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Presentation on IAEA's MESSAGE tool for sustainable energy supply system development assessment

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SPOTLIGHT SESSION

Integrated Energy System Planning







Model for Energy Supply System Alternatives and their General Environmental impacts

- Software designed for setting up optimization models of energy supply systems to assess capacity expansion, related investments, environmental impacts and policies
- Applicable at the national, sub-regional or regional level models

MESSAGE



Key characteristics

- Medium to long-term timeframe
- "Energy system" (as opposed to power system)
- Optimisation principles (as opposed to simulation or accounting frameworks)
- Linear and Mixed Integer Optimisation
- Dynamic (as opposed to static, i.e., snap shots of time)
- Bottom Up (as opposed to top-down, e.g., CGE, econometric or input-output models)

Some Elements of an Energy Supply System



Oil extraction facility, Hydro Power plant, Transmission line, Car etc.





An Energy System



consists of

- Energy Resources and Sources (coal, oil, gas, wind,...)
- <u>Technologies</u> (extract, process, convert energy from one form to another other or to energy service, transmit and distribute)
- Energy Forms (energy extracted from resources, processed, converted, transmitted, and distributed)

Energy Levels & Energy Forms



An Energy Supply model is built by characterizing various energy forms/fuels with:

- various levels
 - e.g., resources, primary, secondary, final
- various energy forms at each level e.g., gas, coal, electricity

An Energy "Chain" or "System"





Reference Energy System (RES)



A first Example in MESSAGE



Reference Energy System (RES)



More complex – Example



9/45





Criteria

minimization of the *total discounted energy system cost*, *subject to* the constraints representing demands, resource scarcity, capacity bounds, environmental constrains, etc.

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Mathematical Techniques

Linear programming Mixed-integer programming



What could be done with MESSAGE?



Modelling of CHP plants

Modelling Environmental Regulations

Modelling Nuclear power and fuel cycle

Modelling Climate Policies

Modelling of Rehabilitation

Modelling Variation of Demand and Production



Electricity Demand variation

Variation in Production Capability





Modelling hydro power plants





Modelling End-Use Energy Technologies

















Modelling of electricity reserve capacity





Modelling water desalinisation and electricity production



Multi-stage flash distillation

Schematic of a multi-stage flash desalinator

- A Steam in
- B Seawater in
- C Potable water out
- D Waste out
- E Steam out
- F Heat exchange
- G Condensation collection
- H Brine heater

Reverse Osmosis



International trade of electricity





Electricity price variation in country 2



Electricity demand in country 1 will be growing, installed capacity of power plants may growth, additional electricity transmission line between countries may be constructed, Electricity price variation in country 2 will remain stable.

What is electricity trade between countries? Which factors may have impact and at what extent?

Modelling of environmental regulations



National Environmental Standards

Environmental regulation

Modelling (accounting) of emissions

Different technologies for pollution abatement (cost, efficiency)



Modelling Climate Policies

- GHG Emission limits imposed and penalties on Emissions
- GHG Emission trading
- Net-zero targets and transition





Country and regional studies

Country studies



KINGDOM OF ESWATINI ENERGY MASTERPLAN 2034

Ministry of Natural Resources and Energy The Kingdom of Eswatini









Country studies





Regional studies – Latin America and the Caribbean

- 3 subregional studies
- 1 regional study

Electricity system (country development and trades) 14 countries



Regional studies – Europe and West Asia



 Analyzing Low Carbon Pathways towards an Ambitious Decarbonized Energy Sector by 2050

24 countries



Regional studies – Africa: Continental Master Plan



IRENA and IAEA to Help African Union Develop Continental Power Master Plan with EU support

01 September 2021 | Articles



- Led by AUDA-NEPAD
- Master plan development: technical team of experts from power pools
- Supported by short-term EU experts (EU TAF team) & modelling partners IAEA & IRENA
- 2021 2023
 - Identify priority projects: type, size, location, timing, etc.
 - To 'unlock' cross-border & inter-power pool power trade
- Aligned with RAF2013 -> Mutual synergies



Thank you!





Extra Slides: MESSAGE screens

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Definition of load regions



Definition of day types

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Definition of load regions



Definition of holidays

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Definition of load regions



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Scenario Preparation (Scenario DB)



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