

SMR 1585 - 1

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**WORKSHOP ON DESIGNING SUSTAINABLE ENERGY SYSTEMS**  
18 October - 5 November 2004

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***OVERVIEW OF MESSAGE MODEL***

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***These are preliminary lecture notes, intended only for distribution to participants.***

# **Overview of MESSAGE Model**

*A.Galinis*

# MESSAGE

- **Model for Energy Supply Strategy Alternatives and their General Environmental impacts**

# **Evolution of MESSAGE**

- **Developed by International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria**
- **Häfele-Manne Model; 1974**
- **MESSAGE-I; 1978**
- **MESSAGE-II; 1984**
- **MESSAGE-III; 1992**
- **MESSAGE-IV; 1998**
- **MESSAGE-V with user-interface; 2001**

## **Features of MESSAGE (1)**

**It is an energy supply model, representing the energy conversion and utilization processes of the energy system (or it's part) and their environmental impacts for an exogenously given demand of final energy;**

**It is used for development of medium-term strategies, the planning horizon being in the order of 30 years. The time scope is limited by the technology orientation of the approach, due to the uncertainties associated with future technological development. The energy system dynamics are modelled by multi period approach;**

## **Features of MESSAGE (2)**

**It is an optimization model which from the set of existing and possible new technologies select the optimal in terms of selected criterion mix of technologies able to cover given country (or other) demand for various energy forms during the whole study period;**

**Criterion:**

**Cost minimization,**

**Profit maximization,**

**Multi-objective optimization.**

## **Features of MESSAGE (3)**

**The mathematical method used in the model can be:**

**Linear programming,**

**Mixed-integer programming,**

**Non-linear programming,**

**Model into account demand variations of various final energy forms during day, week and seasons, as well as different technological and political constrains of energy supply;**

**Model is an energy and environmental model, enabling the user to carry out integrated analysis of the energy sector development and its environmental impacts;**

## **Features of MESSAGE (4)**

**The representation of the energy system in the model is based on a network concept. The activities and relationships of an energy system are described as an oriented graph, depicting the energy chain starting from extraction or supply of primary energy, passing through the several energy conversion processes (e.g. electricity generation, transmission and distribution) in order to satisfy the demand for final energy in the industry, household, transportation and other economy branches. Using the notation of oriented graph, the links of the graph represent technologies or transportation and allocation process of energy, whilst the nodes represent energy forms (like electricity, oil and gas).**



## **Features of MESSAGE (5)**

**The decision variables in the model formulation are the energy flows and the equipment capacities of the several technologies in the different time periods. They are linked by capacity-flow constraints. The model variables are subject to a system of constraints, representing the structural and technological Properties of the energy system, the existing stock of equipment, the projected final energy demand, energy policy, restrictions, and the impact of the energy technologies on air pollution, emission control technologies and emission control policy restrictions.**

## **Features of MESSAGE (6)**

**The technologies are represented by a set of parameters in the model database, which is transformed into the model's system of equations by a matrix generator programme. Such parameters are e.g. prices of primary energy carriers, investment, fixed and variable costs, of various technologies, energy conversion efficiencies, existing capacities, availability factors, emission factors and others.**

## **Features of MESSAGE (7)**

**The model is applied by defining scenarios. Scenarios represent different hypotheses on important parameters, like the future fuel prices in the international market, the market penetration of new technologies, the market penetration of local and renewable energy sources, political decision on development of one or another type of technology, etc., in order to take into account uncertainties in the future.**

## **Features of MESSAGE (8)**

**The application of the MESSAGE model results in a least-cost inter-temporal mix of primary energy, energy conversion and emission control technologies for each scenario. By analysing the results, “what if?” statements on the future energy supply structure can be made, and different strategies of utilization of various primary energy sources can be compared with respect to their emission reduction efficiencies and their impact on structure and economy of the energy system.**

# **Areas of MESSAGE application**

**Preparation and analysis of sustainable energy system development scenarios;**

**Preparation of energy system expansion strategies;**

**Preparation and analysis of environmental strategies and environmental regulation;**

**Analysis of energy supply reliability issues;**

**Modeling of energy and emission trading;**

**Other areas on global, regional, national or utility level.**

## **Steps in modeling of energy system**

Definition of object for analysis

Preparation of energy flow network

Collection of necessary initial information

Definition of load regions

Creation of model data bases (TDB and ADB)

Preparation of scenarios to be analyzed (Scenario DB)

Matrix generation

Optimization

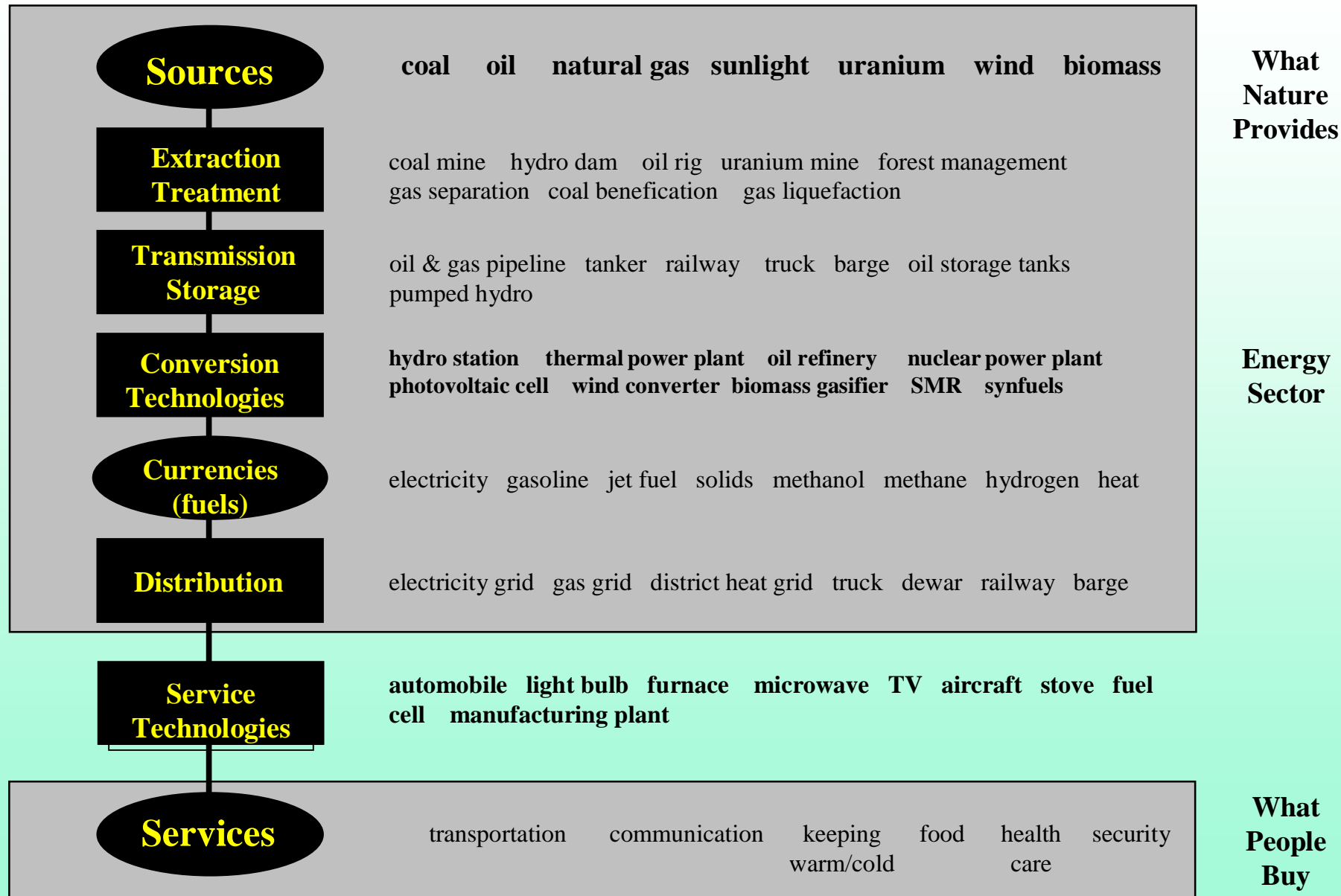
Review of results

## Definition of object for analysis

**MESSAGE models the material or energy flow from resources to demand (so called “energy chain”)**

**If energy system is concern, MESSAGE, depending on user needs can represent entire energy system or it's part**

# Definition of object for analysis





## Preparation of energy flow network

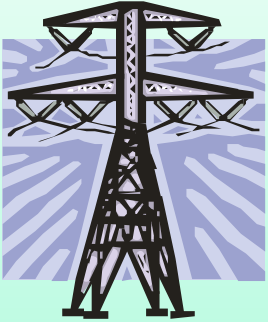
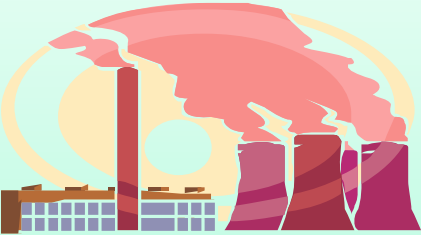
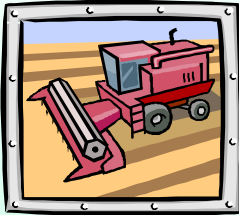
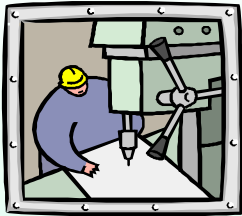
The key elements, based upon which MESSAGE builds energy system, are:

- **Energy forms/energy levels**
- **Technologies** linking energy forms at various levels
- **Relations** which can be defined between energy forms, among various factors describing technologies

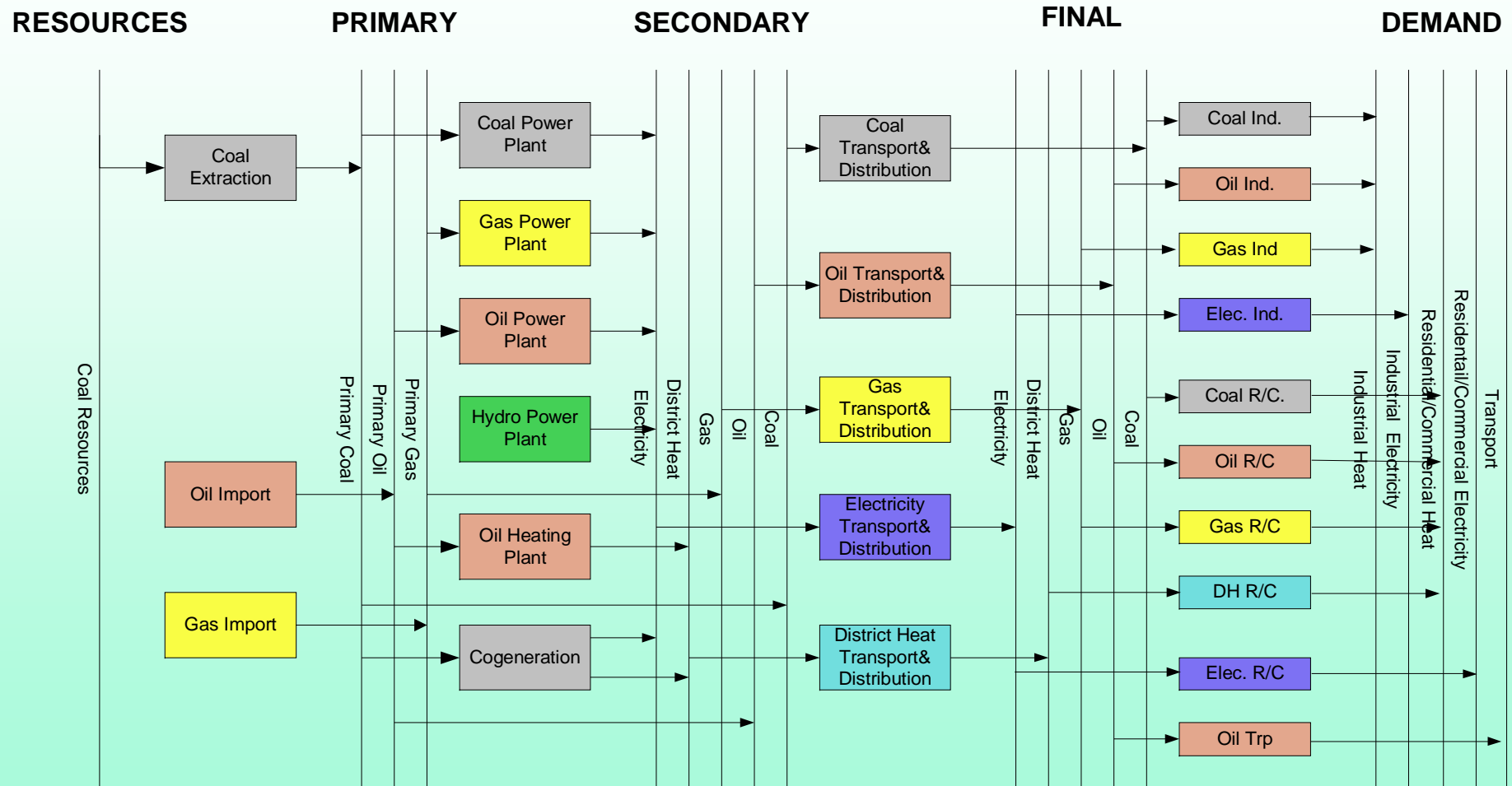
## Preparation of energy flow network

- **Any process**, e.g., extraction, processing, conversion, transformation, transportation, distribution of energy can be represented as a **“technology”** in MESSAGE
- A set of technology **parameters** were built in MESSAGE data base to allow the users to represent various kinds of technologies
- A technology can be as simple as a electricity transmission line or as complicated as a refinery

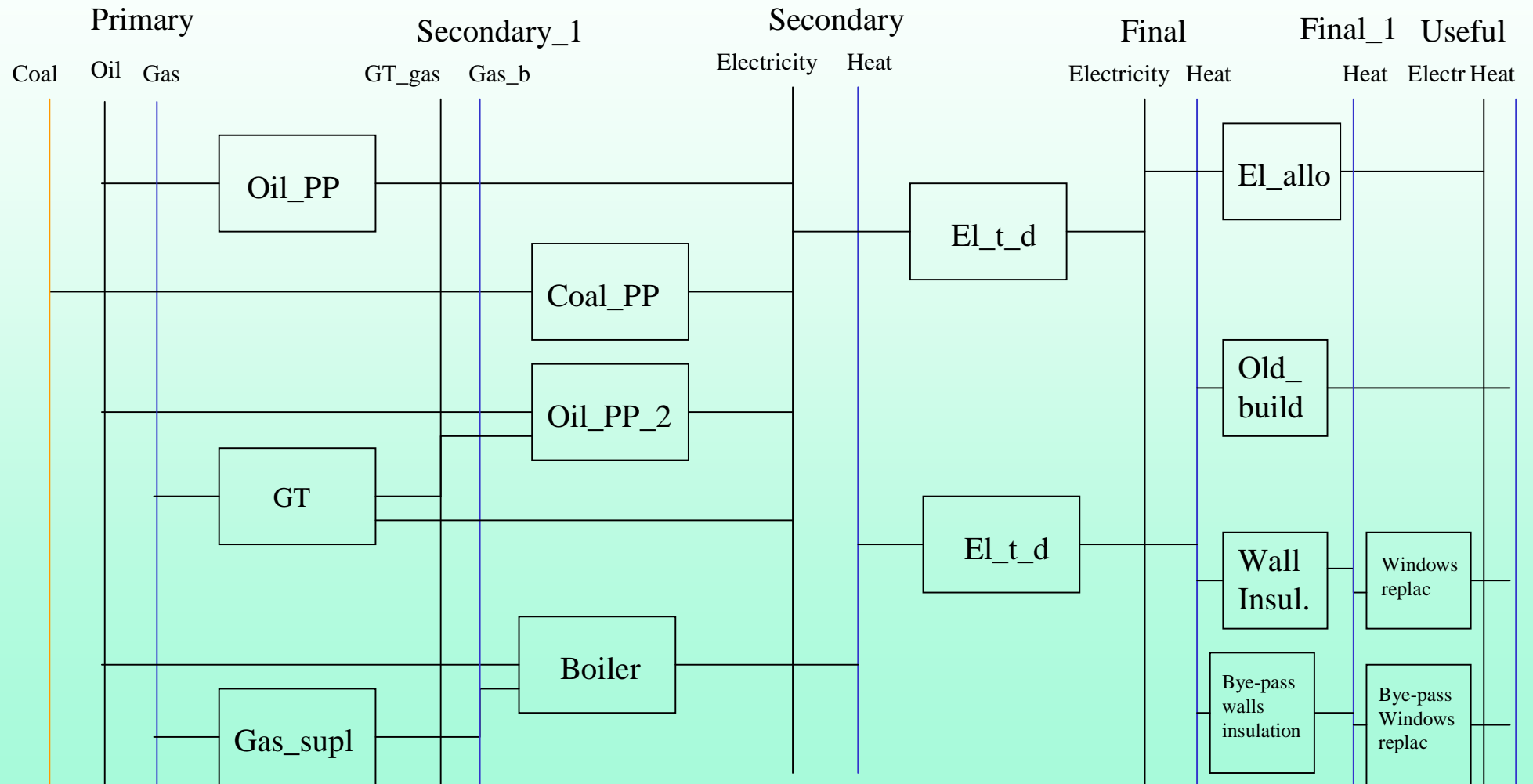
# Energy Technologies



# Preparation of energy flow network



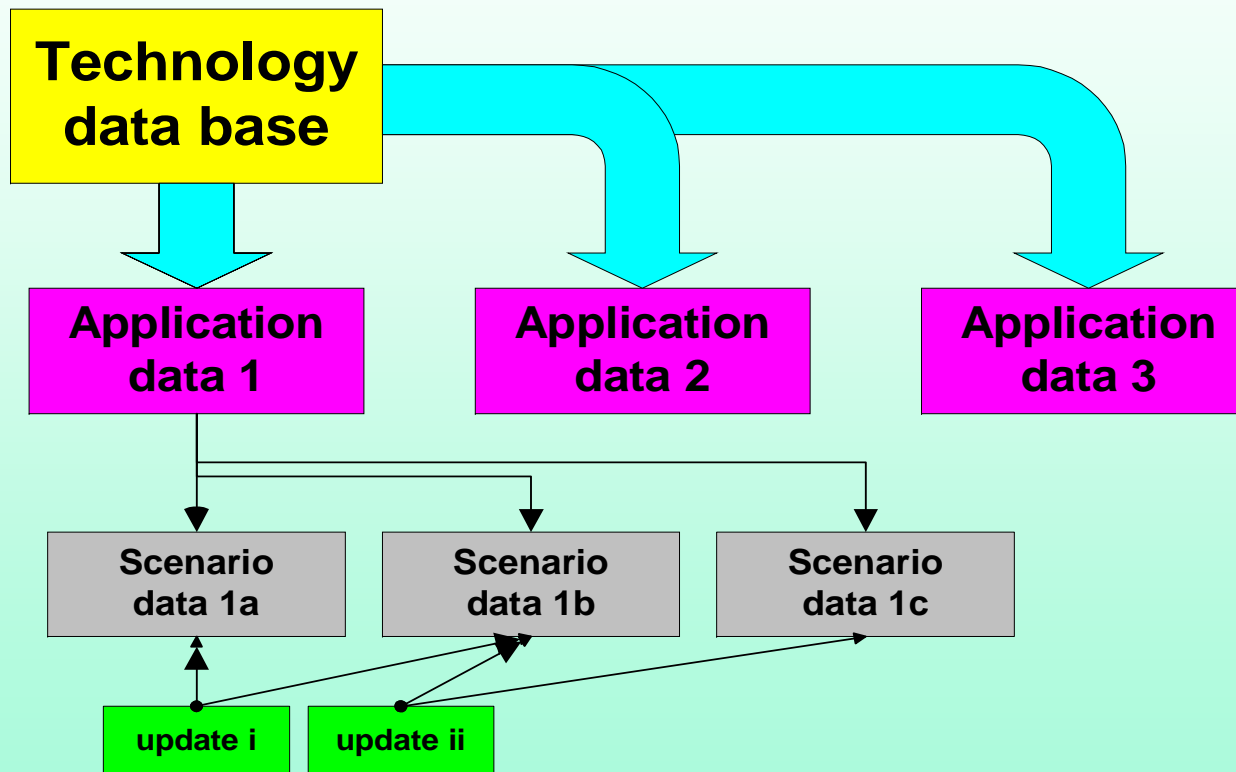
# Preparation of energy flow network (fraction)



## Collection of necessary initial information

- **Technical**
- **Economic**
- **Environmental and parameters used in relations with other technologies**
- **Parameters in MESSAGE are dynamic: they can change over time (seasonal and over year)**
- **Information should be adjusted to the network of energy system**

# Data bases in MESSAGE



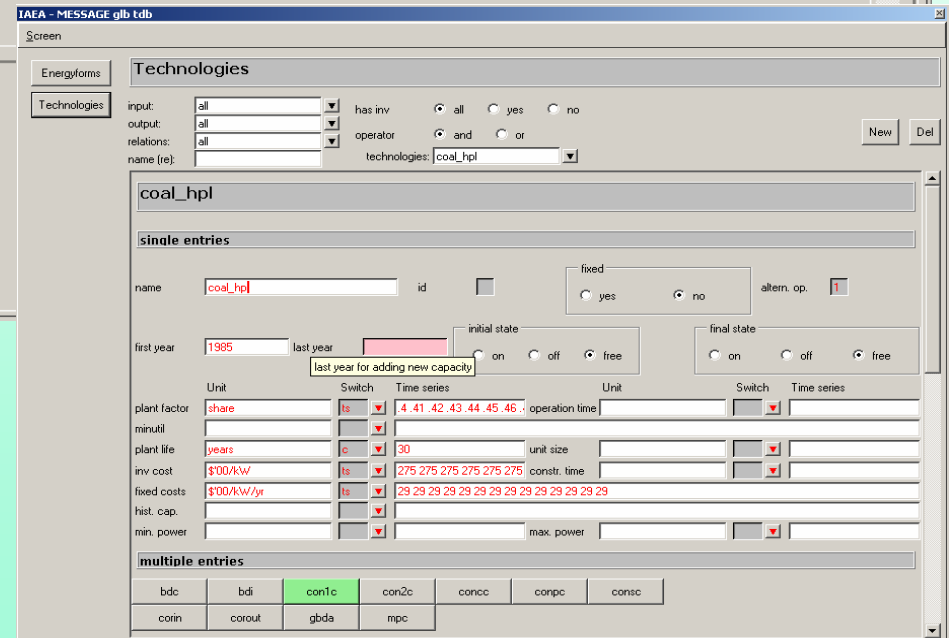
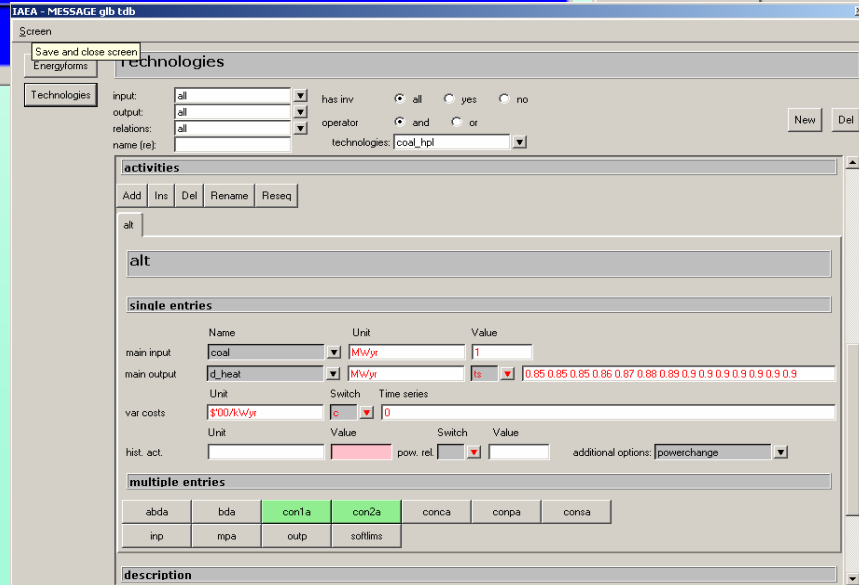
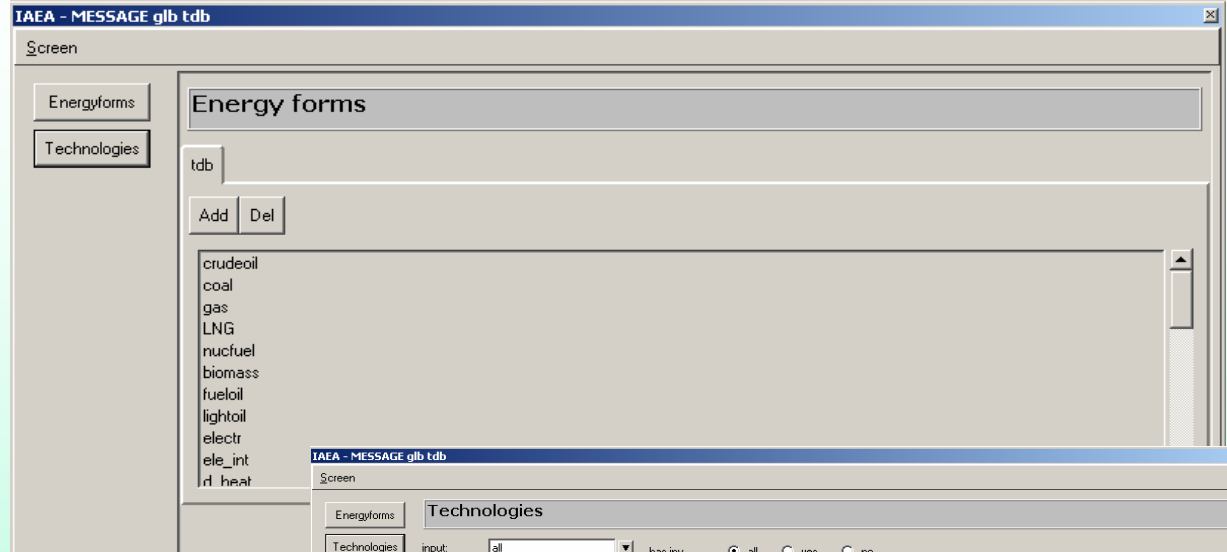
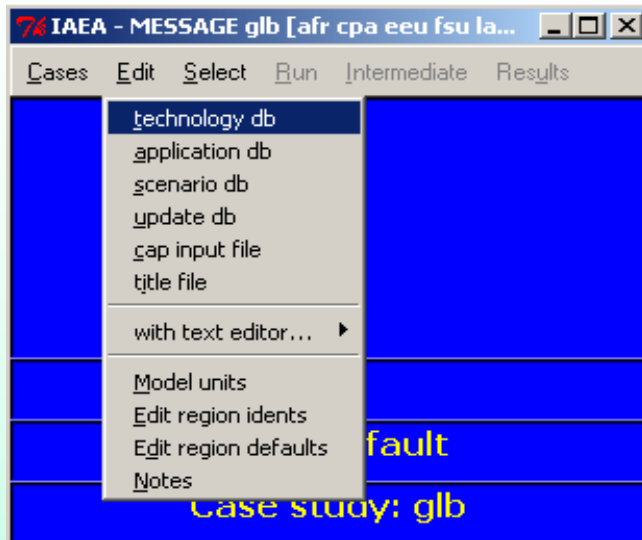
**TDB:**  
Technical information  
on technologies

**ADB:**  
Application Data Base:  
Regional Information

**LDB:**  
Local Data Base:  
Scenario Information

**UPD:**  
Update Files:  
Special cases

# Creation of model data base (TDB)





# Creation of model data base (ADB)

The image shows two windows from the IAEA MESSAGE V software. The top window, titled 'IAEA - MESSAGE V Latvia\_bb', has a menu open with 'application db' selected. The bottom window, titled 'IAEA - MESSAGE V Latvia\_bb adb', shows the 'General data' configuration screen.

**Menu Options:**

- technology db
- application db**
- scenario db
- update db
- update groups
- cap input file
- title file
- with text editor...
- reformat files
- Edit region defaults
- Notes

**General data configuration:**

- country: Latvia
- case name: Latvia\_bb
- date: 8.0
- years: 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2025
- units: energy: MW/yr, power: MW, currency: kEUR'00
- units: volume: Mm3, weight: kton, time: yr, other: MWyr
- ntrun: 22, mixsw: no, actint: 2, invint: 2

**description:**

Latvia\_bb  
Latvia\_aa  
new technologies included

# Creation of model data base (ADB)

The screenshot displays the IAEA MESSAGE V Latvia\_bb adb software interface. The main window is titled "Energy forms" and contains a table of energy forms. A dialog box titled "Level: Useful" is open, showing a detailed view of the energy forms for the "Useful" level.

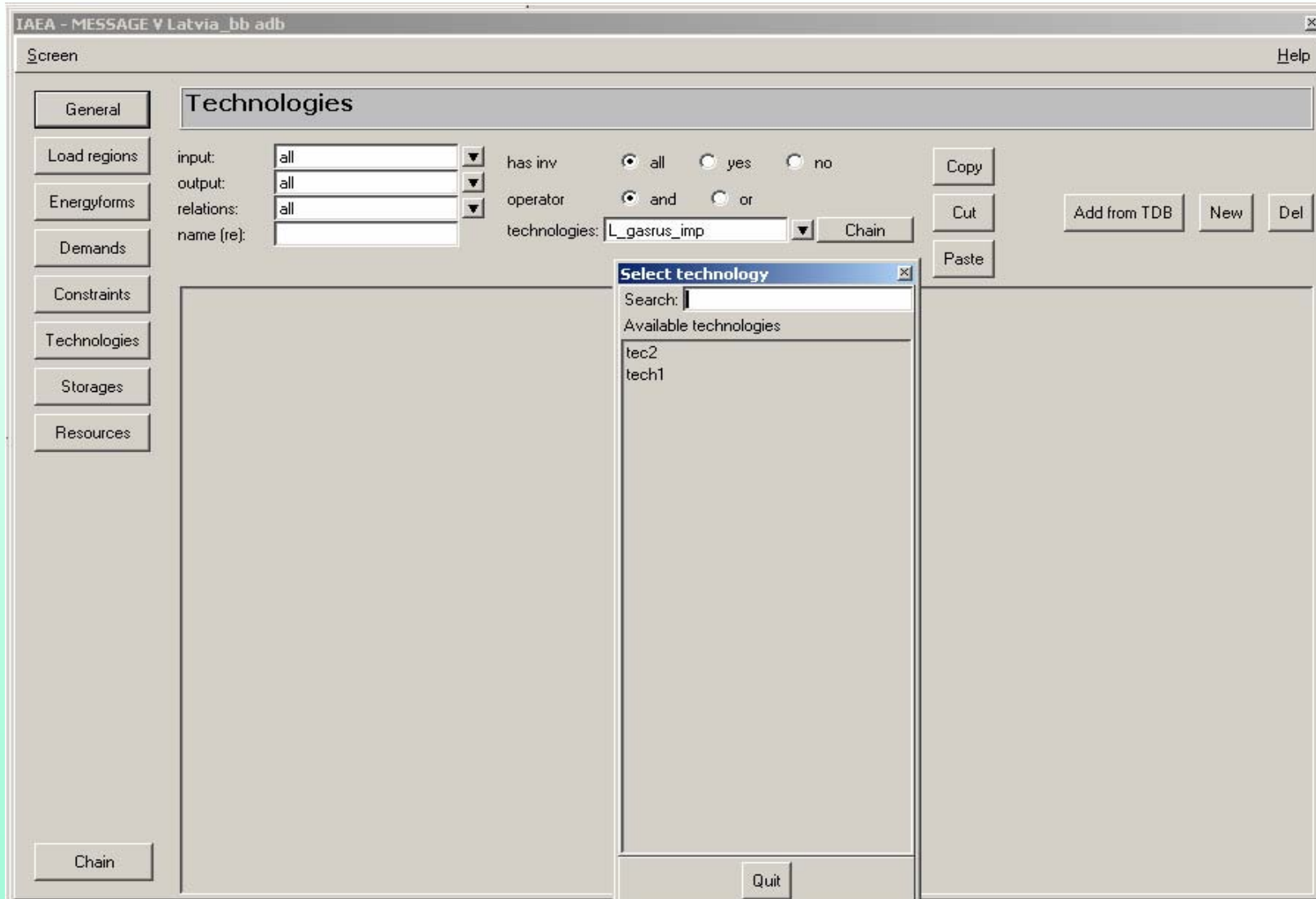
**Energy forms table:**

level name (double click to show fuels)	id	description
Useful	U	
Exported	X	
Distributed	D	
Transmitted	T	
Secondary	S	
Intermediate	I	
Transported	A	
Primary	P	
Resources	R	

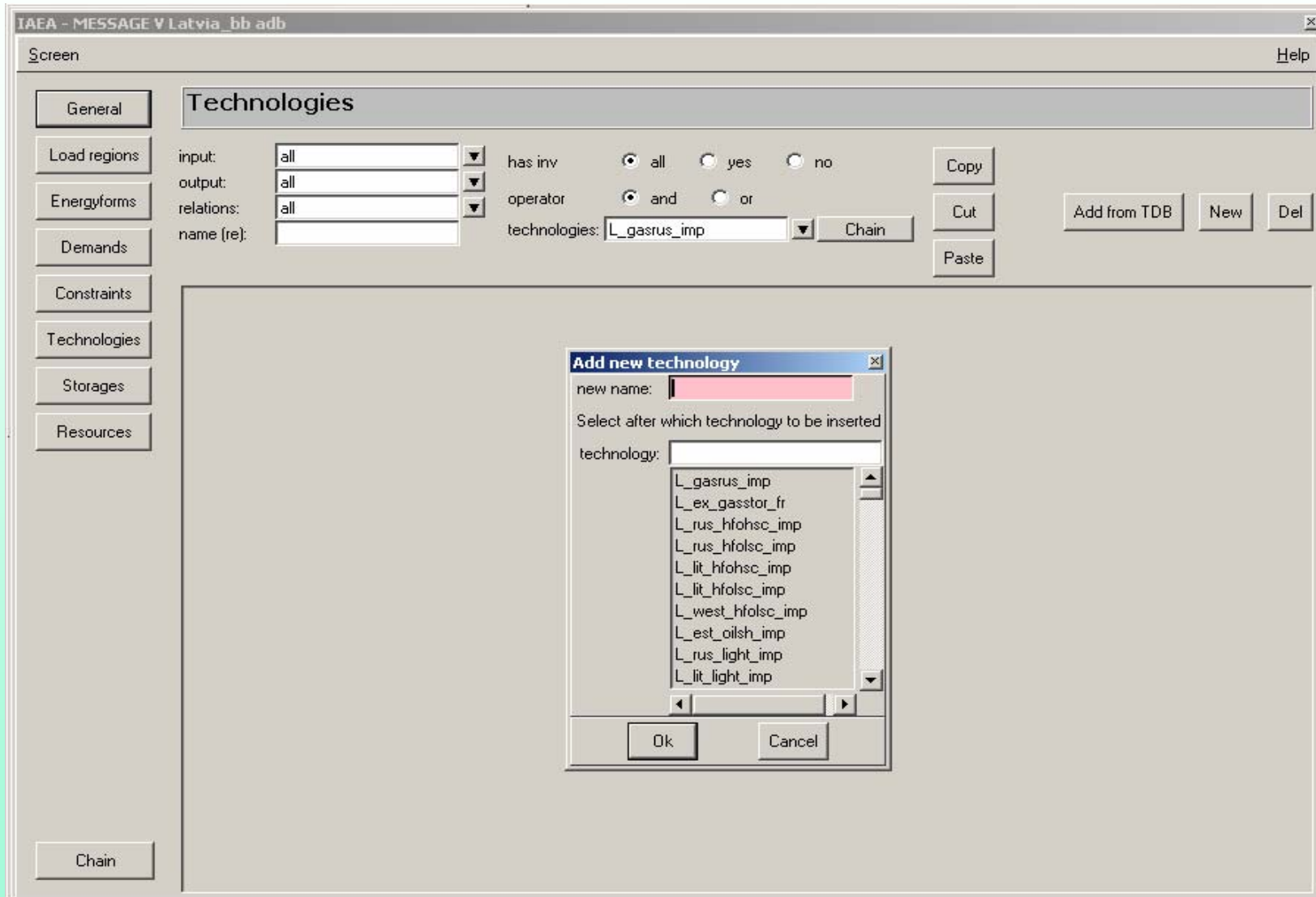
**Level: Useful dialog box table:**

energy form	id	hasldr	fix	unitype	unit	description
Electricity_E	A	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Electricity_W	B	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Heat_Riga	C	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Heat_big_cities	D	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Heat_small_cities	E	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Electricity_pulp	F	<input type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Heat_pulp	G	<input type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Demand_ind	H	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Demand_house	I	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Demand_agric	J	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Demand_service	K	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	
Demand_transp	L	<input checked="" type="checkbox"/>	<input type="checkbox"/>	energy	MWyr	

# Creation of model data base (ADB)



# Creation of model data base (ADB)



# Creation of model data base (ADB)

The screenshot displays the IAEA MESSAGE V software interface for configuring a technology in the ADB. The main window is titled "IAEA - MESSAGE V Latvia\_bb adb" and shows the "Technologies" configuration screen.

**General Settings:**

- input: all
- output: all
- relations: all
- name (re):
- has inv:  all  yes  no
- operator:  and  or
- technologies: L\_ex\_R1chp\_gen

**Capacity Settings:**

- name: L\_ex\_R1chp\_gen
- id: a
- capacity unit: MW
- first year: [redacted] last year: [redacted]
- initial state:  on  off  f

**Table of Multiple Entries:**

Unit	Switch	Time series	Value
plant factor	share	c	1
minutil			
plant life	yr	c	51
inv cost	EUR'00/kW	c	0.001
fixed costs	EUR'00/kW/yr	c	53.0
hist. cap.	MW	hc	1955 83.5
min. power			

**Activities Panel:**

- main input: Gas\_PP/Transported (MWyr) 1.0
- main output: Electricity\_PP\_E/Second (MWyr) 0.23525
- var costs: EUR'00/kWyr (c) 33.28
- hist. act.: MWyr (Value) 0.0, pow. rel. (Switch) 1.1

**Multiple Entries Table:**

Unit	Switch	Value
abda		
alags		
bda		
con1a		
con2a		
conca		
conpa		

# Creation of model data base (ADB)

IAEA - MESSAGE v Lithuania adb

Screen Help

**General**

Load regions

Energyforms

Demands

Constraints

Technologies

Storages

Resources

**Resources**

select resource: Peat/Resources New Del

**Peat/Resources**

name Peat/Resources

unit type energy

	Unit	Switch	Time series
fcost		<input type="checkbox"/>	
uplim	MW/yr	ts	22 30 30 30 30 35 40 40 40

**grades**

Add Ins Del Rename

grade a

**grade a**

**single entries**

	Unit	Value	Unit	Value	Unit	Value
volume		100000	initial		byrex	

	Unit	Switch	Time series
resrem		<input type="checkbox"/>	
cost	EUR'00/kWyr	c	0.01081373
uplim		<input type="checkbox"/>	

**multiple entries**

bda con1a con2a conca conpa mpa

Chain

# Creation of model data base (ADB)

IAEA - MESSAGE V Lithuania adb

Screen Help

General

Load regions

Energyforms

**Demands**

Constraints

Technologies

Storages

Resources

Chain

### Demands

load curves: 
 abs/rel

energy form/level	unit	switch	data (double click to edit)		
Electricity_total/Useful	MW/yr	ts	707.4 779.8 852.2 888.3 1003.1 1079.7 1236.1 1405.1 1584.6 1584.6 1584.6	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Mazeikiai_refinery_electric	MW/yr	c	4.2	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Industry/Useful	MW/yr	ts	1466.68 1597.19 1727.71 1792.97 1885.28 1946.82 2045.41 2173.59 2316.82 23	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
City_heat/Useful	MW/yr	ts	439 458 478 488 522 546 586 625 665 665 665	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Households/Useful	MW/yr	ts	946.23 1007.35 1068.48 1099.04 1118.93 1132.18 1172.75 1208.62 1246.51 124	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Transport/Useful	MW/yr	ts	1387.41 1492.12 1596.83 1649.19 1810.69 1918.36 2133.45 2353.54 2584.95 25	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Elektrenai_heat/Useful	MW/yr	ts	18 18 19 19 20 20 21 23 24 24 24	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Agriculture/Useful	MW/yr	ts	93.07 104.52 115.98 121.71 134.91 143.71 157.78 171.43 188.03 188.03 188.03	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Services/Useful	MW/yr	ts	217.07 225.72 234.36 238.69 252.36 261.47 278.33 295.55 310.62 310.62 310.62	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Mazeikiai_heat/Useful	MW/yr	ts	16 17 17 18 19 19 20 21 22 22 22	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Kaunas_heat/Useful	MW/yr	ts	143 150 158 162 175 184 200 216 234 234 234	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Klaipeda_heat/Useful	MW/yr	ts	98 102 106 109 116 121 129 137 146 146 146	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Vilnius_heat/Useful	MW/yr	ts	238 250 262 269 289 302 327 351 377 377 377	<input type="button" value="Comment"/>	<input type="button" value="Import"/>
Mazeikiai_refinery_heat/L	MW/yr	c	0	<input type="button" value="Comment"/>	<input type="button" value="Import"/>

## Definition of load regions

- **Demand** for energy fuels is an **input** to MESSAGE. It must be defined exogenously by other models e.g., MAED
- MESSAGE allows to specify energy demand at any level
- MESSAGE can represent seasonal **variation** of energy demand

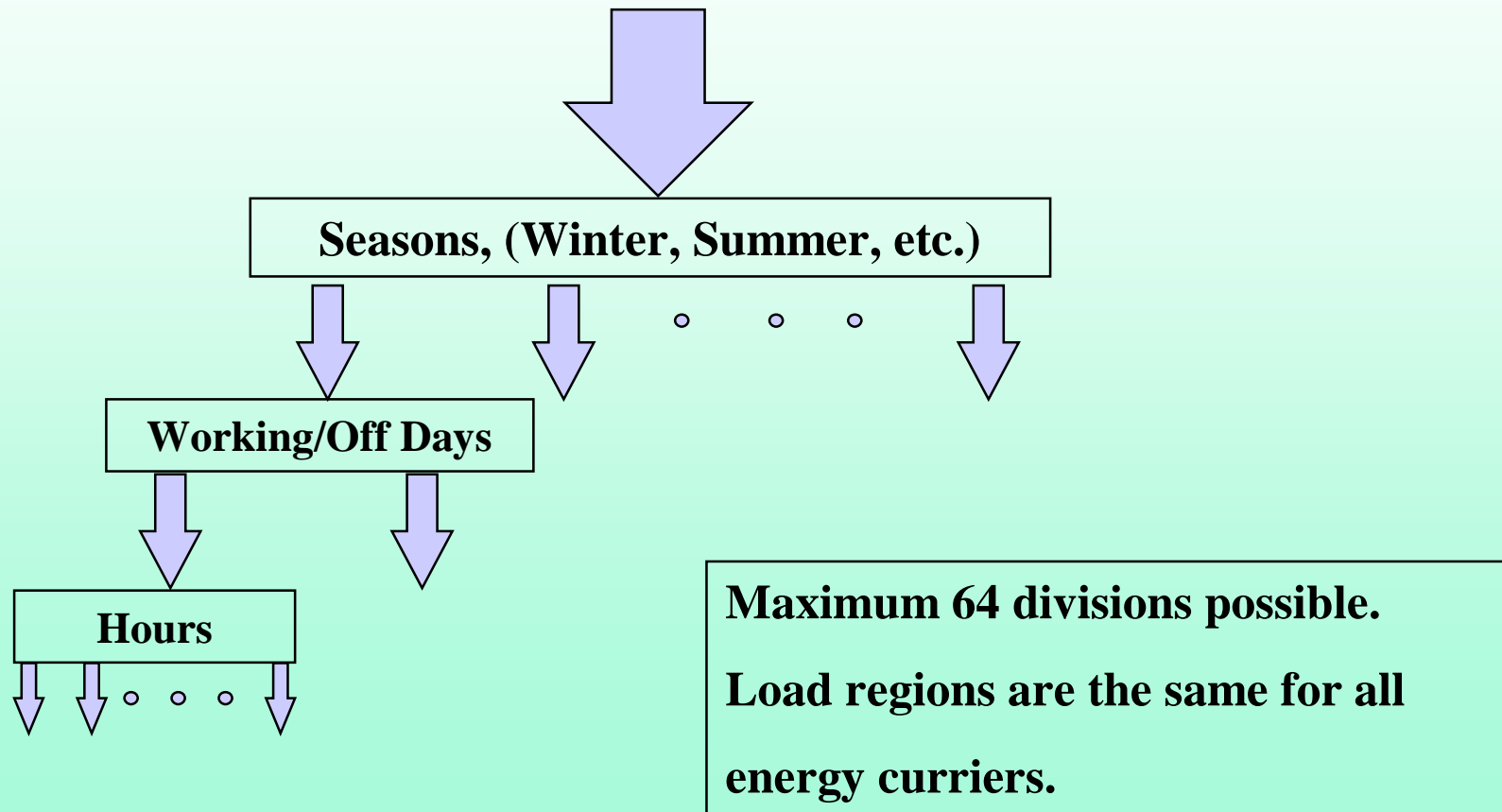


## Definition of load regions

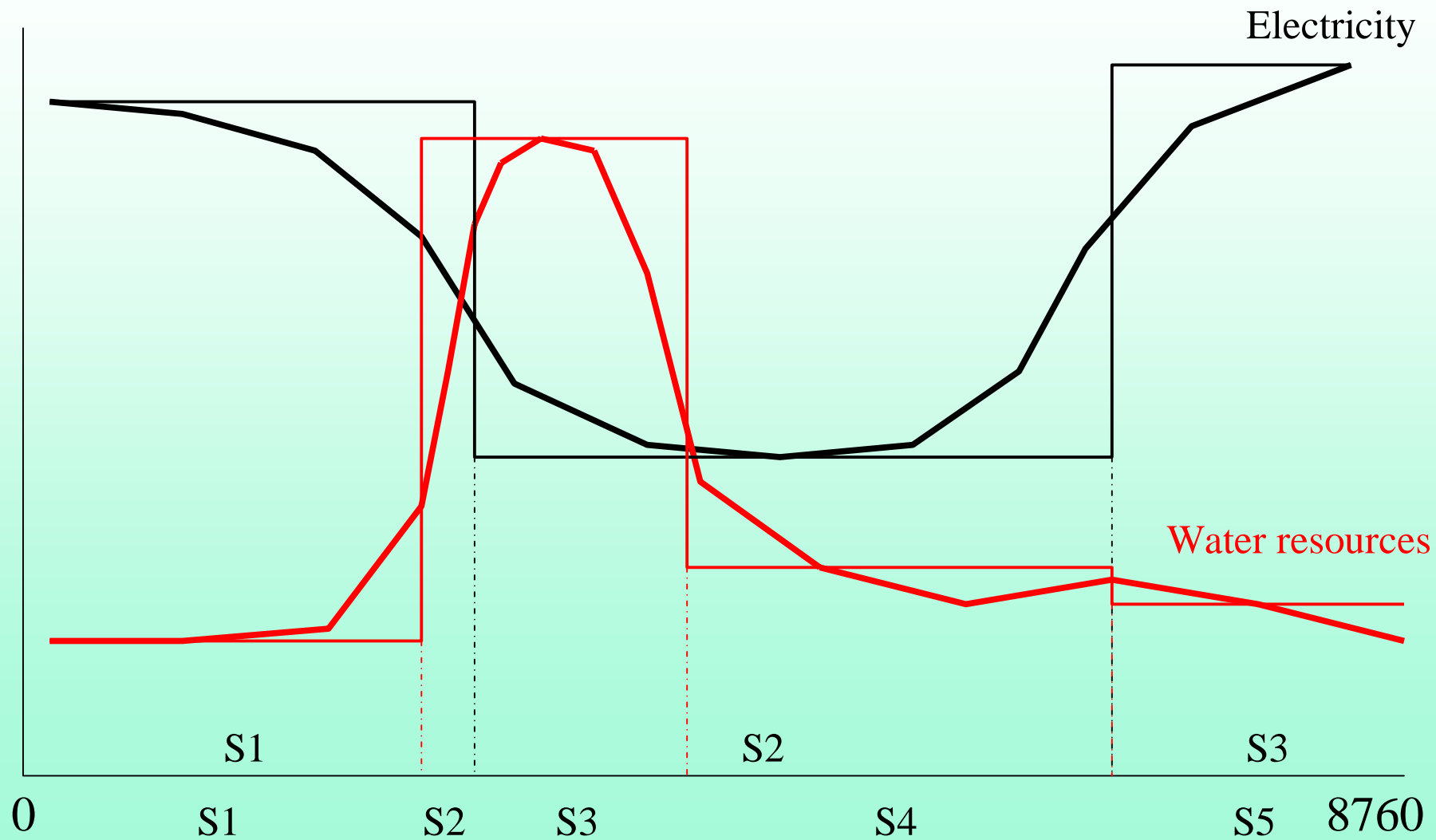
- Variation of energy demand during a year can be represented by **load regions**
- **Other factors** rather than energy demand should be taken into account when load regions are considered
- A year can be divided into **up to 64** load regions
- Number of load regions **may vary** for different years

# Load Regions

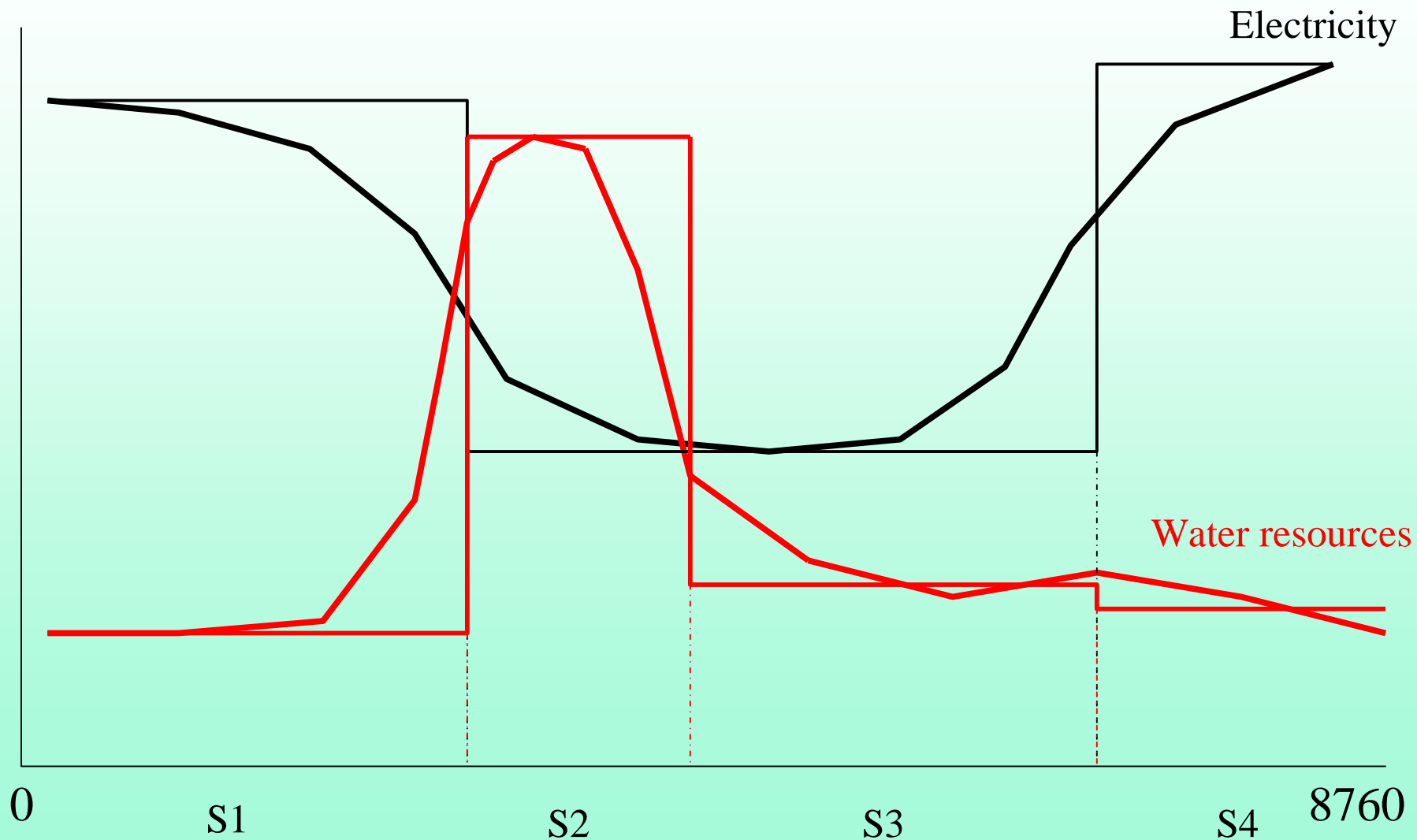
## Seasonal Division of Year



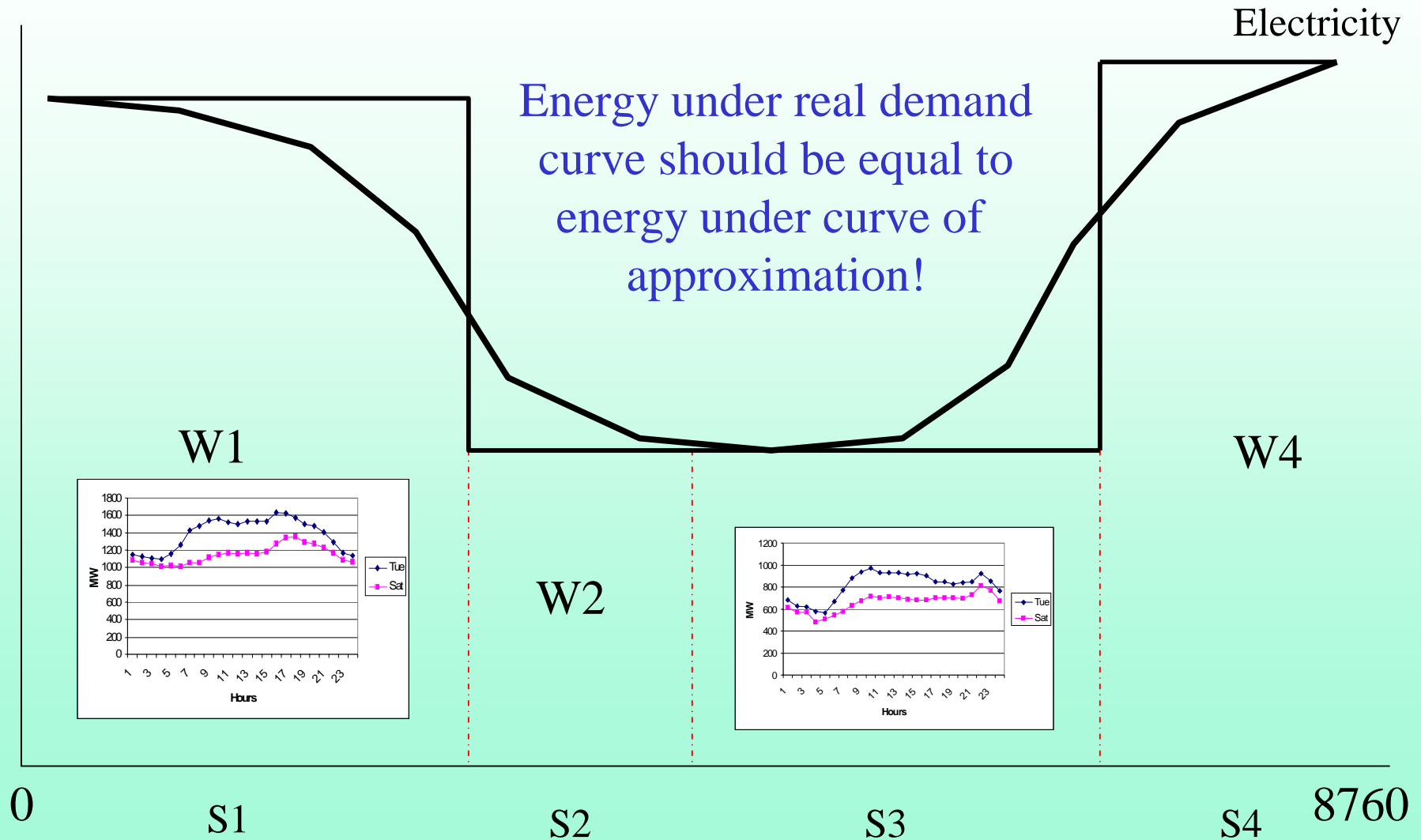
# Definition of load regions (Dividing into seasons)



# Definition of load regions (Reduction of seasons)

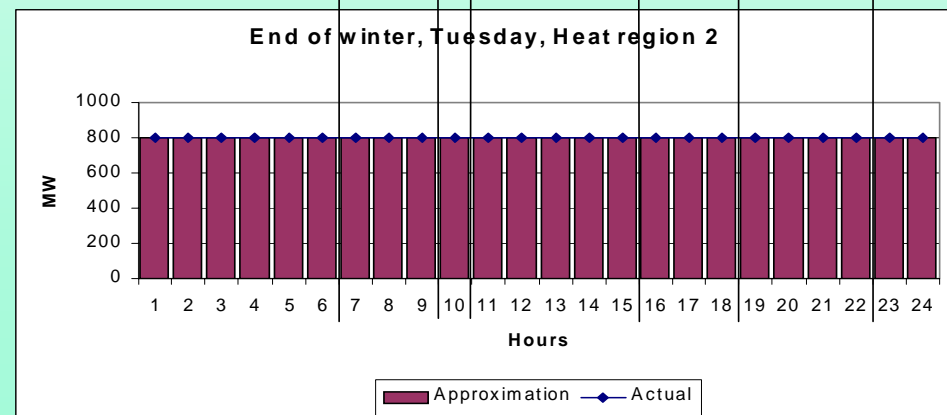
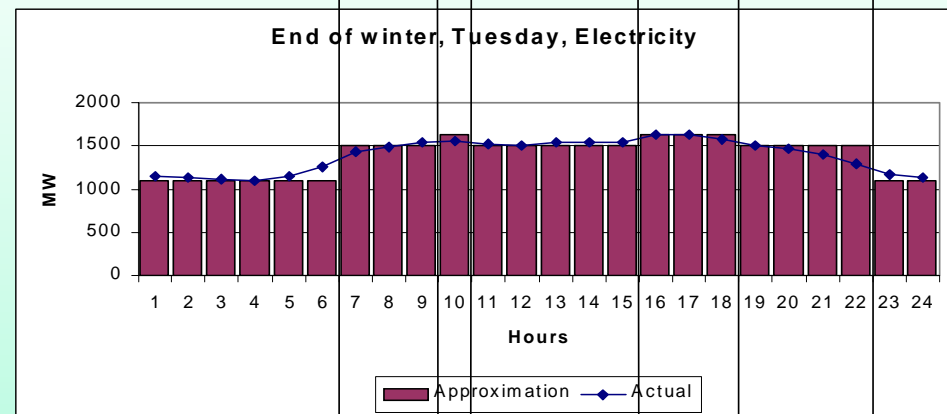
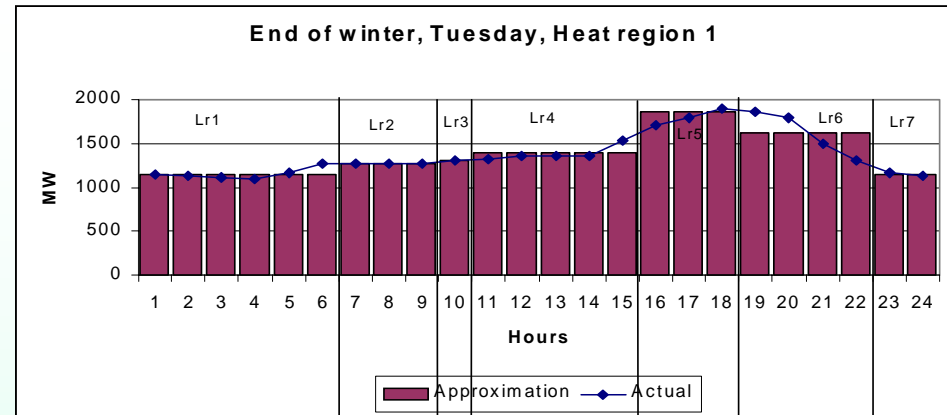


# Definition of load regions (Final representation of demand)



# Definition of load regions (Final representation of demand)

Load regions for whole model are the same!



# Definition of load regions

## (Creation of application data base)

### Definition of day types

IAEA - MESSAGE V Lithuania adb

Screen Help

**Load region definition**

Country:

Type:  Year:  No. of seasons:

Name	Start date	days	parts
Winter1	2000-01-01	2 6 4	
Spring1	2000-03-13	2 6 4	
Spring2	2000-04-24	2 6 4	
Summer	2000-05-29	2 4 3	
Autumn	2000-08-14	2 6 4	
Winter2	2000-10-30	2 6 4	

**MESSAGE V - Day type definitions** \_ | □ | ×

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Holiday
Monday	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tuesday	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wednesday	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Thursday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Friday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Saturday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sunday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Workday	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
SunandHol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
SSH	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
anyday	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

# Definition of load regions (Creation of application data base) Definition of holidays

IAEA - MESSAGE V Lithuania adb

Screen Help

**Load region definition**

Country:

Type:  Year:  No. of seasons:

Name	Start date	days	parts
Winter1	2000-01-01	2 6	4
Spring1	2000-03-13	2 6	4
Spring2	2000-04-24	2 6	4
Summer	2000-05-29	2 4	3
Autumn	2000-08-14	2 6	4
Winter2	2000-10-30	2 6	4

**Holiday table**

prev  next

Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mo	Tu	We	Th	Fr	Sa	Su					
					1	2					
3	4	5	6	7	8	9					
10	11	12	13	14	15	16					
17	18	19	20	21	22	23					
24	25	26	27	28	29	30					
31											



# Definition of load regions (Creation of application data base) Parameters of load regions

IAEA - MESSAGE V Lithuania adb

Screen Help

**Load region definition**

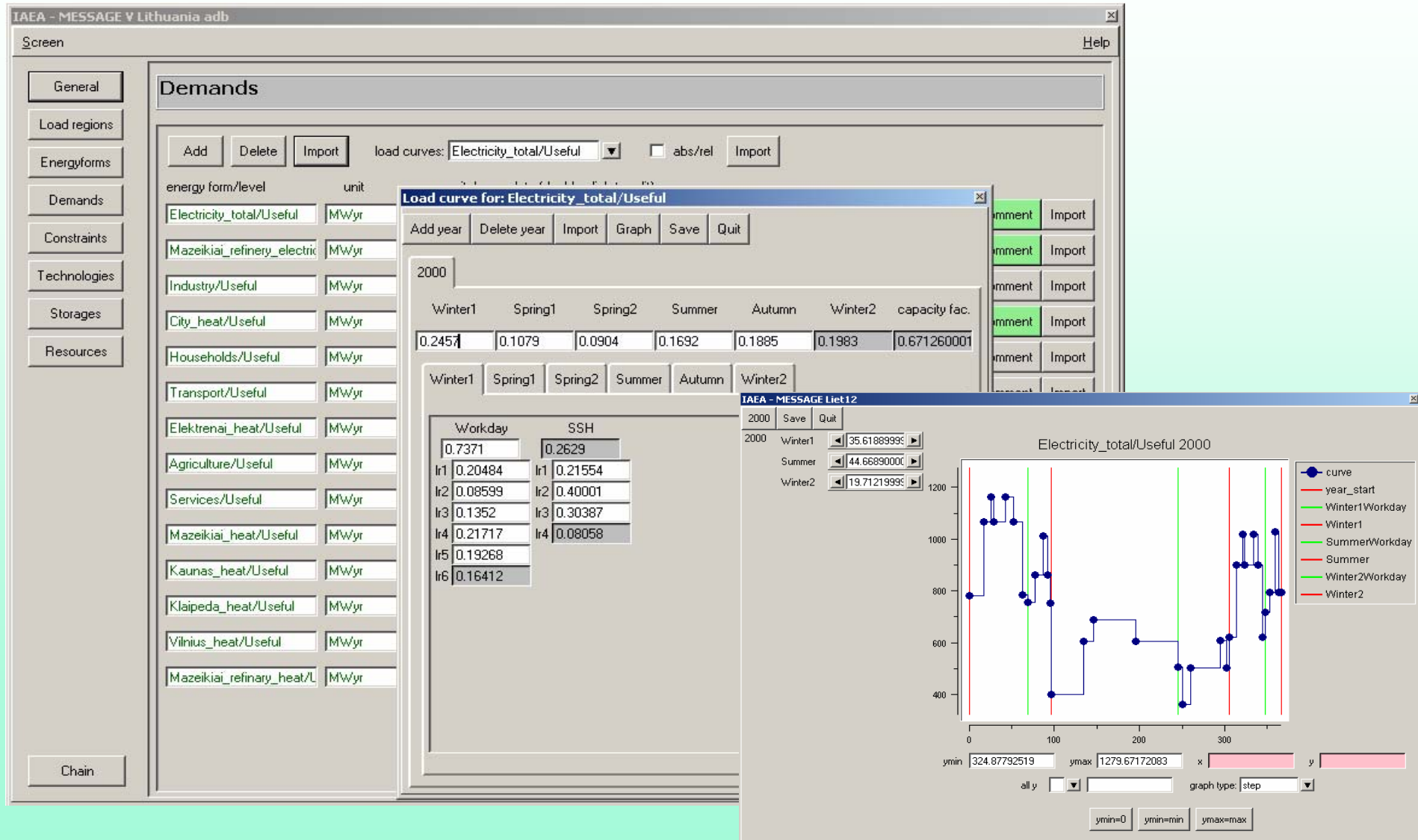
Country:

Type:  Year:  No. of seasons:

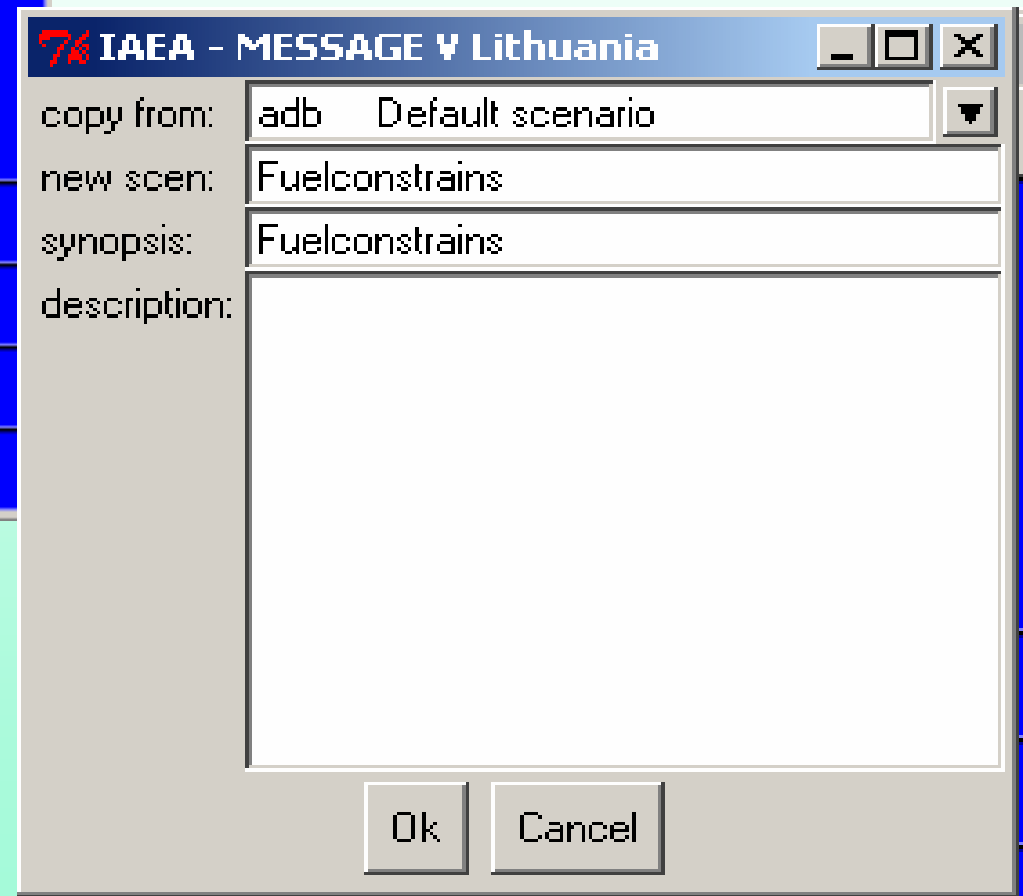
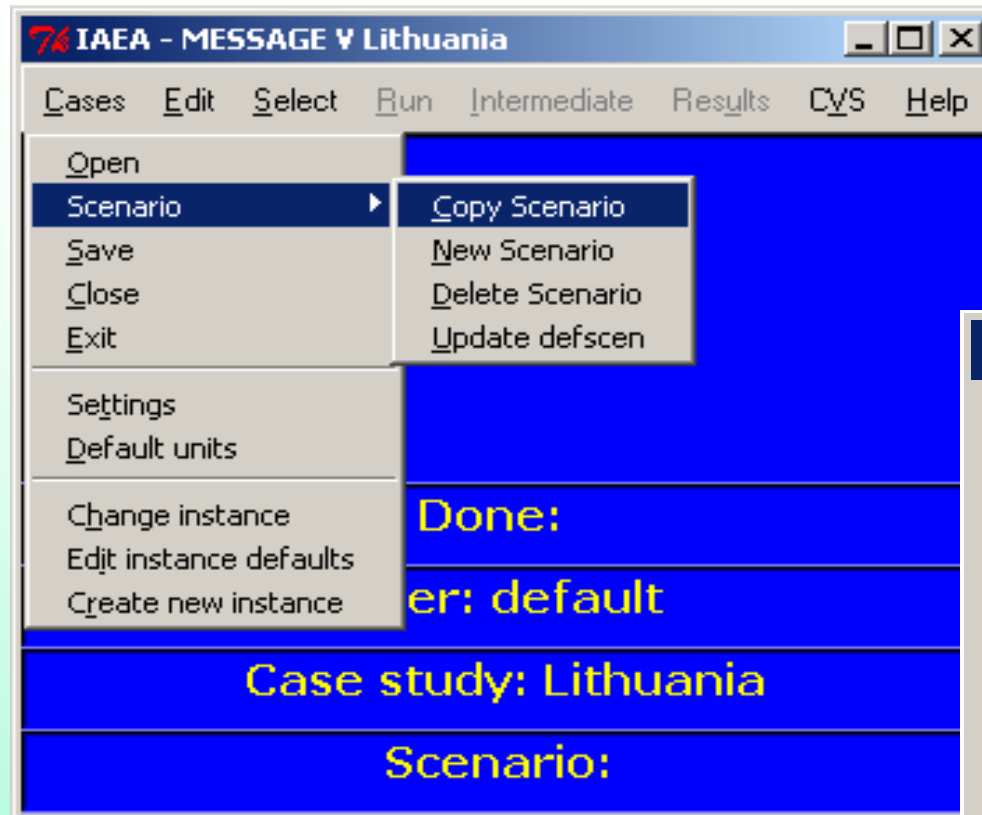
Name	Start date	days	parts
Winter1	2000-01-01	2	6
Spring1	2000-03-13	2	6
Spring2	2000-04-24	2	6
Summer	2000-05-29	2	4
Autumn	2000-08-14	2	6
Winter2	2000-10-30	2	6

/winter		spring		spring		summer		autumn		/winter	
Workday		SSH									
name	length	name	length	name	length	name	length	name	length	name	length
lr1	0.25	lr1	0.25								
lr2	0.0833	lr2	0.4167								
lr3	0.125	lr3	0.25								
lr4	0.2083	lr4	0.0833								
lr5	0.1667	Total	1.0								
lr6	0.1667										
Total	1.0										

# Definition of load regions (Creation of application data base)



# Preparation of scenarios to be analyzed (Scenario DB)



# Preparation of scenarios to be analyzed (Scenario DB)

IAEA - MESSAGE V Lithuania

Cases Edit Select Run Intermediate Results CVS Help

- technology db
- application db
- scenario db**
- update db
- update groups
- cap input file
- title file

with text editor...  
reformat files  
Edit region defaults  
Notes

Case study: Lithuania

Scenario:

Select scenario

Select scenario

- link1 Default scenario
- link2 Self sufficiency scenario
- link20 Self sufficiency scenario
- link3 Without IRIS
- link4 Without IRIS and eICCGT

Ok Cancel

IAEA - MESSAGE V Lithuania ldb link2

Screen

General Technologies

Load regions input: all has inv  all  yes  no Copy

Energyforms output: all operator  and  or Cut

Demands relations: all technologies: electricity\_import Chain Add from TDB Add from ADB

Constraints name (re): imp Paste

Technologies

Storages

Resources

Activity Capacity

activities

Add Ins Del Rename Reseq

alt a

alt a

IAEA - MESSAGE V electricity\_import bounds abda

Screen Edit

Annual bounds on activity

Type	Unit	Tmssw	Data
lo	MWyr	ts	10.39 0
up	MWyr	ts	10.40 0.01 9999.00 9999.00 9999.00 0.10 0.10

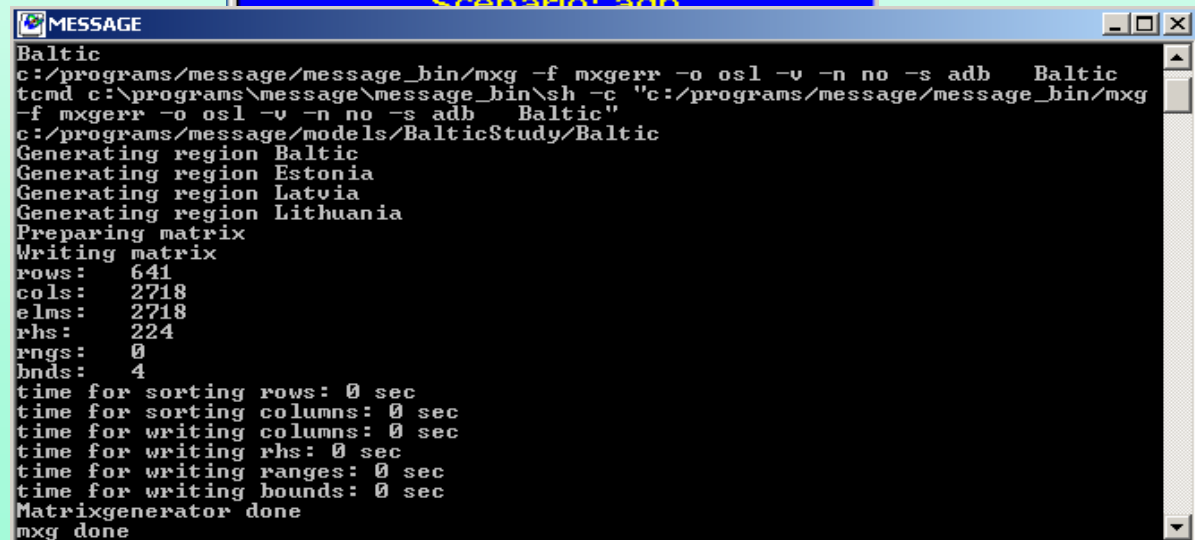
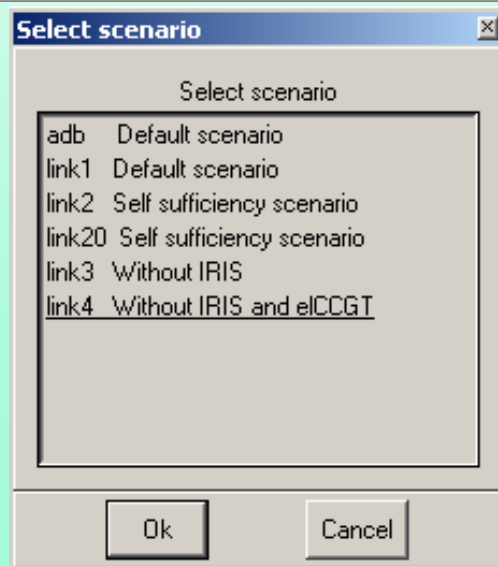
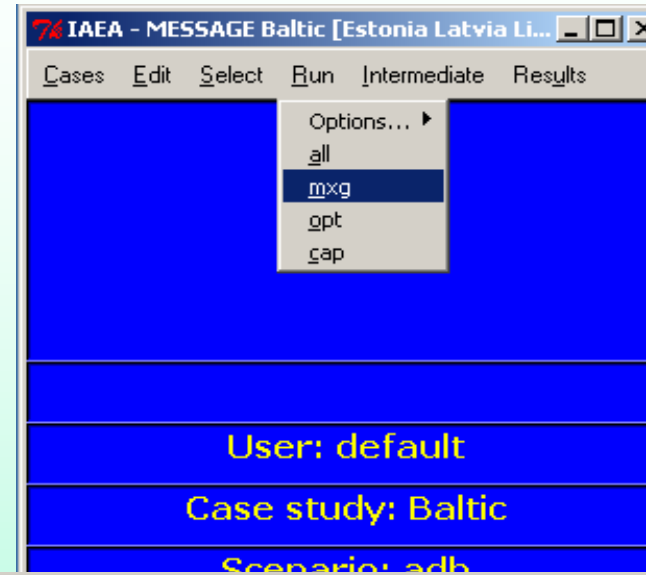
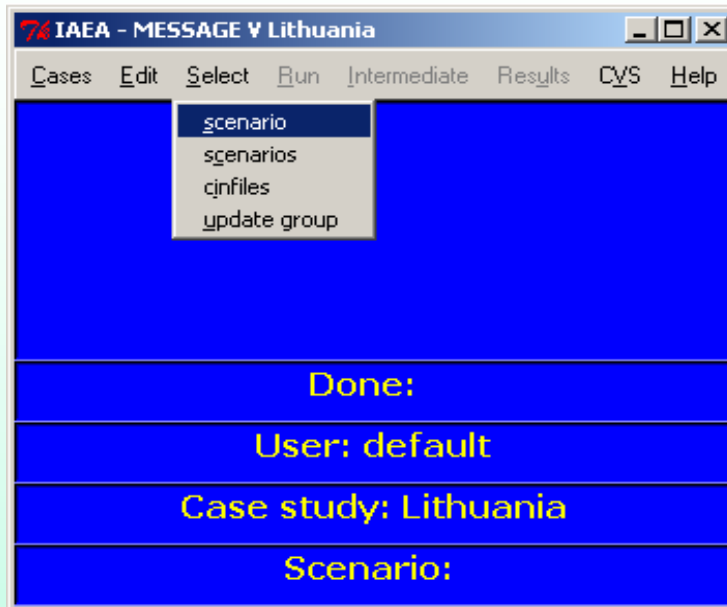
single entries

Name	Unit	Value
main input		
main output	Electricity_for_transportati	MWyr
var costs	EUR'00/kWyr	ts
hist. act.		

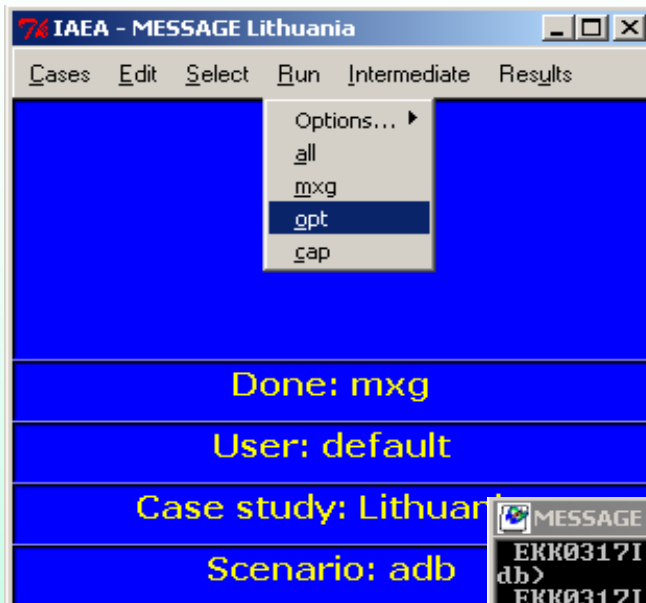
multiple entries

abda	alags	bda	con1a	con2a	conca	conpa
consa	inp	mpa	outp	softlims		

# Matrix generation

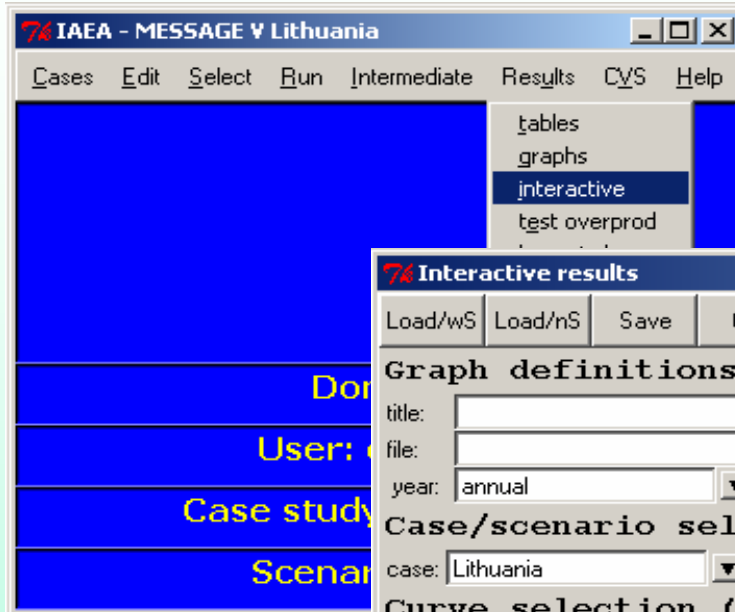


# Optimization



```
MESSAGE
EKK0317I      Entering OSL module ekk_columnNamePointers <Lithuania_a
db>
EKK0317I      Entering OSL module ekk_getInumrows <Lithuania_adb>
EKK0317I      Entering OSL module ekk_rowNamePointers <Lithuania_adb>
EKK0317I      Entering OSL module ekk_rowduals <Lithuania_adb>
EKK0317I      Entering OSL module ekk_getInumcols <Lithuania_adb>
EKK0317I      Entering OSL module ekk_columnNamePointers <Lithuania_a
db>
EKK0317I      Entering OSL module ekk_colrcosts <Lithuania_adb>
EKK0317I      Entering OSL module ekk_getInumrows <Lithuania_adb>
EKK0317I      Entering OSL module ekk_rowNamePointers <Lithuania_adb>
EKK0317I      Entering OSL module ekk_rowacts <Lithuania_adb>
INFO: prtlnsol 0
INFO: printing solution
INFO: End of printoslsol
before postsolve 1
colsol 0.000000
optimization done
c:/programs/message/message_bin/sol2dbm -s adb -o osl Lithuania
tcmd c:\programs\message\message_bin\sh -c "c:/programs/message/message_bin/sol2
dbm -s adb -o osl Lithuania"
sol2dbm done
```

# Review of results



**Interactive results**

Load/wS Load/nS Save Quit Take balance Take curve Clear Graph Table Units

**Graph definitions**

title:   
 file:   
 year:  graph:  fill:  type:

**Case/scenario selection**

case:  scen:  sort:  unit:

**Curve selection (click 'Take curve' to select)**

type:  item:  aspect:  fuel:

**Balance selection (click 'Take balance' to select)**

level:  fuel:  pr/con:  tec:

Selected curves

mazeik_gen/Electricity_fc	Lithuania/adb	Technologies	mazeik_gen	output	Electricity_for_trans	red
electricity_import/Electrici	Lithuania/adb	Technologies	electricity_import	output	Electricity_for_trans	green
hydro_gen/Electricity_for	Lithuania/adb	Technologies	hydro_gen	output	Electricity_for_trans	blue
Ignalina1_gen/Electricity	Lithuania/adb	Technologies	Ignalina1_gen	output	Electricity_for_trans	yellow
Ignalina2_gen/Electricity	Lithuania/adb	Technologies	Ignalina2_gen	output	Electricity_for_trans	cyan
lit300 gen/Electricity for	Lithuania/adb	Technologies	lit300 gen	output	Electricity for trans	magenta

## Review of results

- As a result of the optimization, MESSAGE produces a time-series of **all decision variables**
- With the help of the output calculation program (CAP) or through user interface a full list of outputs can be extracted



## **Review of results**

- **Production and consumption of any energy form at any level and aggregation**
- **New capacity requirement for each technology/process**
- **Values of associated by products (e.g., wastes, pollutions)**
- **Total system costs, discounted to the base year**
- **O&M costs**
- **Fuel costs**
- **Investment requirement**