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Japan after Fukushima: Analysis on the design of FIT using GIS and TIMES Integrated Model

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Contents



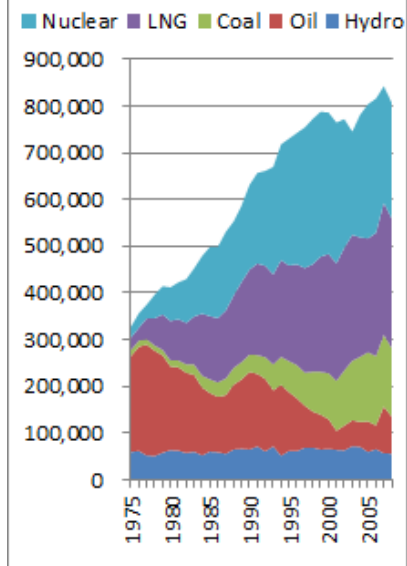
- I. Introductions & Motivations
- II. TIMES-GIS Hybrid Model: JMRT (Japan Multi-Regional Transmission Model)
- III. FIT Simulations (Preliminary)
- IV. Conclusions

I. Introductions & Motivations



- **Nuclear** power generated more than **a quarter of Japan's electricity** over the past few decades.
- The Fukushima disaster eroded people's confidence in nuclear to the extent that **all nuclear plants are forced to be shut down now**.
- Maintaining **a steady electricity supply at reasonable prices without nuclear** is the primary challenge the country faces today.
- This study aims to illustrate the Japanese electricity supply system after the earthquake with consideration of Japanese uniqueness including its **10 separate grids with weak connections between them** and **the geographical gap between renewable potential and electricity consumptions** using GIS data for a TIMES model.

Structure of Electricity Generation (TWh)



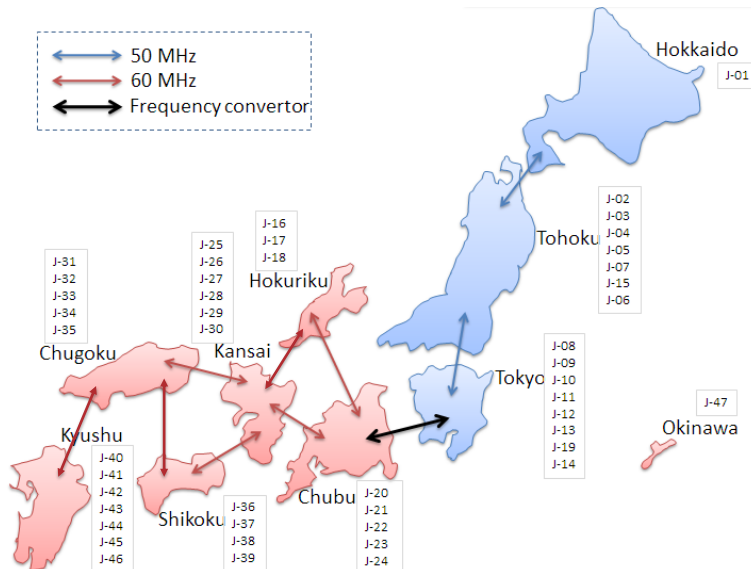
II. TIMES-GIS HYBRID MODEL: JMRT (JAPAN MULTI-REGIONAL TRANSMISSION MODEL)

JMRT is...

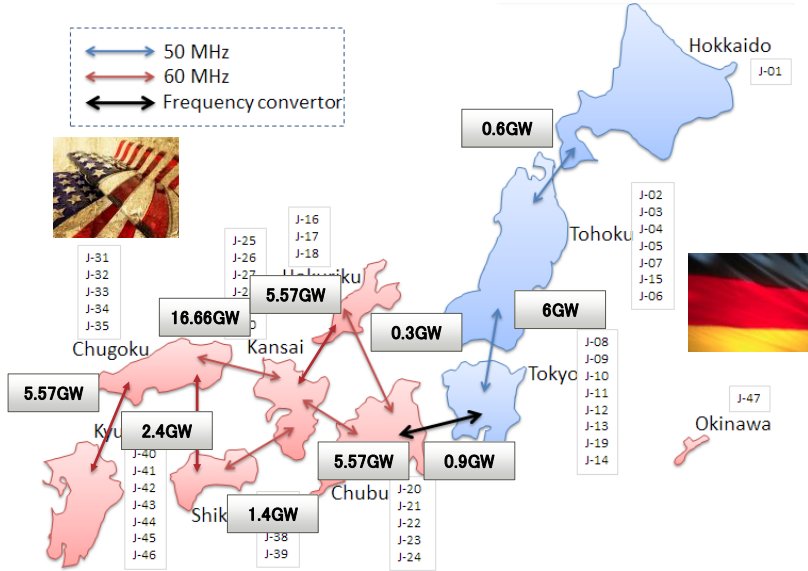


- Detailed **disaggregate Japanese electricity generation system model** based on TIMES.
- **10 electricity grids with weak connections** between grids.
- **Two different electricity frequencies**, 50Hz and 60Hz, with frequency converters to convert one frequency to another.
- **Energy Demands** at Prefecture Level (**47 Prefectures** in Japan)
- **12 Time Slices** (4 Seasons & 3 Times)
- Existing PowerStation Data & Planned PowerStation Data
- Life-time Extension of Existing PowerStation
- Capacity of LNG and Coal Port
- Limits to the capacity share of sum of PV and Wind in each grid (30%)

10 Grids and Grid Connections



10 Grids and Grid Connections

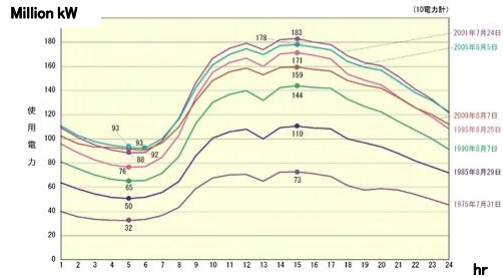


12 Time Slices

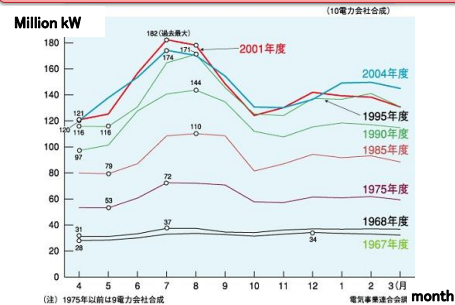
- 3 Time Periods
 - Day (8~13, 16~23)
 - Peak (14~15)
 - Night (0~7)

- 4 Seasons
 - Spring (3~6)
 - Summer (7~9)
 - Autumn (10~12)
 - Winter (1~2)

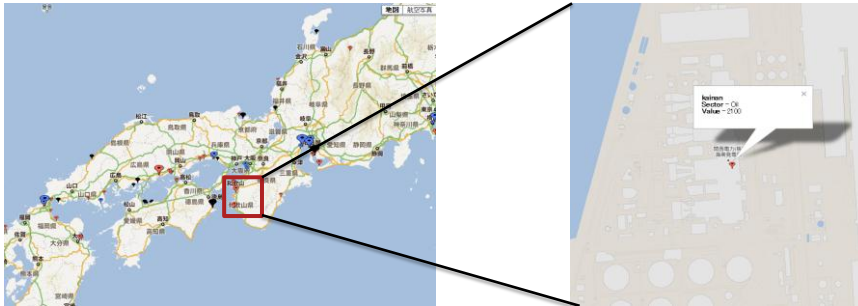
Load Curve in Most Electricity Consumed day



Peak Demand in each Year



Existing PowerStation Data



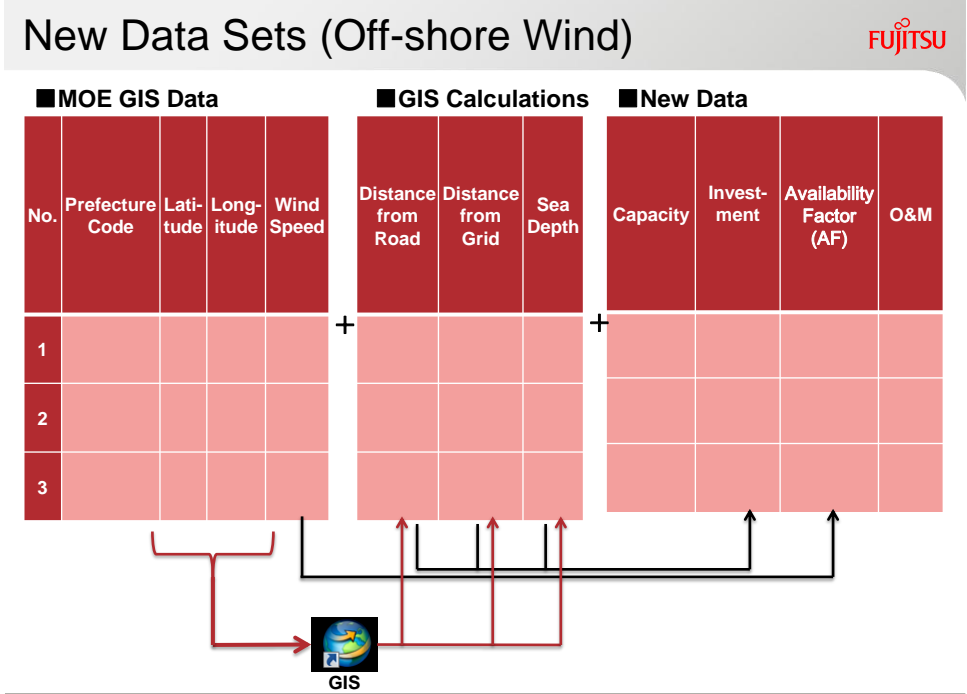
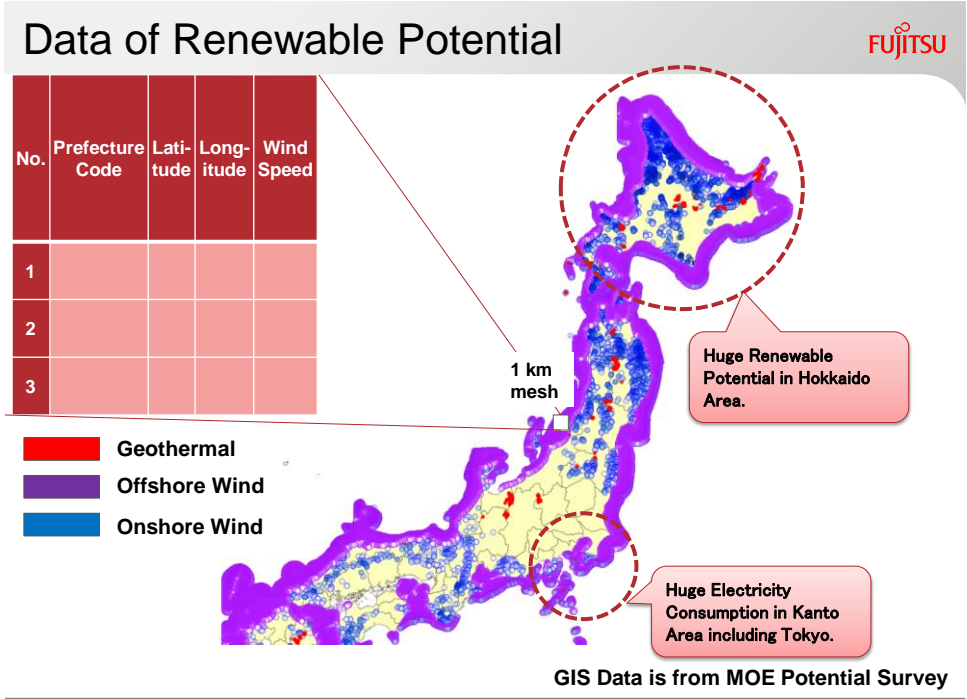
Existing PowerStation Data include

- Type of PowerStation
- Latitude, Longitude
- Prefecture
- Start Year
- Life Time
- Electricity Generation Capacity
- Availability Factor (AF)

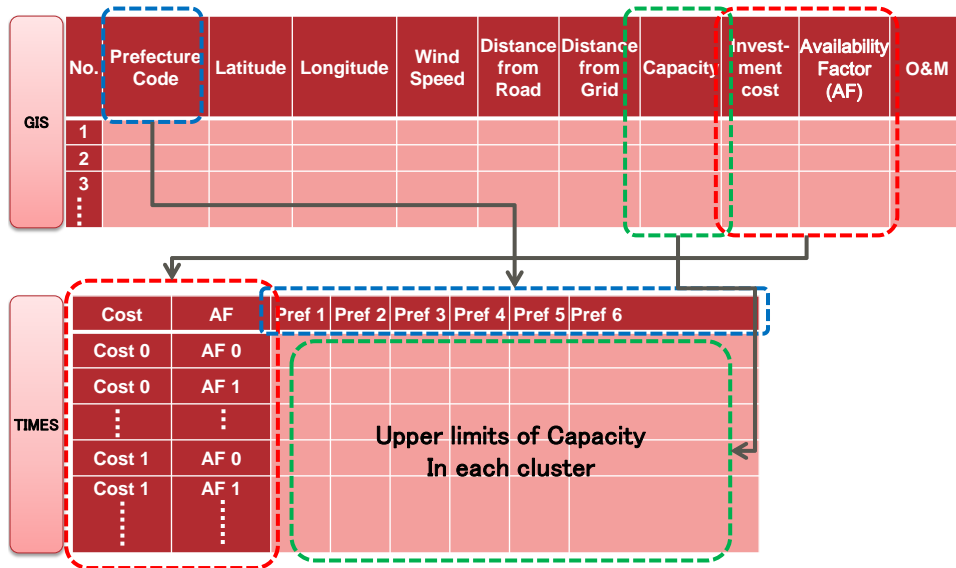
Location is important



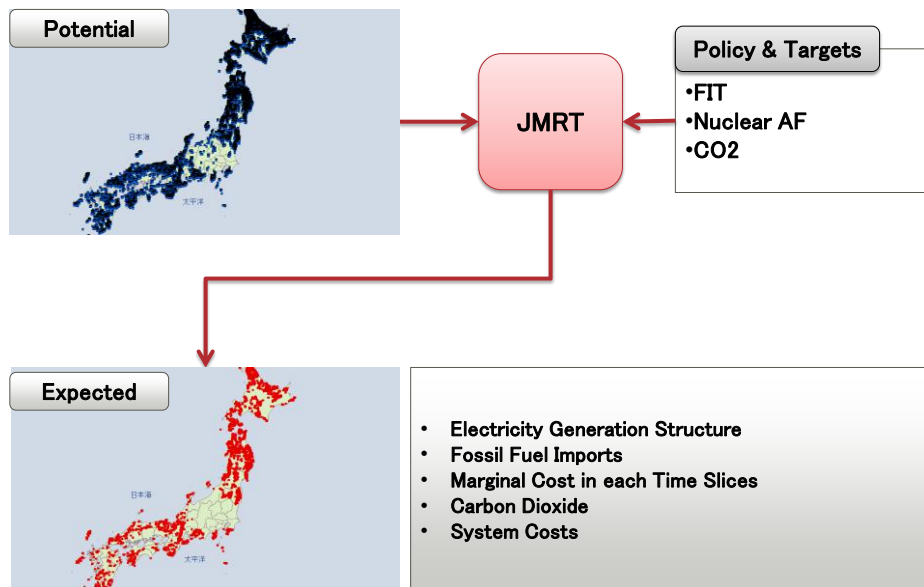
| Wind Speed | |
|------------------|--------|
| Wind Speed (m/s) | AF (%) |
| 5.5 | 15.8% |
| 6 | 19.7% |
| 6.5 | 23.5% |
| 7 | 27.3% |
| 7.5 | 31.0% |
| 8 | 34.5% |
| 8.5 | 37.9% |



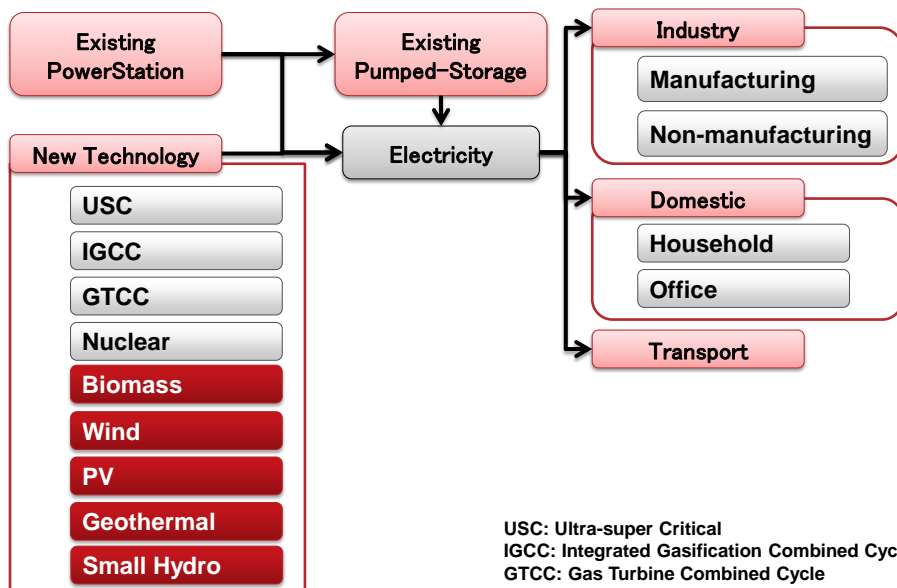
GIS to TIMES (Aggregation)



Simulation Flow



Overview of JMRT



Data Sources

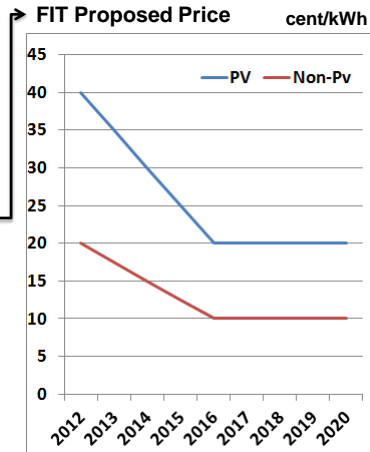


| Categories | Description | Sources | |
|-----------------------------------|--|---|--|
| Existing Power Stations | Capacity, Generation | Agency for Natural Resources and Energy, Overview of Electricity Demand and Supply 2009 Federation of Electric Power Companies of Japan, Handbook of Electricity Business 2010 | |
| Power Stations Under Construction | Capacity | Agency for Natural Resources and Energy, Prefecture Energy Consumption Statistics, Institute of Energy Economics | |
| LNG Port | Capacity | Tex Report, Gas Annual Report 2010 | |
| Renewable Energy | On-shore Wind Turbine, Off-shore Wind Turbine, PV, Geothermal, Small Hydro | Ministry of the Environment (2011), Survey on Potential of Renewable Energy | |
| | Biomass | Potential | New Energy and Industrial Technology Development Organization (NEDO), Biomass Potential and Available Biomass Estimation |
| | | Cost | International Energy Agency (IEA), World Energy Outlook |
| Conventional Power Generation | Coal, Gas, Oil, Nuclear and Hydro | International Energy Agency (IEA), World Energy Outlook | |
| Electricity Consumption | Electricity Consumption by Prefecture | Agency for Natural Resources and Energy, Prefecture Energy Consumption Statistics | |
| Electricity Load Curve | | Federation of Electric Power Companies of Japan, Nuclear and Energy Drawings | |

III. FEED-IN-TARIFF (FIT) SIMULATIONS -PRELIMINARY RESULTS-

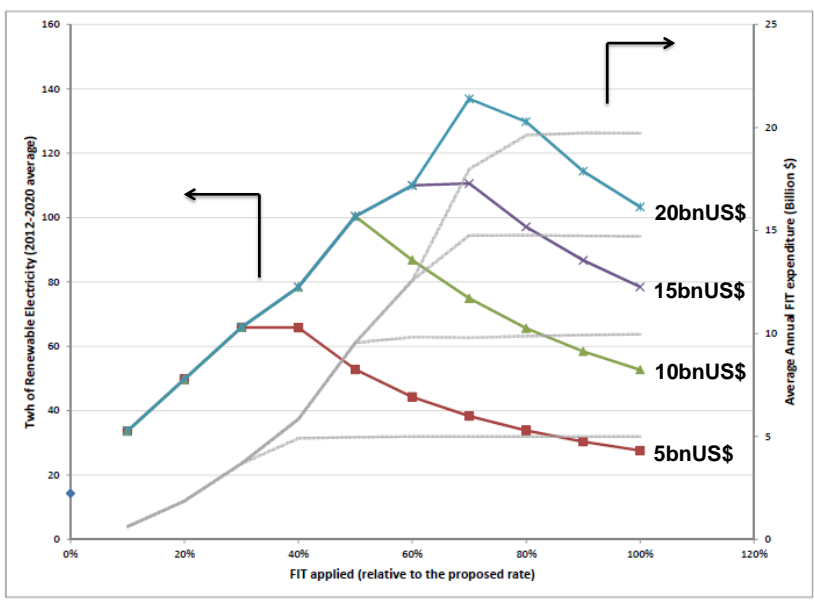
Simulation Design

- We have tried to identify the relationship between FIT price and the quantity of electricity generated by renewables under FIT budget constraints.
- 4 Annual Budget Constraints: 5bnUS\$, 10bnUS\$, 15bnUS\$ and 20bn US\$.
- Proposed FIT Price: **40 cents/kWh for PV and 20 cents/kWh for non-PV in 2012.**
- 4 Nuclear Reactors at Fukushima Dai-ichi are assumed to be decommissioned in 2012.
- The life-time of nuclear PowerStation is 40 yrs and no new nuclear PowerStation will be built.



Before the earthquake, nuclear was expected to play a major role in achieving energy self-sufficiency and carbon mitigation targets by increasing the **availability factor to about 90%** and building **14 new nuclear power stations** by 2030.

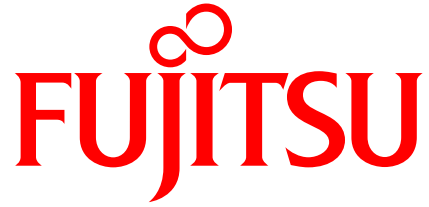
RE and FIT Under 4 Budget Constraints



IV. Conclusions



- The research has challenged
 - a modelling approach where the electricity system of the entire country is represented with **extremely disaggregated information on existing stock and future potentials**.
 - Identifying a mix of new capacity additions, life extensions, along with their locations to tide Japan over during the possible stoppage of nuclear power production in 2013.
 - Next challenge is to include intra-grid data.
- There is no guarantee that a higher FIT price leads to more electricity generation by renewables.
- High FIT prices make the huge potential of renewables commercially viable, but at the same time, they limit the maximum introduction of renewables under budgets constraints.



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