EUSUSTEL
European Sustainable Electricity

Electricity Alternatives in the EU:
The Role of Nuclear

Alfred Voß, Markus Blesl, Ingo Ellersdorfer

Institute for Energy Economics and the Rational Use of Energy (IER)
University of Stuttgart

Brussels, December 19th, 2006

EUSUSTEL – Conceptual Framework for Sustainable Development

- Potential for beneficial supply of energy services for following generations should be enlarged, i.e. extension of the technical-economical accessible resource base for the provision of energy services.

- Energy induced emissions should not exeed absorption capacity of natural resources as a sink.

- Energy services should be provided with the least resource input possible, including the environmental resources.

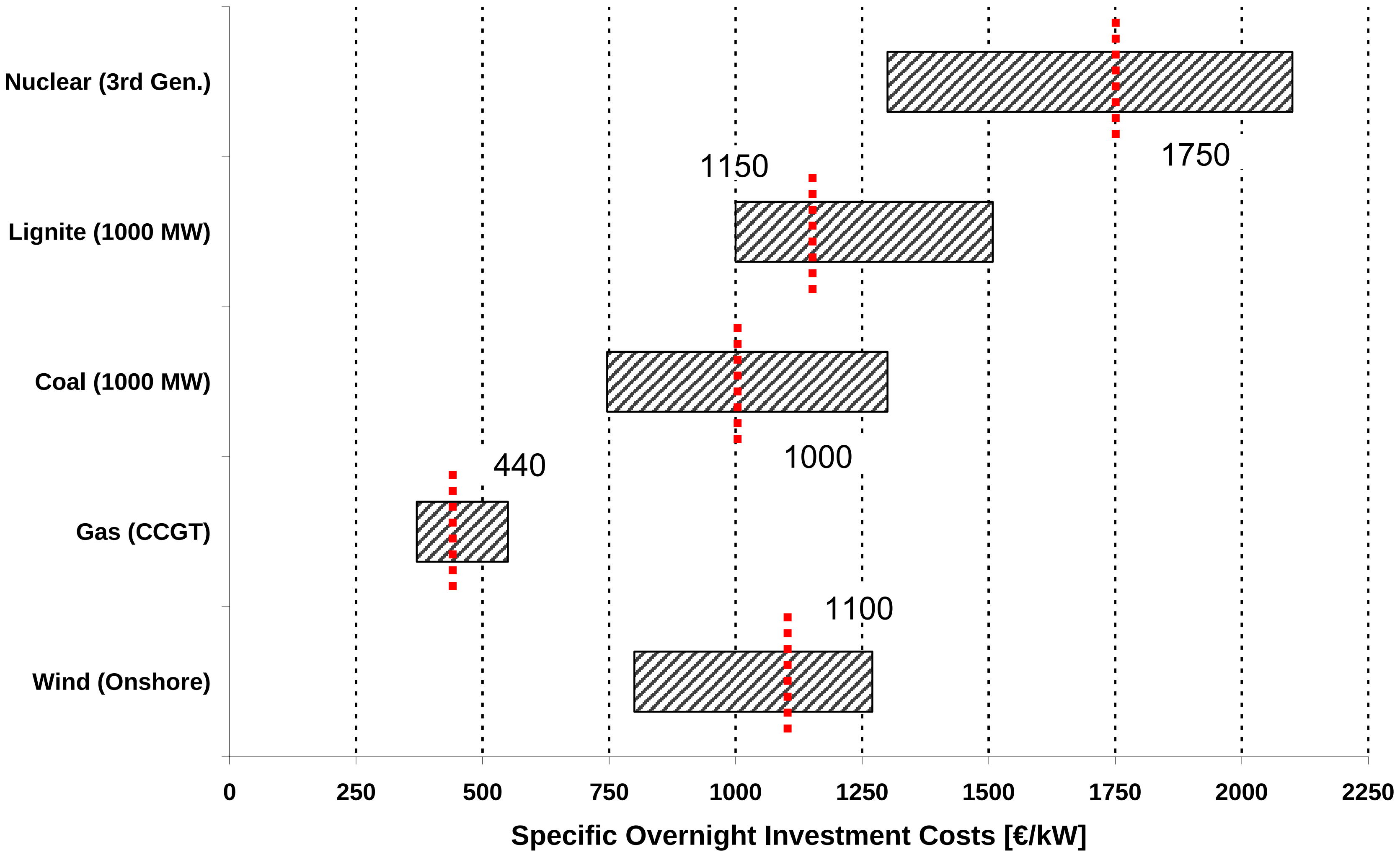
Relative Sustainability of Energy Technologies

- Total resource consumption of energy technologies or energy supply chains is a measure with respect to their relative sustainability.

- Total social cost (i.e. private cost plus external cost) is a useful indicator to account for overall resource consumption per energy service unit.

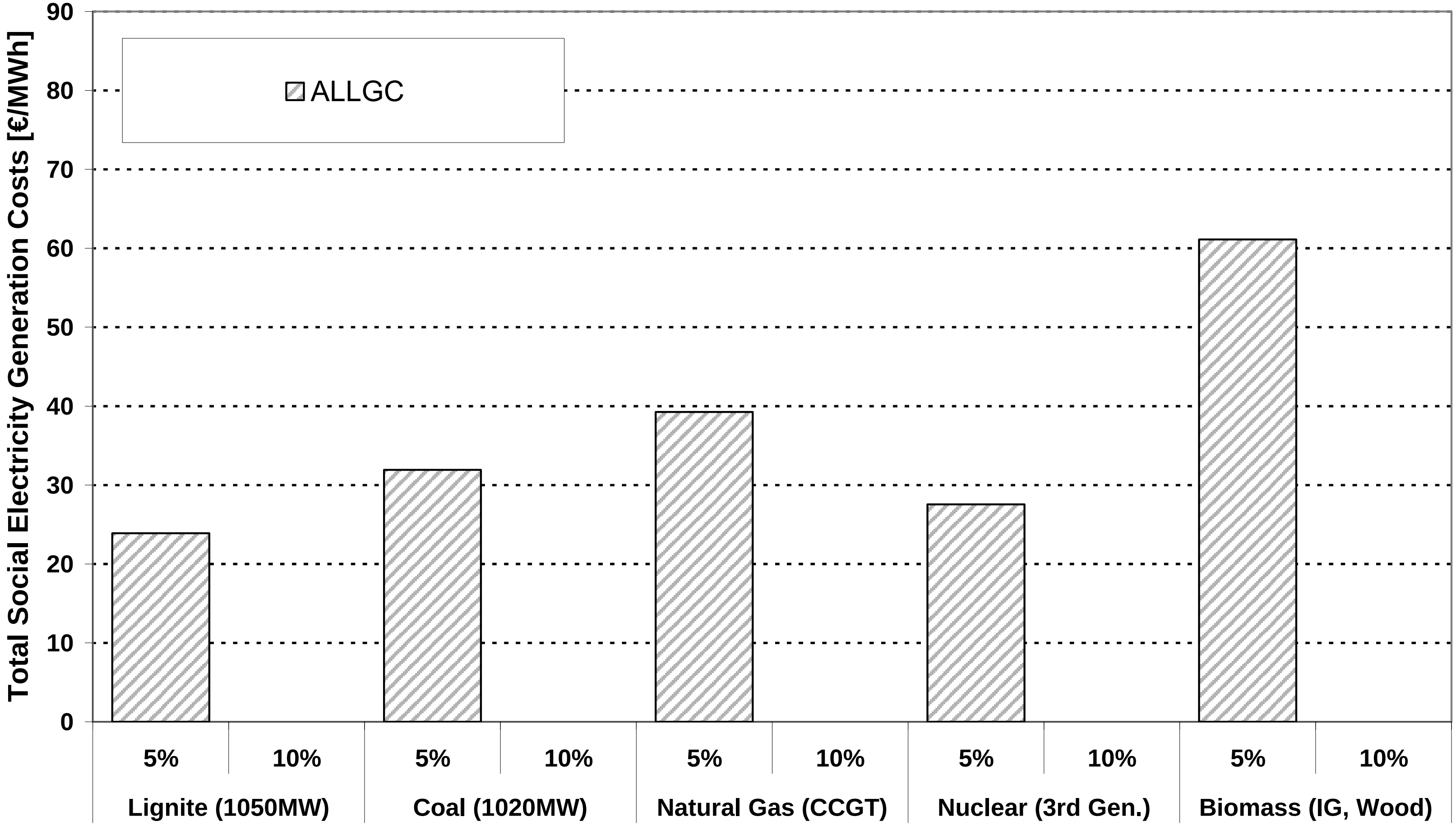
⇨ Measure for the relative sustainability

Range of Specific Overnight Investment Cost



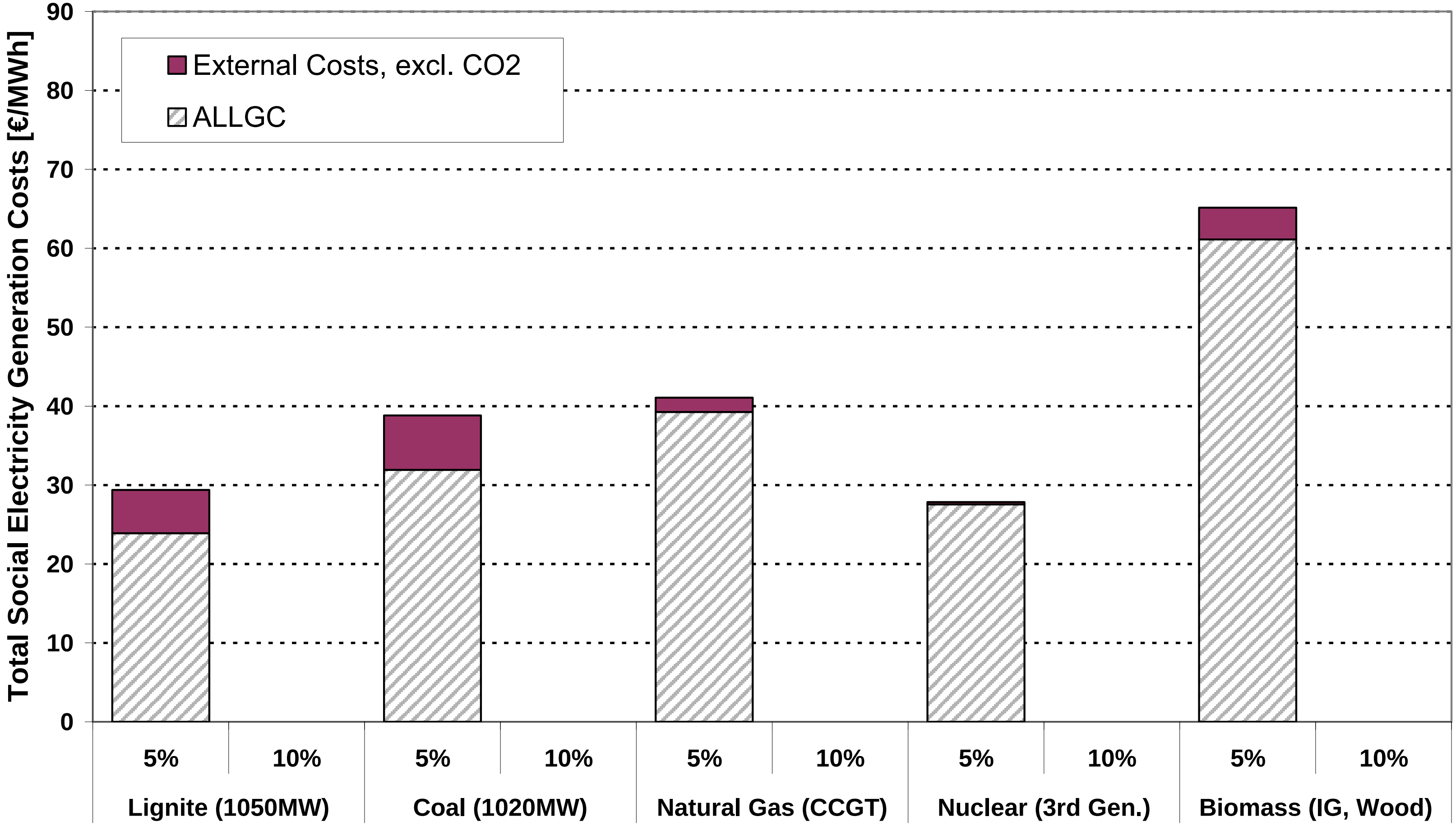
Total Social Costs for different Electricity Generation Technologies 2010 (Baseload)

- *Average Lifetime Levelized Generation Costs (ALLGC). Calculations based on 85 % capacity factor. Discount rate: 5%, 10%.*



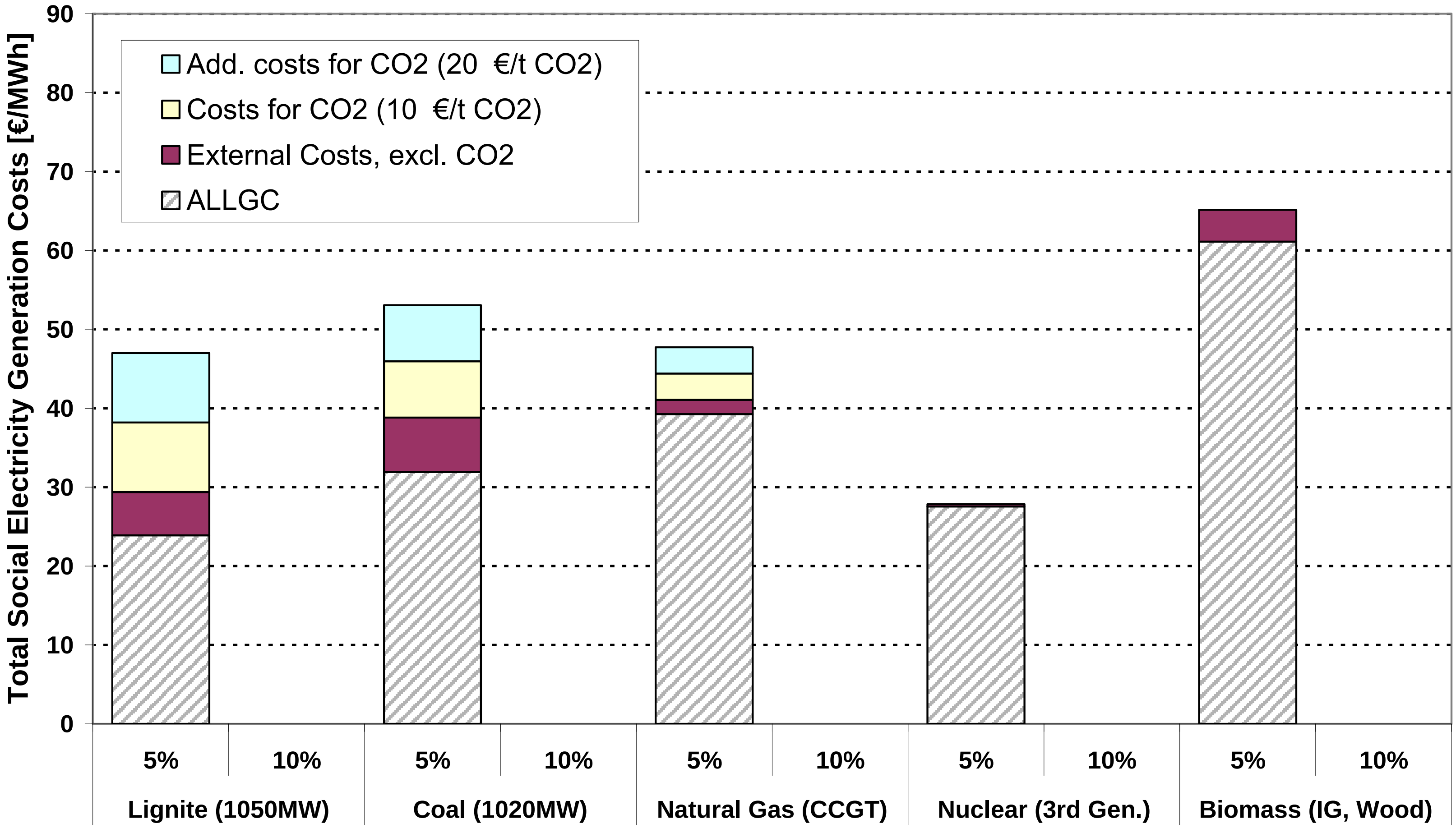
Total Social Costs for different Electricity Generation Technologies 2010 (Baseload)

- *Average Lifetime Levelized Generation Costs (ALLGC). Calculations based on 85 % capacity factor. Discount rate: 5%, 10%.*



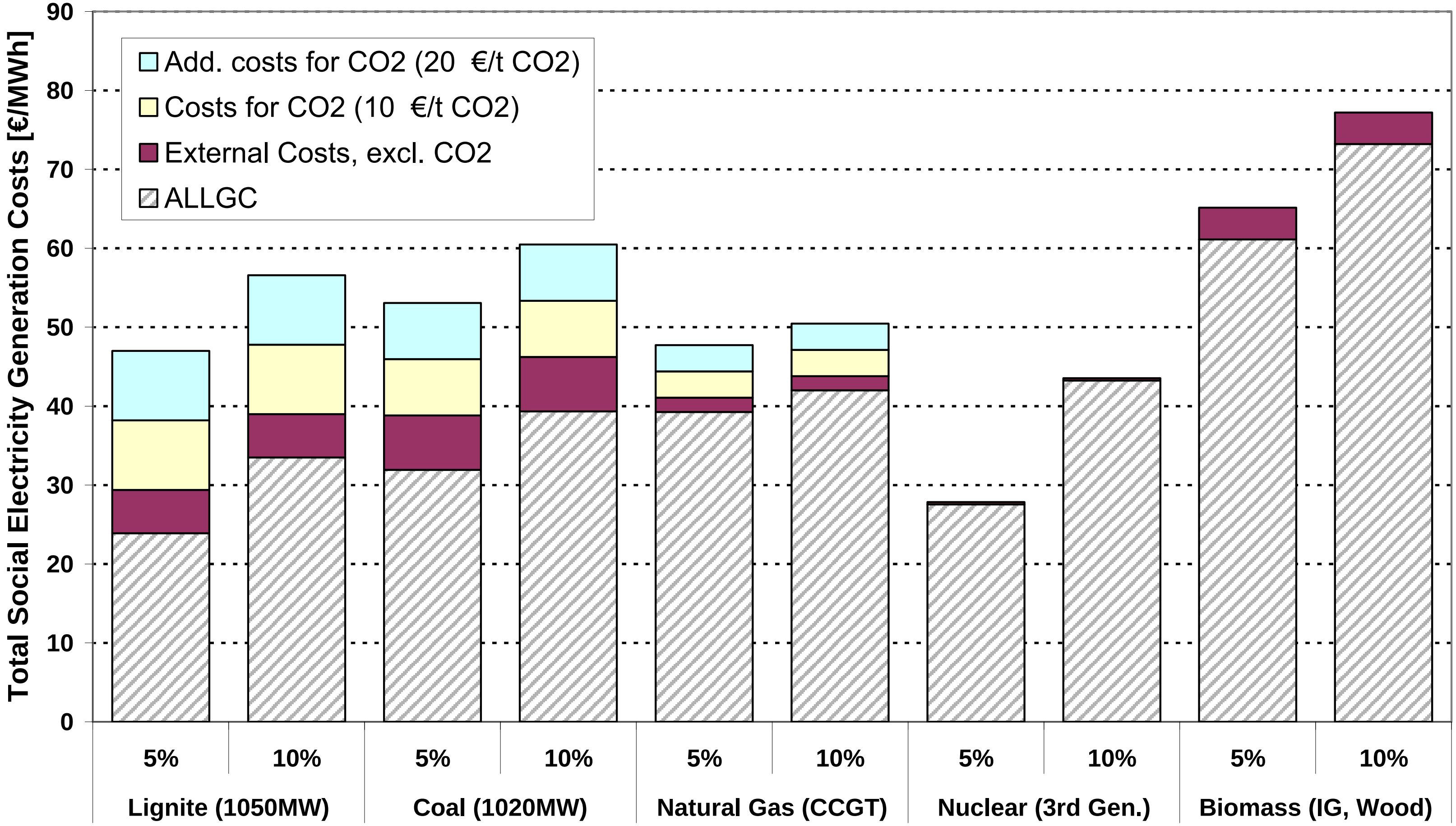
Total Social Costs for different Electricity Generation Technologies 2010 (Baseload)

- *Average Lifetime Levelized Generation Costs (ALLGC). Calculations based on 85 % capacity factor. Discount rate: 5%, 10%.*



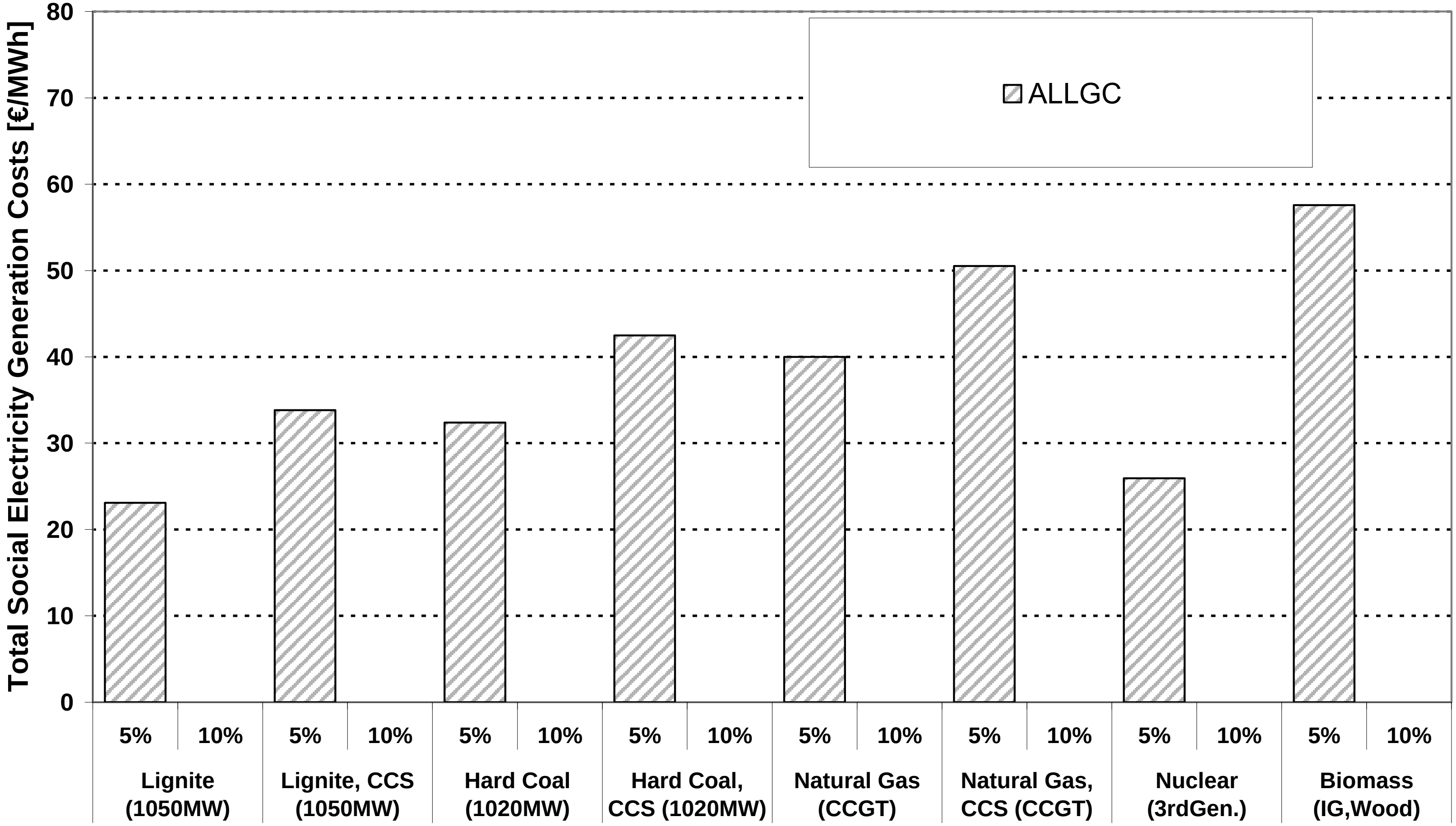
Total Social Costs for different Electricity Generation Technologies 2010 (Baseload)

- *Average Lifetime Levelized Generation Costs (ALLGC). Calculations based on 85 % capacity factor. Discount rate: 5%, 10%.*



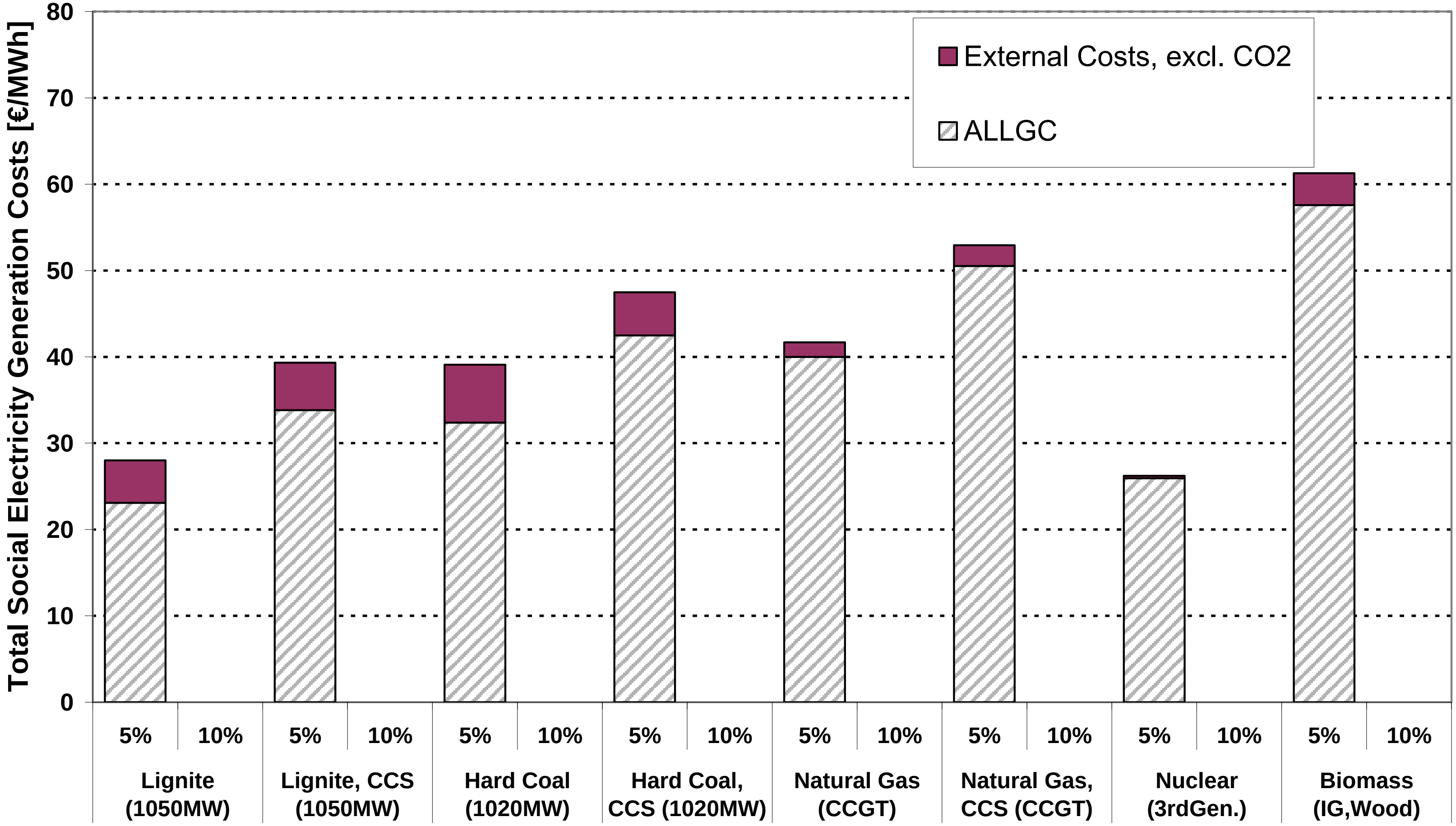
Total Social Costs for different Electricity Generation Technologies 2030 (Baseload)

- *Average Lifetime Levelized Generation Costs (ALLGC). Calculations based on 85 % capacity factor. Discount rate: 5%, 10%.*



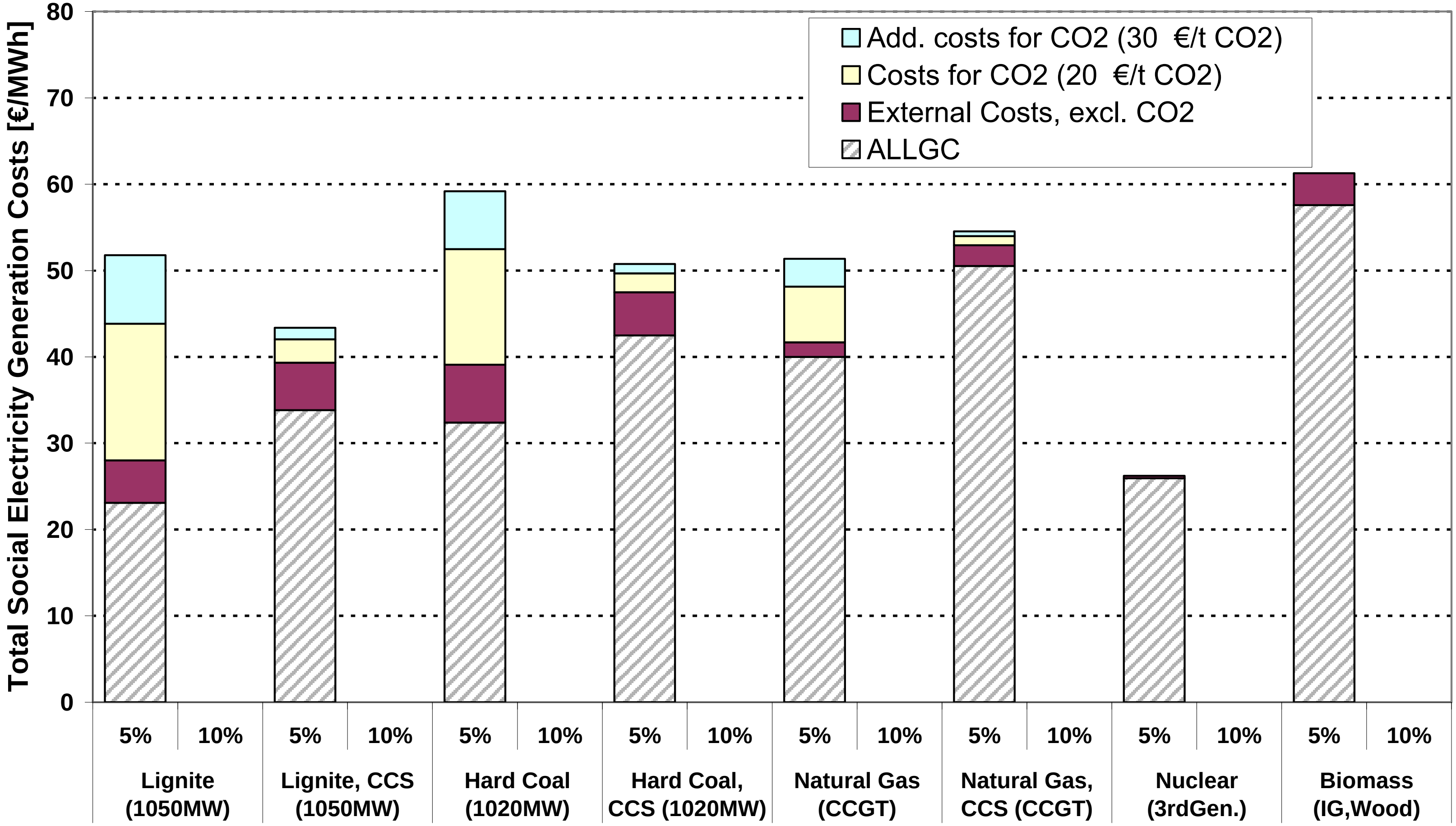
Total Social Costs for different Electricity Generation Technologies 2030 (Baseload)

- *Average Lifetime Levelized Generation Costs (ALLGC). Calculations based on 85 % capacity factor. Discount rate: 5%, 10%.*



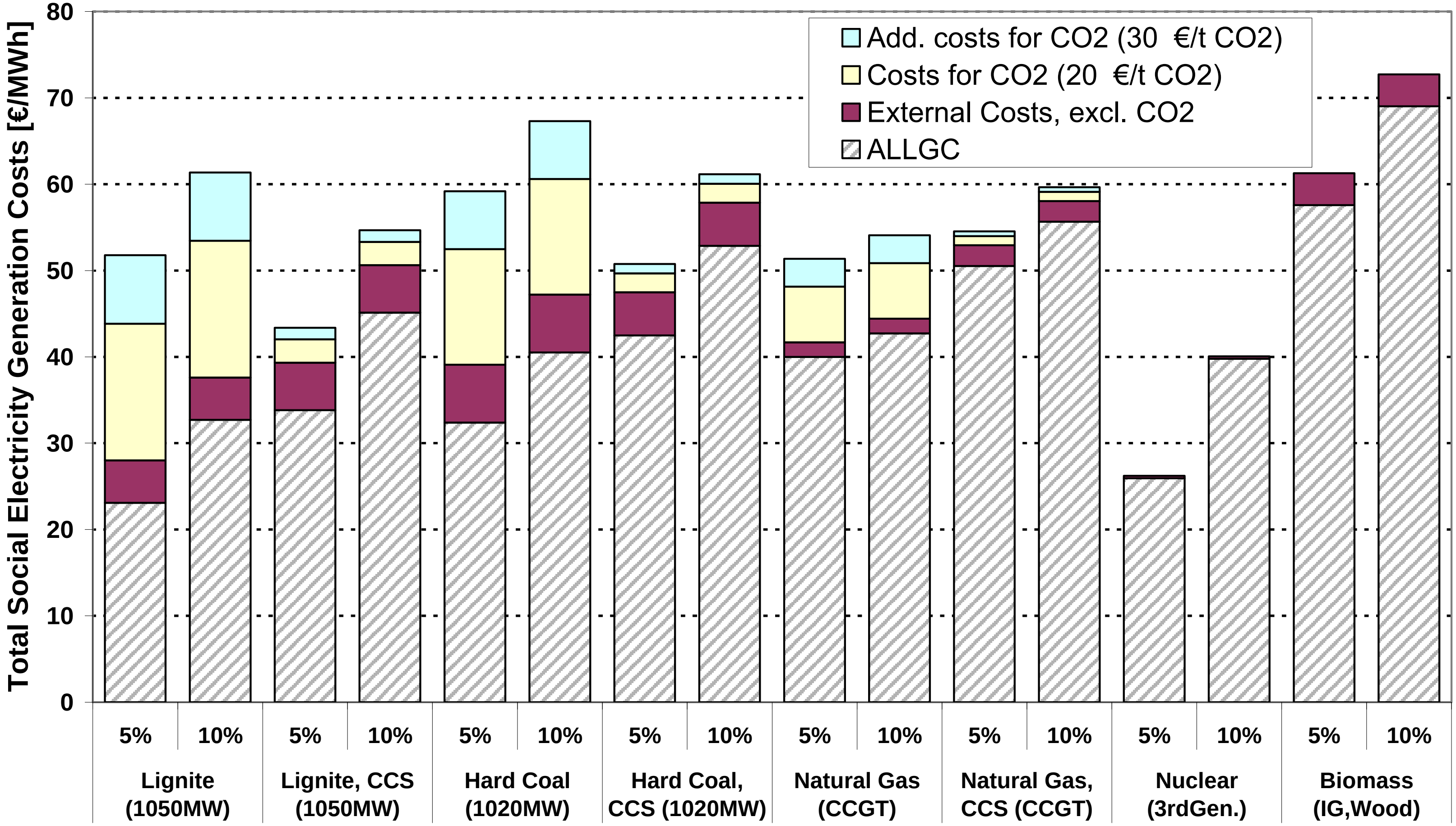
Total Social Costs for different Electricity Generation Technologies 2030 (Baseload)

- *Average Lifetime Levelized Generation Costs (ALLGC). Calculations based on 85 % capacity factor. Discount rate: 5%, 10%.*

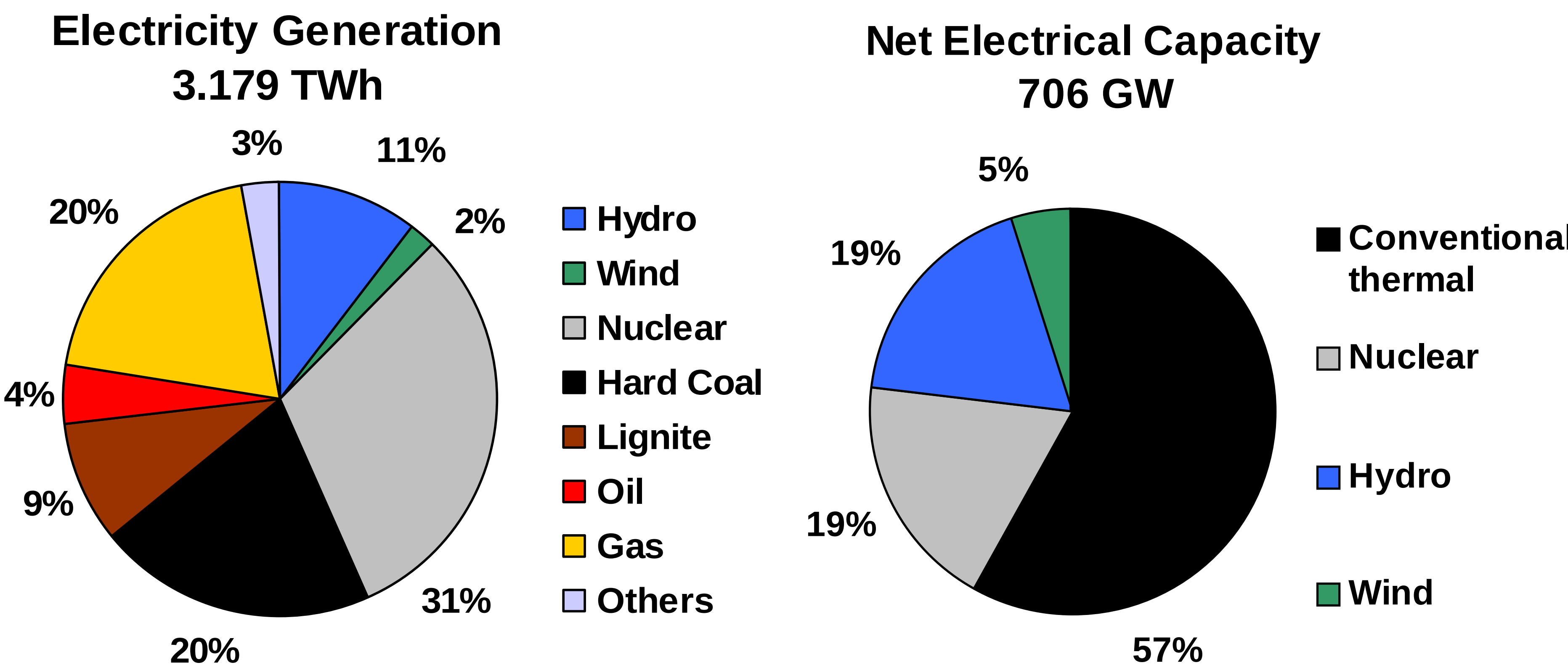


Total Social Costs for different Electricity Generation Technologies 2030 (Baseload)

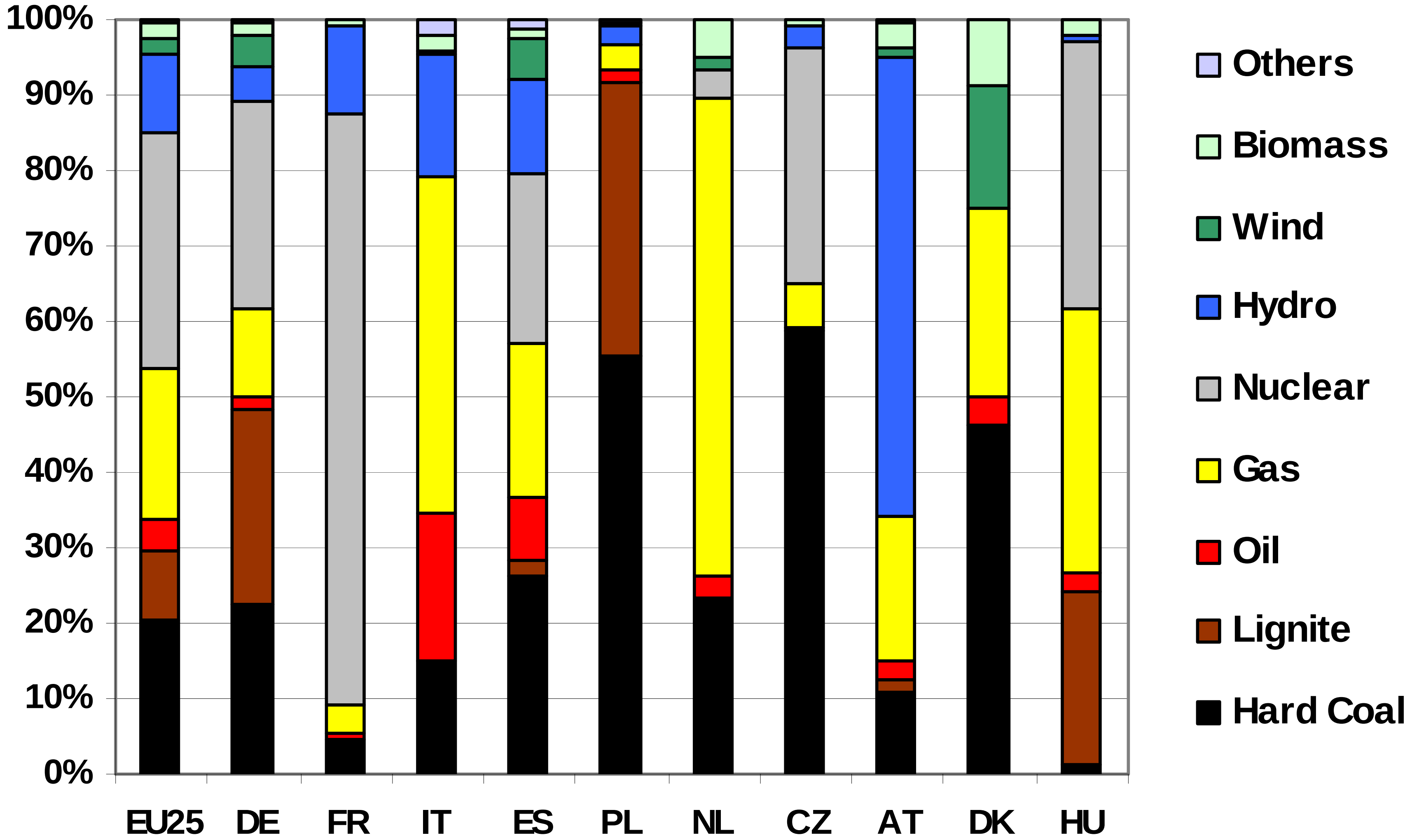
- *Average Lifetime Levelized Generation Costs (ALLGC). Calculations based on 85 % capacity factor. Discount rate: 5%, 10%.*



Electricity Generation [TWh] and Electricity Capacity [GW] in the EU-25 (2004)



Electricity Generation Structure (2004)



Scenarios - Overview

- TIMES-EG is a electricity (and gas) system model for each of the EU-25 or EU-30 countries
- TIMES-EG is a partial equilibrium model of the European electricity market to perform energy, engineering, economic and environmental analysis
- Technological improvement is explicitly characterized and performance of energy technologies is an important driver of structural development
- For EUSUSTEL, TIMES-EG was used to quantify scenarios of the European electricity system using the electricity demand projections from PRIMES

Scenario Characterization (I)

Baseline (BL): Business as usual development in EU-25	
CO_2-Value	5 €/t CO_2 from 2010 until 2030
Nuclear	Nuclear development based on current national policies in EU-25. Nuclear phase-out in Germany, Belgium and Sweden
RES	Continuation of support to renewables

Post-Kyoto (PK): Emission reduction according to Post-Kyoto target of -16% until 2030	
CO_2-Value	25.0 €/t CO_2 in 2010 37.0 €/t CO_2 in 2020 51.5 €/t CO_2 in 2030
Nuclear	Nuclear constrained as in Baseline (BL)
RES	RES policies as assumed in Baseline (BL)

Scenario characterization (II)

Post-Kyoto, All Technologies (PKAT): Emission reduction according to Post-Kyoto target of -16% until 2030 but allowing for free technological choice

CO_2-Value	25.0 €/t CO_2 in 2010 28.0 €/t CO_2 in 2020 31.5 €/t CO_2 in 2030
Nuclear	No premature phase-out. New investments allowed in all countries, except for: AT, DK, EE, GR, IR, LV, LU, PT
RES	RES policies as assumed in Baseline (BL)

Limited Import Dependency (LID): Improving security of supply by forcing the energy system to be more energy efficient and less import dependent

CO_2-Value	Same CO_2–Value as assumed in Post-Kyoto (PK)
Nuclear/RES	Nuclear and RES as in Baseline (BL)
Energy Taxes	Energy taxes on fossil fuels to reduce fossil fuel imports (2030: 1.12 €/GJ for coal; 3.34 €/GJ for gas)

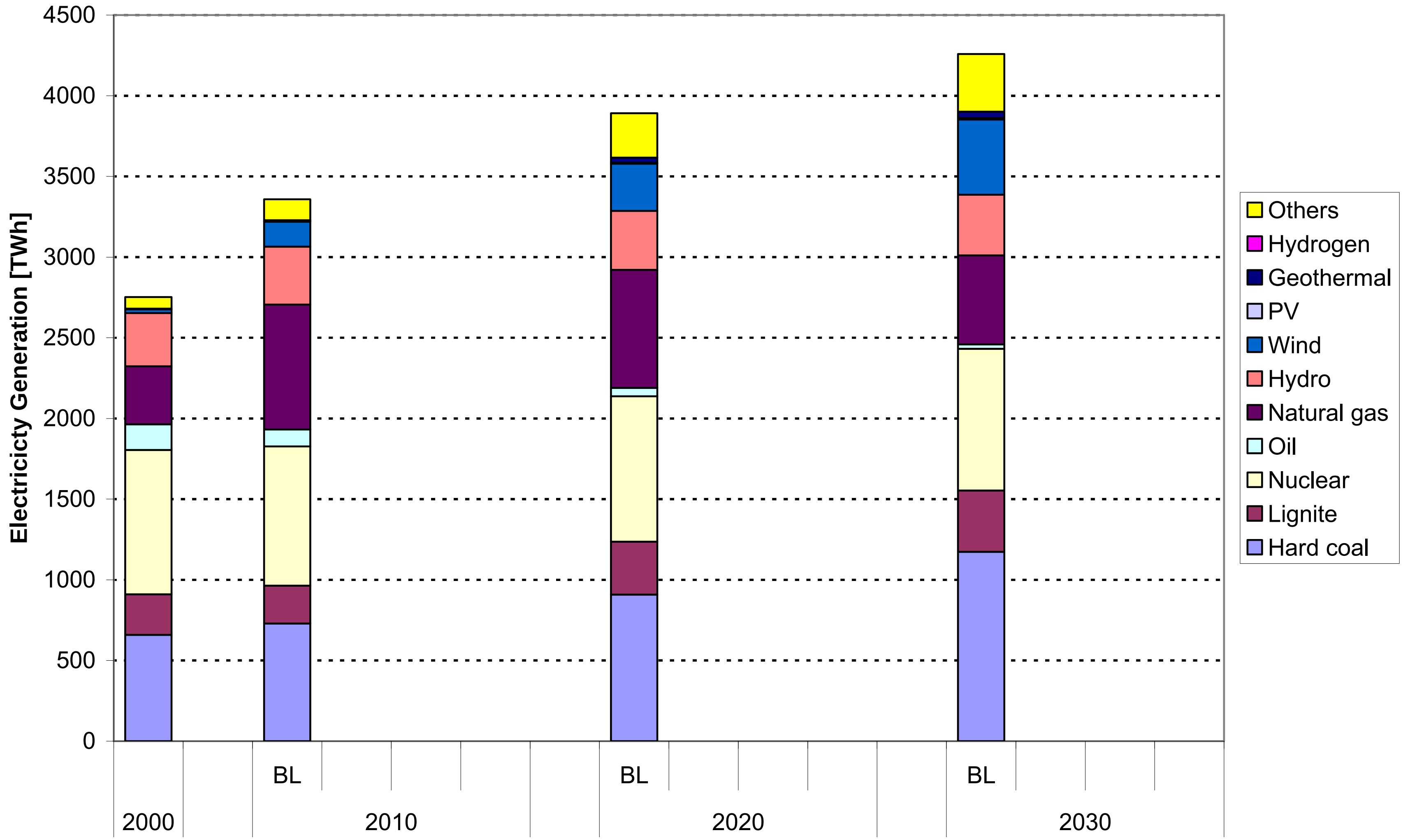
Subcase: Least Cost CO_2-Reduction (LC)

Energy Technology Advancement by 2030

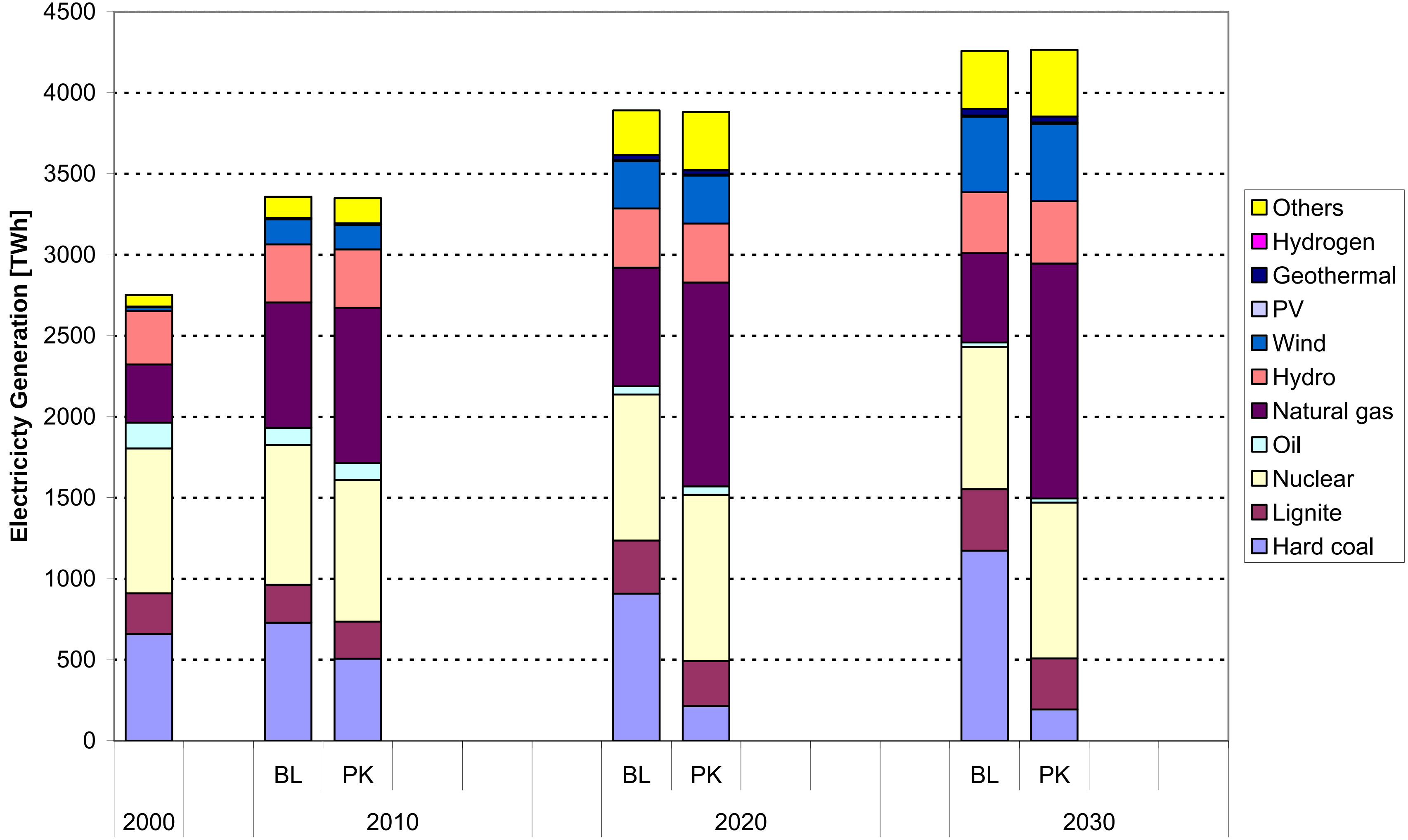
- *Change in characterization for various electricity generation technologies between 2005 and 2030 due to technological progress. Examples for thermal and RES power plants.*

Technology	Parameter	Unit	2005	2030
Lignite (1050 MW)	Overnight investment cost	[€/kW]	1150	1150
	Efficiency	[%]	44	50
Coal (1020 MW)	Overnight investment cost	[€/kW]	1000	1050
	Efficiency	[%]	46	50
Natural Gas (CCGT)	Overnight investment cost	[€/kW]	440	400
	Efficiency	[%]	57.5	62
Nuclear (3rd Gen.)	Overnight investment cost	[€/kW]	1750	1500
	Efficiency	[%]	36	36
Biomass (IG, Wood)	Overnight investment cost	[€/kW]	2150	1900
	Efficiency	[%]	39	42
Wind (Onshore)	Overnight investment cost	[€/kW]	1100	750 - 900
PV (Open Space)	Overnight investment cost	[€/kW]	4950	1650 - 2500

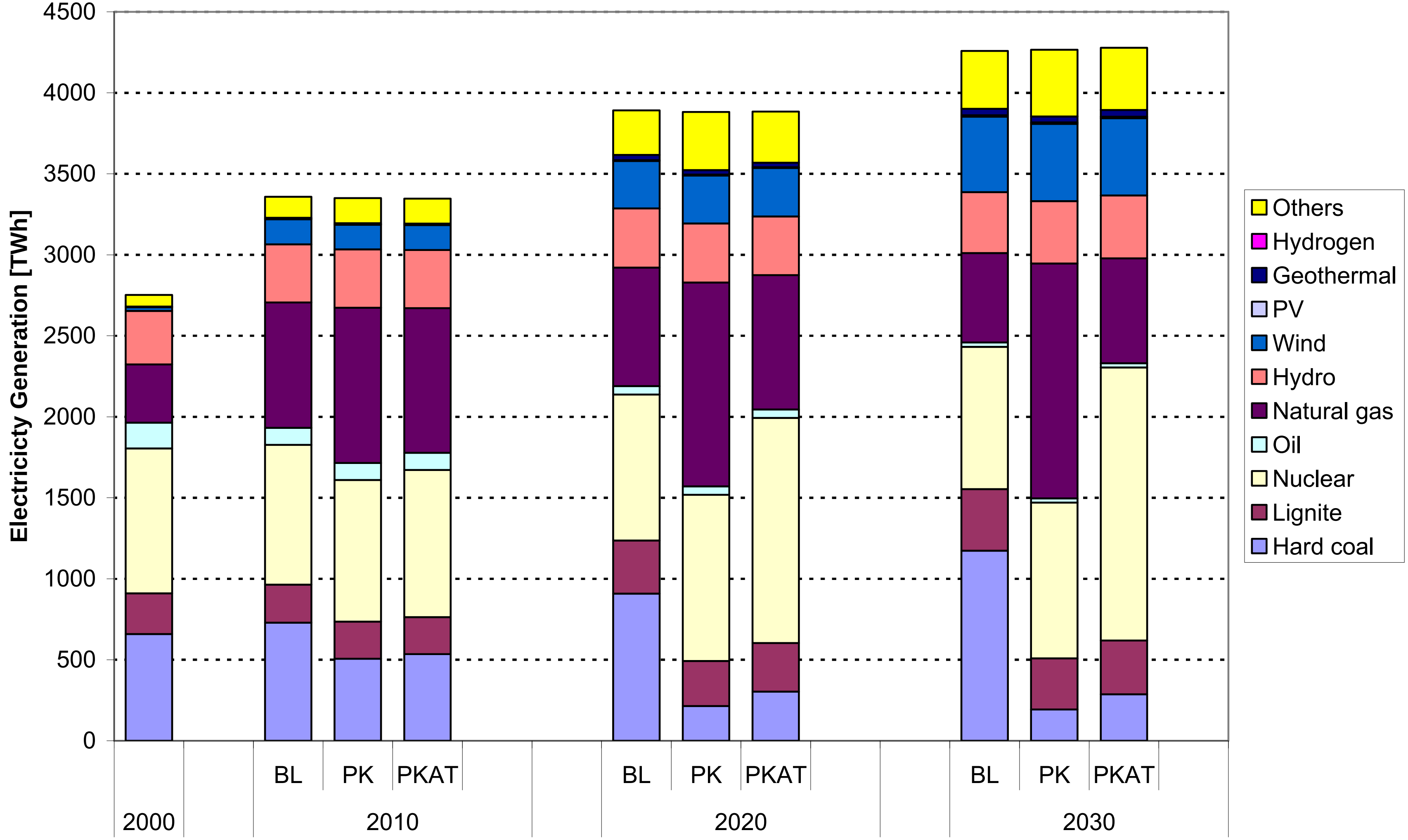
Net electricity generation [TWh] by energy carrier in EU-25



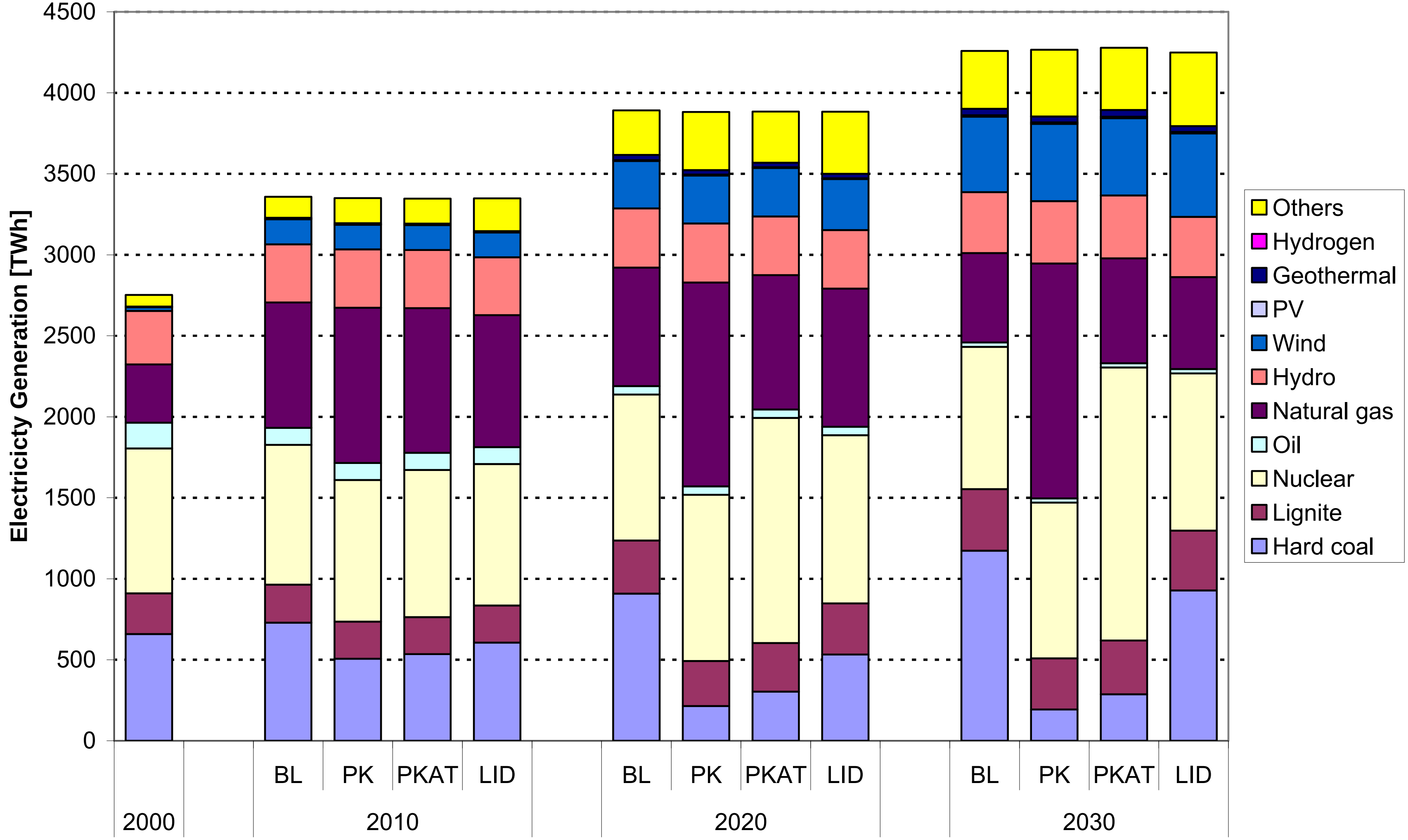
Net electricity generation [TWh] by energy carrier in EU-25



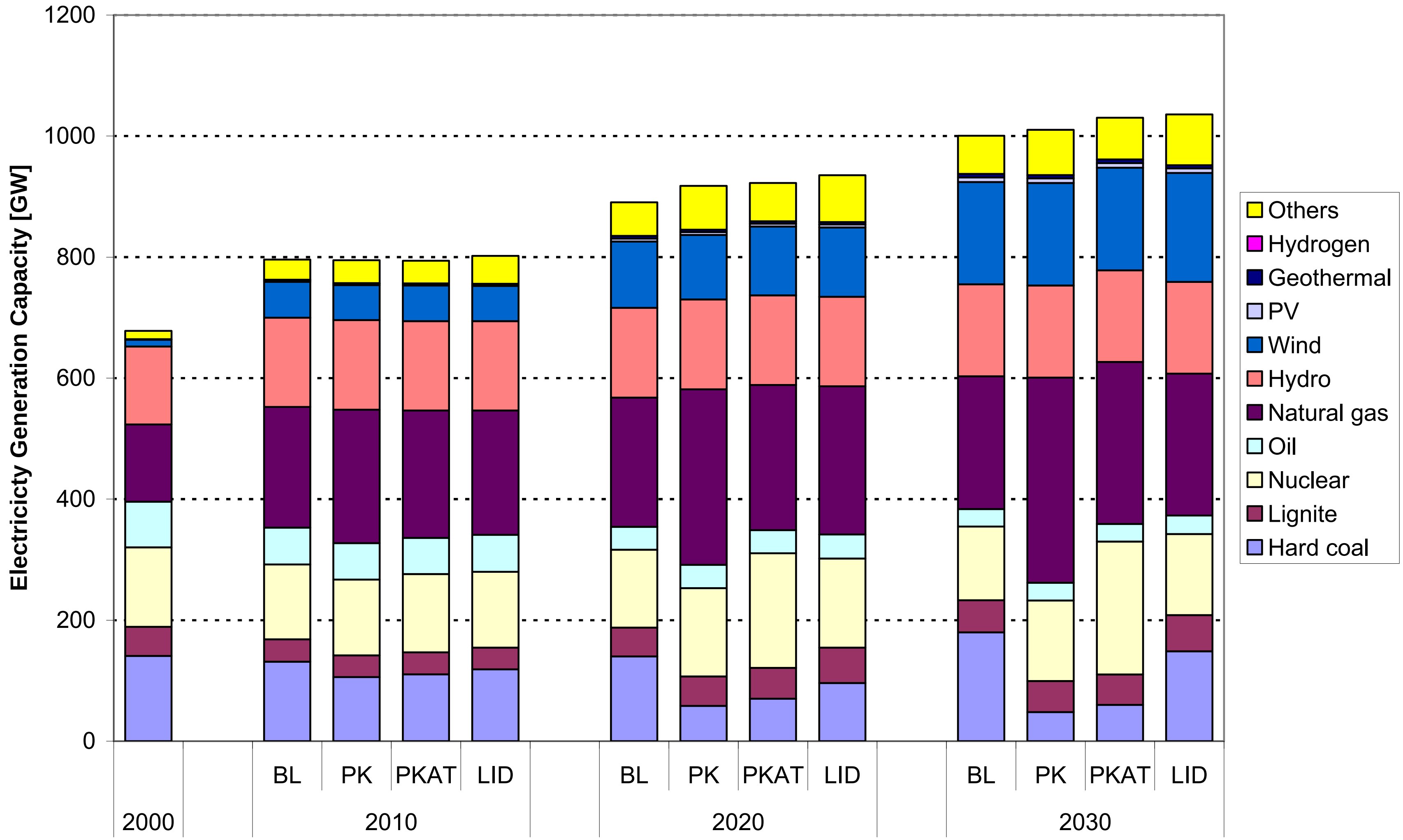
Net electricity generation [TWh] by energy carrier in EU-25



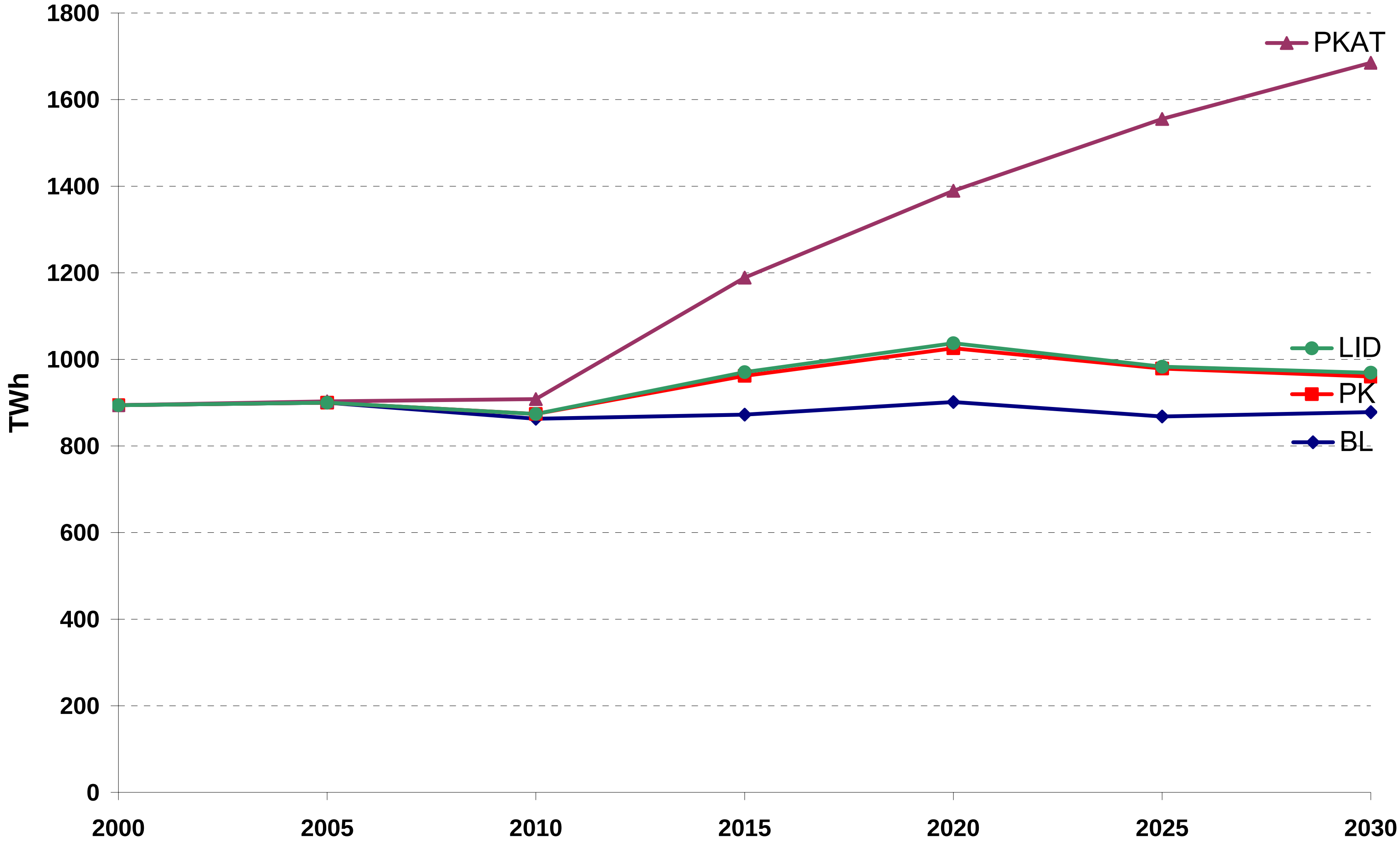
Net electricity generation [TWh] by energy carrier in EU-25



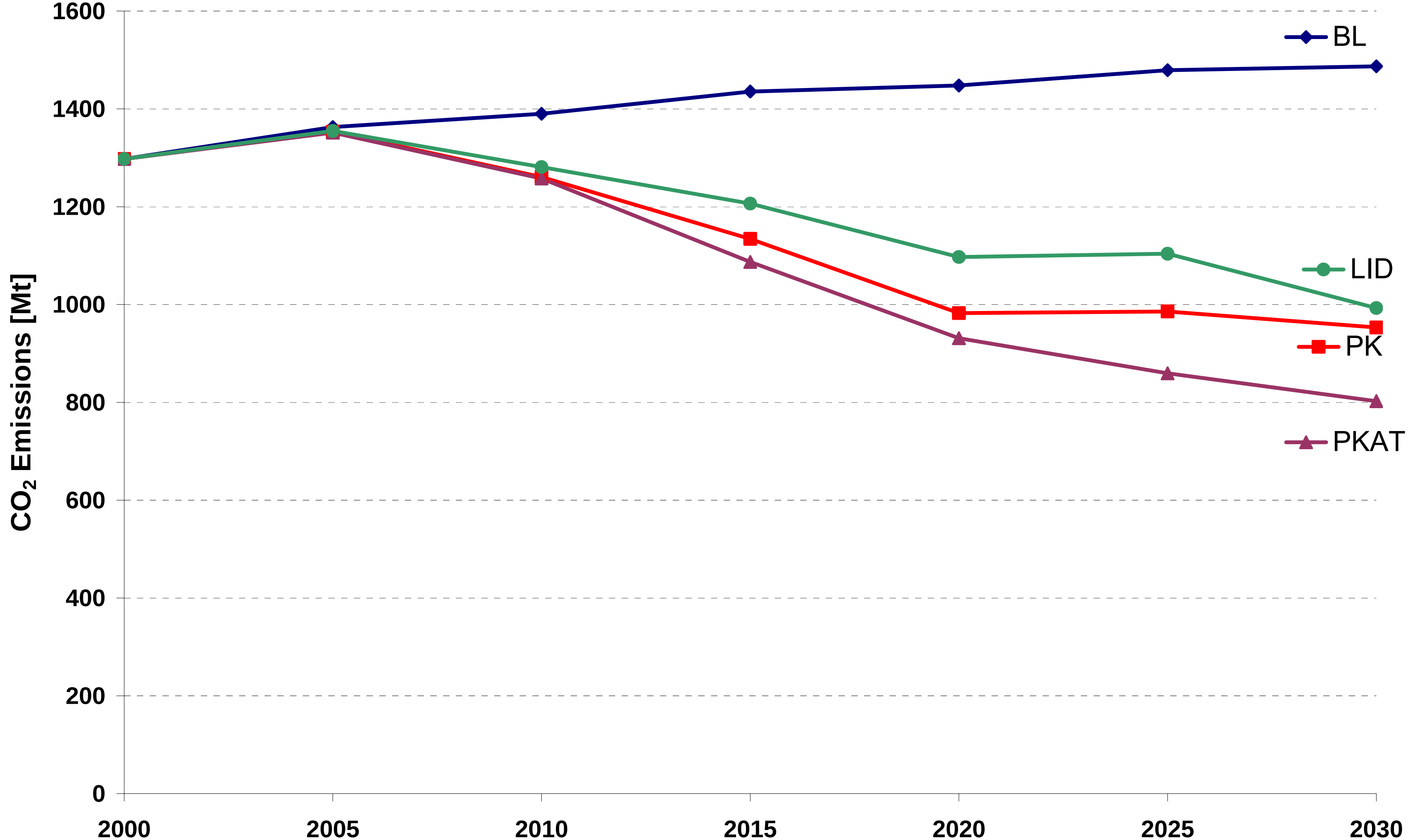
Net electricity generation capacity [GW] by energy carrier in EU-25



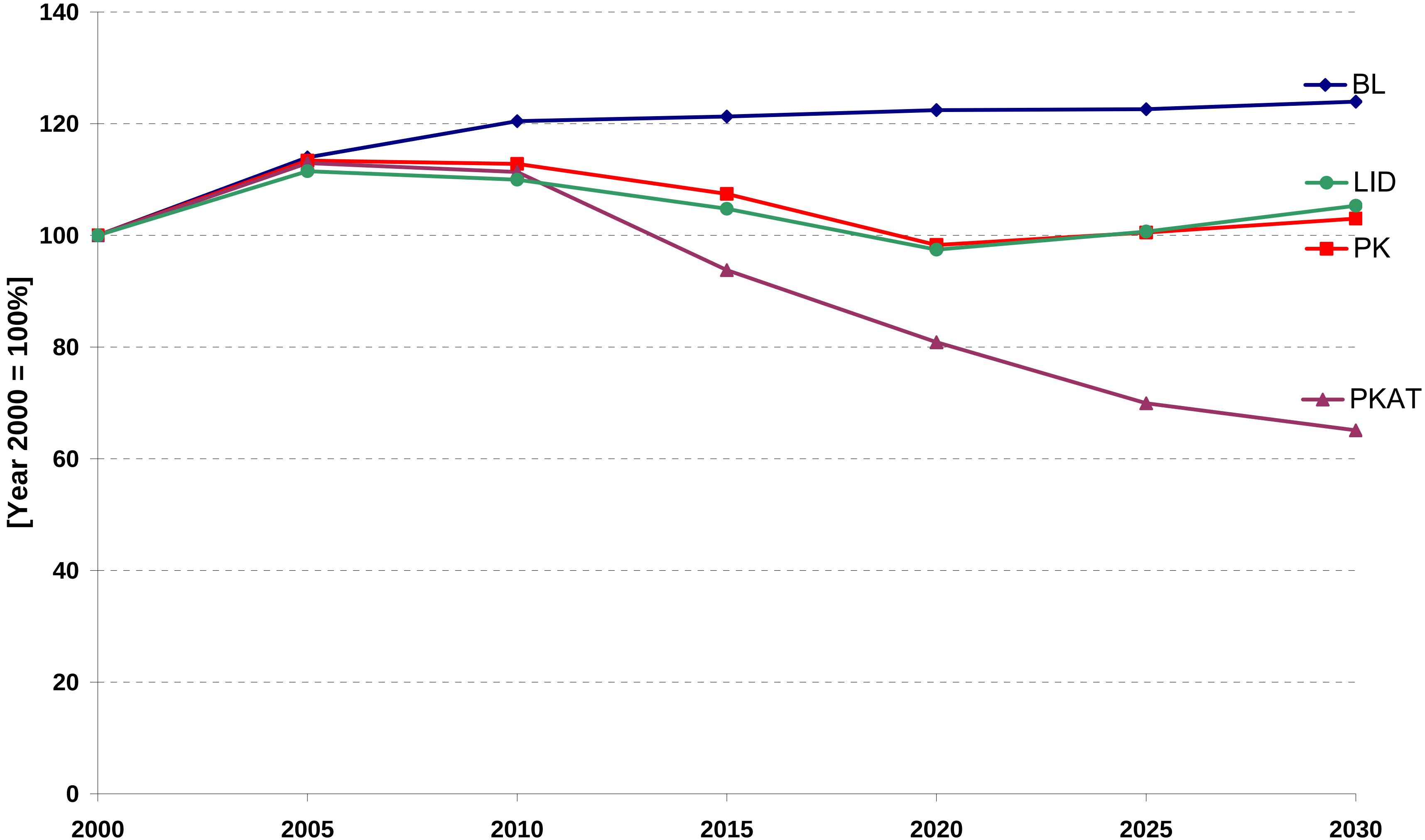
Electricity generation from nuclear [TWh] in EU-25



Development of CO_2 emissions [Mt] from electricity generation in EU-25



Use of gas, oil and hard coal for electricity generation in EU-25



Development of average electricity generation costs

Cost of Electricity Generation [$€_{2000}$/MWh]

	2020	2025	2030
BL	40.7	43.0	44.6
PK	45.4	49.7	48.6
PKAT	41.3	42.9	38.7
LID	50.4	58.7	56.4

Cost implications of various scenarios

	compared with baseline (BL)	
	Total Cost Difference [bn $Euro_{00}$]	Average CO_2 reduction costs in 2030 [Euro/t CO_2]
PK 800	**350.95**	**20.87**
PKAT 800	**-86.55**	**-3.41**
LC 800	**-132.39**	**-7.48**

Concluding Remarks

- Total resource consumption – measured by total social cost – indicates that the relative sustainability of the nuclear power is comparatively high
- The analysis shows that with current knowledge about technology potential and performance improvements nuclear power seems to be the single most important option
  - to reduce the GHG emissions of the electricity sector
  - to alleviate the import dependence of natural gas and coal
  - to obtain least cost effects on electricity costs under climate constraints
- The analysis did not capture the indirect CO_2-reduction potential of electricity in the end-use sectors e.g. by electrical heat pumps, if low-CO_2 and low-cost electricity is available