HOW REALISTIC ARE ENERGY INVESTMENT MODELS? REFLECTING ON GERMAN POWER PLANT INVESTMENT DECISIONS BETWEEN 2005 AND 2014

KRISTINA GOVORUKHA[1], CHRISTOPHER BALL[2], STEFAN VÖGELE[2]

[1]TU BERGAKADEMIE FREIBERG[1]

[2]FORSCHUNGSZENTRUM JÜLICH, IEK-STE

JÜLICH Forschungszentrum

TRENDS IN GERMAN POWER SYSTEM

Policy interventions

1998-2005	2005-2012	2012-2020
• Liberalisation of the electricity market (1998, Energy Act) • Pro-renewables policy: Renewable Energy Sources Act – EEG (2000) • Announcement of nuclear phase out – effectively limiting the lifetime of power stations (2002, Atomgesetz) • EU directive on internal gas and single energy market (2003)	• Phase 1 and Phase 2 of EU ETS ❖ Low prices, “over allocation” and banking of permits • Extension of lifetime of nuclear plants (2010) • Fukushima accident: confirmation of nuclear phase out by 2022 (2011) Broad economic and energy market context: • Renaissance in coal and gas optimism • Global economic crisis • Volatility of global gas and coal prices	• Phase 3 of EU ETS (2013-2020): ❖ EU-wide emissions cap ❖ Auctioning, + sectors, Reserve • Net Reserve • Capacity Reserve • Security Standby Reserve (13g EnWG, 24.06.2016): ❖ Decommissioning of 2.7 GW lignite power plants from 2016 to 2019 • Nordstream 2 Gas pipeline project

OBJECTIVES OF THIS PAPER

- How accurately do investment models reflect actual investment decisions?
  - ➢ Inherent bias, insufficient system boundaries,“narrow assumptions“ (Trutnevyte, 2016)
  - ➢ Scenarios beset by uncertainties, especially over longer time-scale (Trutnevyte et al. 2016)

- Very basic linear optimization model

- Insights for predicting future investment in power plants, esp. large-scale plants that provide capacity

POWER MARKET INVESTMENT MODELS

Purpose and structure

- Dispatch models: capacity exogenous: modelling of the dispatch of electricity subject to different conditions, i.e. electricity prices, trading arrangements, fuel prices and exchange rates

- Investment models: capacity is endogenous & optimised within the model

- Certain models deal with both dispatch and capacity - i.e. extended EMME model, EMMA model (Lion Hirth)

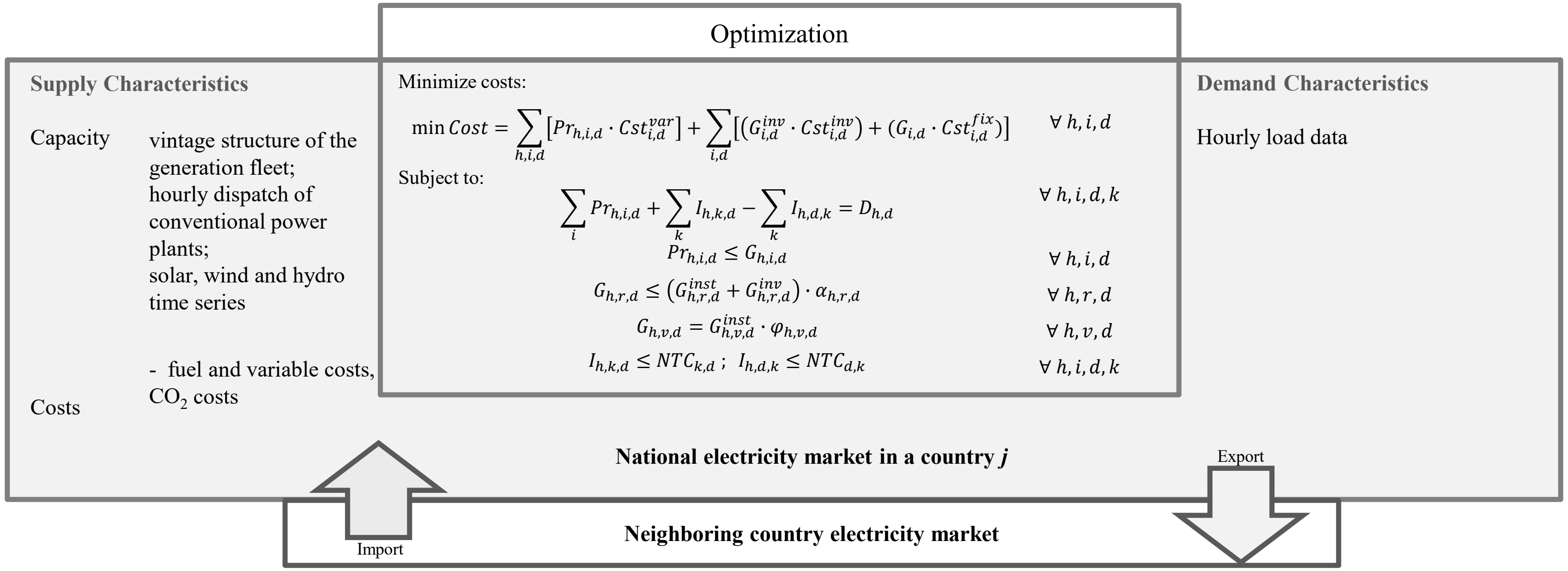
- Demand is exogenous in adapted EMME model

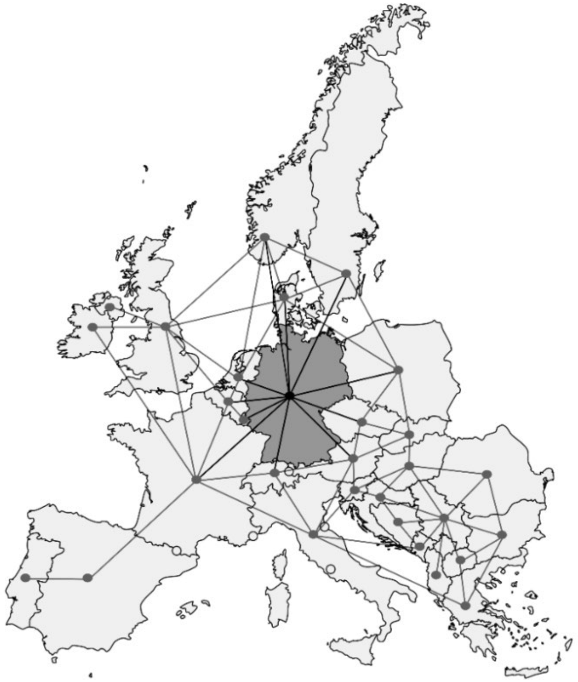
ELECTRICITY MARKET MODEL FOR EUROPE (EMME)

Linear electricity market optimisation dispatch and investment model

Key facts:

- 28 EU countries
- Investment in fossil fuel power plants: gas, hard coal, lignite
- Optimisation of dispatch and investment decision hourly [8760 hour





Schematic representation of the countries considered and cross-border interconnections in the model

JÜLICH Forschungszentrum

LCOE MODEL

- LCOE as decision making metric
- Average cost per unit of electricity a power plant requires to break even
- Technology bundles configured to provide certain level of constant generation
- Relative LCOEs of the technologies within a particular bundle: indicating preference for a particular technology

LCOE Calculation

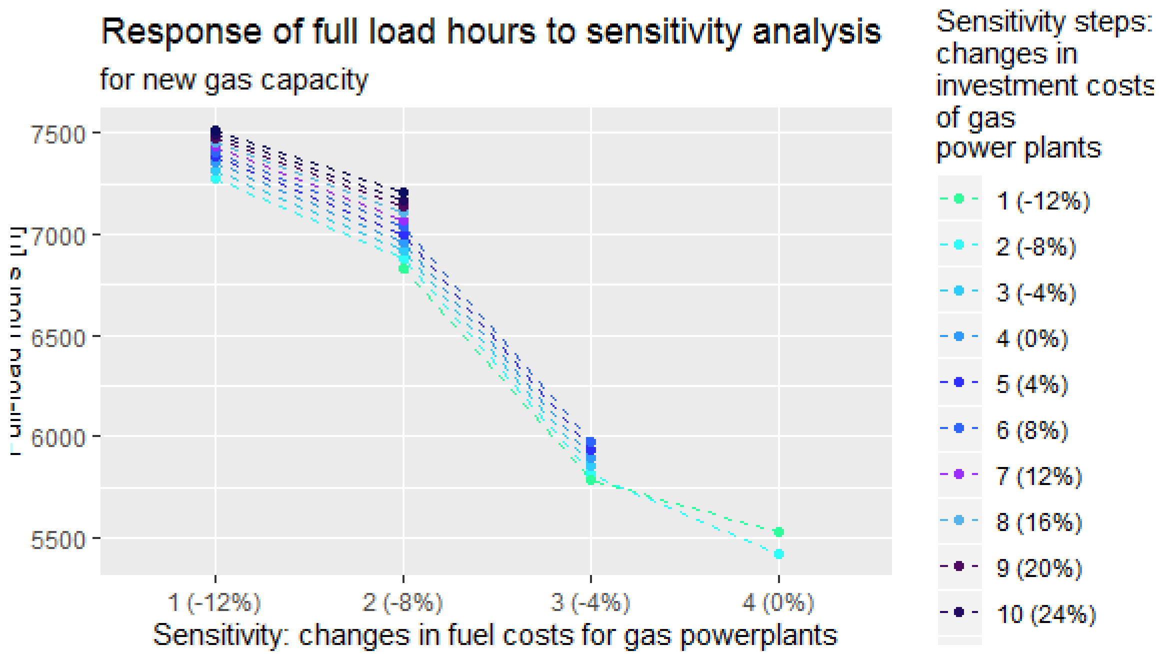
$$\frac{\sum_{0}^{t=0} \frac{C_0}{(1+r)^t} + \sum_{1}^{t=n} \frac{O\&M + VC + DC}{(1+r)^t}}{\sum_{1}^{t=n} \frac{MWh}{(1+r)^t}}$$

- C_0 : Investment Cost
- r: Discount rate
- t: Years of operation
- O&M: Operating and maintenance costs
- VC: Variable costs including fuel costs
- DC: Decommissioning costs

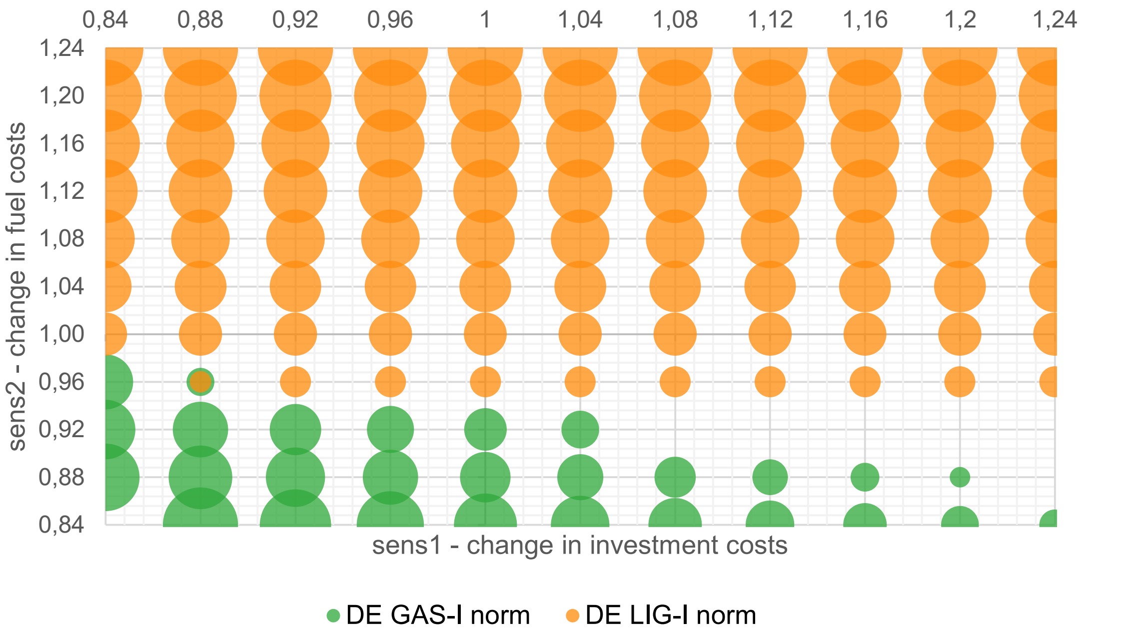
APPROACH WITHIN PAPER

- Coal vs. CCGT
- 1)Determine newly installed capacities and FLH within the EMME model through varying fuel and investment costs
- 2) Newly installed capacities and FLH from EMME model then entered into LCOE model
- LCOEs of coal vs. gas-fired power plants in a technology bundle
- 3)Comparison of results from both models with what was actually built in Germany between 2005 and 2014

WHAT THE MODELS PREDICT: EXTENDED EMME



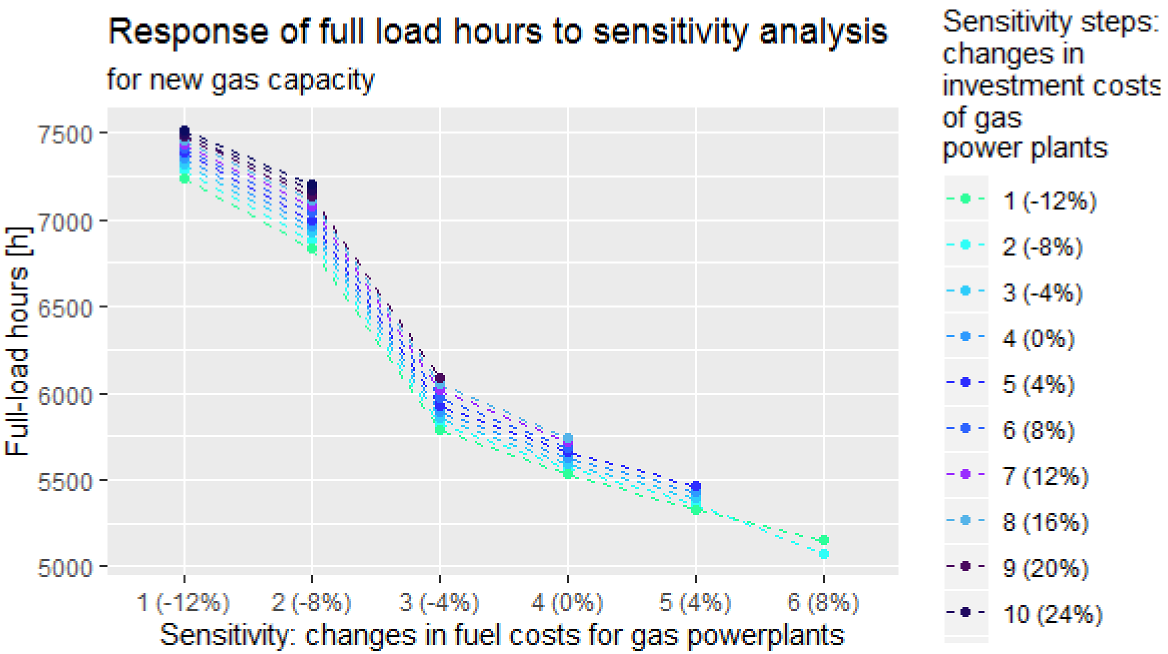
Sensitivity of gas and lignite FLH to variations in fuel and investment costs

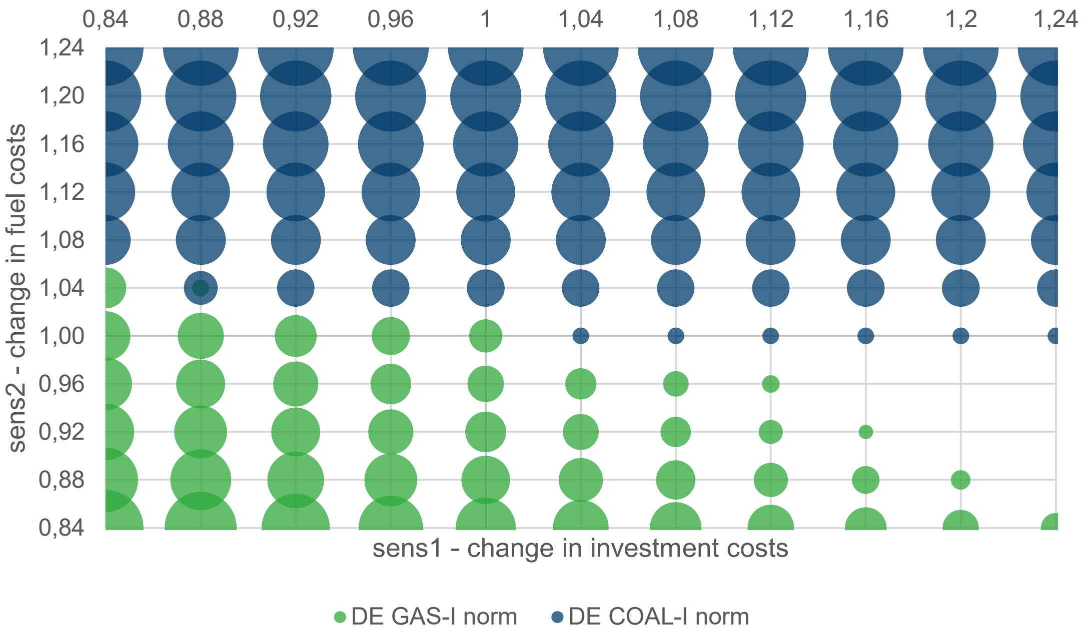


Sensitivity of gas and lignite capacities to variations in fuel and investment costs

JÜLICH Forschungszentrum

WHAT THE MODELS PREDICT: EXTENDED EMME

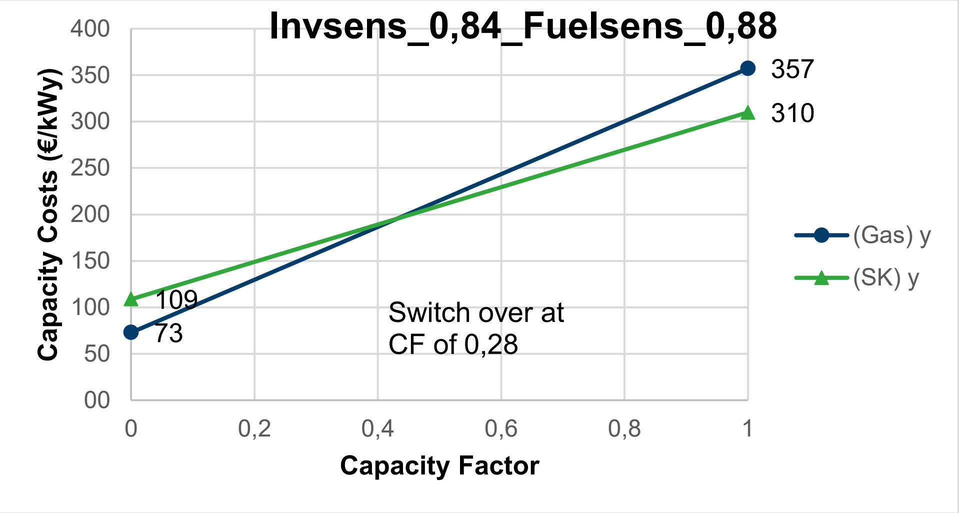


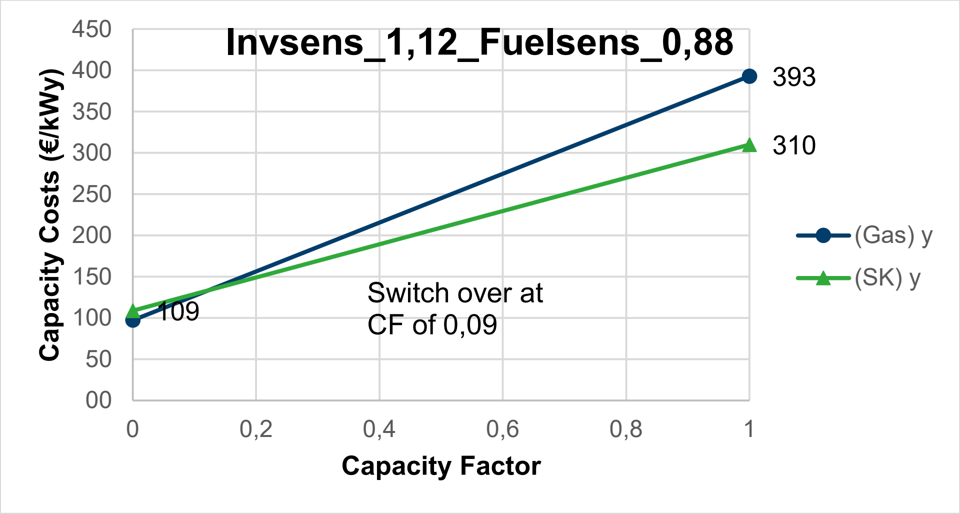


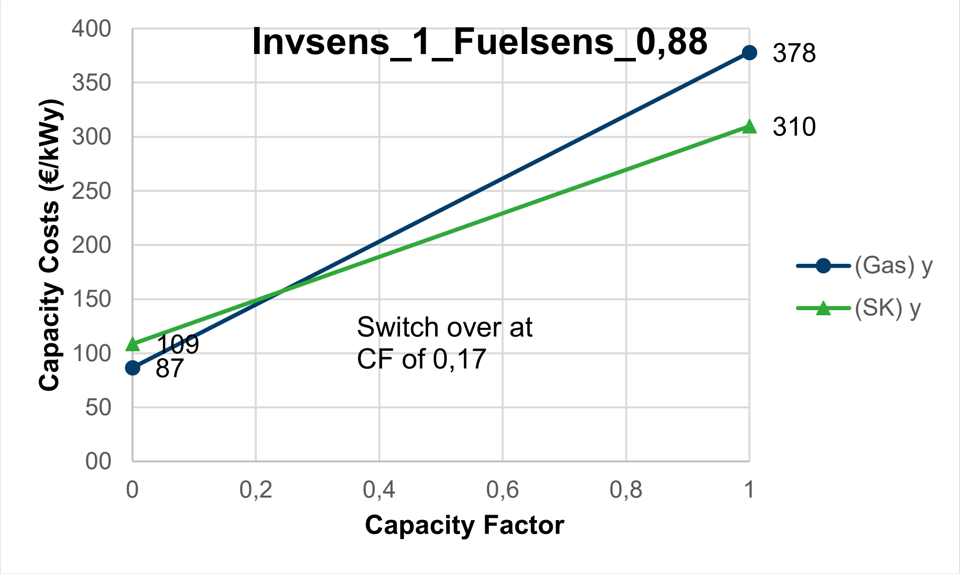
Sensitivity of Gas and Hard Coal FLH to variations in fuel and investment costs

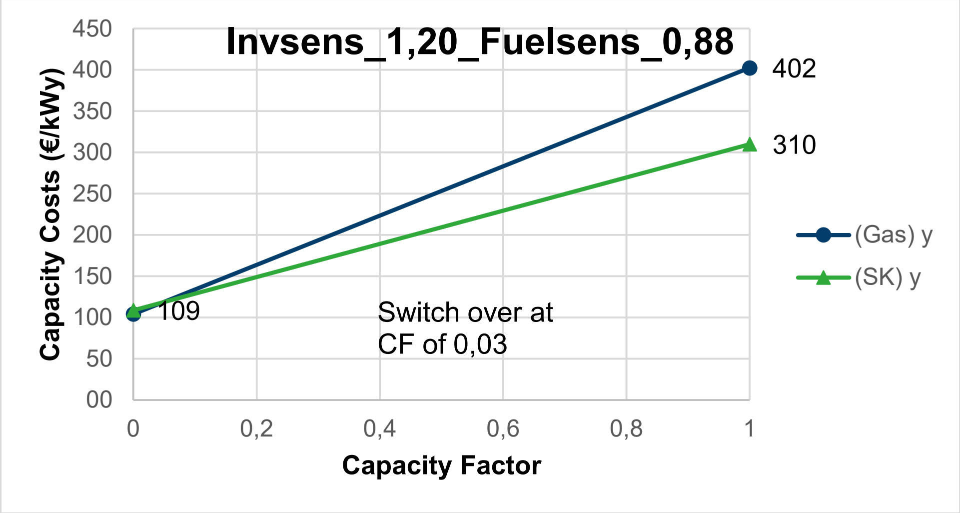
Sensitivity of Gas and Hard Coal capacities to variations in fuel and investment costs

LCOE MODEL: INVESTMENT SENSITIVITIES



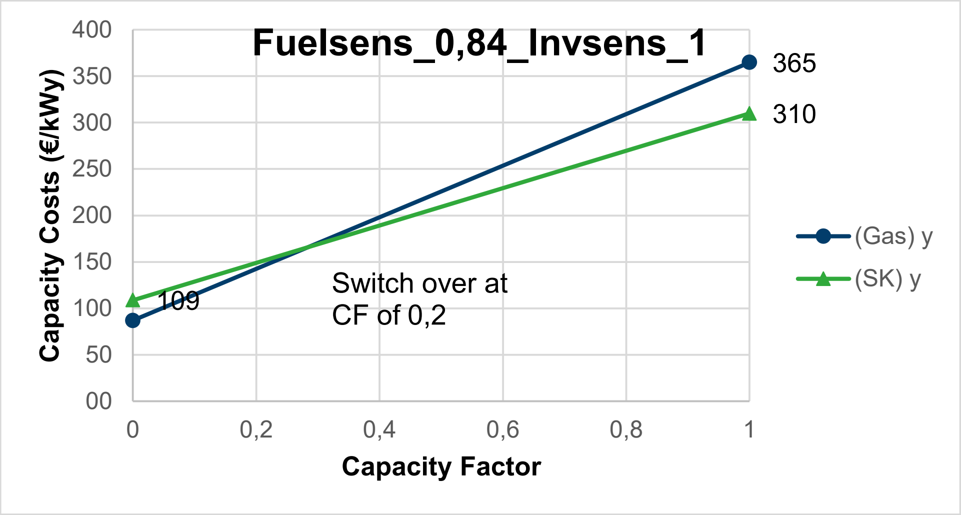


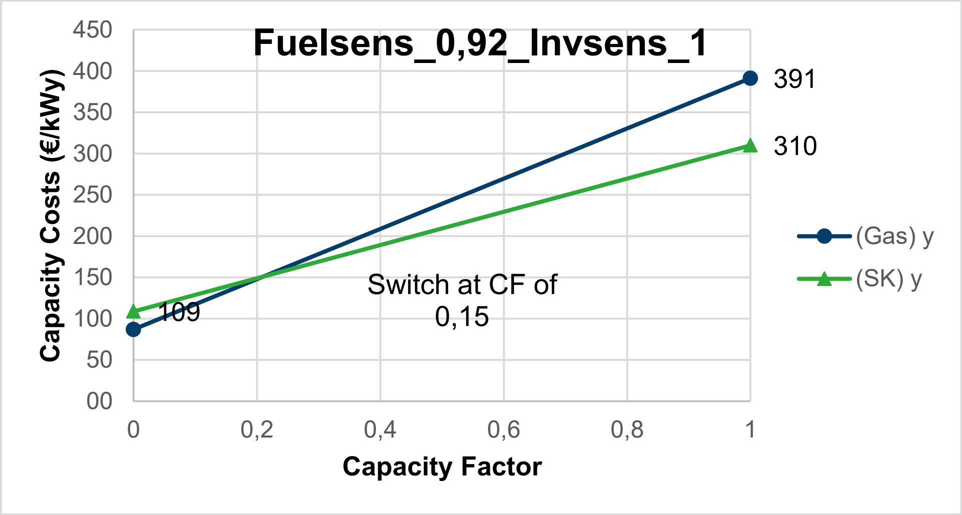


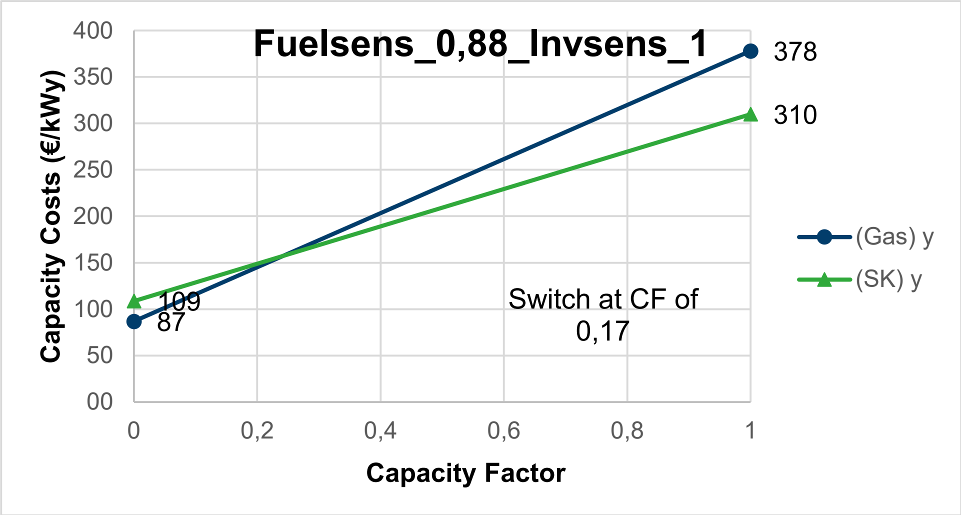


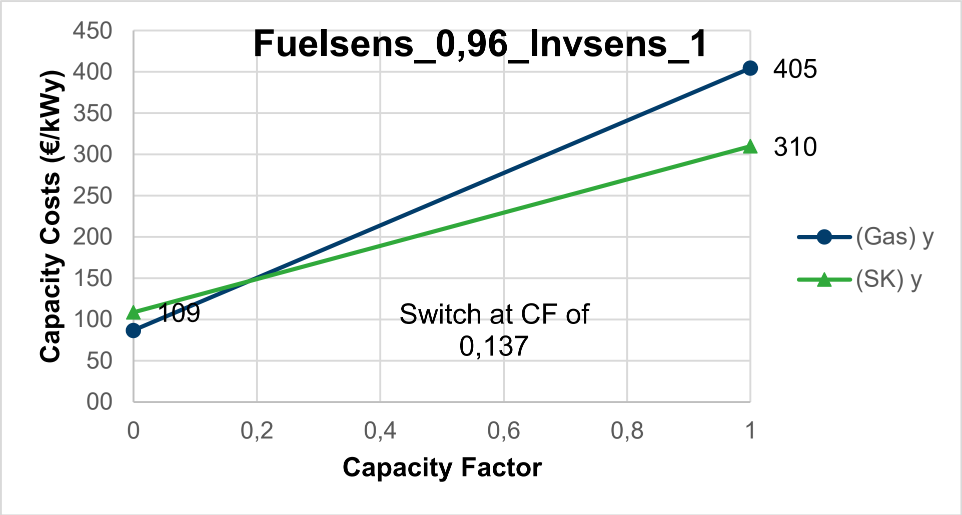
JÜLICH
Forschungszentrum

LCOE MODEL: FUEL SENSITIVITIES



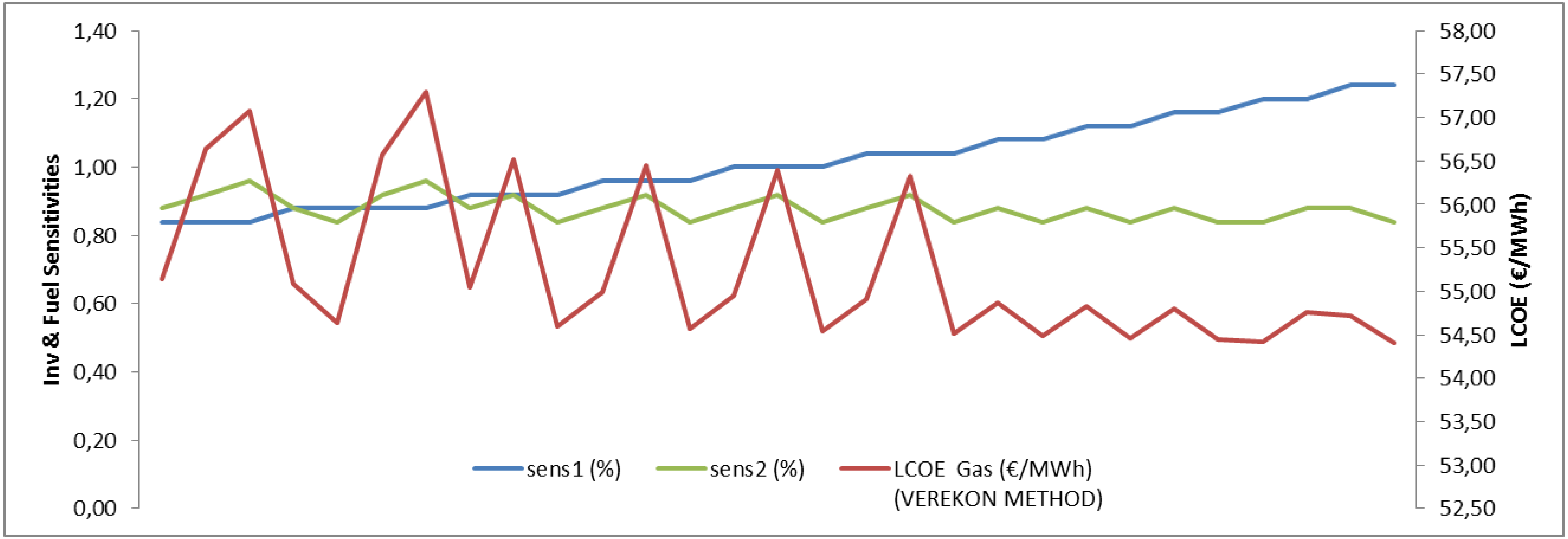






WHAT THE MODELS PREDICT: LCOE MODEL

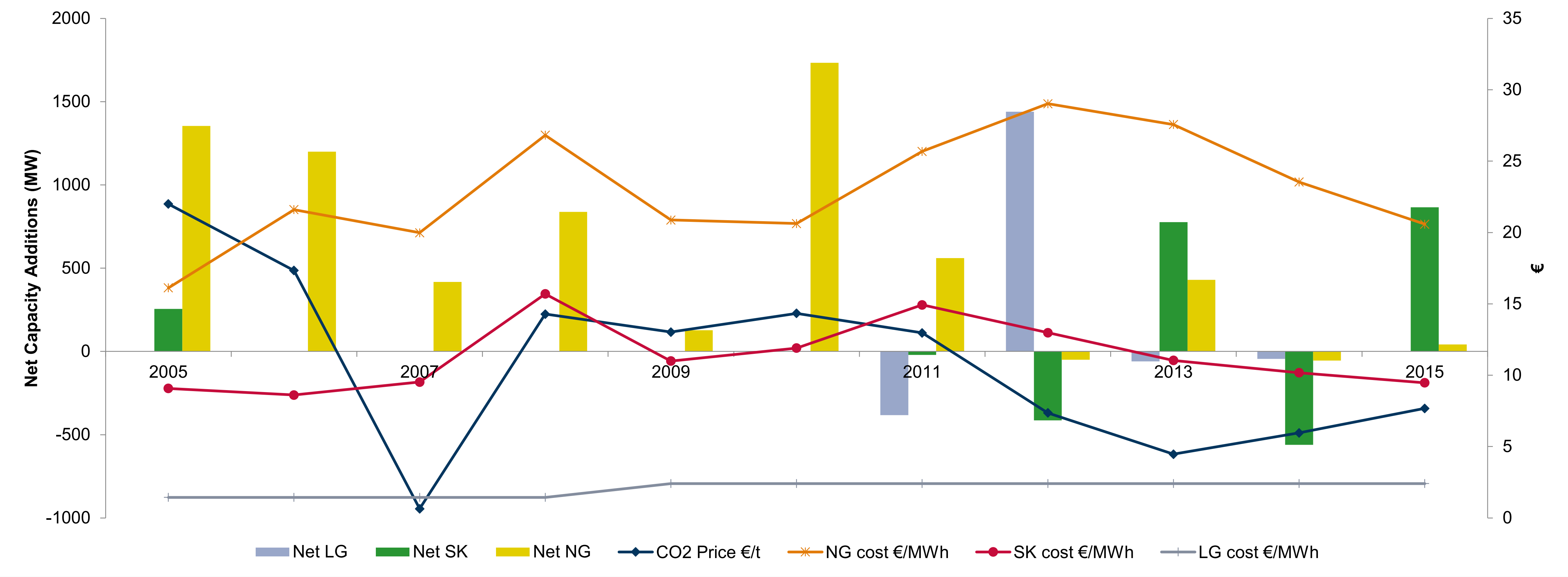
From a certain limit, a decrease in fuel costs loses its impact in comparison to an increase in investment costs



JÜLICH Forschungszentrum

WHAT ACTUALLY OCCURRED

Net capacities added compared to fuel costs and costs for CO_2 certificates



CONCLUSIONS

- Sensitivity of investment decisions to fuel costs should be very high compared to investment costs
- Patterns are difficult to discern in terms of capacity additions
  - ❖Additions are sporadic
  - ❖Investment decisions opaque
- Hidden factors
  - ❖Role of ETS scheme
  - ❖Uncertainty re. movement of fuel prices
  - ❖Bounded rationality
  - ❖Hidden technological lock-ins (i.e. Pahle, 2010)

REFERENCES

Pahle, M. (2010). Germany's dash for coal: Exploring drivers and factors. Energy Policy **38,** p.3431-3442

Trutnevyte, E. (2016). Does cost optimization approximate the real world energy transition? Energy **106**, p.182-293

Trutnevyte et al. (2016). Energy scenario choices: Insights from a retrospective review of UK energy futures. Renewable and Sustainable Energy Reviews, **55,** p.326-337