IAEA's Tool for Energy Supply System Assessment
MESSAGE Modelling Framework

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IAEA's Energy Systems Assessment Tools

- **MAED**
  - Energy Demand Analysis

- **MESSAGE**
  - Energy Supply Optimisation

- **FINPLAN**
  - Financial Analysis of Energy Plans

- **SIMPACTS**
  - Environmental Impacts

- **ISED**
  - Sustainability Indicators

- **WASP**
  - Power Generation Expansion

- **EBS**
  - Energy Statistics and Balances
MESSAGE

Model for Energy Supply System Alternatives and their General Environmental impacts

• Software designed for setting up optimisation models of energy supply systems to assess capacity expansion and energy production policies
Short History of MESSAGE

• Originally developed at IIASA
  • Initiated under Wolfgang Hafele and Alan Manne (in 1970s)
• MESSAGE at IAEA
  • Added graphical user interface
  • Documentation – User manual
  • Capacity building
  • eLearning application
  • Online user support (TSES – Tele Support Expert Service)
  • Further development and improvements
What MESSAGE can do?

- MESSAGE calculates least-cost energy supply system
- Can be used to assess, develop and design different regional and national energy strategies, policies and action plans
- MESSAGE study results are used to support decision and policy making processes
What MESSAGE cannot do?

- Cannot predict future
- Cannot make decisions
Energy Chain / Energy System

**Resources**
- Fossil fuels
- Water
- Uranium
- Geothermal

**Primary**
- Petrol
- Electricity
- Washed coal
- Heat

**Secondary**
- Gas-pipeline
- Electric grid
- District heating
- Coal train

**Final**
- Lighting
- Refrigeration
- Heating
- Air condition

**Useful**
Elements of an Energy System

- Resources
- Energy forms
- Technologies
- Demands
Reference Energy System
Energy Demand

- Demand data exogenously given
- Seasonal variations taken into account
- Demand side management measures can be modelled
Case Study Parameters

- Planning horizon and time steps
- Seasonal division
- Constraints
- Discount rate
Optimisation

• Criteria
  • Minimisation of the total discounted energy system cost, subject to the constraints representing demands, resource availability, capacity limits, penalties, etc.

• Mathematical techniques:
  • Linear programming
  • Mixed-integer programming

• *Finding single optimum solution is not the purpose of the model development and use*
MESSAGE Outputs

- Capacity expansion
- Production plan
- Resource use
- Primary energy mix
- Energy imports/exports
- Investments and operational Costs
- Emission and Waste
- etc.
Case Study Design

1. Scope of the Study
   - Identify **policy issues** and **questions** to be addressed in the study

2. System configuration
   - Identify natural resources, energy forms, and technologies **that are used** and those **that may be used** in the country (Reference Energy System)

3. Scenario development and representation
   - Identify sets of assumptions and prepare the corresponding scenarios to be analysed
1. Scope of the Study
Policy Issues to be Analysed

- Accessibility to modern energy services
- Availability of energy
- Affordability of energy
- Resource management
- Energy trade
- Energy security
- Local and regional development
- Regional and international commitments
- Environmental regulations
- Market restructuring / liberalisation
- ...
1. Scope of the Study

Policy Questions to be Addressed

- Specific policy questions:
  - 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 needs to be done to increase the share of renewable technologies?
  - Can energy conservation program help in reducing cost of energy supply?
  - What if environmental regulations are made more stringent?
  - What will be the consequences of market restructuring and liberalization?
  - What is the suitable level of taxes or subsidies?
  - Should the electricity import be allowed?
  - Should the existing nuclear facilities be closed down?
  - ...

- Target oriented questions
  - Increase share of RES (e.g. to 30% by 2030)
  - Reducing energy import dependency (e.g. to 20% by 2030)
  - Reduce environmental impact (e.g. avoid SO₂ and other emission)
  - ...

- Strategy oriented questions
  - Possible role of renewable energy sources
  - Economic potential of hydropower
  - ...

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Preparatory Work to Facilitate Identification of Issues

- Review of existing studies
- Review of socio-economic development plans
- Review of sectorial policy/plan documents (coal, oil, gas, renewable...)
- Review of studies on resource assessment (e.g., technical potential vs. economic potential)
- Review of environmental regulations
- Cost estimates
2. System Configuration

Reference Energy System

- An energy supply system consists of
  - **Energy forms** (natural resources, primary energy, secondary energy, final energy)
  - **Technologies** which convert energy from one form to another or to energy service
  - **Technologies** which transport and distribute energy

- Total energy system costs are the sum of:
  - Investment costs
  - Fuel costs
  - Operation and maintenance costs
  - Resource costs
  - Environmental penalties

- There is much flexibility – but do not overcomplicated
3. Scenario Representation

What is a scenario?

• Scenario - not prediction, but description of possible future development
  • Consistent set of assumptions (reflecting policies and constraints)
  • Expert judgment on 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. Scenario Development
Scenario Representation for the Future

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

- Based on:
  - Concrete plans and policies
  - Expert judgments and informed guesses
Interpretation of Outputs

- Each plan has various implications
  - Financial, environmental, social, etc.
- Policy implications can be obtained by analysing alternative development path of energy systems, in terms of
  - Resource availability
  - Costs
  - Environmental regulation
  - Strategic objectives (security of supply, availability of energy...)
  - etc.
Model Development

- Model is an abstracted form of the real world
- Keep focus on objectives
- Consider available human resources and data availability
- Define system boundaries and system details
- Design model keeping it as simple as possible
- Build gradually
- Check and interpret results
- Prepare recommendations
MESSAGE

• Offers a powerful and flexible framework for modelling, analysis and assessment of energy system and design of energy policies
• Capacity building for energy planning and support in model use available through IAEA
... atoms for peace.