



On the Interaction between Electricity Generation Technology Formation and Climate Policy Targets

—
A Hybrid CGE Modeling Approach

- Work in progress -

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Modeling Technology and Climate Change

Workshop at Kiel Institute for the World Economy, 15 October 2010



Agenda

1. Climate policy targets in Germany and the EU
2. The NEWAGE Model
3. Scenario specification
4. Discussion of model results



Current climate policies in the EU

- EU: 20-20-20 goals for 2020 [March 2007]
 - i. 20% (30%) reduction of GHG-emissions below 1990 levels
 - ii. 20% renewable energies share in EU energy consumption
 - iii. 20% reduction of primary energy use compared with projected levels (increase energy efficiency)

- EU's 'Climate and Energy Package' [April 2009]:
 - i. Emissions Trading System (EU-ETS)
 - ii. Effort Sharing Decision for non-EU-ETS sectors
 - iii. Binding national targets for renewable energies
 - iv. Legal framework for carbon capture and storage technologies (CCS)



Current climate policies in Germany

- Climate policy targets until 2020 within the ‘Integrated Climate and Energy Programme’ [IEKP, Aug 2007] :
 - i. 40 % reduction of GHG emissions (1990 base)
 - ii. 30 % renewables share in electricity generation
 - iii. 14 % renewables share in heat generation
 - iv. Double up energy productivity (1990 base)
- Concrete measures/laws within IEKP:
 - i. Includes: combined heat and power, Grid, Buildings, Biofuels, etc.
- Recently published Energy Concept [Sept 2010]



The German government's Energy Concept [Sept 2010]

- Long-term strategy for future energy supply (2050 perspective)
 - i. Extension of nuclear power operation periods in average by 12 years
 - ii. Climate policy targets:

	2020	2030	2040	2050
GHG-Emissions (1990 base)	- 40%	- 55%	- 70%	- 80%
Electricity consumption (2008 base)	- 10%	./.	./.	- 25%
Primary energy consumption (2008 base)	- 20%	./.	./.	- 50%
Final energy consumption in the transport sector (2008 base)	- 10%	./.	./.	- 40%
Renewables share in final energy consumption	18%	30%	45%	60%
Renewables share in electricity consumption	35%	50%	65%	80%

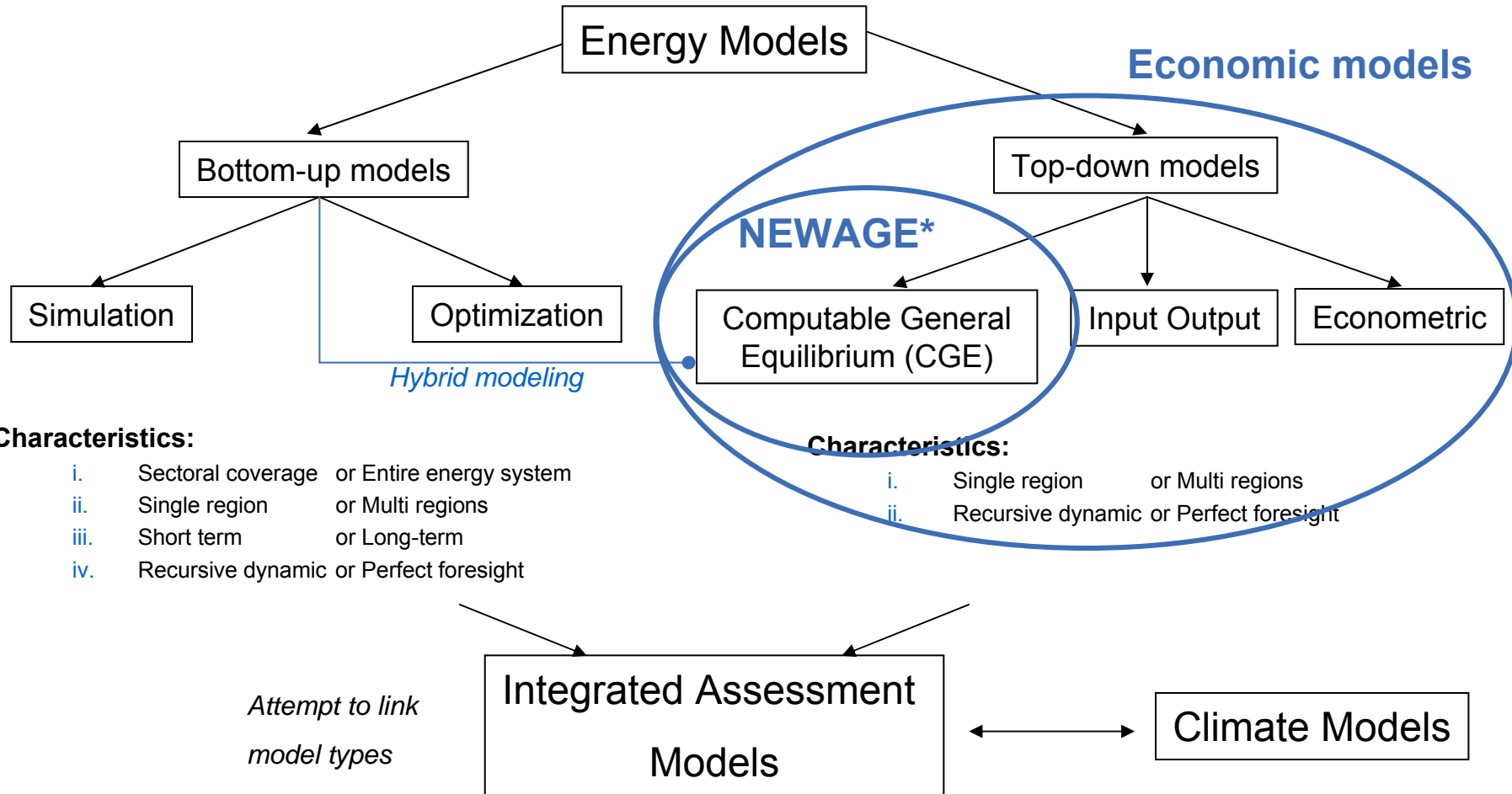


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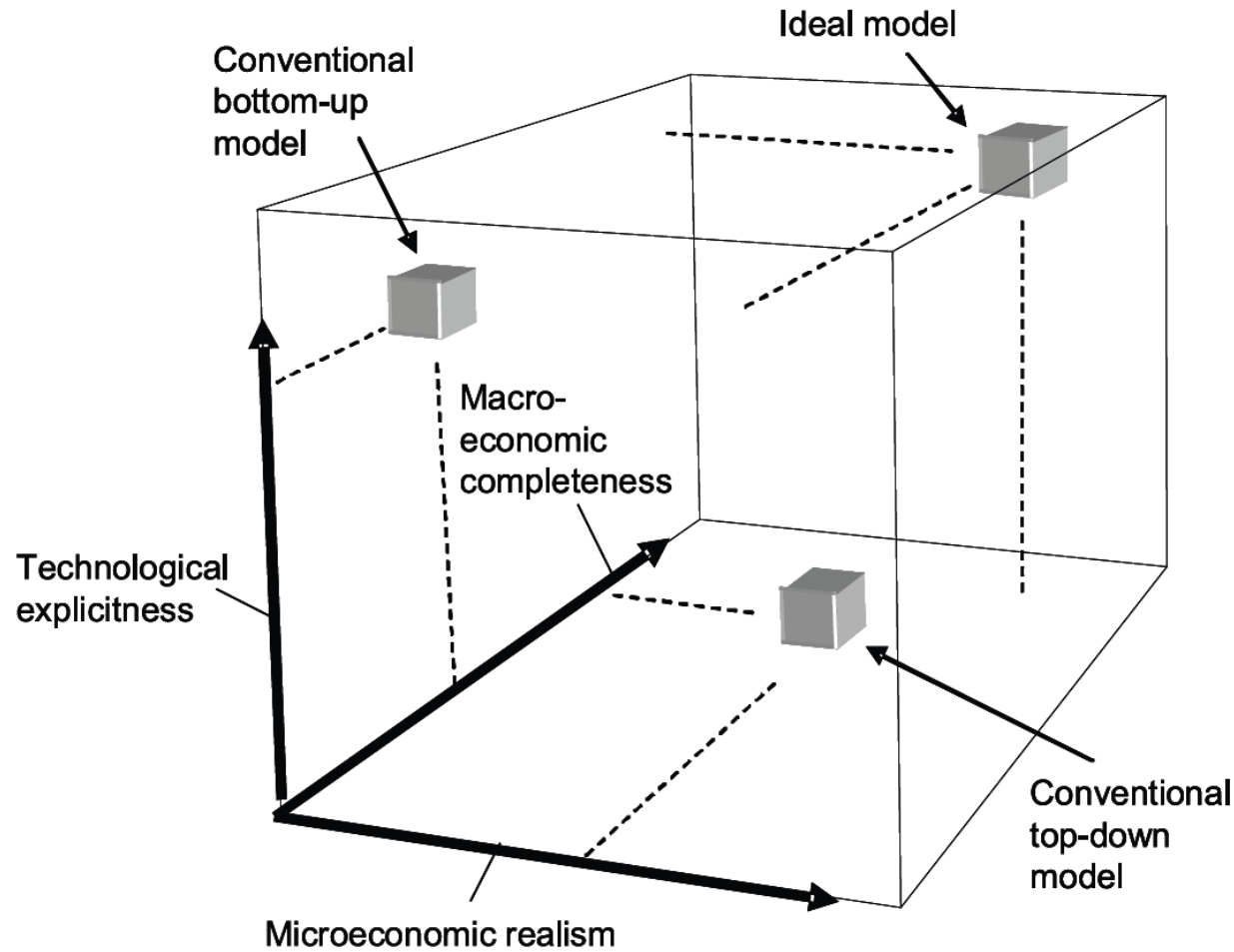


Categories of Energy Models



*NEWAGE = National European Worldwide Applied General Equilibrium

Hybrid modeling: CGE with technological details



Three-dimensional Assessment of Energy-economy Models (Hourcade et al., 2006, Figure 1)



NEWAGE: Concept and Composition

Special / hybrid features:

Imperfect Labor Market:

Rigid wages, wage curve
Differentiation by qualification (skilled, unskilled)

Electricity Generation:

Technology based modeling: portfolio with 18 generation options

Dynamics:

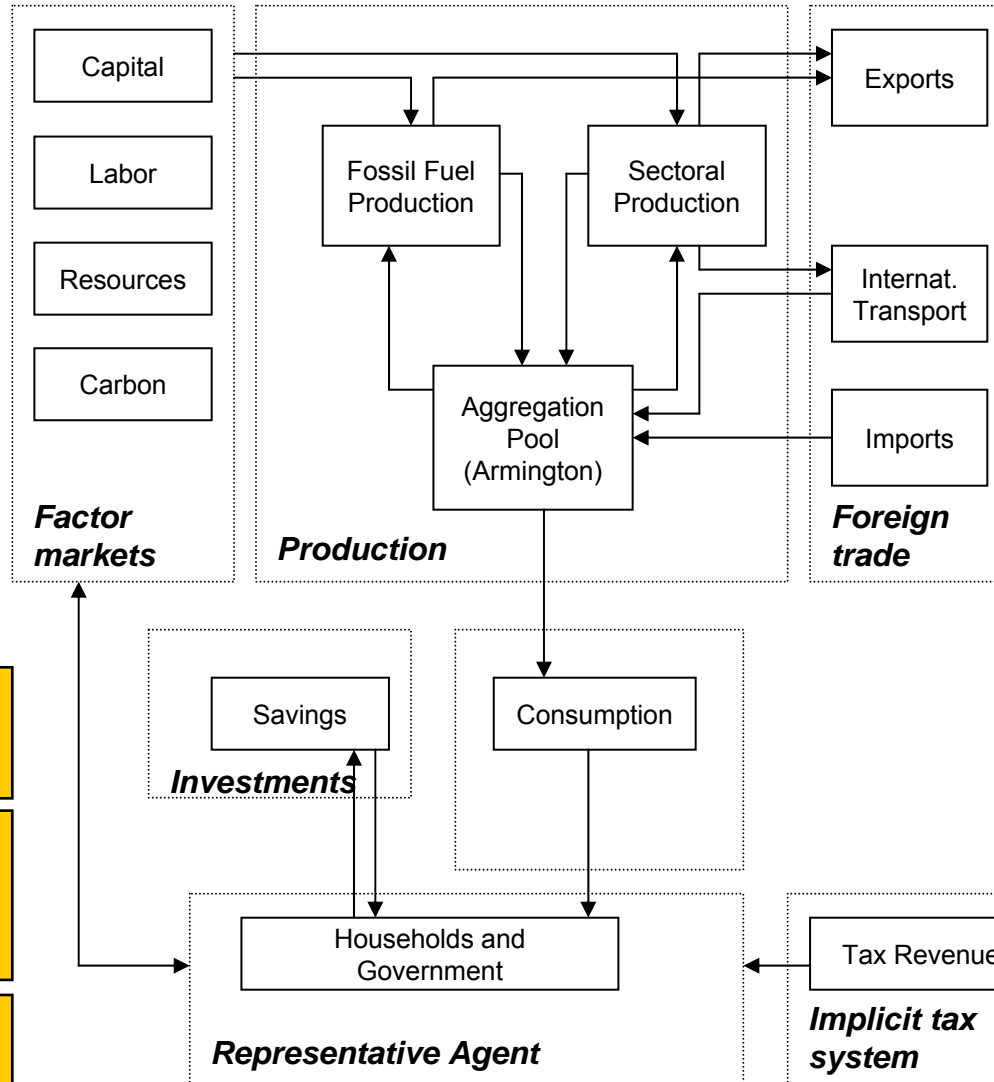
Recursive-dynamic, 2004-2050, 5-year steps

Technological Change:

Autonomous energy efficiency index (AEEI)

Data:

GTAP7, IEA, et al.



16 sectors:

Coal, Gas, Crude oil, Mineral oil, Electricity

Chemicals, Metals, Iron & steel, Minerals, Pulp & paper, Machinery, Rest of industry

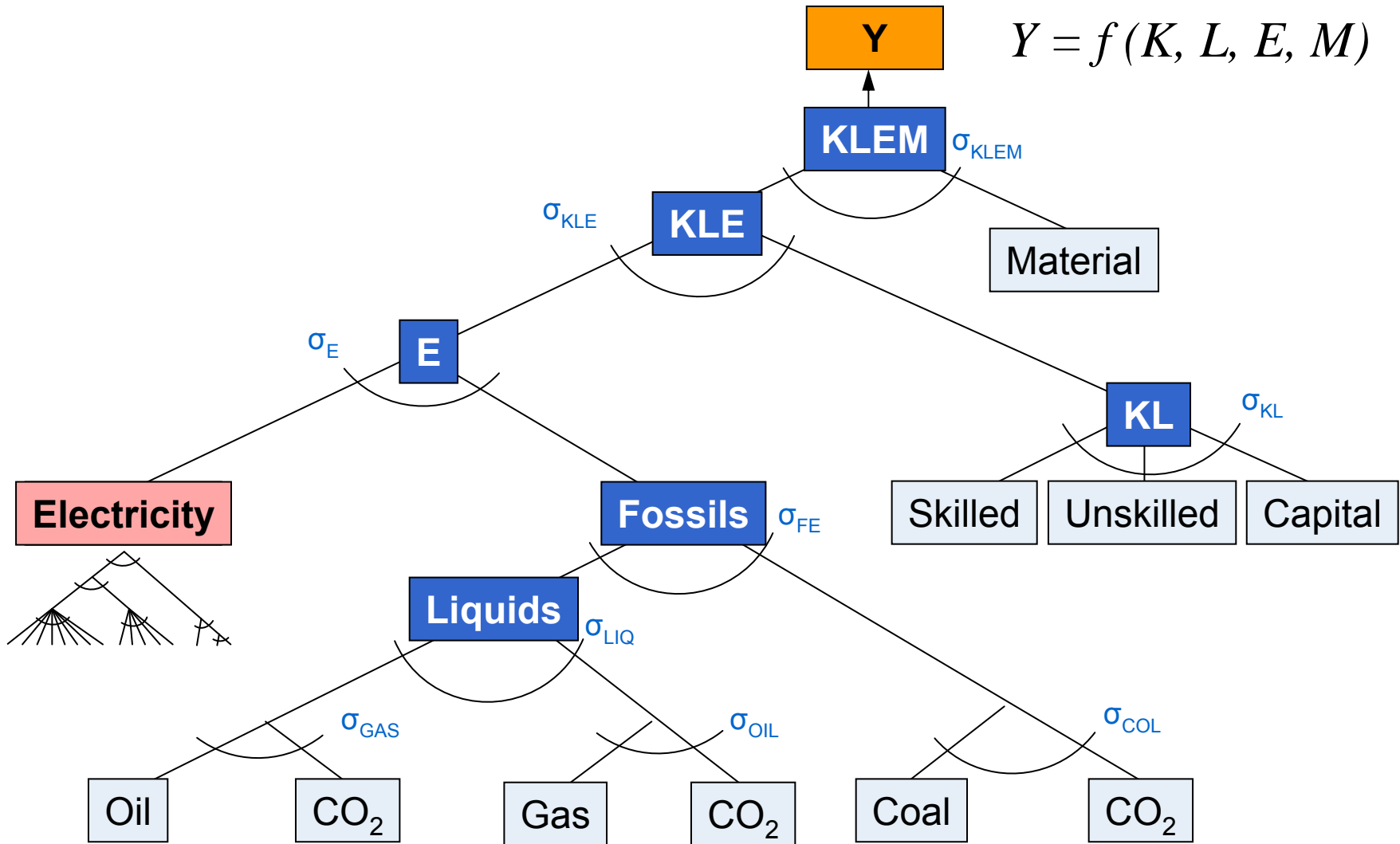
Construction & Building
Transport
Agriculture
Services

10 regions:

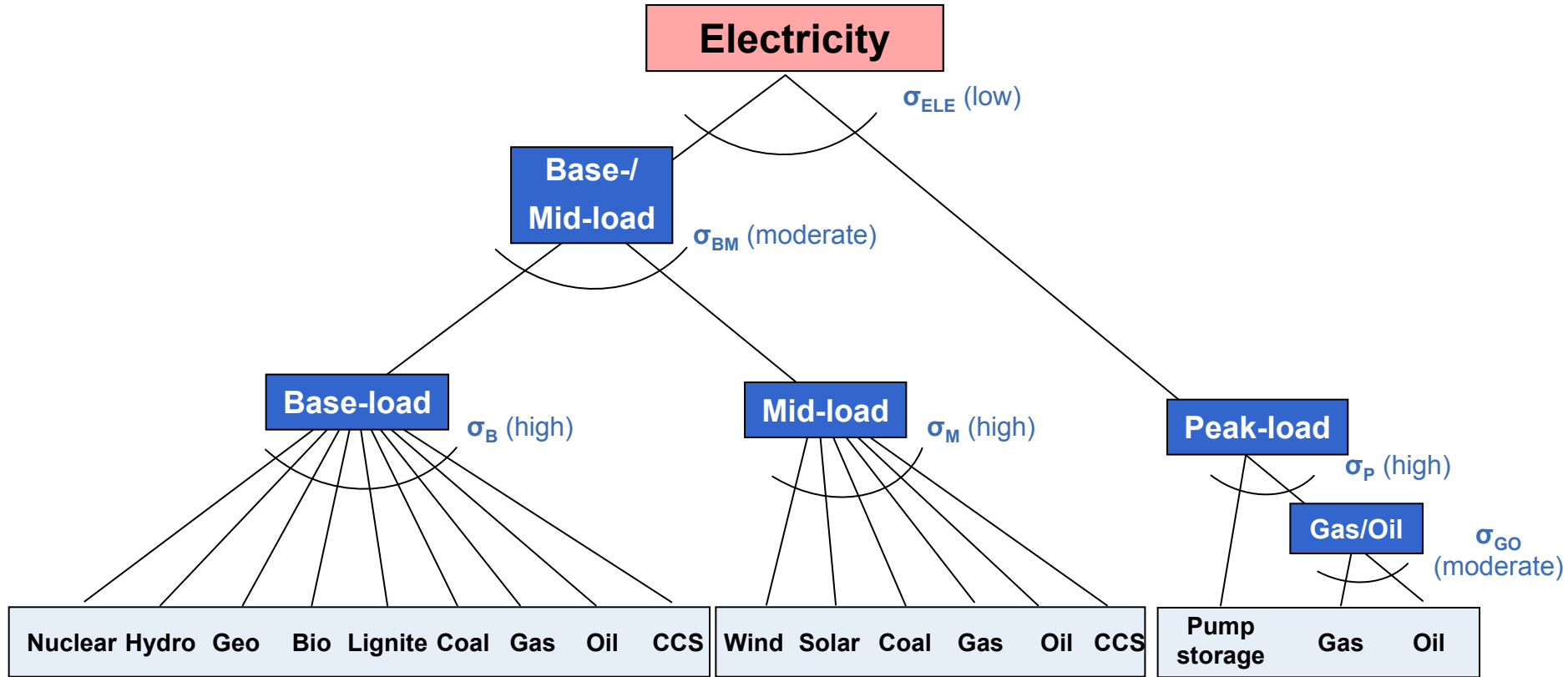
Germany
EU-15 (w/o Germany)
NMS-12
Other Europe Annex-B
Rest of Annex-B
Russia
USA
China + India
OPEC
Rest of world



NEWAGE: Nesting of CES Production Functions



Nesting for Technology Specific Electricity Generation





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Scenario specification for NEWAGE calculations

- Scenario matrix:**

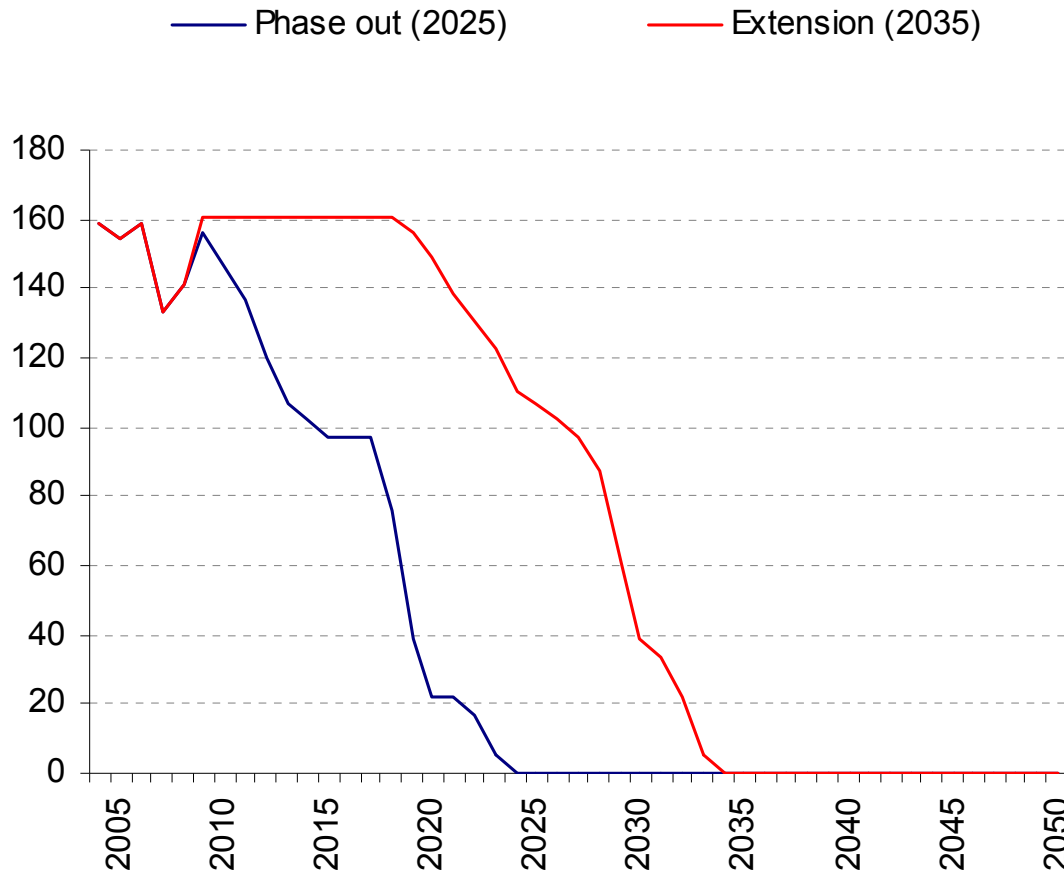
*Renewables share in
Germany (2020-2050)*

		No target	35% - 80%
<i>Nuclear power operation periods</i>	Phase out (2025)	(A) Baseline	(C) Green
	Extension (2035)	(B) Conservative	(D) Energy Concept

- Work in progress: (A) and (B) completed; (C) and (D) to be accomplished



Path of nuclear power use in Germany (TWh/a)

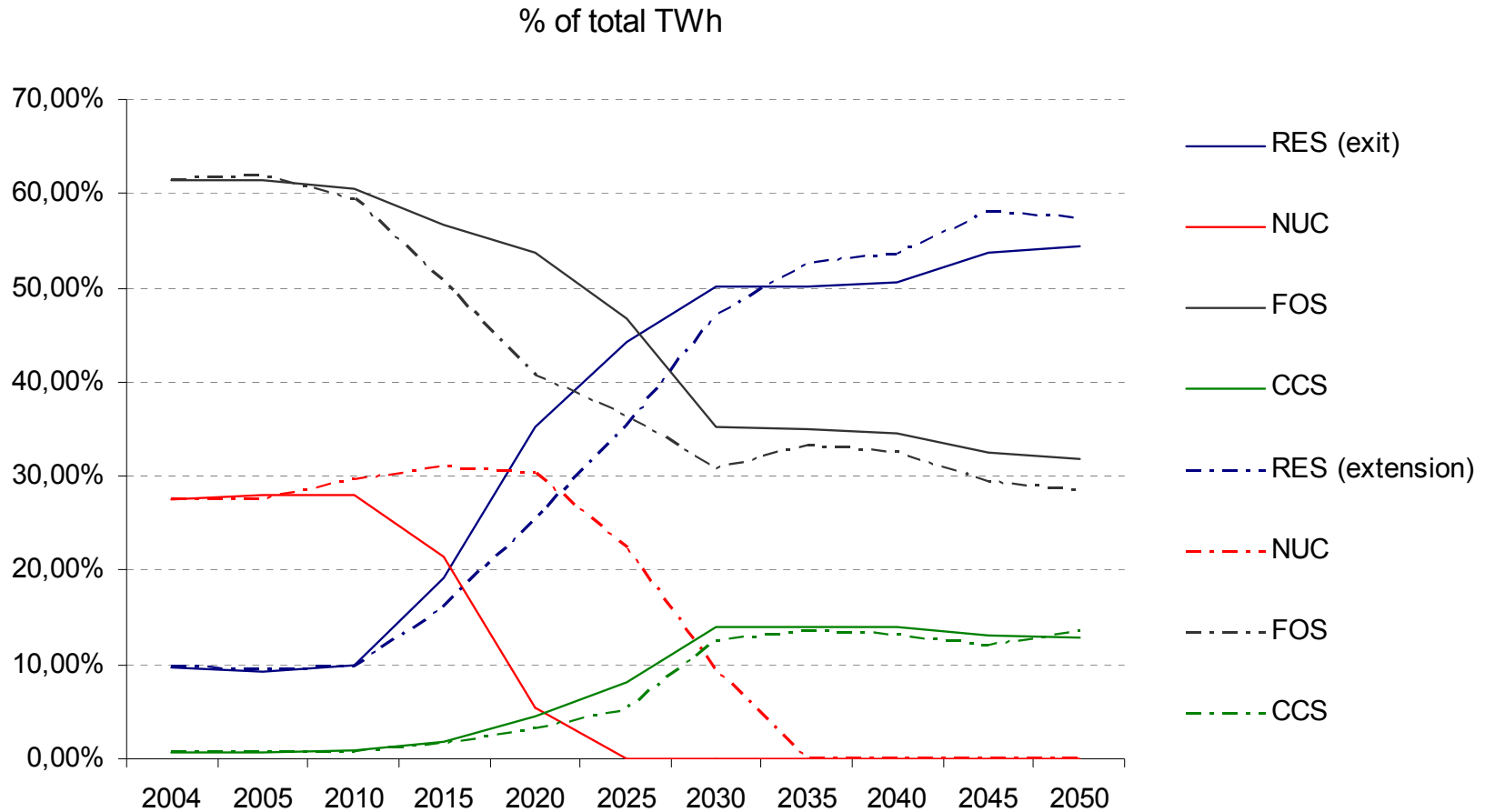




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Technology shares of electricity production in Germany

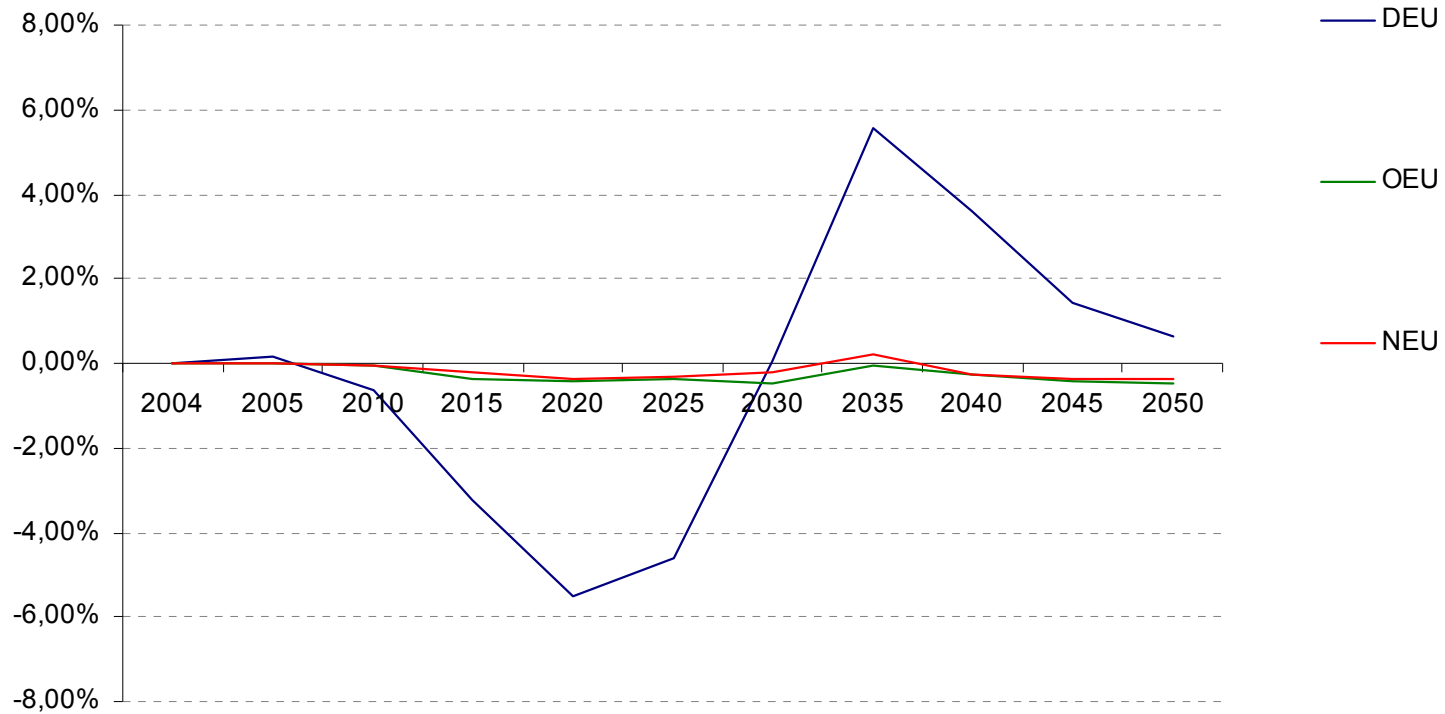


RES = Solar + Wind + Biomass + Geothermal + Hydro (w/o pump storage)

FOS = Coal + Gas + Oil

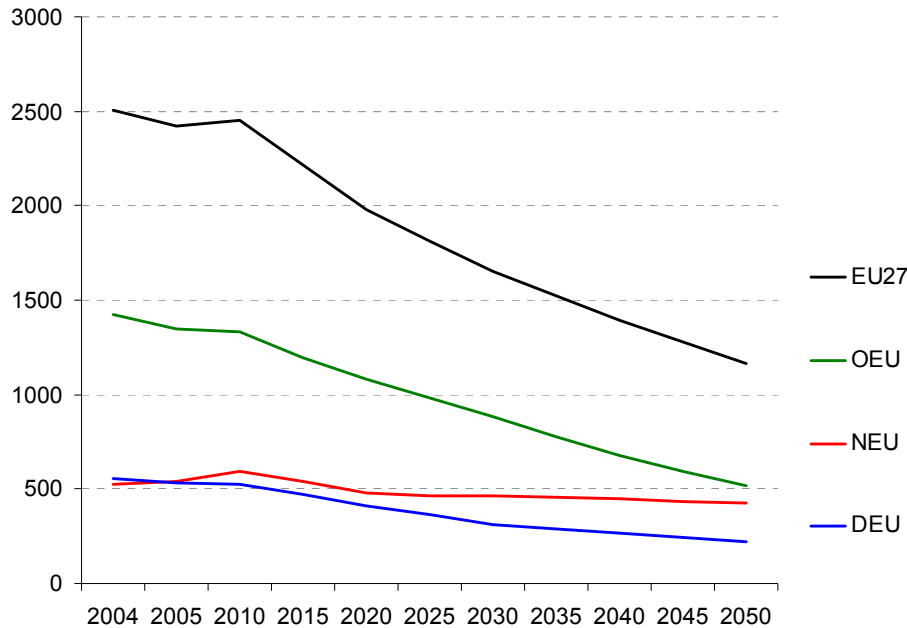
Electricity price

Relative difference of extension scenario

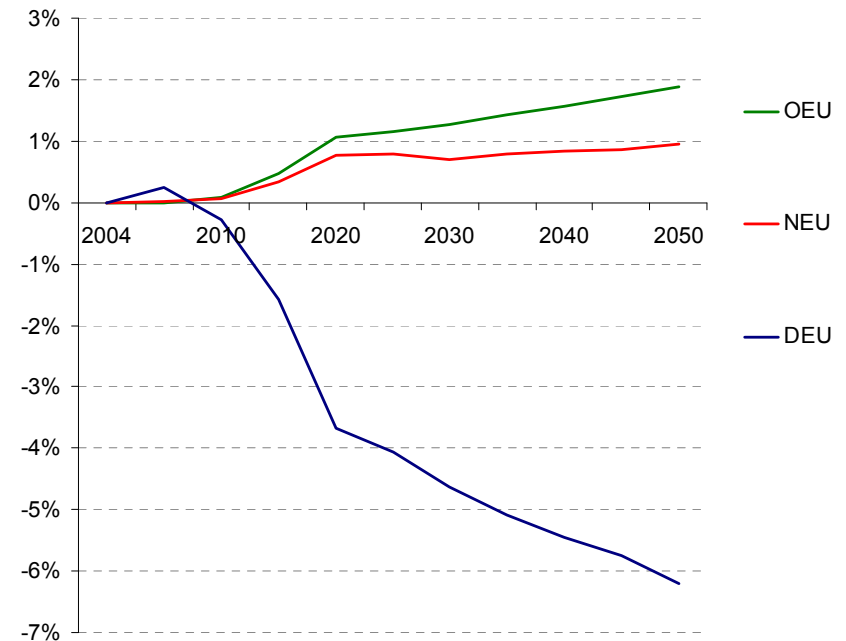


CO₂ emissions in the EU-ETS

Mio. t CO₂ (Phase out scenario)

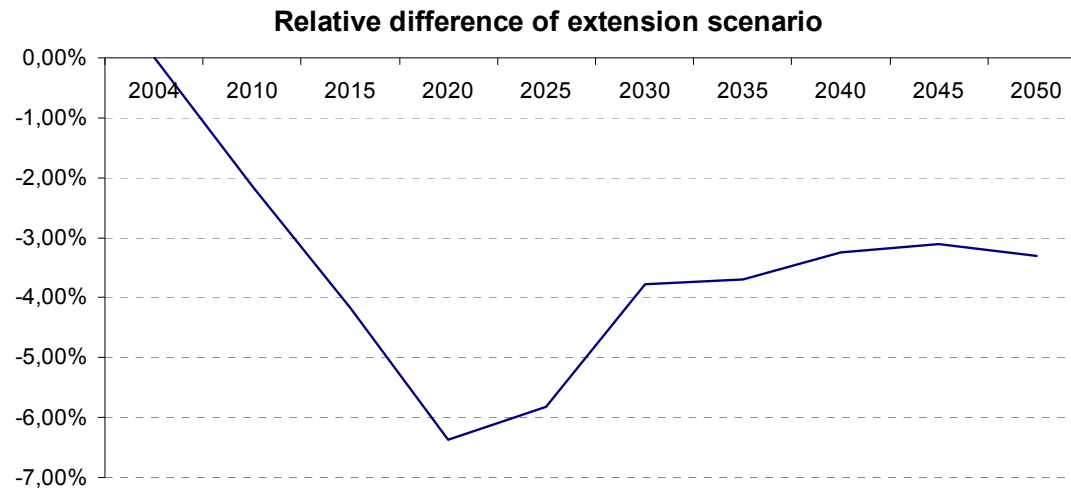
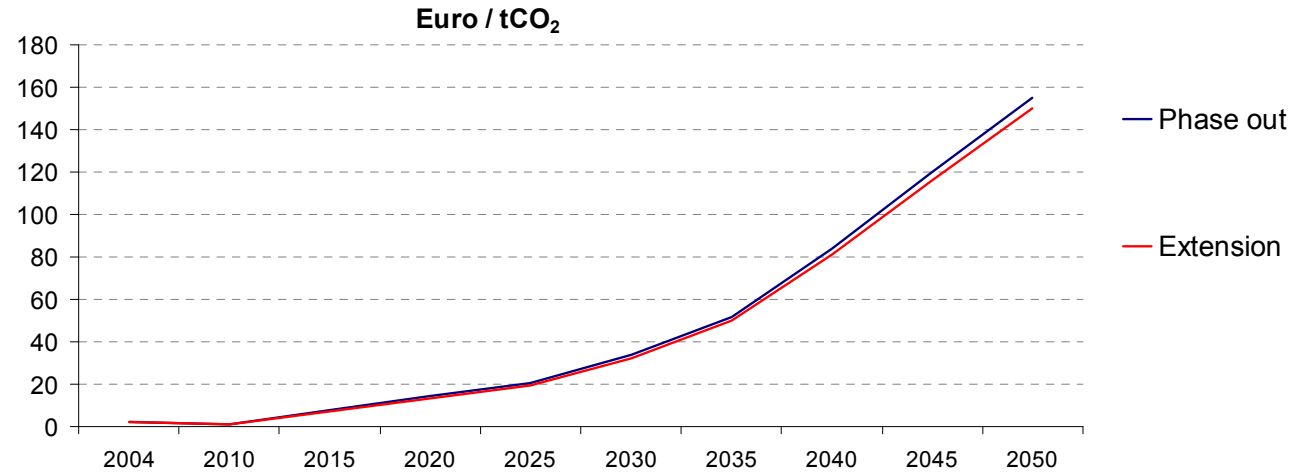


Relative difference of extension scenario



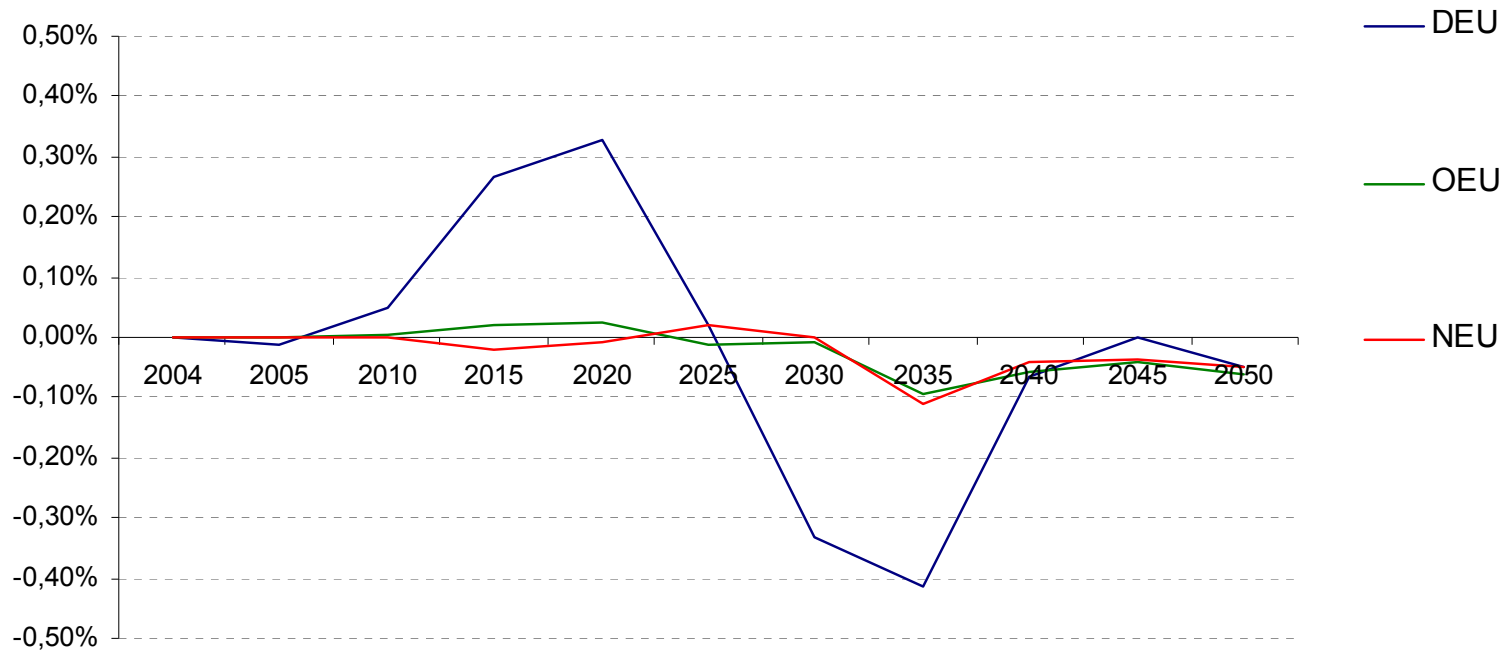


CO₂ prices in the EU-ETS



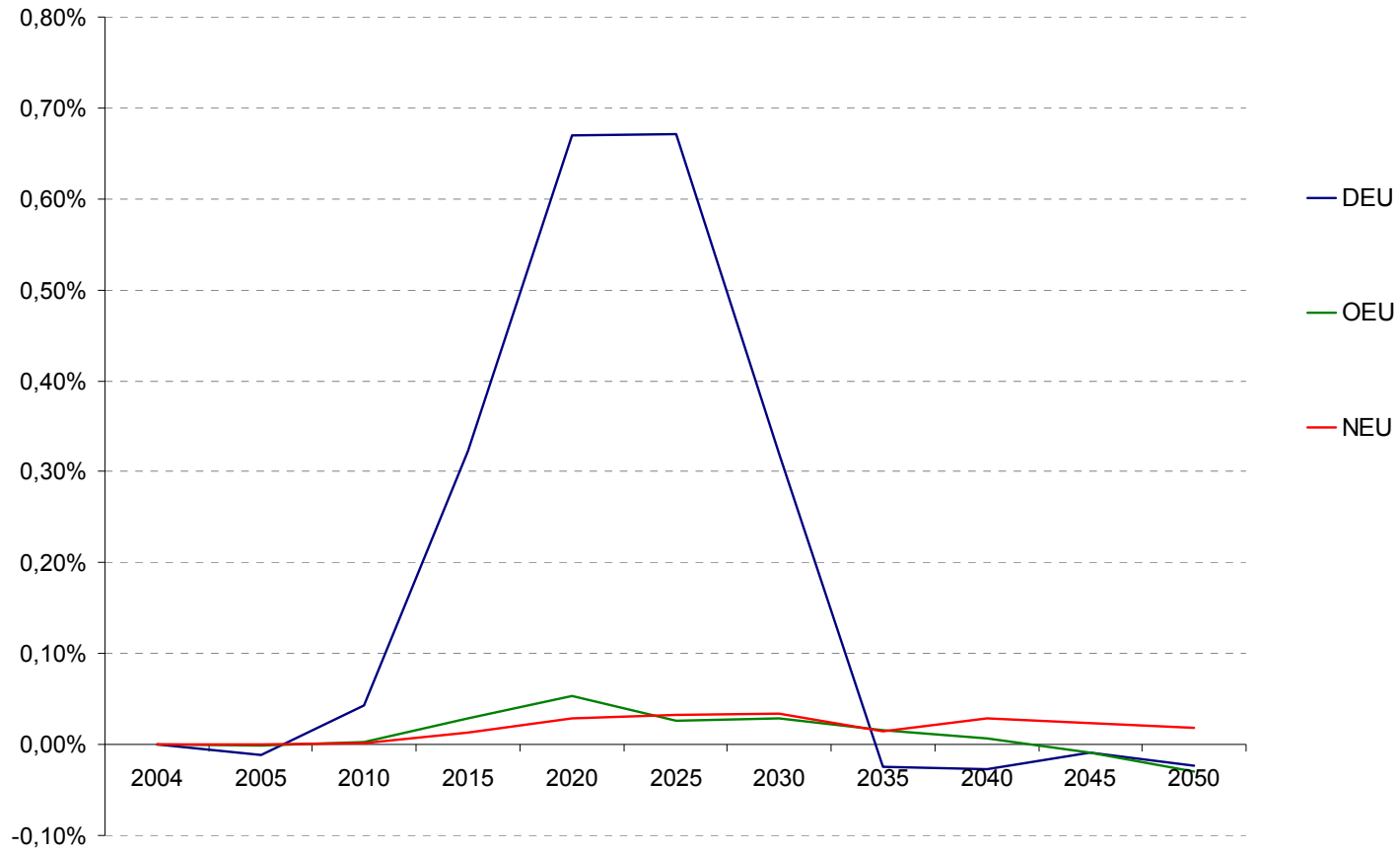
Difference in GDP growth per milestone

Difference of extension scenario (percentage points)



Welfare index (HEV)

Relative difference of extension scenario





Summary and conclusion

- Extension of nuclear power leads to
 - Higher renewables share in 2050
 - First lower, then higher electricity prices
 - Lower CO₂-Emissions in Germany, lower CO₂-Prices in EU-ETS
 - First higher than lower GDP growth per milestone, higher welfare
- The model results promote the extension of nuclear power plant operation periods
 - At least short to mid term (renewables not competitive before 2030?)
 - Cumulative benefits over the whole period (2004-2050) in terms of welfare, emissions
 - Little differences in 2050's electricity generation technology formation