Renewable Energy as Substitute of Nuclear Energy Supply: A Strategic Policy Decision for Japan

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- Risks involved in general energy planning
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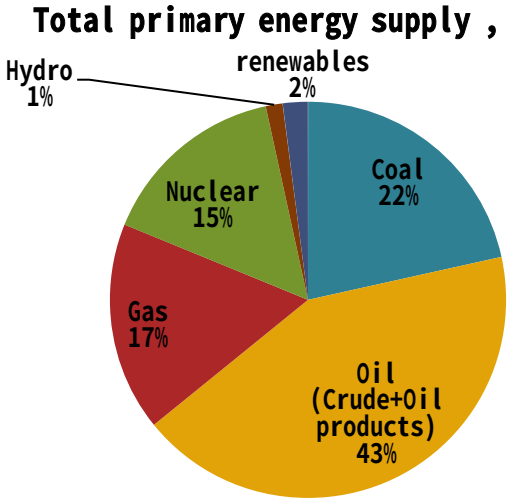
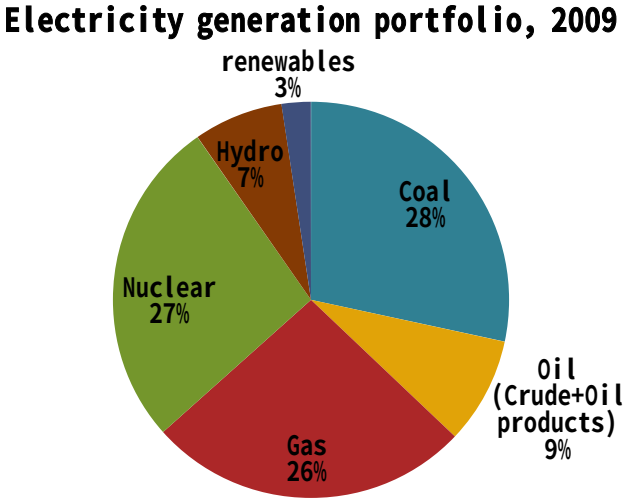
Japanese energy supply situation



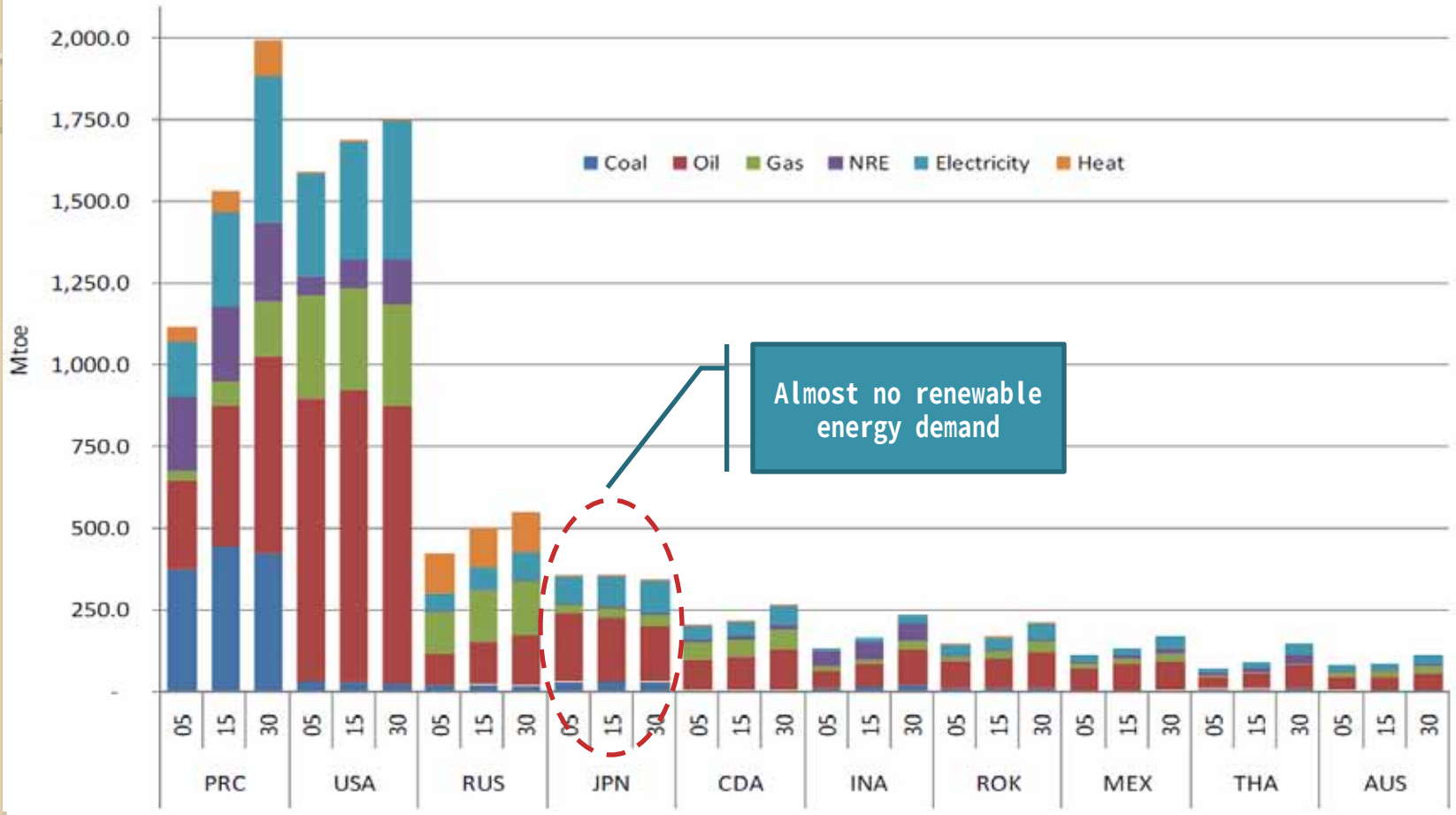


Import status of energy supply in Japan as of 2009

Coal	Oil (Crude+Oil products)	Gas	Nuclear	Hydro	Renewables
100%	98%	97%	0%	0%	0%

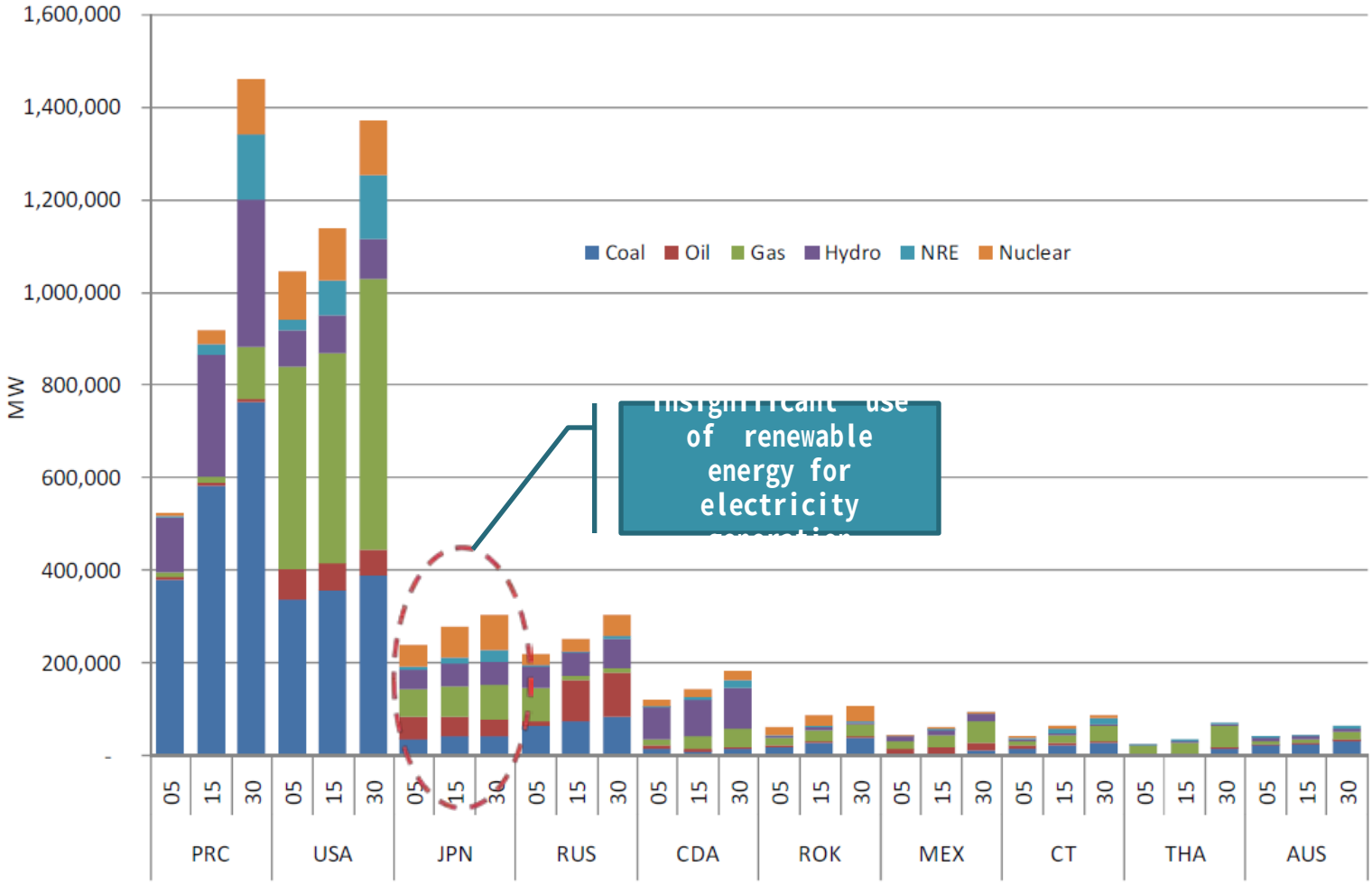
Source: IEA, 2010

Japanese total final energy demand situation



Source: APEC Energy Demand & Supply Outlook, 4th Edition, 2009

Japanese electricity generation by energy sources

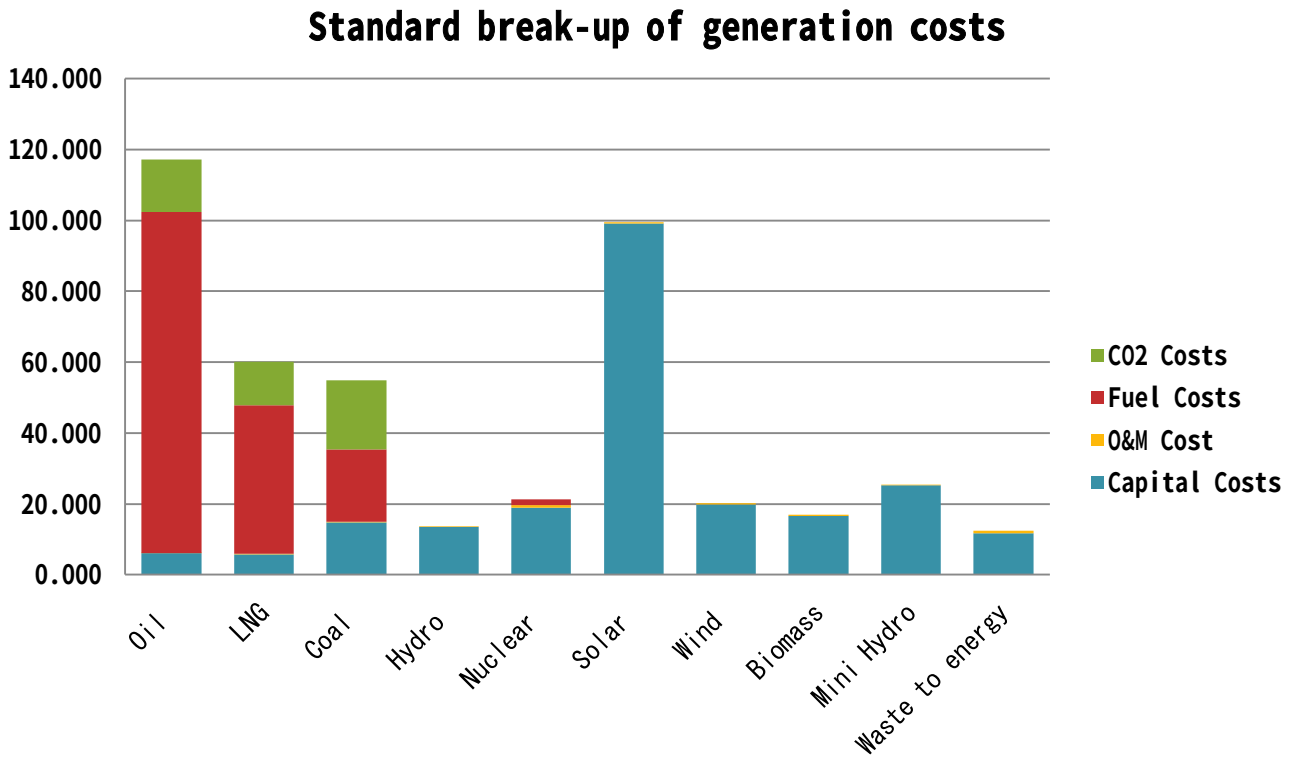


Source: APEC Energy Demand & Supply Outlook, 4th Edition, 2009

Risks involved in general electricity planning

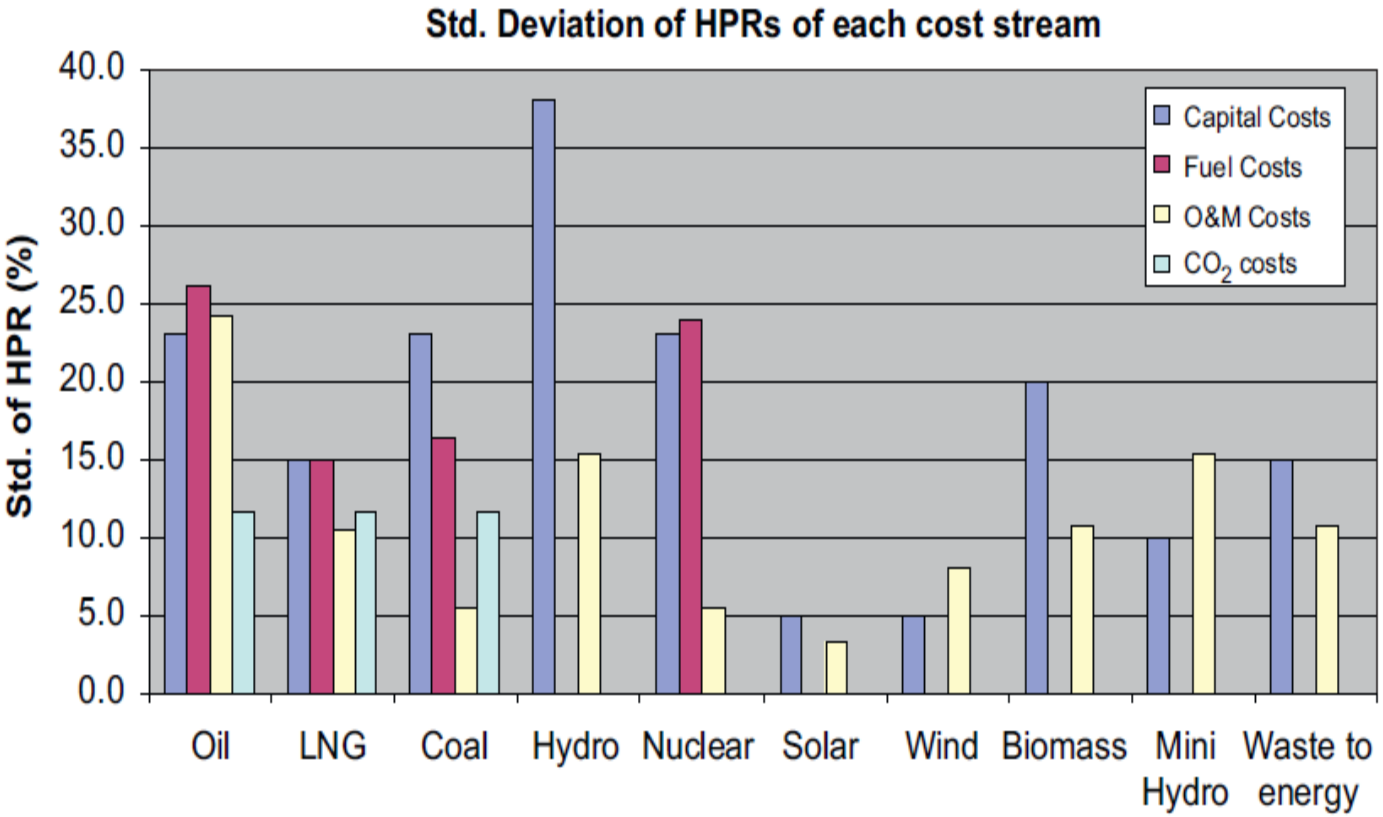
- Financial risk arising from risks involved in project management.
- Economy-wide risks due to fluctuations in electricity demand and availability of labor and capital.
- Regulatory and political risks due to sudden changes in the financing conditions, adverse regulations and imposition of carbon tax.
- Internal risk of companies due to sudden changes in company policy on diversity of generation technologies.
- Price and volume risk in the electricity market.

Sources of financial risks for electricity generation in Japan



Source: Bhattacharya and Kojima, 2010

Category wise risks involved in different energy production in Japan



Standard deviation of Holding Period Return is an indicator for investment related risk in the particular type of generation technology

Source: Bhattacharya and Kojima, 2010

Unseen risks of nuclear energy in Japan

- Apparently nuclear energy is financially as riskier as other conventional fossil fuel based energy supplies like oil and coal.
- The risks which are not considered in the investment decision are:
  - Ø nuclear liability beyond certain limit which is around $2.1 billion USD for third party damage payment only.
  - Ø Burden sharing mechanism between the Government and the utility if the damage cost crosses over the insured value.
  - Ø How to hold the equipment supplier responsible in any accident.
  - Ø How to evaluate the cost of the policy which protect the utility from any natural disaster driven accident in the nuclear power plant which is termed by the government as "EXCEPTAIONAL – Act of God". There is no such quantitative definition for Exceptional level of natural disaster and act of God.
- Taxpayers in Japan will have to bear the enormous cost burden for any nuclear crisis which will cost more than $2.1 Billion USD.

Source : http://nuclearexportcontrols.blogspot.com/2011/03/nuclear-liability-after-fukushima.html

Overview of the analysis

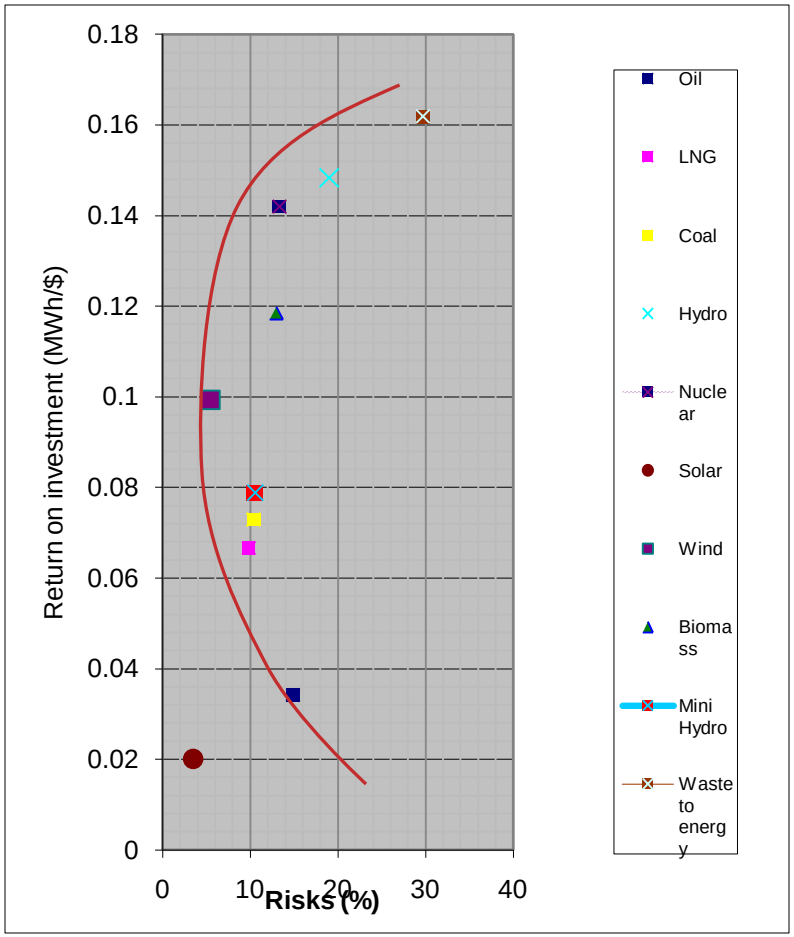
Basic Understanding

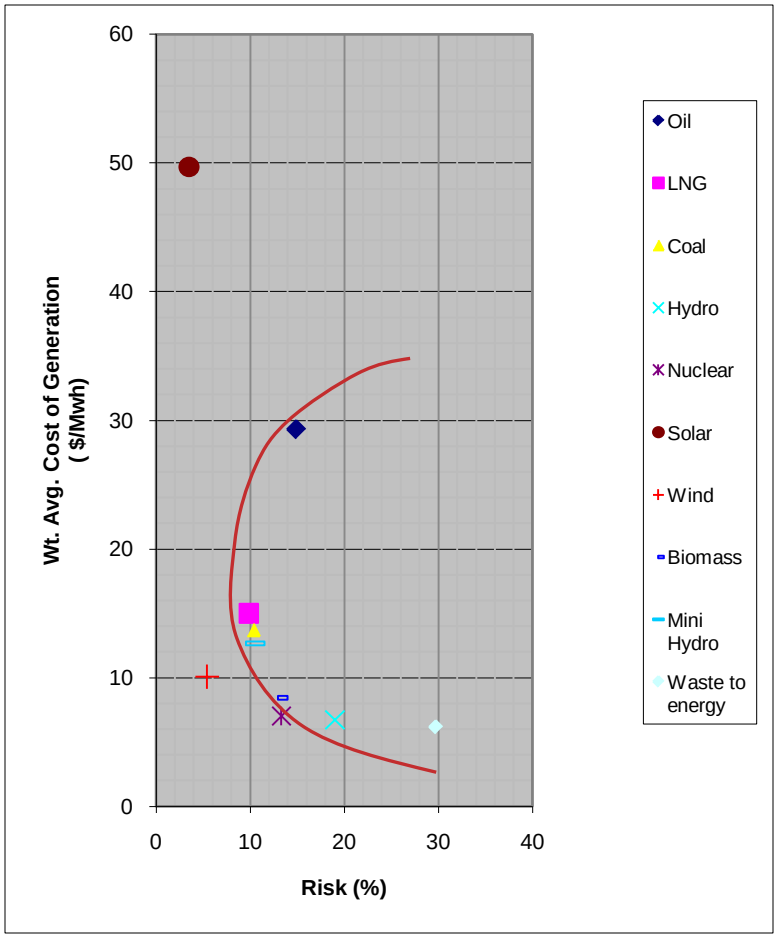
- Electricity generation portfolio of Japan is inherently highly exposed to fuel cost risks, as more than 62% of its electricity is generated from fossil fuels such as coal, oil and natural gas.
- Nuclear energy supply risk is purely undervalued in the cost term.
- Japanese renewable energy supply is only 3% (as of 2009, 1.37% in 2005) of the total supply of electricity which is far below than the potential.

What we analyzed ?

- What will happen if Japan increases renewable energy supply in the grid?
- How much Japan can increase renewable energy supply in the grid with its given potential and costs of power supply?
- If Japan increases it supply of RE what will be the impact in the power sector investment
- How much nuclear energy can be replaced potentially?

Risk-Return-Cost Behavior of electricity supply technologies in Japan (Risk frontiers)





Source: Bhattacharya and Kojima, 2010

Q1. What will happen if Japan increases renewable energy supply in the grid?

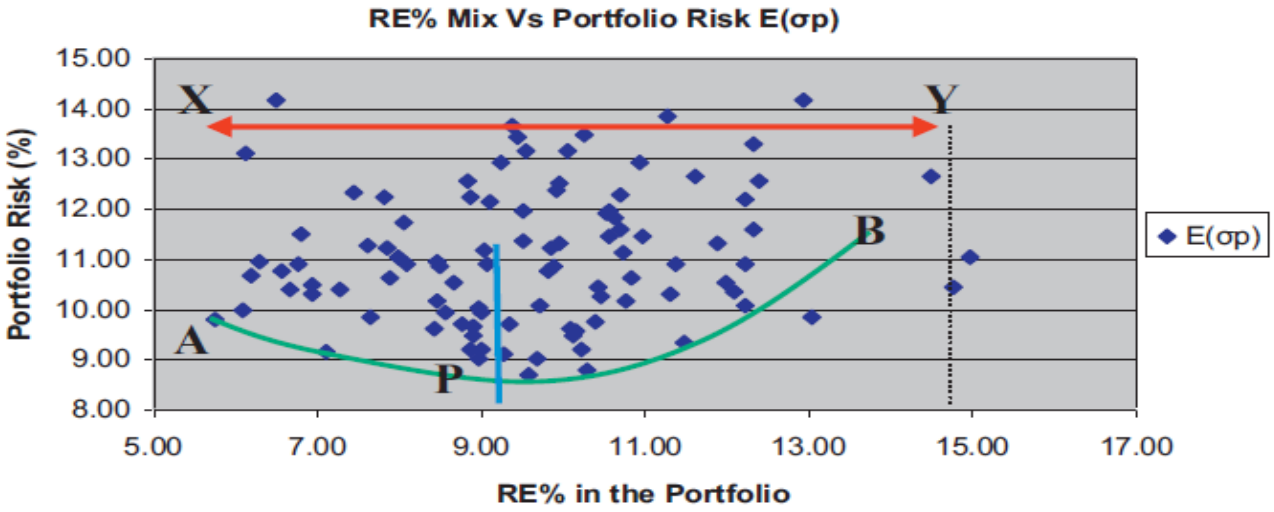
Impact of renewable energy in the portfolio.

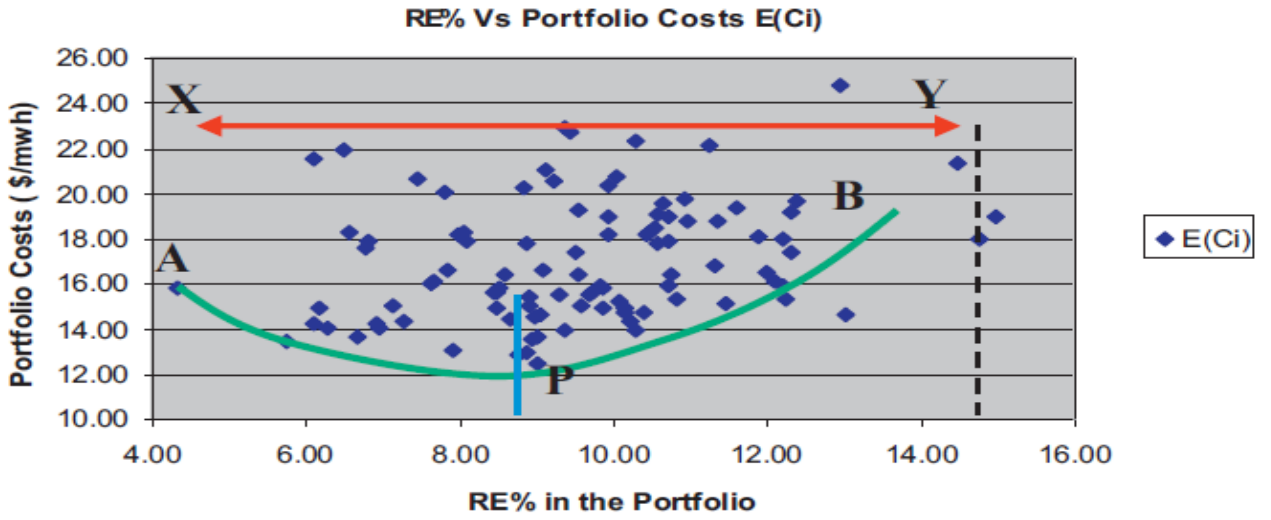
Portfolio	Portfolio risk [$E(\sigma_p)$] (% change)	Portfolio cost [$E(C_i)$] (% change)
Portfolio without renewable energy contribution	10.30	13.87
Portfolio with renewable energy contribution	10.20 (−1%)	13.97 (+0.7%)

Source: Bhattacharya and Kojima, 2010

- For every 1% increase in renewable energy supply in the gird the total supply portfolio risk (mainly financial) will be reduced by 1% and cost of the portfolio will be increased by 0.7%

Q2. How much Japan can increase renewable energy supply in the grid?--Span of RE in the supply portfolio





Q2. How much Japan can increase renewable energy supply in the grid?..(2)

Variables	Constraint range	Optimal value (all in %)
Objective function: Expected portfolio risk $E(\sigma_p)$	Minimization	8.9
Constraints: Minimum RE supply obligation	RE% $>=1.37$	**95% Confidence interval:** Upper 95% limit=9.1% Lower 95% limit=8.5%
Portfolio cost: $E(i)$		**95% Confidence interval:** Upper 95% limit=16.84 $/MWh Lower 95% limit=16.01 $/MWh

Source: Bhattacharya and Kojima, 2010

- In the context of electricity supply portfolio risk minimization Japan can reach up to 9% of total electricity supply from renewable energy without changing any existing condition including fuel price, cost of power plant construction, O&M costs and also international carbon price. This is a big change from existing 1.5% only.

Q3. What will be the impact of increasing RE supply ?

Comparative analysis of different scenarios.

Scenario	Expected portfolio risk (%)	RE supply (%)	Expected portfolio cost (S/MWh)
Baseline scenario	10.20	1.37	13.87
S-1	8.9 (−12.7)	8.8 (528.5)	16.5 (18.9)
S-2	11.03 (8.13)	8.5 (507)	16.7 (20.4)
S-3	12.08 (18.4)	8.5 (507)	16.9 (21.8)
S-4	12.08 (18.4)	8.4 (507)	16.5 (18.9)

(Bracketed figures indicate percentage change to the baseline figures).

Source: Bhattacharya and Kojima, 2010

- If Japan increases its electricity supply from renewable sources (Solar, Wind, Biomass, Mini-hydro, Waste to Energy) in total by 9% it will reduce the total portfolio financial risk by 12% and will increase the cost by 19%.
- Over the period of time due to learning curve mechanism the cost of RE supply will gradually decrease and that 19% will also decrease.

Q4. How much nuclear can be replaced by RE ?..(1)

- 9% cut back in nuclear power supply is possible by renewable energy. All these estimates are based on current financing mechanism of power plants in Japan and it does not include the nuclear accident damage cost.

- What this 9% means :
  - *Reduction of around 100 Twh of electricity generation from nuclear power plants.*
  - *Existing nuclear power generation is around 280 Twh. So around 35% cut back in nuclear power supply can be envisaged.*
  - *Currently there are 55 nuclear power plants in Japan. Out of that, 19 are built more than 30 years back (between 1970-79). All these 19 plants can be considered for gradual phase out and can be replaced by renewable energy.*

    (What is not considered here is the decommissioning costs of nuclear power plants which can run into billions of dollars.)

Q4. How much nuclear can be replaced by RE ?..(2)

What can stop Japan to replace nuclear energy in the short run by renewables

- Nuclear energy serves as the base load supplier. Renewable energy has limited capacity to do it unless adequate technological arrangements are done which are expensive and time consuming.
- Renewable energy power plants need plenty of land area suitably located. Japan land mass is limited. So identification of land will take time.
- Japan being prone to natural disaster including earthquake, tsunami, typhoon etc. extra protection measures are required for the safety of the installations. That will cost addition time and money.

What Japan can do ?

Japan needs to create a market for renewable energy supply in parallel to other fossil fuels. Private sector investment in R&D and project development is must. To do that –

- Japanese energy market needs an explicit accounting of investment risk which are often hidden behind obfuscated accounting system.
- Japan needs two tier policy :
  - Governmental regulation and unconditional policy support for renewable: No boom-bust cycle for renewable energy policy support
  - Making investment risk as explicit as possible for the investors and encourage investors to mitigate those risks by investing more into renewable energy
- Energy sector investment policy should prioritize risk over revenue in Japan.

Immediate comparison

Fukushima Daiichi Nuclear Power Plant on 24th March 2011 Crippled after 15 m Tsunami heat the powe Plant.

Kamisu Wind farm in Ibaraki after 15m Tsunami – working full capacity for TEPCO

Thank you for your attention !

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