Japan’s emission pathways in the context of the 2°C goals and their implications for the mid-century strategy

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Japan’s Mid-century strategy

• Japan submitted the MCS to the UNFCCC in June 2019
• “Proclaiming a “decarbonized society” as the ultimate goal and aiming to accomplish it ambitiously as early as possible in the second half of this century, while boldly taking measures towards the reduction of GHGs emissions by 80% by 2050.”

• Research questions
  ✓ Is the 2050 goal consistent with the global climate goal?
  ✓ When does the decarbonized society need to be attained?

• Climatic Change Special Issue
  Oshiro et al. 2019 https://doi.org/10.1007/s10584-019-02490-x
CD-LINKS national scenario assessment

- Multi-model analysis on national pathways under the WP3 of CD-LINKS
- Linking global and national mitigation scenario based on carbon budget
- Multi model analysis: 2 national and 7 global models

Global budgets

- Global carbon budgets
- Global emission pathways

National budgets

- Regional carbon budgets (2011-2050)

National models

- Cost optimal

Global models

- Multi-model analysis on national pathways under the WP3 of CD-LINKS
- Linking global and national mitigation scenario based on carbon budget
- Multi model analysis: 2 national and 7 global models
## Model

<table>
<thead>
<tr>
<th>Model</th>
<th>Institution</th>
<th>Regional coverage</th>
<th>Model type</th>
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<tr>
<td>AIM/CGE</td>
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<td>AIM/Enduse [Japan]</td>
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<td>GEM-E3</td>
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</table>
Scenarios for Japan scenario analysis

- Mid- to long-term policy dimension: high- and low-budgets
  - Global models: 1000 and 1600 Gt over 2011-2100
  - National models: 31 and 36Gt between 2011-2050 in Japan

- Near-term policy dimension
  - No Policy
  - NPi: policies to limit emission budgets starts after 2020
  - NDC: policies to limit emission budgets starts after 2030

<table>
<thead>
<tr>
<th>Scenario</th>
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<td>NDC1000</td>
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<tr>
<td>NPi1000</td>
<td>NPi</td>
<td>Low: 31</td>
</tr>
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</table>
Near-term national policies

- Some near-term national policies are also taken into consideration in the NPi/NDC scenarios
  - e.g. Energy mix in the Japanese NDC
- Longer-term assumptions are left to each model
  - Nuclear, CCS, etc.

Results: National cumulative emissions

- The median meets the national budgets in the first half of this century (31 and 36 Gt-CO$_2$), but there is large uncertainty range across the models.
- According to the global models, emission budget over 2051-2100 would be negative in Japan in the low-budget scenarios.

![Emission budget in the first and second half of this century in Japan](image-url)
Emission pathways

- Narrow emission gap in 2030 between the NDC1600 and NPi1600 scenarios: Japan’s NDC is broadly on track to the high-budget scenarios.

- CO₂ Emissions in 2050 in the low-budget scenarios: -75% (wrt 2010): the 80% goal can be an effective milestone for the global 2°C goal.
Emission pathways after 2050

• In the 1000Gt scenarios, CO2 emissions become net-zero around 2070-2080
• Net negative emission in the second half of this century
NDC-low budget scenario requires drastic change after 2030

- In the low-budget scenario without enhancing the NDC (NDC1000), drastic emission reduction would be required after 2030 (about -6%/year).
- Japan’s economy has experienced such dramatic emission reduction only in the oil-crisis and economic recession.

Average annual rate of changes in CO₂ emissions by decade

Model
- AIM/CGE
- AIM/Enduse(Japan)
- COPPE-COFFEE
- DNE21+(national)
- DNE21+(global)
- GEM-E3
- IMAGE
- POLES
- REMIND-MAgPIE

Scenario
- NoPOL
- NPi
- NDC
- NDC1600
- NPI1600
- NDC1000
- NPI1000
Energy system transformation

- Low-carbon energy share in 2050:
  - high: 45%, low: 54% of primary energy supply
  - high: 86%, low: 97% of electricity supply

Share of low-carbon energies (nuclear, renewable and CCS) in 2030 and 2050

* Primary energy accounting is based on direct equivalent
Development of low-carbon energy sources differs among models

- Low-carbon energy source dependence differs largely among models (e.g., nuclear- or variable renewable energy-dependent)

Development of energy sources between 2010 and 2050

**Primary energy**

**Electricity**
Energy demand sectors

- Large variation among models

Final energy demand relative to 2010 in 2050

Share of low-carbon carriers in 2050
Mitigation costs

- Large gap in the results of carbon prices (about 150-2100 US$/t-CO$_2$ in the NDC1000 scenarios), especially between the national and global models.
- NPV mitigation cost in the low-budget scenarios is doubled or more compared with the high-budget scenarios.

Carbon prices in 2050, and cumulative mitigation cost between 2021 and 2050.
Discussion and caveats

• National carbon budgets and emissions are based on cost-optimal allocation from the global IAMs
  ✓ The number of national carbon budget may differ among different effort-sharing schemes

• In the 1000 Gt scenarios, large-scale net negative emission is required in Japan in the second half of this century.
  ✓ Their feasibility is not assessed by national models in this study.
Conclusions

• The Japan’s MCS (80% reduction in 2050) can be an effective milestone for the global 2°C goal

• In the 1000 Gt scenarios, Japan’s CO2 emission pathways reach net-zero between 2070-2080.

• The key options for decarbonization and their economic implications vary largely among the models.

  ✓ Low-carbon energy in the energy supply, particularly in power sector, was key options in the most models