Chapter 5

How Do We Evaluate the Ambition Level of INDCs *Ex-ante*? An Initial Assessment on Japan

Takeshi Kuramochi

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Key Messages

- This chapter discusses how the ambition levels of intended nationally determined contributions (INDCs) can be assessed *ex-ante* with some examples of assessments conducted by IGES on Japan's INDC.
- There is a wide range of approaches to evaluate INDCs proposed in the literature and these are complementary to each other. IGES conducted three analyses on Japan's INDC based on a number of evaluation approaches: (1) comparison of economy-wide and sector-specific decarbonisation indicators with the US and the EU; (2) remaining emissions allowances under different effort-sharing principles; and (3) mitigation potential and policy effort.
- All three IGES analyses are based on a large number of scenarios reported in the literature, rather than on a single modelling exercise. This synthesis analysis-type approach takes account of various uncertainties regarding greenhouse gases (GHG) emissions modelling, and thus enhances the acceptability of the results by countries. This inclusiveness can be enhanced by the participation of local research institutes and think tanks through their provision of additional data provision as well as their feedback on the collected data.
- Considering the establishment of an evaluation process of INDCs comprised of research institutes, the research consortium as proposed in Chapter 4 could gather a range of studies and scenarios from international, regional and local research institutes. The research consortium could also encourage the research community to conduct national assessments for developing countries, where GHG mitigation pathway analyses are not readily available.

1. Introduction

In the lead-up to 21st Conference of the Parties (COP21), Parties to the United Nations Framework Convention on Climate Change (UNFCCC) are submitting their intended nationally determined contributions (INDCs). It is highly likely that there will be a large gap between the aggregate of INDCs and the emission levels required in the post-2020 period for the world to stay on a 2°C pathway (e.g. Climate Action Tracker 2015a). It is important for the international community to ensure that the aggregate of post-2020 mitigation actions will keep the world on a 2°C pathway, and an *ex-ante* assessment of INDCs at both collective and individual levels as well as the 'five-year cycle' proposed in Chapter 3 is an important step to achieve this.

While Parties may agree to carry out an *ex-ante* assessment of INDCs at an aggregate level, it is unlikely that a country-level assessment will be conducted under the UNFCCC because no Party seems to support the idea[2]. It is, therefore, crucial that the research community provides independent assessments on INDCs of individual Parties outside the UNFCCC process and inform policymakers on 'what more can be done' for the international community to stay on a 2°C pathway (e.g. Tamura et al. 2013).

Against the aforementioned backdrop, IGES has conducted a number of analyses to quantitatively assess the post-2020 mitigation levels under different assessment criteria for the case of Japan. This chapter provides an overview of IGES' recent analyses on Japan's future greenhouse gases (GHG) mitigation pathways and their implications on the level of post-2020 mitigation commitments that may be considered 'ambitious' in the global efforts to achieve the 2°C target. This chapter is structured as follows. Section 2 briefly describes Japan's INDC and the underlying electricity mix target for 2030. Section 3 provides an overview of approaches for evaluating INDCs. Section 4 presents some examples of IGES research related to the evaluation of Japan's INDC. Lastly, Section 5 summarises the key findings from IGES research and identifies steps forward.

2. Japan's INDC and electricity mix target for 2030

Figure 5.1 shows Japan's historical GHG emissions (excluding land use, land use change and forestry (LULUCF)) and mitigation targets for 2020, 2030 and 2050. On the 17 July, 2015, the Japanese government submitted its INDC to reduce the country's GHG emissions by 26% by 2030 from 2013 levels (Government of Japan 2015). The INDC excludes LULUCF from the base year emissions and includes LULUCF in the target year emissions.[3] With regard to underlying assumptions, the draft INDC is calculated on the basis of the recently-developed electricity mix plan for 2030 (Ministry of Economy, Trade and Industry 2015a): 20-22% nuclear, 22-24% renewables, 26% coal, 27% natural gas, and 3% oil, and the future GDP growth rate is assumed to be on average 1.7% per year for 2013-2030 based on the government's growth target (Ministry of Economy, Trade and Industry 2015b).

INDCs as well as 2020 mitigation targets should serve as milestones for countries' long-term deep decarbonisation. For the long-term future, Japan aims to reduce its GHG emissions by 80% from 1990 levels by 2050 (Ministry of the Environment 2012a).[4] As for 2020 mitigation targets, Japan aims to reduce its GHG emissions by 3.8% by 2020 from 2005 levels (a 3.1% increase from 1990 (Kyoto Protocol Base year levels)) including LULUCF and the use of emission credits (Government of Japan 2013). This target, announced in 2013 at COP19 in Warsaw, Poland, replaced the conditional 25% reduction from 1990 levels, which was pledged at COP15 held in Copenhagen in 2009 (Government of Japan 2010), following the Fukushima nuclear disaster.

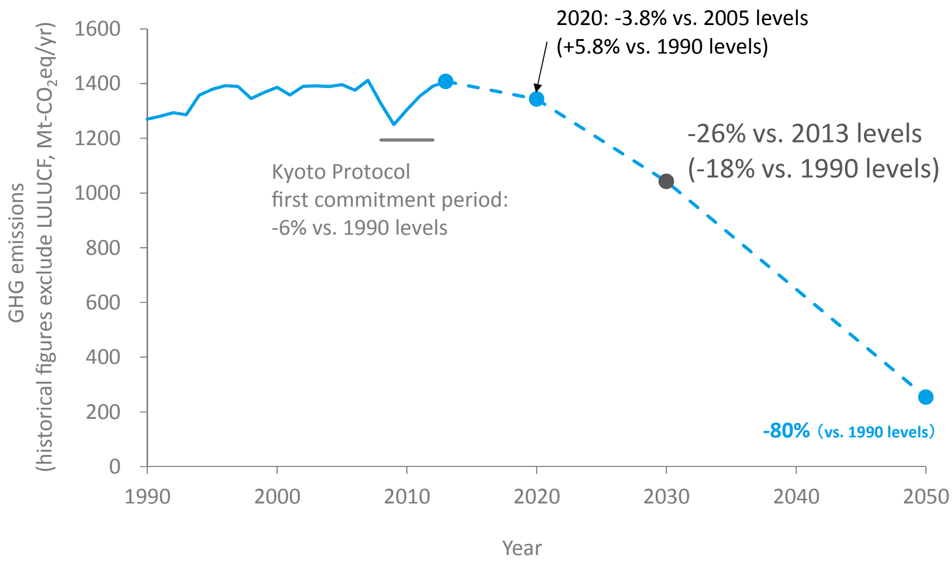


Figure 5.1 ***Japan's historical GHG emissions (excluding LULUCF) and mitigation targets for 2020, 2030 and 2050***

3. Approaches to evaluate INDCs

Many analyses have been conducted on countries' mitigation efforts since COP3 held in Kyoto in 1997 (Aldy et al. 2015). There are several approaches and associated indicators to evaluate the ambition level of an INDC (e.g. Höhne, et al. 2014a; Höhne et al. 2014b; Aldy and Pizer 2014). Based on the aforementioned literature, this paper identifies six approaches to evaluate the ambition level of INDCs, which are presented in Table 5.1. All approaches have their pros and cons, and all six approaches can be applied to evaluate the ambition level of INDCs.

Table 5.1 Overview of approaches to evaluate the ambition level of INDCs

Evaluation criteria	Description	Challenges
(i) Comparison with BAU	An INDC in comparison with a 'business-as-usual' (BAU) pathway can be a good indicator of ambition. Larger deviation from the BAU scenario indicates higher ambition level.	'BAU' can have different definitions; it may assume that all currently existing policies continue or it may assume that no policy take place at all.
(ii) Decarbonisation indicators	Many decarbonisation indicators have been used to assess or compare the ambition levels of country-level mitigation targets. Country-level indicators include CO_2/GHG emissions and energy use per capita or per GDP as well as carbon intensity of a country's energy mix. Sector-level indicators include carbon intensities of electricity and major industrial products such as crude steel and cement. These indicators do not depend on BAU or other counterfactual scenarios, which are sensitive to underlying assumptions. These decarbonisation indicators can be used not only to evaluate a country's progress on mitigation over time, but also to compare across countries to evaluate, e.g. to what extent a country is catching up with the top-runners.	Per GDP indicators require economic growth forecasts. Moreover, the choice between purchasing power parity or current currency exchange rate upon converting GDP from local currencies to a single currency. In addition, modelling may be required for countries with commitments that are not absolute targets. Furthermore, many factors that are unrelated to mitigation policies can affect these indicators (Aldy, Pizer, and Akimoto 2015).
(iii) Energy price indicators	Fossil energy prices, which comprises all cost components from mining to transport to various taxes, are a key driver for energy demand and supply as well as investment in energy efficient technologies in the end-use sectors. Energy prices allow for a comprehensive assessment of all policies implemented in the country. Carbon prices can be explicit or implicit in energy pricing. Energy prices themselves do not indicate the level of progress on GHG mitigation in any particular country. Nevertheless, they do indicate, especially when compared with those in other countries, whether the country's energy market conditions are optimal for driving significant energy efficiency improvement.	There are large regional disparities in natural gas and coal prices due to the differences in fossil energy resource availability. There is also question of whether to look into prices of individual energy sources in different sectors or take the average energy prices of the entire economy.

***Table 5.1* Overview of approaches to evaluate the ambition level of INDCs (cont.)**

Evaluation criteria	Description	Challenges
(iv) Effort sharing	An INDC can be compared to the emissions allowances based on an agreed global carbon budget and effort-sharing approaches. Effort-sharing approaches include historical responsibility (i.e. historical GHG emissions), cost-effectiveness, capability (e.g. expressed in GDP per capita or Human Development Index), and equality (i.e. equal emission rights per capita), as well as the combination of more than two of the above four approaches. While most studies calculated country- or region-specific emissions allowance trajectories up to a certain future year (2050 or 2100), some studies also calculated remaining cumulative emissions allowances (e.g. Kuramochi et al. 2015; de Vos et al. 2014).	The range of possible emissions allowances is wide due to the different focus of the effort-sharing approaches. There is also large uncertainty and debate as to the level of global carbon budget to achieve the 2°C target with a relatively high probability.
(v) Mitigation potential (cost-effectiveness)	Modelling exercises can identify and quantify available mitigation opportunities and the costs to realize them. For example, a contribution could be assessed as to whether it captures (Fekete et al. 2013b): (a) 'No-regret' measures available at negative or zero costs, (b) measures with moderate positive costs or at higher costs but with significant co-benefits (if not expressed in monetary terms), and (c) ambitious measures that are available at higher costs. An INDC can be considered ambitious if it is in the range of levels (b) or (c).	The calculation of mitigation potentials depend on many assumptions, including the extent to which co-benefits are considered in monetary terms as well as the accounting of various costs of inaction. This results in limited transparency of the calculations and large differences of the results across models or studies.
(vi) Policy package or a policy menu	Examples of good policy packages and menus include many policy measures (e.g. renewable energy support policies and building energy efficiency standards) that are best in class. An INDC can be considered as ambitious if the policy package/menu includes many best practice policies.	There may be a debate over a list of policies to be evaluated.

Source: (Höhne et al. 2014b; Höhne et al. 2014c; Aldy et al. 2014; Aldy et al. 2015).

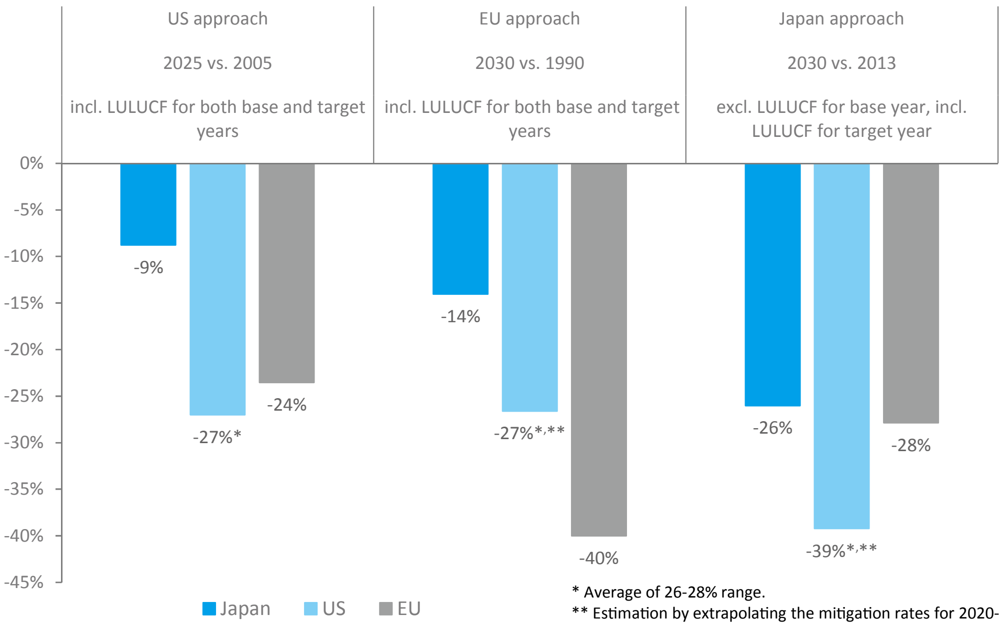
4. Assessment on Japan's future mitigation pathways

At IGES, three sets of analyses were recently conducted on Japan's possible mid- and long-term GHG emissions pathways to assess the level of contributions required in the global efforts to limit the global temperature increase within 2°C compared to the pre-industrial period. First, a number of decarbonisation indicators derived from or underlying the INDCs are compared for Japan, the US and the EU (Kuramochi 2015), which addresses the evaluation criterion (ii) in Table 5.1. Second, a comparative assessment of Japan's long-term carbon budget under different effort-sharing approaches is presented (Kuramochi et al. 2015). This analysis addresses the evaluation criterion (iv) in Table 5.1. Third, a comparative assessment of GHG mitigation scenarios for 2030 reported in the literature that took into account varying levels of policy effort levels as well as technical and economic constraints specifically for Japan are presented (Kuramochi, Wakiyama, and Kuriyama 2015). This assessment addressed elements of evaluation criteria (iv) and (vi) in Table 5.1.

4.1 Decarbonisation indicators

Various forms of decarbonisation indicators derived from or underlying an INDC, e.g. emission intensity indicators derived from INDCs as well as underlying energy-related indicators at economy-wide and sectoral levels can be compared across countries to evaluate the relative ambition level of the INDC.

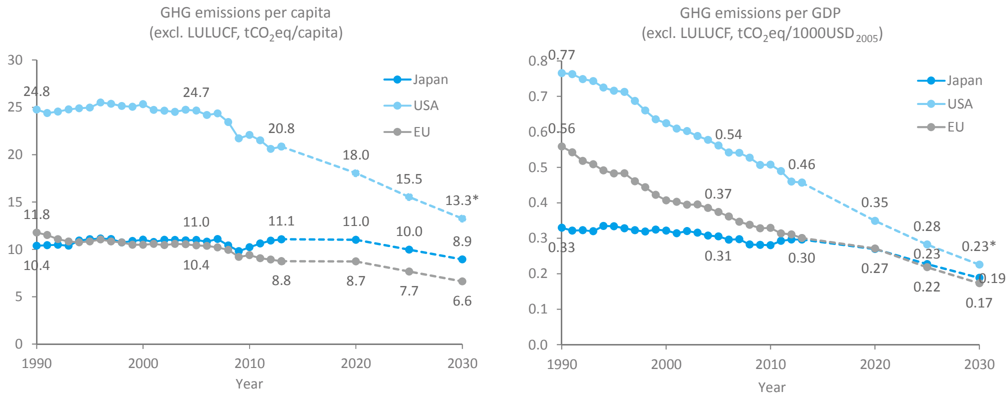
In case of Japan's INDC, it can be compared to that of peer developed countries and regions such as the United States (US) and the European Union (EU) to assess its relative ambition level. In March 2015, the US and the EU submitted their INDCs to reduce their GHG emissions by 26-28% by 2025 from 2005 levels and 40% by 2030 from 1990 levels, respectively (EU 2015). The INDCs of these three countries and regions are, however, not directly comparable because they differ on the base year, target year as well as the accounting of LULUCF (see Table 4.1 in Chapter 4). When they are made comparable, it can be seen in Figure 5.2 that Japan's INDC is comparatively less ambitious than that of the US and the EU, irrespective of how the base year, target year and the LULUCF accounting are defined.



Source: Adapted from Kuramochi (2015).[5]

Figure 5.2 ***Comparison of INDCs of Japan, the US and the EU under different base year, target year and LULUCF accounting***

On the other hand, when the INDCs of the three countries and regions are compared on the basis of emission intensity indicators, Japan will still lag behind the EU but maintain lower emissions per capita and per GDP than the US in 2030 (see Figure 5.3).

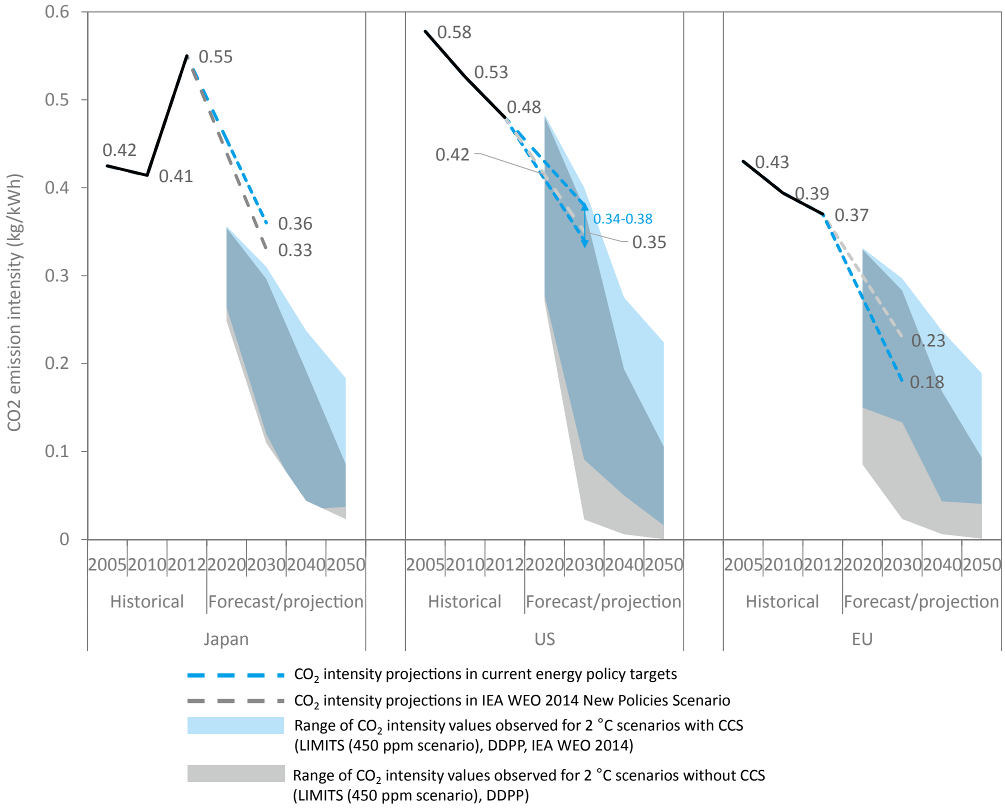


Note: Future projections are based on the INDCs of the three countries.

Source: Adapted from Kuramochi (2015). For GDP, historical figures up to 2012 were taken from OECD (2014) and the projections up to 2030 were taken from IEA (2014). For population, both historical figures (1990-2010) and future projections (2011-2030, medium fertility case) are taken from United Nations (2013).

***Figure 5.3* GHG emissions per capita (left) and per GDP (right) for Japan, the US and the EU**

Alternatively, we can also look into sector-level decarbonisation indicators. Kuriyama and Kuramochi (2015) compared the likely future emission intensity values in 2030 for electricity generation in Japan, the US and the EU under their current energy policy targets as projected by the International Energy Agency (IEA) World Energy Outlook 2014 (IEA 2014). The emission intensity projections were also compared with the emission intensity ranges observed for scenarios consistent with a 450 ppm CO_2 equivalent (CO_2eq) stabilisation (Tavoni et al. 2013). It can be seen in Figure 5.4 that in 2030, CO_2 intensity per kilowatt-hour (kWh) electricity for Japan under the current policy targets will be on a par with that for the US and will lag far behind the EU. Moreover, the CO_2 intensity for Japan's electricity generation will be much higher than the level observed for 450 ppm CO_2eq stabilisation scenarios. Although Japan had to revise its mid- to long-term climate mitigation policy that relied largely on considerable expansion of nuclear power due to the Great East Japan Earthquake and the Fukushima nuclear disaster, the results presented here indicate that Japan would need to raise the ambition level for the emissions reductions in the power sector.

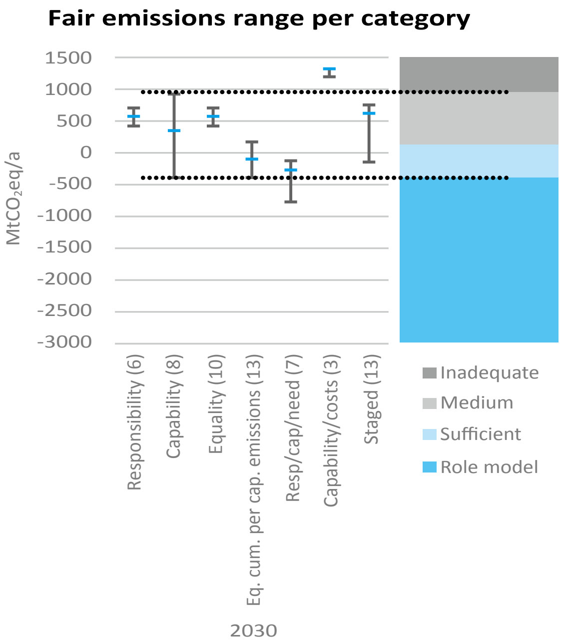


Source: Adapted from Kuriyama and Kuramochi (2015).

Figure 5.4 ***Comparison of electricity CO_2 intensity up to 2030 under currently planned policies for Japan, the US and the EU in comparison with the levels required under 450 ppm CO_2eq stabilisation scenarios***

4.2 Japan's long-term carbon budget under different effort-sharing approaches

The allocation of long-term global 'carbon budgets' that are consistent with a global 2°C target to countries or regions have extensively been investigated for various effort-sharing approaches, and the ranges of emissions reduction levels for specific future years, e.g. 2030 and 2050, reported in the literature have been compiled and compared at regional level in Höhne et al. (2014a). The range of country-level emissions reduction levels under different effort-sharing approaches has been analysed and compared with the national mitigation targets by the Climate Action Tracker. Figure 5.5 shows an example of Japan, which indicates that Japan would need to reduce its GHG emissions by more than 24% from 1990 levels to be evaluated to a 'medium' effort level and 89% to be evaluated to a 'sufficient' level (Climate Action Tracker 2015b).[6] However, there are relatively few studies that investigated the remaining cumulative carbon budgets at a country-level toward the end of the 21st century consistent with a long-term global 'carbon budget' that would maintain a relatively high probability to limit the temperature increase within 2°C (e.g. WBGU 2009; Horstmann and Scholz 2011; BASIC experts 2011; Höhne and Moltmann 2009; Fekete et al. 2013a; de Vos et al. 2014).

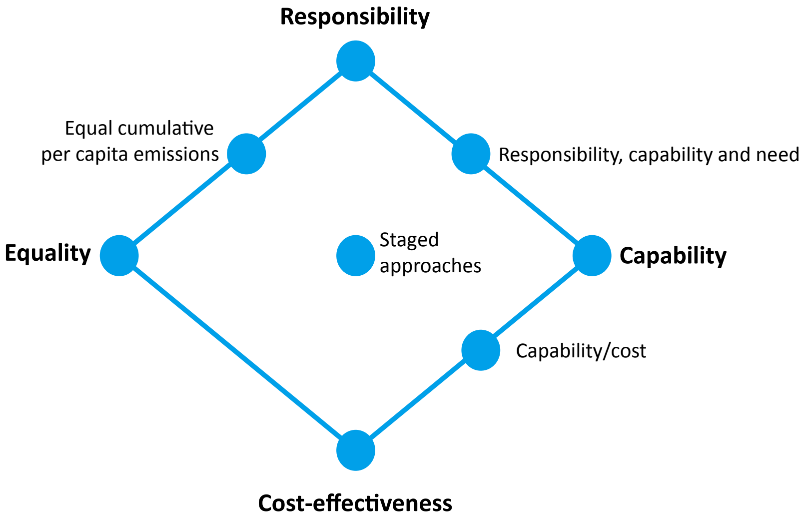


Source: Climate Action Tracker (2015b)

Figure 5.5 ***Ranges of emissions allowances for Japan in 2030 under different effort-sharing approaches***

Kuramochi et al. (2015) assessed Japan's carbon budgets up to 2100 in the global efforts to achieve the 2°C target under different effort-sharing approaches based on long-term effort-sharing scenarios published in thirteen studies. The study compared scenarios from the literature that were calculated for long-term stabilisation levels between 450 ppm and 550 ppm CO_2eq in 2100. Stabilisation levels between 450 ppm and 550 ppm CO_2eq correspond to the temperature increase (in 2100 relative to 1850–1900 levels, 10th to 90th percentile) of 1.5–1.7°C with a 12–37% probability of exceeding 2°C and 2.0–2.3°C with a 54–84% probability of exceeding 2°C, respectively (Clarke et al. 2014).

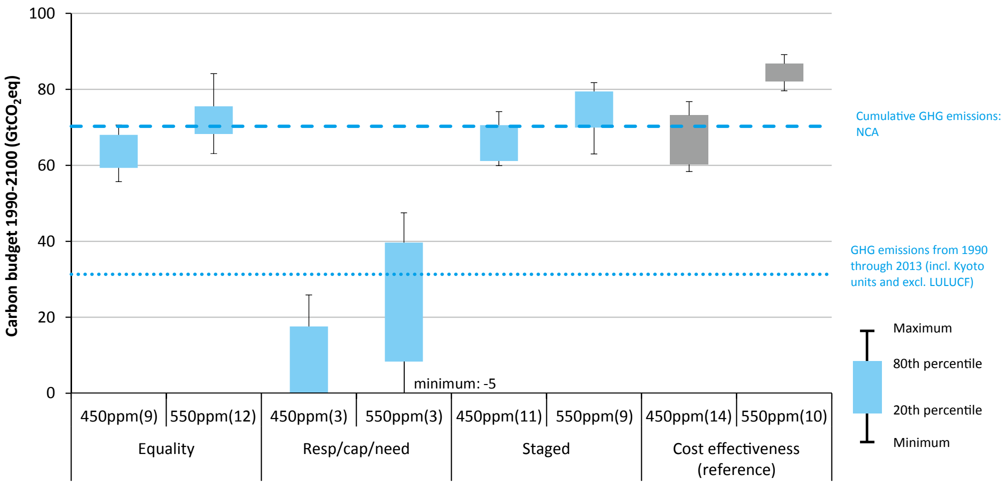
The GHG emissions allowances investigated in this study include all GHGs from all sectors except for land use, land use change and forestry (LULUCF). In order to make the scenario results from the literature comparable, data harmonisation was performed (for details, see Kuramochi et al. (2015)). Scenarios from the literature were categorised into one of the eight effort-sharing categories as shown in Figure 5.6. Detailed description of the eight effort-sharing categories can be found in Appendix 5.1.



Source: Kuramochi et al. (2015)

Figure 5.6 Eight categories for effort-sharing approaches

Of the eight effort-sharing categories presented above, the literature data allowed for an in-depth analysis on four effort-sharing categories ('Equality', 'Cost-effectiveness', 'Responsibility, capability and need', and 'Staged'). The results are presented in Figure 5.7 and Table 5.2. For a 450 ppm CO_2eq stabilisation level, the remaining carbon budgets for 2014–2100 were negative for the effort-sharing category that emphasises historical responsibility and capability ('Responsibility, capability and need').[7] For the other three including the reference 'Cost-effectiveness' category, which showed the highest budget range among all categories, the calculated remaining budgets (20th and 80th percentile ranges) would run out in 21–29 years if the current emission levels continue. A 550 ppm CO_2eq stabilisation level increases the budgets by 6–17 years-equivalent of the current emissions, depending on the effort-sharing category.



Source: Kuramochi et al. (2015).

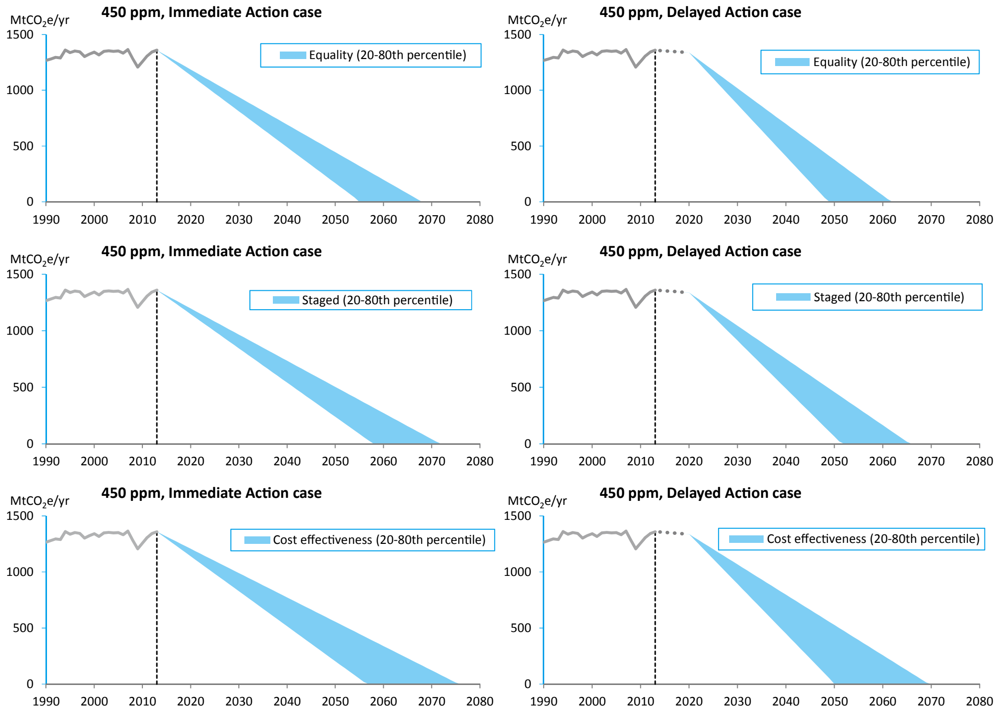
Figure 5.7 ***Carbon budgets between 1990 through 2100 calculated from scenarios reported in the literature***[8,9]

Table 5.2 ***Japan's remaining carbon budgets***[10]

Effort-sharing category	Total budget 1990–2100 ($20^{th}/80^{th}$ percentile range: $GtCO_2eq$)	Remaining budget 2014–2100 ($GtCO_2eq$)	The year the budget runs out if 2013 emission levels continue
450 ppm scenarios			
Equality	59–68	28–37	2034–2040
Staged	61–71	30–39	2035–2042
Cost-effectiveness (reference)	60–73	29–42	2034–2044
550 ppm scenarios			
Equality	68–76	37–44	2040–2046
Staged	70–79	39–48	2041–2048
Cost-effectiveness (reference)	82–87	51–55	2050–2054

Source: Adapted from Kuramochi et al. (2015)

Exemplary emissions trajectories staying within the calculated budgets were also analysed for 'Equality', 'Staged' and 'Cost effectiveness' categories (Figure 5.8). For a 450 ppm CO_2eq stabilisation level, for example, Japan's GHG emissions would need to phase out sometime between 2045 and 2080 and the emissions reductions in 2030 would need to be at least 16–29% from 1990 levels even for the most lenient 'Cost-effectiveness' category and 29–36% for 'Equality' category. The figure also indicates that Japan's GHG emissions would converge to zero between 2049 and 2076, depending on the effort-sharing category and the start year for accelerated mitigation action towards the convergence to zero emissions. The mitigation trajectories become steeper in the Delayed Action case (i.e. drastic emissions reductions start in 2021) than in the Immediate Action case (i.e. drastic emissions reductions start in 2014), and the year of emission convergence needs to be moved up by about 5 years.



Source: Kuramochi et al. (2015).

Figure 5.8 ***Japan's exemplary GHG emission pathways both for Immediate Action case (starting from 2014) and Delayed Action case (starting from 2021) for carbon budgets under three effort-sharing categories at 450 ppm CO_2eq stabilisation[10]***

These results indicate that Japan's INDC, which is equivalent to a 15% reduction from 1990 levels when excluding LULUCF, may not be considered sufficiently ambitious in the global efforts to stabilise the atmospheric GHG concentration level at 450 ppm CO_2eq.

4.3 Mitigation potential and policy package

Kuramochi et al. (2015) conducted a comparative assessment of GHG mitigation scenarios for 2030 reported in the literature that investigated the GHG mitigation potential under varying policy effort levels, taking into account technical and economic constraints specifically for Japan.

The mitigation scenario data were collected from selected studies published since 2011 that provided results for 2030 and met the following criteria: (1) publication based on a detailed bottom-up assessment of technology deployment potentials for all sectors taking into account foreseeable policy measures; (2) published or co-authored by the research institutes that provide energy and GHG emissions scenarios to the government or by other internationally accredited energy research institutes; or (3) published in the peer-reviewed literature. These criteria were set to filter out the scenarios that make overly optimistic (or pessimistic) assumptions on low-carbon technology deployment as well as societal and economic transitions that are not widely accepted by experts.

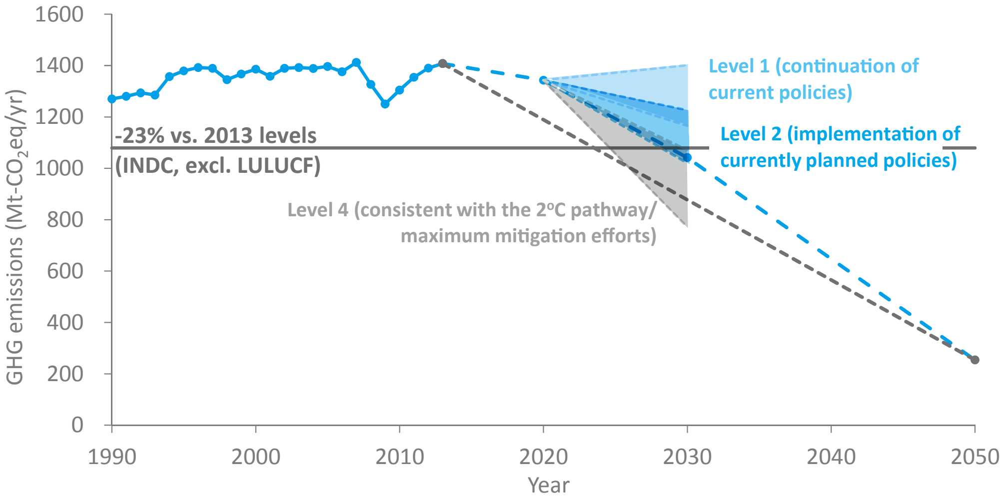
As a result, this study covered in total 48 scenarios from seven studies (Ministry of the Environment 2012b; IEEJ 2013; IEA 2014; Takase and Suzuki 2011; IEEJ 2014; IEEJ 2015; SDSN and IDDRI 2014). A number of data harmonisation procedures were taken in this study to make all data comparable. The scenarios were categorised into four mitigation effort levels and assessment was made of the value ranges for GHG emissions (excluding LULUCF) as well as the key underlying energy-related indicators for each effort level category (Table 5.3). Level 1 represents the lowest mitigation effort assuming the continuation of currently existing policies at the time of publication of the referenced literature and no additional policy implementation.[11] Level 1 can be considered as a BAU. Level 2 takes into account the policies that are currently in planning or consideration in addition to those considered for Level 1. Level 4 represents the highest mitigation effort. The mitigation scenarios that indicate any of the following were classified as Level 4: (i) consistency with the global 2°C target; (ii) consistency with the long-term target of 80% reduction of GHG emissions from 1990 levels by 2050; or (iii) maximum deployment of advanced technologies based on bottom-up techno-economic potential assessments. It should be noted that the three criteria are not fully comparable, and there are wide ranges of interpretations within each criterion. All scenarios that considered stronger policies than Level 2 but do not meet the criteria for Level 4 are categorised as Level 3.

Table 5.3 Categorisation of GHG emissions scenarios by effort level

Level 1	Level 2	Level 3	Level 4
Continuation of currently existing policies and actions and no additional policy implementation	Takes into account the policies and actions that are currently in planning or consideration in addition to those considered in Level 1.	More aggressive policies and actions compared to Level 2, including those that are not currently considered, but it does not meet the criteria for Level 4.	Indicate one or more of the following: (i) consistency with the global 2°C target, (ii) consistency with the long-term target of 80% reduction of GHG from 1990 levels by 2050, (iii) maximum deployment of advanced technologies based on techno-economic potential assessments.

Source: Kuramochi et al. (2015)

Figure 5.9 presents the GHG emissions reduction ranges for mitigation effort Levels 1, 2, and 4 in comparison with the historical emissions as well as the two linear reduction pathways to achieve the 80% reduction in 2050: one with immediate action from 2014 and the other with delayed action until 2020. For the scenarios that are categorised to assume the highest level of mitigation efforts including those consistent with a global 2°C target, GHG emissions levels ranged between 16-39% below 1990 levels (23-44% below 2005 levels) with the nuclear power share ranging between 0-29%. As shown in Table 5.4, the wide range observed for GHG emissions is also attributable to the differences in assumptions and projections on the share of renewable electricity and carbon capture and storage-equipped electricity (hereinafter, "RE/CCS electricity"), the share of unabated coal-fired electricity, the reduction level of energy end-use (12-28% from 2010 levels), which is partly influenced by the future economic growth rates, as well as the electrification rates. In contrast, for the scenarios that were designed to reflect the continuation of existing and currently planned policy measures – as opposed to consistency with the 2°C target – the GHG emissions reductions ranged at 3-20% below 1990 levels (12-26% below 2005 levels)



Source: Updated from Kuramochi et al. (2015)

Figure 5.9 ***Historical GHG emissions, emission ranges for mitigation effort Levels 1, 2 and 4, as well as two linear reduction pathways to achieve 80% reduction in 2050***

These results also indicate that Japan's INDC does not have sufficient ambition in the global efforts toward the 2°C target not only in terms of GHG mitigation levels but also in terms of target levels for the power sector. It is evident from Table 5.4 that the unabated coal-fired electricity share is on the higher end of all values observed across the four effort Levels in the literature and the RE/CCS electricity share corresponds with the range observed for Level 2 scenarios, which are not in line with the global 2 °C target.

Table 5.4 ***The value range of key indicators related to GHG emissions reductions for 2030 observed in the literature***

Effort level category (number of scenarios)	Electricity mix: shares in total power generation (%)			Total final consumption as a change from 2010 levels (%)	GHG emissions as a change from 1990 levels (excluding LULUCF: %)
	Nuclear power	RE/CCS power	Unabated coal-fired power		
Level 1 (3)	10 – 15	14 – 22	25 – 30	-8 – -9	+10 – -8
Level 2 (9)	0 – 25	21 – 26	17 – 29	-9 – -15	-3 – -20
Level 3 (12)	0 – 30	21 – 35	10 – 25	-10 – -20	-11 – -30
Level 4 (24)	0 – 29	27 – 47	1 – 28	-12 – -28	-16 – -39
Japan's INDC/energy mix target for 2030	20 – 22	22 – 24	26	-14	-15

Source: Kuramochi et al. (2015)

5. Summary and way forward

This chapter provided an overview of IGES' recent analyses on Japan's future GHG mitigation pathways and their implications on the level of post-2020 mitigation commitments that may be considered 'sufficiently ambitious' in the global efforts to achieve the 2°C target.

Among the six approaches identified in this chapter to evaluate INDCs, IGES conducted analyses using three approaches to evaluate Japan's INDC. Each of the three analyses provides a unique picture and they collectively present a multifaceted nature of Japan's INDC. For future work, it is recommended for other evaluation approaches to be applied to Japan's INDC and such assessments to be conducted for other countries' INDCs.

It should also be stressed that all three IGES analyses are based on a large number of scenarios reported in the literature and thus, a relatively wide range was observed for all results. Nevertheless, these results combined indicate that Japan's INDC may not be considered sufficiently ambitious in the global efforts to achieve the 2°C target. The synthesis analysis-type of approach takes into account various uncertainties regarding GHG emissions modelling and thus enhances the acceptability of the results by countries. This inclusiveness can be enhanced by the participation of local research institutes and think-tanks through their provision of additional data provision as well as their feedback on the collected data. In the *ex-ante* evaluation process of INDCs proposed in Chapter 4, the proposed research consortium could gather a range of studies and scenarios from international, regional and local research institutes. The research consortium could also encourage the research community to conduct national assessments for developing countries, where GHG mitigation pathway analyses are not readily available.

Last but not least, many studies published to date emphasise the level of "efforts required" or "burden borne" by each country to achieve the global 2°C target. By contrast, there are a limited number of studies that focused on long-term benefits delivered through the transition to low-carbon economy. One of the few examples include the recent New Climate Economy reports (New Climate Economy 2015; New Climate Economy 2014a), which investigated a range of economic opportunities that can be seized in the global transition to a low-carbon economy such as the increase in agricultural productivity, energy efficiency improvement and improved quality of life in cities through low-carbon urban infrastructure development.

It would be useful and important to include indicators of such development benefits, which are "forward-looking", in the assessment of INDCs. However, country-level in-depth analyses on the benefits of the transition to low-carbon economy are currently available only for a few countries (e.g. China (New Climate Economy 2014b)). Therefore, the research consortium could play an important role in developing the aforementioned benefit-based indicators.

Notes

1. This chapter is a compilation of the following materials published earlier by IGES researchers (Kuramochi 2015; Kuramochi et al. 2015; Kuramochi, Wakiyama and Kuriyama 2015; Kuriyama and Kuramochi 2015). Part of Kuramochi et al. (2015) is reused with permission from Taylor & Francis.
2. http://www4.unfccc.int/submissions/Lists/OSPSubmissionUpload/106_128_130773935819571701-Aide%20m%C3%A9moire_Paris%20informal%20mtg_%206-8%20may%202015.pdf

3. The emissions reduction rate would become smaller if it is calculated on a net-net basis (i.e. including LULUCF for both the base year and the target year) or on a gross-gross basis (i.e. excluding LULUCF for both the base year and the target year). The consequences are presented in Section 4.1.
4. In the original Japanese version, the base year is not clarified. In the English version, however, it is indicated that the base year is 1990 (Ministry of the Environment 2012a).
5. For the EU, LULUCF is included for both base year and target year emissions. Historical emissions up to 2013 were taken from respective GHG inventory reports (Ministry of the Environment and Greenhouse Gas Inventory Office of Japan 2015; EPA 2015; EEA 2014). The 2025 emissions projections for Japan and the EU are linearly interpolated between 2020 and 2030 mitigation targets, and the 2030 emissions projections for the US are linearly extrapolated from 2020 and 2025 mitigation targets. The future projections for carbon sequestration in the LULUCF sector are taken from Biennial Reports submitted to the UNFCCC for Japan and the US (average of high and low projections)(Government of Japan 2013; U.S. Department of State 2014), and from European Commission (2014).
6. A country's INDC is evaluated as 'medium' when 'the emissions resulting from its proposal are in the upper half of the range of what could be considered as "fair"' and as 'sufficient' when the resulting emissions are in the lower half of the range. 'Medium' level is defined as the level that 'would only be 2°C compatible if other countries moved to the more ambitious end of their effort sharing range'.
7. This is a result of Japan's high historical responsibility, i.e. high cumulative historical GHG emissions, and high capability for taking mitigation actions, i.e. high GDP per capita. The number of scenarios for the 'responsibility, capability and need' category is smaller than the other three categories investigated, but this effort-sharing approach generally allocates very small carbon budgets to developed countries (Höhne et al. 2014a).
8. For the 'Responsibility, capability and need' category, 20th percentile and minimum values were -16 $GtCO_2eq$ and -31 $GtCO_2eq$, respectively, for 450 ppm CO_2eq scenarios (therefore not shown here). Cumulative GHG emissions between 1990 through 2013 (including Kyoto units) as well as the Nationally Committed Amount (NCA) are also presented.
9. In addition to the GHG mitigation scenarios produced in the literature, we also calculated the amount of cumulative GHG emissions expected under the current 2020 and 2050 mitigation targets in Japan, which we refer to as the 'Nationally Committed Amount' (NCA). The NCA assumed that Japan adheres to the currently existing future GHG mitigation targets. Japan's current 2020 mitigation target (Government of Japan 2010) aims to reduce its GHG emissions by 3.8% below 2005 levels and the country's long-term mitigation target is a 80% reduction by 2050 below 1990 levels (Ministry of the Environment 2012a).
10. The results for 'Responsibility, capability and need' are not presented here because the discussions based on negative remaining carbon budgets do not lead to any constructive policy recommendations.
11. This effort level accounts for policies and measures that are not yet fully implemented, but does not account for the mitigation impacts that would have been delivered in case they are fully implemented.

Appendix 5.1 Description of effort-sharing approaches

Effort-sharing approaches investigated in the literature are often based on one or more of the following four basic dimensions (Kuramochi et al. 2015):

- *Responsibility*: This category includes approaches that are based on historical contributions to global emissions or warming, originally proposed by Brazil in the run-up to the Kyoto negotiations (UNFCCC 1997) to differentiate commitments among Annex I countries. The proposal was later elaborated for global application by introducing a per capita income threshold for participation of non-Annex I regions (den Elzen and Lucas 2005; den Elzen et al. 2005), thus taking some account of 'Capability' dimensions.
- *Capability*: This category concerns the ability to pay for mitigation, which is represented by GDP per capita or Human Development Index (HDI). An example of approaches under this category is the Emission Intensity Target approach, which assumes that all Parties adopt emission intensity targets after reaching a certain income threshold (den Elzen and Lucas 2005).
- *Equality*: The approaches in this category assume the convergence to equal emission allowances per capita immediately or over time, depending on studies and scenarios.
- *Cost-effectiveness*: This category is in most cases represented by the application of an equal carbon pricing ('equal marginal abatement cost') across countries in an economic model.

In addition to the above four, this study identified the following four effort-sharing categories that combine two or more of the above four dimensions:

- *Responsibility, capability and need ('Res/Cap/Need')*: This category includes approaches that combine indicators for *Responsibility* (i.e. historical cumulative emissions) and *Capability* (e.g. GDP per capita) as well as the need for sustainable development to allocate emissions allowances, for example by applying weighting factors (e.g. Baer et al. 2008; Knopf et al. 2012). Under the approaches in this category, wealthier and higher emitting countries receive a much smaller share of the budget than poorer and less emitting countries.
- *Equal cumulative per capita emissions*: This category includes approaches that calculate country-level emissions allowances by allocating equal cumulative per capita emissions. The definition of 'cumulative per capita emissions' of a country, however, differ across studies.
- *Capability/cost*: This category uses equal costs or welfare losses GDP to allocate emissions allowances across countries and essentially combines 'Capability' and 'Cost-effectiveness' dimensions.
- *Staged approaches* ('*Staged*'): This category includes a wide range of approaches where countries take differentiated commitments in various stages by taking account of multiple principles. Indicators used for differentiating emissions allowances are tuned to keep the atmospheric GHG concentration level below given long-term goals. Examples include the Common but Differentiated Convergence approach (Höhne, den Elzen, and Weiss 2006) and the Multi-Stage approach (e.g. Berk & den Elzen 2001; den Elzen et al. 2003), in which developing countries are required to gradually scale up their mitigation commitments based on their per capita GDP and/or emission levels. 'Staged' category also includes the 'Triptych' approach, which calculates future emissions allowances based on a long-term convergence of per capita emissions for the domestic sector and sector-level energy and CO_2 performances for other sectors (Phylipsen et al. 1998; Groenenberg, Blok, and van der Sluijs 2004). The Triptych approach contains elements of 'Cost-effectiveness' in that sectors with high emissions or poor energy efficiency have to reduce more, while taking account of 'Capability' by allowing for a long period of time for sector-level performances to catch up with the best performers and elements of 'Equality' for the domestic sector.

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