

The E in TIMES

Results of the conversion of the German E3Net Model to TIMES

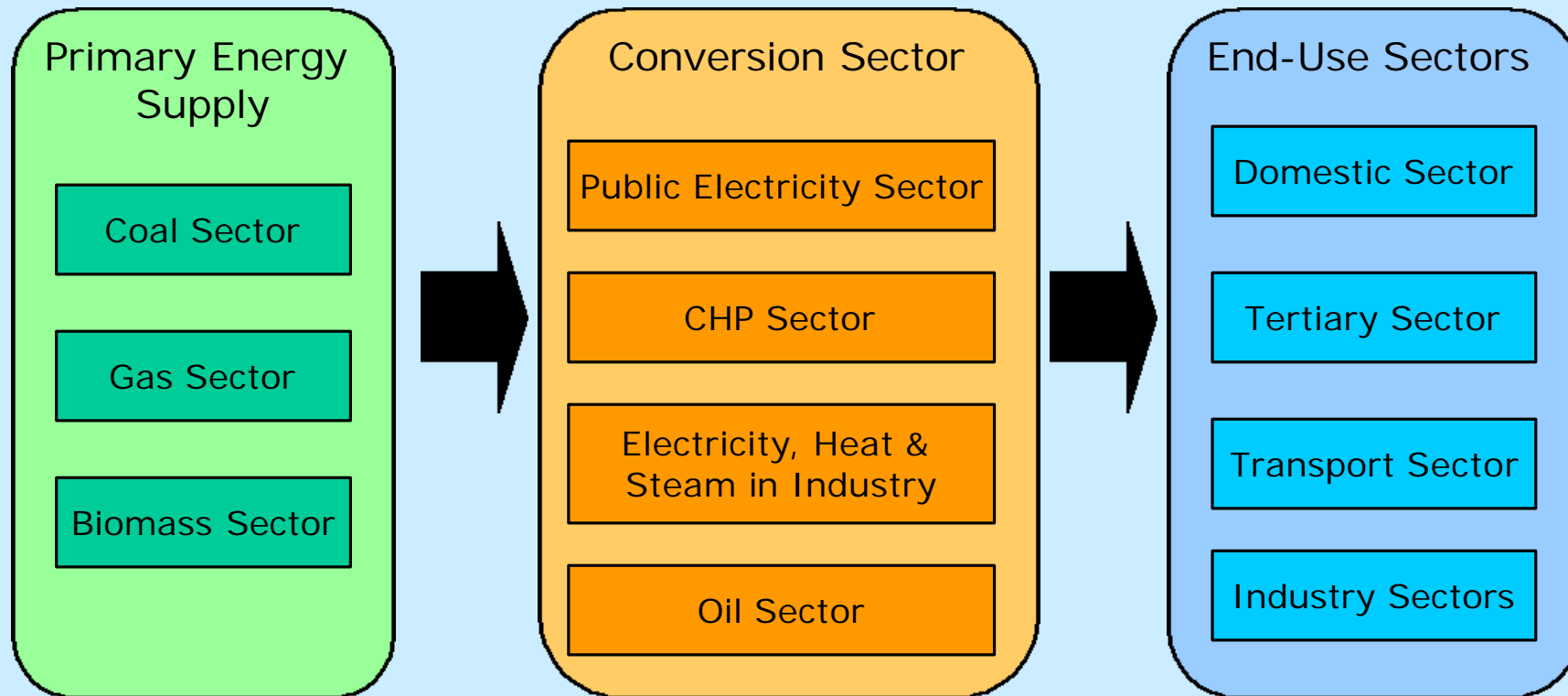
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IER, University of Stuttgart

ETSAP Workshop October 2001, Paris

Overview

- E3Net model
- Conversion process
- Problems
- Results & Next steps

Structure of the E3Net model

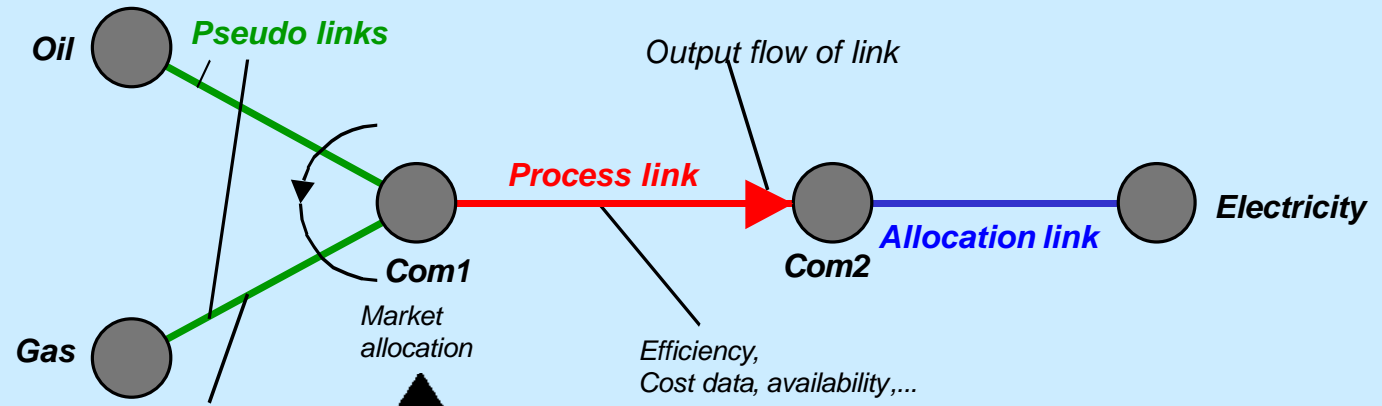


Characteristics of the E3Net model

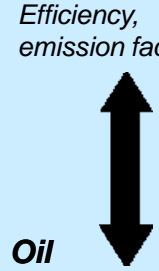
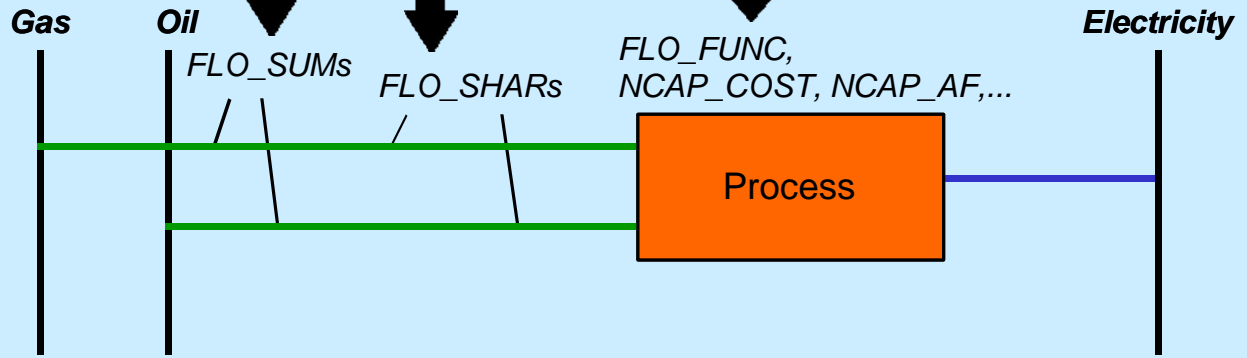
- GAMS version of EFOM-ENV model
- Two regions: West & East Germany
- Model horizon 1990-2050 divided in 12 periods of 5 years
- 4 time segments on daily level: WB, WP, SB, SP
- 120 conversion and 380 end-use technologies per region

Modelling a process in E3Net and TIMES

E3Net



TIMES



Conversion routine

- GAMS routine

E3Net set and param files



Adjusted E3Net files



- Changing names of sets being identical in TIMES
- Create sets with pseudo, process, allocate links

Comparison of TIMES and E3net results



Corrected TIMES dd file



Model run

Re-run conversion for selected links without aggregation



Conversion routine

Creation of TIMES sets

- reduction of topology based on pseudo, process, allocate link information
- Process&Commodity characterization

Creation of TIMES parameters

- Trying to aggregate links with market /product shares with upstream/downstream process
- Create list of non-converted parameters

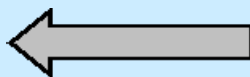


TIMES dd file



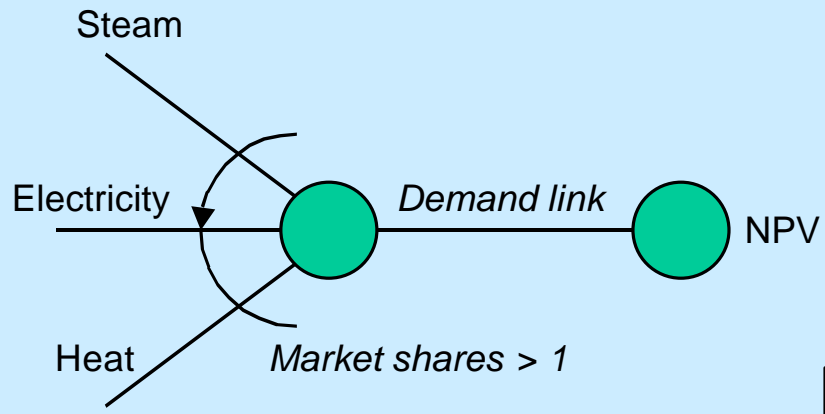
Checking non-converted parameters

Manual conversion of extraction condensing CHP plants und oreste constraints



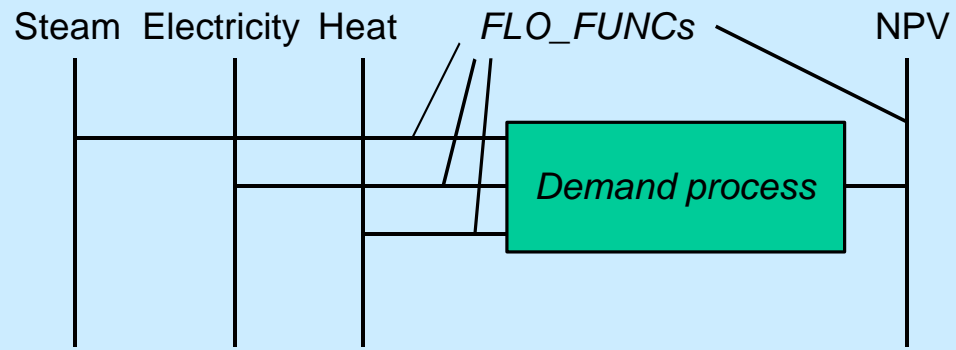
Pitfalls

E3Net



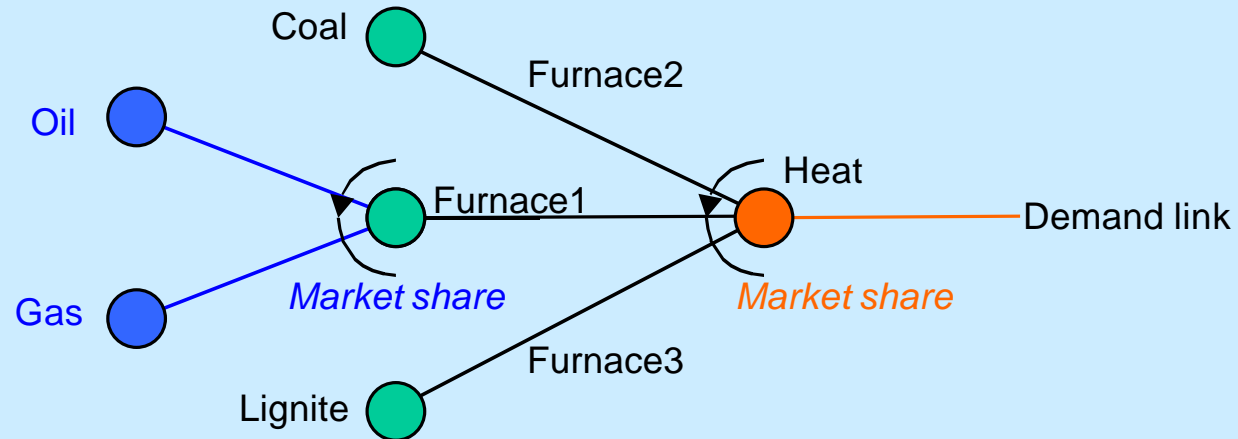
Market shares are converted to FLO_FUNCs in TIMES.

TIMES



Pitfalls cont.

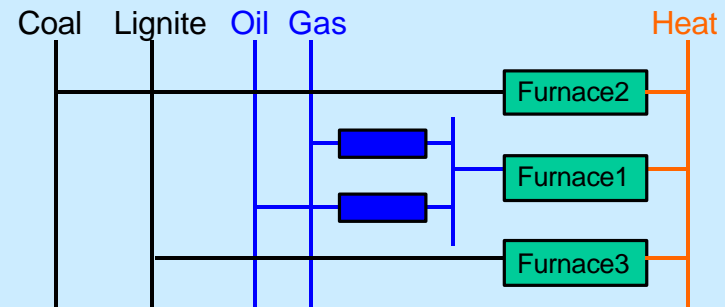
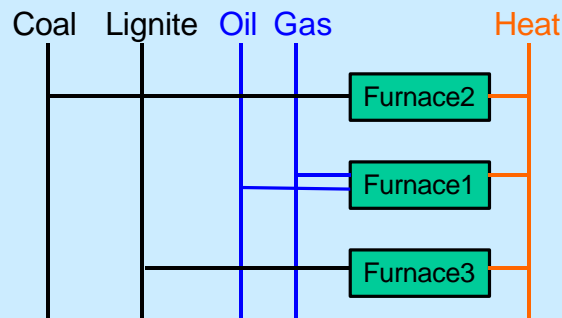
E3Net



Correct representation in TIMES

1:1 conversion

TIMES



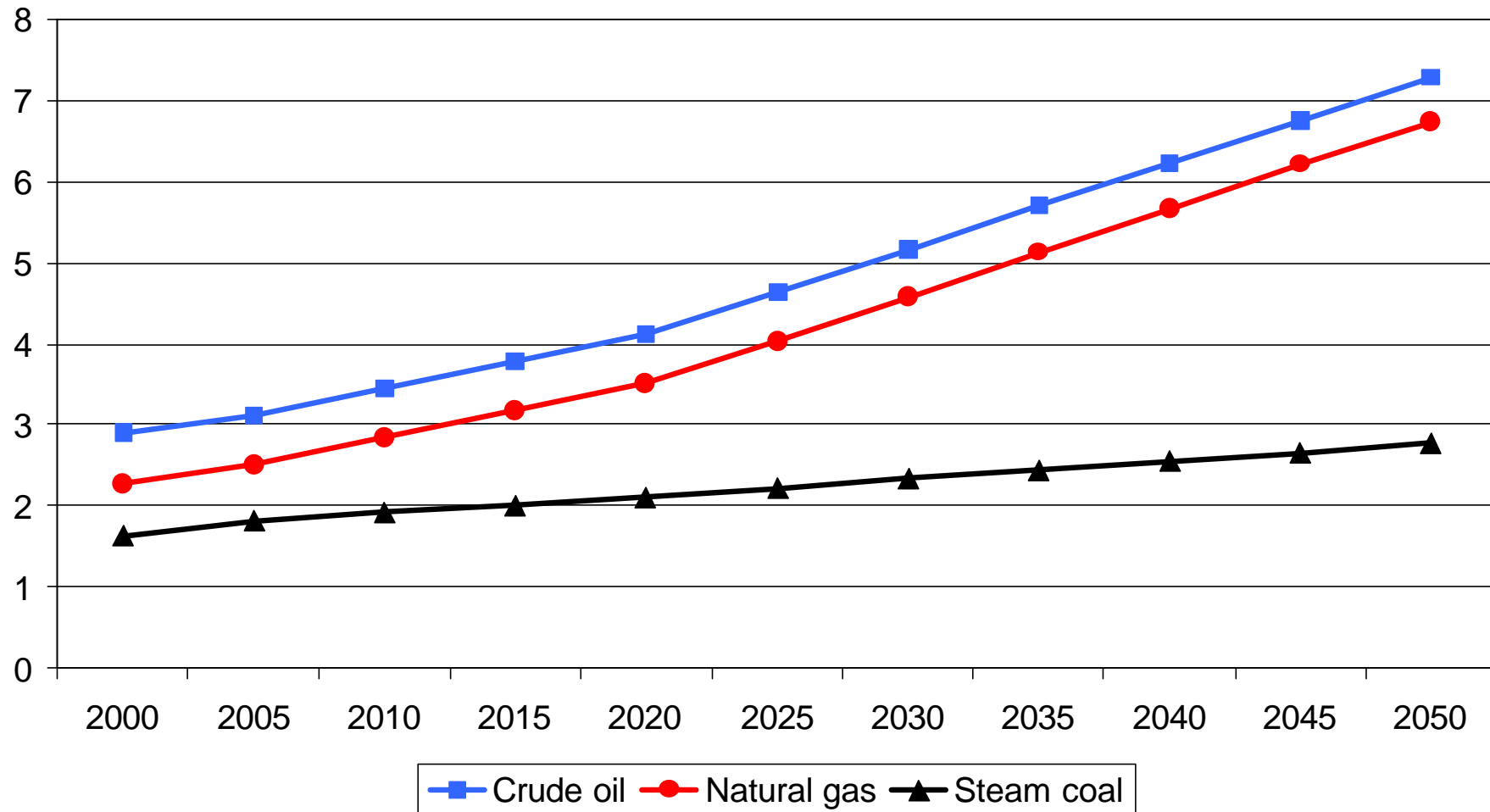
Flow shares for Oil and Gas

User constraint for distribution of heat on furnaces

User constraint

User constraint

Import prices [EUR95/GJ]



Policy Measures

- Phase-out of nuclear energy
- Use of domestic hard coal will decline (1120 PJ in 2000 => 210 PJ in 2030)
- Subsidies for renewable energy sources and CHP
- Efficiency improvement programme for buildings
- Self commitment of German car industry to reduce specific fuel consumption

Net production

Net production value of industry (10 ⁹ EUR ₉₅)	1998	2010	2020	2030	2040	2050
production of rocks, mining	3.7	2.3	2.1	1.8	1.5	1.2
nutrition and tobacco	32.8	39.0	42.9	44.6	44.7	43.5
paper industry	8.5	11.2	13.7	15.7	17.5	19.0
basic industry	23.9	32.9	40.7	46.1	50.8	54.5
other chemical industry	20.3	24.4	32.0	39.2	47.7	59.5
rubber and plastic goods	20.0	25.1	29.2	32.4	35.2	37.9
glass and ceramics	6.0	8.1	9.7	11.1	12.3	13.6
processing of rocks	10.7	14.3	17.2	19.7	21.8	23.9
production of metals	7.0	8.2	8.8	9.4	9.1	8.0
non-ferrous metals, foundries	7.6	10.4	12.6	14.2	14.8	14.1
processing of metals	38.5	53.8	65.5	75.9	85.9	95.3
mechanical engineering	60.0	85.6	108.8	130.8	152.5	175.1
car industry	62.7	81.9	106.0	121.0	132.1	136.6
other economical branches	109.1	137.6	163.4	191.4	218.9	246.4
business of processing	407.3	532.4	650.7	751.6	843.3	927.4
processing business, ..	410.9	534.7	652.8	753.3	844.7	928.5

Demand projection of households and transportation

saturation of household appliances

		1995	2010	2020	2030	2040	2050
electrical stoves	%	74.9	81.6	84.3	85.5	86.4	87
gas stoves	%	23.8	17.6	15.1	13.9	13.1	12.6
fridges/comb. with freezers	%	108.3	117.8	124.7	128.3	130.8	132.3
freezers	%	55.5	63.4	66.4	67.8	68.7	69.2
washing mashines/comb. with dryers	%	92	96.7	97.4	97.5	97.6	97.6
dryers	%	29.5	48.6	59.8	64.8	68.3	70.4
light	%	100	100	100	100	100	100
dishwasher	%	38.9	62.1	67.7	70.2	71.9	73
TV	%	131.4	154.7	165.4	169.7	171.8	172.5
PC	%	25.4	78.4	105.8	118.1	127.1	132.4

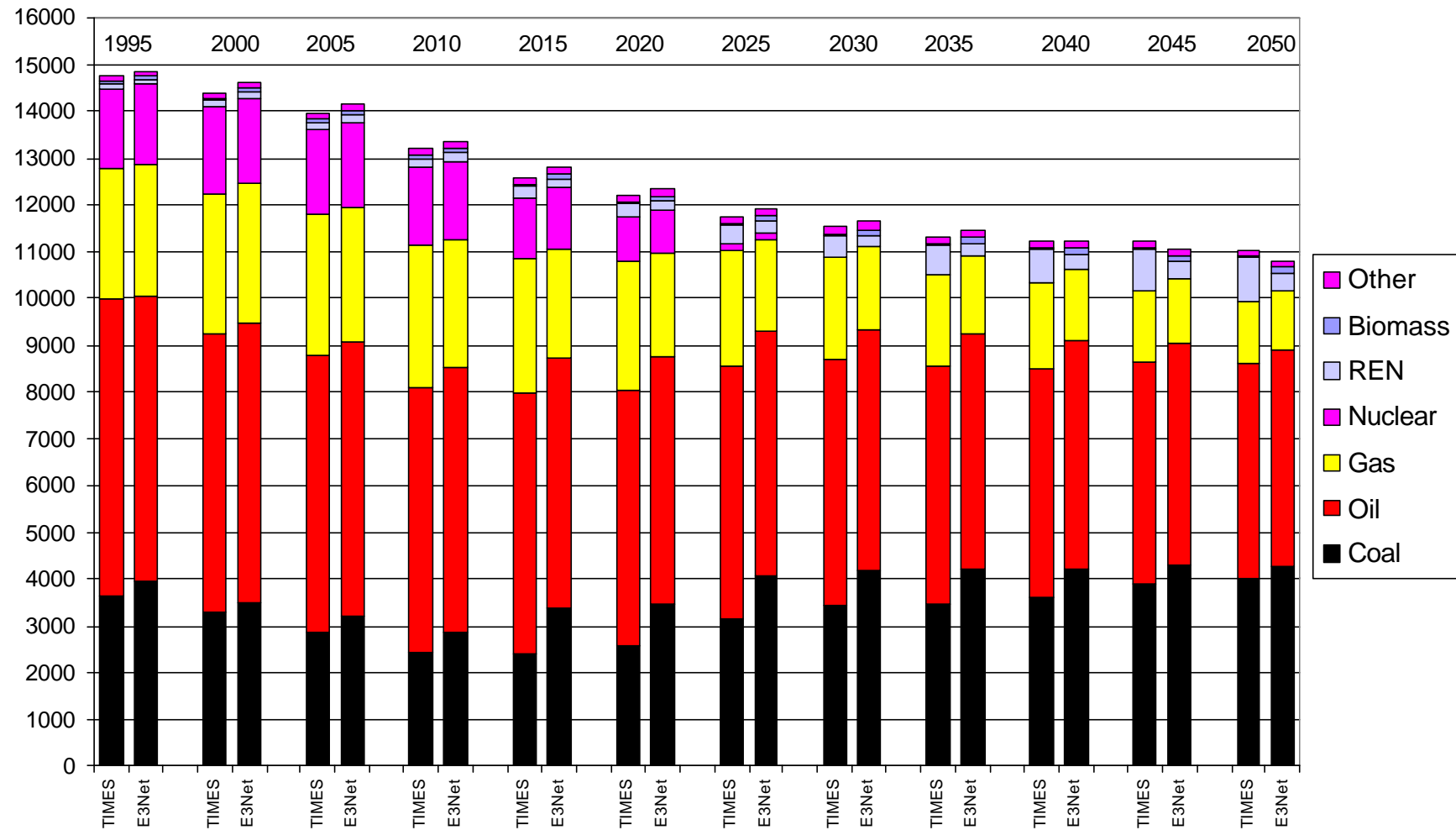
heated living space		1995	2010	2020	2030	2040	2050
one/two family houses	10 ⁶ qm	1,727.00	2,155.00	2,425.00	2,492.60	2,458.90	2,356.10
multiple dwelling; other buildings	10 ⁶ qm	1,327.0	1,578.00	1,717.00	1,738.30	1,696.90	1,615.60

traffic		1998	2010	2020	2030	2040	2050
people	10 ⁹ Pkm	941.3	1,090.86	1,138.18	1,139.13	1,099.84	1,026.90
goods	10 ⁹ tkm	454.4	607.35	732.4	839.23	919.89	964.42

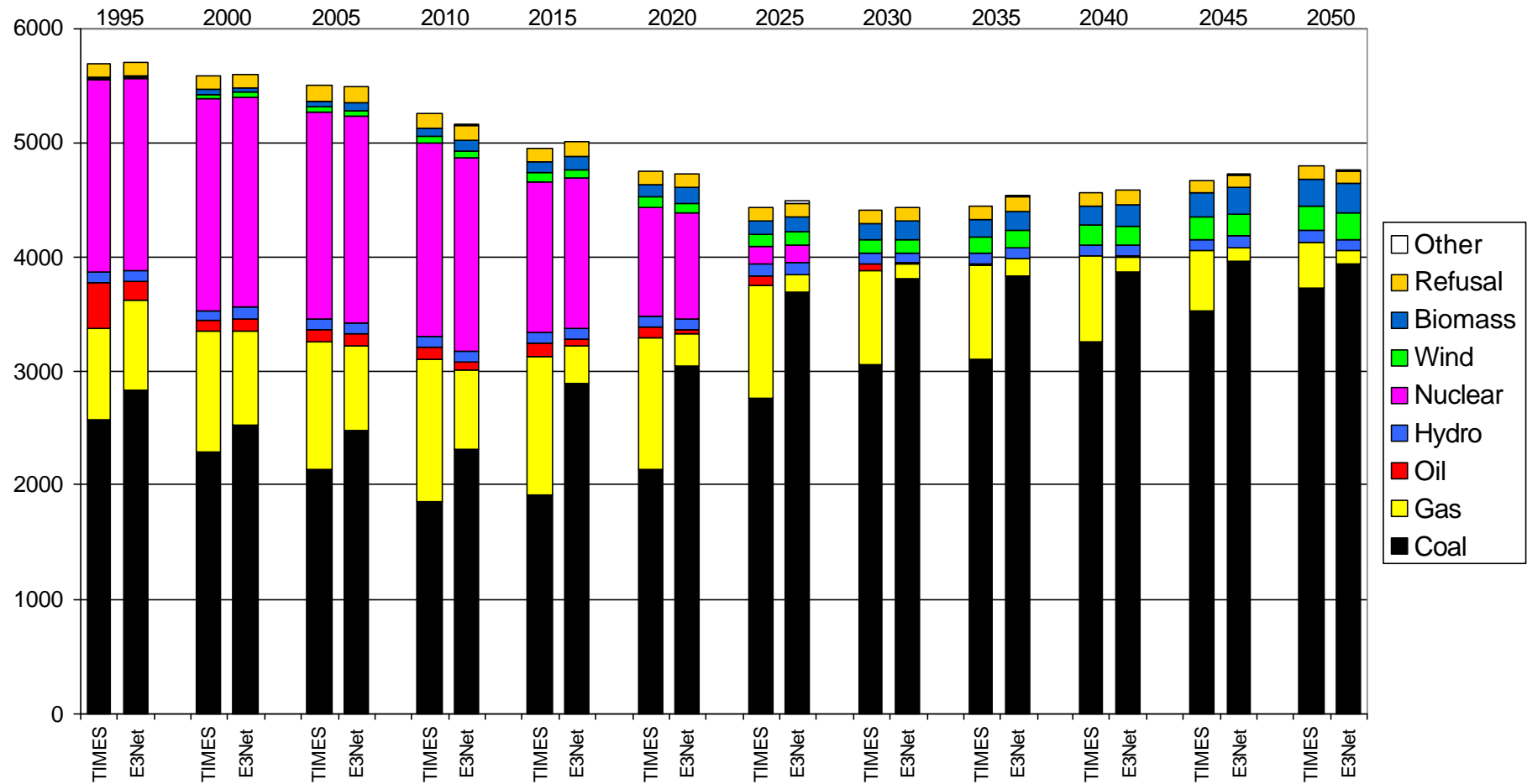
Economic and demographic development

		1998	2010	2020	2030	2040	2050
GDP	10^9 EUR ₉₅	1,960.55	2,470.39	2,920.09	3,329.38	3,704.52	4,042.35
Population	10^6 cap	82	82.1	80.8	77.9	73.3	67.8
GDP/capita	EUR ₉₅	23,909	30,090	36,139	42,739	50,539	59,622

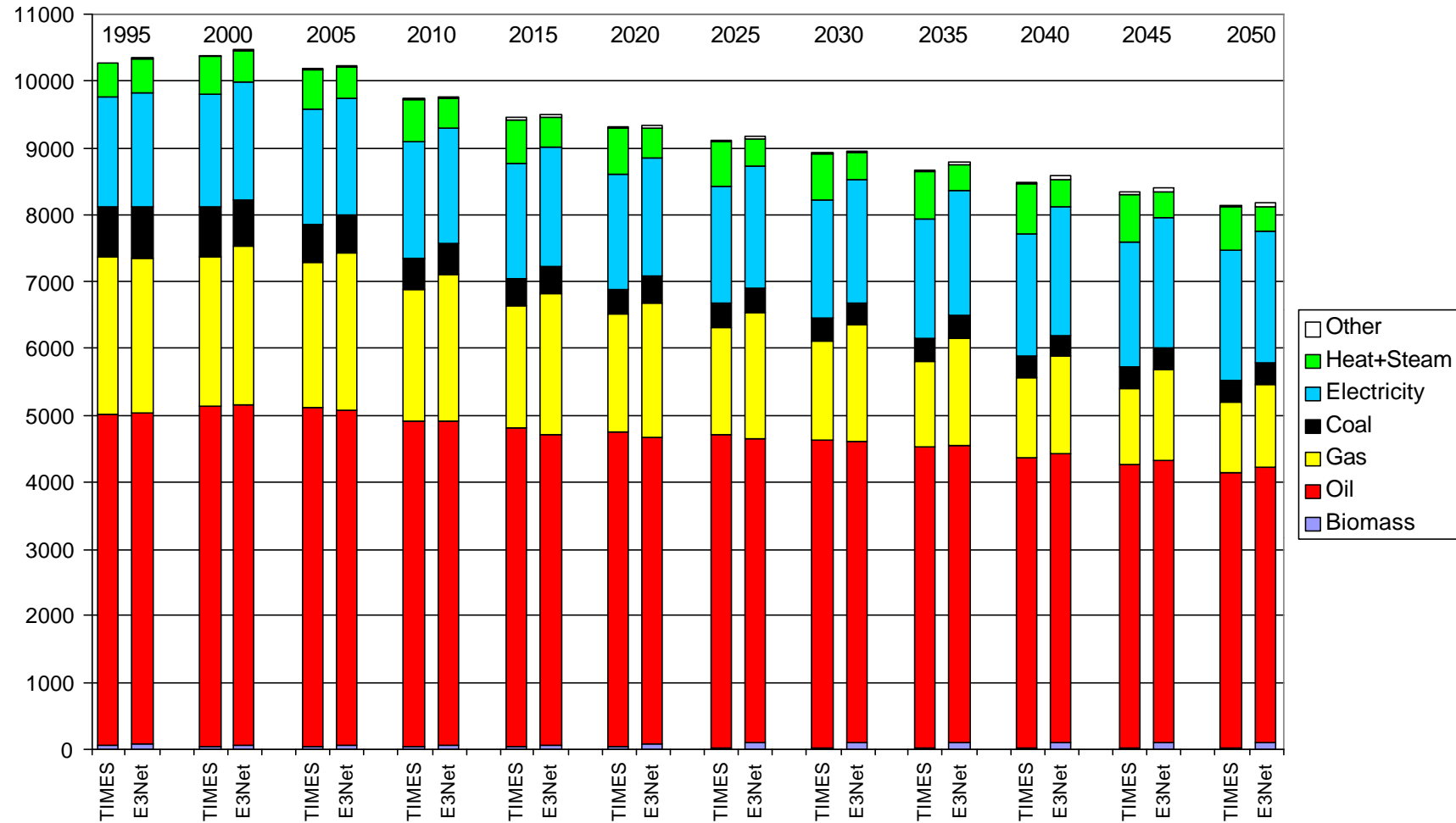
Primary Energy [PJ]



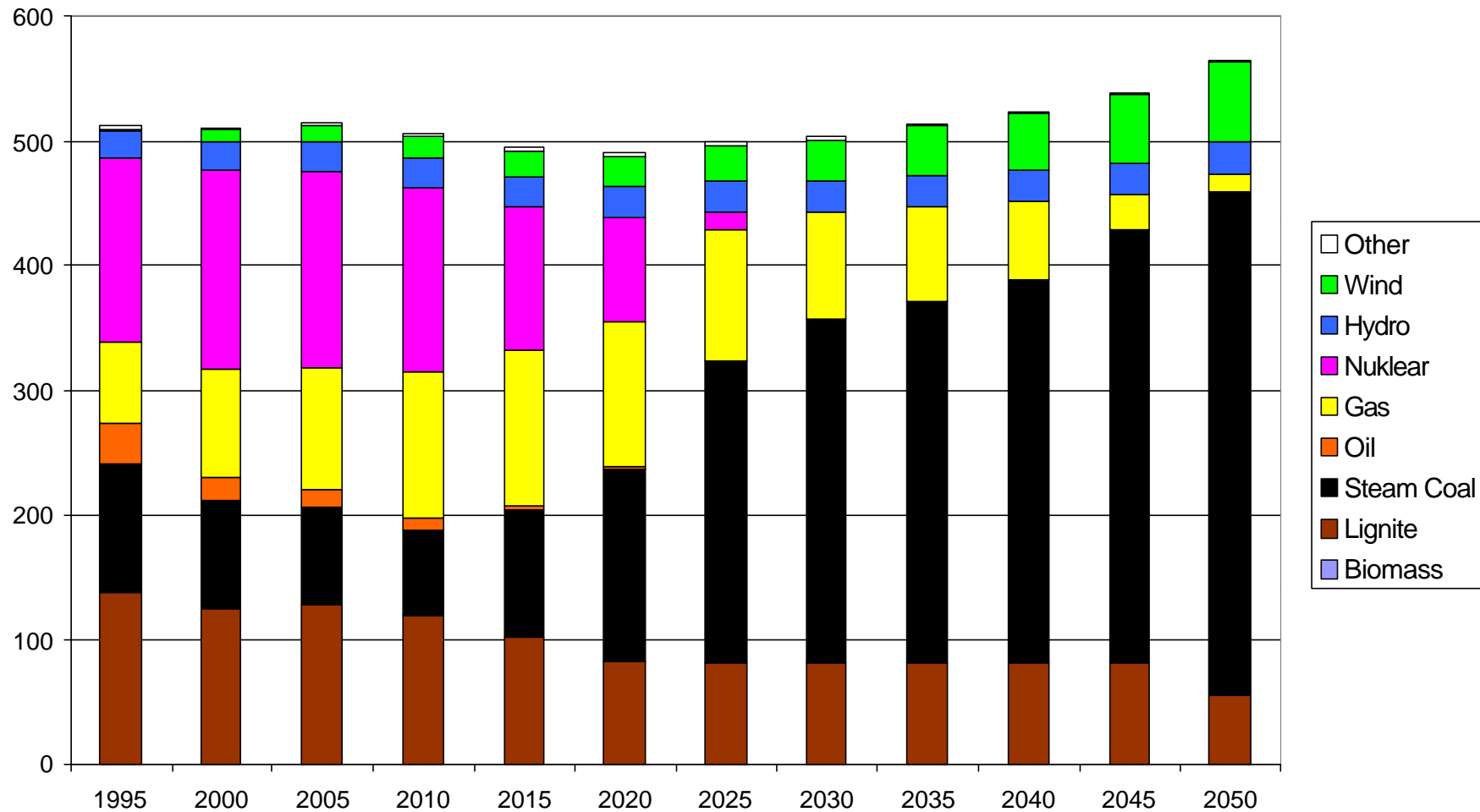
Primary energy consumption for heat and electricity generation [PJ]

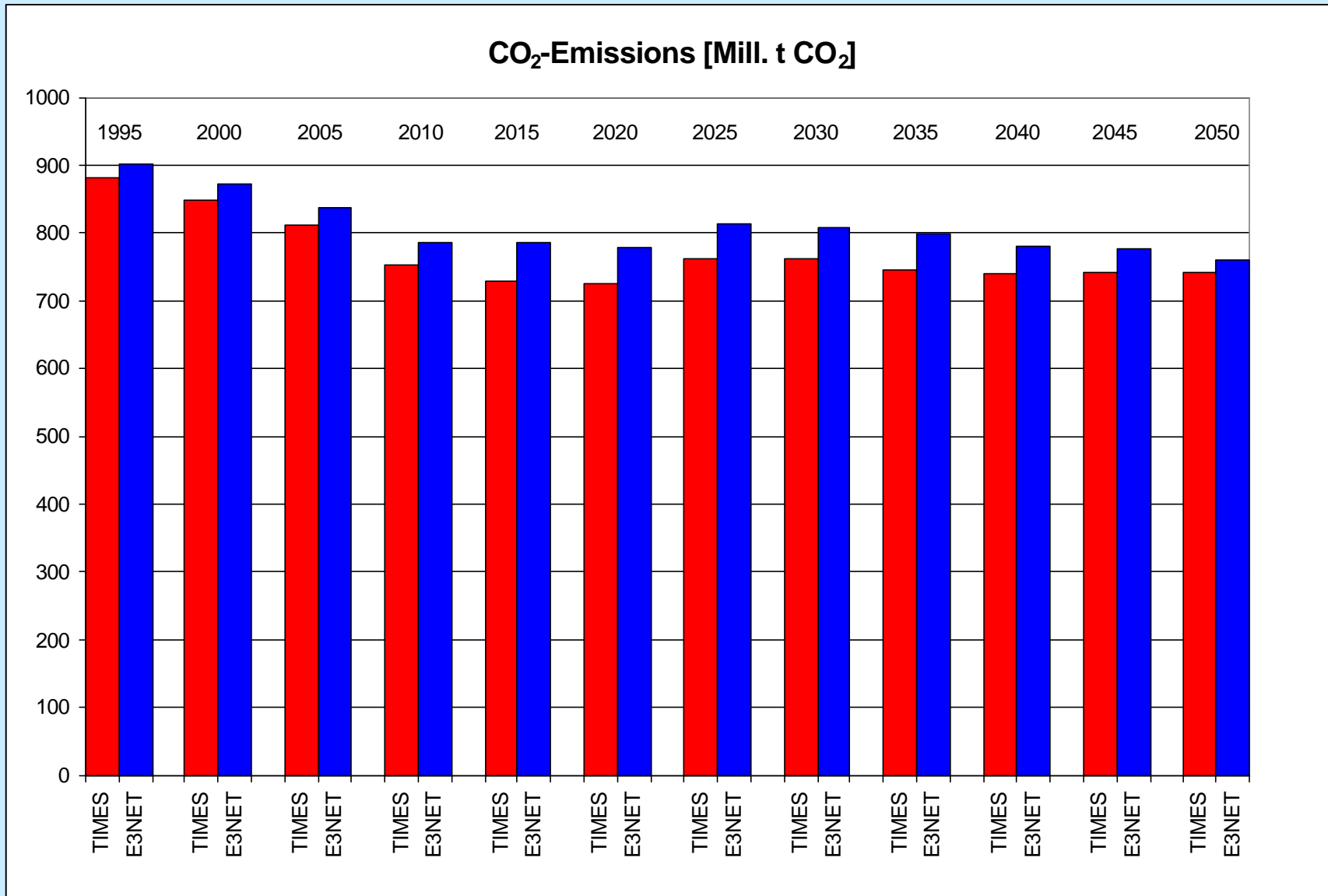


Final Energy Demand [PJ]



Net Electricity Generation [TWh]





Objective value and performance

- Objective values discounted to the base year:
 - E3Net: 9,685,768 Mill. DM₉₅
 - TIMES: 10,567,458 Mill. DM₉₅ ⇒ 9% higher than E3Net

- Problem size and solution time

	E3Net			TIMES		
	# rows	# columns	# nonzeros	# rows	# columns	# nonzeros
<i>Initial matrix</i>	87,477	77,649	491,806	310,563	318,523	1,196,821
<i>Reduced matrix</i>	43,177	42,019	247,685	56,824	50,255	394,211
<i>Execution+generation time</i>	5 min			27 min		
<i>Solution time</i>	4 min			15 min		

Summary of comparison

- Primary goal: converting data set
- Conversion not automatically, manual corrections or conversion required in some places
- Nearly all E3Net parameters converted to TIMES, new parameters/equations included in TIMES: FLO_FR and FLO_BND
- Validation only qualitative due to differences in objective function
- Software tools used: ANSWER, VEDA, MESAP ResEditor
- Overall calculation of TIMES four times higher than E3Net
- Next steps:
 - Testing model under different scenarios (variation of prices, demands, reduction targets)
 - Aggregation of processes
 - Updating technology data (especially renewables)