The Abdus Salam
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2242-16

Joint ICTP-IAEA Workshop on Uncovering Sustainable Development CLEWS; Modelling Climate, Land-use, Energy and Water (CLEW) Interactions

30 May - 3 June, 2011

An Overview of MESSAGE

HOWELLS Mark Idwal

International Atomic Energy Agency IAEA
Planning and Economic Studies Section, PESS
Dept. of Nuclear Energy NE
Wagramerstrasse 5
P.O.Box 100, A-1400
Vienna

An Overview of MESSAGE

Mark Howells, IAEA, NE-PESS

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MESSAGE

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 and energy production policies

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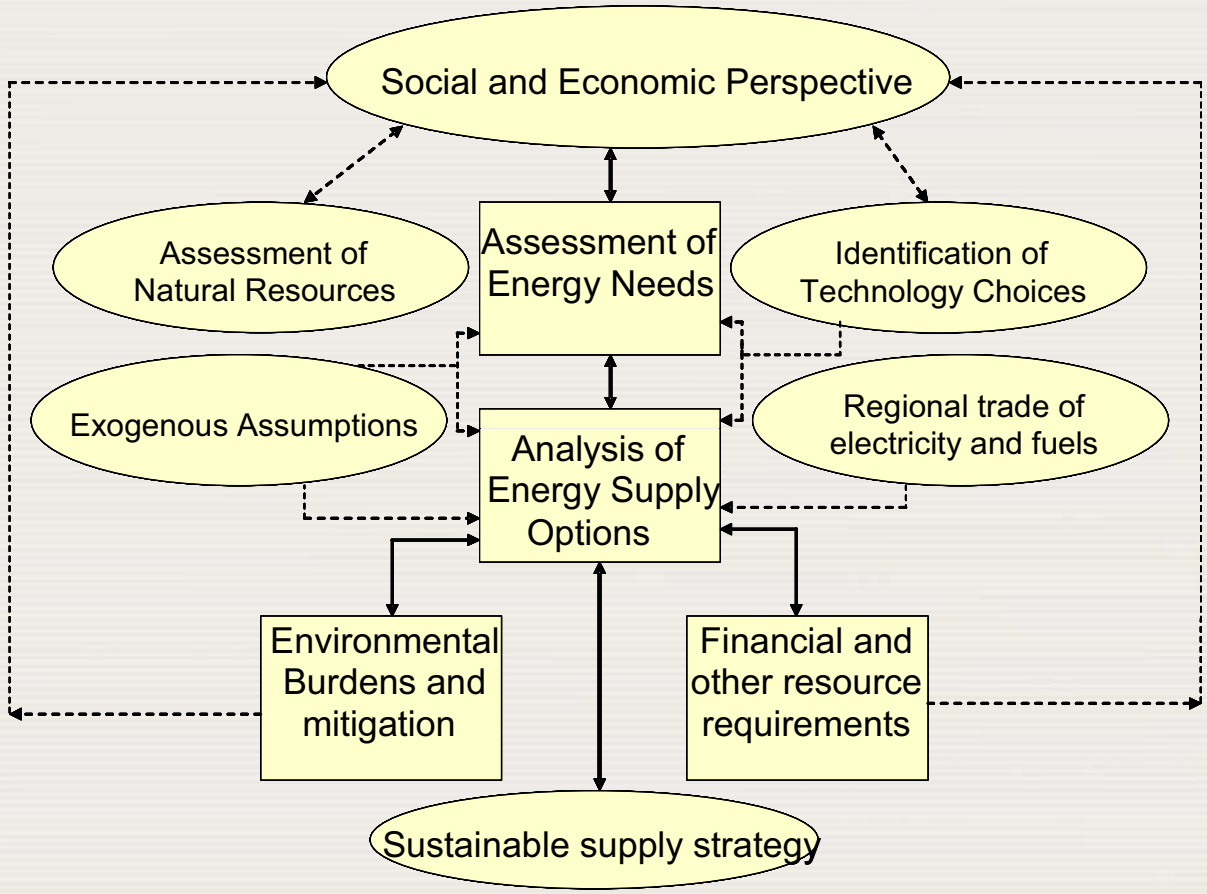
Analytical Framework and Tools for Energy Assessments



MAED

WASP

MESSAGE

FINPLAN

SIMPACTS

ISED

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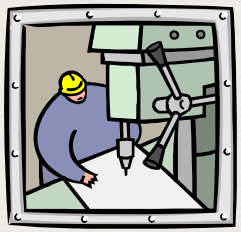
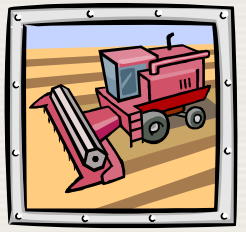
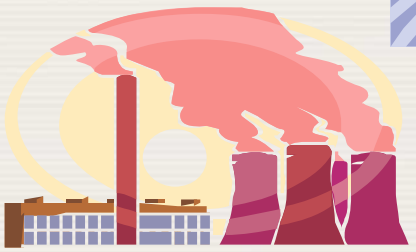
Some Elements of an Energy Supply System

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







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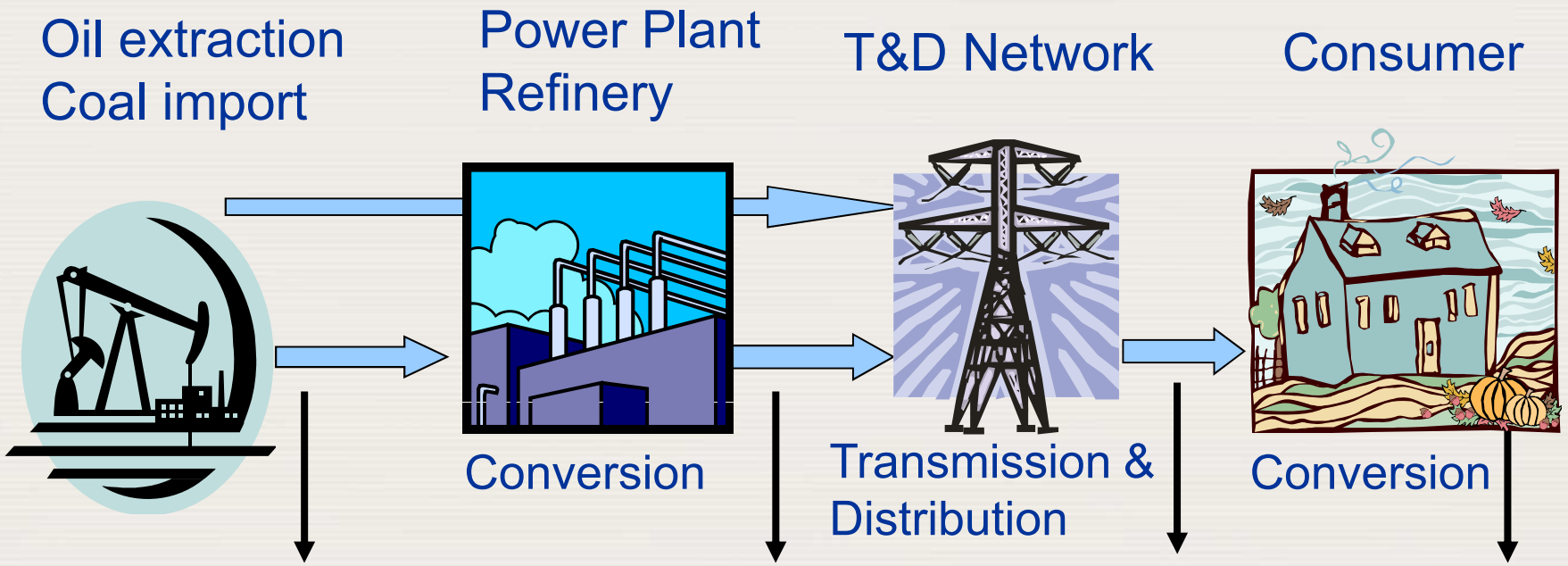
An Energy "Chain" or "System"



PRIMARY	SECONDARY	FINAL	USEFUL
- oil	-diesel	- diesel	- heat
- gas	- kerosene	- kerosene	- light
- coal	- gas	- gas	- mechanical energy
- water	- electricity	- electricity	
	- coal	- coal	

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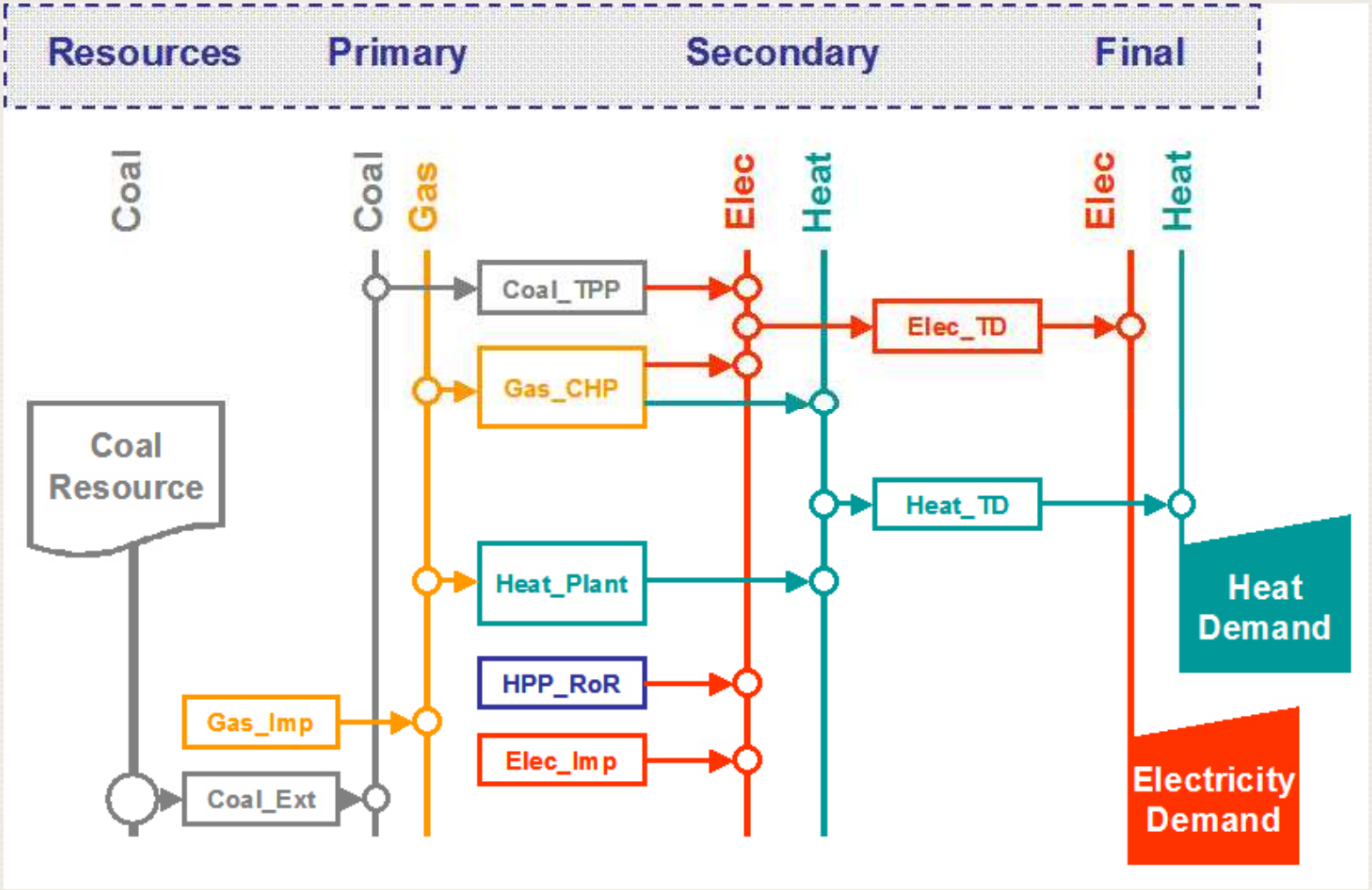
An Example of a Reference Energy System (RES) in MESSAGE



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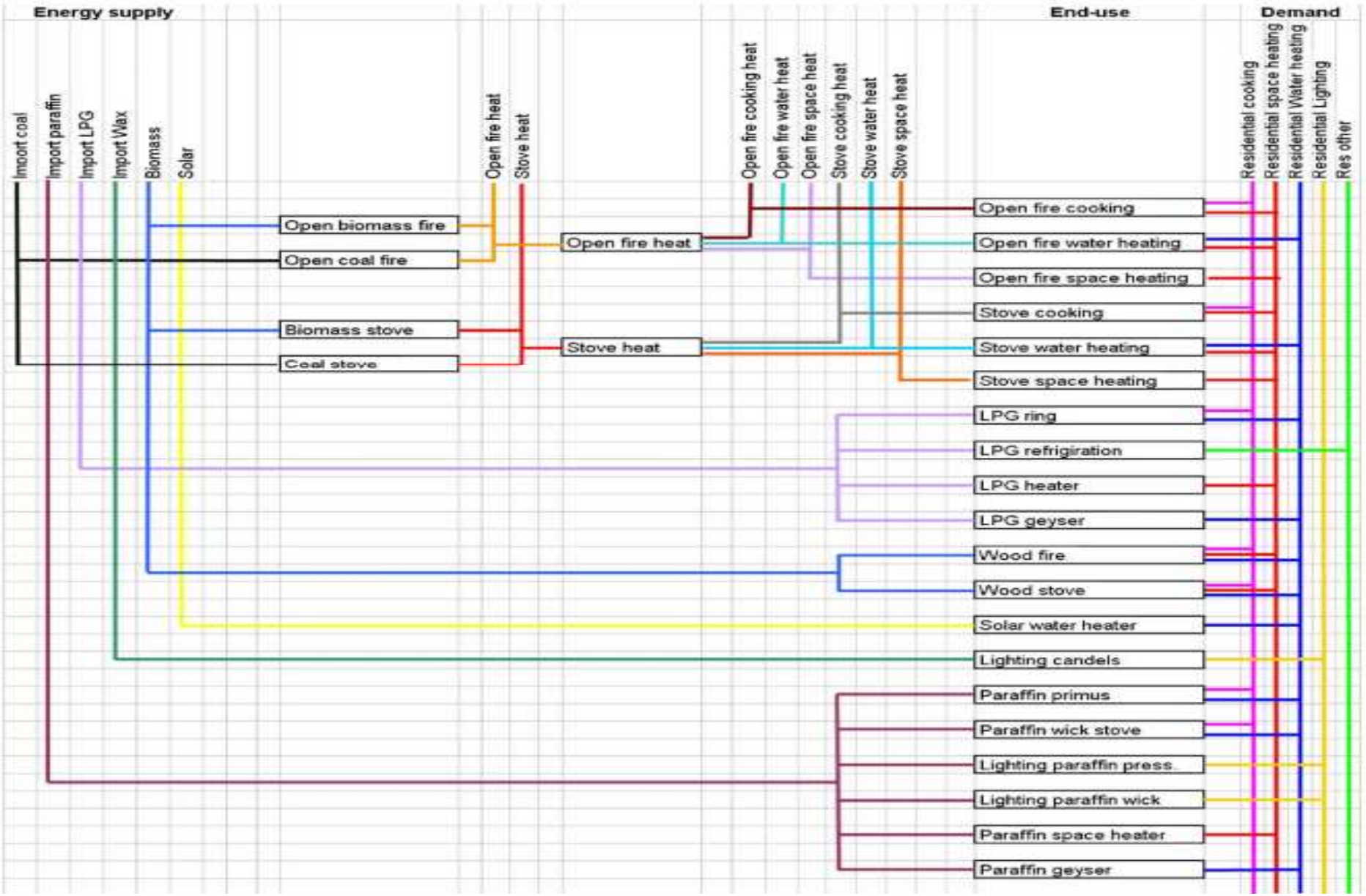
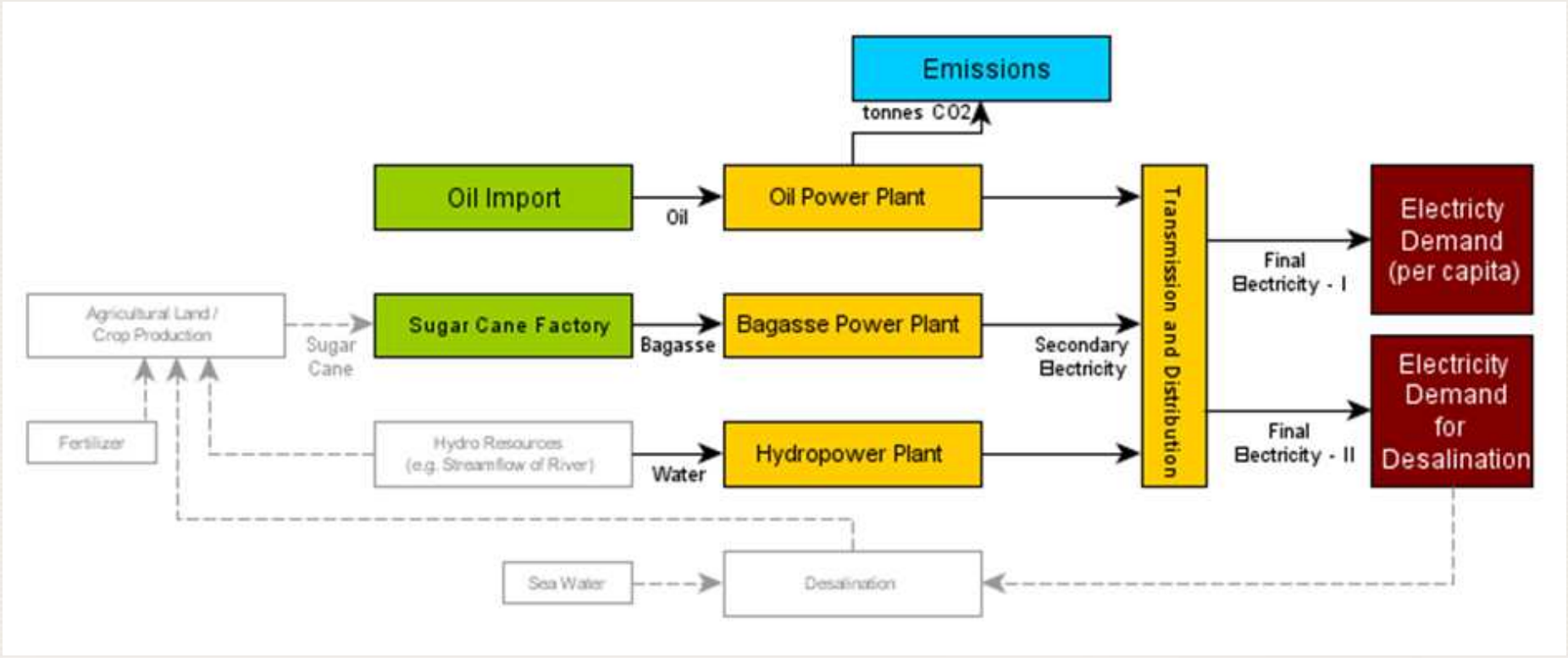
Another Example of a RES: Rural village



Another Example of a RES: CLEW..



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An Energy System

consists of

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

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Energy Levels & Energy Forms

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

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Resources in MESSAGE

Resource level can be grouped into different grades based on

- Geographic locations
- Geological uncertainty

and can be characterized by different resource extraction costs

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Technologies in MESSAGE

A Technology represents a process that

- Converts one energy form into another energy form or into energy service

  e.g. conversion of crude oil to oil products, oil products to electricity, electricity to light

- Transfers/transmits/distributes an energy form
- Supplies/produces an energy form (e.g. hydro power, oil import)

(Note the terms energy "form" and energy "carrier" are used interchangeably)

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Technologies in MESSAGE

Characteristics of a technology that can be built into the model may include:

- Multiple inputs and outputs
- Seasonal variation in capacity
- Efficiency varying with time
- Costs varying with time
- Limits on production
- Capacity build-up constraints
- Market penetration
- Emission control

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Energy Demand

- Demand data are exogenously given for all the energy forms defined at the secondary, final, or useful level
- The demand may have seasonal variations
- MESSAGE computes seasonal demand using information on “load region” (seasonal division of the year specified by the analyst), and “load data” (distribution of the demand by load region)

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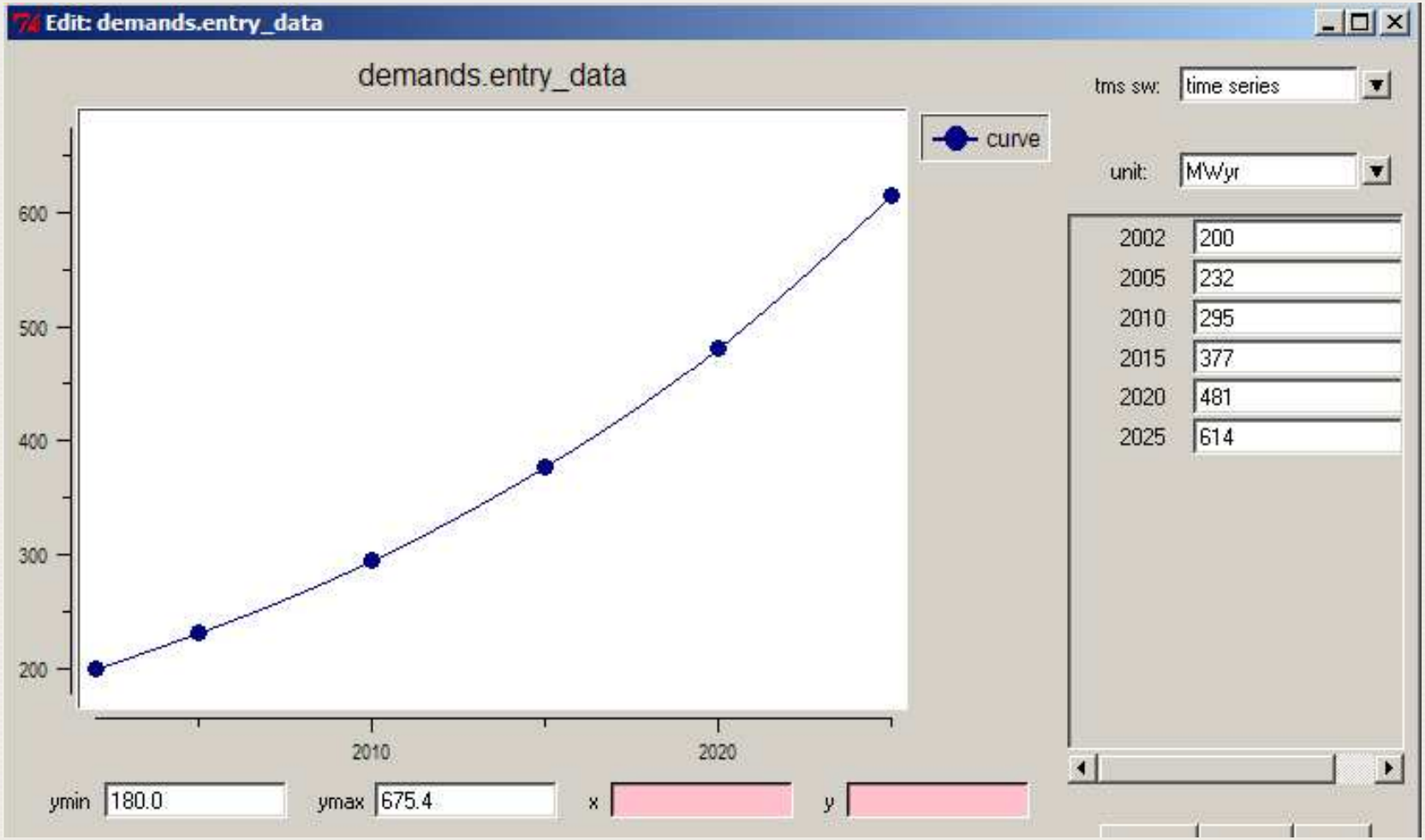
Energy Demand in MESSAGE



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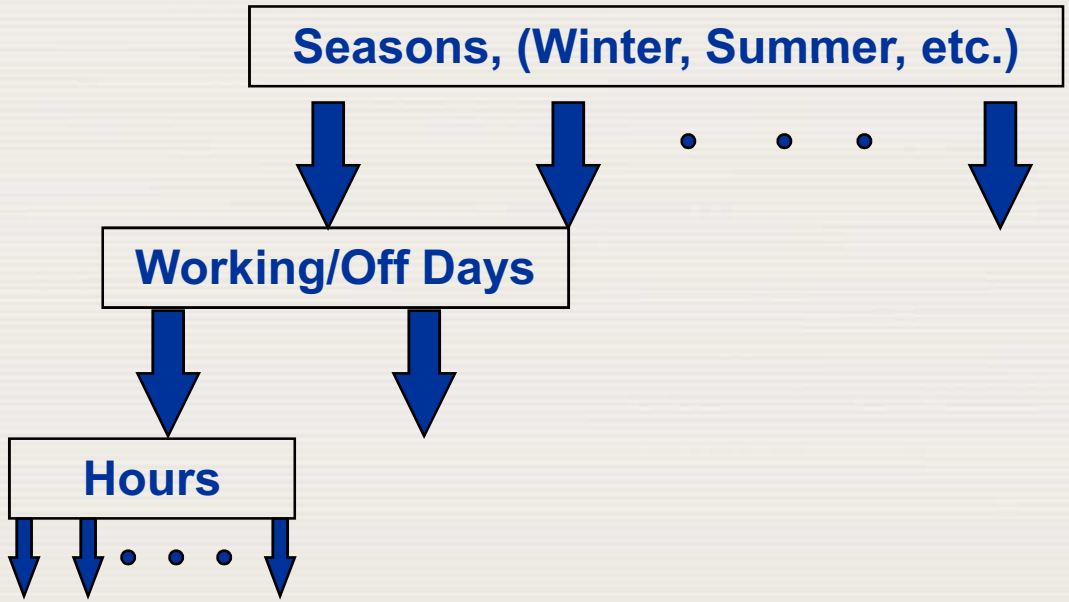
Load Regions

Sub-division of a year: e.g. by seasons

- Number of seasons,
- Division of each season by type of day
- Division of each type of day by parts



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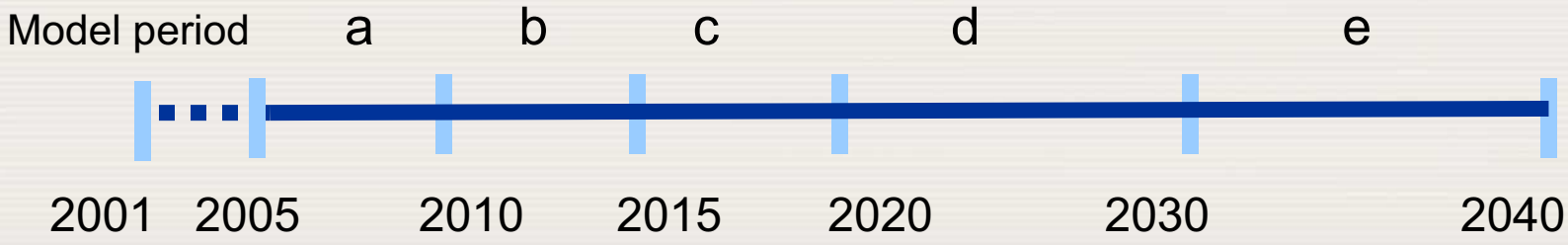
Time Frame – Model periods

- A base year is needed to specify initial conditions
- The first model year and the last model year determine the study period
- Study period is divided into time steps
- Time Steps can be of varying lengths
- Max. number of time steps is unlimited, but more steps will slow down the solver



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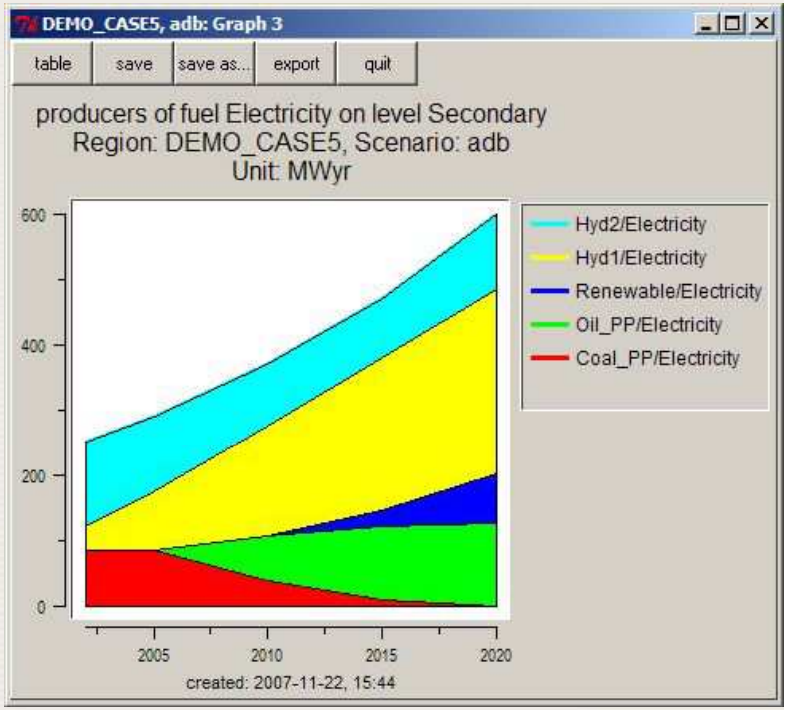
MESSAGE Output

- **Capacity expansion plan & production schedule**

  MESSAGE computes the new capacity requirement taking into account the existing capacities and their retirement time, and the necessary production to satisfy a growing demand



This plan will have various implications: e.g. financial, environmental, energy security, etc.

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Limits on Energy Resource/Technology

- limit on a technology in relation to some other technologies (e.g., a maximum share of wind energy in total electricity generation),
- a common limit to be met by a set of technologies (e.g., maximum limit on emission of SO_2 from all technologies emitting it; given in millions tons of SO_2),
- constraints between production and installed capacity
- … and others (MESSAGE is flexible)

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Optimization

Optimization is used to calculate the least-cost energy supply system under defined constraints

- **Criteria**

  minimization of the total discounted energy system cost, subject to the constraints representing demands, resource scarcity, capacity bounds

- **Mathematical Techniques**

  Linear programming

  Mixed-integer programming

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Optimization

- Optimization is a technique used in MESSAGE
- But to find the optimal solution is not the goal of a MESSAGE SUTDY
- Please do not confuse these!

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Total System Costs

The discounted sum of the following cost items:

- Investment cost (minus salvage costs)
- Fixed and variable operation and maintenance costs
- Fuel costs
- any additional penalty costs defined for the limits, bounds and constraints on relations

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Discounting

- Discounting makes the costs occurring in different points in time comparable by using weights given to the cost incurred at different periods in the total system cost
- Discounting takes into account opportunity costs which can be represented by the long-term real interest rate

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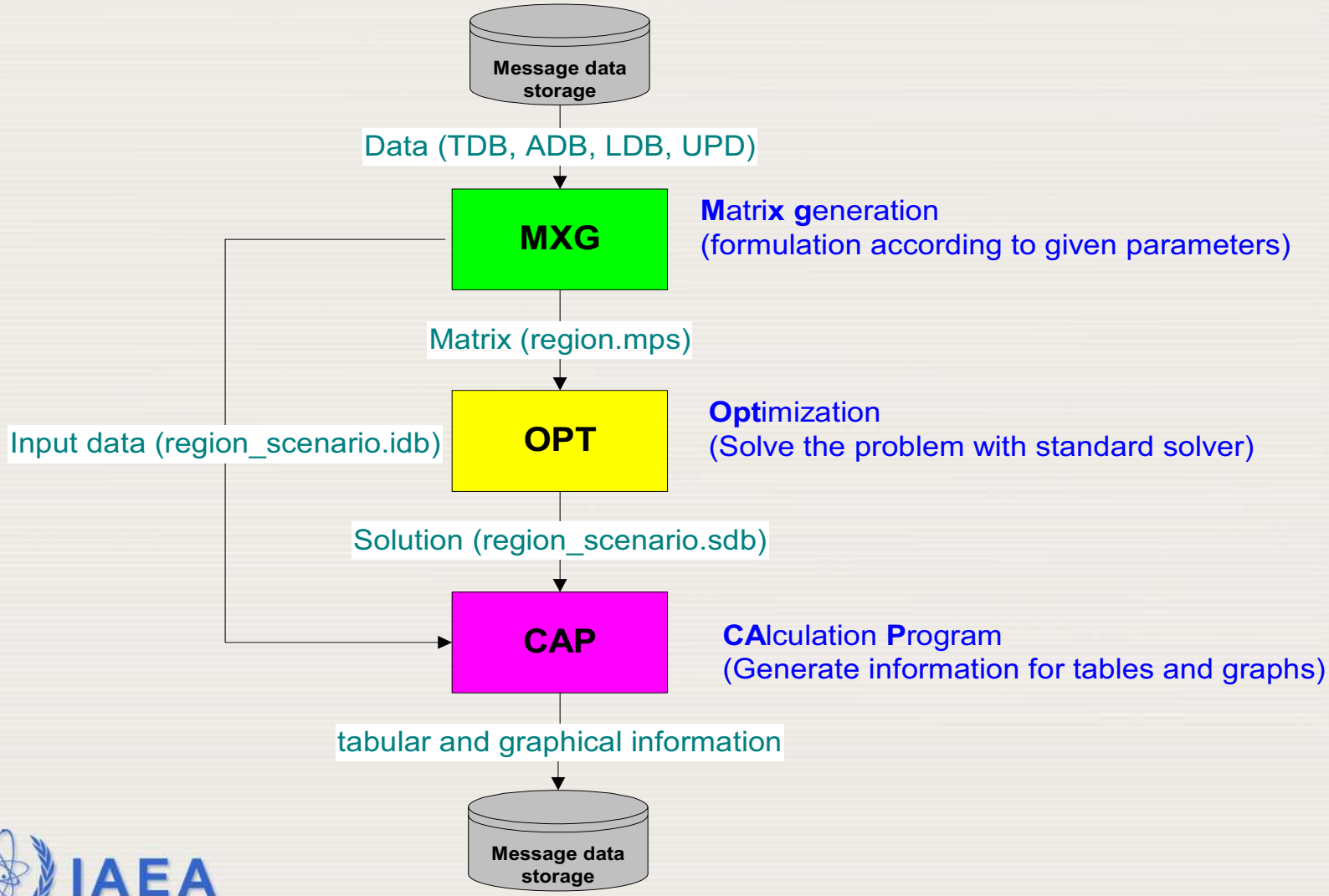
Program Flow in MESSAGE



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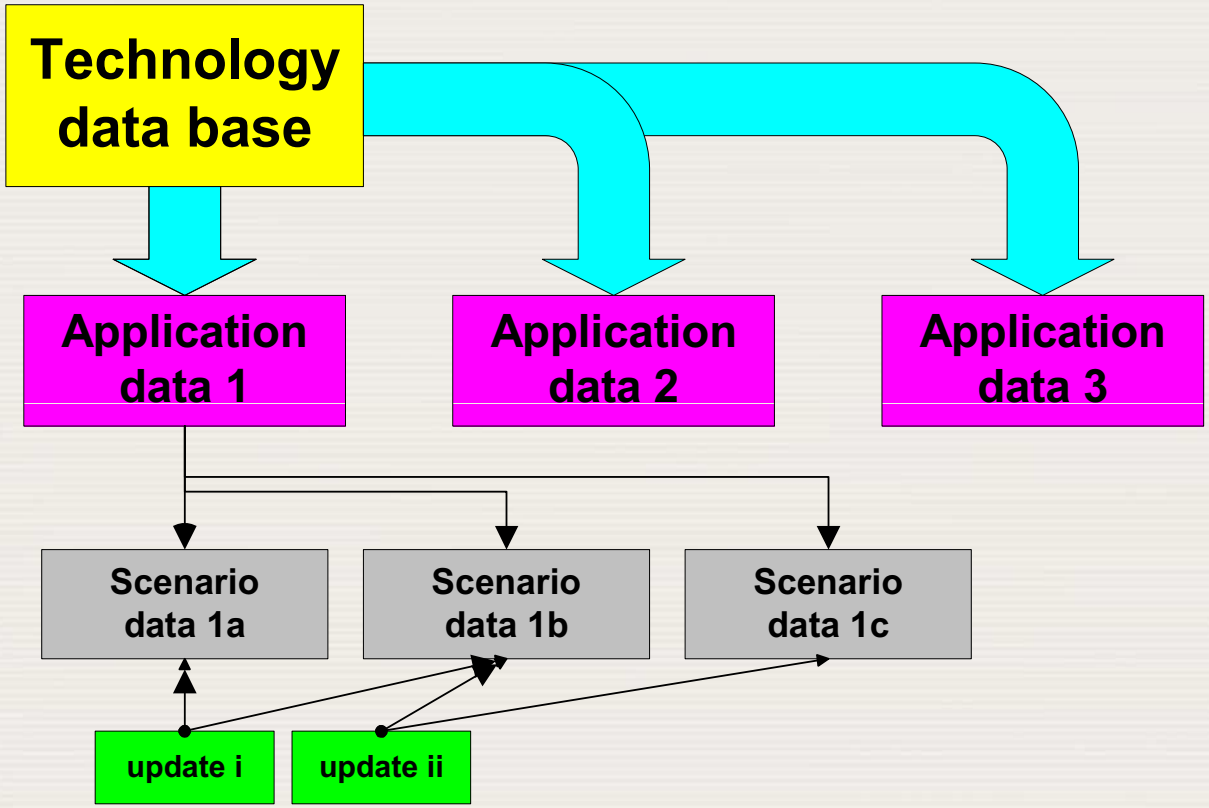
Data Structure in MESSAGE



TDB:
Technical information on technologies

ADB:
Application Data Base: Regional Information

LDB:
Local Data Base: Scenario Information

UPD:
Update Files: Special cases

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…atoms for peace.