



JAPAN 2050 Low Carbon Navigator

A User's Guide

The Institute for Global Environmental Strategies (IGES) and the National Institute for Environmental Studies (NIES) jointly developed the Japan 2050 Low Carbon Navigator, a simulation tool for energy supply and demand scenarios that aim at building a low-carbon society with a long-term perspective towards 2050.

Japan 2050 Low Carbon Navigator (Low Carbon Navigator) is built on the modelling framework of the UK 2050 Pathways Calculator¹. The UK Department of Energy & Climate Change (DECC) published the first 2050 Pathways Calculator in 2010. Since then, it has been used as a practical tool by policymakers, academia, the business sector, the general public and teachers at schools to help explore the various options on how the UK can best meet energy needs while achieving the ambitious 80% GHG reduction target by 2050. Over the past three years, another five national or regional 2050 Pathways Calculators were developed in China's Mainland, Republic of Korea, Belgium (Wallonia region), Taiwan and India.

Acknowledgements

The core team of Japan 2050 Low Carbon Navigator fully appreciates those Japanese experts and the 2050 Pathways Calculator Team at the UK DECC who provided advice and assistance from a scientific and practical point of view. We would also like to acknowledge the support that we received in various ways from the British Embassy Tokyo and the Ministry of the Environment of Japan for the implementation and promotion of the project.

¹ <https://www.gov.uk/2050-pathways-analysis>



Why have we developed the Japan 2050 Low Carbon Navigator?

Japan approved its Fourth Basic Environment Plan in April 2012 with an ambitious long-term target to reduce greenhouse gas (GHG) emissions by 80%. Following the Great East Japan Earthquake and the Fukushima nuclear accident in 2011, all nuclear reactors have stopped operating as of July 2014. Without nuclear energy, which accounted for about 25% of the total electricity generation and a lion's share in low-carbon and more independent energy scenarios, there will be great uncertainty in Japan's energy and climate policies. As a result, Japan is now placed at the crossroads for deciding on its future energy structure and low-carbon technologies which can best ensure energy security while at the same time achieving the ambitious long-term mitigation target. We believe that the Low Carbon Navigator, supported by its transparent dataset and user-friendly interface for presenting the results, can be a useful tool for engaging domestic policy dialogues among various stakeholders and for education purposes of university students and the general public.

What can the Japan 2050 Low Carbon Navigator do?

As a pathways simulation tool, the Low Carbon Navigator can help policymakers as well as the energy producers and consumers (including the public) to understand the energy and emission-related choices that Japan faces. It allows users to develop their own pathway combinations to achieve emissions reduction and ensure energy security based on available resources, technologies and behavioural changes. This transparent and handy tool can help answer the fundamental questions of how the energy system can evolve over the coming decades and its impact on GHG emissions, energy security, energy mix for electricity generation and related costs. It can provide a platform for engaging in dialogues on the challenges and opportunities of the future energy system and the responses to climate change by addressing such critical issues as:

- If there is no nuclear power generation, what will be the energy mix if Japan wants to achieve 80% emissions reduction by 2050? What will be the costs compared with moderately keeping nuclear power in the energy mix?
- If other sectors remain the same, how much CO₂ reduction can be achieved using the most ambitious renewable energy scenarios? At what cost?
- If all demand sectors remain the same, how much CO₂ reduction can be achieved using the most ambitious efforts made by the supply side? At what cost?
- If all supply sectors remain the same, how much CO₂ reduction can be achieved using the most ambitious efforts made by the demand side? At what costs?
- What is the full potential of CO₂ reductions in Japan? At what cost? What does the low-carbon pathway look like?

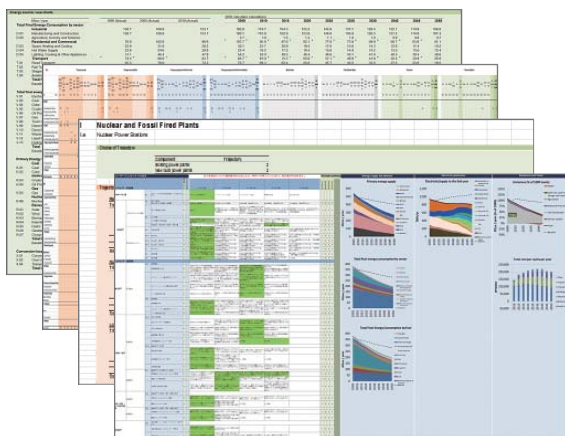
How was the Japan 2050 Low Carbon Navigator developed?

The Low Carbon Navigator was developed following the general model structure of the UK 2050 Pathways Calculator. Several fundamental changes were made to accommodate the actual situation in Japan. These include:

- Japan-specific data on scenario setting, technology specifications, and social and economic indicators are used based on extensive literature review and expert consultation.
- Sectoral coverage is set to reflect Japan's priority sectors for energy supply and demand.
- Five society scenarios for 2050 reflecting future macro-economic and social indicators are set at the top level of the model structure which link with relevant sectoral scenarios for the supply and demand sides.
- For energy supply sectors, five levels of option are set to reflect the level of efforts ranging from no efforts (Level 1), low (Level 2), medium (Level 3) and high (Level 4) efforts and an additional Level 5 for the supply sectors, representing the physical limits of energy resources or technical potential.
- Technology options are provided based on Japan's situation.
- In Japan's Low Carbon Navigator, energy supply is set to match energy demand by adjusting the imports of hydrocarbon fuels and the amount of electricity generation from fossil fuels (coal, oil and gas). In contrast, the UK 2050 Pathways Calculator allows for a large amount of oversupply of energy compared with energy demand based on selected options for energy supply and demand. Energy deficiency caused by selected options is automatically filled by electricity imports in the UK's Calculator setting.
- In the current version of Japan's Low Carbon Navigator, the levels of other air pollutants (PM10, NO_x, SO₂ and NMVOC²) associated with the users' options on energy supply and demand are not included. However, the UK 2050 Pathways Calculator captures these air quality vectors.

What does the Low Carbon Navigator look like?

Two versions of the Low Carbon Navigator, the Excel version and the Web Tool version, were developed (see the website at <http://www.2050-low-carbon-navi.jp/web/en/>). The Excel Spreadsheet model provides the fundamental model, data and calculations based on which the Web Tool was developed.



Excel Spreadsheet



Web Tool

² Non-methane volatile organic compounds.



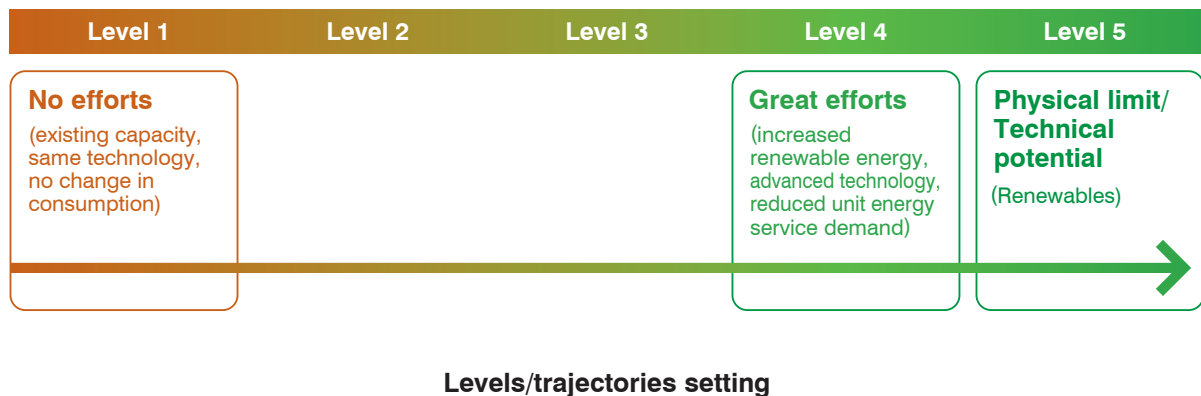
Sectoral coverage

All the supply and demand sectors of the Japanese economy have been considered. Instead of combining the sectors together, the Low Carbon Navigator takes a sector-by-sector approach.

Energy supply sectors	Energy demand sectors
<p>Nuclear and fossil fuel fired plants Nuclear power stations Conventional power plants Biomass</p> <p>Renewables Solar PV Wind (Onshore, offshore and floating) Hydropower (Small & medium and large) Geothermal electricity Ocean power</p> <p>Biomass energy supply Volume of wastes and recycling Bioenergy production and imports</p> <p>Hydrogen production Hydrogen production for transport</p> <p>Refineries Coke production Petroleum refinery Town gas production</p>	<p>Transport Passenger transport Freight transport</p> <p>Residential Space heating and cooling Hot water supply Cooking, lighting and appliances</p> <p>Commercial Heating, cooling and hot water Cooking, lighting and appliances</p> <p>Industry Industrial activity Own power generation Agriculture, forestry and fisheries</p>

Levels setting under the Low Carbon Navigator

For each sector, the Low Carbon Navigator sets out a range of four or five (in the cases of renewable energy and nuclear power generation) trajectories for the types of changes that might occur. These trajectories are intended to reflect the whole range of potential future scenarios that might be seen in that particular sector. In the energy supply sectors these trajectories represent a potential roll-out of energy generation infrastructure. This is slightly different for the nuclear sector where other considerations such as a nuclear restart policy have been taken into account. For the energy demand sectors, the trajectories represent the behavioural and technological changes. In general, these trajectories are described as “levels” as they indicate scales of change. However, for certain sectors, such as nuclear power stations or domestic and freight transport, the changes indicate choices rather than scales, and therefore are described as “trajectories” or “options”.



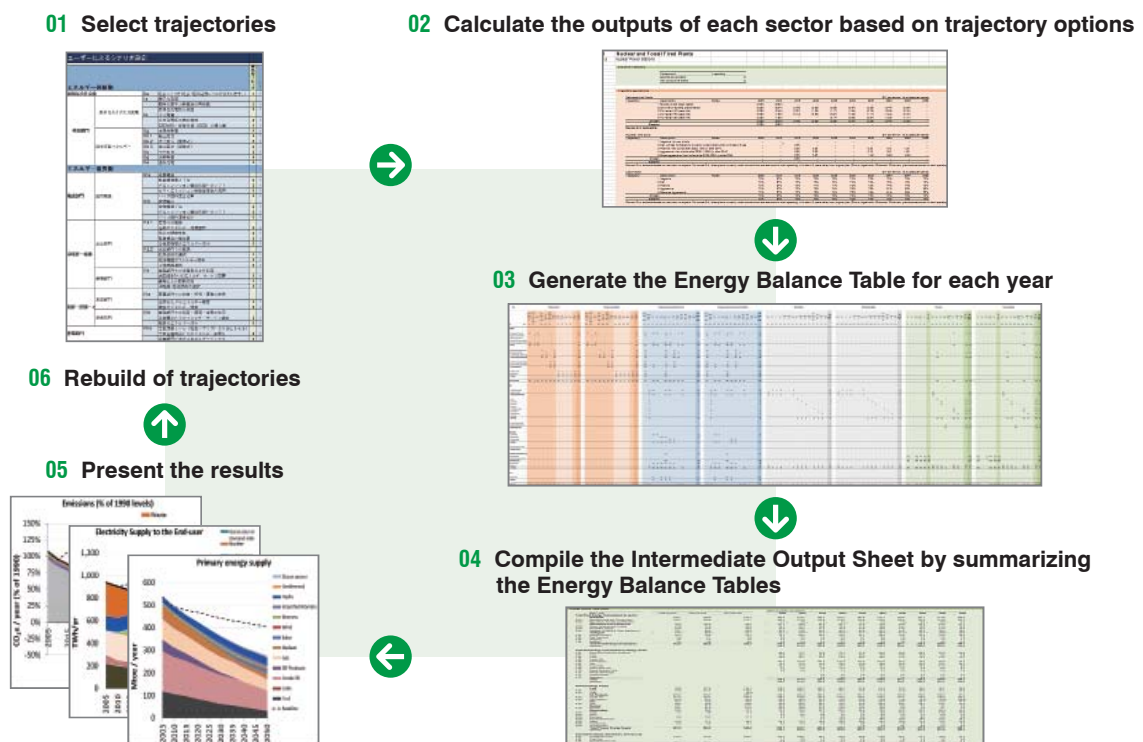
Levels/trajectories setting

The levels/trajectories have been set up on the basis of progressively higher efforts toward transition to a low-carbon society. For example, Level 1 represents low effort and continuation of existing capacity, technology and no change in consumption behaviour, whereas Level 4 represents great effort leading toward increased use of renewable energy, advanced technology, and reduction of energy service demand. For nuclear power generation and renewable energy, Level 5 is added to represent the physical limits or technical potential of energy supply from that particular energy source. For details, please see the research report on “Japan 2050 Low Carbon Navigator: Overview and Trajectory Setting” (available at <http://www.2050-low-carbon-navi.jp/web/en/>).

Calculation procedure

The Low Carbon Navigator follows a six-step calculation procedure. Using the Excel Spreadsheet model as an example, the calculation procedure is explained as follows:

- Step 01:** The users select their 2050 society scenarios and sectoral trajectories for both supply and demand sectors to form one low-carbon pathway (see details in the model structure).
- Step 02:** Sectoral sheets then calculate the outputs based on user trajectory selections.
- Step 03:** Energy balance sheets for each defined years (2010, 2015, 2020, 2025, 2030, 2035, 2040, 2045 and 2050) are generated based on sectoral outputs.
- Step 04:** A summary sheet is compiled by compiling all yearly energy balance sheets.
- Step 05:** Results are presented in charts based on the summary sheet for primary energy supply, total final energy consumption, energy mix for electricity generation, emissions and total additional costs.
- Step 06:** The users modify their trajectory selections to simulate another low-carbon pathway.



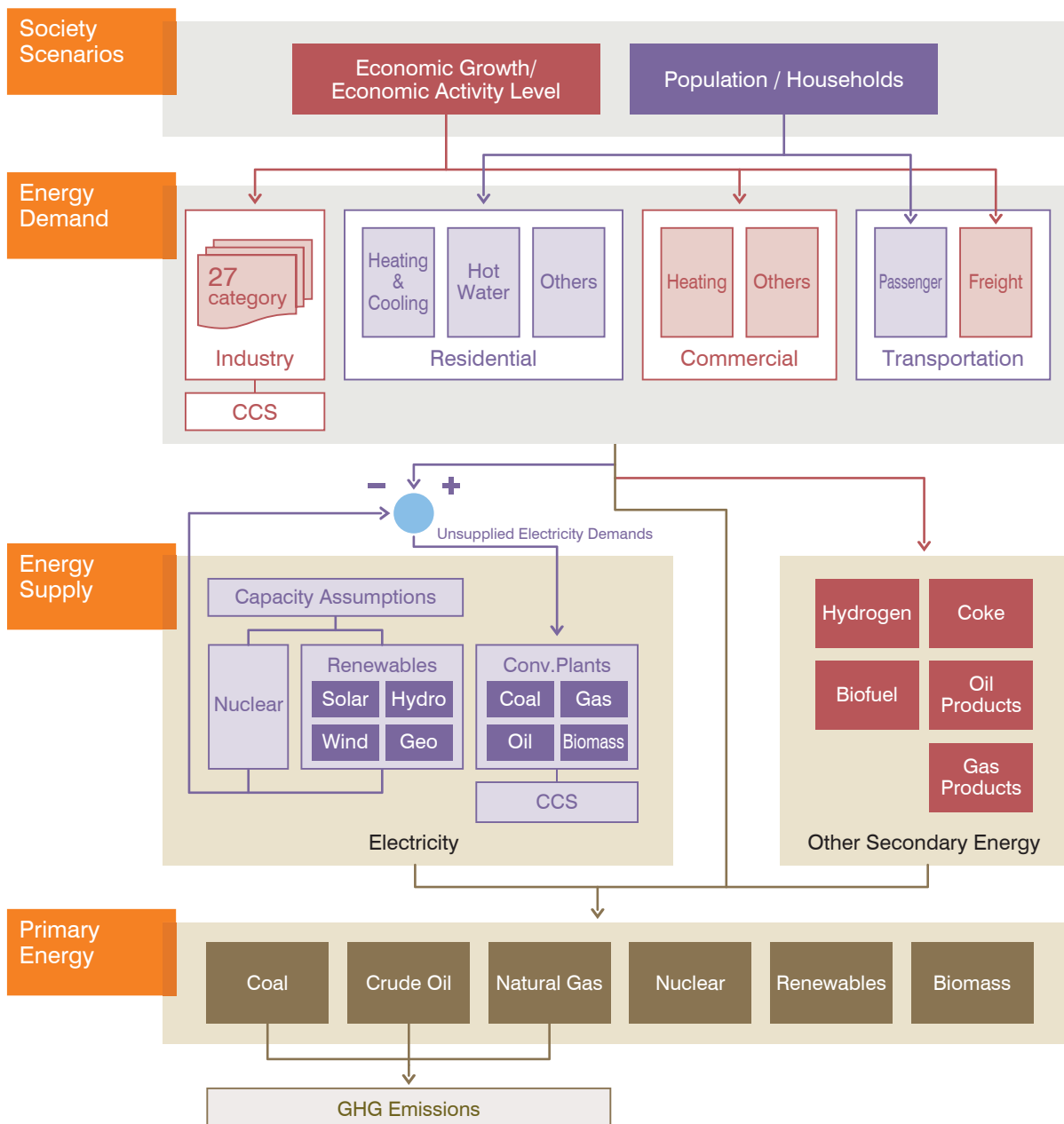
Calculation procedure



Structure of the Low Carbon Navigator model

The structure of the model is depicted in the figure below.

- First, at the top of sectoral trajectory setting are the five society scenarios based on which economic indicators in terms of GDP growth and sectoral output levels and social indicators in terms of population size and number of households, etc. will be determined. The society scenarios setting will then impact on energy demand sectors. In particular, the GDP growth and sectoral output levels are linked with industrial sectors, freight transport sector and commercial sectors, while the population size and the number of households are linked with residential sectors and the passenger transport sector.



Model structure

- Second, for energy demand, four categories of energy end users are considered, i.e. industry, residential, commercial and transport sectors. The activity levels of each sector, consumption behaviours, technology penetration (technology options) and energy efficiency advancement, etc. will influence the sectoral outputs in terms of energy demand, GHG emission levels and corresponding additional costs per person.
- Third, for energy supply, secondary energy supply including electricity generation and other secondary energies are included in the model. Electricity is generated from conventional power plants using fossil fuels and biomass, nuclear power plants and renewable energy. Other secondary energies include hydrogen production, biofuels, and refinery products.
- Fourth, primary energy resources include hydrocarbon energy carriers (coal, crude oil and natural gas), nuclear energy, renewable energy, and biomass.
- Both primary energy and secondary energy transformed from primary energy will be provided to satisfy energy demand. Emissions are generated from fossil fuel combustion influenced by way of energy supply and energy demand levels.

How to install and start up the Excel Spreadsheet model

- i) If you install from the Internet (available at <http://www.2050-low-carbon-navi.jp/web/en/>), find “Excel Spreadsheet version”, click the icon of the Excel Spreadsheet model, download the Excel file and save on your PC. If you use USB or CD, please copy the Excel file and save on your PC.
- ii) Open the Excel file.
- iii) Find the “Control” sheet, click and open.
- iv) From the manual bar, you can select “Formulas” and click, and then select “Calculation Options” and click on “Manual”. This will deactivate automatic calculation unless you presses “F9” on the keyboard to enable the calculation.
- v) On the “Control” sheet, you can select your own choices for the trajectory setting of the society scenarios and for each sector of the demand side and the supply side.
 - **Columns A-D:** Given definition of technology, energy efficiency, and behavioural drivers influencing sectoral trajectory settings;
 - **Column E:** Levels of efforts which require the users to input;
 - **Column F:** The upper limits (most are 4 or D with some exceptions set as 5 or E and 2) set for each corresponding selection in Column E;
 - **Columns H-L:** Explanations on the level setting for Column E;
 - **Columns T-AD:** Calculation results of energy supply and demand including three figures, i.e. Primary Energy Supply, Total Final Energy Consumption by Sector and Total Final Energy Consumption by Fuels;
 - **Columns AF-AP:** Calculation results of electricity generation;
 - **Columns AR-BB:** Calculation results of emissions and costs including two figures, i.e. Emissions as % of 1990 levels and Total Costs Per Capita Per Year in Japanese yen valued for the year 2010.




- vi) You can select one among several options provided in Columns H-L and then input the value of selection (e.g. 4) into the corresponding cell in Column E. For Society Scenarios (Cell E5), you can select among A, B, C, D and E. For other sectors except for renewable energy (Solar PV, Onshore Wind, Offshore Wind, Floating Wind, Small-Medium Hydropower, Geothermal Electricity and Ocean Power) and Existing Power Plants of Nuclear Power Stations, values can be inputted as decimals (e.g. 1.2 for Fuel Mix for Conventional Power Plants for Cell E10, or 2.5 for Passenger Transport Behaviour for Cell E21). For renewable energy (Cells E12-18) and Existing Power Nuclear Power Stations (Cell E5), values inputted as decimals are allowed only for the range from 1 to 4, but not allowed for the range from 4 to 5. For the range from 4 to 5, only the value “5” can be selected.
- vii) Upon the completion of all selections required for Column E, press F9 on the keyboard. The Low Carbon Navigator will calculate based on your selection. You can find the information on the status of calculating in terms of percentage of completion on the right of the bottom bar. Upon 100% completion of the calculation, the results will be shown on the right side in Columns T-AD, AF-AP, AR-BB.

How to access and use the Web Tool

- i) Connect to the internet;
- ii) Type in the website address: <http://www.2050-low-carbon-navi.jp/web/en/>;
- iii) Find “Web Tool version”, click the icon of “Web Tool”, and open the web page of Low Carbon Navigator;
- iv) Select between 1 to 5 for the Society Scenario setting on the top;
- v) Switch to different pages on Energy, Electricity, Security, Flows, Costs and Share by clicking on the top bar under the Society Scenario selection;
- vi) On the lower part of each page, you can select your own sectoral choices from Level 1 to Level 4 for (or Level 5 for many of energy supply-related sectoral setting). On the left side are energy demand-related levers and on the right side are energy-supply related levers. Upon the completion of selection, the results calculated based on your unique sectoral selections will then be presented immediately on the upper part of the webpage.
- vii) When you make your sectoral selections on one of the webpages, e.g. the Energy page, the same selections will be reflected on all other pages (i.e. Electricity, Security, Flows, Costs and Share). If you want to change your selections on another page (for example, Electricity page), the same changes will be reflected on all pages again.

Several functions designed for the convenience of the users include:

- On the left of the available Society Scenarios as well as each sectoral scenarios, there is a question mark , and if you click this, the descriptions on the sector and trajectory settings will appear in PDF.
- If you move your cursor over one of the sectoral scenarios, e.g. Level 1 of the New Build Nuclear Power Plants under Electricity Supply of the Energy Page, a message box of “Negative: No new builds” will pop up.
- If you move your cursor over the title of the sectoral factors, e.g. “New Build Nuclear Power Plants”, and stay on this, the results of the selection from Level 1 to Level 5 will be shown on the upper figure of Primary Energy Supply one by one.

Caveats for using the Low Carbon Navigator

Several caveats need to be noted when using the Low Carbon Navigator.

The Low Carbon Navigator demonstrates the scale of changes that are likely to be required for Japan to make the transition to a low-carbon economy, as well as the choices/trade-offs available to the country. However, it does not make predictions or projections for the future. In other words, while the Low Carbon Navigator is helpful in exploring a range of available pathways, none of these generated pathways should be prejudged as optimal.

The Low Carbon Navigator does not adopt a cost-optimization approach. Instead of focusing on identifying the least-cost pathway to meet Japan's 2050 emissions reduction target, it looks at what might be achievable in each of the covered sectors under different assumptions. Nonetheless, the Low Carbon Navigator does acknowledge the significance of costs in making choices. It allows the users to see the incremental cost to society of their chosen pathways, and make sensitivity analysis by comparing the costs of their selected pathways with other pathways.

The model has been developed focusing exclusively on Japan and its options for GHG emissions reduction and energy security. It includes associated data (but no trajectories) on the imports of bioenergy and hydrocarbons to Japan and the exports of petroleum and petrochemical products from Japan. Additionally, this model considers emission credits for bioenergy but does not provide trajectories. It does not include emissions from international aviation and shipping assigned to Japan.

The underlying data for the Japan 2050 Low Carbon Navigator comes from various sources including government documents and scientific literature. The model describes how the trajectories might look like under various assumptions. Relevant developments, such as the 2011 Fukushima nuclear accident and the renewed focus on alternative and renewable energy sources, have been taken into consideration. Thus the analysis under this model looks at what might be possible to deliver in the coming years up to 2050, but does not propose or identify the required policy decisions to ensure this future. In other words, the Low Carbon Navigator does not provide a detailed policy framework and the trajectories should not be considered as projections based on policy decisions.

Example pathways

We present two example pathways to explain how to understand and interpret the results from the Low Carbon Navigator. The first pathway demonstrates what is likely to happen if no effort is made in mitigating emissions and combatting climate change, while the second one shows what could happen if Japan puts great efforts toward transitioning to a low-carbon society. For both pathways, the Society Scenario is selected as "Research and Development (R&D)" society, under which the population size will be 95 million; the number of households will be 49.8 million; and GDP growth rate will be 0.9% and per capita GDP growth rate will be 1.6% in 2050.

2050 Society scenario: R&D; Population: 95 million; No. of Households: 49.8 million;
Average GDP growth rate: 0.9% per year; Per capita GDP growth rate: 1.6% per year

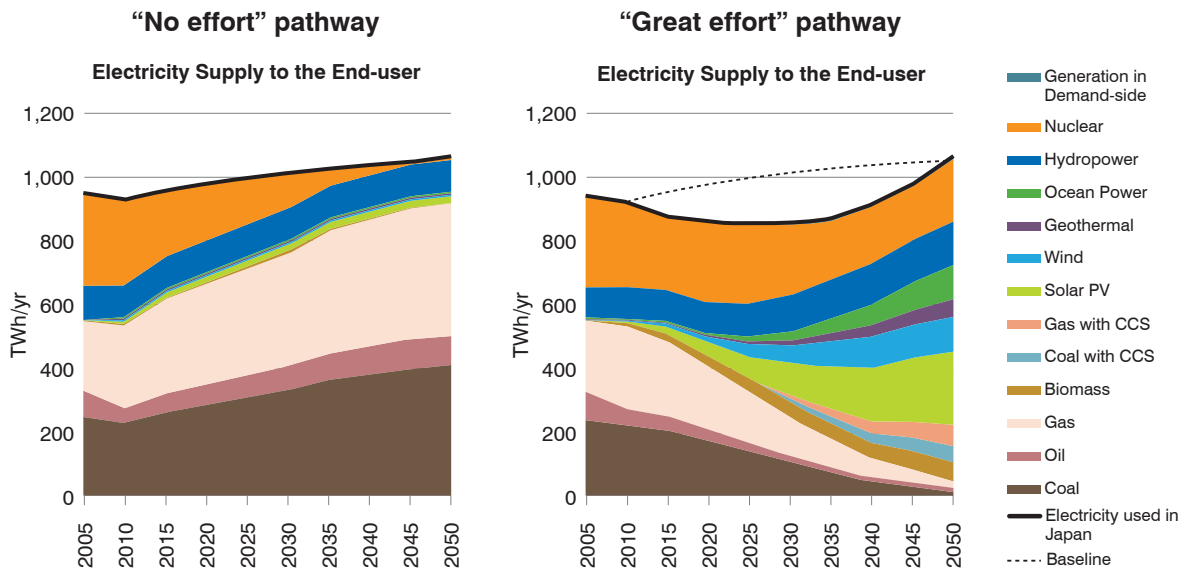
	No effort pathway	Great effort pathway
My choice	All Level 1 setting, except for the restart of existing nuclear capacity (Level 3)	All Level 4 setting.



Under the “No effort” pathway, all the sectors are locked at the Level 1 setting, reflecting the continuation of existing capacity, technology and no change in consumption behaviour. There is an exception for the restart policy of existing nuclear capacity, which is set at trajectory 3 (where Japan only allows all existing nuclear plants with a 40 year lifespan to operate). In the “Great effort” pathway, all the sectors (including the nuclear lever on restart policy) are locked at the Level 4 setting, reflecting increased use of renewable energy, advanced technology, and reduction of energy service demand.

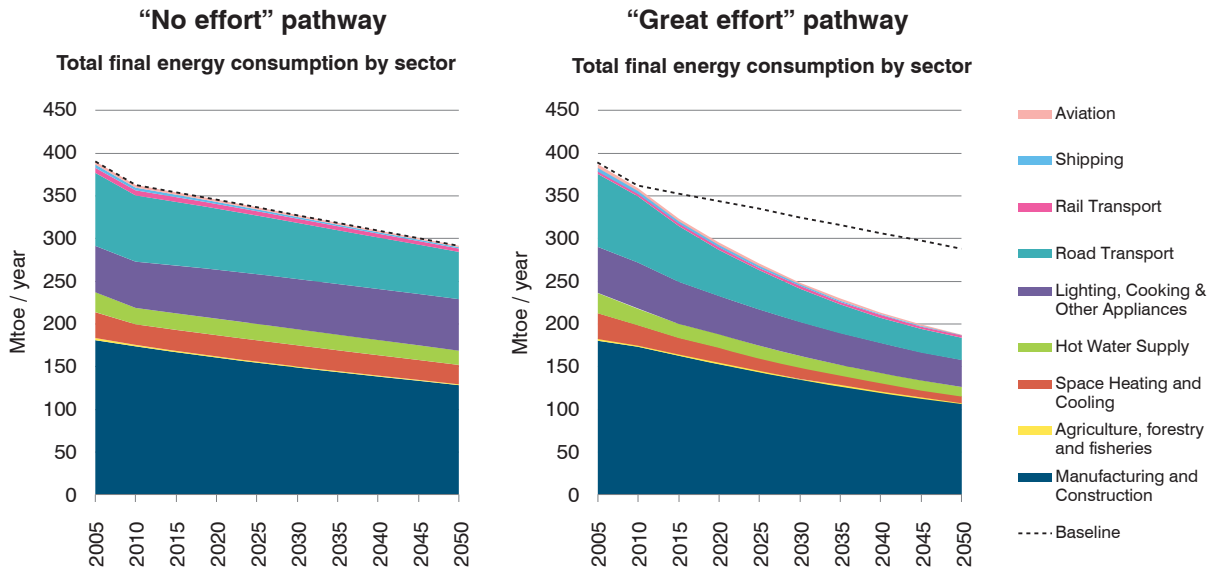
Results: Energy mix for electricity generation

Energy mix varies significantly under the two scenarios. In “No effort” pathway, the use of fossil fuels, particularly gas and oil, increases over the years. This is particularly because Japan’s nuclear capacity gradually decreases and reaches zero in the 2040s. On the other hand, in the “Great effort” scenario, Japan still generates a significant amount of electricity from nuclear sources. In addition, the share of all the renewables increases significantly whereas the use of fossil fuels as well as biomass gradually comes down to zero. This shift to renewable energy sources will facilitate the development of a low-carbon economy in Japan.



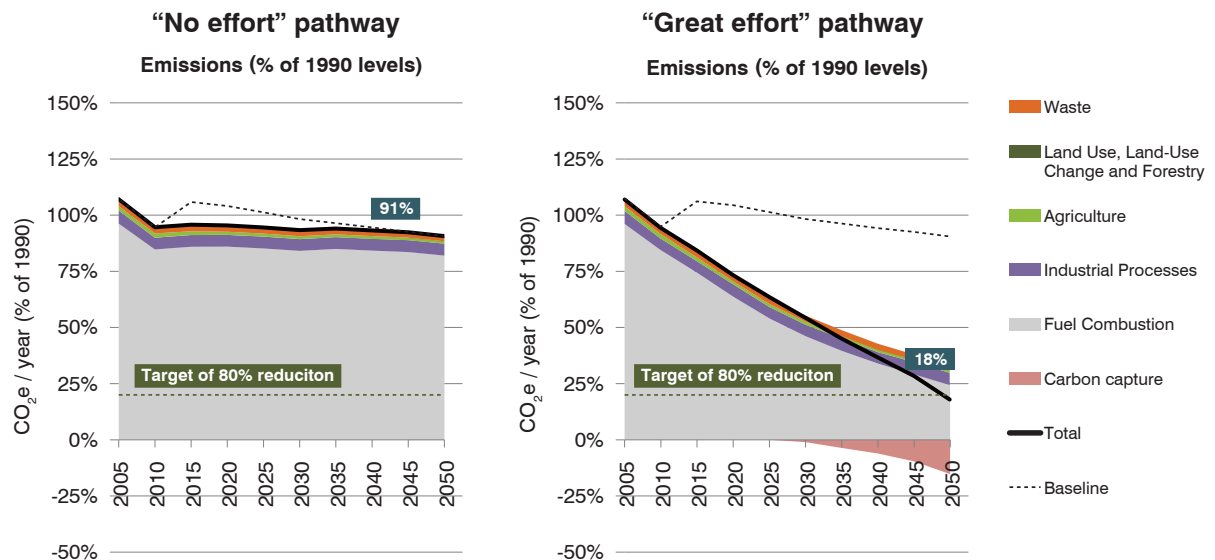
Results: Energy used by end consumers

The overall total of final energy consumption reduces over the years until 2050 under both pathways, but the degree of reduction is significantly higher under the “Great effort” scenario. A combination of factors, including policy intervention, efficiency enhancement as well as behavioural change, is reflected in this reduction of energy consumption. In terms of comparison among the sectors, major changes are seen in energy consumption for road transport and space heating and cooling. More and more people will use public transport such as buses, and nearly 100% of the privately-owned vehicles will be zero-emission ones. For space heating and cooling, the changes are due to both enhance efficiency of appliances and people’s habitual changes in using these appliances.



Results: GHG Emissions

Under the “No effort” scenario, Japan is far from achieving its committed 80% reduction of GHG emissions. Emissions are reduced only in a limited manner, reaching around 90% of 1990 levels. On this pathway, Japan is stuck with frozen technology, and consumption patterns do not change much. The reduction is basically due to the reduced size of the population. On the other hand, thanks to the efforts by policymakers as well as by the Japanese people, the country can achieve dramatic reductions from the 1990 levels. The use of low-carbon technologies significantly enhance efficiency and reduce emissions.



A simulation tool helping communications among various stakeholders regarding energy-secured and low-carbon society and educating people to take action

We believe that the Low Carbon Navigator can be a handy educational and communication tool that will not only help the general audience to better understand the situation, but also assist policymakers in the consultation and decision-making processes.

We hope you will join us in the exploration of low-carbon pathways for Japan by using the Low Carbon Navigator.

Your comments on the improvement of the tool and contribution of your pathways are very much appreciated.

Information

- > For accessing to the Web Tool version: <http://www.en-2050-low-carbon-navi.jp/>
- > For downloading the Excel version: <http://www.2050-low-carbon-navi.jp/web/en/>

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