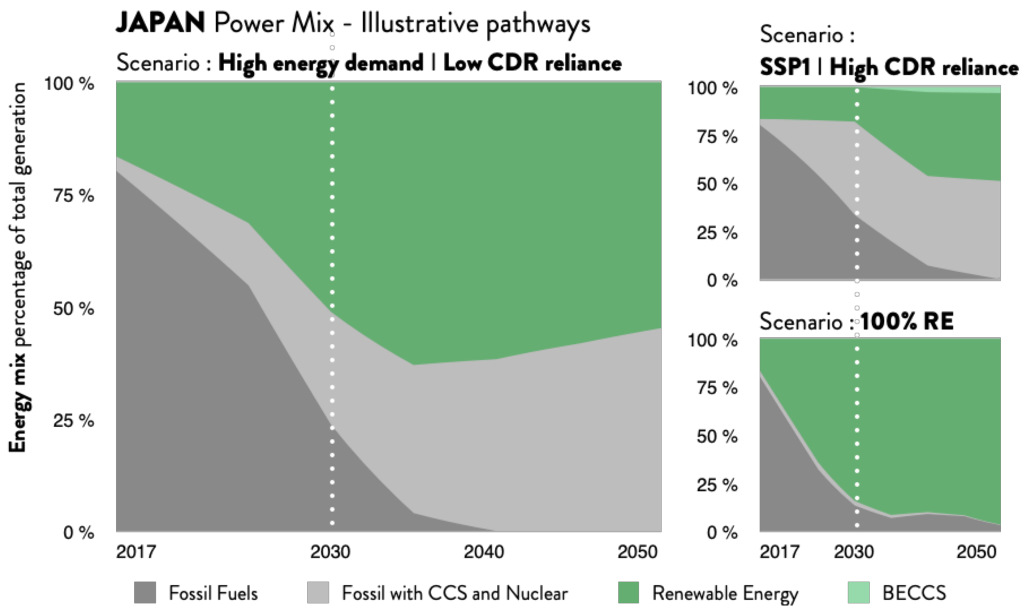

Figure 23: Power mix per technology consistent with 1.5°C compatible emissions pathways presented in figure 1. The shaded area represents the different scenarios analysed here.

3.6.4 Key characteristics of 1.5°C compatible trajectories

	Unit	Historic			1.5°C compatible benchmarks			Net zero years	Country targets 2030
		2010	2013	2017	2030	2040	2050		
Total GHG (excl. LULUCF)	$MtCO_{2e/yr}$	1303	1408	1289	487 (387 / 566)	148 (51 / 252)	29 (−6 / 75)	2060 (2050 /2075)	1079
	% (below 2013)				−65% (−73% / −60%)	−89% (−96% / −82%)	−98% (−100% / −95%)		-23%
	% (below 2010)				-63% (-70% / -57%)	-89% (-96% / -81%)	-98% (-100% / -94%)		
Total CO2 (excl. LULUCF)	$MtCO_{2e/yr}$			1186	452 (340 / 524)	111 (13 / 226)	−2 (−36 / 42)	2050 (2040 /2060)	
	% (below 2013)			-10%	−66% (−74% / −60%)	−92% (−99% / −83%)	−100% (−103% / −97%)		
Power Emissions intensity	gCO2e/kWh			540	80 (80 / 200)	10 (10 / 110)	−30 (−30 / 40)	2040 (2040 /2050)	
Share of renewable power	%			16	44 / 84	63 / 90	65 / 97		22-24%
Share of unabated fossil fuel in power	%			80	13 / 16	1/ 9	0/3	2031 (coal) 2040 (gas)	

Annex: Downscaling methodology description

Different methods are deployed for the downscaling process: for most sectors we employ an *intensity convergence method*; however other approaches are utilised where best suited depending on the sector/emissions to be downscaled. Below is a description of how the different sectoral emissions were downscaled and harmonised for the analysis.

The scenario data underlying 1.5°C compatible pathways specifies how future energy consumptions and emissions should be composed in different regions of the world. Typically, this data is only available for regional aggregates called *macro regions*. For example, in the integrated assessment model IMAGE, the North Africa macro region "NAF" comprises the countries/subregions Algeria, Egypt, Libya, Morocco, Tunisia and Western Sahara. This again means that in order to determine national energy consumption and emission pathways, the data of the macro regions needs to be downscaled to the national level.

The downscaling process itself can be broken down into several sub-steps:

1. **Defining the macro region(s)** in which the country of interest is located. The European Union is a special case – as an agglomeration it can span over several macro regions.
2. **Countries' historical emissions and energy consumption** are determined for all countries in the macro region(s).
3. **Future emissions and energy consumption** are obtained from the scenario data underlying the to-be-downscaled 1.5°C compatible pathway.
4. **The macro region's scenario data is adapted to match the country's historical data** in a base year. This process is called *harmonisation*. Harmonisation is required to update the pathways to the latest available historical data.
5. **The macro region's emissions and energy consumption are downscaled to its countries.** They are distributed to the countries in an internally consistent way, which preserves total values and matches the historical value of each country.

i.1 Illustrative Pathways

i.1.1 Energy - CO_2 emissions

Energy consumption in the energy sector in general and the power sector specifically are downscaled with the Simplified Integrated Assessment Model with Energy System Emulator (SIAMESE) method as described in Sferra et al. (Sferra et al. 2019). Through this method, energy emissions pathways are derived directly from the downscaled energy consumption at national levels brought back to emissions by applying emissions factors, providing national emissions pathways directly consistent from the related energy system (Sferra, Schaeffer, and Torres 2018).

The method is wrapped in the general downscaling process as follows:

Downscaling energy consumptions:

- **Historical primary and secondary energy consumptions** are obtained from the International Energy Agency (IEA) World Energy Balances (WEB) (IEA 2020d).

Consumption by fuel	Determination method
Non-biomass renewable	The sum over the consumption of wind, solar, geothermal and hydro energy.
Biomass	The difference between renewable energy consumption and the aforementioned non-bio renewable energy consumption.
Coal	The sum over peat and coal.
Oil	The sum over oil, oil products and natural gas liquids.
Gas and Nuclear	Directly obtained from the database.

  It has to be noted that in the IEA database, secondary energy consumptions are assigned to both electricity and heat generation. For downscaling purposes, the assumption is made that a majority of the consumption is dedicated to the power sector, with heat generation being a by-product of centralised electricity generation.

- **The consumption projections for the macro region(s)** are obtained from the integrated assessment models IMAGE, AIM and MESSAGE as well as a 100% renewable scenario dataset (EWG LUT), see section above. For the integrated assessment models, the primary energy consumptions and secondary energy consumptions (electricity) are directly obtained from the available data set. For the EWG LUT scenario, the data is processed and aggregated to the consumption classes.

- During the **harmonisation process**, the historical energy consumptions in the macro region(s) are set equal to the determined historical energy consumptions in the subregions. The energy consumption projections are not altered.

- The **energy consumptions are downscaled from Macro-Region(s)** to countries by applying the method SIAMESE described by Sferra et al (Sferra et al. 2019). Conceptually, the model allocates energy consumption (and emissions) to the country level by maximising welfare in all countries belonging to the same macro-region under a common set of assumptions (e.g. technological availability, expected GDP and population growths at the country level, common SSP storylines).

- To **reduce the computational load of the method**, the countries are aggregated into two regions before the downscaling. The first region holds the country of interest and the second region holds all other countries.

Once the consumptions are downscaled, the emissions can be determined:

- Historical emissions are obtained from the PRIMAP dataset for the energy sectors and from an IEA dataset for the power sector, again with the caveat of including combustion related CO_2 emissions from both electricity and heat.

- Emissions intensities are derived from the macro-region(s) model's emissions datasets and their respective energy consumptions. A calibration is run to match national emission projection to the downscaled energy consumptions

- For the energy and power sectors, emissions are obtained by applying respective emissions intensities to the downscaled energy consumptions.

It has to be noted that for the emissions in the energy sector, this process is done with the full primary energy consumption set due to data availability rather than more accurately only with the primary energy consumptions specifically allocated to the energy sector.

i.1.2 Agriculture sector

The emissions on the macro region level for the agriculture sector are collected from variables in the scenario data and harmonised to historical data. The emissions for individual subregions are determined by assuming their shares in the base year are constant over the whole scenario period, a simple downscaling methodology called *base-year pattern*.

i.1.3 Industrial processes, waste and energy non-CO_2 emissions

The macro region emissions for the industrial processes, waste and non-CO_2 emissions in the energy sector are taken from variables in the IAM scenario data and harmonised to historical data in a base year, as described in the previous section. To perform the downscaling from macro regions to the subregions a methodology based on *intensity convergence* is used; more specifically the Impact, Population, Affluence, and Technology (IPAT) method that was developed by Van Vuuren et al. (2007) (van Vuuren, Lucas, and Hilderink 2007) and extended by Gidden et al (2019)(Gidden et al. 2019).

It assumes that emission intensities (the ratio of emissions to GDP) will converge from their values in the historical base year to the macro region intensity in the last year of the scenario data, in the year 2100. This is made possible by an exponential interpolation of emission intensities from the base-year to the convergence year. Together with the yearly GDP by the given scenario, this interpolation defines how the emissions of the macro region are shared amongst the countries.

For determining the 1.5°C compatible range introduced in section 3.2, the IPAT emissions intensity convergence method is also used to downscale the energy CO_2 emissions of the Paris compatible global pathways provided by the IPCC special report 1.5°C, in order to consistently assess all scenarios in the dataset. In most pathways, these emissions become negative long before 2100. To account for the shift from positive to negative emissions in the downscaling routine, the exponential model is pulled into negative emission intensity space with an affine transform.

i.2 The 1.5°C compatible range

Each country is provided with illustrative pathways as well as a 1.5°C compatible range (blue shaded area). While the illustrative pathways are emissions pathways consistent with a downscaled energy mix from regional to national as described in section 4, the 1.5°C compatible range is based on the full set of Paris compatible global pathways provided by the IPCC special report 1.5°C considering sustainability limits. The IPCC SR1.5 finds limits for a sustainable use of both CDR options globally by 2050 to be below 5 $GtCO_2$ p.a. for BECCS and below 3.6 $GtCO_2$ p.a. for sequestration through AR while noting uncertainty in the assessment of sustainable use and economic and technical potential in the latter half of the century (Fuss et al. 2018; IPCC 2018b). These selected pathways are further downscaled with the methodology presented in sections i.2 and i.3. For this specific purpose, all emissions in the energy sector are downscaled using the emission intensity convergence downscaling method. The range is based on the 5^{th} percentile and the 50^{th} percentile of the obtained results thus illustrative pathways might be appearing out of the range for some specific countries.

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Climate Analytics is a non-profit climate science and policy institute based in Berlin, Germany with offices in New York, USA, Lomé, Togo and Perth, Australia. It seeks to empower those most vulnerable – Small Island Developing States and Least Developed Countries – to use the best science and analysis available in the international climate negotiations, as well as in developing policies and institutional capacity to adapt to climate change. Climate Analytics undertakes extensive research on the 1.5°C temperature limit in the Paris Agreement, evaluates progress on climate action and shows governments how they can act on their policies to keep global warming to this limit.

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