



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

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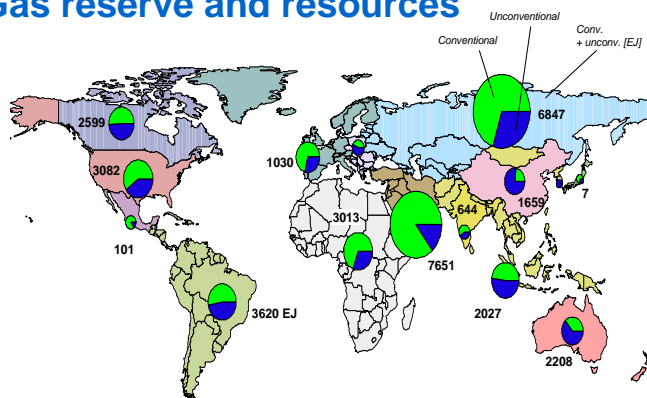
Institute of Energy Economics and the Rational Use of Energy (IER)  
Energy Economics and System Analysis (ESA)

Joint TERI - ETSAP Workshop  
January 22<sup>nd</sup>, 2010, New Delhi

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## Natural Gas reserve and resources



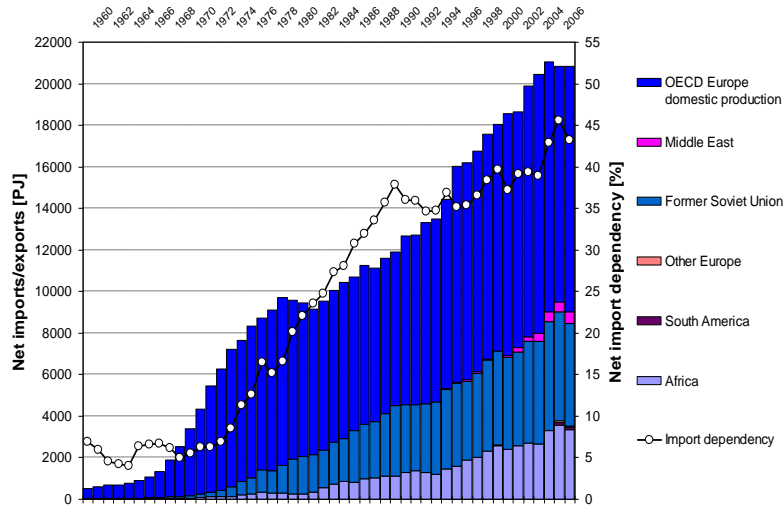
Conventional [EJ]		Unconventional reserves + resources [EJ]			Total [EJ]	Gas hydrates resources [EJ]	Gas production 2008 [EJ]
Reserves	Resources	Coal-bed methane	Tight gas	Aquifer gas			
7137	8336	2827	1694	14496	34490	47400	116

Sources: BGR, WEC, USGS

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



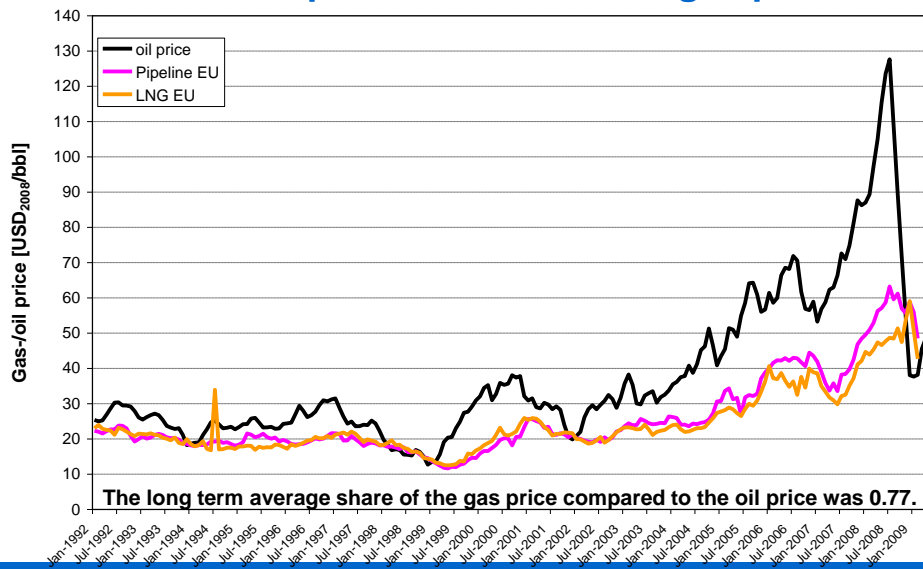
## Natural gas consumption by source in Europe



- Growth of import dependence of Europe from Russia

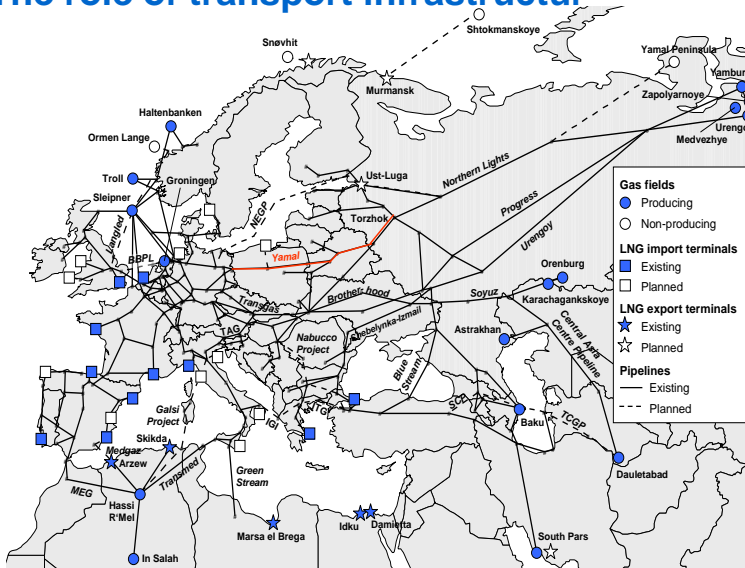


## Historical development of the natural gas price





## The role of transport infrastructure



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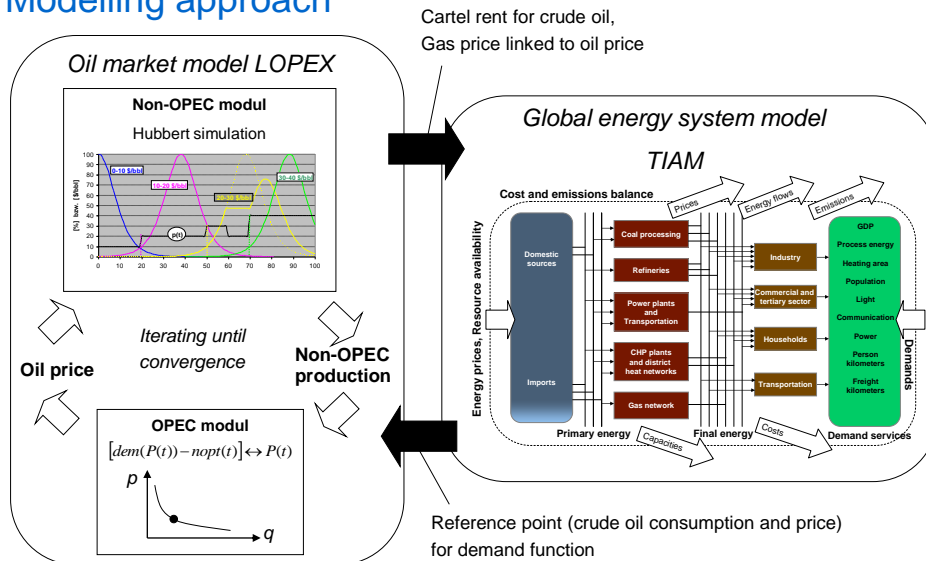
Gas prices in Europe

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## Modelling approach



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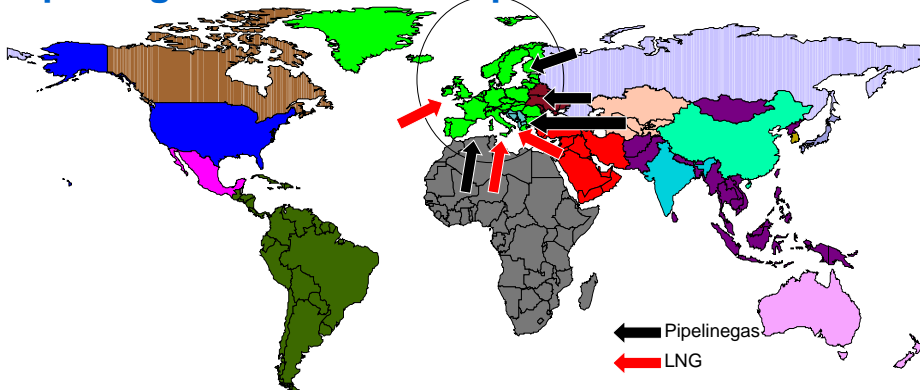
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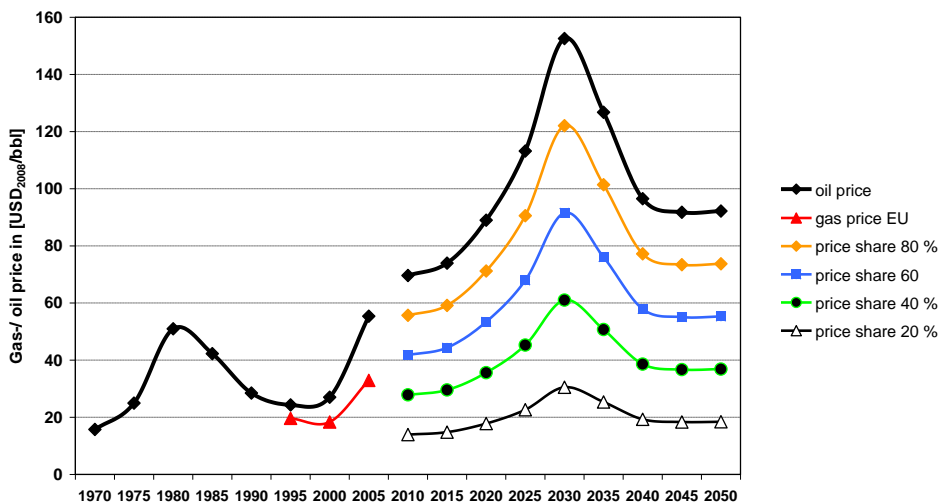
## What is the maximum profit of the natural gas exporting countries to Europe ?



- 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



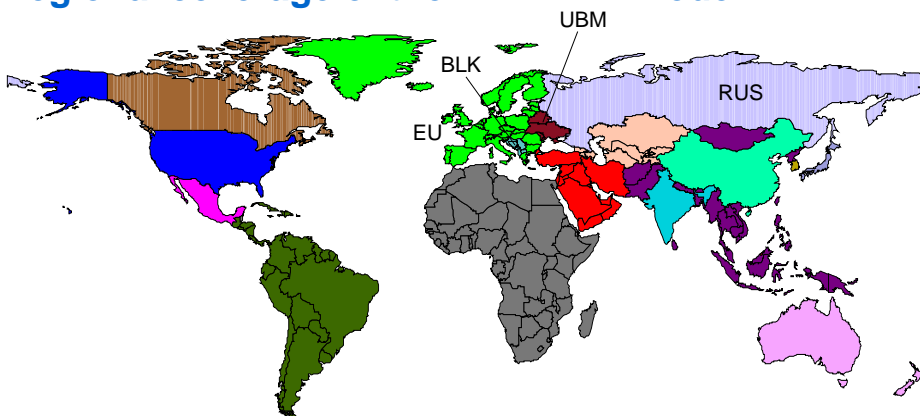


## Global energy system model: TIAM-IER

- **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: CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>**
  - i. Carbon capture and sequestration (power generation and alternative fuel production)
  - ii. Mitigation options for N<sub>2</sub>O and CH<sub>4</sub>
- **Climate module** (3-reservoir model for calculating atmospheric CO<sub>2</sub> 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, Moldovia), CAC (Central-Asia, Causcasus), EU (EU-27 + norway,swiss, Iceland), BLK (Balkan state)
- **Replaced region:** WEU (West Europe), EEU (East Europe), FSU



## Scope of scenario analysis

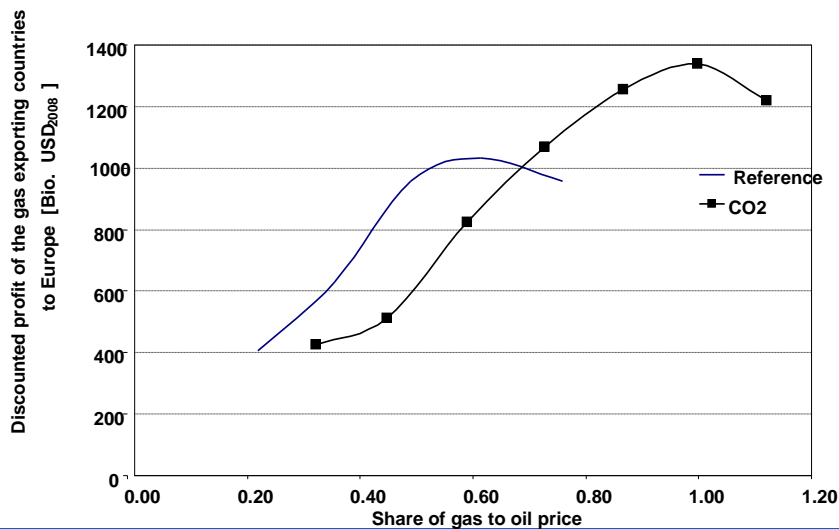
- Scenarios analyzed:
  - i. REFERENCE scenario: Long-term equilibrium on oil market incl. OPEC's cartel behavior

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. CO<sub>2</sub> or climate policy scenario: Introduction of a CO<sub>2</sub> price of up to 350 \$/t by 2050

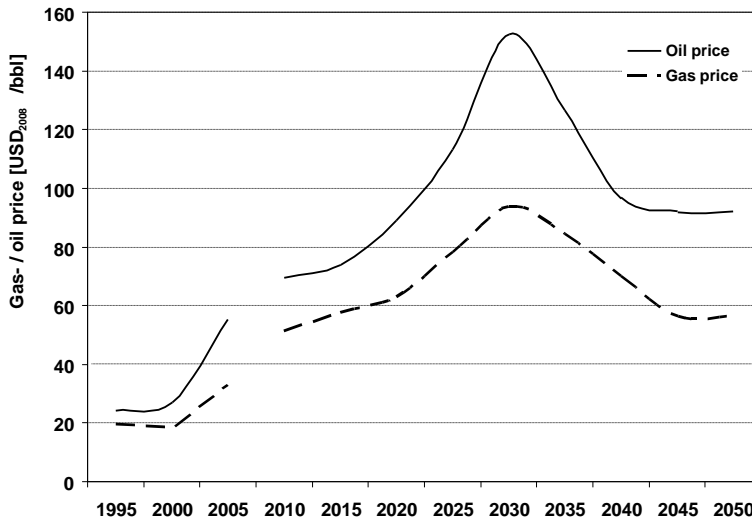


## Profit of the gas exporting countries depending on the scenario





## Development of price of natural gas in the reference scenario



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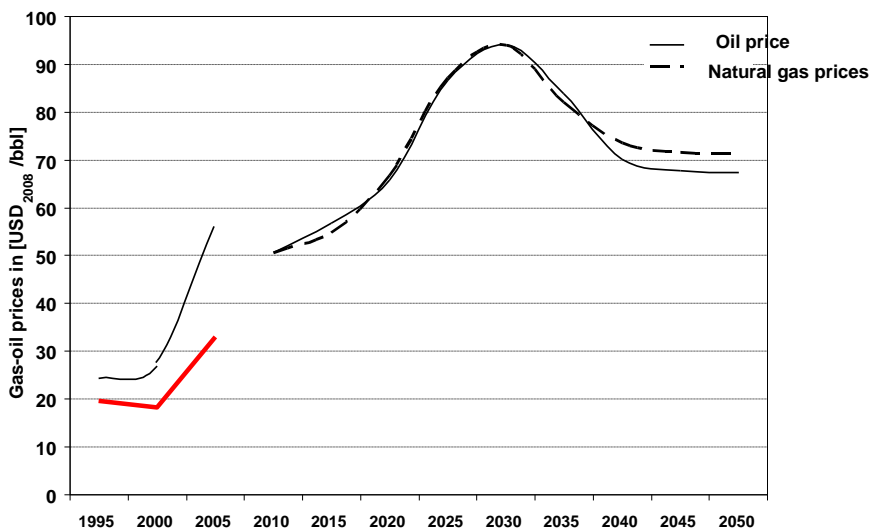
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## Development of price of natural gas in the CO2 scenario



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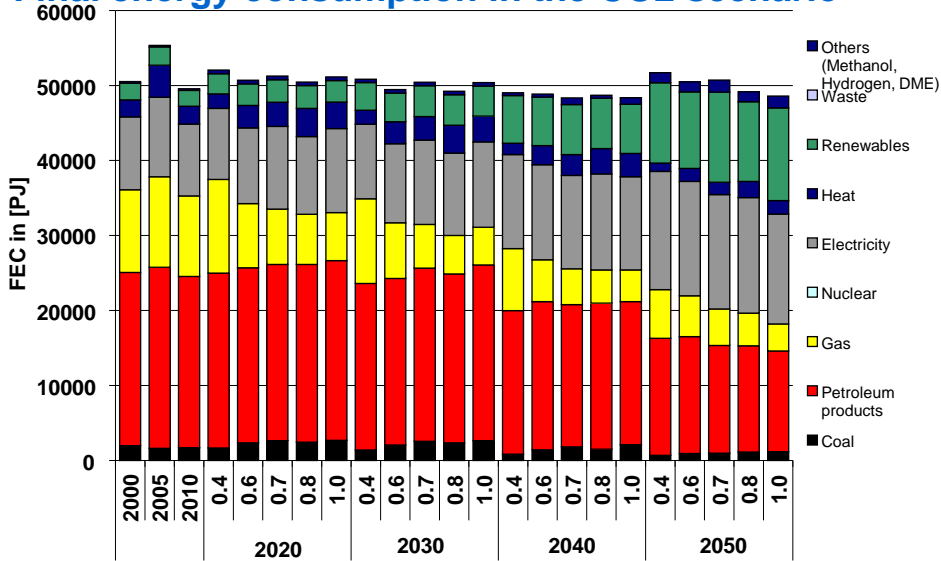
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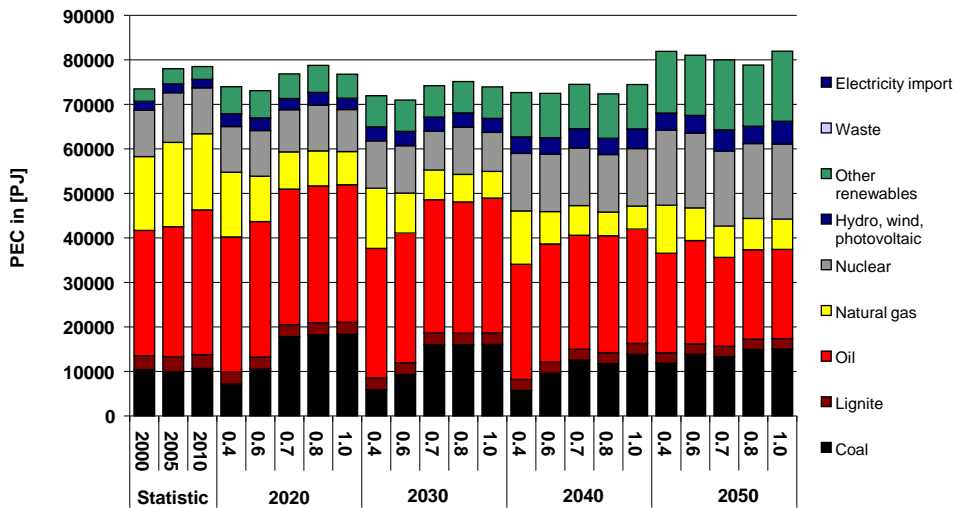
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## Final energy consumption in the CO2 scenario



## 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.**