MESSAGEix Workshop – Modelling Forum
Developing an Energy Model

MESSAGEix Workshop team:
Behnam Zakeri, Paul Kishimoto, Oliver Fricko, Francesco Lovat, Muhammad Awais

Energy Program, International Institute for Applied Systems Analysis (IIASA), Austria
Developing an energy model.

How to develop an energy model?

1. Before starting to model.
2. Scenario storyline vs. scenario variants.
3. Reference Energy System - the model map!
4. Start simple; add complexity in a stepwise manner to understand each change.
5. Data
Developing an energy model.

**Before starting to model.**

1. **What is my research question(s)?**
   - Point of reference - focus on key requirements to answer questions.
   - Distinguish “nice-to-have” features from “essentials”.
   - What is non-target?

2. **What is the hypothesis?**
   - What are the expected results?
   - What additional information can I provide other than the obvious?

3. **Who is my target audience?**
   - Journal, fellow researchers, political audience, students.
   - Determines messages and level of detail to be communicated.
Developing an energy model.

*Scenario storyline vs. scenario variants.*

<table>
<thead>
<tr>
<th>Scenario storylines</th>
<th>Variant 1.</th>
<th>Variant 2.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• GDP - Low</td>
<td>• GDP - High</td>
</tr>
<tr>
<td></td>
<td>• Population - High</td>
<td>• Population - Medium</td>
</tr>
<tr>
<td></td>
<td>• Fossil technology focus</td>
<td>• Green technology focus</td>
</tr>
<tr>
<td></td>
<td>• Disparity (trade, R&amp;D)</td>
<td>• Globalization (trade, R&amp;D)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario variants</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Short-term climate policies – conditional vs. unconditional NDCs</td>
</tr>
<tr>
<td>• Long-term climate policies – 2 vs 1.5 degrees</td>
</tr>
<tr>
<td>• Different GWP for emission species e.g. CH4 (21 SAR, 25 AR4, 28 AR5)</td>
</tr>
<tr>
<td>• Technology exclusion e.g. nuclear phase-out vs revival; BECSS</td>
</tr>
<tr>
<td>• Different discount rates</td>
</tr>
</tbody>
</table>

The target is to provide consistent and logically entwined “plots” with underlying drivers. These will essentially also determine demand projections.
Developing an energy model.

*Draw out a Reference-Energy-System*

A stylized reference energy system model for Westeros

This tutorial is based on the country of Westeros from the TV show "Game of Thrones".
Developing an energy model.

*Start simple and gradually introduce complexity.*

- **Step 1.** Add more supply technologies
- **Step 2.** Add resources
- **Step 3.** Detail End-Use
- **Step 4.** Add Land-Use
- **Step 5.** Add other regions

**Workflow**

- **Add/Change** the model
- **Document** workflow and data
- **Extend** Reporting
- **Validate** the model output

*Start simple and gradually introduce complexity.*
Developing an energy model.

Data

1. Separate data processing for use as input from “inputting” data into the model.
2. More granularity ≠ better model.
3. Scaling – units should be adjusted to avoid too large or too small numbers.
4. Avoid “flat” optimization – avoid too similar options.
5. Be transparent – when adding assumptions; be clear about what and why they have been used.
Workflow 1. “export and re-importing”

- Raw data
  - Data formatting and import script
  - Export data script
  - Model data
  - Model in “framework X”
  - Import data script
  - Model in “MESSAGEix”

Workflow 2.: Importing raw data

- Raw data
  - Data formatting and import script
  - Model in “framework X”
  - Model in “MESSAGEix”
  - Data formatting and import script
Developing an energy model.

Data

1. Interface

- **Database**
  - *ixmp* (ix modeling platform)

Option 1.:
  a) Create a pandas dataframe with data.
  b) Use commands `add_set()`, `add_cat()`, `add_par()`

Option 2.:
  a) Prepare data in the correct format in an Excel file.
  b) Use commands `read_excel()`

...the latter can be an option for model transition process i.e. moving data from a given modeling platform to MESSAGEix.

Two tutorials to illustrate the useage:
- westeros/westeros_baseline_using_xlsx_import_part1.ipynb
- westeros/westeros_baseline_using_xlsx_import_part2.ipynb