GPES | Graduate Program on Environmental Sciences

THE UNIVERSITY OF TOKYO

Japan's Energy Policy

-A cost-benefit analysis of restarting Japan's nuclear

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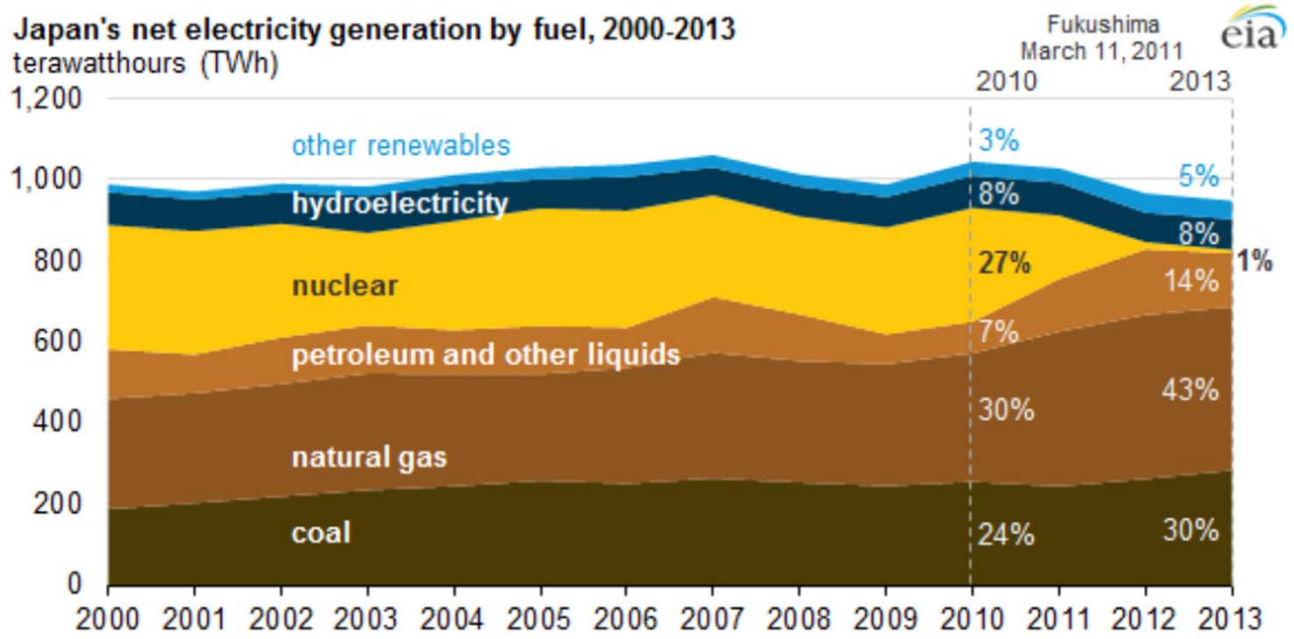
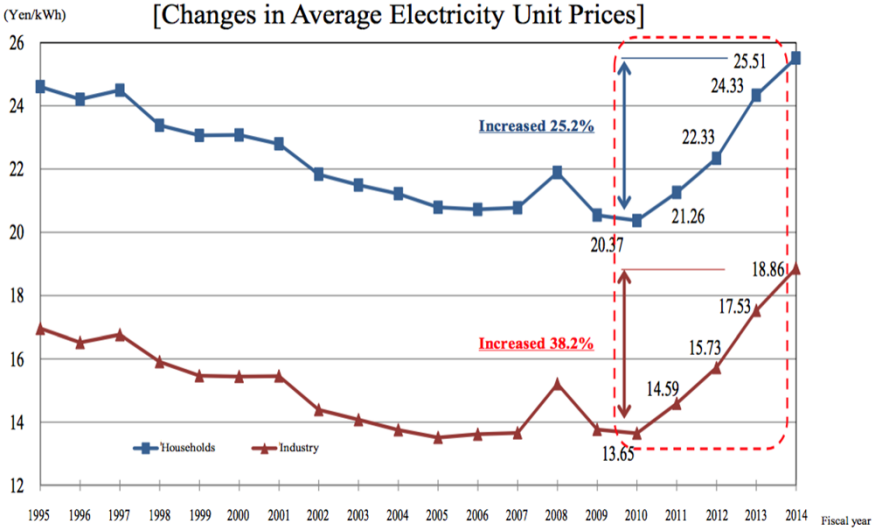
1.Introduction



Source: U.S. Energy Information Administration

- **Economic impact of shutdowns**

Increased fuel cost:
12.4 trillion Yen from
FY2011 to FY2014



Source: Based on *Electricity Demand Report*, Federation of Electric Power Companies in Japan and the materials concerning the power companies' final settlement reports

- **Climate change effects**

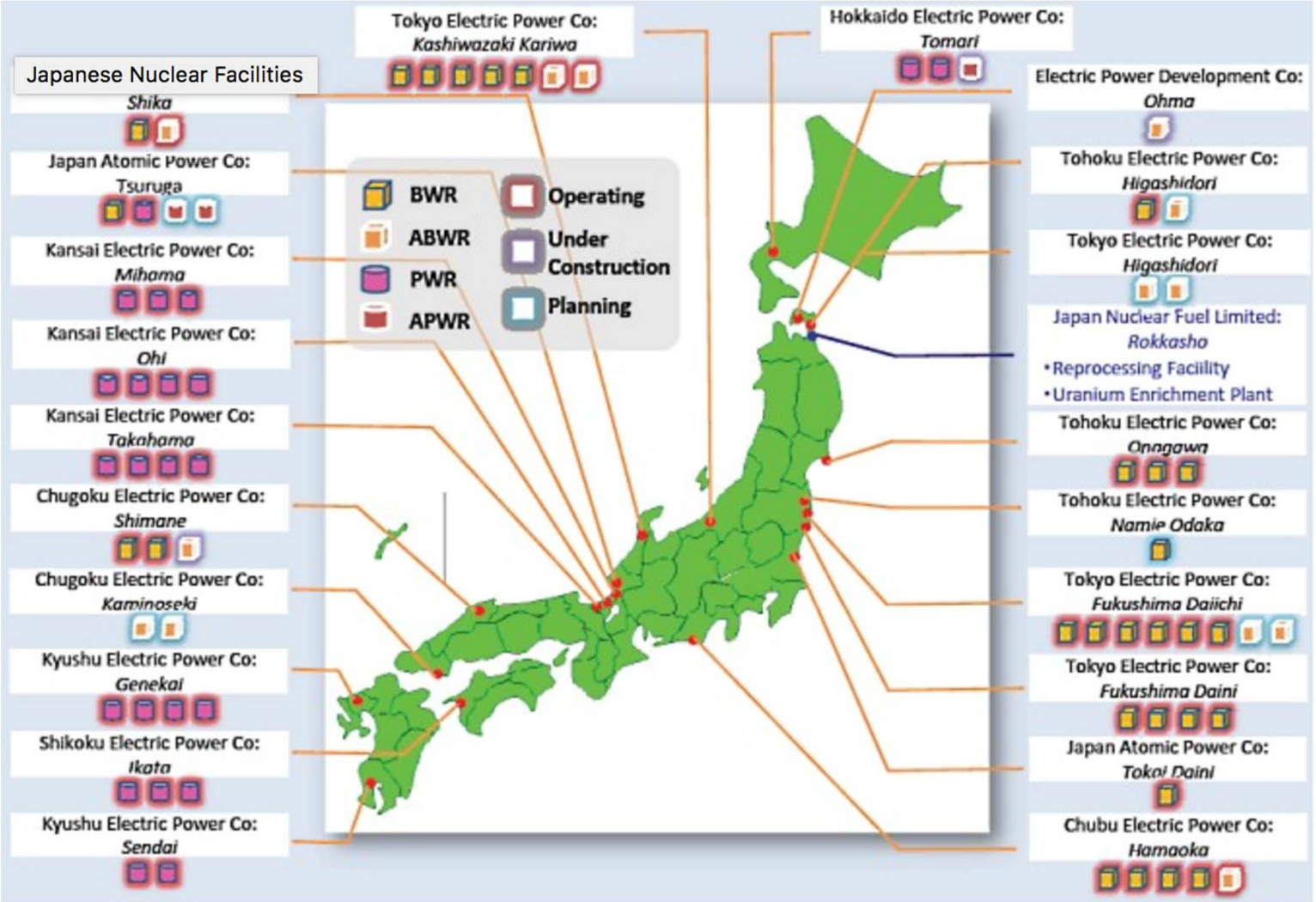
CO_2 intensity of power generation :350 g/kWh up until March 2011 to 487 g/kWh in FY2012

Climate change goal: Reduce CO_2 emissions 26 percent below 2013 levels by 2030 (INDC target, 2015)

Japan Nuclear Facilities

42 reactors are operable

Source: World Nuclear Association



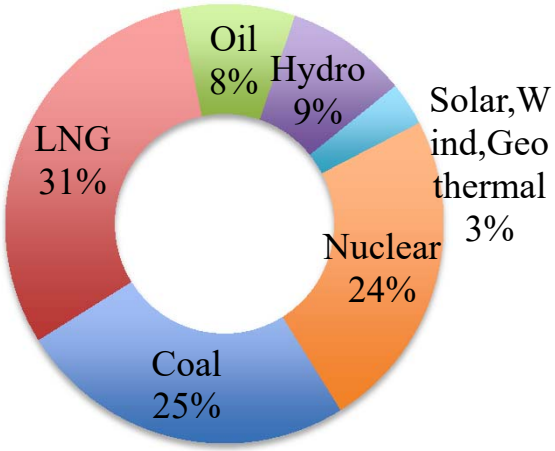
Local residents and anti-nuclear activists stage a demonstration in front of the Takahama nuclear power plant on Jan. 29, 2016

Picture Source: Asahi Shimbun (Eijiro Morii)

Research objective

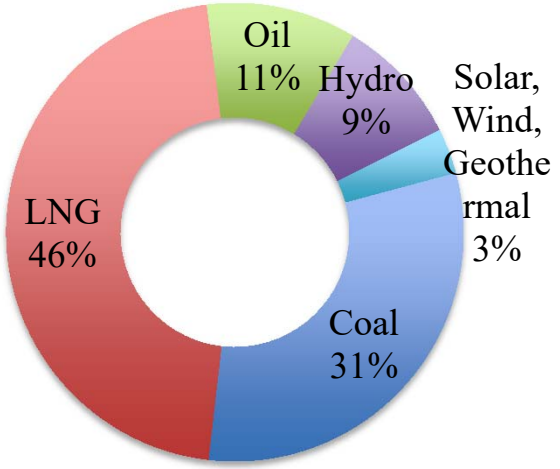
- With Restarting

Revert back to similar energy mix percentage before the Fukushima incident in 2011



- Without Restarting

Energy mix percentage of 2014



2. Methodology

- Estimate Costs and Benefits of restarting nuclear using Discounting Method.
- Calculate NPV (net present value) and BCR (benefit-cost ratio)

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$$

$$BCR = \sum_{t=0}^{n} \frac{B_t}{(1+i)^t} / \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$$

i: social discount rate Bt: Benefit at year t Ct: Cost at year t

Basic Assumptions

- Time horizon: 19 years (average shutdown time)
- Exclude plants under construction and planned
- Decommissioning cost will occur at the last year
- Power generation per year remain at the 2014 level
- Social discount rate: 5%

3. Benefits

I. Reduction in greenhouse gas emission

Social Cost of Carbon (SCC)：marginal cost of emitting one extra ton of carbon

GHG Emission of Each Type of PPs

Technology	Tonnes CO_2 e/GWh
Nuclear	29
Coal	888
Oil	733
Natural Gas	499
Solar PV	85
Hydro	26
Wind	26

Source: WNA Report (2011)

Social Cost of CO2, 2015 - 2050 (in 2011 dollars)			
Year	Scenario		
	Lower estimates	Baseline estimates	Higher estimates
2015	12	39	61
2020	13	46	68
2025	15	50	74
2030	17	55	80
2035	20	60	85
2040	22	65	92
2045	26	70	98
2050	28	76	104

Source: EPA Report (2013)

II. Increasing energy security

- Energy security:being able to secure energy in the necessary quantity for social activities at affordable prices.

Uneven distribution of energy supplies led to significant energy security problem.

- Cost of power failure

Power failure time:26.5 mins (Avg.2002-2007) to 44 mins (Avg. 2011-2013) per household[1]

Average economic damages:1700 yen per household[2]

References: [1] Japan's White Energy Paper 2015

[2] CRIEPI Research Report:Impact of Supply Reliability and Blackout on Residential and Business Customers of Electric Power Companies in Japan(2012)

III. Reduction in Fuel cycle cost

Type	Fuel Cycle Cost (Yen/KWh)
Nuclear	1.5
Coal	5.5
LNG	10.8
Oil	21.7

Data Source: The Cost Estimation and Review Committee (2015)

Fuel Cycle: All front and back end costs of various energies including procurement, distribution, refinement, storage, and disposal.

4. Costs

I. Upgrading and safety regulations compliance cost

II. Operational and Maintenance cost

III. Decommissioning cost

Type	Upgrading and safety regulations compliance (Yen / KWh)	Operational and Maintenance Cost (Yen / KWh)	Decommisioning Cost (Yen / KWh)
Nuclear	0.60	3.30	0.43
Coal		1.70	0.10
LNG		0.60	0.05
Oil		5.15	0.35
Hydro		12.80	0.10
Solar, Wind, Geothermal		3.56	0.38

IV. Risk of Reactors' accident

$$Expected\ accident\ cost\ for\ model\ plant = \frac{Total\ Damage\ (yen) * Accident\ frequency\ (per\ reactor\ year)}{Gross\ Annual\ Output\ (kWh)}$$

Total damage: sum of expenses for decontamination cost, additional decommissioning cost and damage compensation associated with a severe accident at model plant.

Frequency (/reactor year) Capacity factor 70%	Accident risk cost per model plant (yen/kWh)
1.0×10^{-5} (IAEA safety standard for early large release from existing reactor)	0.011
3.5×10^{-4} (Severe accident frequency of world's commercial reactors, equivalent to once every 57 years)	0.44
2.0×10^{-3} (Severe accident frequency of domestic commercial reactors, equivalent to once every 10 years)	2.48

Adapted based on Data Source from Japan Atomic Energy Commission (2011)

5. Results

I. Restarting Nuclear

Year	Undiscounted Values			Discount Factor	Discounted Values		
	Benefit	Cost	Net Benefit		Benefit	Cost	Net Benefit
0	2.98.E+12	8.42.E+11	2.14.E+12	1.00	2.98.E+12	8.42.E+11	2.14.E+12
1	3.02.E+12	8.42.E+11	2.18.E+12	0.95	2.87.E+12	8.02.E+11	2.07.E+12
2	3.03.E+12	8.42.E+11	2.19.E+12	0.91	2.75.E+12	7.64.E+11	1.99.E+12
3	3.05.E+12	8.42.E+11	2.21.E+12	0.86	2.64.E+12	7.28.E+11	1.91.E+12
4	3.08.E+12	8.42.E+11	2.24.E+12	0.82	2.54.E+12	6.93.E+11	1.84.E+12
5	3.10.E+12	8.42.E+11	2.26.E+12	0.78	2.43.E+12	6.60.E+11	1.77.E+12
6	3.12.E+12	8.42.E+11	2.27.E+12	0.75	2.33.E+12	6.28.E+11	1.70.E+12
7	3.13.E+12	8.42.E+11	2.29.E+12	0.71	2.23.E+12	5.99.E+11	1.63.E+12
8	3.15.E+12	8.42.E+11	2.31.E+12	0.68	2.13.E+12	5.70.E+11	1.56.E+12
9	3.15.E+12	8.42.E+11	2.31.E+12	0.64	2.03.E+12	5.43.E+11	1.49.E+12
10	3.17.E+12	8.42.E+11	2.32.E+12	0.61	1.94.E+12	5.17.E+11	1.43.E+12
11	3.18.E+12	8.42.E+11	2.34.E+12	0.58	1.86.E+12	4.92.E+11	1.37.E+12
12	3.20.E+12	8.42.E+11	2.36.E+12	0.56	1.78.E+12	4.69.E+11	1.31.E+12
13	3.22.E+12	8.42.E+11	2.37.E+12	0.53	1.71.E+12	4.47.E+11	1.26.E+12
14	3.23.E+12	8.42.E+11	2.39.E+12	0.51	1.63.E+12	4.25.E+11	1.21.E+12
15	3.25.E+12	8.42.E+11	2.41.E+12	0.48	1.56.E+12	4.05.E+11	1.16.E+12
16	3.27.E+12	8.42.E+11	2.42.E+12	0.46	1.50.E+12	3.86.E+11	1.11.E+12
17	3.28.E+12	8.42.E+11	2.44.E+12	0.44	1.43.E+12	3.67.E+11	1.07.E+12
18	3.30.E+12	8.42.E+11	2.46.E+12	0.42	1.37.E+12	3.50.E+11	1.02.E+12
Total	**5.99.E+13**	**1.60.E+13**	**4.39.E+13**		**3.97.E+13**	**1.07.E+13**	**2.90.E+13**
NPV							2.90E+13
BCR							**3.72**

II. Sensitivity Analysis

Scenarios	Social Discount Rate		
	10%	5%	3%
High SCC & Low Risk	4.74	4.77	4.79
High SCC & Baseline Risk	4.14	4.18	4.19
High SCC & High Risk	2.60	2.62	2.63
Baseline SCC & Low Risk	4.22	4.25	4.26
Baseline SCC & Baseline Risk	3.69	3.72	3.73
Baseline SCC & High Risk	2.32	2.33	2.34
Low SCC & Low Risk	3.47	3.48	3.48
Low SCC & Baseline Risk	3.03	3.04	3.05
Low SCC & High Risk	1.90	1.91	1.91

6. Discussion

- Health risk of nuclear

I. No discernible increase in health risks is expected outside Japan.

II. Human disease attributable to the additional radiation exposure are likely to remain below detectable levels.

III. In Japan, lifetime risk for some cancers may be somewhat elevated above baseline rates in certain age and sex groups that were in the areas most affected.

- The same problem arises with thermal power plants, where the burning of coal leaves ash and ash has adverse effects on human health.

References: World Health Organization: Health risk assessment from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami based on a preliminary dose estimation

Limitations

- Better to calculate the time horizon and decommissioning cost separately for each power plant
- More widely used renewables will greatly change the relative cost/benefit contributions of nuclear energy as a clean and secure energy alternative.
- Better Energy security proxy

7. Conclusion

I. The benefits of Restarting nuclear outweighs its costs a lot.

I. The government of Japan should aim to implement restarting nuclear power. By implementing this policy:

- Reduce greenhouse gas emissions
- Reduce the dependency on the import of fossil fuels, which has greatly burdened Japan's trade balance.

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Thank you very much!