Energy security performance in Japan: past and future

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Introduction

Situation of Japan

- Self-sufficiency rate of energy in 2013: 6%.
- High dependence on fossil fuels: more than 80% of energy supply before the Fukushima Daiichi nuclear disaster; and now more than 90% (only one nuclear power plant is in operation).
- Import of fossil fuels: mostly from politically unstable Middle East

- More difficult to rely on cheap imported fuels in the near future (increasing energy demand in emerging countries (e.g., China and India)).

  -> Producing own energy sources and reducing dependence on energy import are essential.

- Nuclear energy was considered essential to reduce dependence on fossil fuels.

  -> Fukushima nuclear disaster changed the situation, due to the safety issues of using nuclear energy.

Energy strategy and policy

- Renewable energy
  - One of the most important elements in securing national energy supply (and solving other environmental issues).
  - Still accounted for only a small percentage of total primary energy supply (except for hydropower) , though multiple national policies have been introduced.
  - After the FIT scheme (in 2012), the share increased larger than the historical trend.
- The Basic Energy Plan in 2014
  - Completely revised the energy strategy of Japan, particularly reducing dependency on nuclear power.
  - The policy prioritizes energy security, but also considers economic efficiency and the conservation of the environment, all with a strong focus on safety (3E+S).

Challenges

- The main challenges of energy policies toward a sustainable society:
  - No best energy mix defined in the Basic Energy Plan.
  - No numerical targets for renewable energy (though need to increase the share of renewable energy)
  - Coal-thermal power still considered an important baseload power.
  - Unclear position of the government regarding nuclear power
  - Energy structure closely relates to energy security (energy imports)

Purpose of this study

- Evaluation of energy security performance in Japan from the history to the future, using comprehensive energy security indicators.
  - Long-term historical analysis is important to understand what contributes for improving energy security.
  - Scenario analysis for the future can show how energy mix that considered under energy policy or scenarios in Japan can contribute (or not contribute) to improve energy security.

Methods

Energy security indicators

- $S1 = -\sum_{i=1}^{N} p_i \ln(p_i)$

- $S2 = -\sum_{i=1}^{N} c2_i p_i \ln(p_i)$
  - $c2_i = \left(1 - m_i \left(1 - \frac{S_{i2}^m}{S_{i2}^{max}}\right)\right)$
  - $S_{i2}^m = -\sum_{j=1}^{M} m_{ij} \ln(m_{ij})$
  - $S_{i2}^{max} = -M \frac{1}{M} \ln(\frac{1}{M})$

- $S3 = -\sum_{i=1}^{N} c3_i p_i \ln(p_i)$
  - $c3_i = \left(1 - m_i \left(1 - \frac{S_{i3}^m}{S_{i3}^{max}}\right)\right)$
  - $S_{i3}^m = -\sum_{j=1}^{M} A_j m_{ij} \ln(m_{ij})$
  - $S_{i3}^{max} = -M \frac{1}{M} \ln\left(\frac{1}{M}\right)$
  - $A_j = \frac{r_j}{\max_j r_j}$

i: types of primary energy
j: origin of primary energy imports
p: share of primary energy
m: share of imports
r: risk indicator
N: the number of primary energy types
M: the number of the origin of primary energy imports

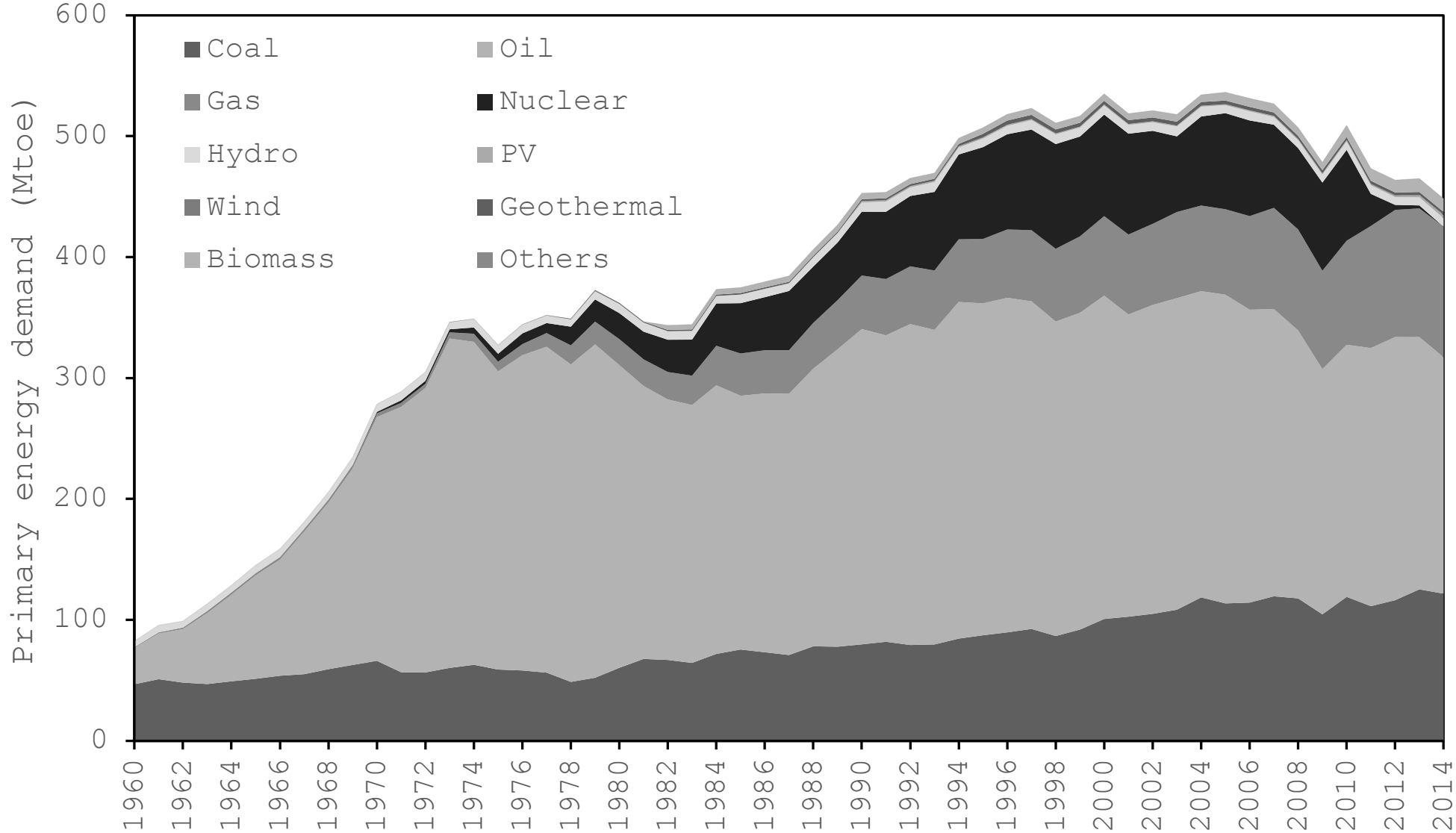
Historical data (past)

- Years for analysis: 1978-2014
- Energy types: 10 types

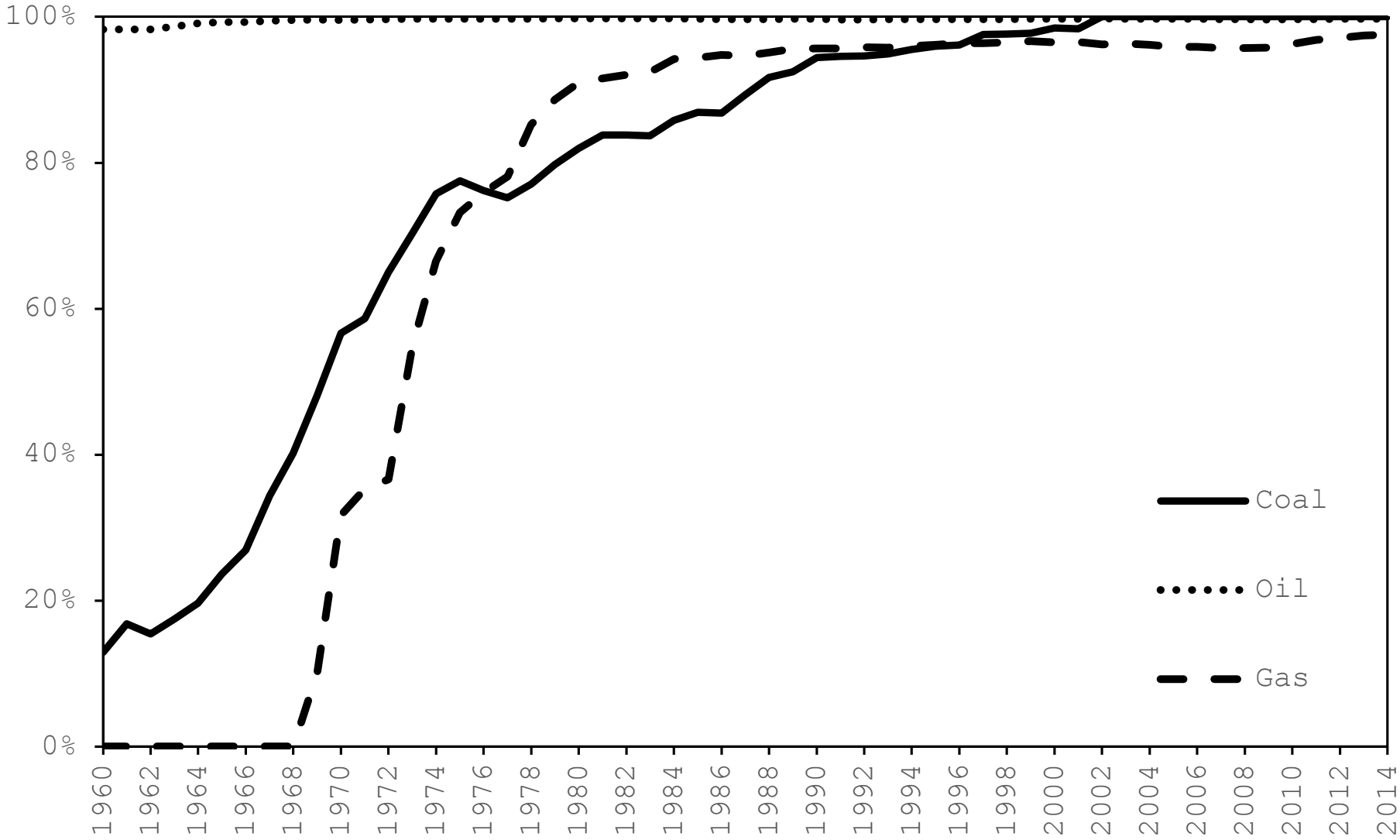
- Data sources:
  - Primary energy p_i: Energy Balances of OECD Countries (IEA)
  - Primary energy imports by origin m_{ij}: Coal Information, Oil Information, Natural Gas Information (IEA)
  - Risk Indicator r_j : World Governance Indicators (WB)

- Notes
  - Natural gas imports by origin lacks before 1992 -> data on 1993 is applied to before 1992
  - Risk indicator lacks before 1995 -> data on 1996 is applied to before 1995

Primary energy demand in Japan



Japan’s dependence on import (fossil fuels)



Source: IEA (2015b)

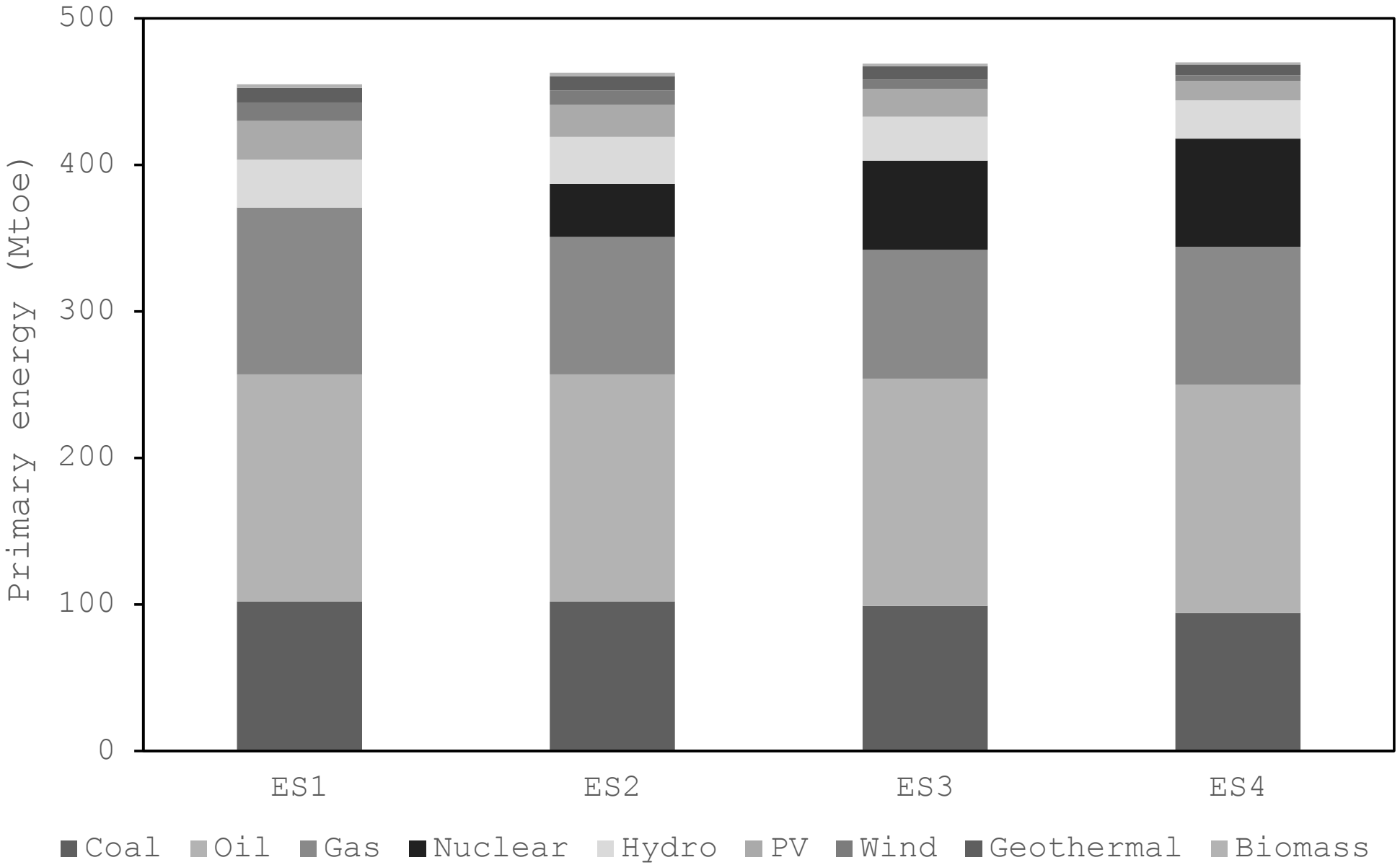
Scenario analysis (future)

- Year for analysis: 2030
- Energy types: 9 types (the share of “others” in historical data is very small)

- Scenarios: four scenarios developed by the Institute of Energy Economics, Japan

		ES1	ES2	ES3	ES4
Power generation mix	Renewable energy (%)	35	30	25	20
	Thermal (%)	65	55	50	50
	Nuclear (%)	0	15	25	30
	Power generation (PWh)	1.1	1.2	1.2	1.2
Economy	Power generation costs (JPY/kWh)	21.0	19.0	16.4	14.8
	Real GDP (trillion JPY)	684	690	693	694
Energy	Self-sufficiency ratio (%)	19	25	28	28
Environment	CO_2 emissions (percent change from 2005 level)	-20	-24	-26	-26
Source: IEEJ (2015a,b)					

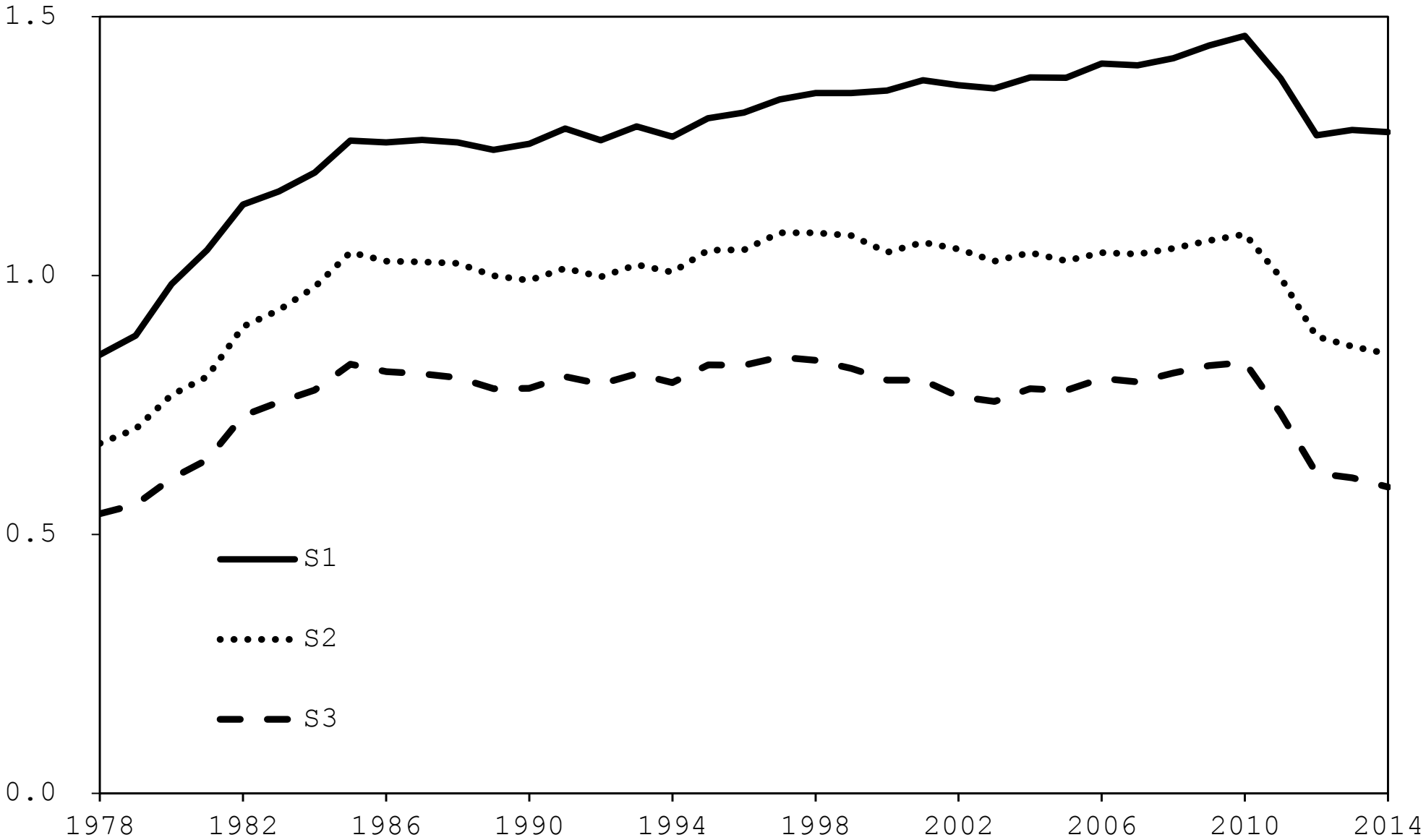
Primary energy structure under IEEJ's scenarios



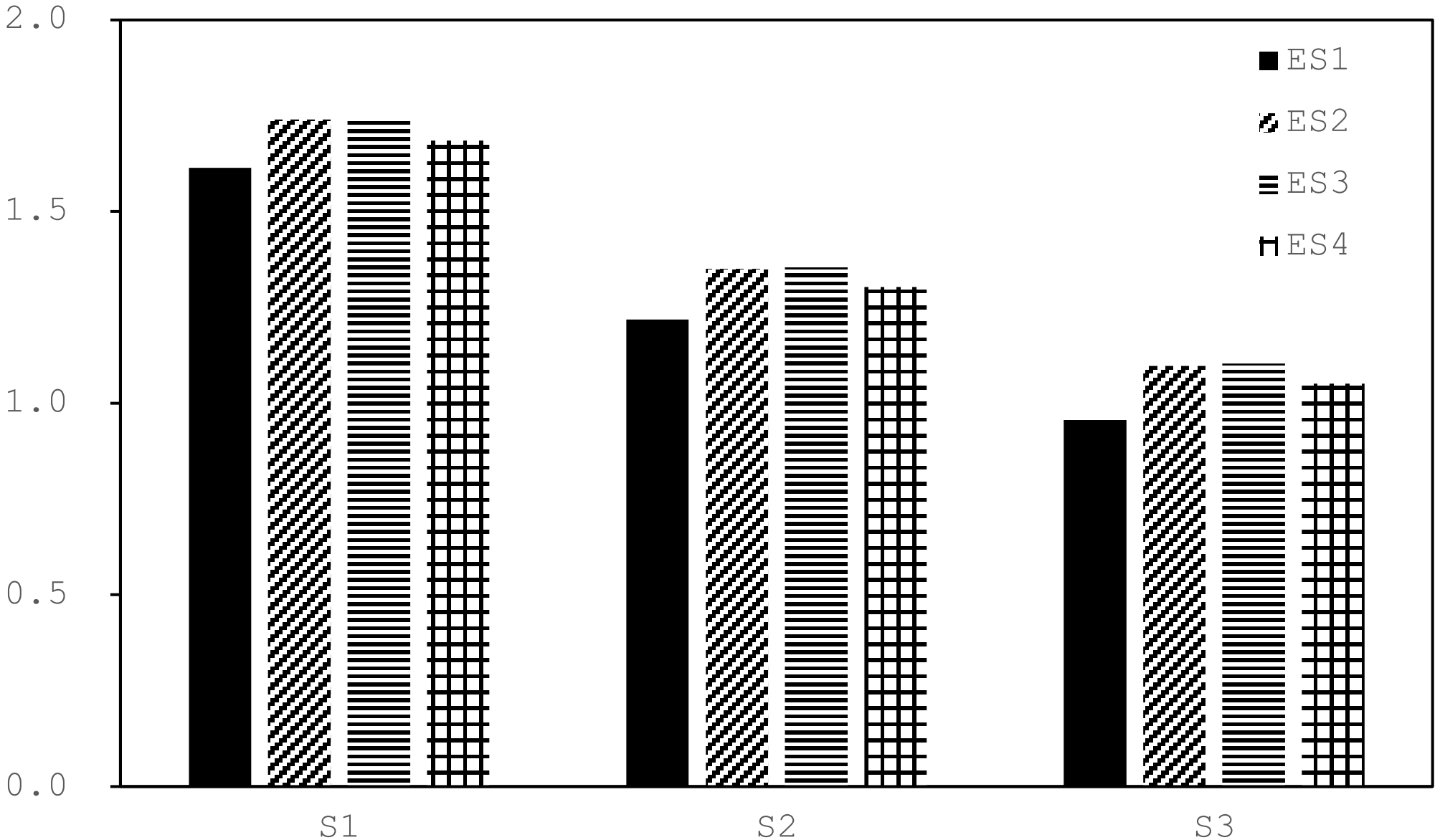
Source: IEEJ (2015a,b)

Results

Historical energy security performance in Japan



Future energy security performance under IEEJ's scenarios



Conclusions

Summary

- The historical analysis showed that
  - Energy security performance improved over time.
    - The indicators S2 and S3 were almost flat from the late 1980s to the early 2010s.
  - Energy security declined from 2011 due to the Fukushima nuclear disaster.

  -> Diversity of primary energy sources, including nuclear power, is important for high energy security performance.

- The scenario analysis showed that
  - Energy security will improve under the future scenarios.
  - Energy balances mentioned above and energy saving can improve the energy security performance of Japan compared to the historical situation.

Suggestions to further improve energy security

- Increasing the share of renewable energy
  - Balancing primary energy structure
  - Decreasing dependence on imported fossil fuels
  - increases of stable renewable sources (e.g., medium- and small-hydro, biomass, and geothermal power) to avoid unstable power supply
  - Introducing energy storage systems to reduce unstability, although need additional cost.
- Balancing the origin of imported energy and reducing imports from high-risk countries
  - Affecting only the indicators S2 (only the former) and S3.
- Reducing energy demand (energy saving)
  - Reducing energy supply from fossil fuels: balancing primary energy sources, balancing the origin of energy import, and reducing energy imports from high-risk countries.