Introduction to Energy Systems Modelling

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- What do we mean by energy system?
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Context
Medium to long term planning is capable of producing insights that can inform policies related to SDGs.
Sustainable Development Goals (SDGs)

Illustrative linkages between SDGs
Sustainable Development Goals (SDGs)

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Given the present status and expected future energy demands, it is necessary to plan ahead how the energy resources could be used to meet the demands, in the near and far future.
Energy policy is the manner in which a given entity has decided to address issues of energy planning including energy supply, distribution and end-use.

It includes aspects related to:

- Energy security
- Environmental protection
- Market structures
- Incentives or disincentives (e.g., FITs, carbon taxes)
- Directives (e.g. measure for efficiency improvements)
Examples of energy policy questions

• What needs to be done and what will be the costs to supply modern energy sources to remote areas?
• What if environmental regulations are made more stringent?
• What needs to be done to increase the share of renewable technologies?
• Should electricity import be allowed?
• Should existing nuclear facilities be closed down?
• Can an energy conservation program help in reducing cost of energy supply?
What do we mean by energy system?
Energy system

Complex system including numerous supply chains linking energy resources to final energy demands.
Energy system

Complex system including numerous supply chains linking energy resources to final energy demands.
What is Energy Systems Modelling?
The complexity of the energy system can be simplified and represented in an organised model structure.
What is Energy Systems Modelling?

It creates simplified images of real life energy systems by translating the components and flows into tractable mathematical formulations (equations).

The equations represent rule-based interactions between the key system components.

Also future technology and fuel options to satisfy future energy demands can be evaluated.

Energy modelling provides insights NOT answers
Governments/public have **qualitative** ideas on the future development of the country and its energy system, for example:

- Policy goals (e.g. economic development, financial constraints, environmental constraints, energy security, rural development...)
- Preferred technology options (e.g. using domestic resources, increasing RES shares...)
- Future availability and prices of energy forms...
- Public perception: may prefer some technologies over others

Energy systems models provide frameworks to **quantitatively** assess implications of different energy policy / development options on the energy supply system.
Modelling insights

They cannot predict the future
  • But can help understand future better and stay prepared to take informed decision

They cannot make decisions
  • The main task of an energy analyst is to evaluate different options and provide clear inputs for decision makers
Development of a case study
Steps for developing a case study

1. Define the scope of the Study:
   • Identify policy issues and questions to be addressed and design the case study accordingly

2. Map schematically the system:
   • Identify natural resources, energy carriers and technologies that are used and those that may be used in the country (build a ‘Reference Energy System’)

3. Define scenarios:
   • Identify sets of assumptions and prepare the corresponding scenarios to be analyzed
1. Define the scope of the study

The scope of the study depends on the energy policy question that you want to address, e.g.:

- What policy interventions are necessary to ensure adequate, reliable, and affordable energy supplies?
- What needs to be done and what will be the costs to supply modern energy sources to remote areas?
- What if environmental regulations are made more stringent?
- What needs to be done to increase the share of renewable technologies?
- Should the electricity import be allowed?
- Should the existing nuclear facilities be closed down?
- Can energy conservation program help in reducing cost of energy supply?
Given the scope of the study, what is it important to analyse?

- What technologies could play a role under different demand projections?
- Are there sub-national, national or regional dimensions which have to be taken into account?
- Are there boundaries and limitations in the energy system?
- One or more/all energy forms/fuels?
- One part of complete energy chain?
- ...

Do not over complicate! Bigger model usually means more problems!
2. Map schematically the system

To model the initial conditions of the system

To identify the existing competitions in the system

You may represent the energy system in an aggregated fashion. E.g.:

- Aggregate transmission and distribution networks
- Aggregate some facilities with common features: e.g. one technology to represent a set of existing coal-power plants
Identify any possible alternatives in the supply system that could be introduced to help meet the policy objectives and targets

- Identification of new technologies e.g. combined cycle power plant, e.g., concentrated solar power
- Identification of new energy supply sources e.g. coal or gas import options
- Identification of "future" technologies
2. Map schematically the system

Identify physical / technical constraints in exploitation of each energy source and technology

Identify limits for each source in terms of quantity and time of supply
2. Map schematically the system

Based on the above, design a **Reference Energy System (RES)**

- RES is a *simplified and aggregated graphical representation* of the real energy system under analysis;
- RES covers *not just the present* configuration of the energy system, but also possible development paths;
- It shows *all existing and potential new energy supply chains*, from primary energy resources to final demand;
- The level of simplification depends on issues to be analysed and data availability;
- RES should be a *minimum representation of reality* needed to answer the policy questions to be addressed;
RES consists of:

- **Energy Levels**
  Resources, Primary, Secondary, ..., Final, ...
  *(extracted from resources, processed, converted, transmitted, distributed, ...)*

- **Energy carriers/commodities**
  Coal, oil, gas, wood, nuclear fuel, electricity, heat, ...

- **Technologies**
  Which extract, process, convert energy from one to another form or to energy service, transmit and distribute
2. Map schematically the system
2. Map schematically the system
3. Define scenarios

Scenario - **not prediction**, but **description** of possible future development:
- Consistent set of assumptions (reflecting policies and constraints)
- Expert judgment/informed guesses how the future may evolve (prices, technologies...)
- Model results

Set of alternative scenarios:
- Provide alternative development paths
- Assist in understanding possible future developments of complex systems
- Helps identify robust investment choices and policies
3. Define scenarios

Specify:

- Available technologies
- Development of technological parameters (e.g., investment costs, unit size, construction time, efficiency, O&M costs, emission factors, limitation etc.)
- Trends of resource availability & costs; import and export prices for fuel
- Policy constraints (fixed investment plan, environmental regulation, other socio-economic policies)

Based on:

- Literature
- Concrete plans and policies
- Expert judgments / informed guesses / experience from historic developments
3. Define scenarios

Examples of scenarios based on **policy constraints**:

- Introducing nuclear beyond 2030
- Achieving given share of electricity produced from renewable technologies
- Limiting air emissions
- Limiting import dependency
- ...
General recommendations

• Keep focus on objectives (easy to forget)
• Consider available human resources and data availability
• Define system boundaries and system details accordingly
• Keep model as simple as possible
• Build gradually
• Introduce constraints step by step
• Interpret the results
• Prepare recommendations
High disaggregation in certain parts of the system can help in analyzing some policy options

The remaining supply system can be aggregated. E.g.:

- High disaggregation at the final and useful levels in order to analyze energy conservation programs
- High disaggregation at the secondary level to assess the role of different generation options
General recommendations

When preparing your study...

• Review existing studies
• Review socio-economic development plans
• Review sectorial policy/plan documents (coal, oil, gas, and renewables …)
• Review studies on resource assessments (e.g., technical potential vs. economic potential)
• Review environmental regulations
• Collect reliable cost estimates
General recommendations

Prepare summary of the existing energy supply system

Prepare a base scenario

• A scenario based on highly likely development path of the energy supply system – often named "Business-as-Usual"

• Based on inputs from sub-sectors of energy sector e.g. power sector development plan, gas/oil sector development plan...
Thank you

For questions: https://groups.google.com/forum/#!forum/osemosys

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