Political Shocks and Efficient Investment in Electricity Markets

by

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Our Paper …

- ◆ presents a detailed power market investment and dispatch model (LP) with consistent electricity price estimators

- ◆ illustrates the effects of political uncertainty

  - – using the example of the change in profit contribution

  - – for a specific CCGT-power plant

  - – due to the political decisions in Germany with respect to nuclear power

Nuclear Phase-Out (June 2000)
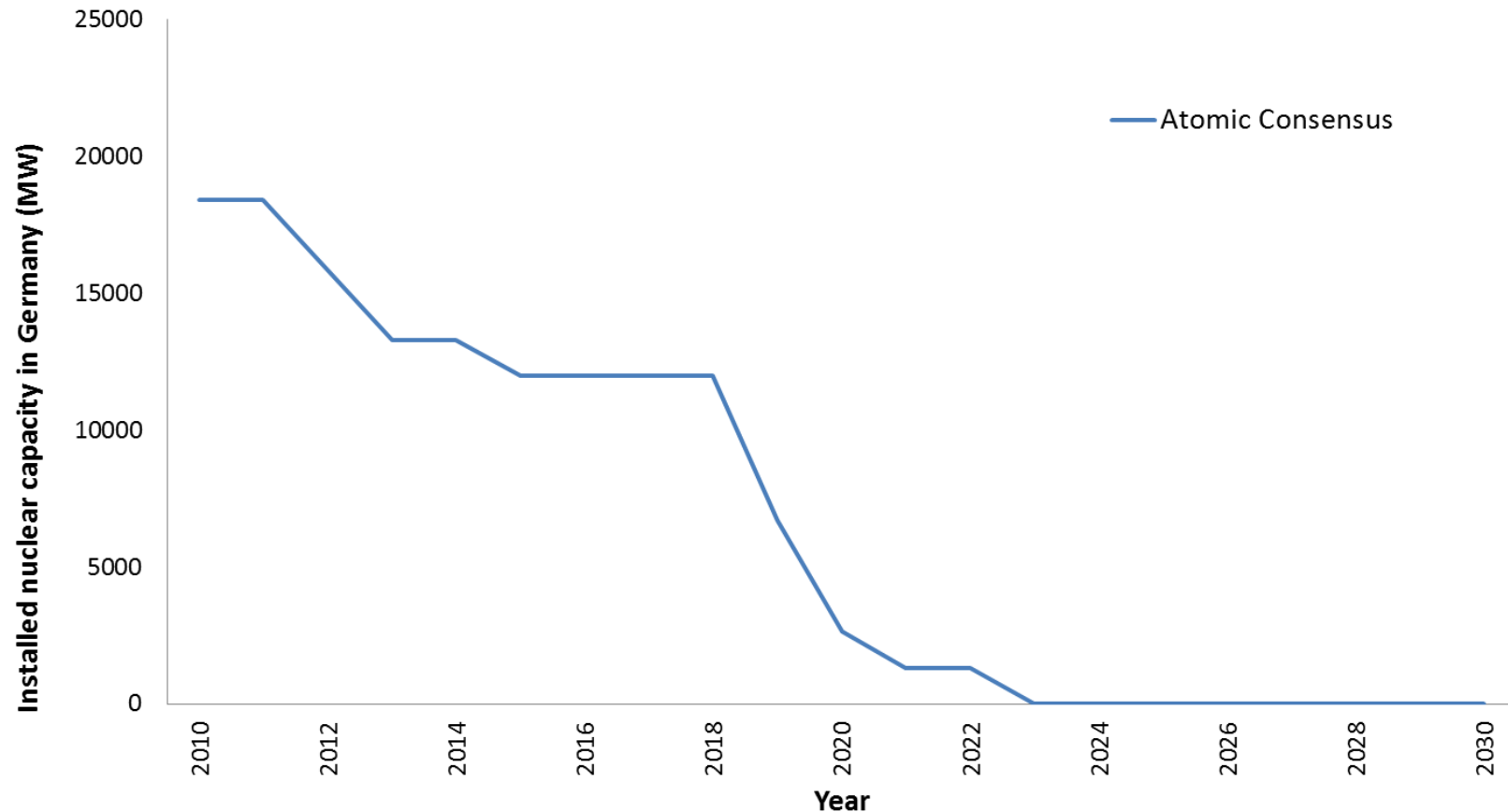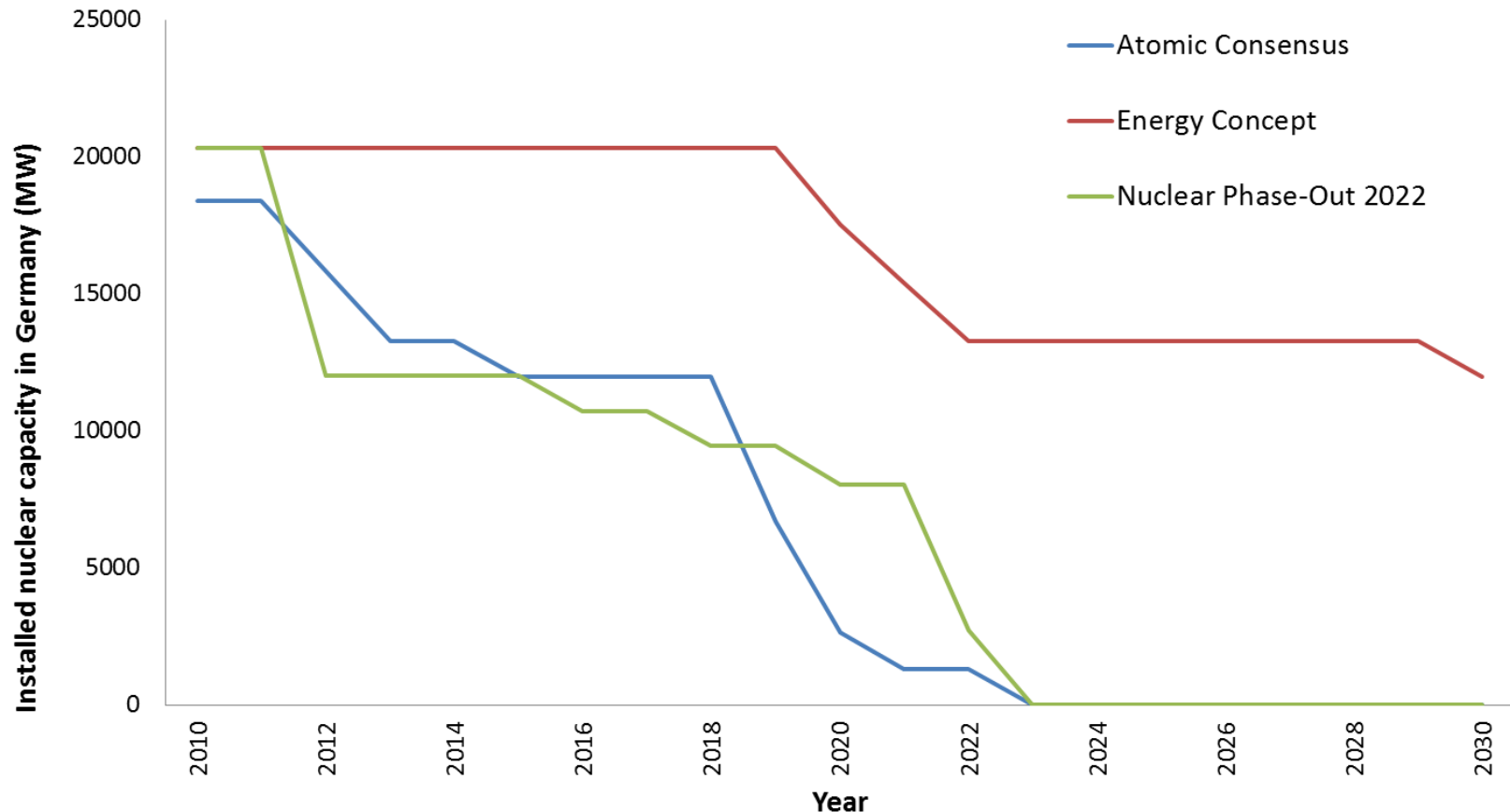

- Decided by red-green coalition government in June 2000
- An average of 32 years of operation for nuclear power plants in Germany
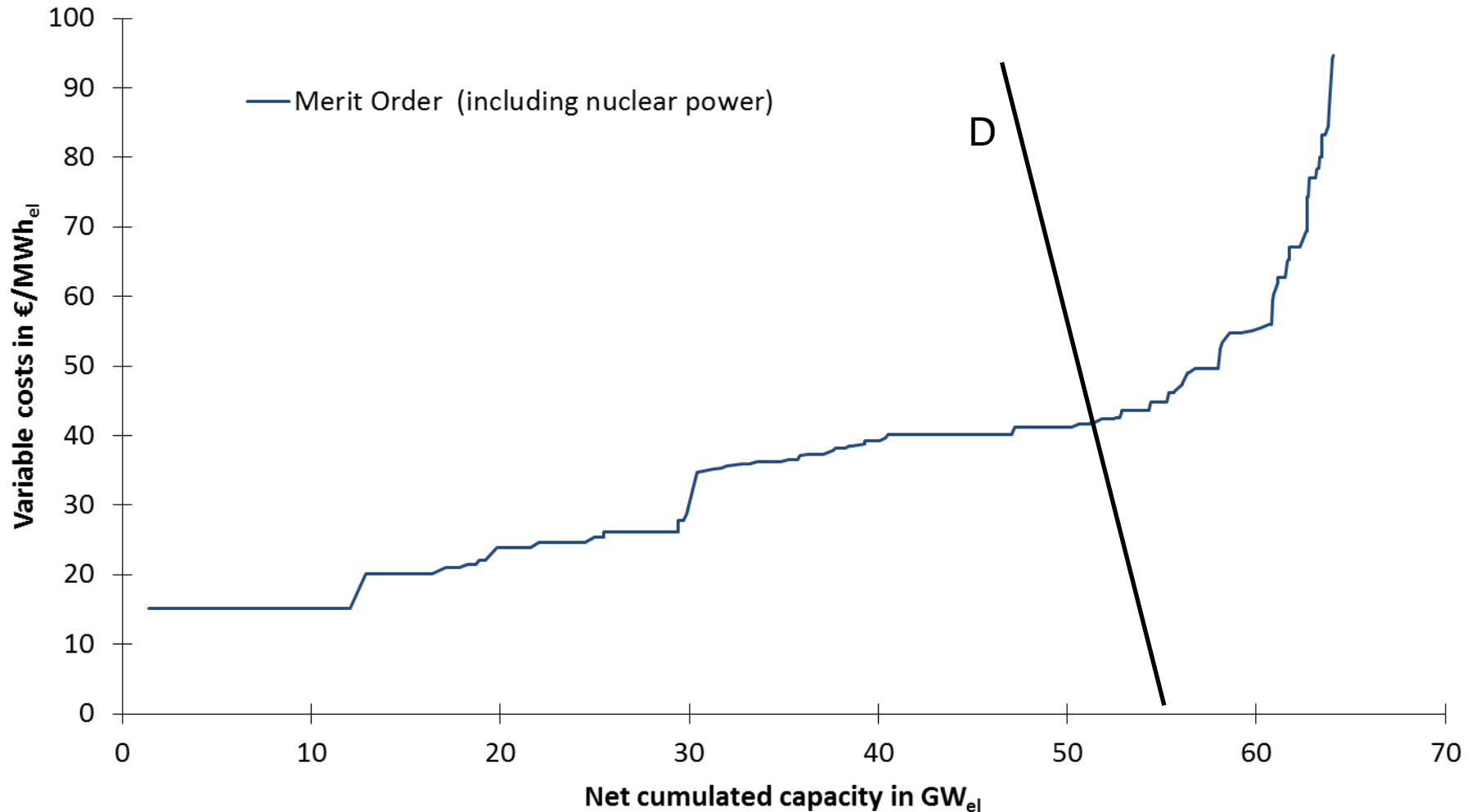
Energy Concept (2010 September)
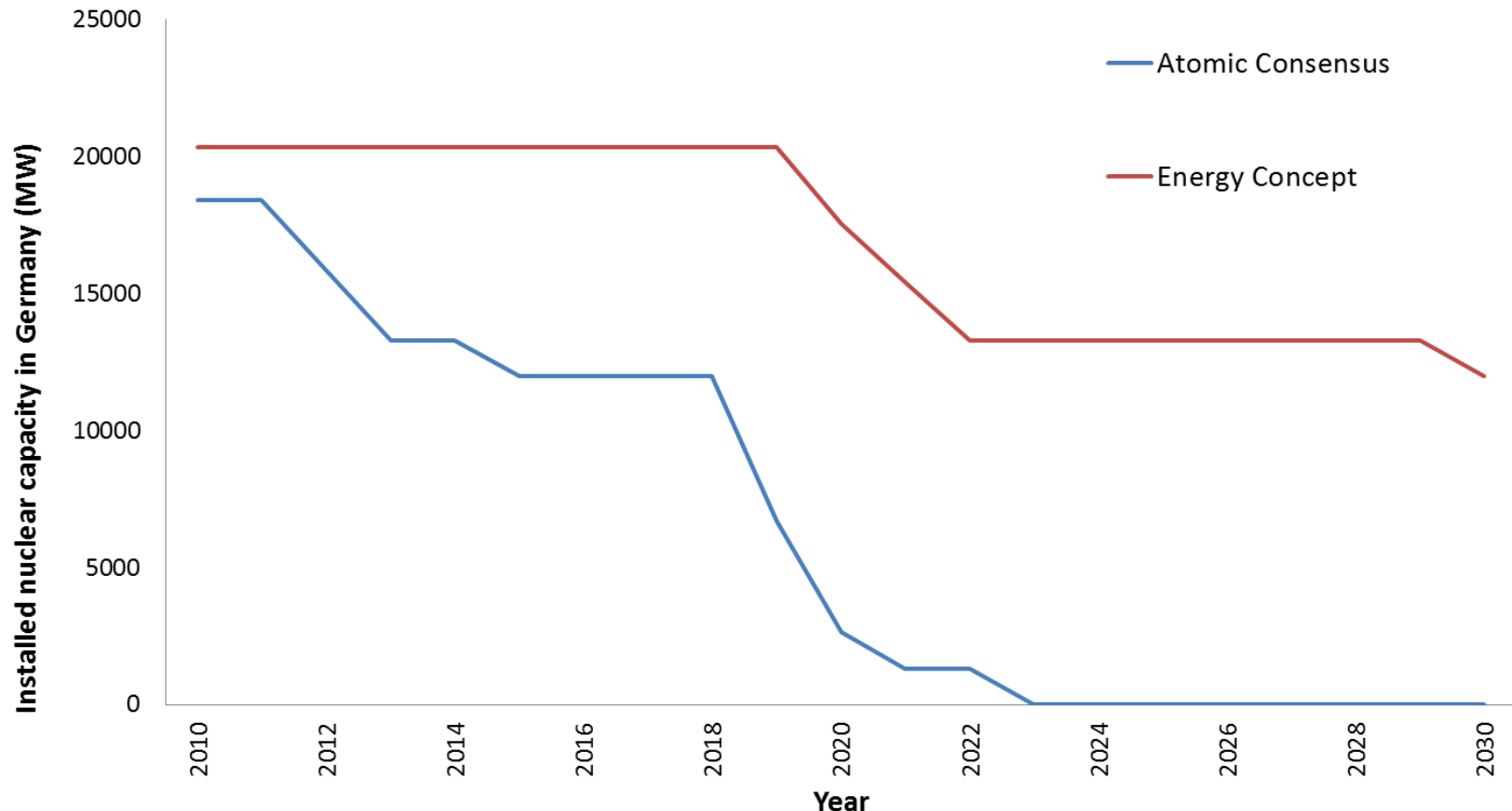
- ◆ Decided by conservative-liberal coalition government end of September 2010
- ◆ Prolongation of running times by 8 and 14 years respectively

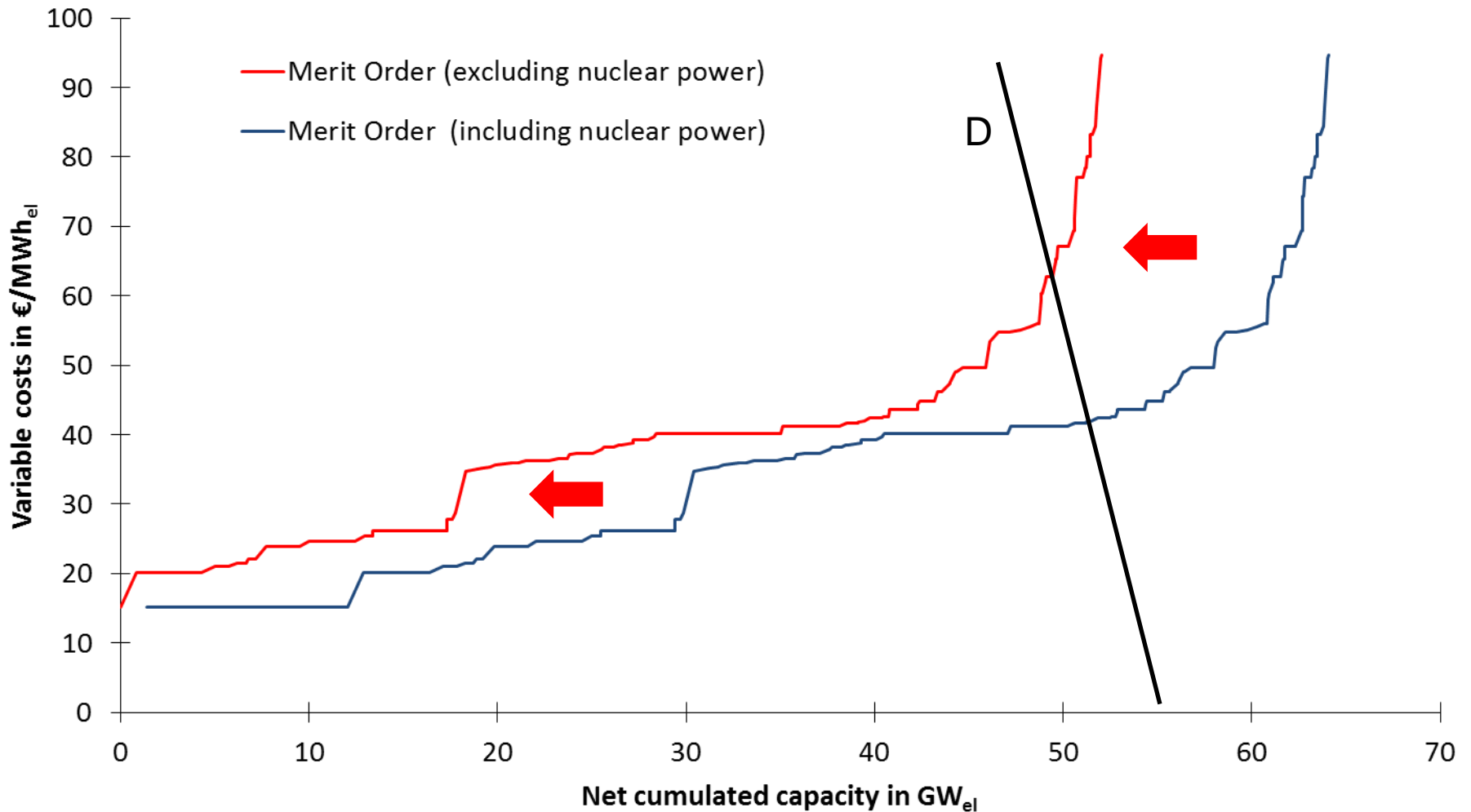# Nuclear Phase-Out Nuclear Phase out (2011 June)

- ◆ Decided by conservative-liberal coalition government in June 2011
- ◆ Successive shutdown until 2022

The German Merit Order (without CHP and RES)

The German Merit Order (without CHP and RES)

In addition to the merit order, the model …

- ◆ … considers non-dispatchable generation (wind, solar, CHP, …)

- ◆ … includes endogenously capacity additions (and reductions)

- ◆ … includes endogenously international power exchange by modeling several regions simultaneously

- ◆ … includes endogenously dynamic effects (e.g. start-up costs, balancing power, pump storage, planned power plant revisions, …)

The Model

- ◆ Long-term investment and dispatch model

- ◆ Fundamental optimization model (LP)

- ◆ Objective: minimization of total system costs

- ◆ Resolution

  - – 10 reference years

  - – 4,380 periods per year

  - – 10 model regions (Germany and neighboring countries)

  - – up to 23 technologies per region

- ◆ Shadow prices (i.e. marginals of demand constraint) used as price estimators

European Electricity Market Model
Objective Function

$$\min Z = \sum_y f_y^d(y) *$$

$$(num\_years(y) *$$

variable costs

$$[\sum_{p,t} num\_hours * f_p^d(p) * z^{var}(y,p,t) * G_{PLANT}(y,p,t)$$

startup costs

$$+ \sum_{p,t} f_p^d(p) * z_{up}(y,p,t) * C_{UP}(y,p,t)$$

shutdown costs

$$+ \sum_{p,t} f_p^d(p) * z_{down}(y,p,t) * C_{DOWN}(y,p,t)$$

fixed costs

$$+ \sum_t z^{fixed}(t,y) * C_{INST}(y,t)]$$

investment costs

$$+ \sum_t s_{invest}^{cost}(y,t) * z_{invest}(t,y) * C_{ADD}(y,t))$$

European Electricity Market Model
Constraints (1)

- **Capacity** of a technology determined by commissioning and decommissioning

- Certain part of the capacity in **overhaul** over the course of a year

- **Capacity ready-to-operate** determined through startups and shutdowns and limited to the installed capacity minus the capacity in overhaul (startups and shutdowns linearized) and unexpected outages

- **Generation**

  – upwards limited by the capacity ready-to-operate

  – downwards limited by linearized minimum load requirements (defined as share of capacity ready-to-operate)
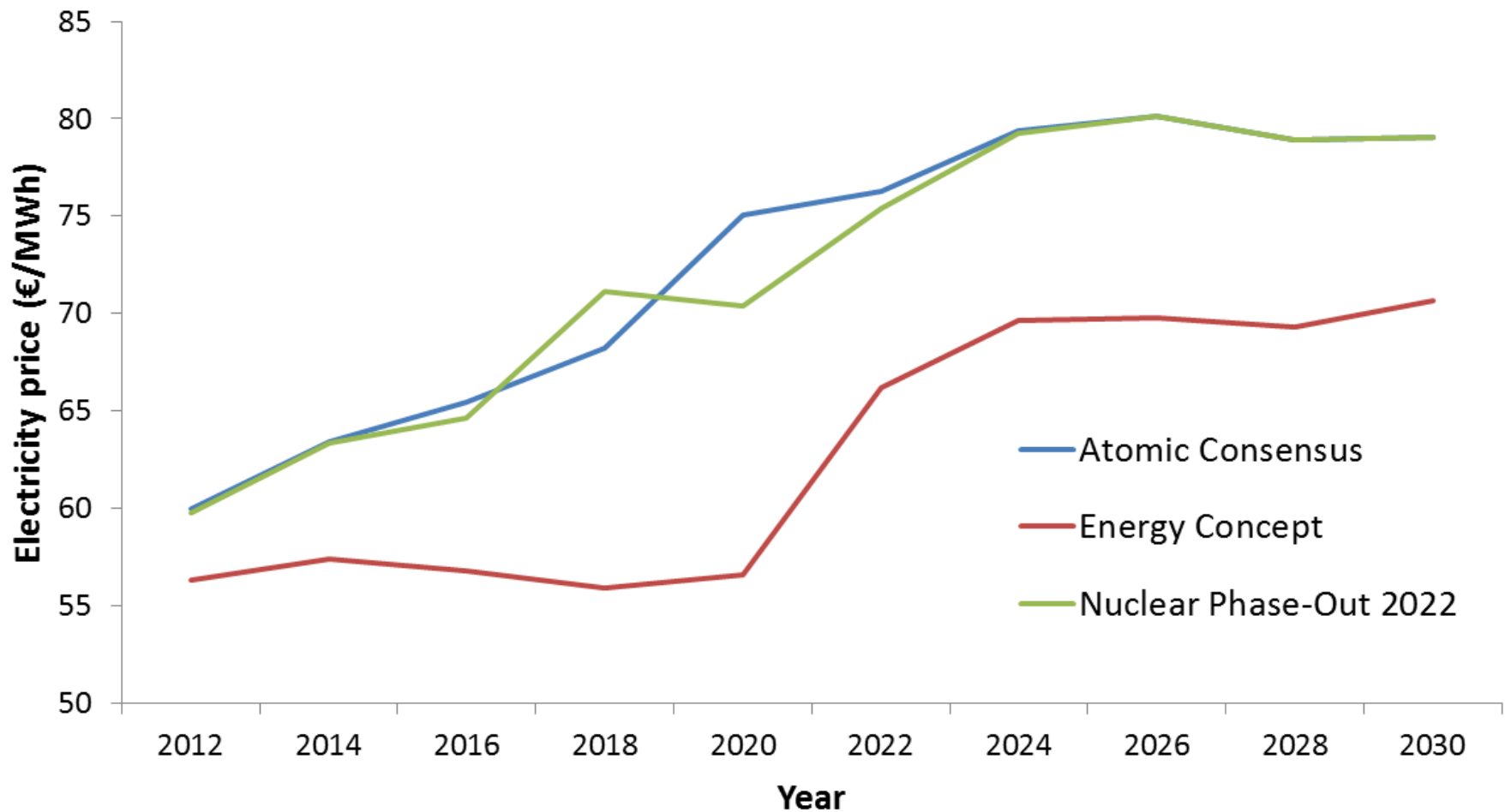
- **Generation** equals **residual demand** plus/minus **international exchange** plus **electricity consumption from pump storage**

- **Exchange** between countries limited by net transfer capacities

- Stored energy of (**pump) storage plants** determined by pumped and turbined energy amounts plus natural inflow
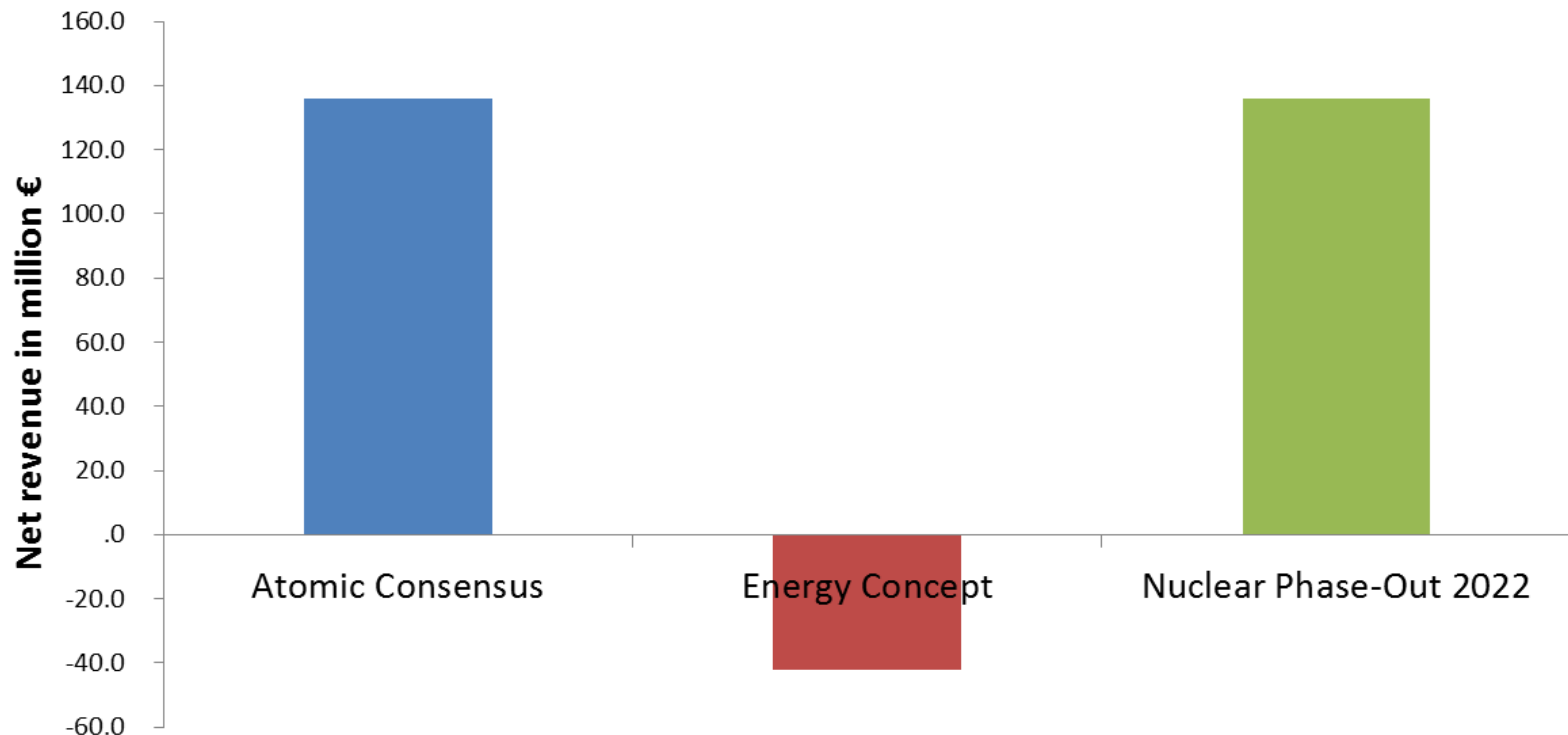
Results
System Marginal Costs of Demand

Results
Profit contribution for Trianel's CCGT power plant

- ◆ CCGT project in Hamm-Uentrop with 800 MW installed net generating capacity
- ◆ commercial operation since end of 2007 (expecting atomic consensus, i.e. nuclear phase out)

Thank you very much!
Questions?

- Changes in nuclear power policy affect the entire energy market

- Nuclear power

  - is a technology with low variable costs

  - covers base load (high full load hours)

- Shutting down nuclear power capacity

  - changes the merit order

  - increases electricity prices

Results

- ◆ Trianel CCGT

  - – begin of operation at the end of 2007

  - – expected time of operation 30 years (until 2037)

  - – calculation horizon (2012-2037) - last 25 years of operation time

	Atomic Consensus	Energy Concept	Nuclear Phase-Out 2022
Revenue electricity generation (million €)	2,646	1,430	2,610
Variable production costs (million €)	-2,153	-1,136	-2,117
Startup and shutdown costs (million €)	-87	-66	-87
Fixed costs (million €)	-270	-270	-270
Net revenue (million €)	**136**	**-42**	**136**

➔ Significant effect on the profitability of the CCGT

CO$_2$ Prices