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MESAP/TIMES

Advanced Decision Support for Energy and Environmental Planning

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Gary Goldstein, International Resources Group (IRG), Washington

OR 2001, September 4 2001, Duisburg

Contents

- Energy system model TIMES
  - Overview
  - Characteristics
- Planning system MESAP
  - Architecture and features of MESAP
  - Integration of TIMES into MESAP
  - Components of MESAP
- Outlook
  - Future developments

Energy system model

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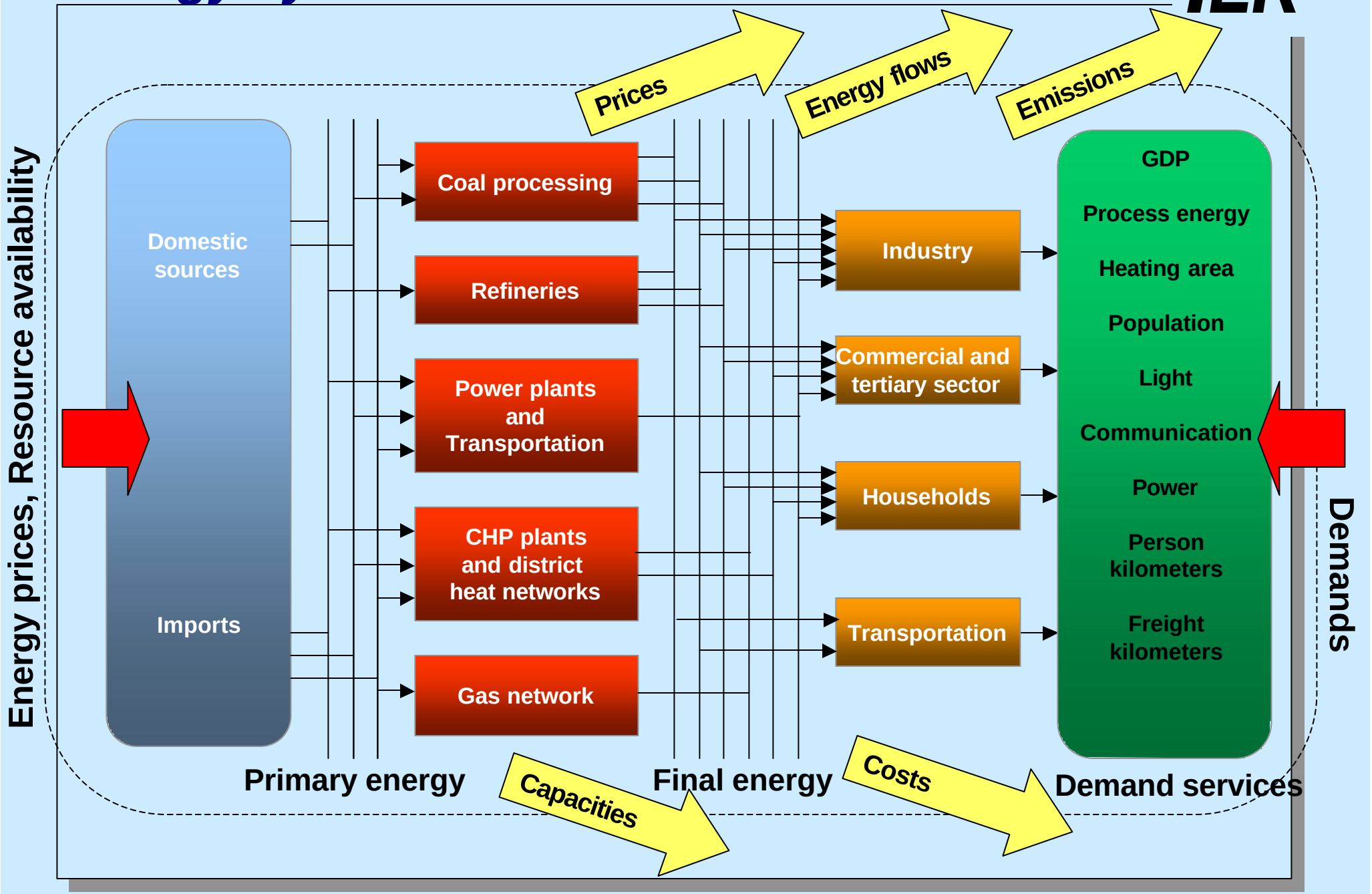


Goals of the TIMES development

EFOM-ENV

- Limited subannual resolution
- Difficult to move time horizon
+ Flexible process description

MARKAL

- Dummy processes
- Difficult to move time horizon
+ RES based

The Integrated MARKAL EFOM System

+ Flexible description
  - Subdivisions of the year
  - Regions
+ Modularity
+ Prepare for ongoing research

TIMES

Development
- The Integrated MARKAL EFOM System
- By ETSAP
- Implementation in GAMS

TOOLS
- ANSWER, ABARE
- VEDA, GERAD
- MESAP, IER

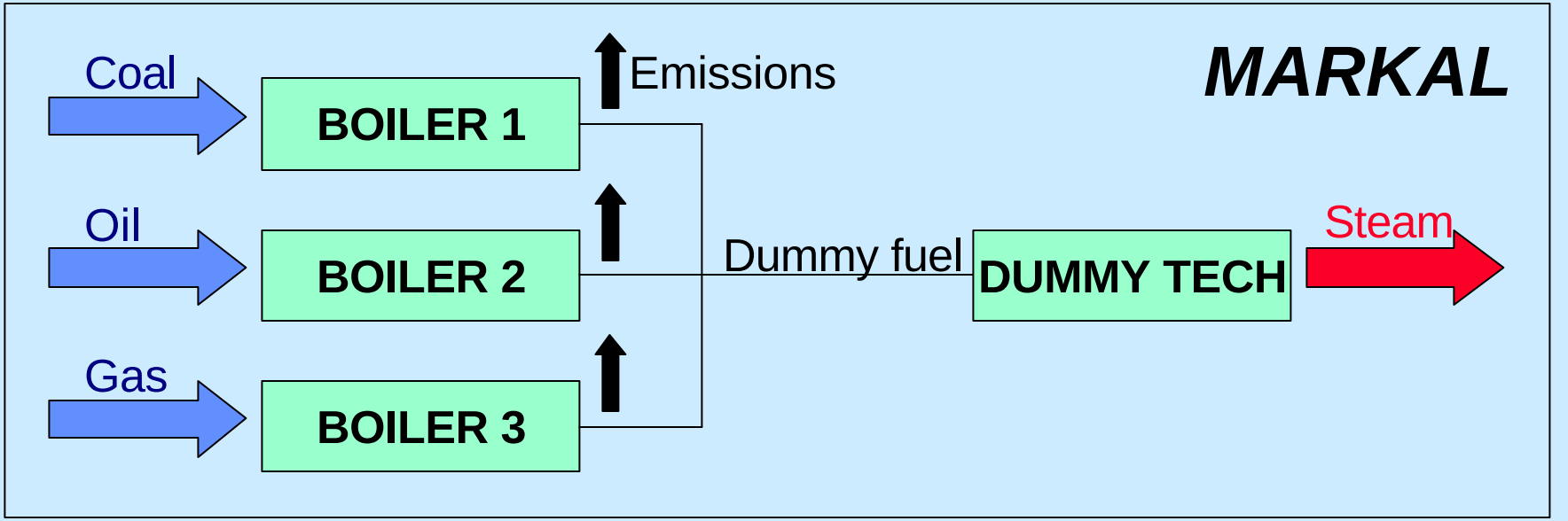
Applications (IER)
- TIMES-BY
- TIMES-GES
- TIMES-D

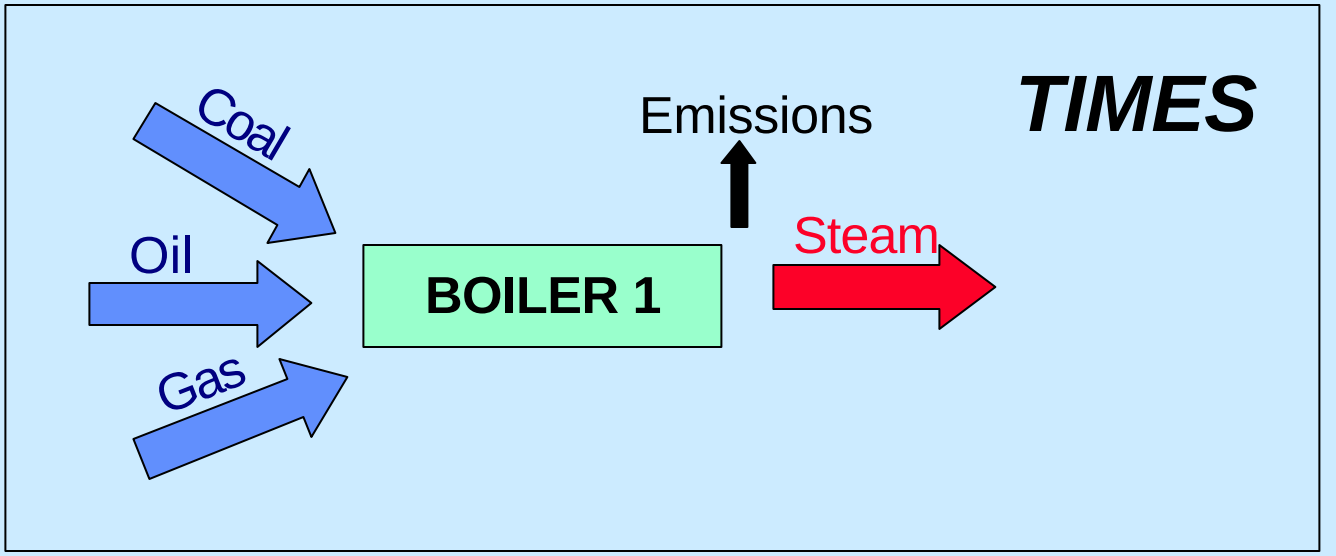
Methodology
- Bottom-up Model
- Perfect competition
- Perfect foresight
- Optimisation (LP)

Min / Max Objective function
s.t.
Equations, Constraints
Decision Variables <=> Solution
Input parameters

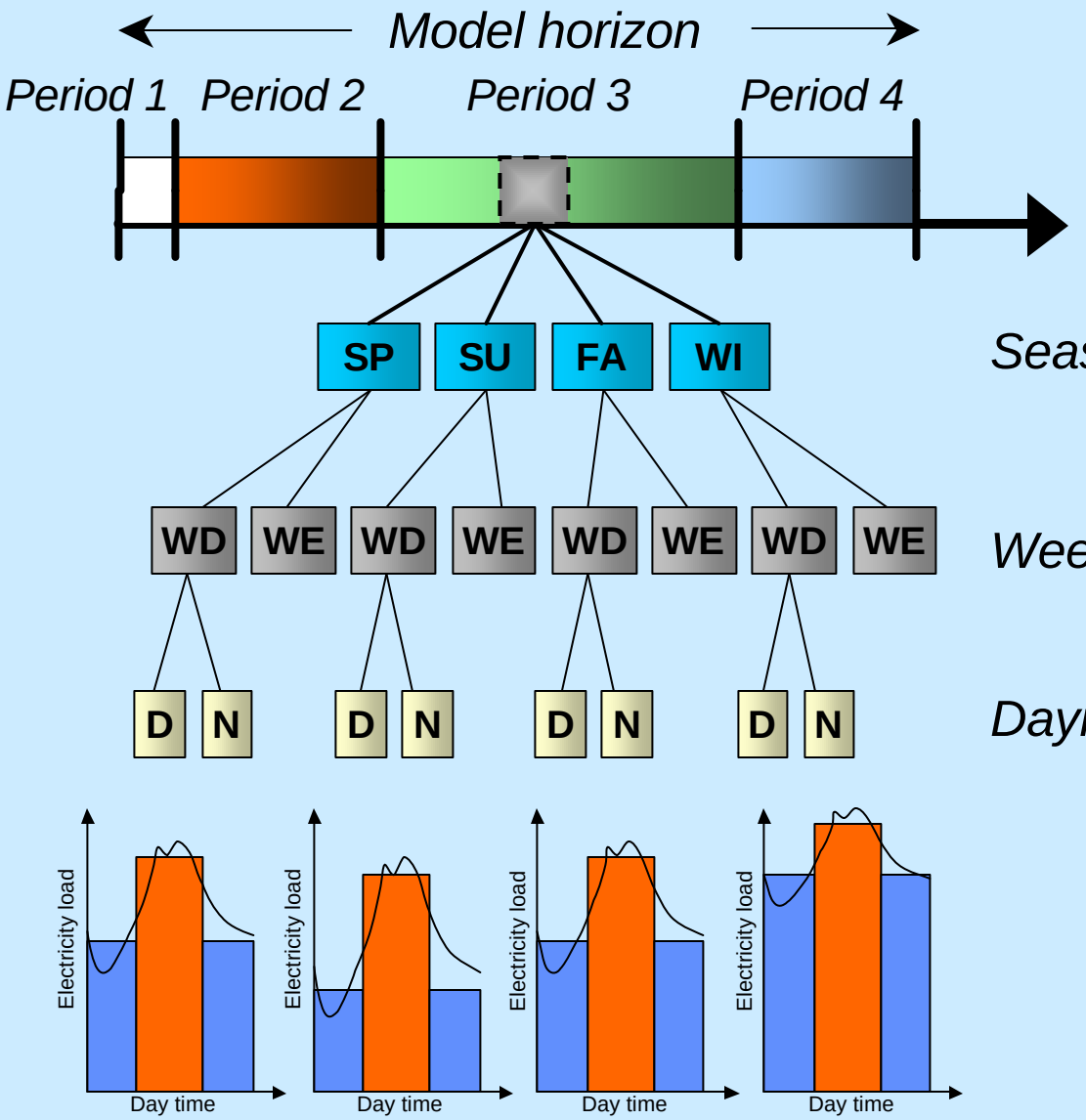
Features
- Elastic demands
- Vintaging
- Inter-temporal
- User-defined constraints
- Flexible process description
- Load curve
- Regions

Flexible Processes





Flexibility in time

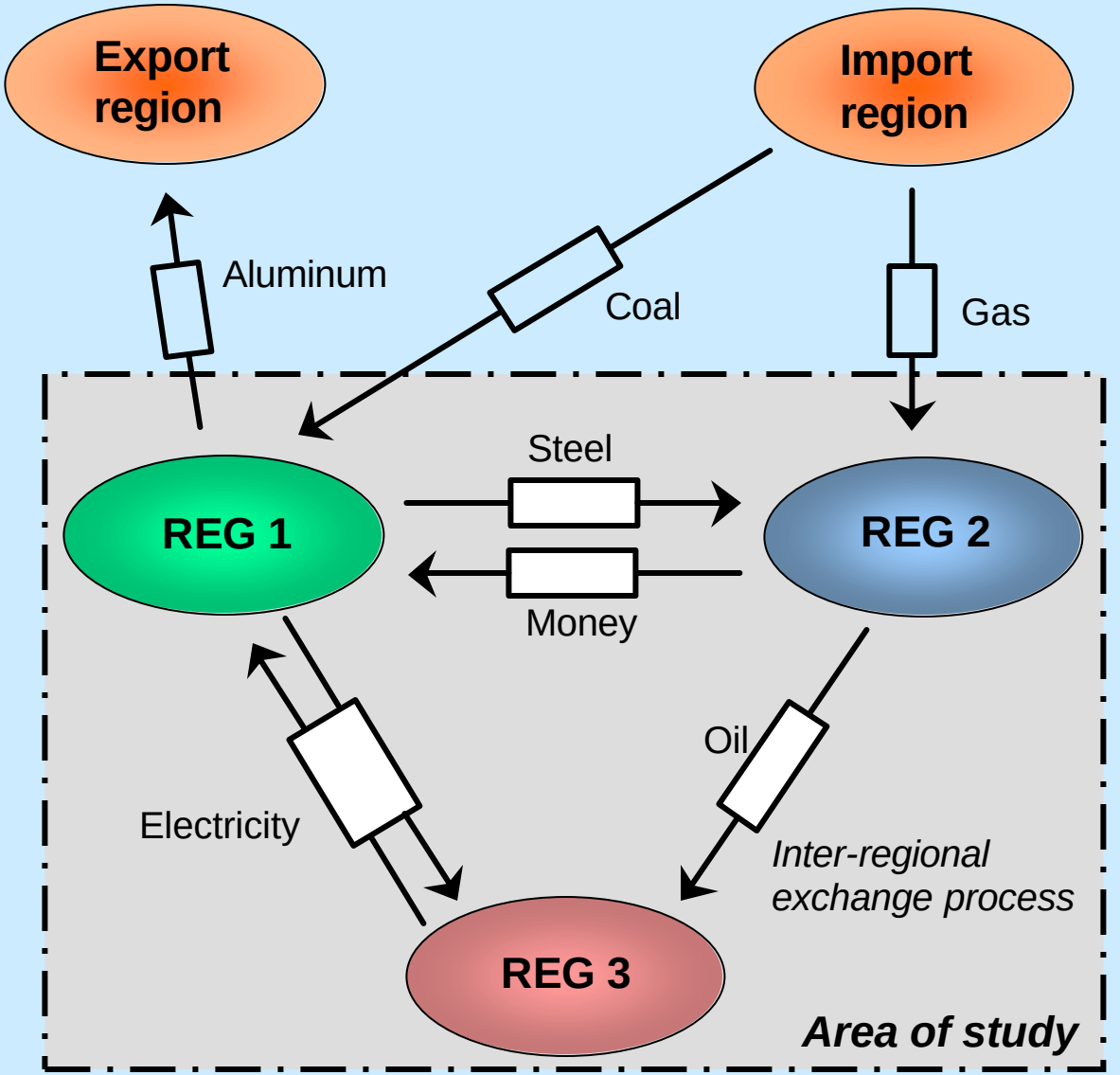


Seasons, e.g. hydro power

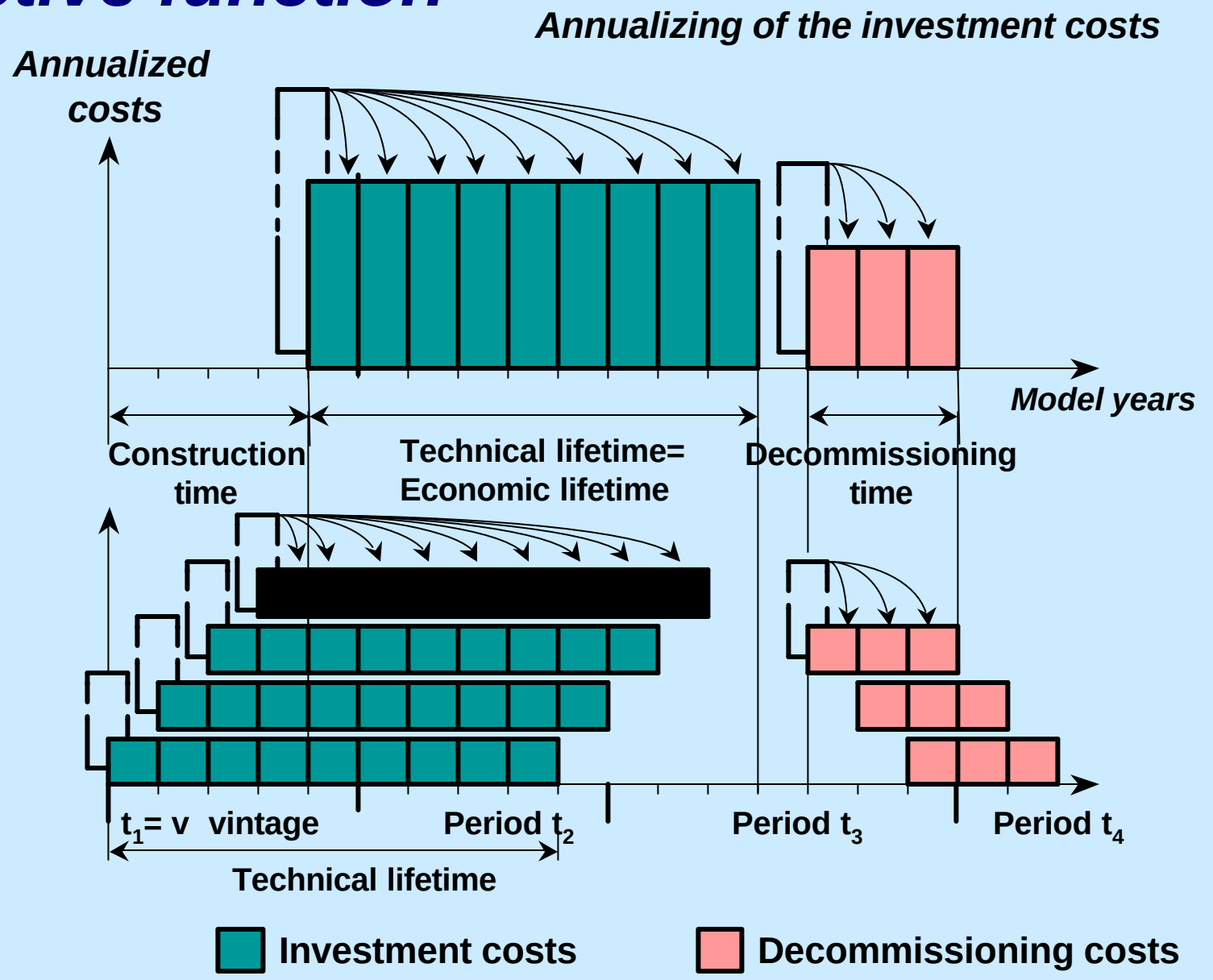
Weekly, e.g. electricity demand

Daynite, e.g. electricity demand

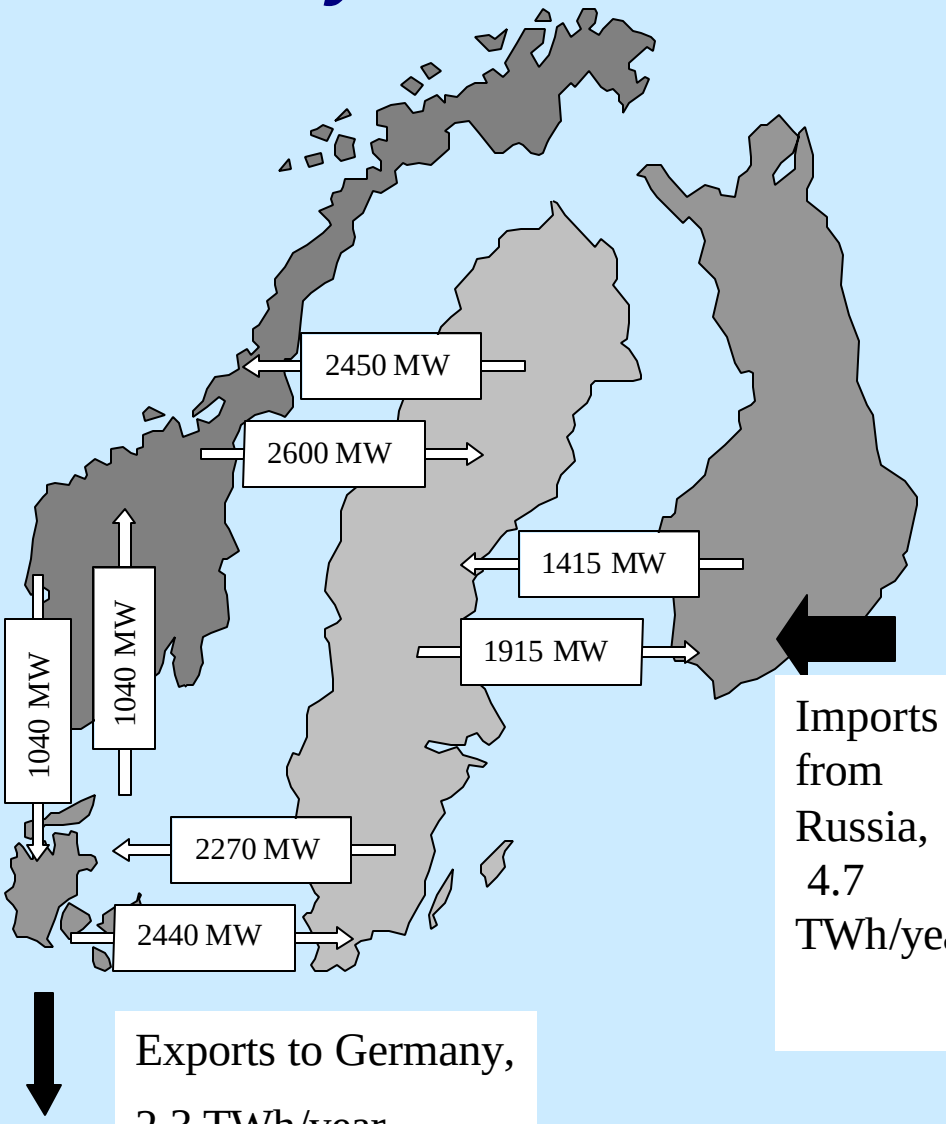
Multi regions



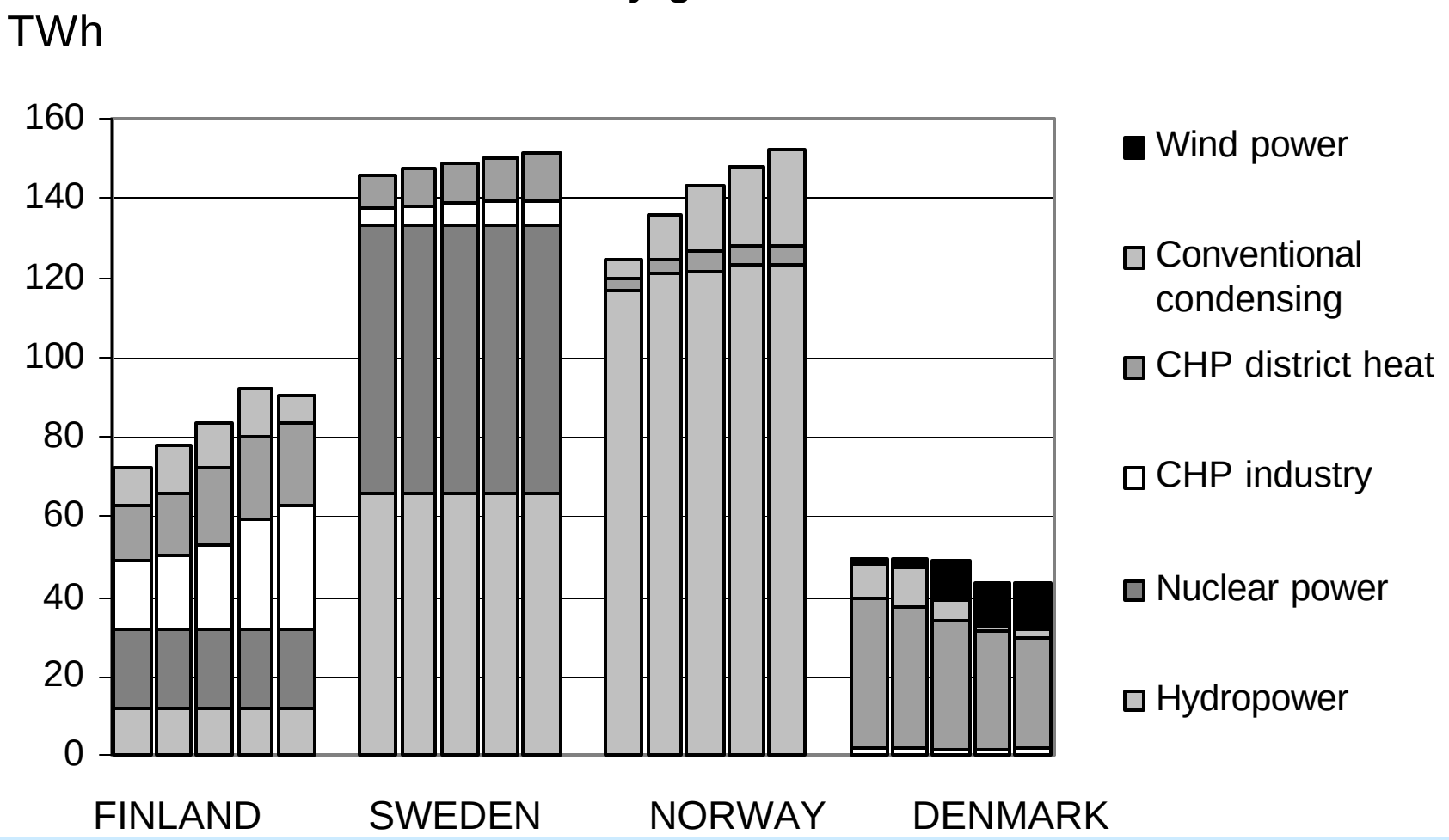
Objective function



Example: Electricity model of Nordic countries

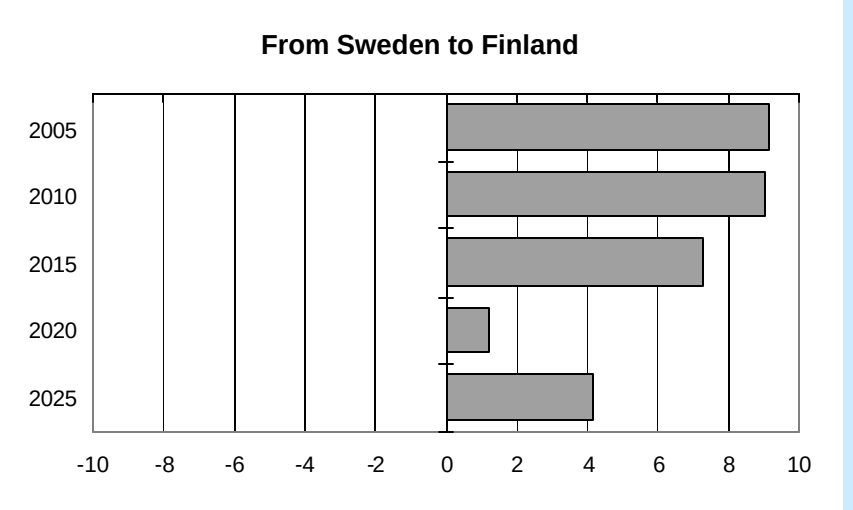


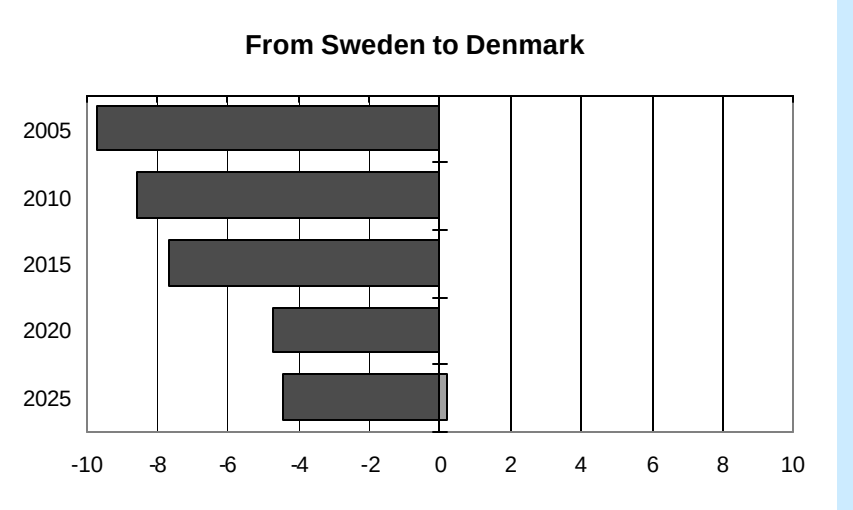
Electricity generation

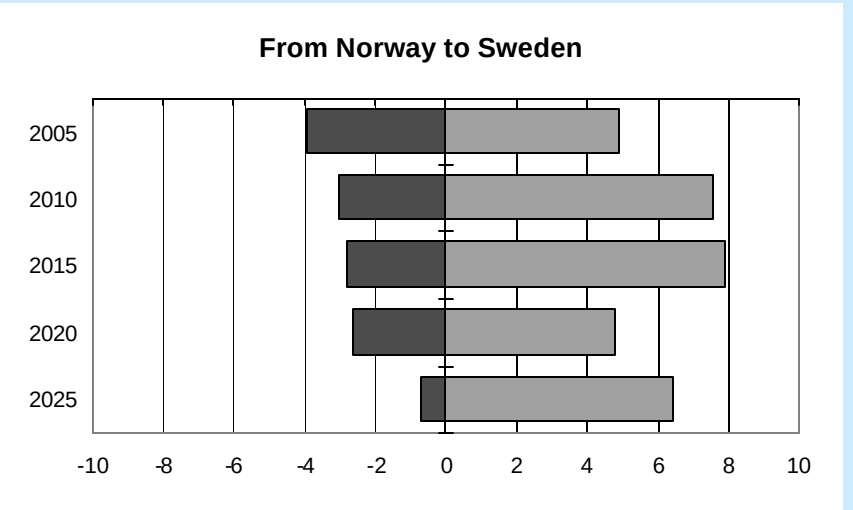


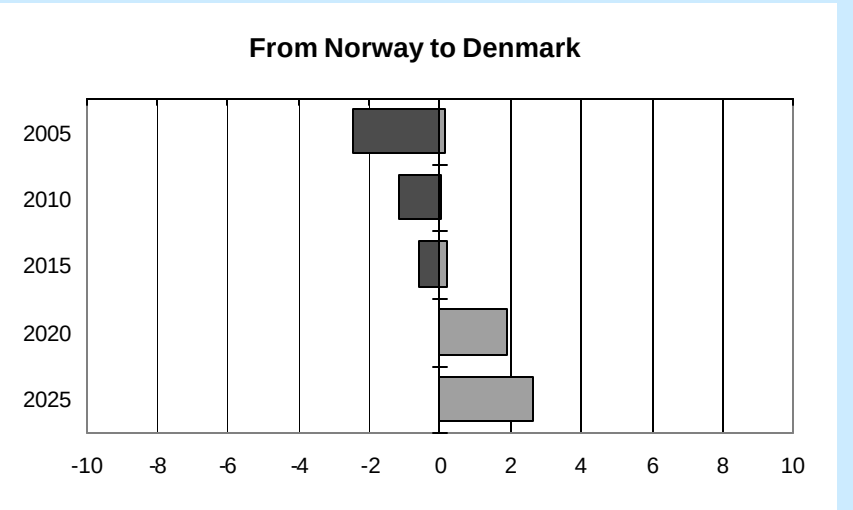
Periods: 2005, 2010, 2015, 2020, 2025

Electricity trade, TWh



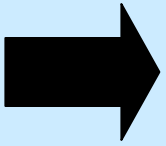






Complexity of an energy system model

- Large system to analyze. Size depends on the number of
  - technologies
  - time periods
  - regions
  - time segments for representing load curves.
- Interdependencies between different parts of the system
- Many scenarios



Software tools needed to build, manage a model and analyze its results !

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MESAP
Modular Energy System Analysis & Planning

INCA	PlaNet	TIMES	PROFAKO	Xtractor	CalQlator
Investment Calculation	Energy System Simulation	Energy System-Optimization	Operational Planning for Electricity and District Heat	GAMS Model Interface	General Equation Editor

MESAP Information System

DataSheet | ANALYST

Master Data | Explorer | DataCube

RES-Editor | Internet | Interfaces

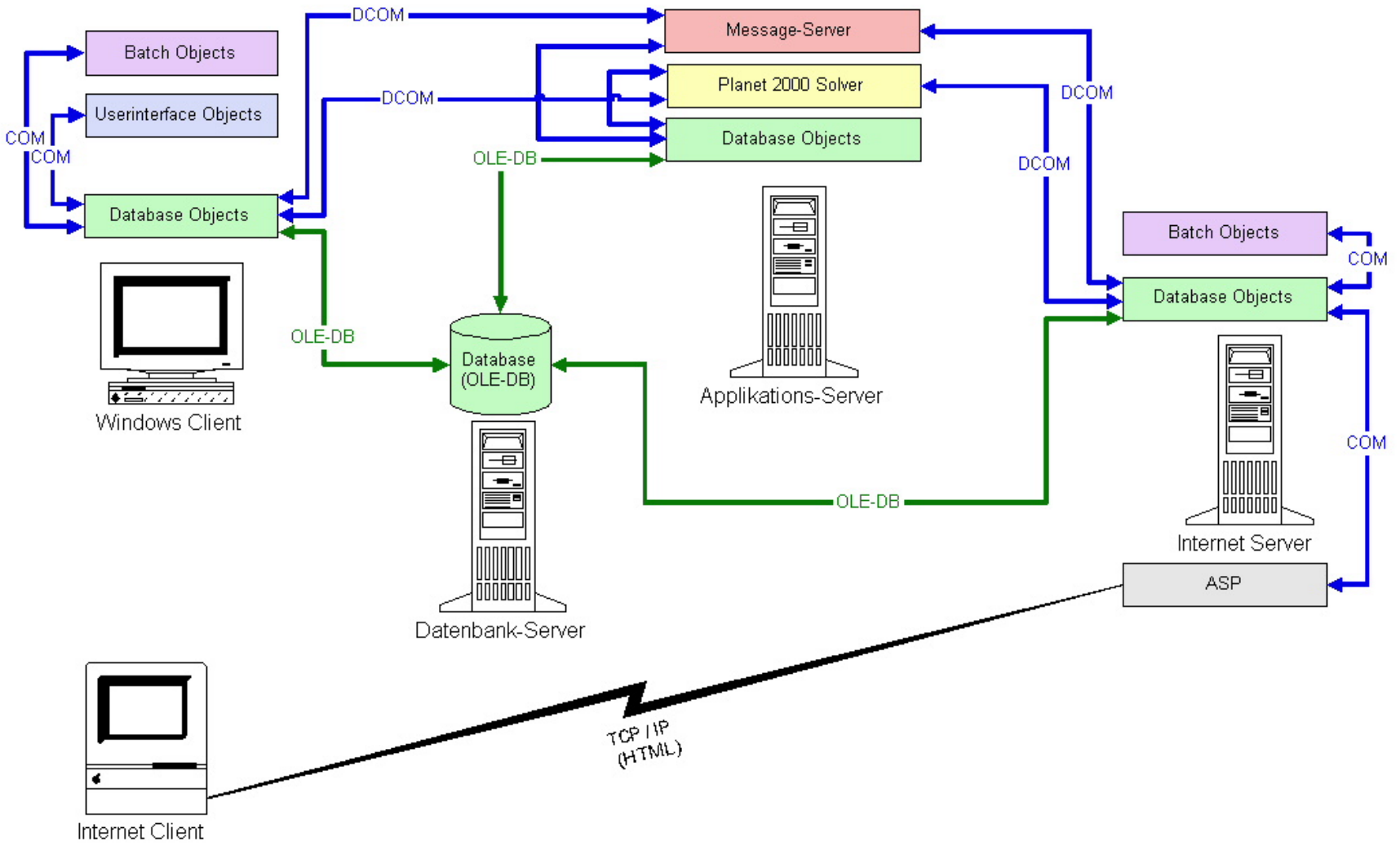
- Excel, csv, ASCII
- DataLink
- Internet Crawler

Case Manager | Im/Xporter

Characteristics of MESAP 4

- Software
  - ✓ Windows 2000 Standard
  - ✓ Client-Server Architecture
  - ✓ Access / SQL Server / Oracle DB
  - ✓ Open User Interface as public DLL
- New Database structure
  - ✓ Multi-dimensional Data Key
  - ✓ User Interface Multi-lingual
- Functional Extension
  - ✓ Multi-dimensional, containerised RES-Editor
  - ✓ Flexible Unit and Currency Handling
  - ✓ Flexible Multi-user Access rights

MESAP 4 Software Architecture



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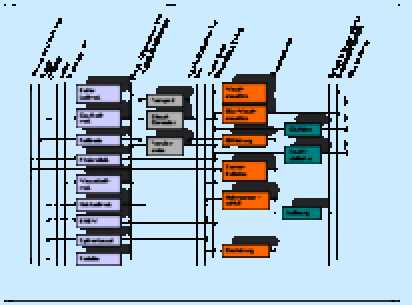
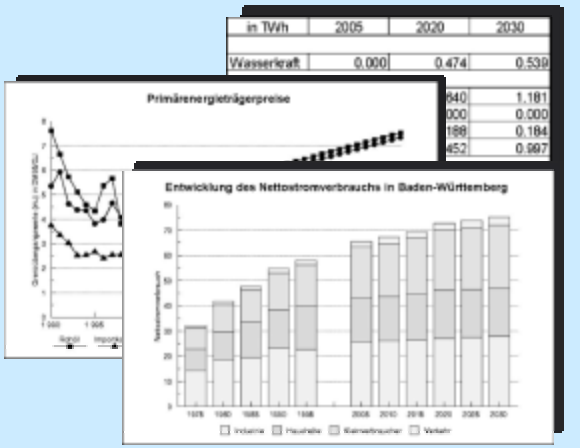
Modelling steps

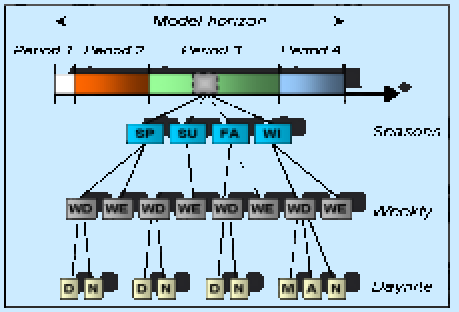
RES



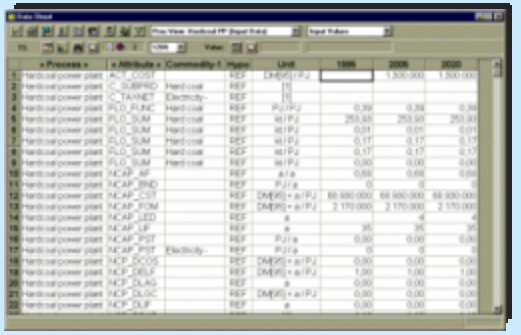
Analysis of results



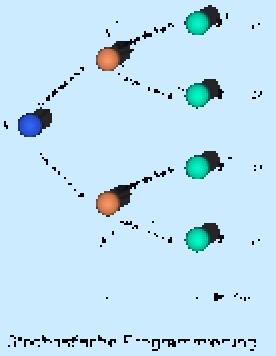
Characterization



Model data

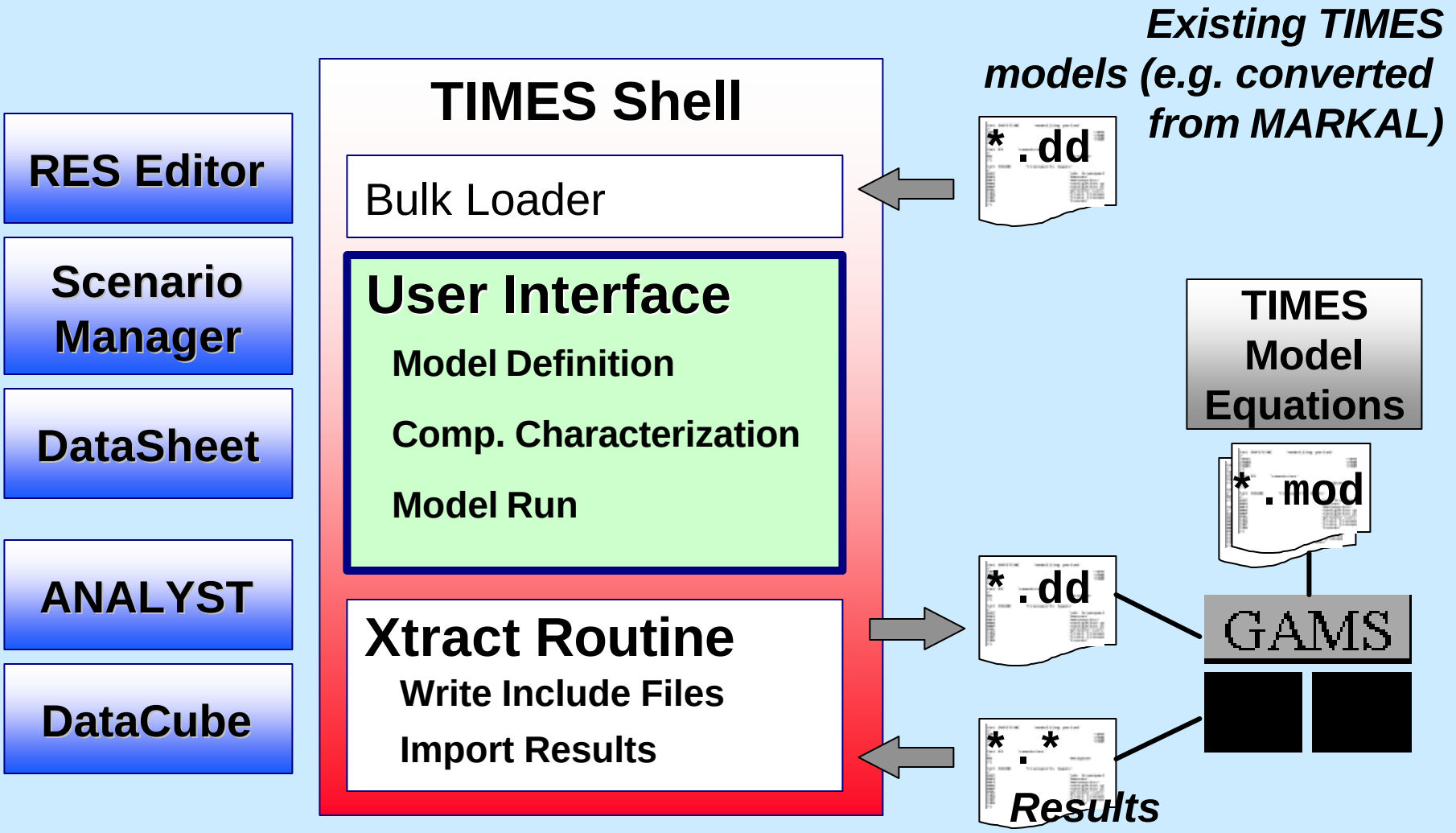


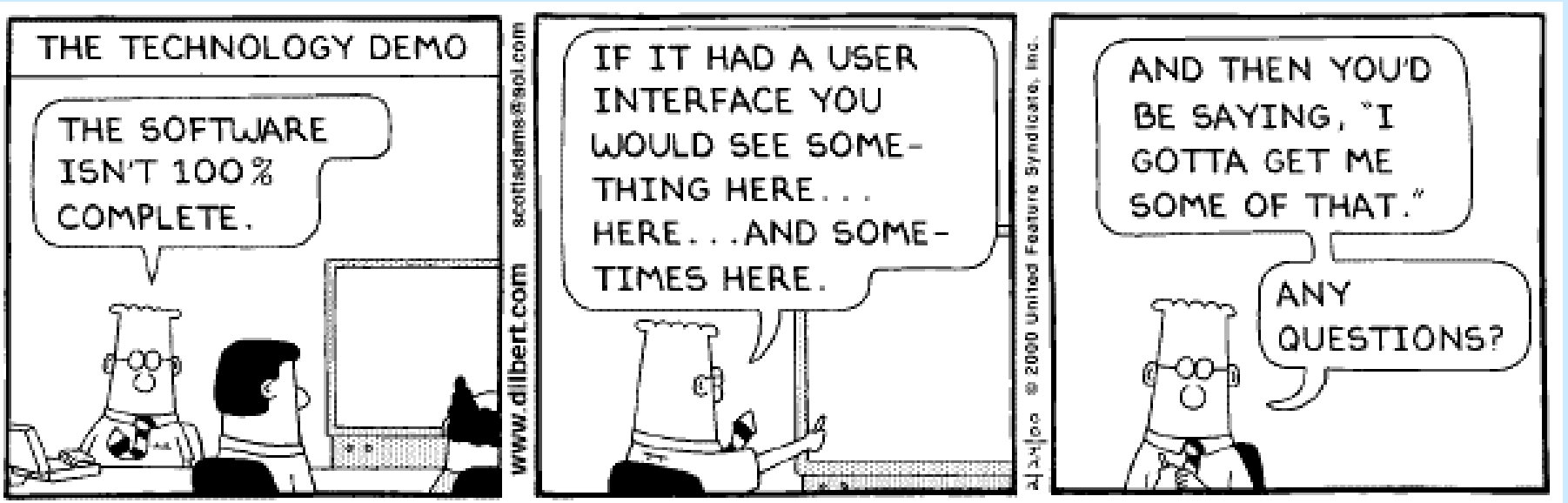
Scenarios



Solving

TIMES Shell in MESAP 4





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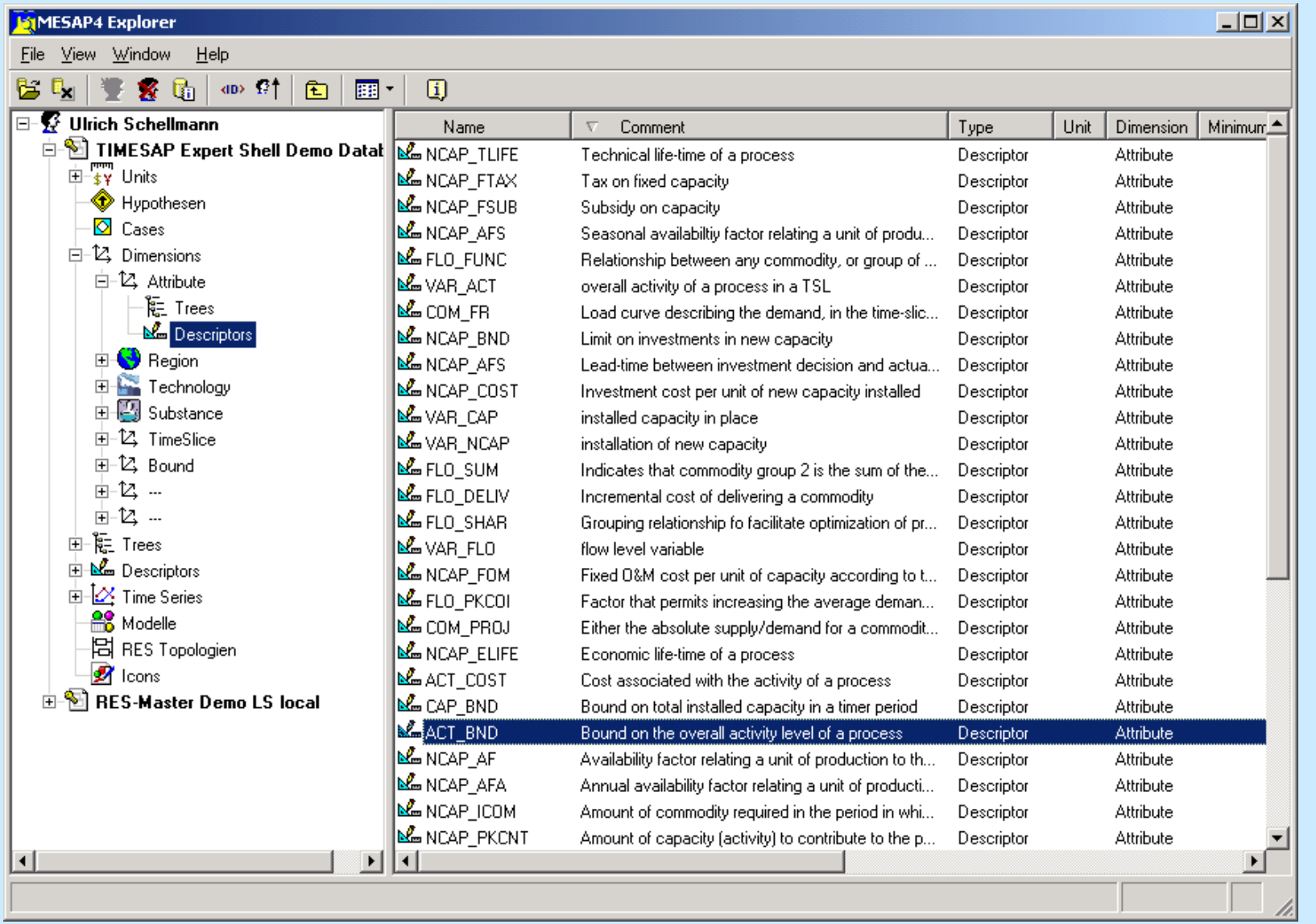
MESAP Explorer



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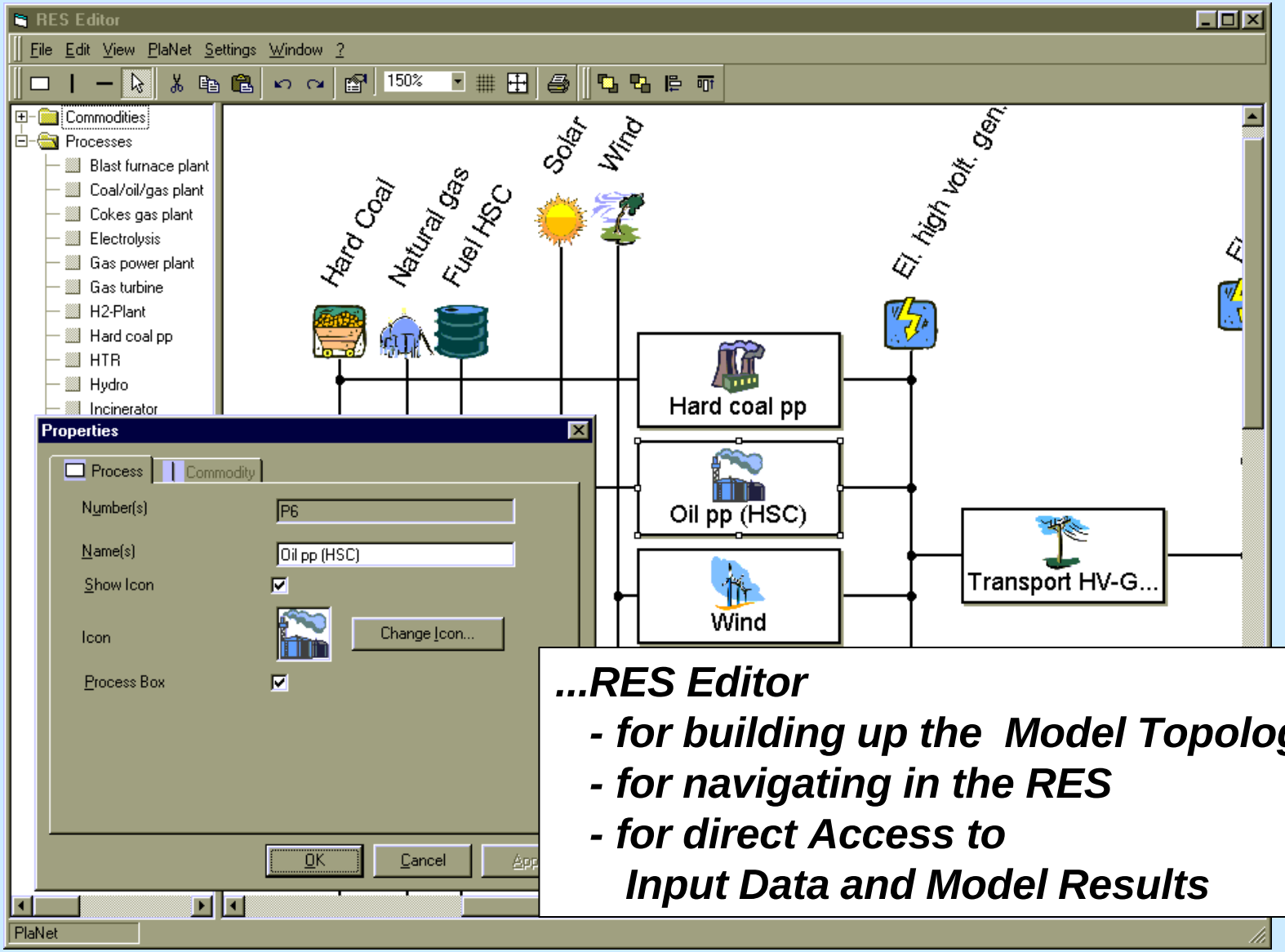
MESAP RES Editor



...RES Editor

- ***for building up the Model Topology***
- ***for navigating in the RES***
- ***for direct Access to Input Data and Model Results***

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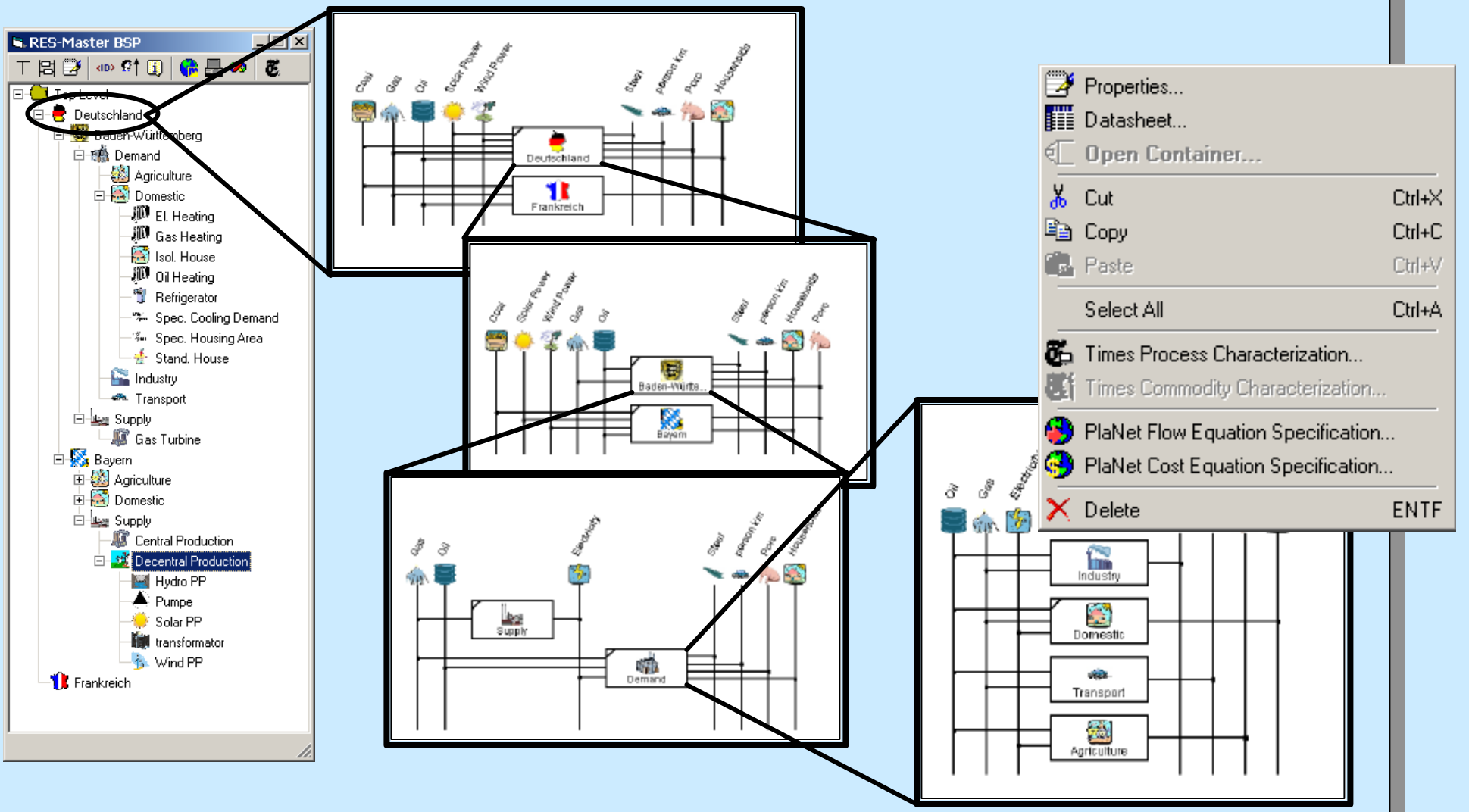
RES Editor Container View



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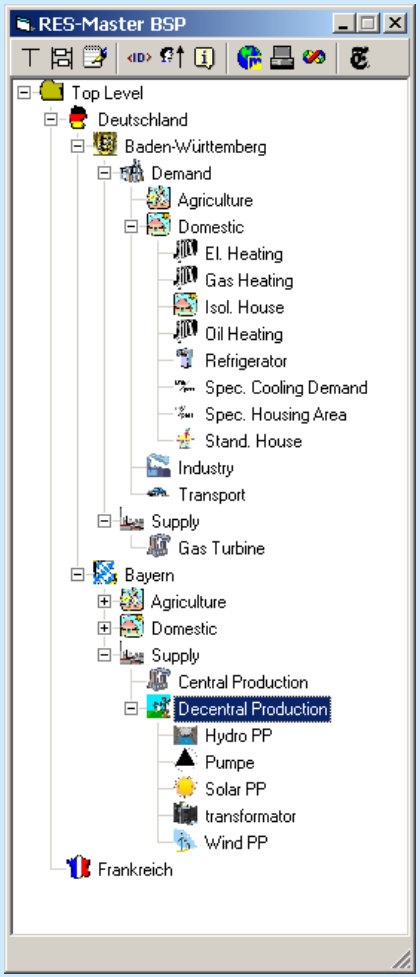
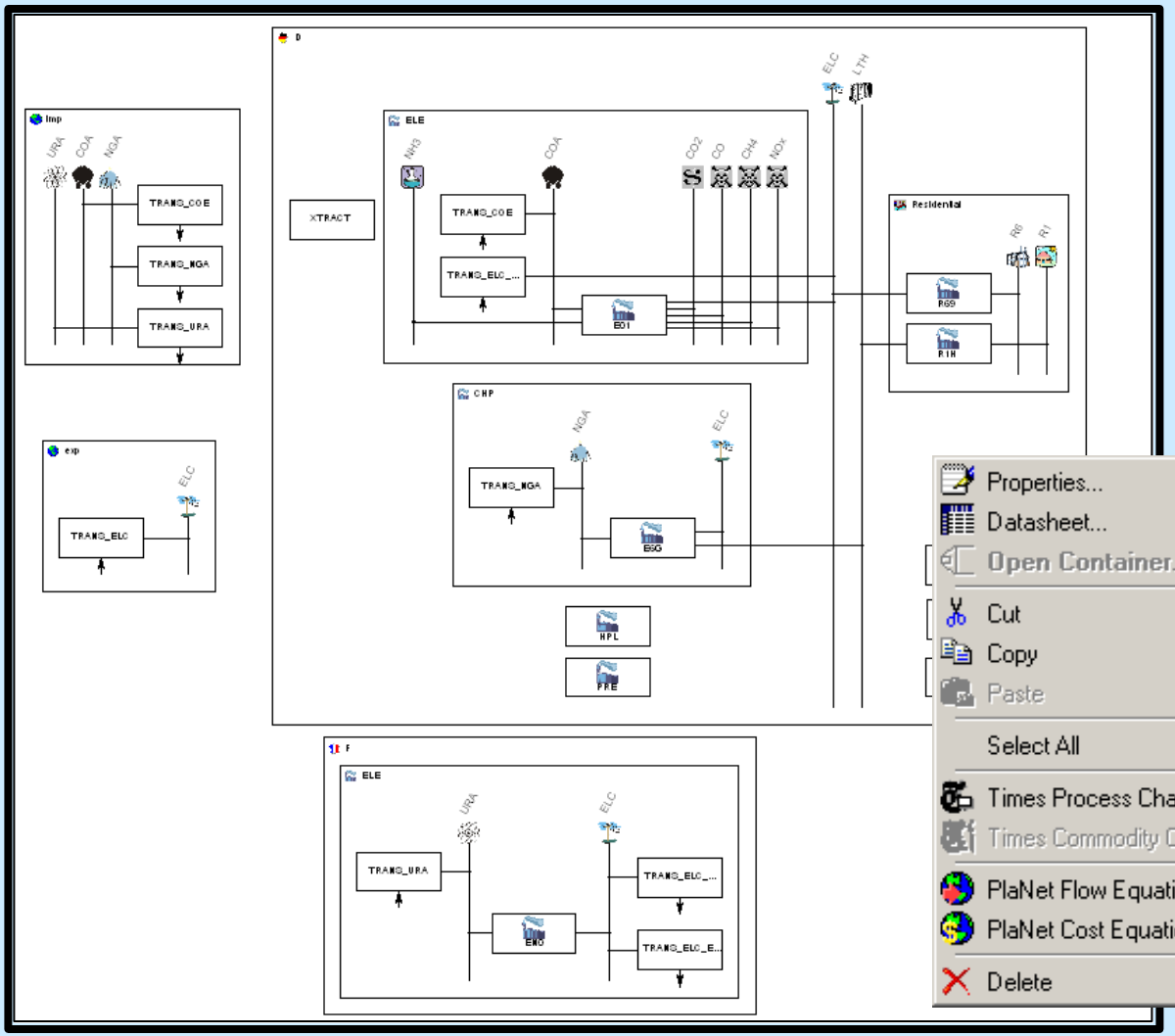
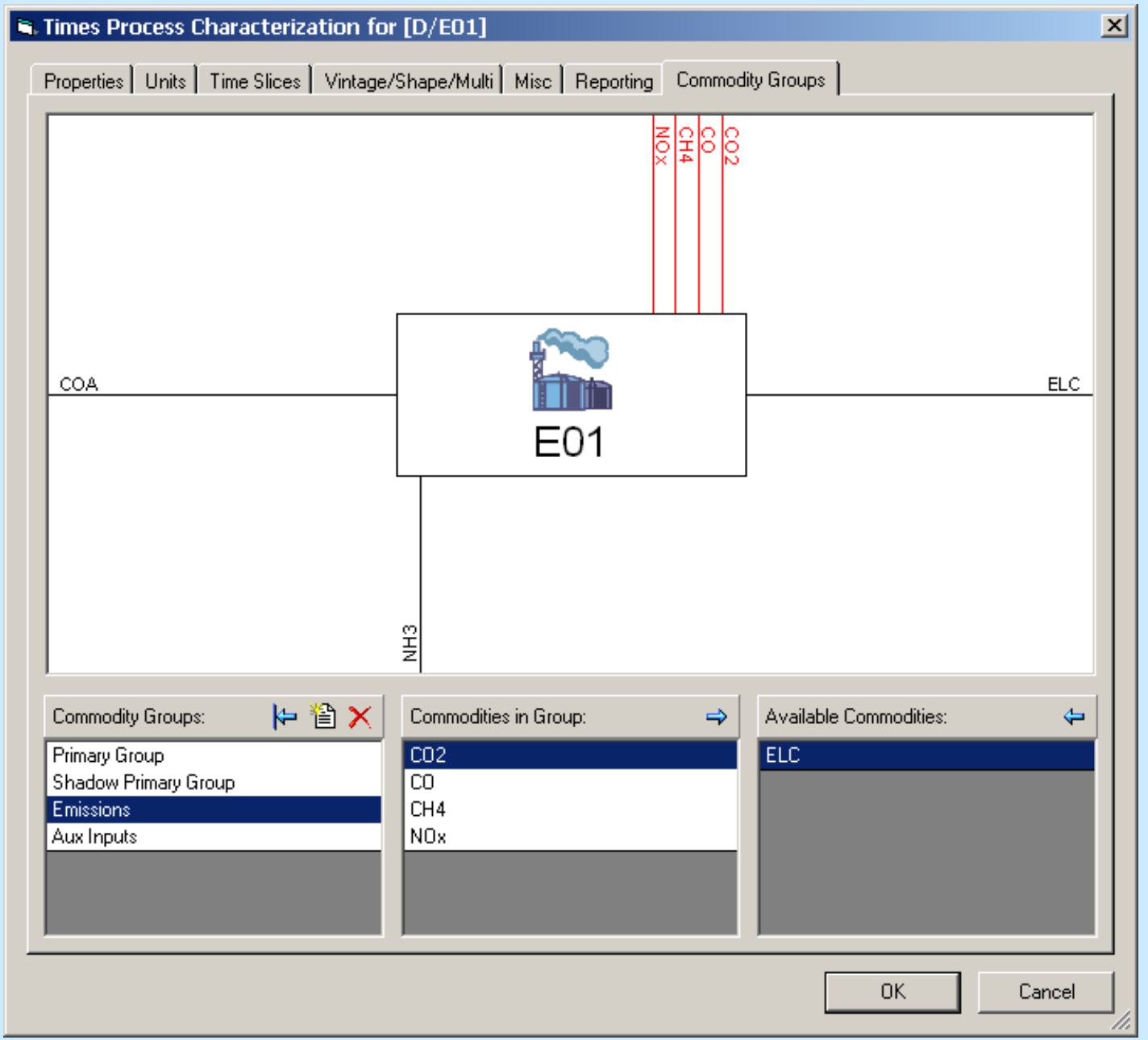
RES Editor Total View






Times Process Characterization for [D/E01]
Properties
Units
Time Slices
Vintage/Shape/Multi
Misc
Reporting
Commodity Groups
NOx
CH4
CO
CO2
COA
ELC
E01
NH3
Commodity Groups:
Primary Group
Shadow Primary Group
Emissions
Aux Inputs
Commodities in Group:
CO2
CO
CH4
NOx
Available Commodities:
ELC
OK
Cancel

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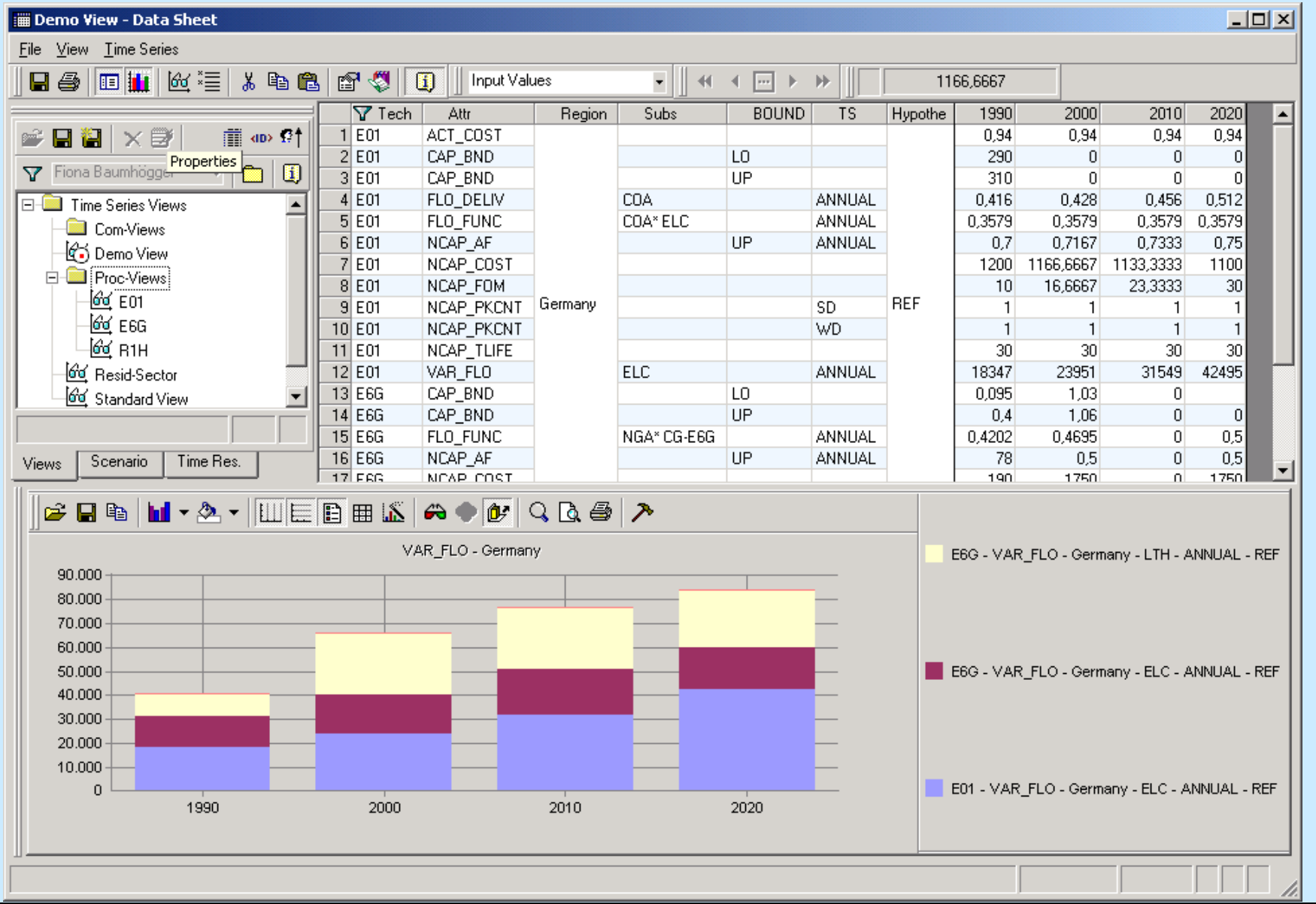
MESAP DataSheet



	Tech	Attr	Region	Subs	BOUND	TS	Hypothe	1990	2000	2010	2020
1	E01	ACT_COST						0,94	0,94	0,94	0,94
2	E01	CAP_BND			LO			290	0	0	0
3	E01	CAP_BND			UP			310	0	0	0
4	E01	FLO_DELIV		COA		ANNUAL		0,416	0,428	0,456	0,512
5	E01	FLO_FUNC		COA* ELC		ANNUAL		0,3579	0,3579	0,3579	0,3579
6	E01	NCAP_AF			UP	ANNUAL		0,7	0,7167	0,7333	0,75
7	E01	NCAP_COST						1200	1166,6667	1133,3333	1100
8	E01	NCAP_FOM						10	16,6667	23,3333	30
9	E01	NCAP_PKCNT	Germany			SD	REF	1	1	1	1
10	E01	NCAP_PKCNT				WD		1	1	1	1
11	E01	NCAP_TLIFE						30	30	30	30
12	E01	VAR_FLO		ELC		ANNUAL		18347	23951	31549	42495
13	E6G	CAP_BND			LO			0,095	1,03	0	
14	E6G	CAP_BND			UP			0,4	1,06	0	0
15	E6G	FLO_FUNC		NGA* CG-E6G		ANNUAL		0,4202	0,4695	0	0,5
16	E6G	NCAP_AF			UP	ANNUAL		78	0,5	0	0,5
17	E6G	NCAP_COST						190	1750	0	1750

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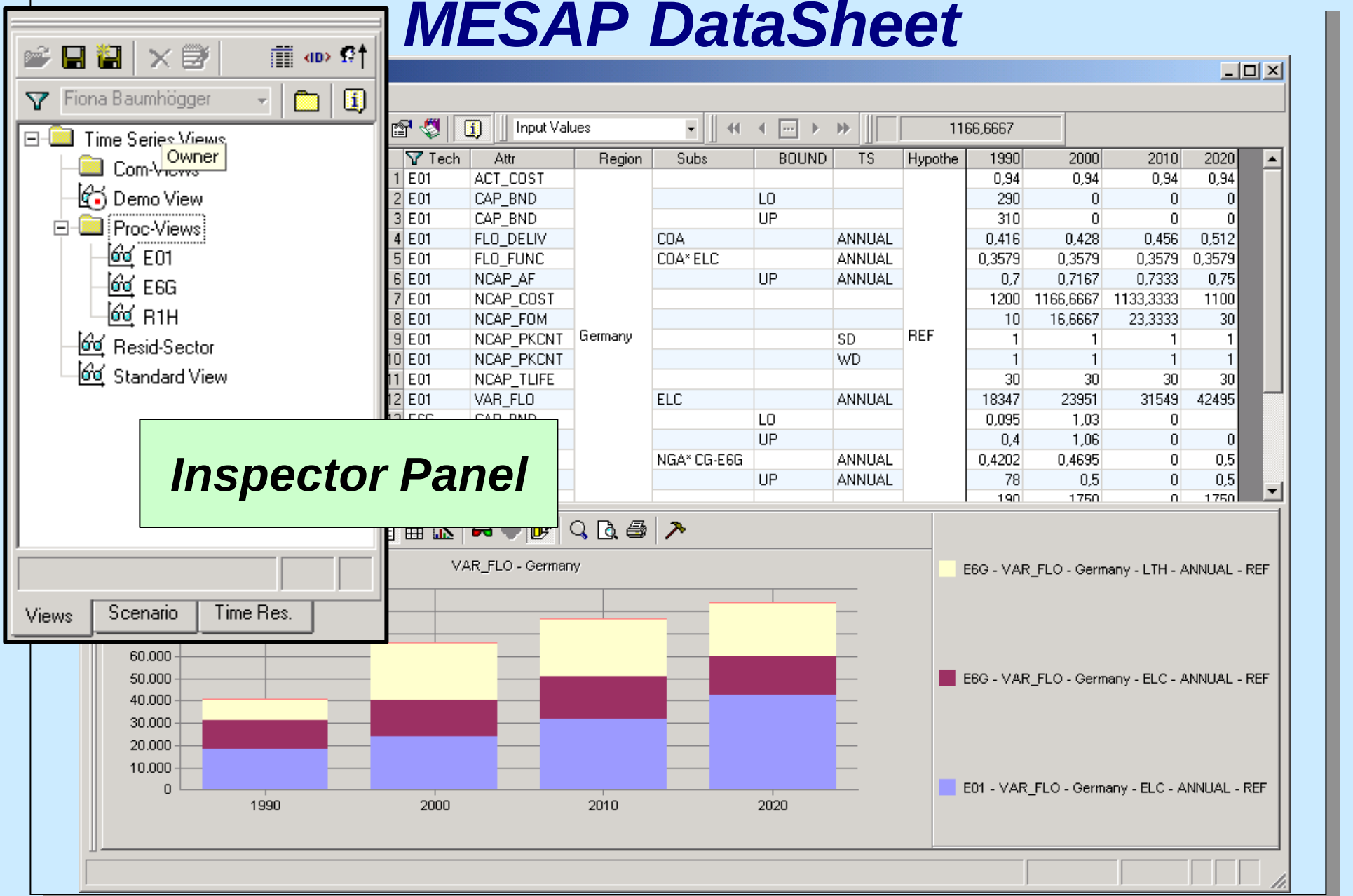
MESAP DataSheet



Inspector Panel

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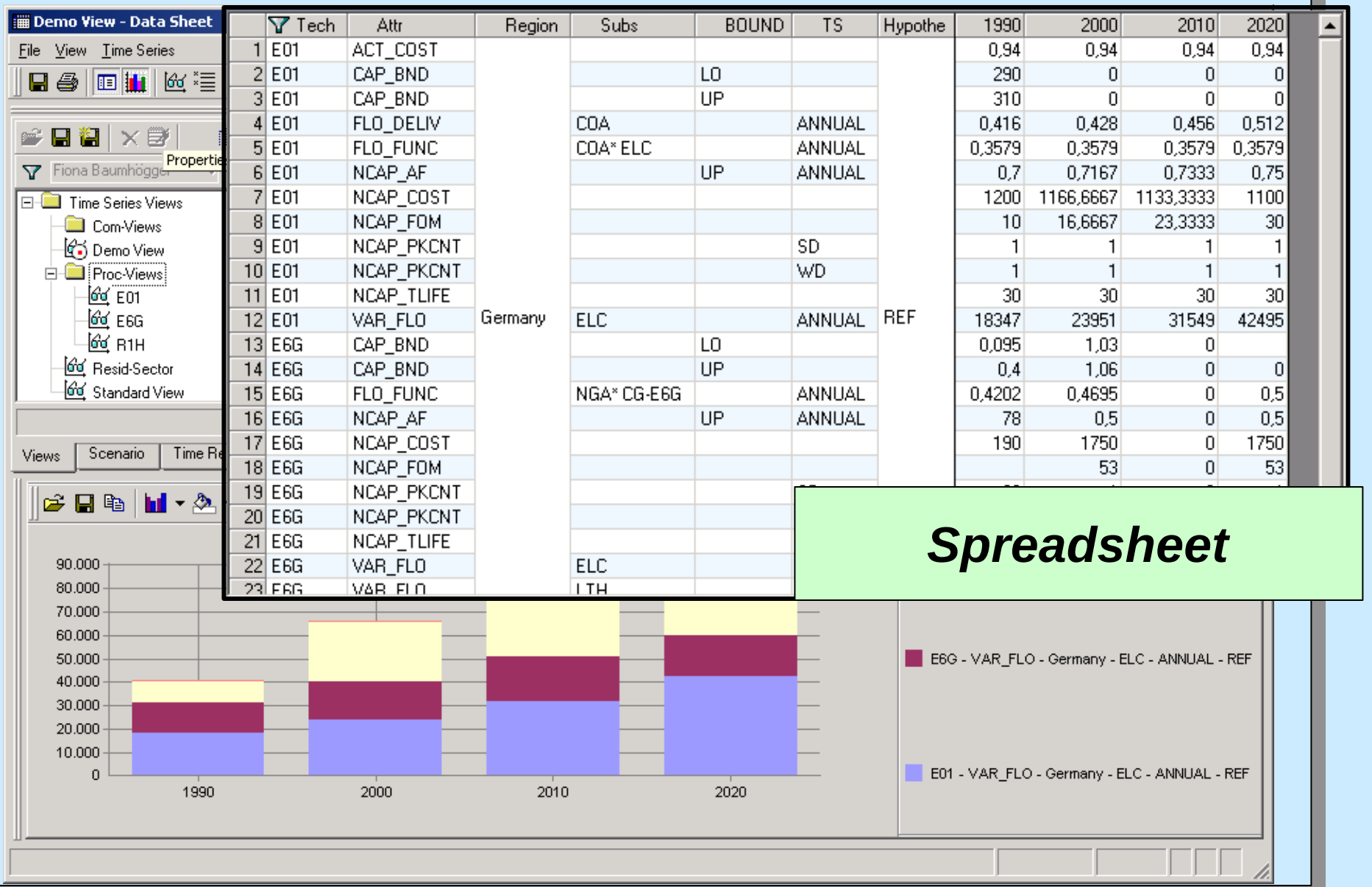
MESAP DataSheet



	Tech	Attr	Region	Subs	BOUND	TS	Hypothe	1990	2000	2010	2020
1	E01	ACT_COST						0,94	0,94	0,94	0,94
2	E01	CAP_BND			LO			290	0	0	0
3	E01	CAP_BND			UP			310	0	0	0
4	E01	FLO_DELIV		COA		ANNUAL		0,416	0,428	0,456	0,512
5	E01	FLO_FUNC		COA* ELC		ANNUAL		0,3579	0,3579	0,3579	0,3579
6	E01	NCAP_AF			UP	ANNUAL		0,7	0,7167	0,7333	0,75
7	E01	NCAP_COST						1200	1166,6667	1133,3333	1100
8	E01	NCAP_FOM						10	16,6667	23,3333	30
9	E01	NCAP_PKCNT				SD		1	1	1	1
10	E01	NCAP_PKCNT				WD		1	1	1	1
11	E01	NCAP_TLIFE						30	30	30	30
12	E01	VAR_FLO	Germany	ELC		ANNUAL	REF	18347	23951	31549	42495
13	E6G	CAP_BND			LO			0,095	1,03	0	
14	E6G	CAP_BND			UP			0,4	1,06	0	0
15	E6G	FLO_FUNC		NGA* CG-E6G		ANNUAL		0,4202	0,4695	0	0,5
16	E6G	NCAP_AF			UP	ANNUAL		78	0,5	0	0,5
17	E6G	NCAP_COST						190	1750	0	1750
18	E6G	NCAP_FOM							53	0	53
19	E6G	NCAP_PKCNT									
20	E6G	NCAP_PKCNT									
21	E6G	NCAP_TLIFE									
22	E6G	VAR_FLO		ELC							
23	E6G	VAR_FLO		LTH							

Spreadsheet

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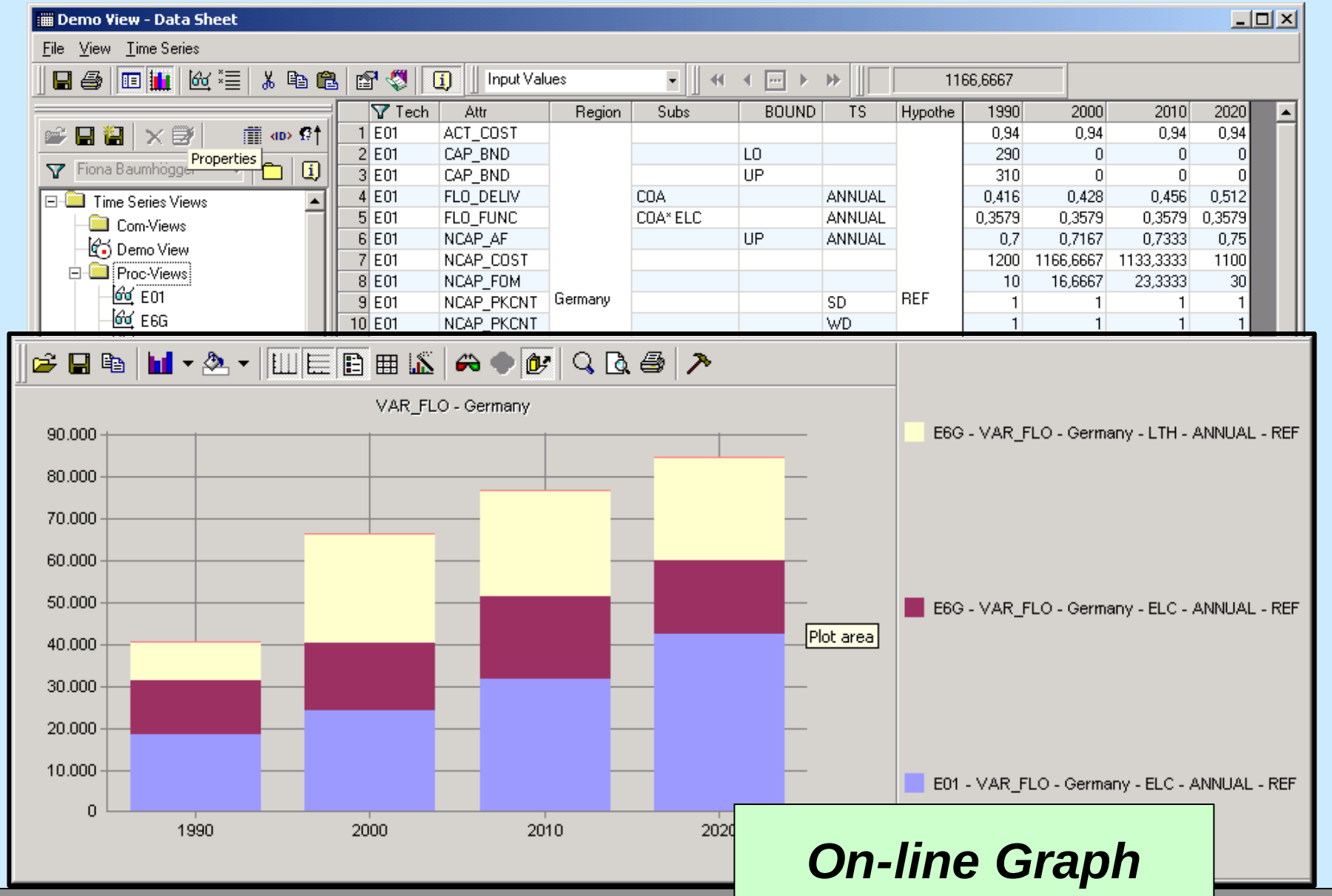
MESAP DataSheet



	Tech	Attr	Region	Subs	BOUND	TS	Hypothe	1990	2000	2010	2020
1	E01	ACT_COST						0,94	0,94	0,94	0,94
2	E01	CAP_BND			LO			290	0	0	0
3	E01	CAP_BND			UP			310	0	0	0
4	E01	FLO_DELIV		COA		ANNUAL		0,416	0,428	0,456	0,512
5	E01	FLO_FUNC		COA* ELC		ANNUAL		0,3579	0,3579	0,3579	0,3579
6	E01	NCAP_AF			UP	ANNUAL		0,7	0,7167	0,7333	0,75
7	E01	NCAP_COST						1200	1166,6667	1133,3333	1100
8	E01	NCAP_FOM						10	16,6667	23,3333	30
9	E01	NCAP_PKCNT	Germany			SD	REF	1	1	1	1
10	E01	NCAP_PKCNT				WD		1	1	1	1

On-line Graph

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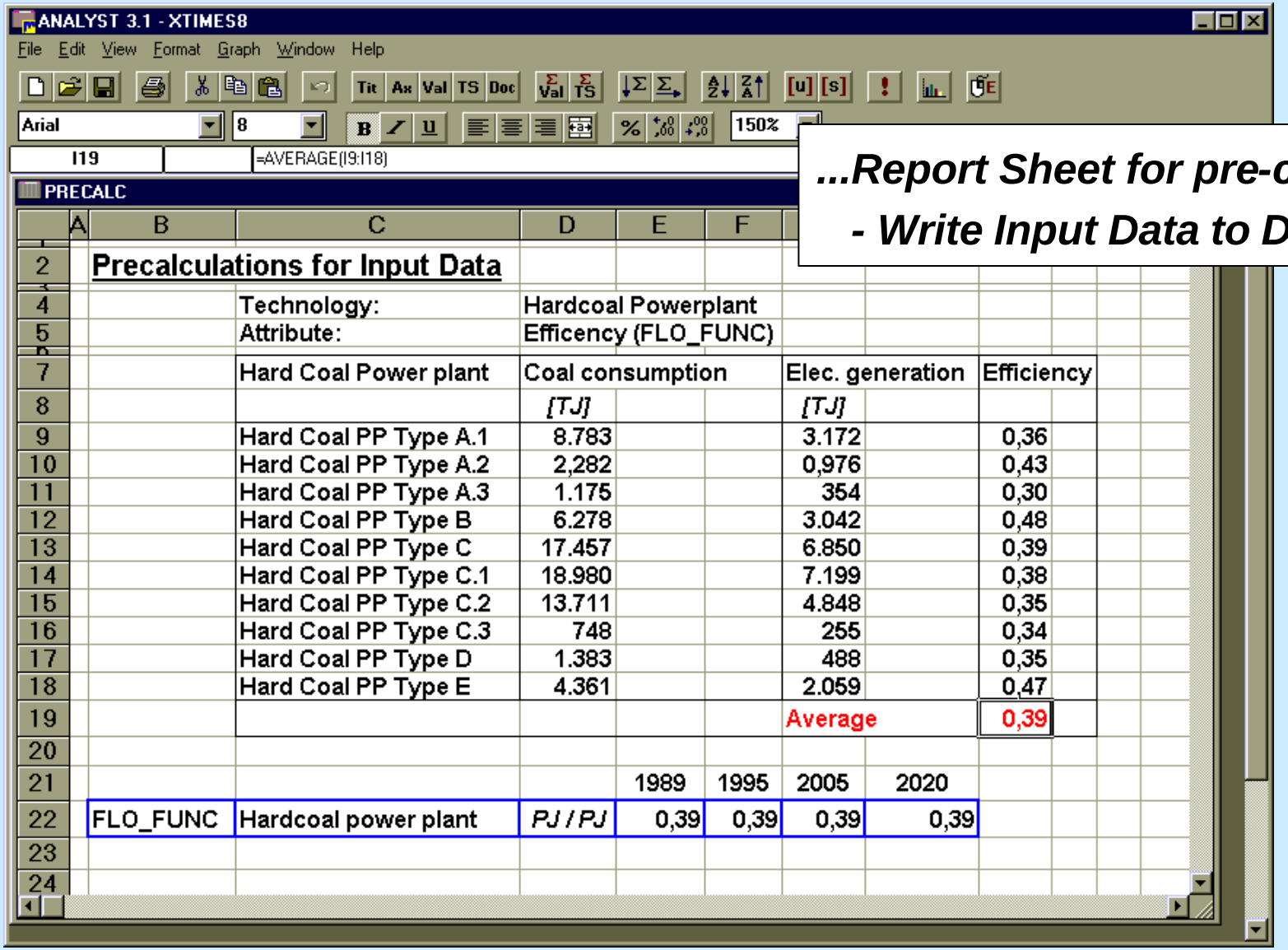
MESAP Analyst



Precalculations for Input Data

Technology:	Hardcoal Powerplant	
Attribute:	Efficency (FLO_FUNC)	

Hard Coal Power plant	Coal consumption	Elec. generation	Efficiency
	[TJ]	*[TJ]*	
Hard Coal PP Type A.1	8.783	3.172	0,36
Hard Coal PP Type A.2	2,282	0,976	0,43
Hard Coal PP Type A.3	1.175	354	0,30
Hard Coal PP Type B	6.278	3.042	0,48
Hard Coal PP Type C	17.457	6.850	0,39
Hard Coal PP Type C.1	18.980	7.199	0,38
Hard Coal PP Type C.2	13.711	4.848	0,35
Hard Coal PP Type C.3	748	255	0,34
Hard Coal PP Type D	1.383	488	0,35
Hard Coal PP Type E	4.361	2.059	0,47
		Average	0,39

			1989	1995	2005	2020
FLO_FUNC	Hardcoal power plant	*PJ / PJ*	0,39	0,39	0,39	0,39

...Report Sheet for pre-calculations

- Write Input Data to Data Base

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MESAP Analyst

...Report Sheet for Displaying Model Results in Data Base using Table and Graph Templates

ANALYST 3.1 - XTIMES8

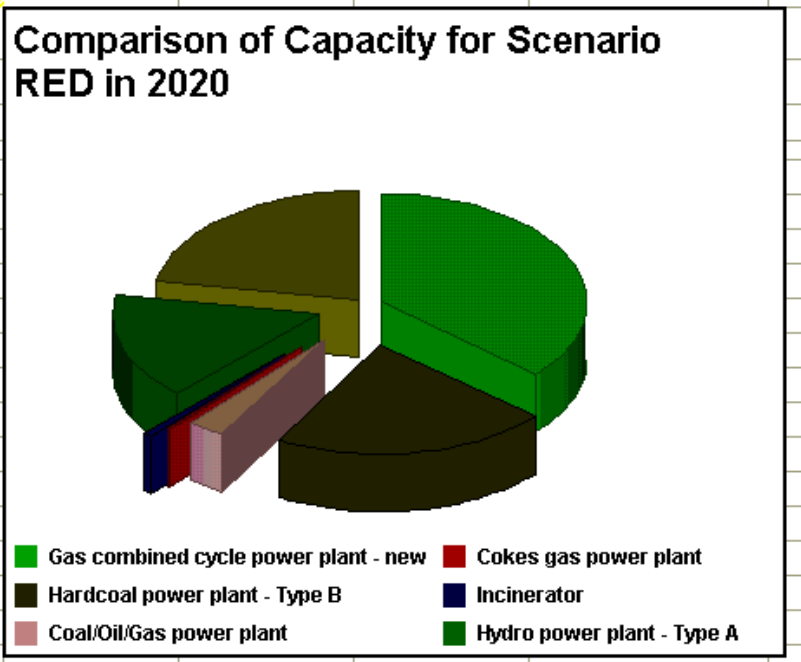
File Edit View Format Graph Window Help

Arial 10 150%

H51

Comparison of Capacity in 2020

RED uction Scenario	Unit	1989	1995	2005	2020
Coal/Oil/Gas power plant	PJ / a	0	0	0	12,75
Cokes gas power plant	PJ / a	0	0	0	0,8
Gas combined cycle power plant - new	PJ / a	1,4	41,01	101,36	157,31
Gas combined cycle power plant - old	PJ / a	58	21,09	0	0
Gas turbine	PJ / a	0	0	0	0
Hardcoal power plant - Type A	PJ / a	25	25	7,5	0
Hardcoal power plant - Type B	PJ / a	28	28	29,79	94,18
Hydro power plant - Typ B	PJ / a	0	0	0	0
Hydro power plant - Type A	PJ / a	68	68	68	68
Incinerator	PJ / a	7,35	7,35	7,35	2,94
Light water reactor	PJ / a	192	192	192	96
Lignite power plant - new	PJ / a	0	0	0	0
Lignite power plant - old	PJ / a	22,55	22,55	9,02	0
Oil power plant (fuel_hsc) - new	PJ / a	3,94	3,94	3,15	0
Oil power plant (Fuel_hsc) - old	PJ / a	78	56,73	0	0
Wind turbine - Type E	PJ / a	0,02	0,01	0	0



MESAP DataCube

Cube

Attribute | P_Fuels | C_Type

				Annum							
				1989		1995		2005		2020	
P_Sector	Comm_1	Process	Unit	CO2-RED	REF	CO2-RED	REF	CO2-RED	REF	CO2-RED	REF
Fossile	Blast furnace gas	Blast furnace power plant	PJ	0	0	0	0	0	0	4	0
	Cokes gas	Cokes gas power plant	PJ	0	0	0	0	0	0	5	0
	Fuel-HSC			0	0	0	42	0	0	0	0
	Fuel-LSC			0	0	0	0	0	0	0	0
	Hard coal			76	76	87	87	56	150	123	281
	Lignite			55	55	31	55	0	22	0	0
	Natural gas			74	74	81	42	117	34	223	76
Nuclear	HTR-fuel	HTR	PJ	0	0	0	0	0	0	0	0
	Uranium	Light water reactor	PJ	589	589	589	589	589	589	295	295
Others	Hydrogen	Hydrogen power plant	PJ	0	0	0	0	0	0	0	0
	refusal	Incinerator	PJ	5	5	5	5	5	5	2	2
Renewables	Natural gas	Wind turbine - Type E	PJ	0	0	0	0	0	0	0	0
	Solar	Photovoltaics - Type C	PJ	0	0	0	0	0	0	0	0
		Photovoltaics - Type D	PJ	0	0	0	0	0	0	0	0
	Water	Hydro power plant - Typ B	PJ	0	0	0	0	0	0	1	0
		Hydro power plant - Type A	PJ	68	68	68	68	68	68	68	68
	Wind	Wind turbine - Type E	PJ	0	0	0	0	0	0	0	0

...Cube View for analyzing Model Results in Data Base using the Online Analysis Processing (OLAP)

- ***free configuration of the dimensions by drag&drop***
- ***collapsing / de-collapsing for automatic aggregation***

Outlook

- Methodology
  - Technological learning
  - Macroeconomic linkage, e.g. TIMES-MACRO
  - Multi-stage stochastic programming
  - …
- Application
  - Converting existing MARKAL and EFOM models
  - Building a global model