Dynamic Transition Analysis with TIMES: I²CNER Initiative on Challenges in Energy Assessment and Energy Transtitions

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Objectives

Evaluate potential impact of novel energy technologies within Japan's energy system. Specifically:

- Help guide practical near term (2010-2050) transition strategies to minimize carbon emissions within realistic constraints.
- Identify high impact technologies.
- Assess role of technology readiness.
- Predict impediments to strategically optimal technology deployment.
- Identify ideal timelines for energy system deployment, infrastructure development, high impact R&D investment.

Collaborators

I²CNER collaborators will include primarily the members of the Energy Analysis Division (EAD), including those members at other institutes, universities or industries with connections to the EAD.

Methodology

Multiple studies have been conducted to compare the impact of innovative energy technologies in different regions of the world using *static* scenario analyses [1] [2] [4] [5] [7] [8]. We will simulate *dynamic transition scenarios* [3] [9] , with realistic constraints and technology readiness of energy generation technologies (in terms of generation, transmission & storage), aimed at minimizing carbon emissions. We will further extend previous work by combining multiple technologies in a single heterogeneous system.

The TIMES (The Integrated MARKAL-EFOM System) model generator [6] [10] optimizes energy systems of a model using linear and mixed-linear algorithms while implementing user-defined objective functions (such as minimizing carbon emissions or costs) within user defined constraints such as energy generation demand. It will be used to simulate near-term energy transitions while focusing on reduction of carbon emissions.

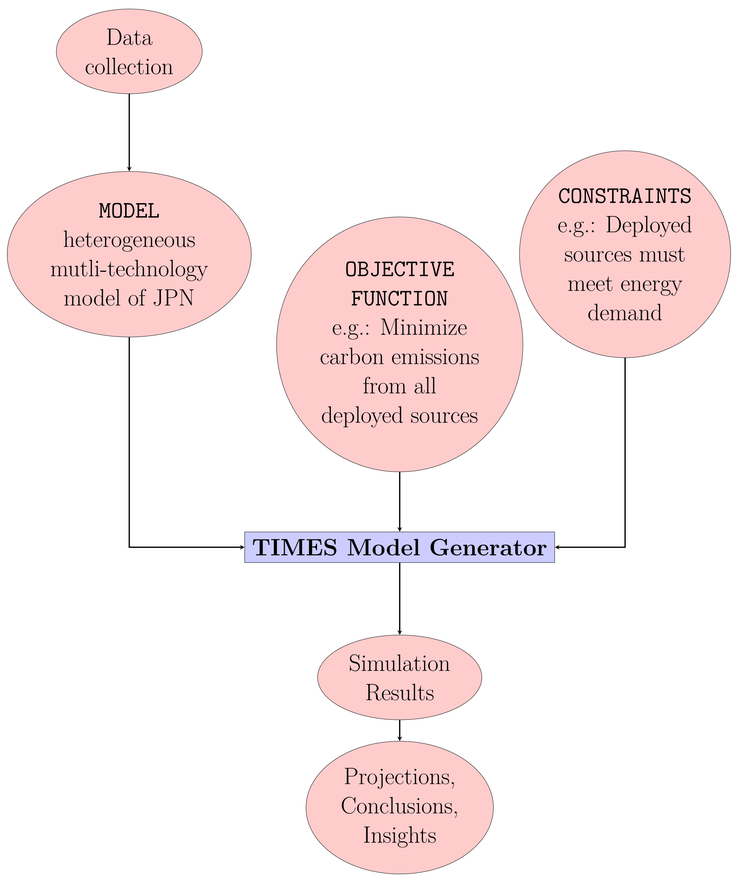

Figure: Basic methodology for dynamic simulation of Japan's energy system.

Anticipated Results

- Analysis results can be filtered by sector (commercial, industrial, residential, building etc) or by region.
- Many metrics are automatically postprocessed- such as energy intensity, thermal energy efficiency, transmission capacity.
- Technology deployment transitions driven by constrained optimization will have valuable strategic value.

Impact

Results will:

- Assist in creation of realistic decarbonization roadmaps that maximize efficiency.
- Identify potential bottlenecks during transitions.
- Help Japan's policymakers create timelines for R&D investment and for appropriate infrastructure development.
- Quantify system sensitivity to technology readiness.

Challenges

- Reliable data for each technology's deployment and operation is required, such as:
  - Technology readiness
  - Carbon intensity
  - Capacity and availability factors
  - Fuel costs and demands
  - Thermal/electric generation capacity
  - Storage capacity
  - Thermal efficiency
  - Construction time
  - Construction costs
  - Operation and maintenance costs
- Mutiple constraints cause complications.
- Variation of goals or the objective function can significantly change each simulation. e.g.: cost could be objective function whereas carbon reduction up to a certain percentage (50-70%) could be the constraint, flipping the script.
- Calculation of constituent parameters, such as carbon emissions per component and quantification of deployment, will be complex.
- Intermediate objective functions for a multi-objective formulation could additionally include intermediate-resolution-goals such as Efficiency Increase (EI) and Lower Carbon Intensity (LCI). These intermediate objectives will increase the complexity of the calculation.

Summary

- Dynamic simulation of Japan's energy system in TIMES model generator using a heterogeneous model and realistic constraints will help develop near-term decarbonization strategies.
- Policymakers will benefit from identification of high impact technologies, and creation of R&D investment and infrastructure development timelines.
- Simulations will quantify system sensitivity to technology readiness, and also account for secondary scenarios where decarbonization is not the main priority.

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Advanced Reactors & Fuel Cycles

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