TIMES Course for MSc Students in DTU: Reflections and the Way Forward

Olexandr Balyk
Energy Systems Analysis Group
Systems Analysis Division

With inputs from K. Karlsson, M. Münster, S. Petrovic, J. Tattini, and G. Venturini
Overview

- General info
- Course design
- Outcomes
- Main challenges
- Way forward
General Info: Course

Title: National energy system modelling with TIMES
Workload: 5 ECTS
Duration: 3 weeks
Occurrence: January
Students: 41 (no upper limit)
Crew: 2 Senior Researchers, 2 Postdocs, 3 PhD Students
General Info: Students

Study programme: Master in Sustainable Energy
Year: 2\textsuperscript{nd} (intended)

Course prerequisites (previous DTU courses):
• Modelling and Analysis of Sustainable Energy Systems using Operations Research
• Energy Economics, Markets and Policies
• Feasibility studies of energy projects
Course Design: Learning Objectives

- Collect and evaluate data critically e.g., by comparing production costs of technologies
- Develop and analyse internally consistent future energy scenarios
- Critically reflect on a tool functionalities as well as main assumptions and limitations of that type of tool in general and specifically for the applied tool
- Validate and explain results
- Use TIMES model generator for creating a national energy system model and describe its structure
- Analyse national energy system scenarios applying a TIMES model
- Apply constraints in TIMES to represent e.g., limited renewable resource potentials
- Represent energy demand, transmission, conversion and resource potentials for different sectors of an existing energy system in TIMES
- Explain the modelling of specific technologies in a TIMES energy system model and compare the system consequences of implementing them
- Clarify sensitivities of main assumptions through sensitivity analysis
- Synthesise the main conclusions and discuss results in relation to results of other energy system analyses and current debate in society
- Coordinate model development
Course Design: Teaching Methods

• Project-based learning
  – Develop a national TIMES model
  – Use it for an analysis

• Spiral learning
  – Gradual exposure to TIMES and VEDA
  – Increasing sophistication of model sectors
Course Design: Teaching Activities

• Lectures

• Exercises

• e-Learning
  – Mostly video tutorials (e.g. building up model sectors, introducing constraints etc.)

• Group work (matrix structure)
  – Every "work group" (4-5 students) develops a country model and uses it for an analysis
  – Every "study group" (up to 11 students) contains students responsible for a single sector (e.g. transport)
Course Design: Assessment

- **Summative**
  - Group posters (60%)
  - Multiple choice test (40%)

- **Formative**
  - Pre-test
  - Feedback from students after each lecture
Course Design: Core Elements

- Temporal aggregation
- Validation and calibration
- Data quality
- Scenario analysis
- Error checking
- Sector modelling
- TIMES
- VEDA
- Geographical aggregation
- ESA and tools
Course Design: Course Plan

- Week 1: lectures, exercises, data
- Week 2: model structure and data
- Week 3: validation and analysis

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ESA &amp; tools, Scenario analysis</td>
<td>Supply, EX</td>
<td>Power &amp; Heat, EX</td>
<td>RES &amp; IND &amp; COM, EX</td>
<td>Transport, EX</td>
</tr>
<tr>
<td></td>
<td>Intro TIMES, group forming</td>
<td>CG</td>
<td>CG</td>
<td>CG</td>
<td>CG</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Week 2</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1 – country overview and agenda</td>
<td>Time and geography, EX</td>
<td>Demand projections, EX</td>
<td>SG/CG</td>
<td>Exam</td>
</tr>
<tr>
<td></td>
<td>Validation &amp; calibration</td>
<td>SG/CG</td>
<td>SG/CG</td>
<td>SG/CG</td>
<td>SG/CG</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Week 3</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P2 – model structure and analysis</td>
<td>CG</td>
<td>CG</td>
<td>CG</td>
<td>CG</td>
</tr>
<tr>
<td></td>
<td>SG</td>
<td>SG</td>
<td>SG</td>
<td>SG</td>
<td>P3 - Analysis</td>
</tr>
</tbody>
</table>
Course Design: Other Practicalities

• Software installation before course starts
  – We provide/refer to step-by-step guides

• Modelling sophistication and heterogeneity
  – We provide example structure for sectors (developed in exercises)

• Data availability
  – We point out data sources (e.g. make sure some data is available for students)
Course Outcomes: Analysis Undertaken

- Countries analysed: Denmark, France, Germany, Greece, Italy, Norway, Spain, Sweden, Switzerland, UK

- Issues analysed (examples):
  - How can Italy reach the goals of the National Energy Strategy with regards to 2050?
  - Swiss Energy Plan 2050

- Model characteristics:
  - Similar to templates from the lectures
  - Simple with regard to TS
"It was a very interesting course, but there was too much work, which made it less enjoyable. Like being forced to stay at a theme park for 3 weeks. Just not fun in the end :p"
Main Challenges

• Academic
  – Recommended (not mandatory) prerequisites => varying background knowledge
  – Assessment of students within groups => difficult to judge through poster presentations
  – Groups were late putting together their models => little time for debugging
  – Data availability => too much time for datamining

• Technical challenges
  – Heterogeneous systems => software does not always work / takes time to setup
  – Software stability

• Practical / Planning
  – Flexible class size
  – X-mas holidays
  – Very resource intensive
Worked Well

- Video tutorials
- Step-by-step installation guides
- Overall assessment => groups remained intact
Way Forward

• Optimise resource utilisation
• Develop an FAQ (technical issues)
• Supervision of CGs
• Increase exercise time / decrease lecture time
• Reduce datamining (limit the number of countries)
• Reduce the number of poster presentation
• Take the test after the course
• Improve course description

More options:
• Summer 3 week period
• Transform to 10 ECTS and 13 weeks
Questions?

Thank you for attention!