

New PRIMES Baseline Scenario for DG TREN (2005)

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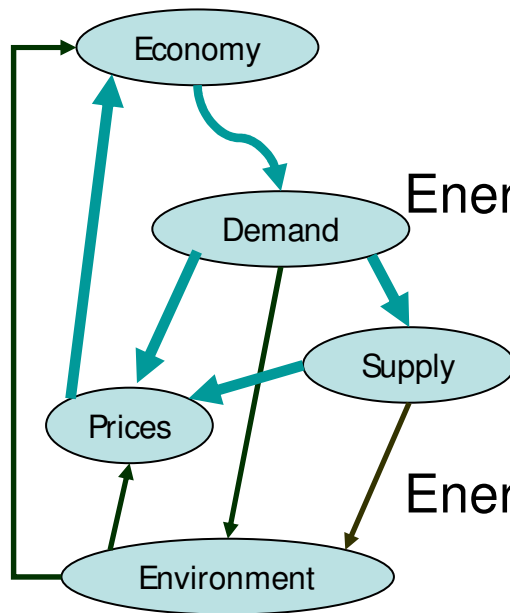
Part A

Presentation of PRIMES model

Scenarios for Policy Analysis

- Energy and Transport Scenarios → • This is the objective of Long Run Energy Modelling activity
- Models: mainly PRIMES, in connection with POLES, GEM-E3, SCENES, RAINS and others → • Network of experts in modelling cooperating since early 90s
- Baseline scenario (new available in Nov. 2005, update starting April 2006) → • Important to update the baseline scenario and inform all stakeholders
- Alternative scenarios → • Examples: renewables, oil and gas prices, nuclear, efficiency, combined cases for CO2 mitigation
...

Energy-Economy-Environment System Coverage



Economy system

- GDP, demographics, exchange and interest rates
- Activity by sector (18 sectors), income of households
- Transport flows

Energy demand system

- Consumption habits, durable goods and comfort
- Manufacturing technology, kind of industry and energy needs
- Transportation modes/means and technologies as drivers of energy needs

Energy supply system

- Primary energy supply (depletable and renewable sources)
- Secondary energy supply (power generation, refineries, etc.)
- Energy System Balances

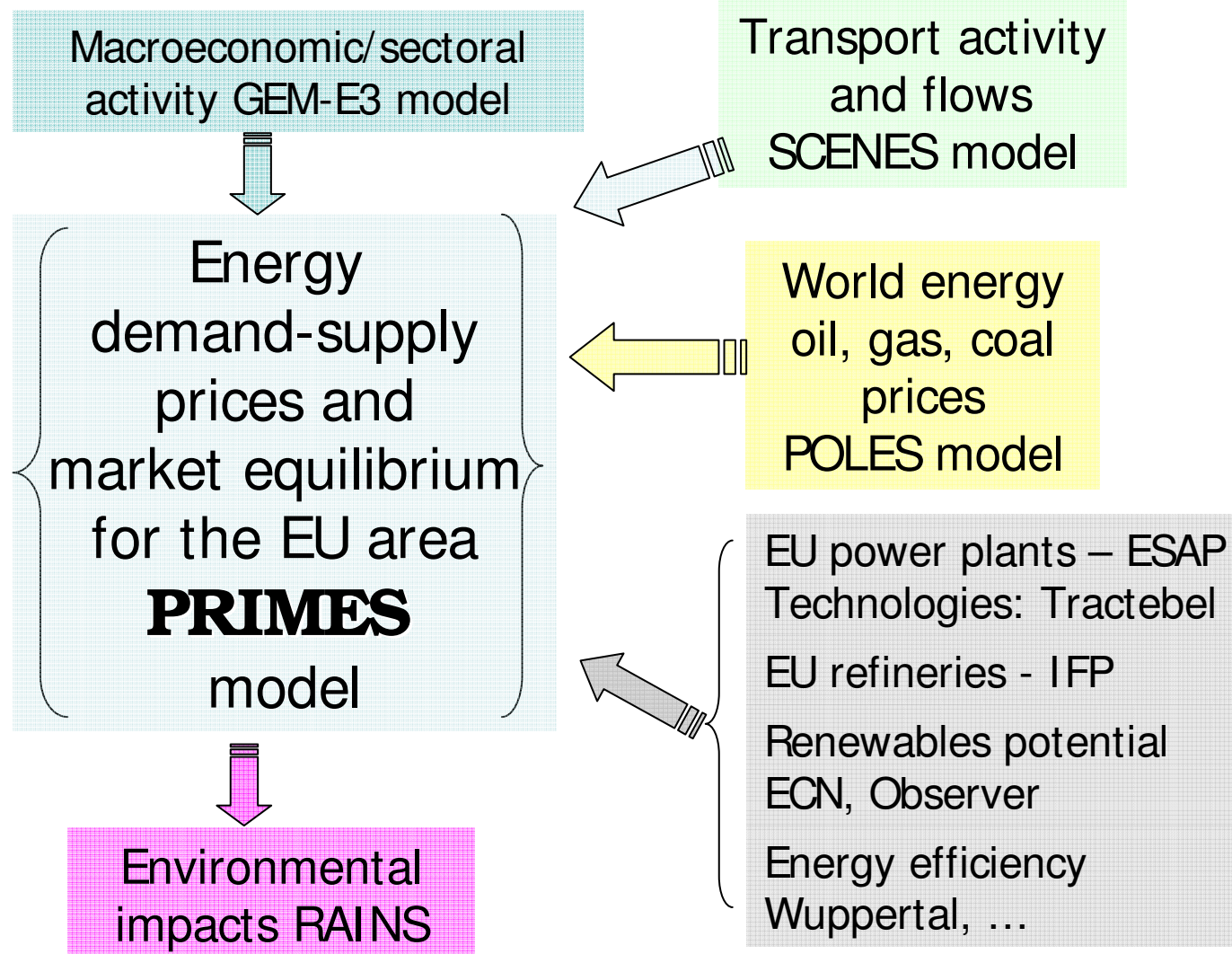
Energy Markets

- Competition, price formation and regulation, import/export

Environment Impacts

- Energy-related emissions
- Environmental impacts and pressures, damages

Energy-Economy-Environment Models and their links



Energy-Economy-Environment System Coverage

- Geographical coverage
 - Each EU-25 member-state taken individually
 - In addition candidates and neighbours, such as Norway, Switzerland, Bulgaria, Romania, Turkey
 - Western Balkan countries (in 2006)
- Network coverage
 - Electricity and gas interconnections over Eurasia
- Time frame
 - 2000 to 2030 by five-years periods
 - Seasonal and daily patterns for electricity, steam and gas load

Plans for Extension

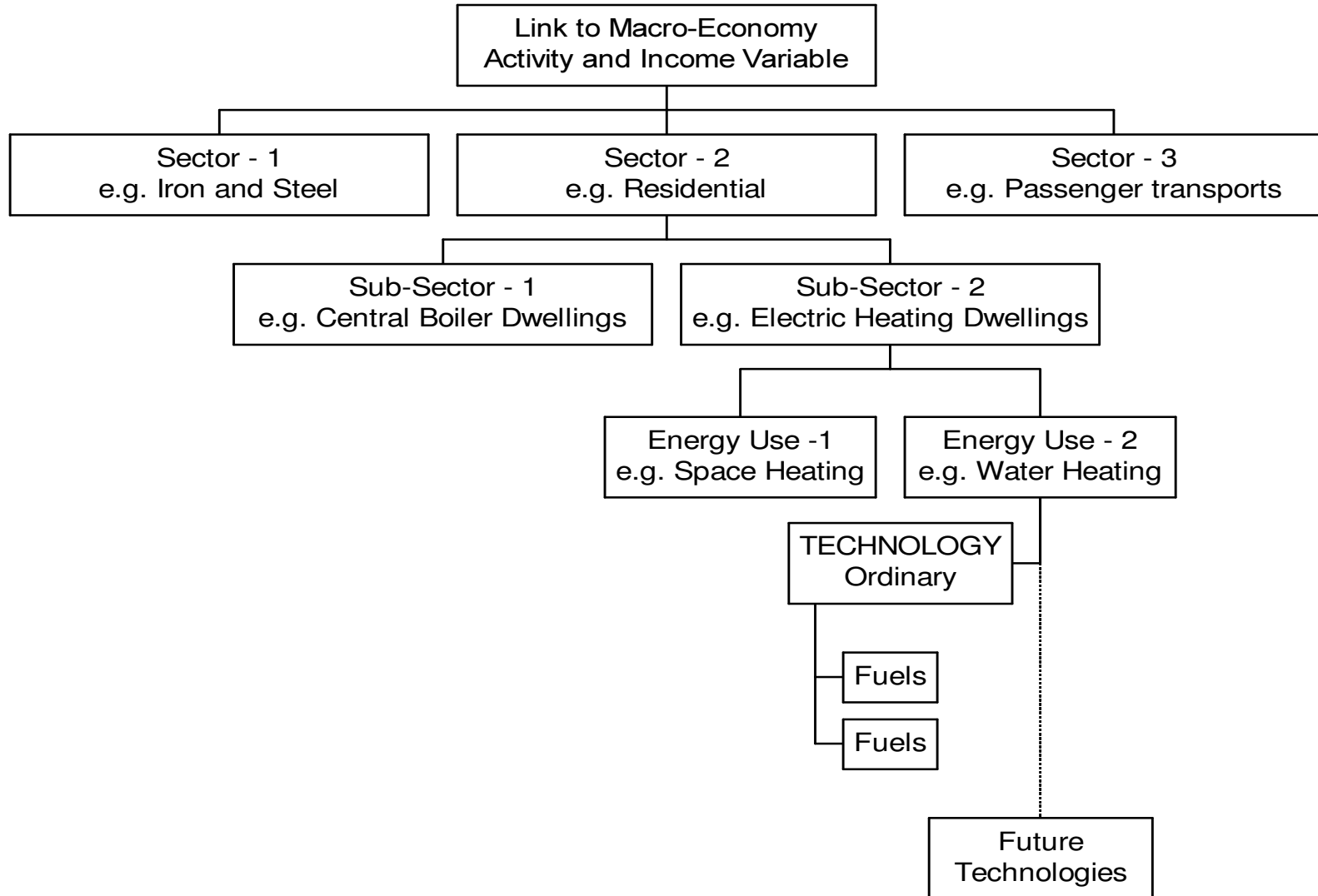
- Ukraine, Russia
- Middle East
- North Africa

-2050 with new technologies (advanced efficiency, nuclear, biomass, hydrogen and carbon capture)

Energy-Economy-Environment System Coverage

- 12 industrial sectors, subdivided into 26 sub-sectors using energy in 12 generic processes (e.g. air compression, furnaces)
- 5 tertiary sectors, using energy in 6 processes (air conditioning, office equipment)
- 4 dwelling types using energy in 5 processes and 12 types of electrical durable goods (e.g. refrigerator, washing machine, television)
- 4 transport modes, 10 transport means and 10 vehicle technologies
- 14 fossil fuel types, 4 new fuel carriers (e.g. hydrogen, methanol, biofuels) 10 renewable energy types
- Sub-systems: power and steam generation, refineries, gas supply, biomass supply(*), hydrogen supply(*), primary energy
- 150 power and steam technologies
- 7 types of emissions from energy processes (partly unabated)

Example of model structure in demand side



Output of a scenario

- Per country and time period (PRIMES, SCENES, RAINS)
 - Detailed energy balance (Eurostat format)
 - Transport activity, modes/means and vehicles
 - Association of energy use and activities
 - Power system investment and use of plants
 - Energy supply per subsystem
 - Energy costs, prices and investment
 - Emissions and concentrations from energy
- Additional material
 - GDP and economic outlook
 - World energy supply outlook

PRIMES: Price-driven and agent-based simulation of markets

- Fundamental distinction of PRIMES from other modelling methodologies:
 - The behaviour of agents is simulated separately from others (agents: e.g. households, steel industry, trade sector, power generation, etc.); the behaviour is modelled according to microeconomic theory, including behavioural patterns, such as habits, comfort, risk management and simultaneity with other economic decisions
 - As a result of individual behaviours, demand and supply of energies is formulated
 - A set of simultaneous energy markets are then cleared to determine prices that balance demand and supply; if price regulation applies, price determination follows a Ramsey-Boiteux methodology (adaptable to both regulated monopoly and competitive markets);
 - Market equilibrium is static within a period but evolution is dynamic in a time forward manner as investment is endogenously driven by supply demand imbalances and technology profitability expectations.
- A series of policies and measures, as well as external influences (like world energy price developments, macroeconomic activity, autonomous technology progress) drive behaviour and market equilibrium.

Part B

Baseline Scenario 2005

Most likely development of energy system in the future, in the context of current knowledge, technology forecasting and policy objectives and actions

Major updates

- Data
 - Energy balances by member States (up to 2003)
 - Energy prices and fiscal policies (up to 2005)
 - Macroeconomic data (up to 2004)
 - Power generation data (2005)
 - 2005 updated statistics and latest potential estimations for renewables
- Expected macroeconomic environment
 - higher energy import prices
 - more subdued economic growth prospects

Recent trends

- Oil and gas prices are more than 50% higher than expected three years ago
 - Oil 55-60 \$/bbl – Gas 6-7 \$/MMBtu
- Renewable support policies have promoted penetration of wind and other energies more than expected
- Investment in combined cycle gas plants developed slower than expected, signals of reemergence of coal plant investment
- Generally slowdown of investment under the context of liberalized market
- Discussions about nuclear and coal for the longer term

Demographic assumptions

Million inhabitants					
	1990	2000	2010	2020	2030
EU15	365.75	378.06	390.65	397.46	398.74
NMS	75.04	74.85	73.40	71.81	70.63
EU-25	440.79	452.92	464.05	469.27	469.37
annual growth rate					
	90/00	00/10	10/20	20/30	00/30
EU15	0.33	0.33	0.17	0.03	0.18
NMS	-0.02	-0.20	-0.22	-0.17	-0.19
EU-25	0.27	0.24	0.11	0.00	0.12
Million households					
	1990	2000	2010	2020	2030
EU15	141.14	157.37	175.15	190.25	201.59
NMS	25.70	28.18	30.05	30.63	31.16
EU-25	166.85	185.55	205.20	220.88	232.75
annual growth rate					
	90/00	00/10	10/20	20/30	00/30
EU15	1.09	1.08	0.83	0.58	0.83
NMS	0.92	0.65	0.19	0.17	0.34
EU-25	1.07	1.01	0.74	0.52	0.76

Macroeconomic assumptions

	000 MEuro'00				
	1990	2000	2010	2020	2030
EU15	6982	8572	10391	12836	14949
NMS	313	375	555	821	1103
EU-25	7295	8947	10947	13656	16051

	<i>annual growth rate</i>				
	90/00	00/10	10/20	20/30	00/30
EU15	2.07	1.94	2.13	1.54	1.87
NMS	1.82	4.01	3.98	3.00	3.66
EU-25	2.06	2.04	2.24	1.63	1.97

- dominated by the evolution of the EU-15 economy
- structural changes away from the primary and secondary sectors towards services and high value-added products

International fuel prices

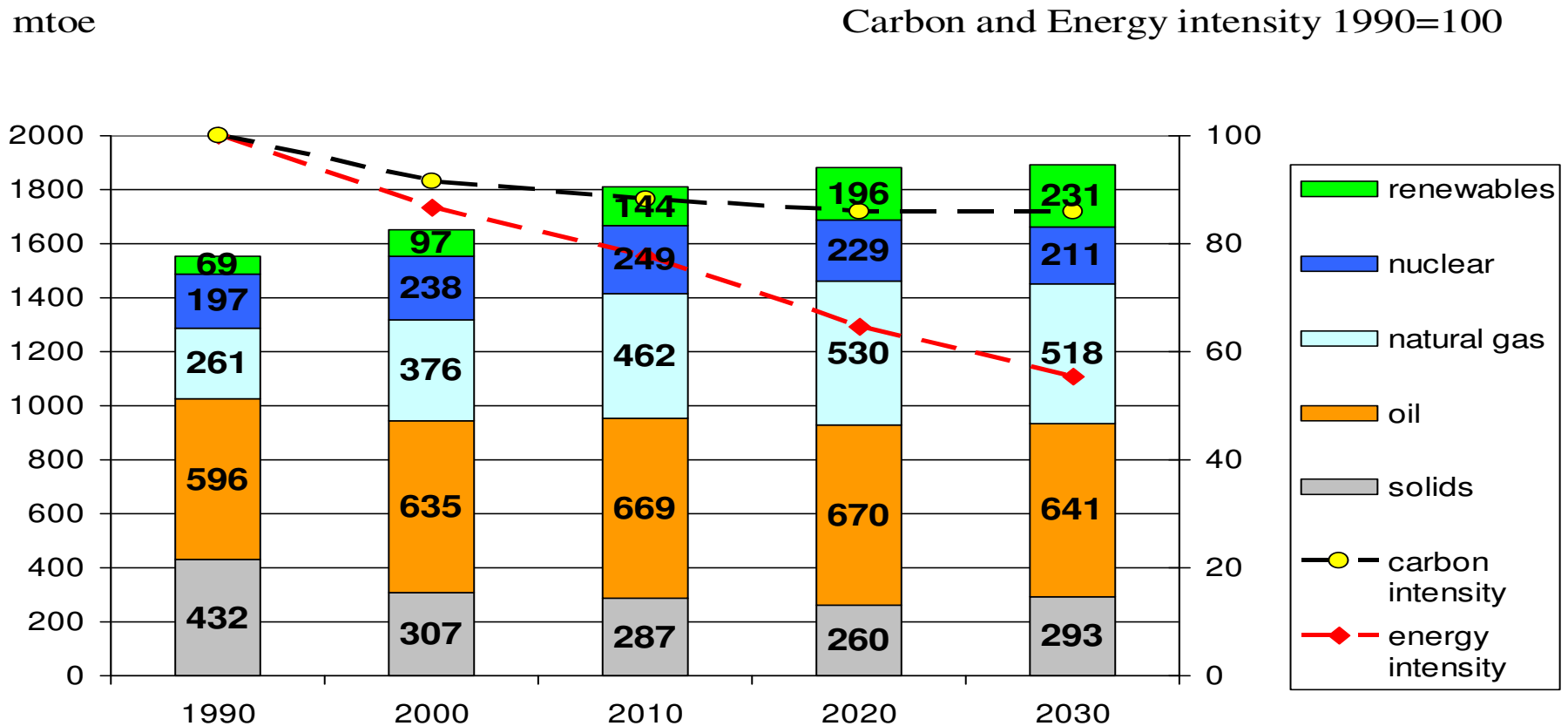
Average border prices in the EU-25 (\$00/boe)					
	1990	2000	2010	2020	2030
Crude oil	32.4	31.3	44.6	48.1	57.6
Natural gas	18.3	16.8	33.9	37.0	44.7
Hard coal	15.4	8.4	12.5	14.1	14.9

annual growth rate					
	1990-2000	2000-2010	2010-2020	2020-2030	
Crude oil	-0.34	3.59	0.76	1.82	
Natural gas	-0.88	7.29	0.89	1.91	
Hard coal	-5.86	4.04	1.18	0.58	

- Oil prices reached 55\$(2000)/boe in 2005
- considering gas-to-gas competition gas prices are progressively decoupled from oil
- coal prices increased slowly after 2005 (13.3\$(2000)/boe)

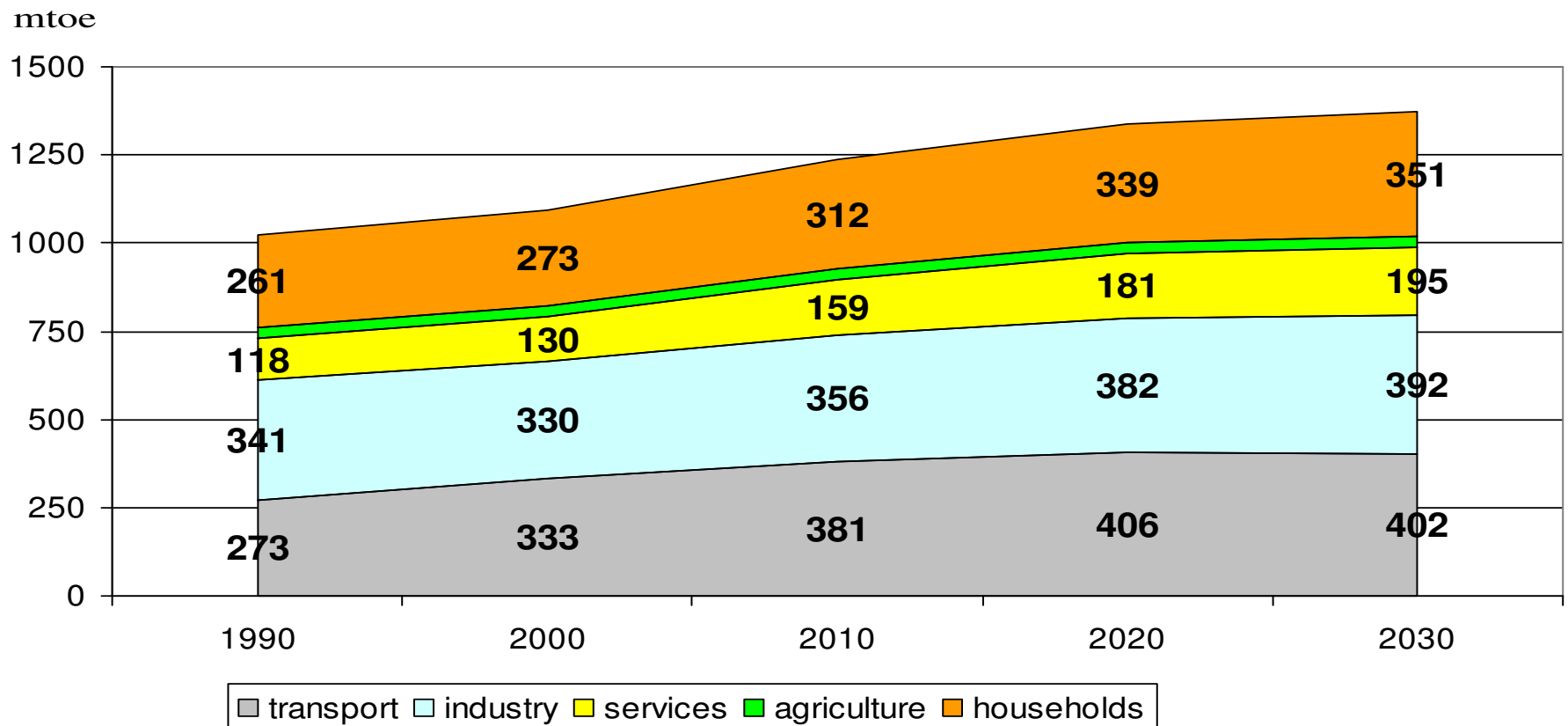
Baseline scenario results

Energy consumption by fuel and carbon and energy intensity



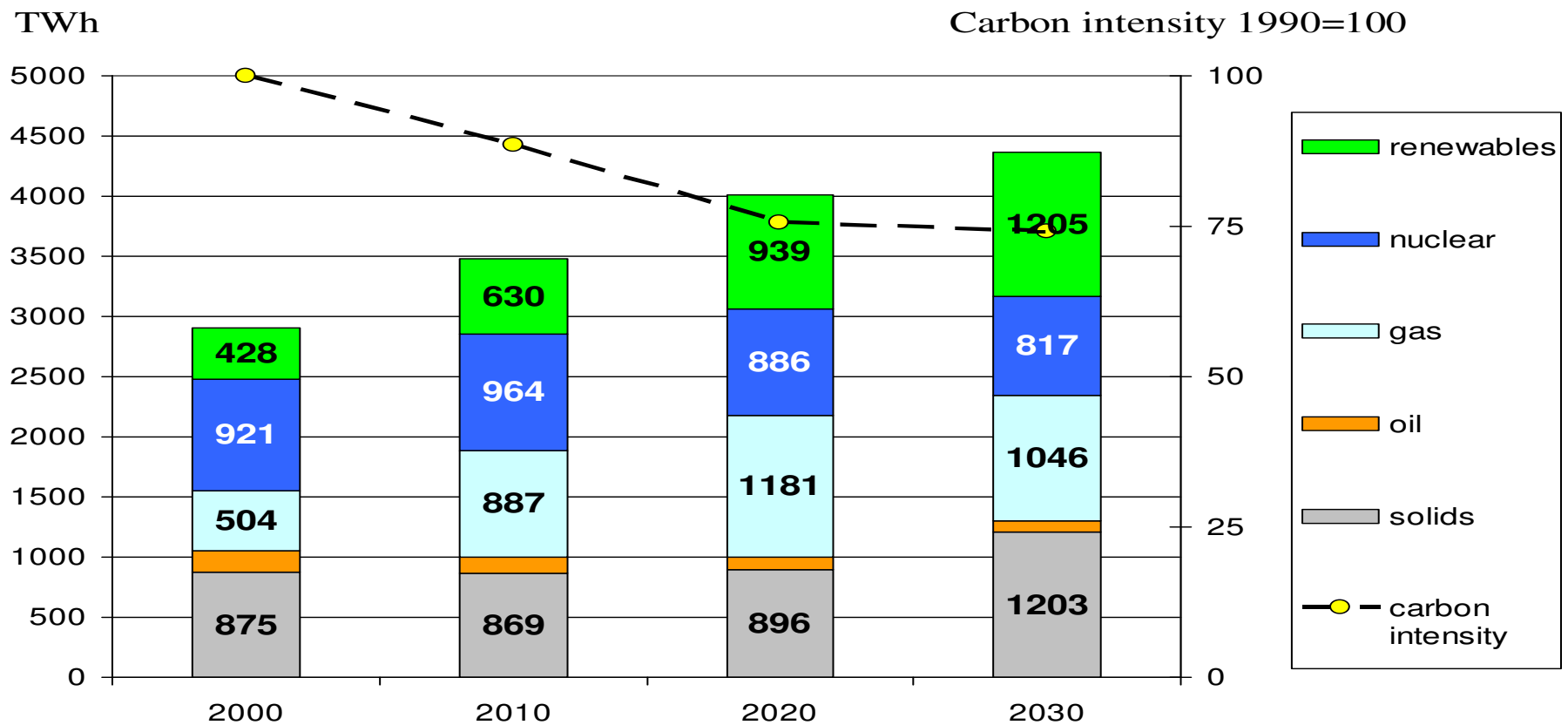
Baseline scenario results

Final energy consumption by sector



Baseline scenario results

Electricity production by fuel and carbon intensity



Baseline scenario results

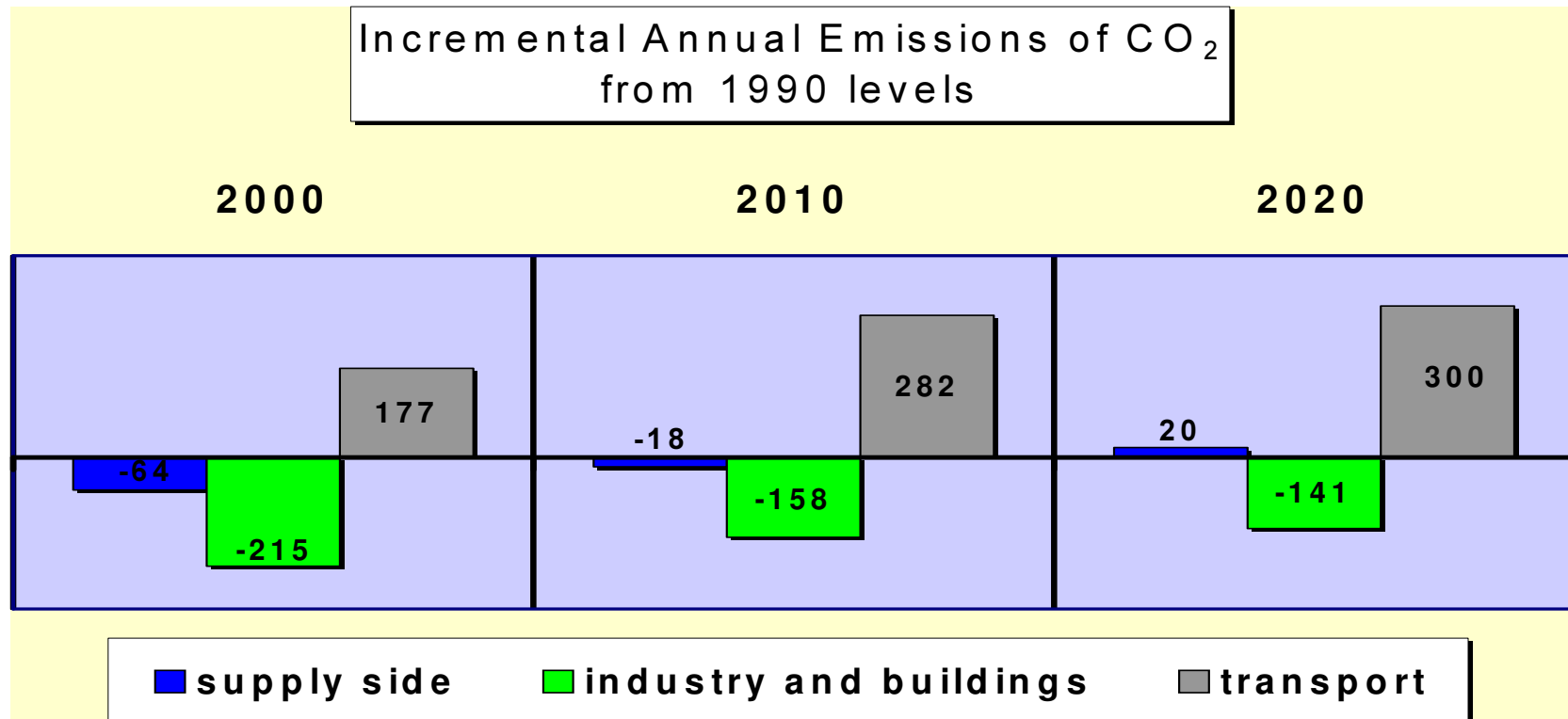
EU-25 primary energy needs:

Structure by fuel

	2000		2010		2030		Increment 2030-2000	
	Mtoe	%	Mtoe	%	Mtoe	%	Mtoe	%
Solids	307	19%	287	16%	293	15%	-13	-4%
Oil	635	38%	669	37%	640	34%	6	1%
Nat. Gas	376	23%	462	26%	518	27%	142	38%
Nuclear	238	14%	249	14%	211	11%	-27	-11%
Renewables	96	6%	144	8%	231	12%	134	139%
Gross Energy	1654	100%	1813	100%	1895	100%	241	15%

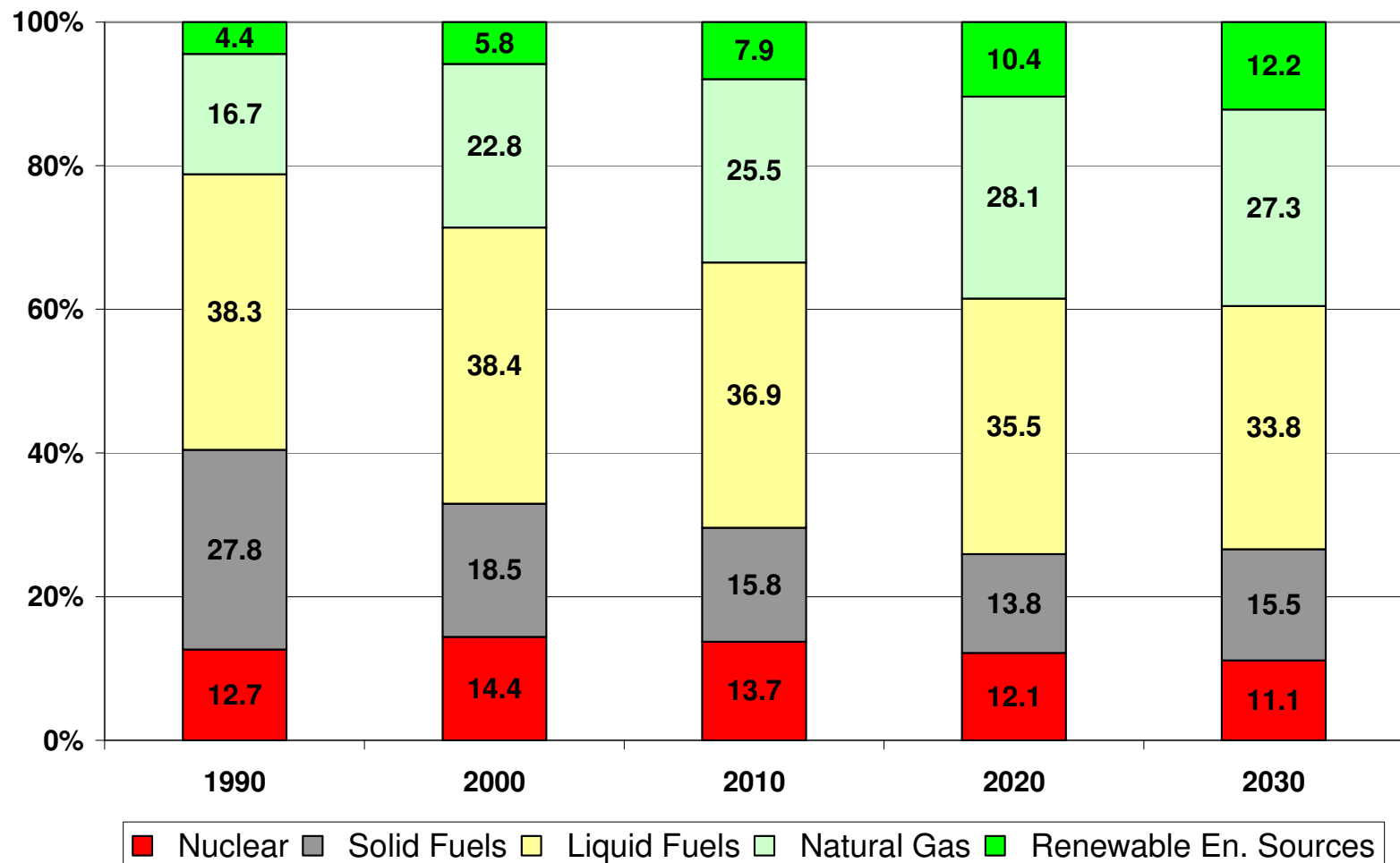
- **Solids**: lower in the medium term but re-emerge in the long run
- **Natural Gas**: strategic importance, 58% of incremental demand
- **Oil**: sector-specific fuel, stable demand but maintains high share in consumption
- **Renewables**: high growth but still have a low share (12% in 2030)
- **Nuclear**: decreases after 2010, depends on plants' lifetime and nuclear phase-out policies

EU-25: CO₂ Emissions

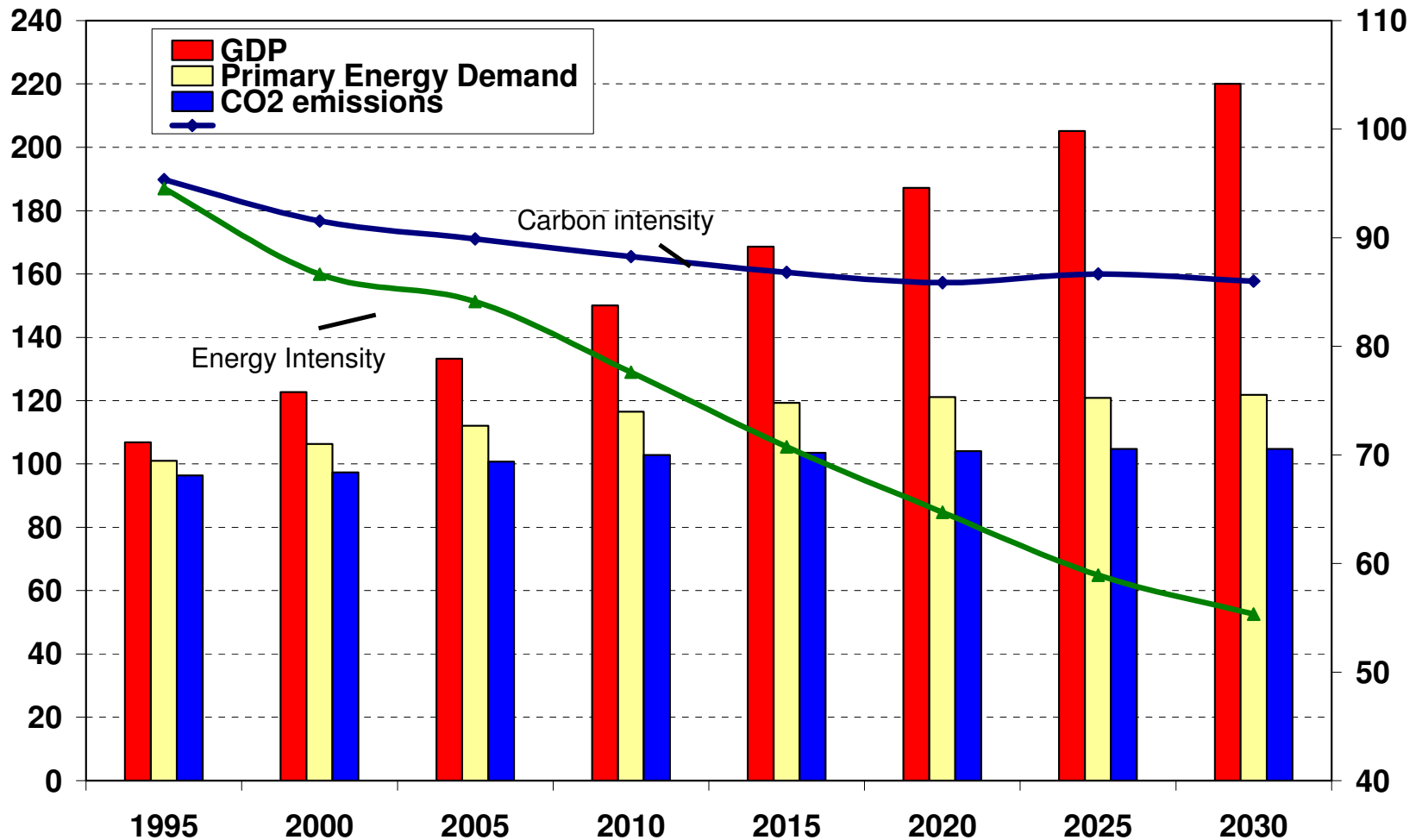


- The Transport sector is mainly responsible for increased emissions and the persisting dependence on oil imports
- The Electricity Generation sector (part of Supply Side) is responsible for higher CO₂ emissions in the long run, as part of nuclear is decommissioned and coal re-emerges

Structure of primary energy demand in EU-25.



EU-25 primary energy indicators (index 1990=100), 1995-2030



Final energy demand in EU-25 by sector

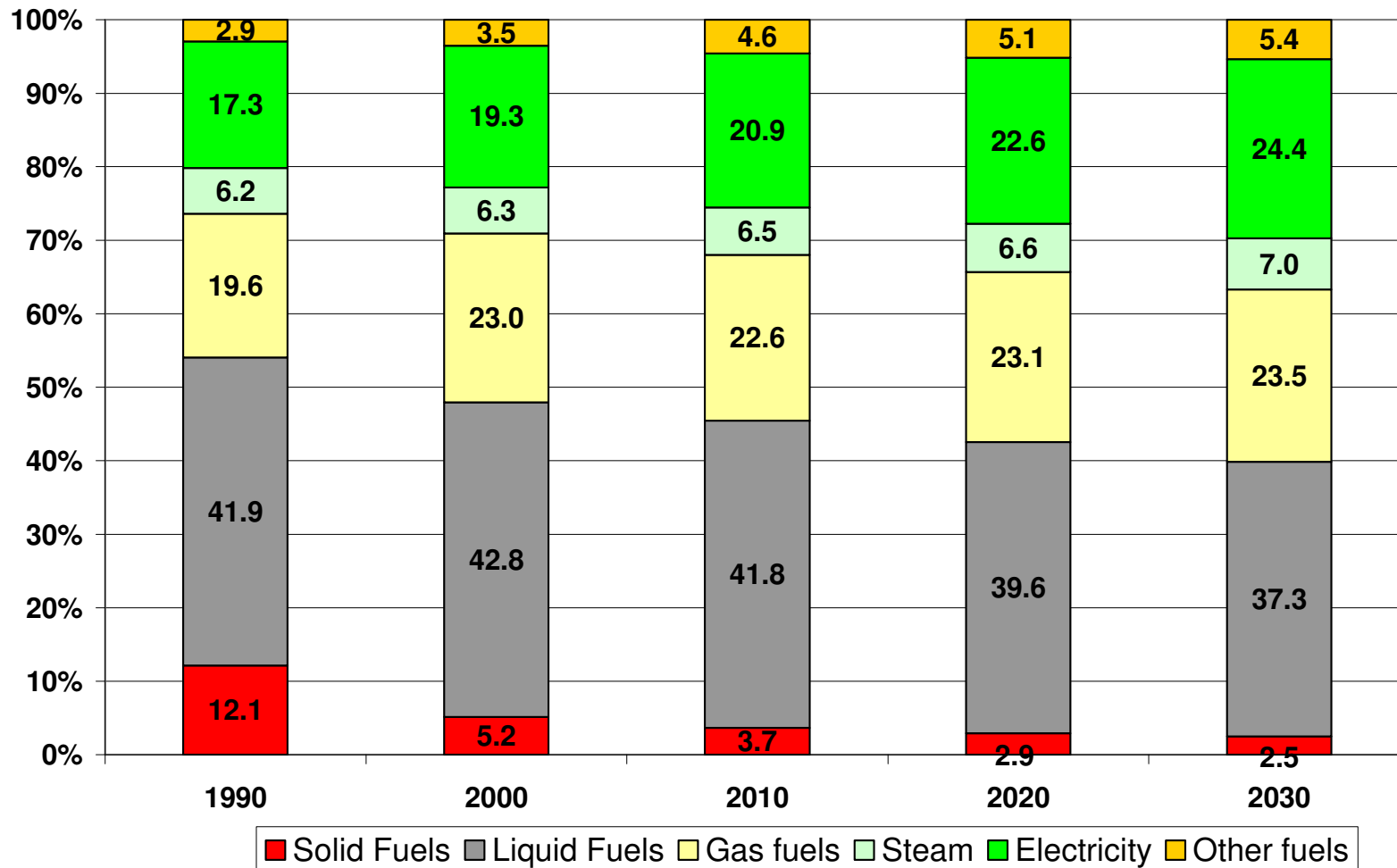
	Mtoe				
	1990	2000	2010	2020	2030
Industry	341.1	330.1	356.4	382.4	391.6
En. intensive industries	216.8	211.6	220.8	228.4	224.9
Other industrial sectors	124.3	118.4	135.7	154.0	166.6
Domestic	407.6	432.3	500.5	550.6	576.6
Tertiary	146.6	159.0	188.5	211.9	225.3
Households	261.0	273.3	312.0	338.7	351.3
Transport	273.2	333.0	381.1	405.5	402.3
Total	1021.9	1095.4	1238.0	1338.5	1370.5
EU-15	866.5	970.7	1086.7	1155.1	1163.9
NMS	155.5	124.7	151.3	183.4	206.5

	Annual Growth Rate (%)				
	90/00	00/10	10/20	20/30	00/30
Industry	-0.3	0.8	0.7	0.2	0.6
En. intensive industries	-0.2	0.4	0.3	-0.2	0.2
Other industrial sectors	-0.5	1.4	1.3	0.8	1.1
Domestic	0.6	1.5	1.0	0.5	1.0
Tertiary	0.8	1.7	1.2	0.6	1.2
Households	0.5	1.3	0.8	0.4	0.8
Transport	2.0	1.4	0.6	-0.1	0.6
Total	0.7	1.2	0.8	0.2	0.7
EU-15	1.1	1.1	0.6	0.1	0.6
NMS	-2.2	2.0	1.9	1.2	1.7

Final energy demand in EU-25 by fuel

	Mtoe				
	1990	2000	2010	2020	2030
Solid Fuels	123.9	56.6	45.2	39.4	34.0
Liquid Fuels	428.1	468.3	517.3	529.9	511.8
Gas fuels	200.2	251.9	279.2	309.7	321.4
Heat (from CHP/Dist. Heating)	63.1	68.7	80.2	87.7	95.3
Electricity	176.5	211.4	259.3	302.9	334.0
New fuels (hydrogen etc.)	0.0	0.0	0.3	1.2	1.8
Biomass and waste	29.6	37.7	54.6	64.8	67.8
Other renewables	0.5	0.8	1.9	2.9	4.1
Total	1021.9	1095.4	1238.0	1338.5	1370.5
	Annual Growth Rate (%)				
	90/00	00/10	10/20	20/30	00/30
Solid Fuels	-7.5	-2.2	-1.4	-1.5	-1.7
Liquid Fuels	0.9	1.0	0.2	-0.3	0.3
Gas fuels	2.3	1.0	1.0	0.4	0.8
Heat (from CHP/Dist. Heating)	0.9	1.6	0.9	0.8	1.1
Electricity	1.8	2.1	1.6	1.0	1.5
New fuels (hydrogen etc.)	-	-	13.4	4.6	-
Biomass	2.4	3.8	1.7	0.5	2.0
Other renewables	5.2	9.1	4.5	3.7	5.7
Total	0.7	1.2	0.8	0.2	0.7

Structure of Final Energy Demand by fuel in EU-25.



Electricity requirements by sector in EU-25

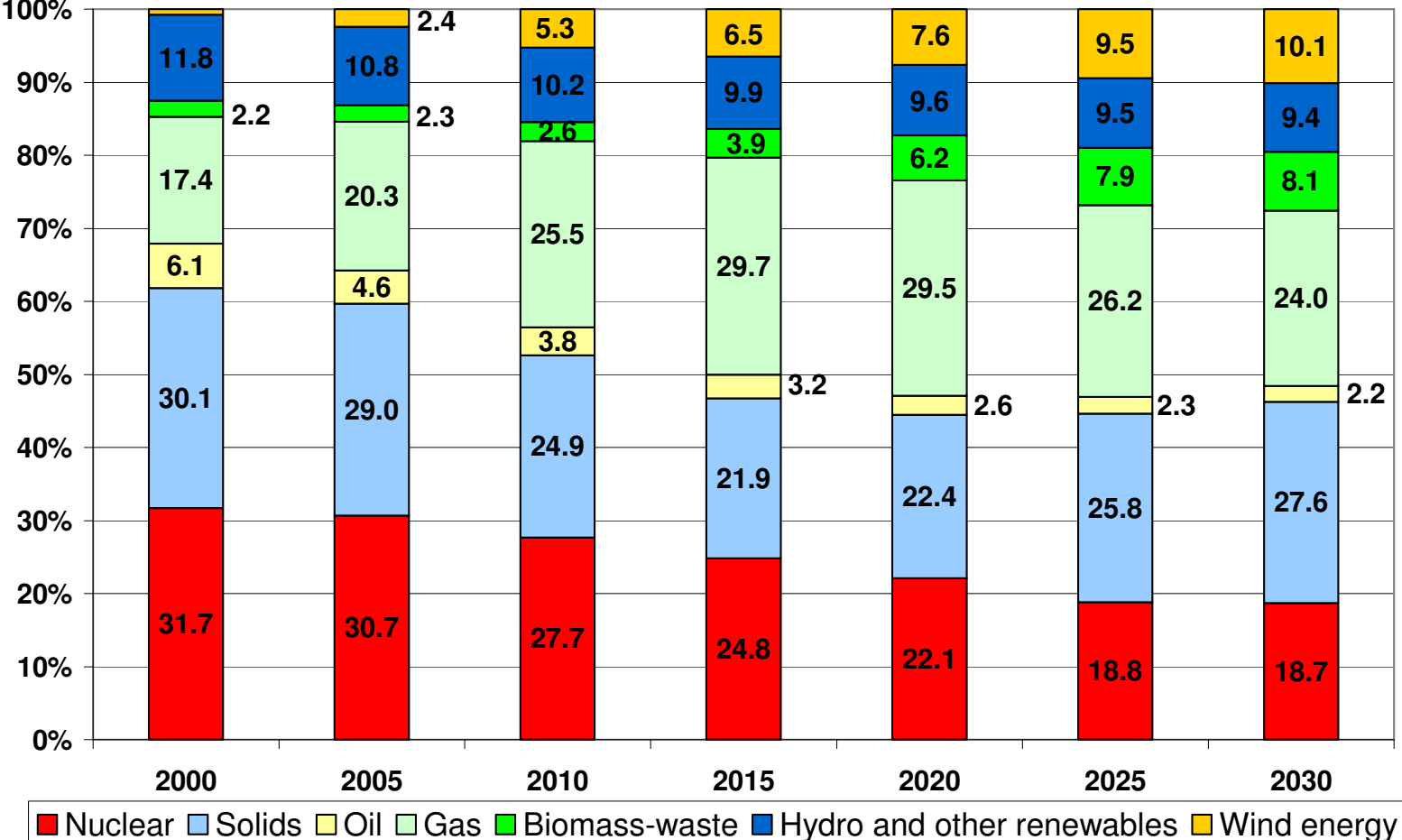
	TWh				
	1990	2000	2010	2020	2030
Industry	922	1042	1200	1319	1397
Tertiary	503	652	856	1032	1144
Households	569	695	880	1097	1272
Transports	59	69	79	74	71
Energy sector	269	268	299	312	317
Trans. and distr. Losses (Net imports)	160	200	195	196	191
	25	25	26	25	26
Electricity generation	2456	2901	3483	4006	4367
EU-15	2139	2577	3083	3485	3735
NMS	317	324	400	521	631

	Annual Growth Rate (%)				
	90/00	00/10	10/20	20/30	00/30
Industry	1.2	1.4	0.9	0.6	1.0
Tertiary	2.6	2.8	1.9	1.0	1.9
Households	2.0	2.4	2.2	1.5	2.0
Transports	1.5	1.4	-0.6	-0.4	0.1
Energy sector	0.0	1.1	0.4	0.2	0.6
Trans. and distr. Losses (Net imports)	2.2	-0.3	0.0	-0.3	-0.2
	-0.2	0.4	-0.5	0.4	0.1
Electricity generation	1.7	1.8	1.4	0.9	1.4
EU-15	1.9	1.8	1.2	0.7	1.2
NMS	0.2	2.1	2.7	1.9	2.2

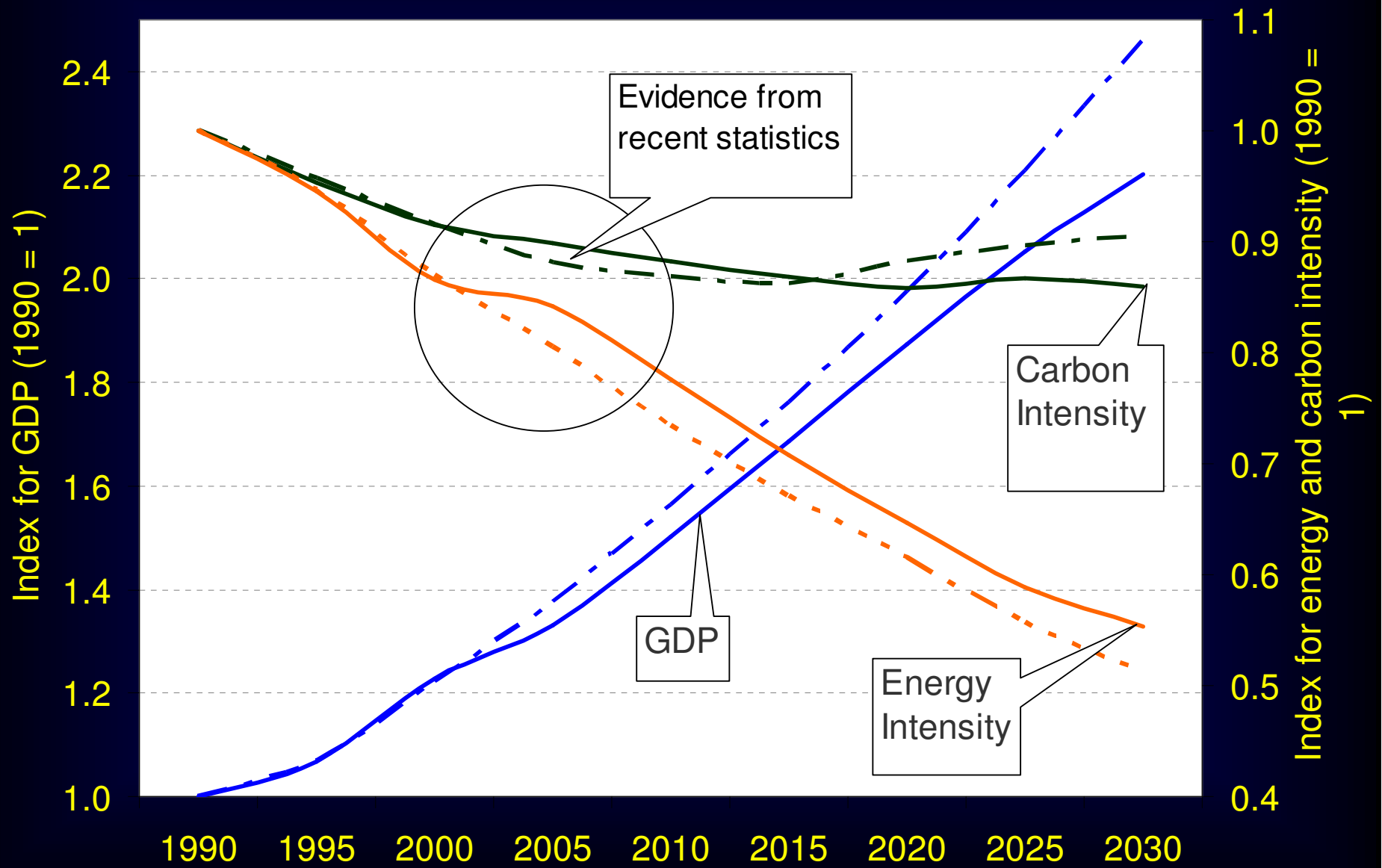
Power Capacities development

- Technology advance and progressive deregulation of electricity markets supports significant growth of gas based plants in the medium term
- Recent uncertainty with high gas prices slows down this process; however the EU ETS related costs may sustain gas plant investments
- Nuclear capacity marked by phase-out in some MS and decommissioning in NMS
- Reconsiderations in favour of lignite and coal based units: certainly revival in the long term (after 2020) but also remarkable resistance in the medium term despite ETS
- Continuous development of renewables (mostly wind, and secondarily biomass); distributed electricity not developed in the baseline.

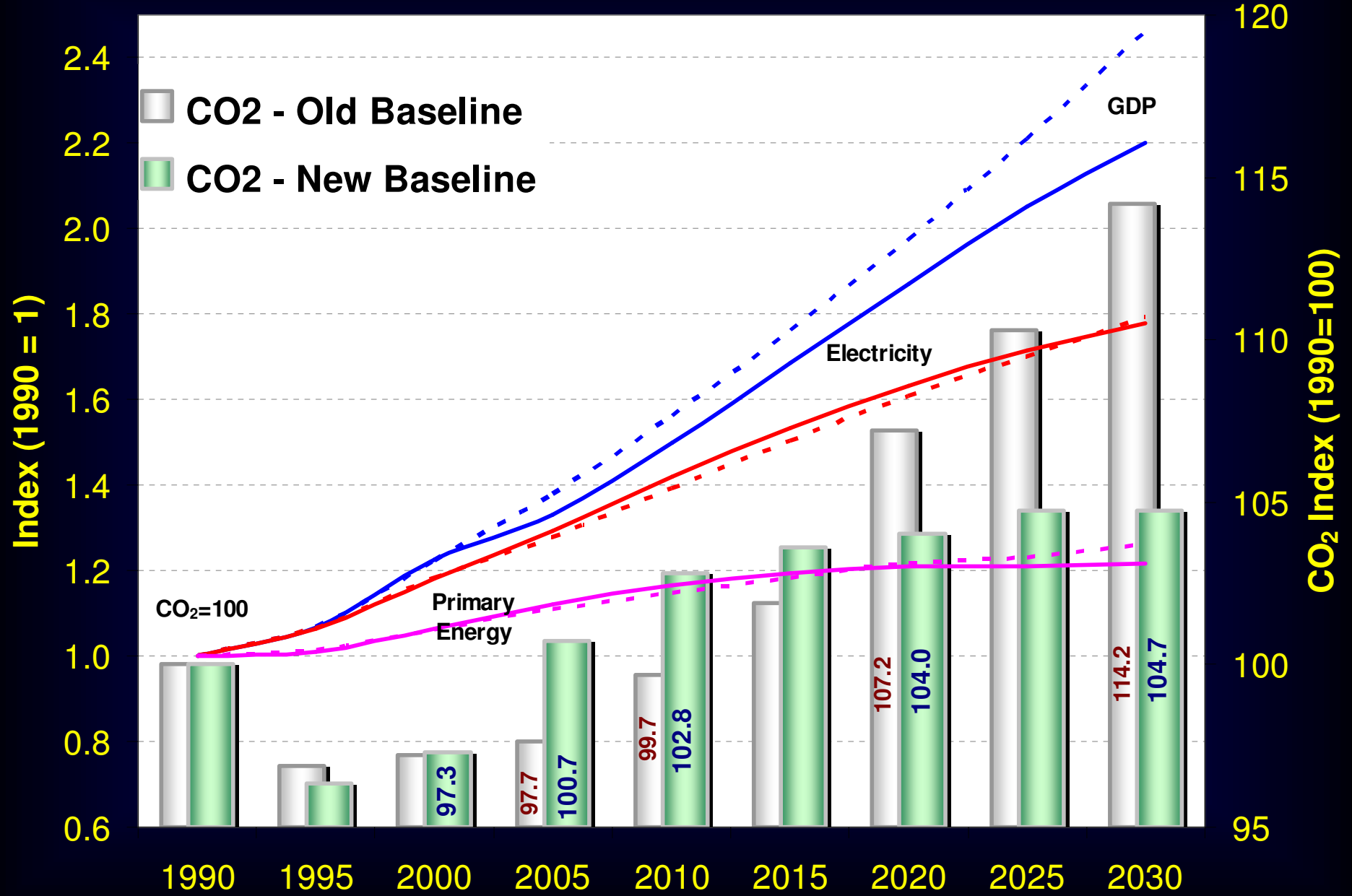
Electricity generation by fuel in EU-25



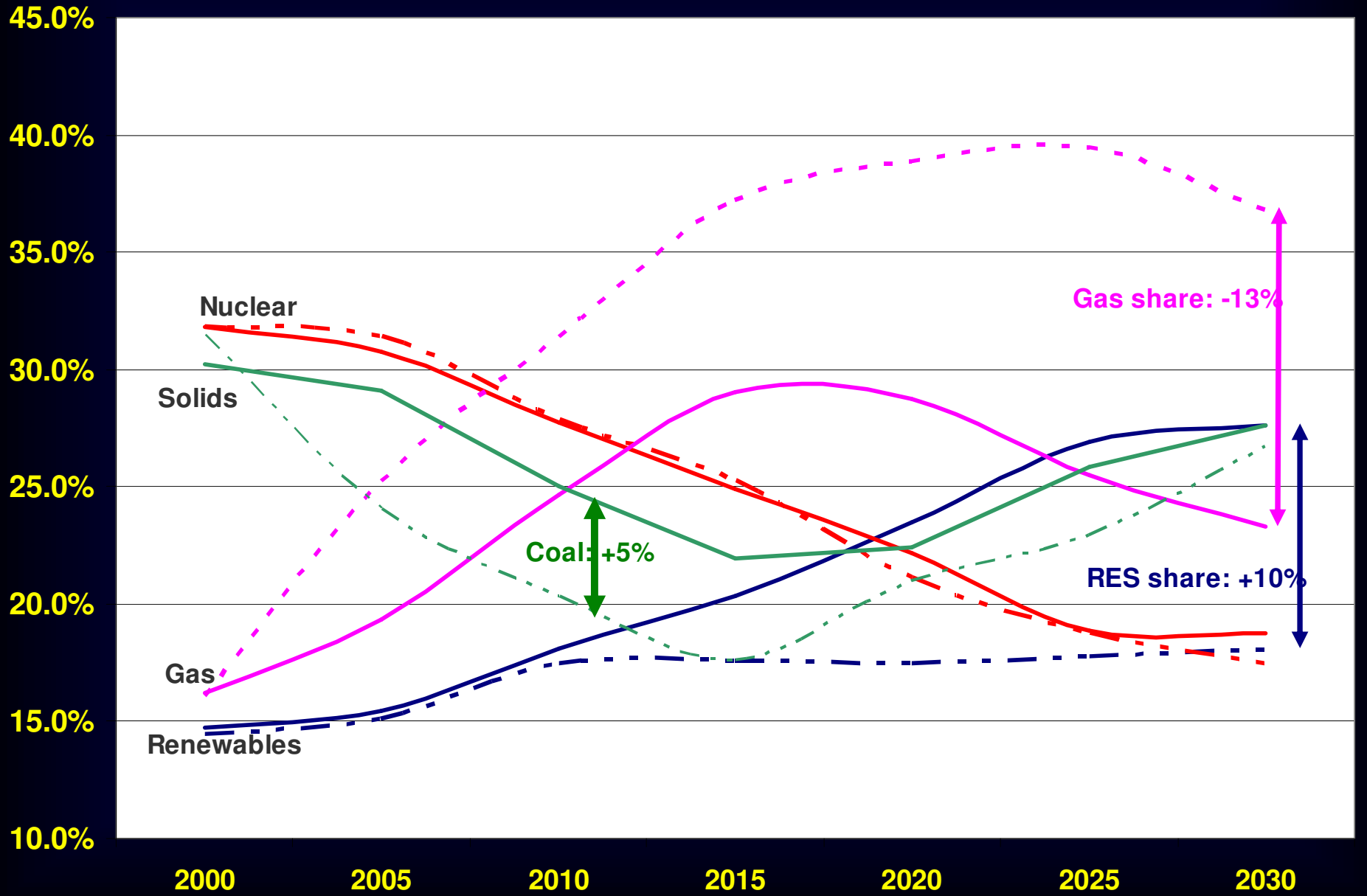
Baseline 2005 vs Baseline 2003: aggregate results EU-25



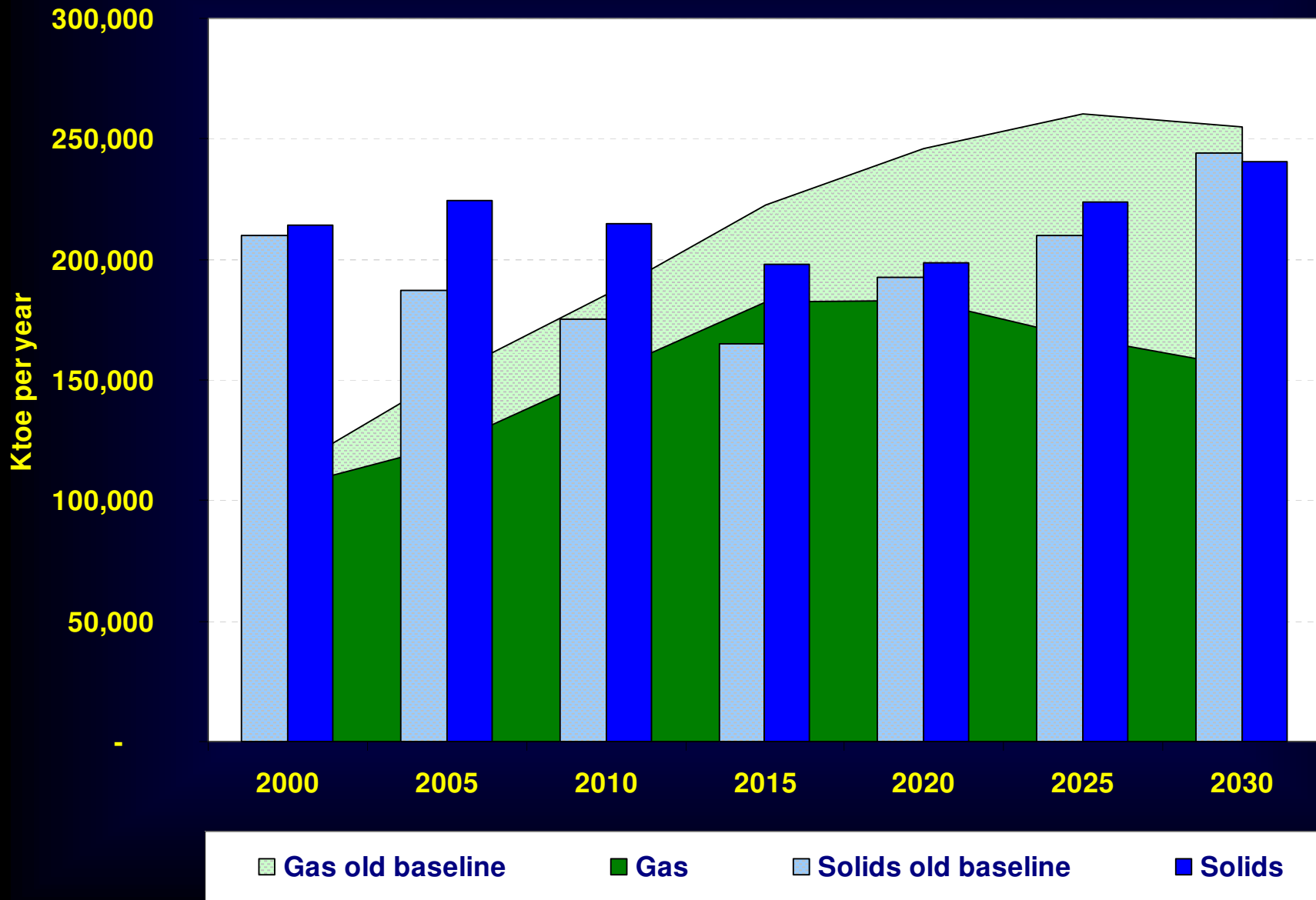
Baseline 2005 vs Baseline 2003: aggregate results EU-25



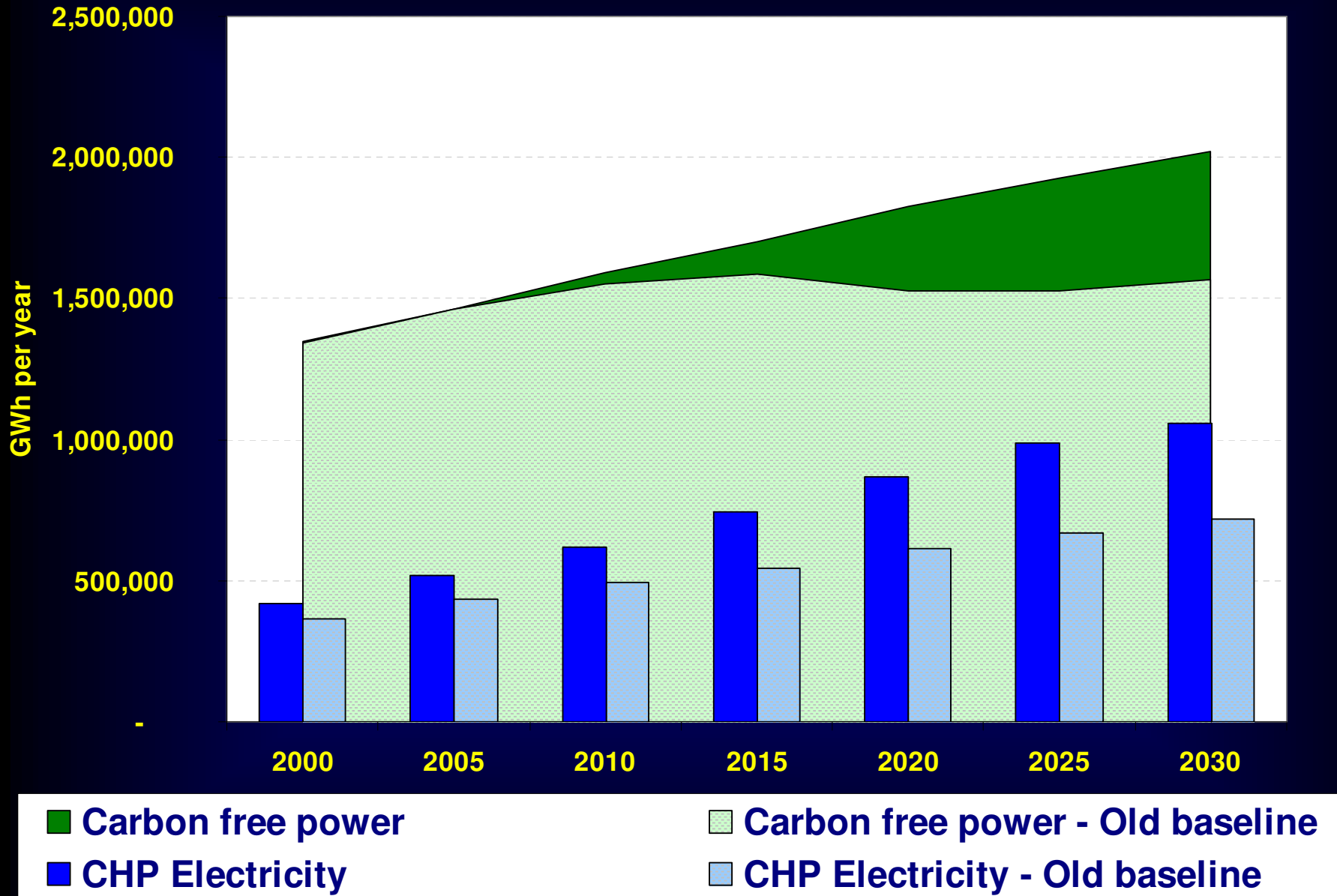
Shares in Power generation (%) - EU-25 New Baseline



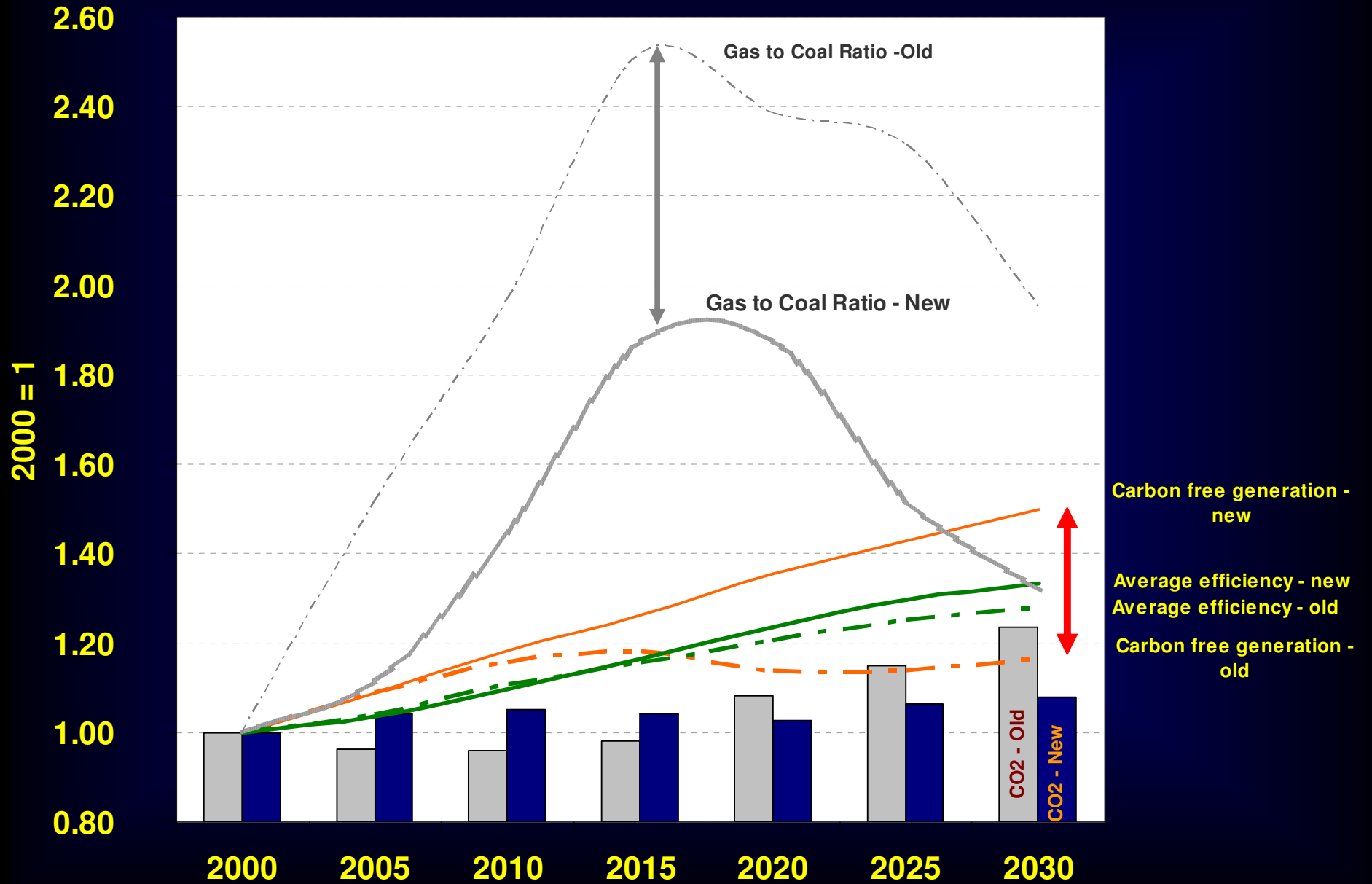
Consumption of fuels for Power and Steam



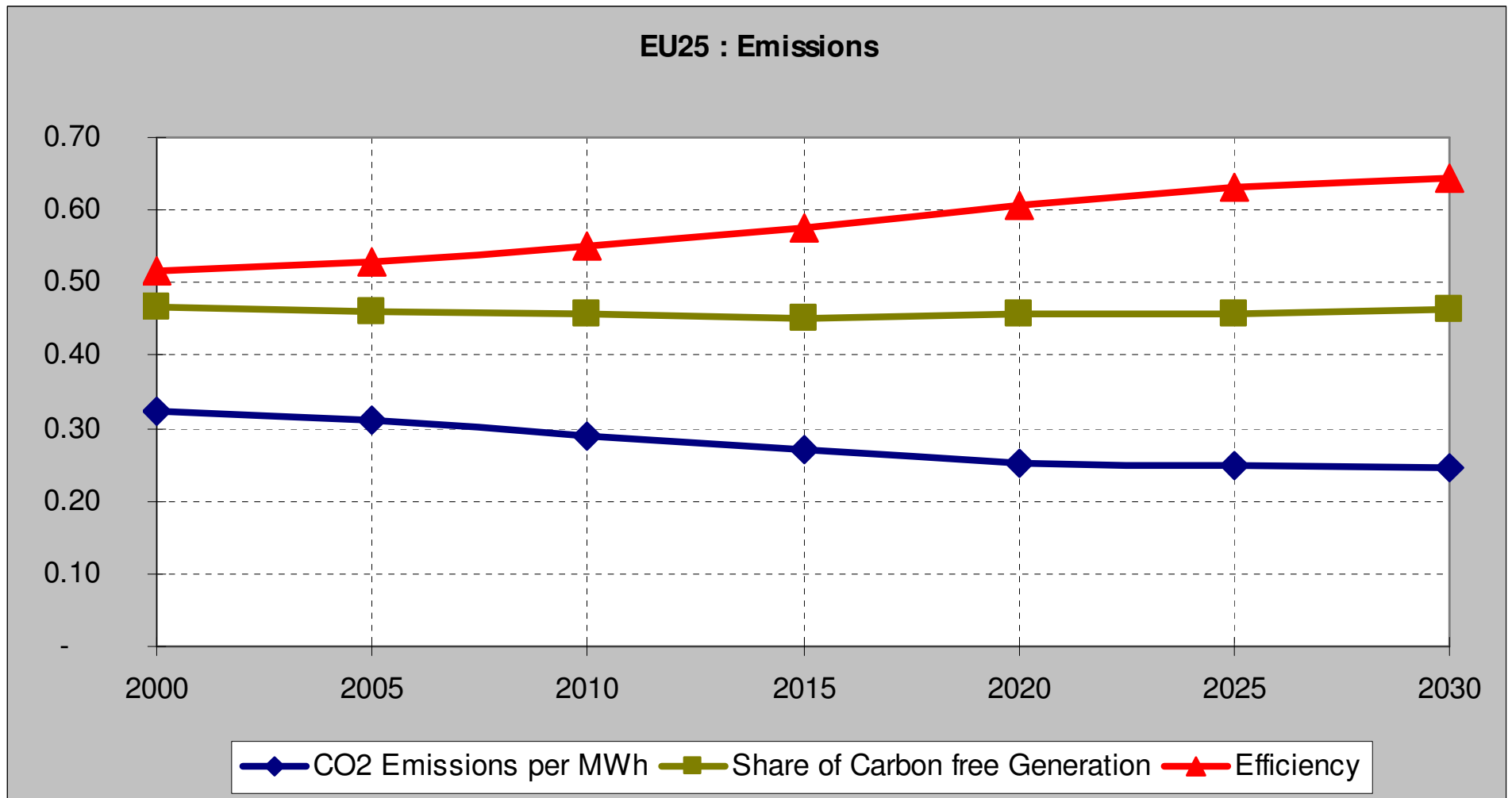
Carbon free generation and CHP



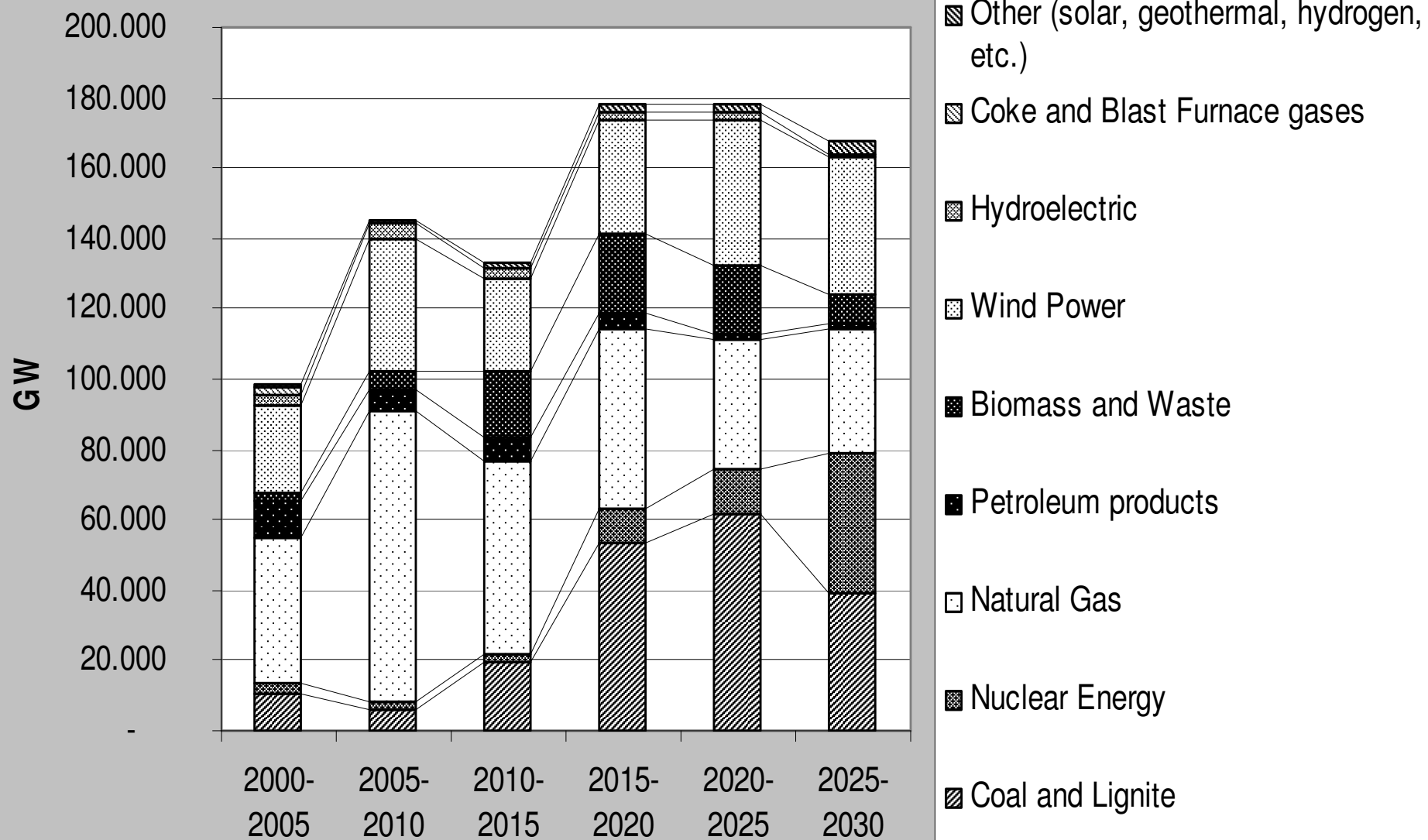
Carbon Indicators - Power Generation EU 25 (New baseline)



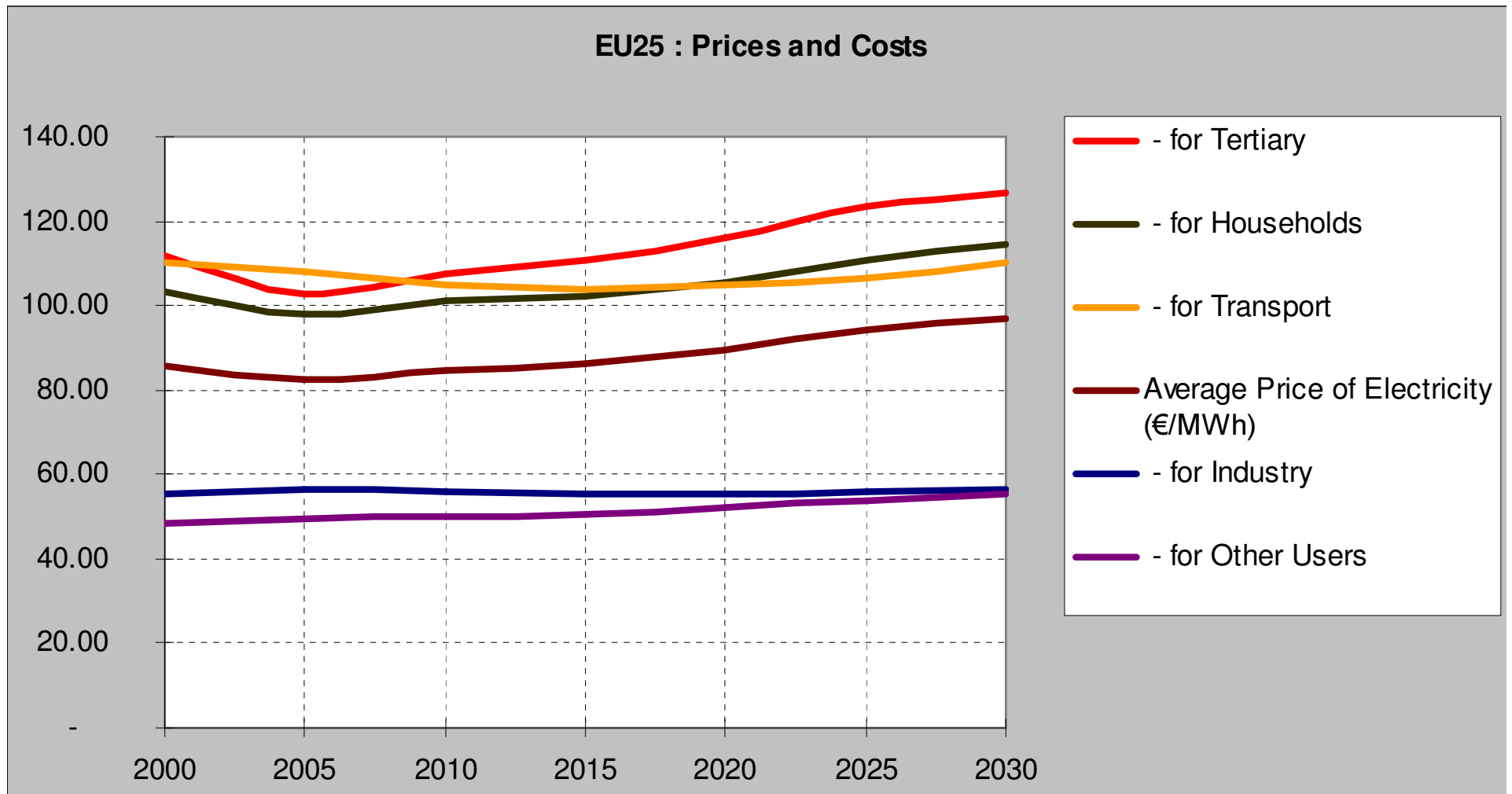
Efficiency and carbon in power supply



EU25 : New power capacity built by primary energy



Electricity Prices in Baseline



Some messages...

- Electricity remains a growing market due to
 - Its high efficiency and comfort in final uses
 - The growing market for new electrical appliances
 - Electricity embeds higher technology for manufacturing and services and induces welfare
- Structure of power generation changes with increasing contribution of renewables and secondarily CHP
- Despite high fuel prices, electricity prices increases are relatively small
- Under baseline trends, the power sector developments are incompatible with a climate change mitigation strategy

Uncertainty about fuel mix in power

- Under high oil prices and uncertain long-run gas supply, CC gas plants will not be competitive for expansion of base load generation
- Alternative sources for power generation do exist, but need time to develop
 - New nuclear cannot commission before 2020
 - Carbon capture and sequestration involve technological and storage uncertainties
 - Renewables develop fast but are not sufficient
- Gas GTCC is the cheapest carbon abatement option for the short/medium term: this explains the pressure on EU ETS prices
- Vulnerability of the EU mainly with respect to upstream gas supply concerns the next 15-20 years
- Uncertainty about gas use in power generation is considerable: range of 50 to 200 bcm per year, depending on long run competitiveness of gas for base and mid load
- All scenarios that are climate change friendly show inelasticity about gas use on power generation for the next 20 years, until carbon free power techniques become commercially mature...