Assessment of long-term low-emission pathways in Japan using AIM/Enduse [Japan]

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Backgrounds and objectives

• Japan submitted its INDC on July 2015, which is to reduce GHG emissions by 26.0% in 2030 below the 2013 level.

• According to the Plan for Global Warming Countermeasures published on May 2016, Japan aims to reduce greenhouse gas emissions by 80% by 2050 as its long-term goal.

• However, quantitative analysis regarding consistency between the 2030 and 2050 targets is not yet yet provided.

• This study assess emissions pathways by 2050 considering both the 2030 target (NDC) and the 2050 target (long-term goal) using AIM/Enduse [Japan].
Overview of AIM/Enduse [Japan]

- Bottom-up of end-use sectors, hard-linked with energy supply sectors
- Recursive dynamic model
- Minimizing total system costs; capital, O&M, and emission costs

Parameters
- CO₂ price
- Energy prices
- Emission factors
- Demand load curve
- Technical/economic characteristics (Energy efficiency, Capital/O&M costs, Lifetime, etc.)
- Energy/Climate Policies
- Energy service demand

Results
- GHG emissions
- Carbon sequestration
- Sectoral energy supply/demand
- Share of technologies
- Additional total system costs

Primary Energy Supply

- Oil
- Coal
- Natural Gas
- Nuclear
- Hydro
- Solar
- Wind
- Geothermal
- Biomass
- Ocean

Energy Conversion Technologies

- Electricity dispatch module
- Energy conversion modules
  - Oil refinery
  - Gas processing
  - Coal upgrading
  - Heat generation
  - Hydrogen generation

Final Energy Consumption

- Electricity
- Oil
- Coal
- Gas
- Heat
- Renewables
- Hydrogen

End-use Technologies

- Industry
  - Iron & Steel
  - Paper & Pulp
  - Petrochemical
  - Cement
  - Machinery, etc.
- Transport
  - (Passenger, Freight)
    - Vehicles
    - Train
    - Maritime
    - Aviation
- Residential/Commercial
  - Space heating / cooling
  - Water heating
  - Cooking
  - Lighting
  - Appliances
- Non-energy
  - Industrial processes, Agriculture, Waste, etc.
Examples of measures in AIM/Enduse [Japan]

- Wide range of mitigation technologies are included.
- Unlike the NDC, most of measures for energy conservation are excluded. (e.g. behavioral change, modal shift to public transport)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Technologies</th>
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<tbody>
<tr>
<td>Energy conversion</td>
<td>efficiency improvements of power generation; coal and gas with CCS; nuclear power; hydropower; wind power; solar PV; geothermal; bioenergy; ocean; PHS; reinforcing electricity interconnection; Hydrogen generation (electrolysis)*</td>
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<tr>
<td>Transport</td>
<td>fuel economy improvement of ICE, train, maritime, and aviation; NGV; BEV*; PHEV; FCEV; biofuels; eco-driving</td>
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<tr>
<td>Residential/commercial</td>
<td>Improvement of energy-efficiency performance of buildings (e.g. insulation); high-efficiency equipment and appliances; electric heat pump water heaters; electrification for heating, cooling, and cooking; energy-management systems</td>
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<tr>
<td>Industrial (incl. agriculture)</td>
<td>energy-efficiency improvements in industrial processes; CCS for iron making and cement lime; high-efficient boiler, furnace, and motor; industrial heat pump; fuel economy improvements of agricultural machines; bioenergy use; management of nitrogen fertilizer</td>
</tr>
</tbody>
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* BEV, electric water heater, and electrolysis could act as flexible resources to integrate VREs in this version of AIM/Enduse
The 2030 and 2050 target in Japan

- 2030 target: 25.4% reduction wrt. 2005 based on the NDC
- 2050 target: 80% reduction based on the national goal that considers the global 2 degrees goal

* Excluding LULUCF
Cases

1. **Reference**
   No carbon price.

2. **NDC-Extended**
   Implicit carbon prices are implemented to meet the NDC by 2030. Between 2030 and 2050, carbon prices are constant.

3. **NDC-80**
   Implicit carbon prices are implemented to meet the NDC by 2030, and strengthened thereafter toward the 80% reduction by 2050.

4. **Immediate-80**
   Compared with NDC-80, higher carbon prices are implemented by 2030 to the level of around a half of 2050.

5. **No nuclear**
   Meeting both the 2030 and 2050 target without restart of nuclear power.
Assumptions on nuclear power

- Lifetime: Extension to 60 years for the plants built since mid-1980s, 40 years for all others (excluding No-Nuclear case)
- Electricity supply from nuclear power:
  - 232 TWh in 2030 (almost consistent with the assumption of NDC)
  - 184 TWh in 2050
Results: GHG emissions

- Both 2030 and 2050 targets are technically feasible without nuclear power, however rapid reduction is required after 2030.
- Immediate-80 case results 29% reduction in 2030 (wrt. 2005).
- Carbon prices range 600-740 US$/t-CO2 in 2050 to meet the 2050 target.
Results: GHG emissions by sector

- Residential and commercial sectors are almost decarbonized in 2050 to meet the 2050 target.

GHG emissions by sector (direct + indirect)
Results: Primary energy mix

- Energy efficiency and low-carbon energies are key options
- Share of low-carbon energies (NDC-80):
  - 12% in 2030, 59% in 2050
- Innovative technologies such as CCS could be important options by 2050
Results: Electricity supply

- Renewables account for 23% in NDC-80, 30% in Immediate-80 in 2030. In 2050, electricity is almost decarbonized.
- Integration of variable renewable energies (VREs) is a challenge after 2030.
Final energy consumption

- Energy efficiency continues to be a key option by 2050
  - Around 10-11% in 2030, 43% in 2050 (wrt. 2010)
- Electrification is another challenge, especially after 2030.
  - Around 28% in 2030, 46% in 2050

Final energy consumption by sources

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Conclusions

• Japan’s NDC would be effective to consolidate a transition from the baseline trajectory, by improvement of energy efficiency and deployment of low-carbon electricity.

• The 80% target by 2050 requires significant electrification in end-use sectors as well as the acceleration of energy efficiency and decarbonization of electricity between 2030 and 2050.

• The implementation of NDC is meaningful, however, rapid transformation of energy systems would still be required to meet the national long-term goal.