



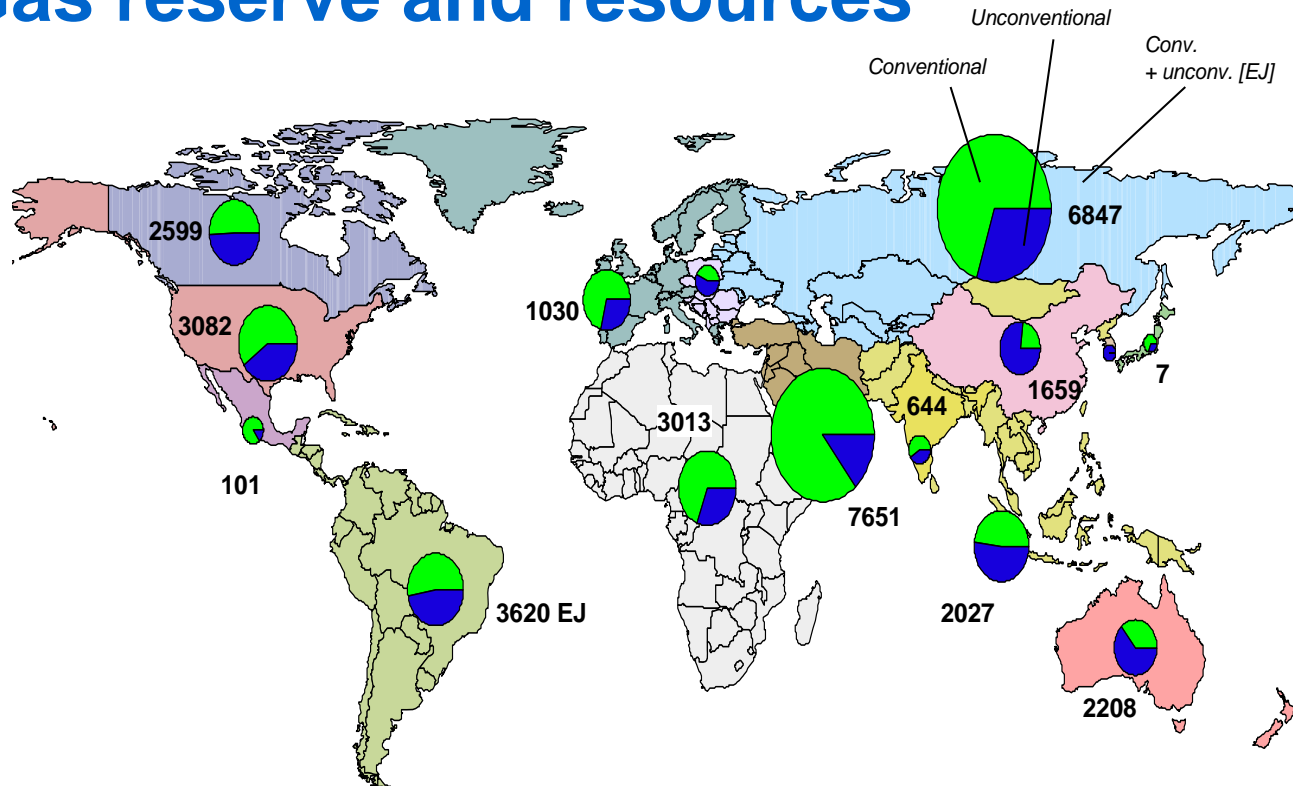
Natural gas supply for Europe: an analysis with TIAM-IER

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Energy Economics and System Analysis (ESA)**

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Natural Gas reserve and resources



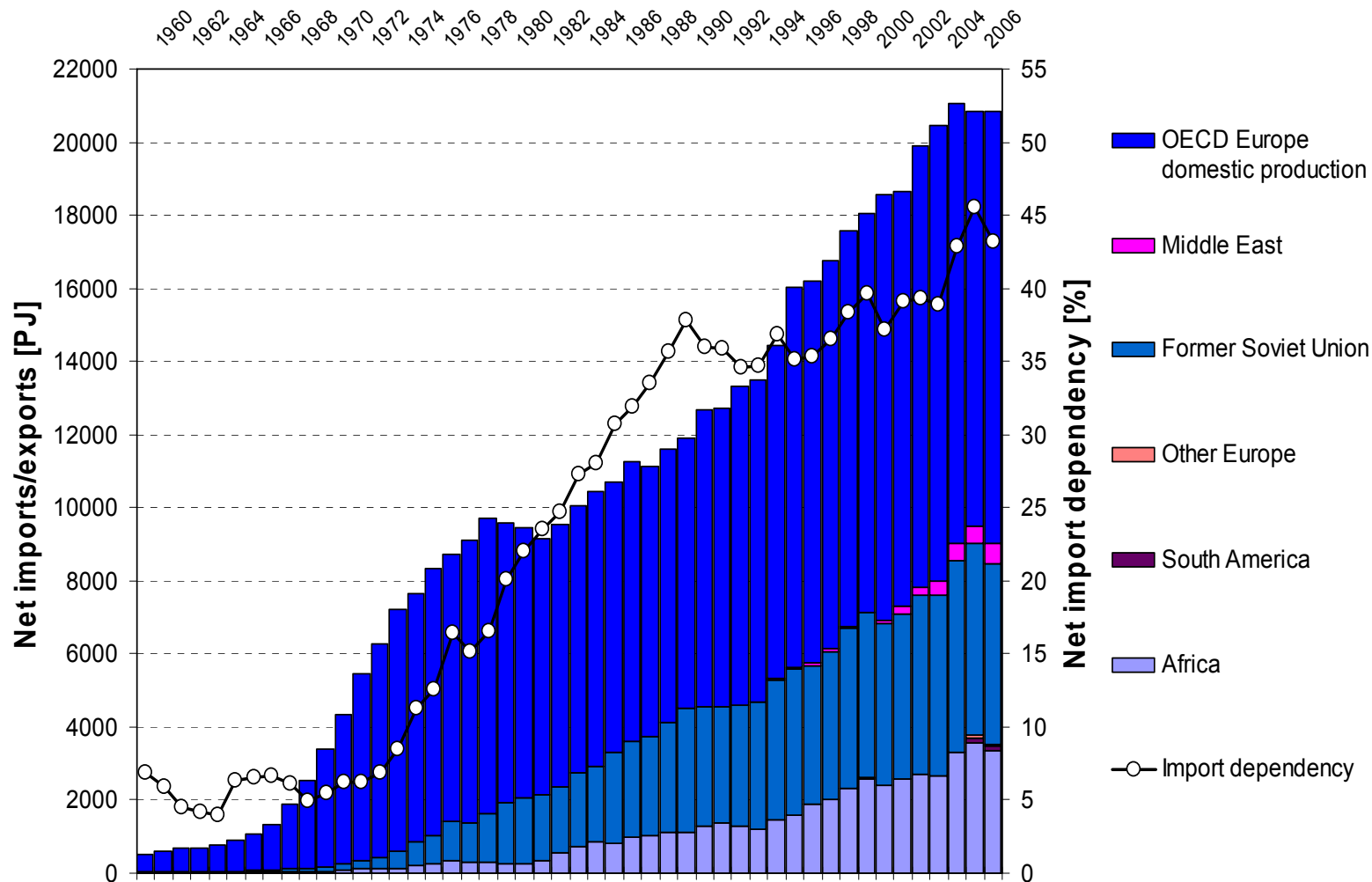
Conventional [EJ]		Unconventional reserves + resources [EJ]			Total [EJ]	Gas hydrates resources [EJ]	Gas production 2008 [EJ]
Reserves	Resources	Coal-bed methane	Tight gas	Aquifer gas			
7137	8336	2827	1694	14496	34490	47400	116

Sources: BGR, WEC, USGS

- **Russia and the countries of the middle east control more then 75 % of the natural gas reserves and resources**



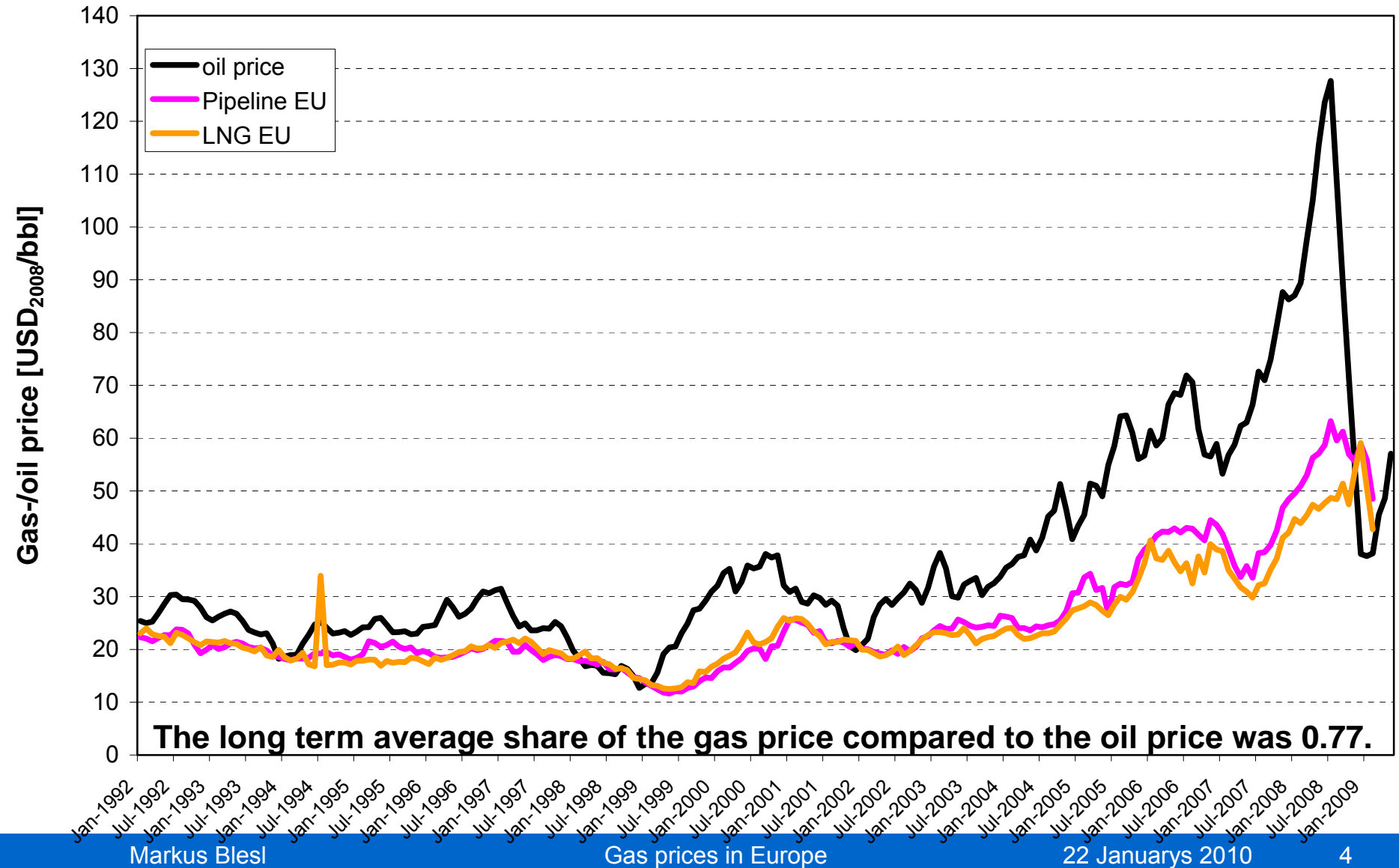
Natural gas consumption by source in Europe



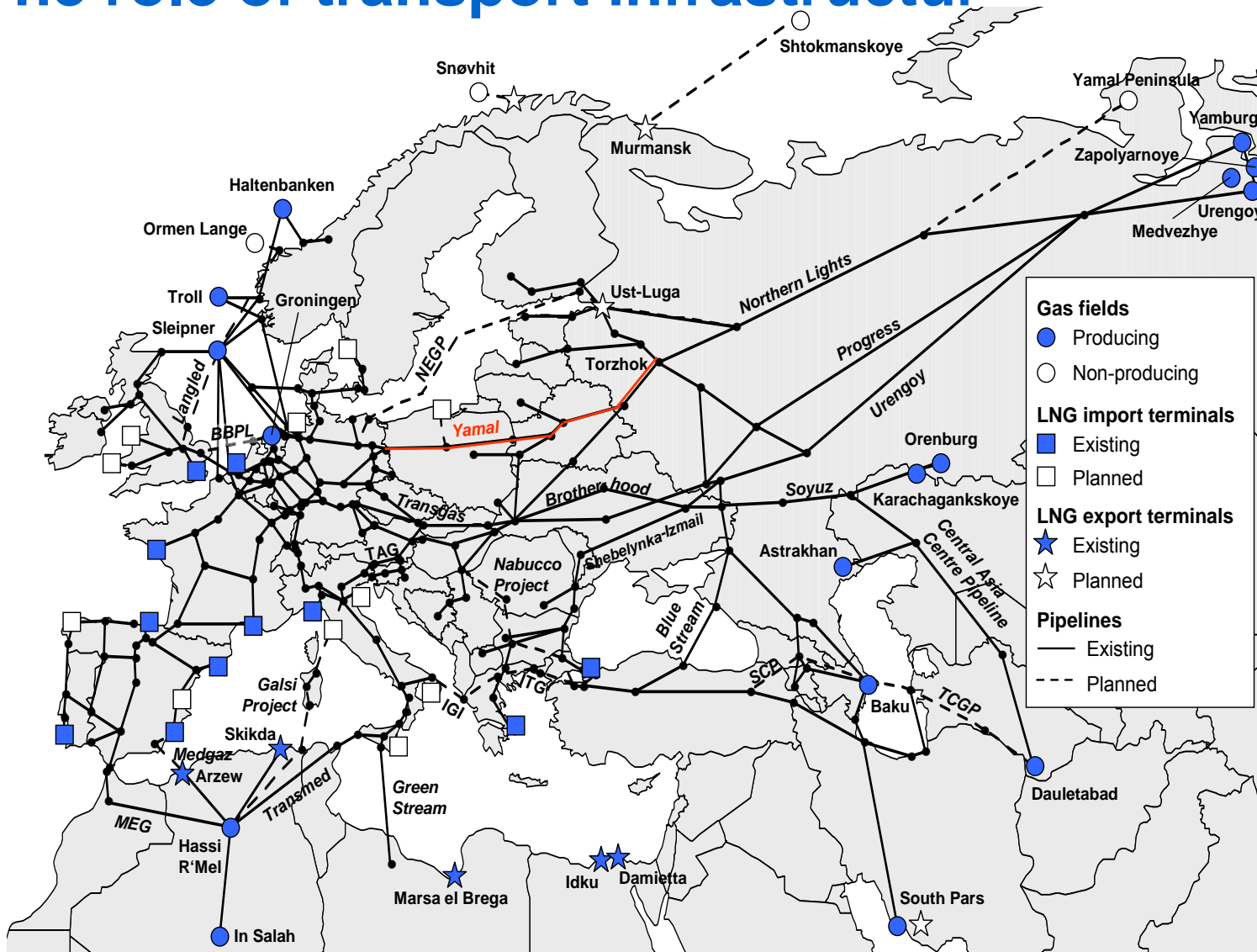
● Growth of import dependence of Europe from Russia



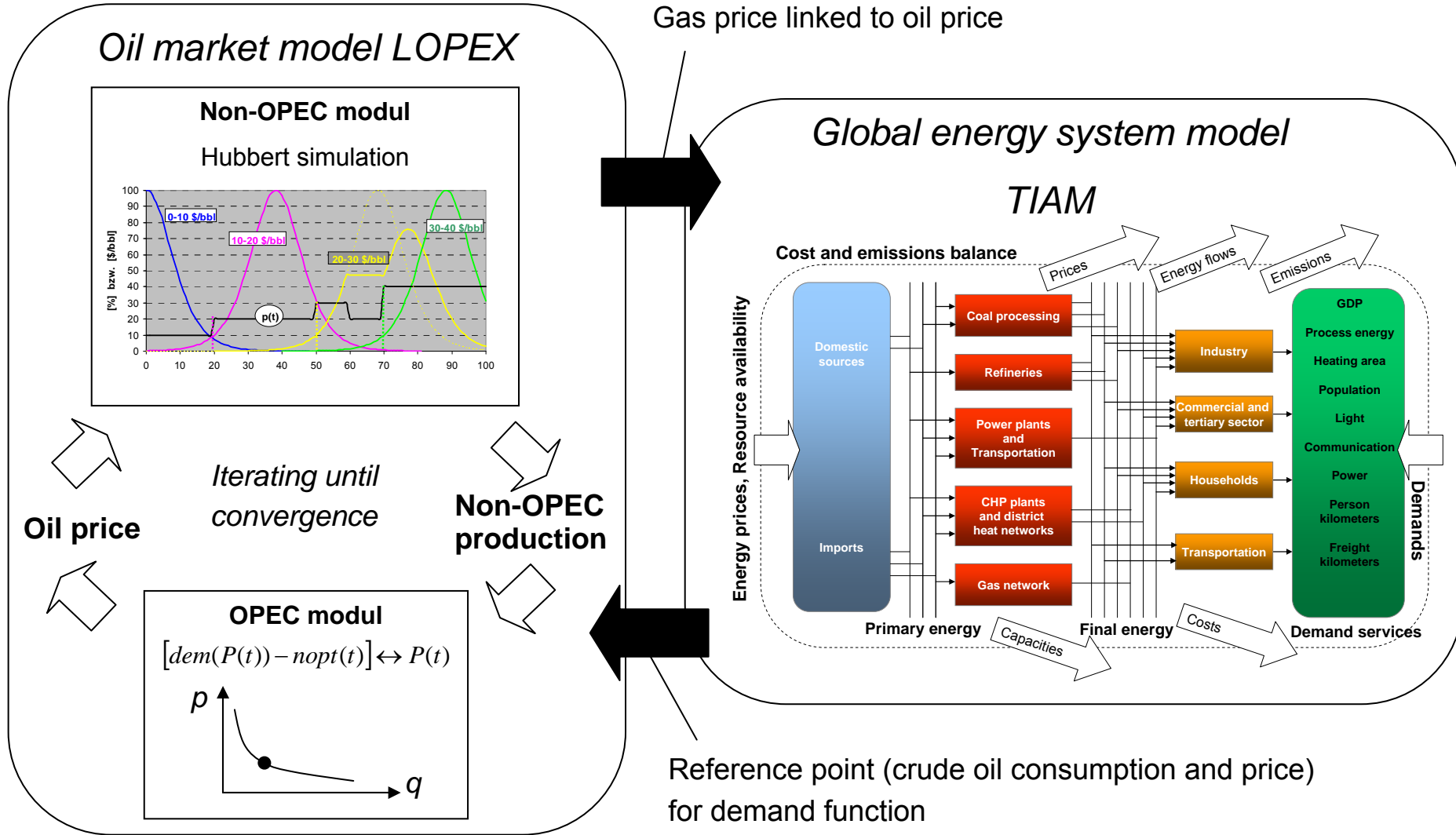
Historical development of the natural gas price



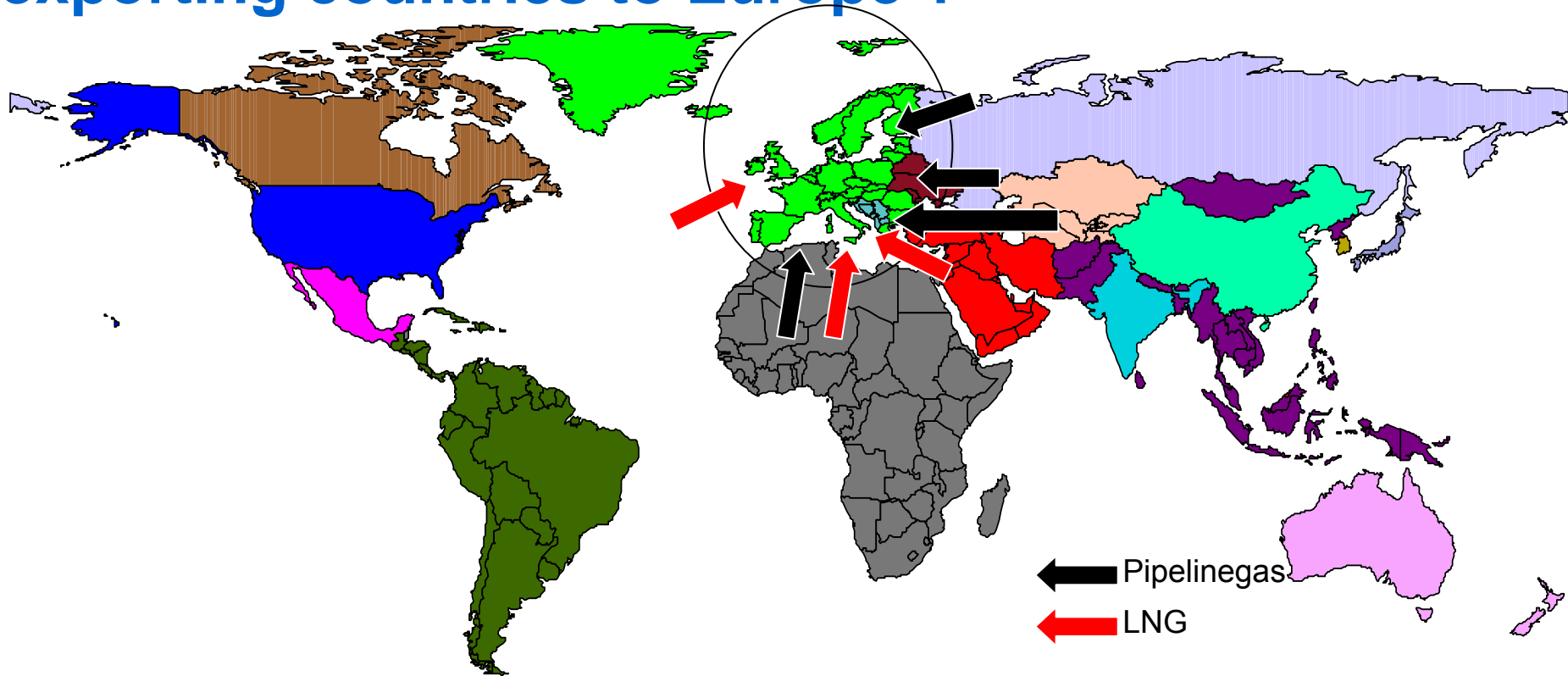
The role of transport infrastructure



Modelling approach



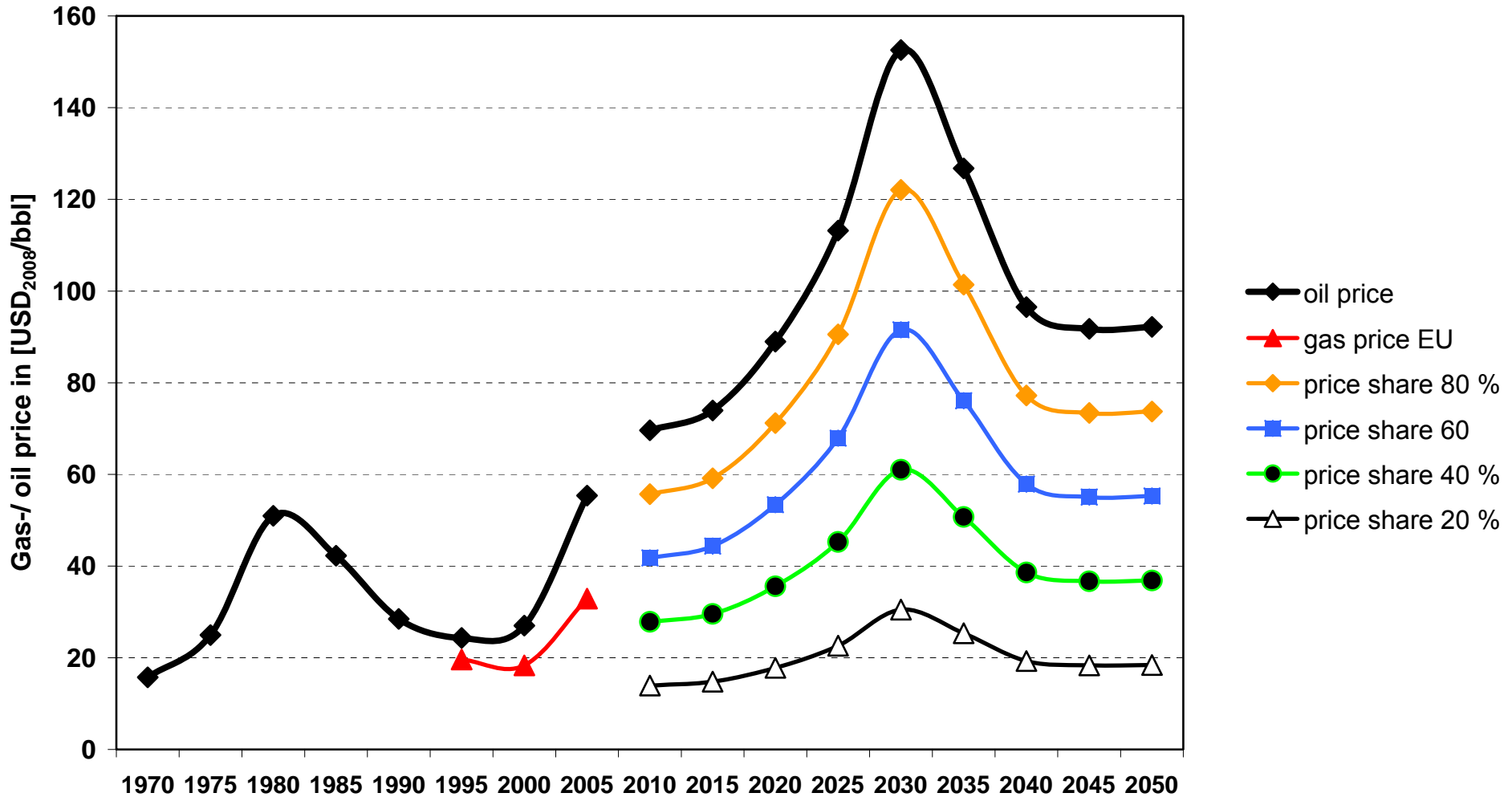
What is the maximum profit of the natural gas exporting countries to Europe ?



- Profit of the gas exporting countries modeled as add on-costs.
- Profit of the exporting countries = (gas price Europe – gas cost) x import quantities
- Variation of the add on costs depending of different cost profiles



Profiles of cost shares of natural gas related to oil

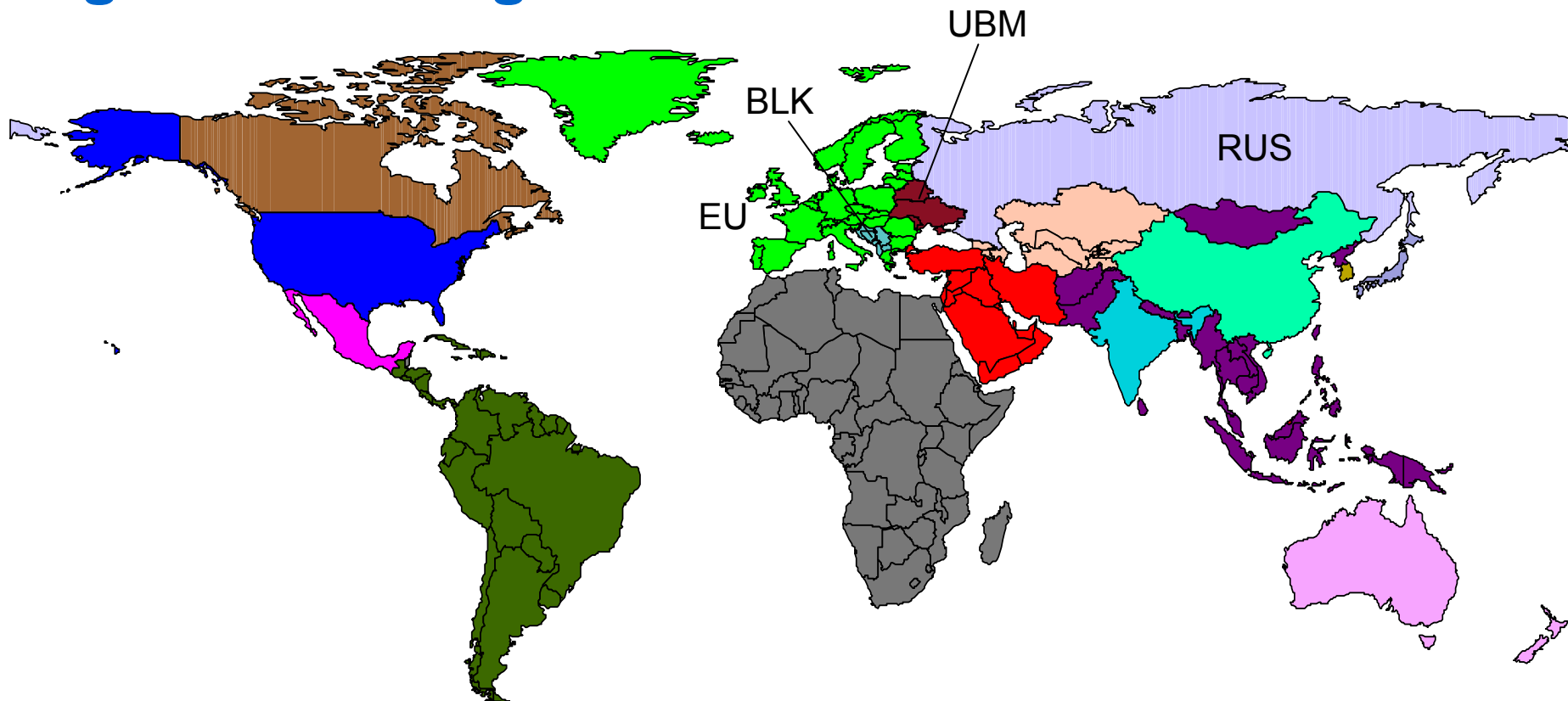




Global energy system model: TIAM-IER

- **TIMES Integrated Analysis Model**
- **Based on TIMES model generator:**
 - i. Developed by ETSAP
 - ii. Dynamic partial equilibrium model approach with inter-temporal objective function (perfect foresight) minimizing total discounted system costs
 - iii. Technologically detailed „bottom-up“ model for each region
 - iv. Covering energy flows from the useful energy demand over end-use sectors and conversion sector to the primary supply
- **Time horizon 2000 – 2100**
- **17 world regions with**
 - i. Bilateral trade in hard coal, pipeline gas, LNG, crude oil, petroleum products (distillates, gasoline, heavy fuel oil and naphtha) and bioethanol
 - ii. Global trade in emission permits possible
- **Emissions: CO₂, N₂O, CH₄**
 - i. Carbon capture and sequestration (power generation and alternative fuel production)
 - ii. Mitigation options for N₂O and CH₄
- **Climate module** (3-reservoir model for calculating atmospheric CO₂ concentrations)
- **Multi-stage stochastic programming** (uncertainties in emission targets, demands, bounds)

Regional coverage of the TIAM-IER model



- New regions: RUS (russia), UBM (Ukraine, Belarus, Moldova), CAC (Central-Asia, Caucasus), EU (EU-27 + norway,swiss, Iceland), BLK (Balkan state)
- Replaced region: WEU (West Europe), EEU (East Europe), FSU



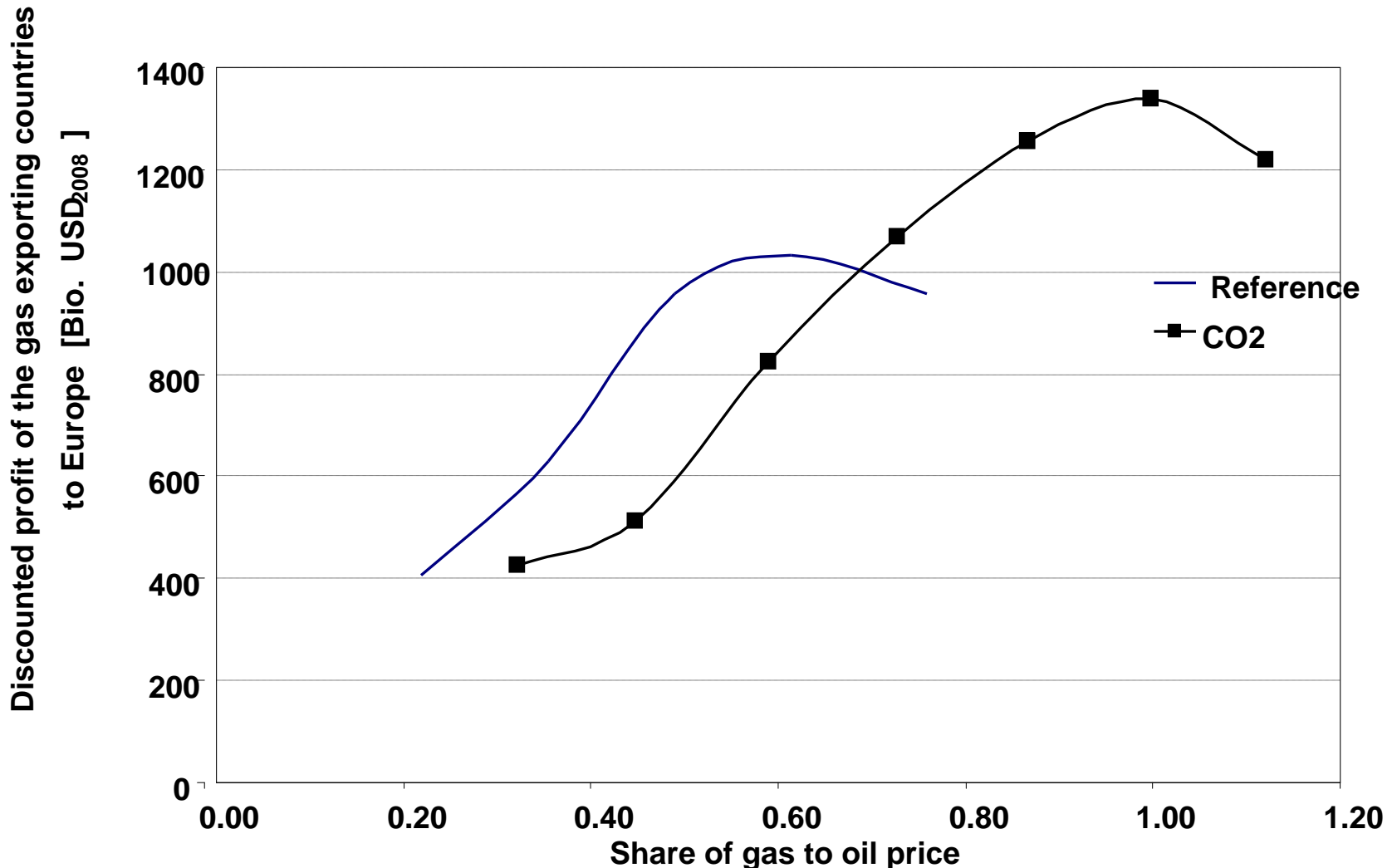
Scope of scenario analysis

- Scenarios analyzed:
 - i. REFERENCE scenario: Long-term equilibrium on oil market incl. OPEC's cartel behavior

Socio-economic assumptions	2000 - 2010	2010 - 2020	2020 - 2030	2030 - 2040	2040 - 2050
Global GDP growth	3.1%	2.9%	2.8%	2.6%	2.5%
Global population growth	1.1%	0.9%	0.7%	0.7%	0.6%
Maximum liquid supply [million bbl/d]:	2010	2020	2030	2040	2050
Unconventional	2	5	8	15	25
Alternative fuels	0.6	6	12	25	50

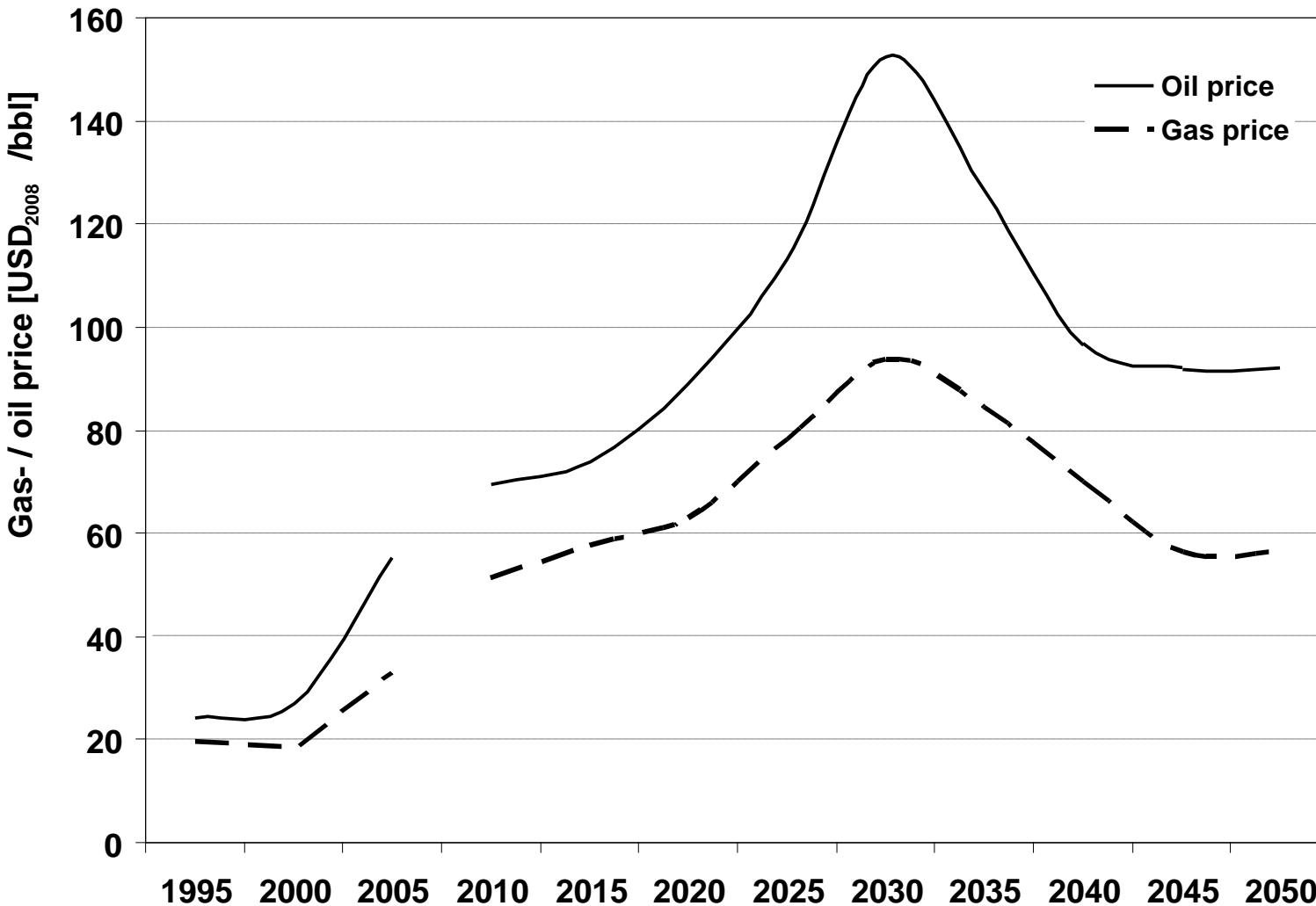
- ii. CO₂ or climate policy scenario: Introduction of a CO₂ price of up to 350 \$/t by 2050

Profit of the gas exporting countries depending on the scenario



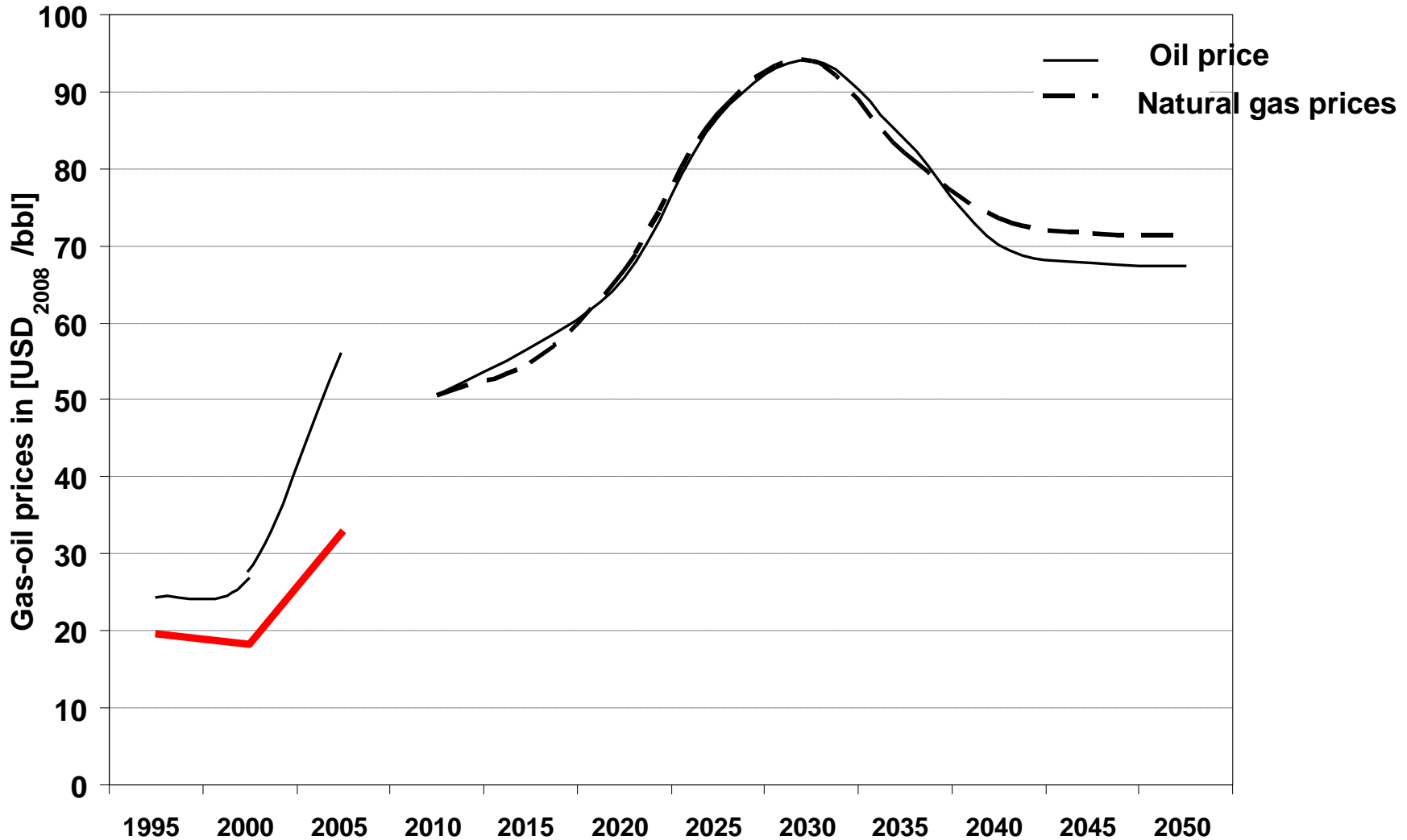


Development of price of natural gas in the reference scenario



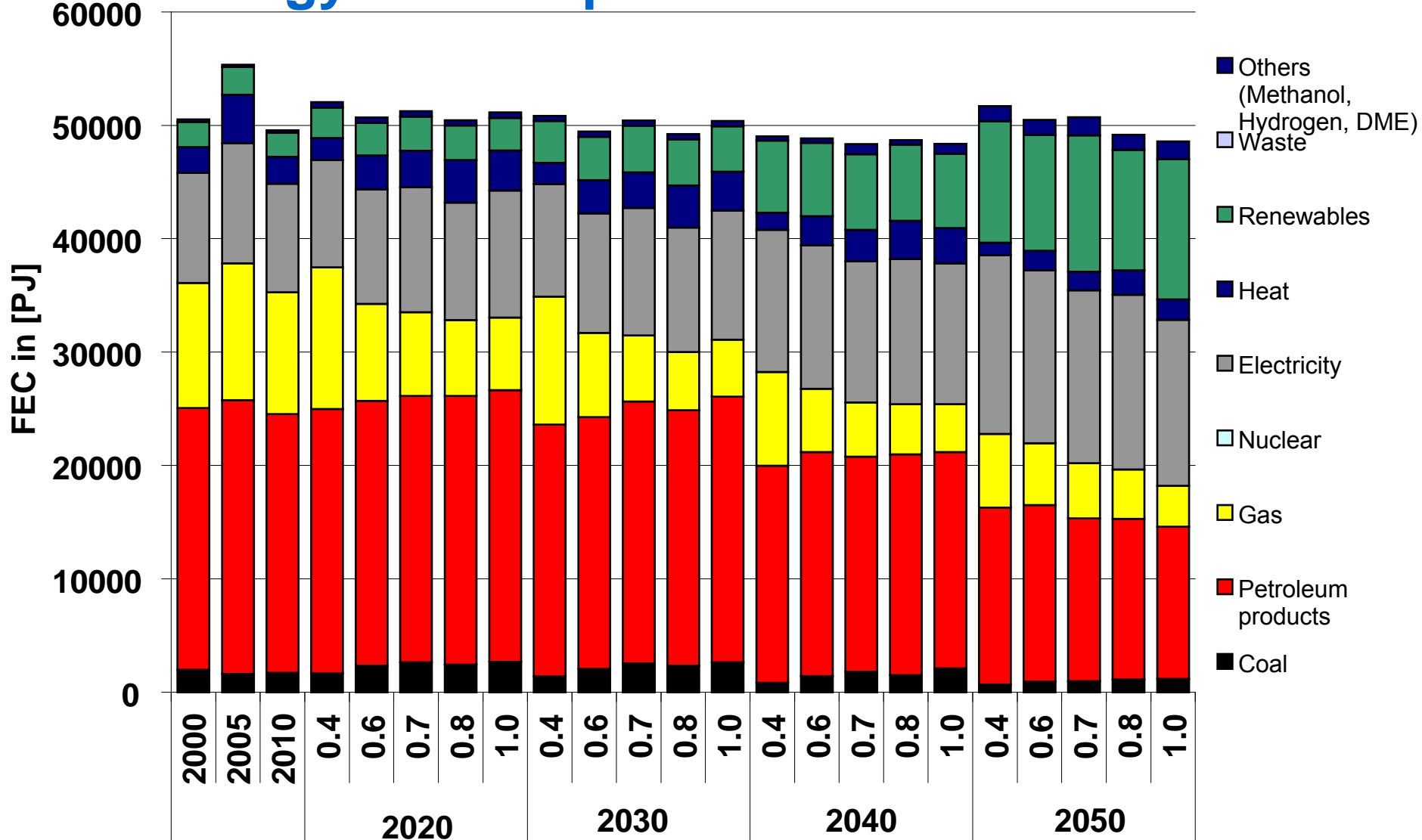


Development of price of natural gas in the CO2 scenario



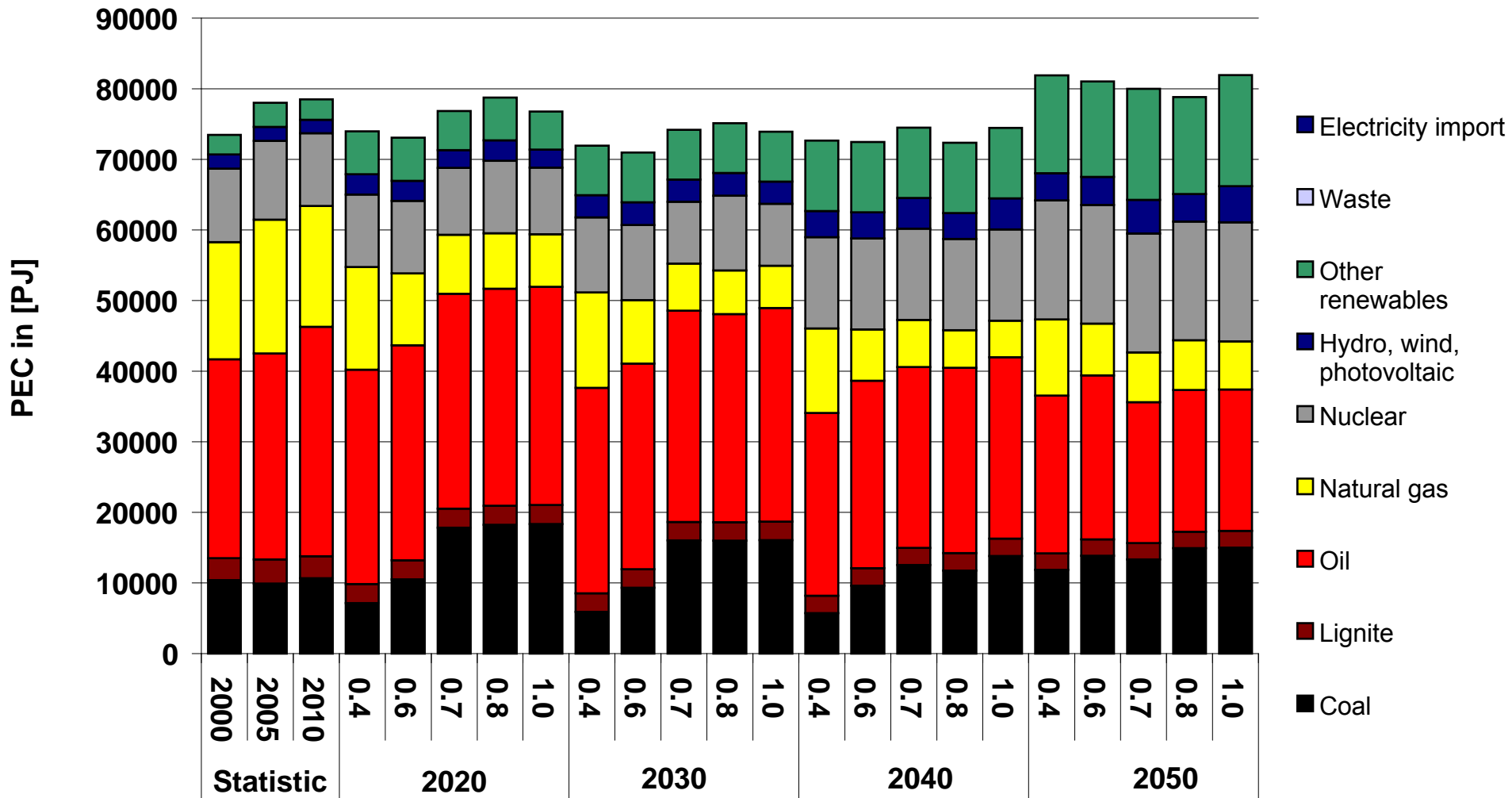


Final energy consumption in the CO2 scenario





Primary energy consumption in the CO2 scenario





Conclusion

- **In the long term based on efficiency improvement in the conversion sector and in the heat market the total amount of gas consumption in Europe will be reduced.**
- **In the conversion sector this reduction is only possible if CCS will be successful.**
- **Also if there will be a gas cartel the oil - gas price binding will not be substituted.**
- **Under a climate regime the share of coupling gas and oil price will increase to 1 compared with the long average of 0.77 in the past.**