Dynamic Transition Analysis with TIMES

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Objectives

Division: Energy Analysis Division

Project: I^{2}CNER Initiative on Challenges in Energy Assessment and Energy Transitions

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

Milestones:

- Minimize carbon emissions within realistic constraints.
- Optimize realistic 2010-2050 decarbonization roadmaps.
- Identify high impact technologies.
- Identify potential transition bottlenecks.
- Help Japan's policymakers create timelines for R&D investment and infrastructure development.
- Quantify system sensitivity to technology readiness.
- Predict impediments to strategically optimal technology deployment.

Introduction

Previous work has compared the impact of innovative energy technologies in various world regions using **static** scenario analyses [1, 2, 4, 5, 7, 8]. We will simulate **dynamic** transition scenarios [3, 9] aimed at minimizing carbon emissions in Japan by 2050. These scenarios will include realistic constraints regarding technology readiness (in terms of generation, transmission & storage) and will combine multiple technologies in a single heterogeneous system model.

Methodology

The Integrated MARKAL-EFOM System (TIMES) model generator [6] [10] optimizes energy systems using linear and mixed-linear algorithms. A user-defined objective function (such as minimizing carbon emissions or costs) is solved within user defined constraints such as energy generation demand.

Sector Analysis: TIMES models can resolve generation and consumption by sector (commercial, industrial, residential, building etc).

Regional Analysis: TIMES can also resolve regions.

Post-Processing: Many metrics are automatically postprocessed (i.e. energy intensity, thermal energy efficiency, transmission capacity).

Constrained Optimization Modeling technology deployment transition as a constrained optimization problem will drive insights.

The key objective function is minimization of carbon emissions in 2050 and a key constraint will be that deployed generation capacity must meet energy demand. This can naïvely be written:

minimize:

$$\sum_{g}^{G} C_g x_g \tag{1}$$

subject to:

$$\sum_{g}^{G} x_g = d \tag{2}$$

where

$$C_g = \text{carbon emissions from generation component g} \tag{3}$$
$$x_g = \text{deployment of generation component g} \tag{4}$$
$$d = \text{generation demand} \tag{5}$$

A simple **static** formulation is straightforward to write, as above. However this formulation is quickly complicated by including **dynamic time** as well as additional constraints (energy storage, variable demand, CO_2 sequestration, efficiency, costs, etc.)

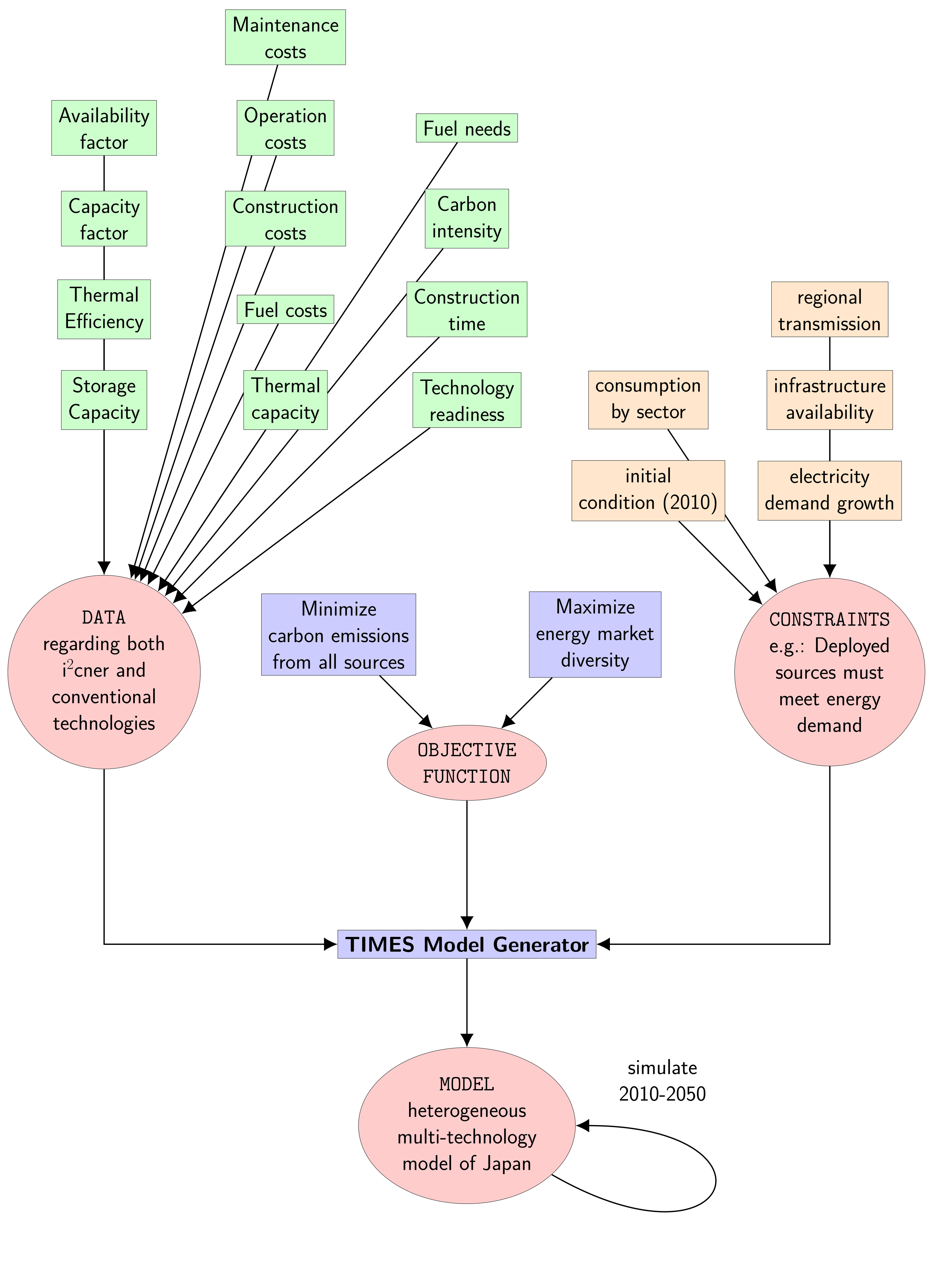

Figure: Basic methodology for dynamic simulation of Japan's energy system.

Take Aways

- Dynamic simulation of Japan's energy system transition in the TIMES model generator 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.
- Dynamic analysis will identify potential transition bottlenecks.

Timeline

Jan. 2018	Project start:	Literature Review.
Feb. 2018	Data collection:	Japan's current grid.
Mar. 2018	Data collection:	Static projections.
May. 2018	Data collection:	Conventional technologies.
Jun. 2018	Data collection:	i^{2}cner generation technology.
Jul. 2018	Data collection:	i^{2}cner efficiency technology.
Aug. 2018	Data collection:	i^{2}cner storage technology.
Sep. 2018	Scenario simulation:	2010-2050 conventional.
Oct. 2018	Scenario simulation:	2010-2050 i^{2}cner driven.
Dec. 2018	Scenario simulation:	2010-2070.
2019	Sensitivity analysis:	Vary key parameters.

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