APPLICATION OF LEAP IN JAPAN: THE "POWER SWITCH" ENERGY PATH

East Asia Energy Futures (EAEF)/Asia Energy Security Project

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OUTLINE OF PRESENTATION:

- Background of Study
  - Funding and rationale of study
  - Data set and approach used
- The Japanese Power Sector
- The “Business-As-Usual” Path
- The “Power Switch” Path
- Cost and Emissions Comparison between Paths
- Benefits of and Barriers to a Power Switch Path in Japan
BACKGROUND OF STUDY

- WWF-Japan “Power Switch” Study commissioned in early 2003, completed this month (and to be released shortly)
  - Funded by WWF-Japan as part of a broader International WWF Power Switch campaign
  - Researchers involved: Masami Nakata, David Von Hippel, Junichiro Oda, Charlie Heaps
  - Reviewed by WWF staff in Japan and elsewhere, as well as by Prof. Tatsujiro Suzuki

- The “Power Switch” Study builds on results of earlier EAEF work by the Japan EAEF team, as well as on work done for the PARES study
BACKGROUND OF STUDY

- **Approach**: Use LEAP to study the potential reductions in emissions from a Power Switch path that includes a shift toward energy-efficiency and low/no-carbon fuels
  - The Japan EAEF team’s LEAP data set was used as a starting point
- **Intent**: Show the possible impact of an aggressive, but conceivable, set of measures on Japan’s greenhouse gas emissions, evaluate--quantitatively and qualitatively--relative costs and benefits of a “Power Switch” path
  - Meet Japan’s Kyoto Protocol obligations
THE JAPANESE POWER SECTOR

- Fuels used: coal, oil, gas, nuclear, and some hydro, MSW, others
  - In recent years, share of output from coal has increased, as output from oil has decreased
- Power generation sector accounts for about 30% of Japan’s CO₂ emissions
- Recent increases in electricity production
  - 27.8 percent between 1990 and 2000
- Increases in carbon dioxide emissions from electricity generation
  - 16.5 percent between 1990 and 2000
THE JAPANESE POWER SECTOR

- Fraction of Generation by Fuel Type, 1990 - 2000
THE JAPANESE POWER SECTOR

Power Sector CO$_2$ Emissions, 1990 - 2000

![Graph showing CO$_2$ emissions from 1990 to 2000.]
THE JAPANESE POWER SECTOR

- Coal Imports, ~1990 to 2002 (mostly for power)
THE “BUSINESS-AS-USUAL” PATH

- Key data sources for base-year supply and demand data: EDMC Energy Handbook and Japan Energy Statistics, published by IEEJ
- BAU Path assumptions largely derived from BAU “scenarios” outlined by the Ministry of Economy, Trade and Industry (METI) and the Institute of Energy Economics, Japan (IEEJ)
  - GDP growth assumed 0.5 percent annually until 2005, 1.5 percent/yr after 2005
THE “BUSINESS-AS-USUAL” PATH

**Overall assumptions:**

- Current trends in electricity consumption continue
  - Trend of increasing consumption since ~1986
- No extensive additional energy conservation measures are imposed
- No drastic policy changes are implemented
THE “BUSINESS-AS-USUAL” PATH

Electricity demand in the BAU Path (average growth, 0.9%/yr)
THE “BUSINESS-AS-USUAL” PATH

Electricity generation capacity in the BAU Path
THE “BUSINESS-AS-USUAL” PATH

GHG Emissions from the electricity sector

- Coal
- Natural Gas
- Renewables
- Oil
- Cogen & Fuel Cells

- Projection Year
- CO₂ Emissions (million tonnes)
THE “POWER SWITCH” PATH

- Demonstrates savings in GHG emissions that Japan could achieve through a program of switching power generation technologies or fuels to low- or no-carbon resources, coupled with a timely, aggressive program of increasing energy-efficiency/demand-side generation.

- Incorporate WWF Japan studies:
  - Energy efficiency study by Dr. Haruki Tuchiya of the Institute of System Technology.
  - Renewable energy study by the Institute of Sustainable Energy Policies (ISEP).
THE “POWER SWITCH” PATH

- Stronger emphasis on substitution of natural gas for coal
- A gradual (partial) nuclear phase-out
- Explicit emphasis on renewable energy implementation (supply- and demand-side), natural gas-fired cogeneration (central and distributed) and highly efficient natural gas-fired combined cycle generation
- Implementation of energy efficiency and energy conservation measures
THE “POWER SWITCH” PATH

- Net electricity demand in PS Path - incorporating Tsuchiya study results
THE “POWER SWITCH” PATH

- Generation (TWh) by type in PS Path

![Graph showing electricity generation by type from 2000 to 2020. The graph indicates a decrease in coal and oil generation, an increase in natural gas and renewables, and stable generation in nuclear and hydroelectric.]
THE "POWER SWITCH" PATH

- Generation capacity (GW) by type in PS Path

![Graph showing generation capacity by type over time](image)
THE “POWER SWITCH” PATH

- GHG Emissions from the electricity sector

![Graph showing GHG emissions from different sources over time (2000 to 2020). The graph indicates a reduction in emissions for coal, oil, natural gas, and cogeneration/fuel cells, with renewable sources showing a steady increase.](image-url)
Emissions, Security, and Cost Comparison Between Paths

- Overall (power sector and some demand-side) emissions markedly lower in PS Path, declining by 20 percent vs. emissions in 2000.
- Emissions in 2020 PS case are 31 percent lower than they are in the BAU case.
- Major emissions differences between scenarios: reduced emissions from coal-fired, oil-fired power in the PS case, slightly reduced emissions (1%) from gas-fired power.
EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

Power Sector and Selected Demand-side GHG Emissions Comparison: Power Switch and BAU Cases

- Business as Usual Case
- Power Switch Case

Million Tonnes CO₂ Equivalent

EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

- Relative to the BAU path, the PS path reduces Japan's GHG emissions by
  - 94 million tonnes of CO₂ equivalent per year by 2010
  - 190 million tonnes per year by 2020
  - Overall GHG reductions from the PS scenario, relative to the BAU scenario, total nearly 2.0 billion tonnes of CO₂ equivalent between 2000 and 2020
EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

- PS Path changes overall gas use for electricity generation very little, but increased use of power generation from renewable, domestic sources relative to BAU yields improved fuel supply diversity.
  - Reduction in coal imports (70%), crude oil (3%), nuclear fuel (20%)
  - LNG imports increase, but only modestly (less than 2 percent)
- Lowered vulnerability to supply disruptions, less reliance of Japan on imports, more reliance on domestic energy
EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

Fraction of Generation by Path

- MSW and other indigenous
- Renewables
- Natural Gas
- Nuclear
- Hydro
- Oil
- Coal

1320 TWh
1035 TWh

BAU
Power Switch
EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

Electricity Fuel Supply Diversification Index

Electricity Generation Fuel Supply Diversification Index by Scenario

- Business as Usual Scenario
- Power Switch Scenario
EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

- **Cost Assumptions**
  - Demand-side changes range widely in cost, but generally assumed **1.5 times US-based costs**
  - Costs for renewable generation, cogeneration **fall over time**
  - Costs for other power supplies remain constant
  - Costs for **fuels change relatively little** over study period (coal costs, oil/gas costs rise after 2015)
EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

- **Cost Results**
  - PS Transformation costs over 2000 to 2020 14.5 trillion Yen **less** than costs in BAU
  - Additional costs for demand-side energy-efficiency measures, on-site generation: ~20 trillion Yen, of which more than 50% for distributed PV, cogen
  - Import fuel costs avoided: 4.4 trillion yen

- 31% reduction in annual GHG emissions relative to BAU by 2020, at net cost 1.1 trillion yen over study period, or 57 billion yen/yr

- Net 850 JPY/ tonne of CO$_2$, **equivalent to 0.3 % tax on electricity use**--350 Yen/HH-yr
EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

Costs for Power Switch Scenario Relative to BAU Scenario

- Trillion Yen (NPV, 2000 to 2020)

- Demand Costs
- Transformation Costs
- Resource Costs
- Total Net Costs
EMISSIONS, SECURITY, AND COST COMPARISON BETWEEN PATHS

Variation of Net Cost of PSE Scenario with Emissions Value

Trillion Yen Net Present Value

Emissions Value: Yen per Tonne CO₂
BENEFITS OF AND BARRIERS TO A POWER SWITCH PATH IN JAPAN

- Additional Benefits
  - Improvements in domestic investment through reduction of money spent on imported fuel
  - Boost to Japan’s renewable energy industry.
  - Overall increase in domestic employment
  - A reduction in coal ash, nuclear waste to be disposed of
  - Reduction in emissions of nitrogen oxides and other air pollutants
BENEFITS OF AND BARRIERS TO A POWER SWITCH PATH IN JAPAN

- Barriers to Power Switch Path
  - Existing institutional structure of the electric and gas utilities sectors
  - Lack of information about demand-side measures among electricity consumers.
  - Lack of information about the climate change problem/opportunities for solutions among consumers.
  - Lack of funding for demand-side measures and for renewable power development
  - Entrenched interests, expertise within government and utilities, favoring "BAU" approach to energy sector development