IAEA's Tool for Energy Supply System Assessment

MESSAGE Modelling Framework

IRENA-ECREEE Workshop on Energy Planning

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Planning and Economic Studies Section

Department of Nuclear Energy

IAEA

International Atomic Energy Agency

IAEA 's Energy Systems Assessment Tools

MESSAGE

Energy Supply Optimisation

MAED

Energy Demand Analysis

WASP

Power Generation Expansion

SIMPACTS

Environmental Impacts

FINPLAN

Financial Analysis of Energy Plans

EBS

Energy Statistics and Balances

ISED

Sustainability Indicators

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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

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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

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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

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What MESSAGE cannot do?

- Cannot predict future
- Cannot make decisions

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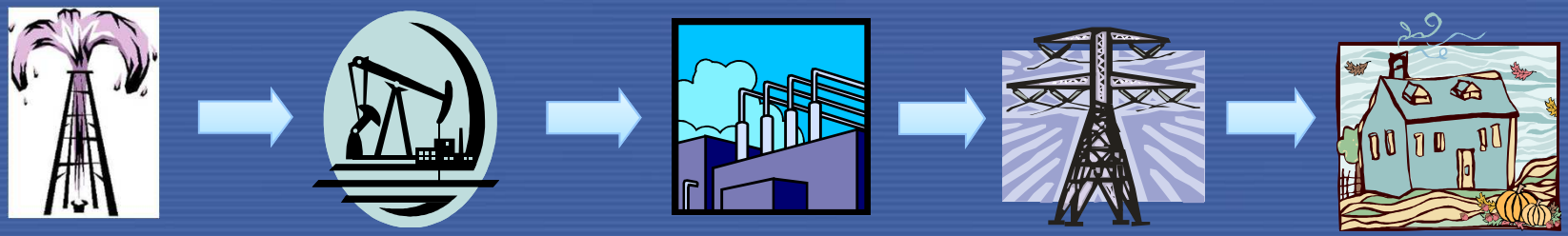
Energy Chain / Energy System

Resources	Primary	Secondary	Final	Useful



Extraction	Conversion	T&D	Appliances
▪ Fossil fuels ▪ Water ▪ Uranium ▪ Geothermal	▪ Petrol ▪ Electricity ▪ Washed coal ▪ Heat	▪ Gas-pipeline ▪ Electric grid ▪ District heating ▪ Coal train	▪ Lighting ▪ Refrigeration ▪ Heating ▪ Air condition

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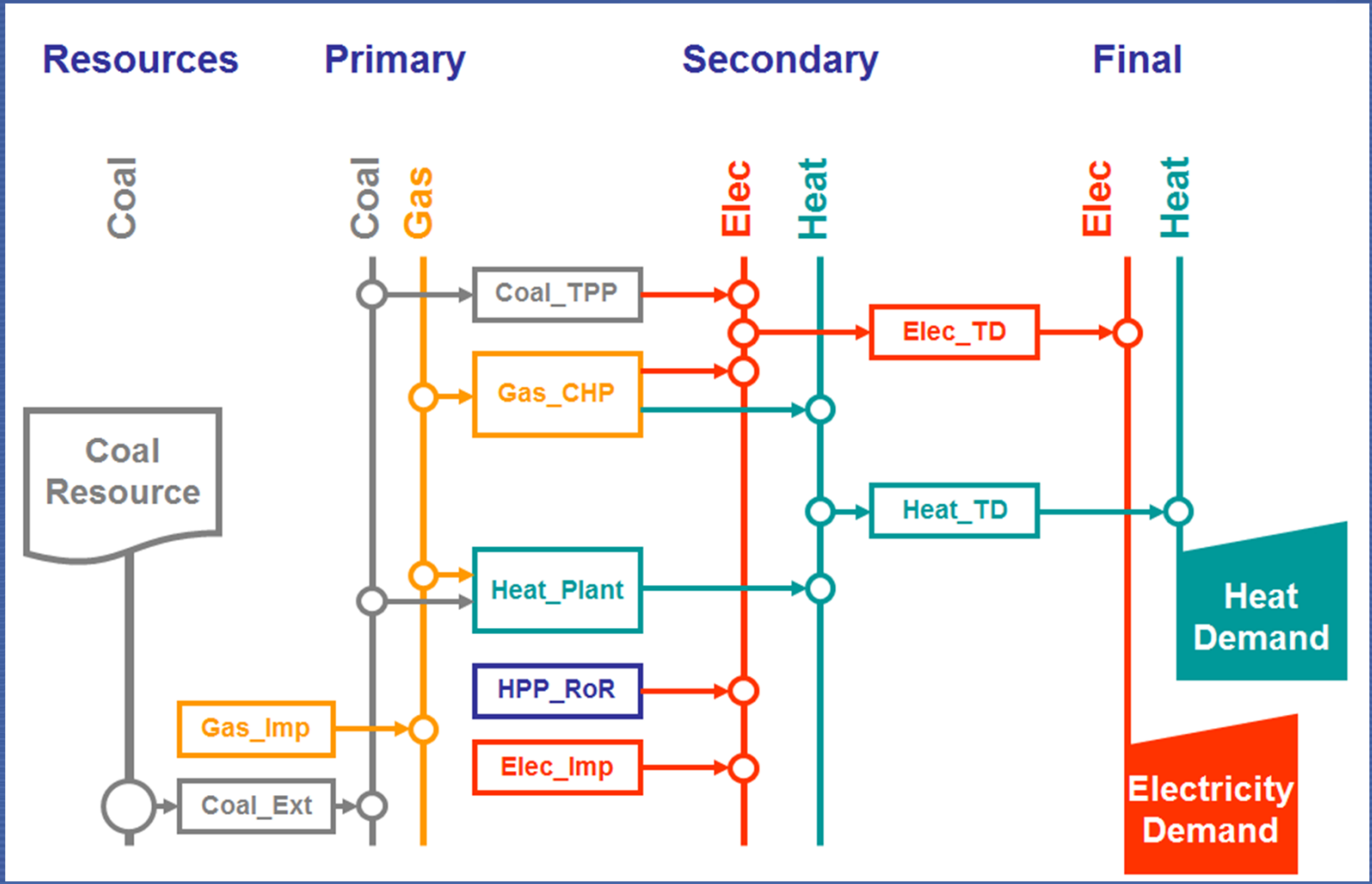
Elements of an Energy System

- Resources
- Energy forms
- Technologies
- Demands

Reference Energy System



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Energy Demand

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

Case Study Paremeters

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

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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***

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MESSAGE Outputs

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

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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

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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
- …

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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 SO_2 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

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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 other, 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

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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

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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

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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.

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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

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- 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

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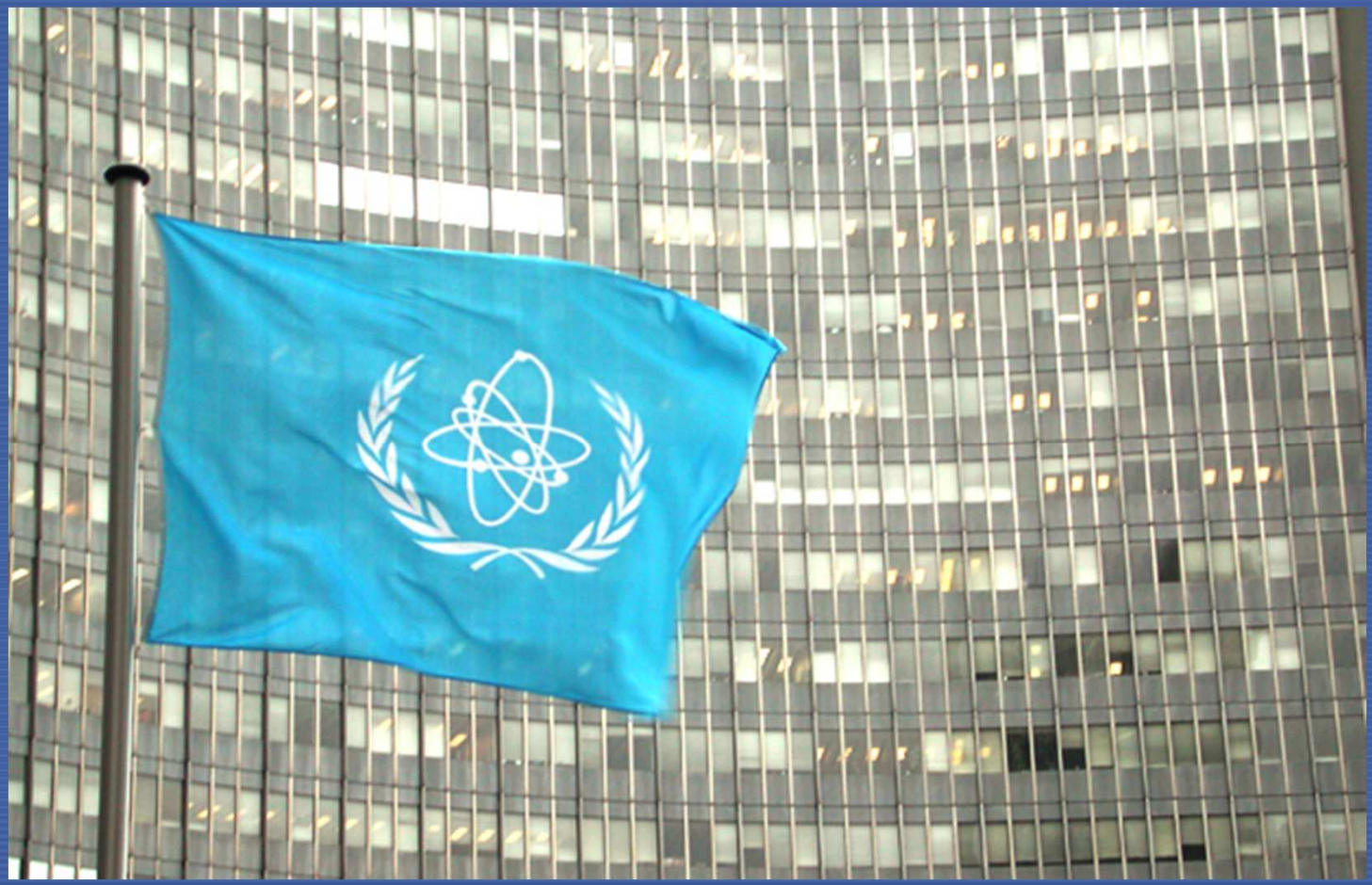

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… atoms for peace.