Power Market Analytics and Forecasting - Germany

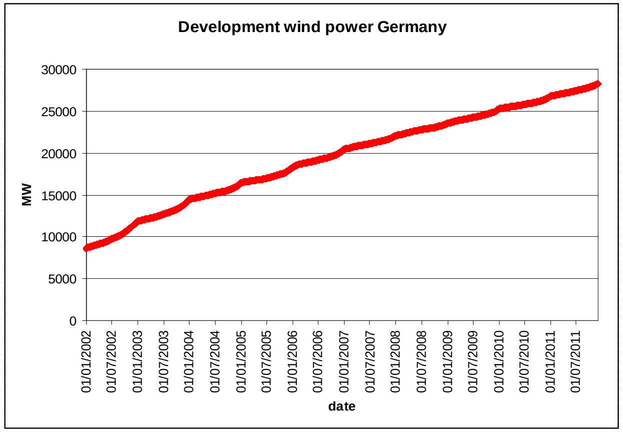
Tarjei Kristiansen

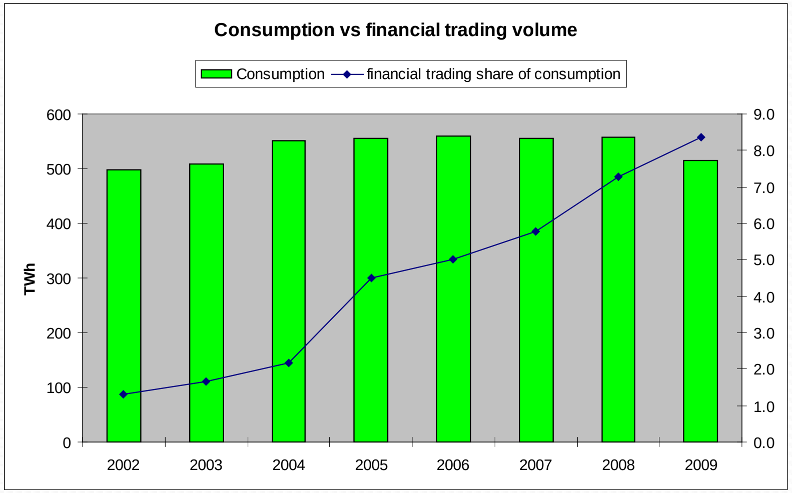
Analytics

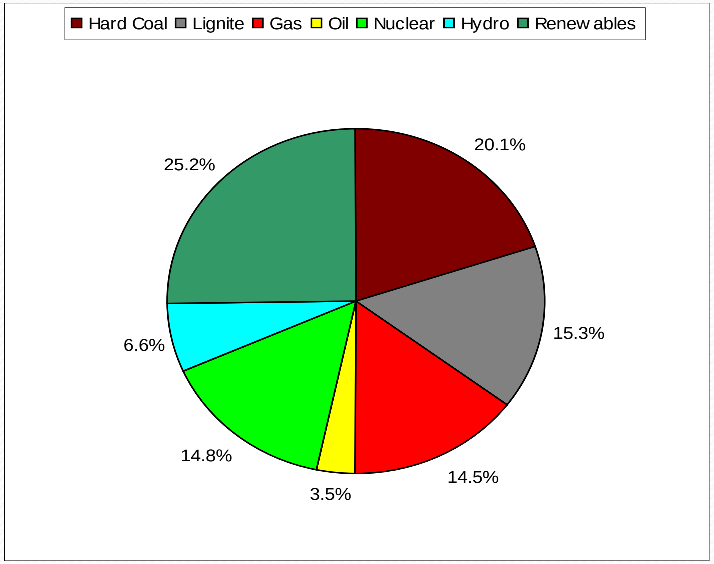
- Utilize fundamental and technical analysis to identify trading opportunities such as outright contracts, fuel spreads, country or time spreads, options
- Fundamental analysis:
  - Examines the reasons behind the price action and appears to have greater predictability power
  - Utilize public information: available generation capacity, weather forecasts, demand forecast, energy stored in hydro reservoirs, interconnection capacities at different time frames, planned generation maintenance , etc.
  - Utilize proprietary information: expert opinion about fuel and emission prices, customer flows, in-house price forecasts, systematize complex information and data to facilitate trading decisions
- Technical analysis
  - Prices discount all information available
  - Price movements are not random and technical tools can used to establish the underlying currents behind the price action
  - Prices tend to repeat themselves
  - More appropriate for liquid markets
- This presentation: focus on fundamental analysis

German Electricity Market

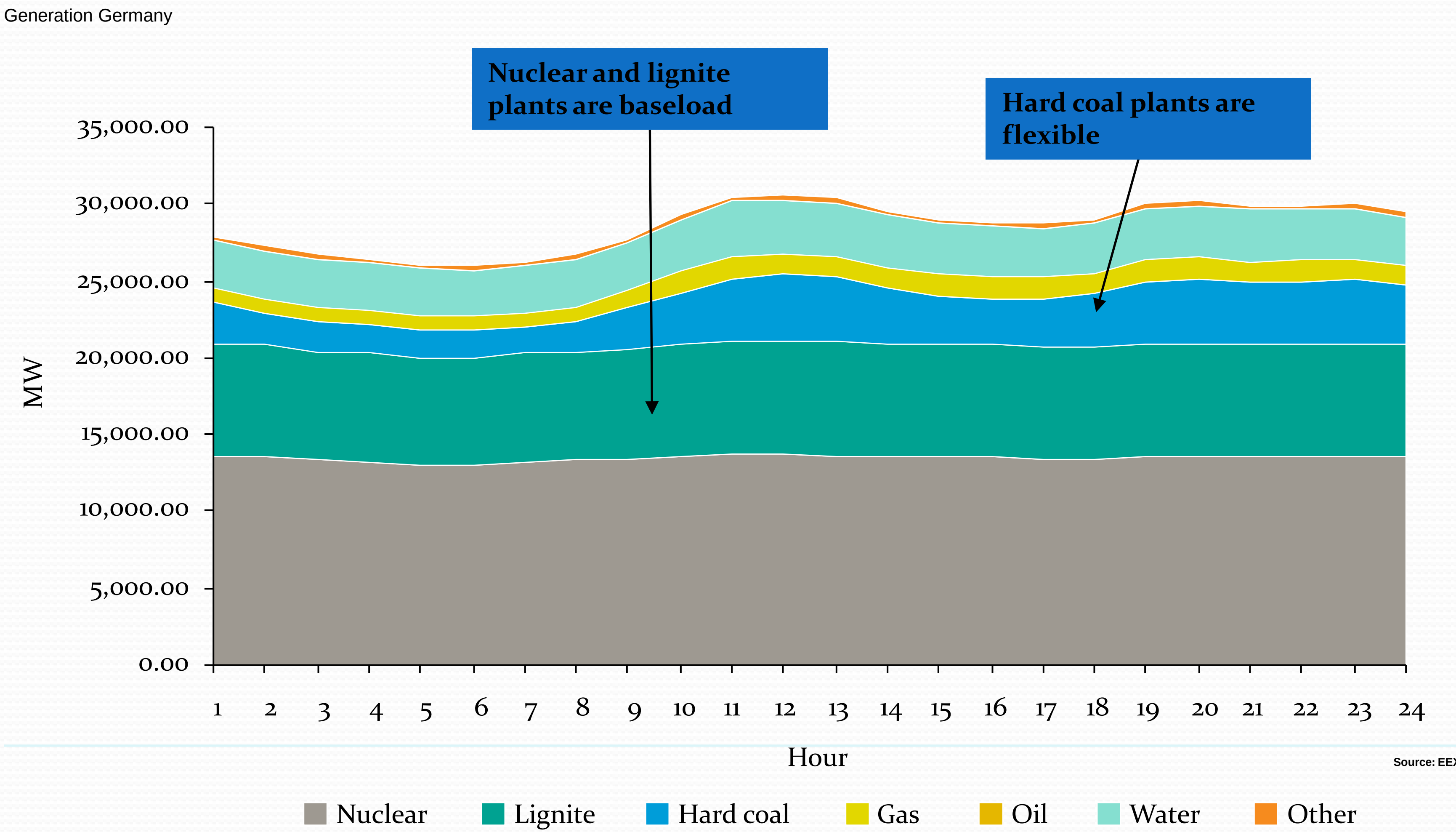
- Market design: single price in four different transmission grids, no transmission risk, little congestion in Germany but potentially a problem with increasing amounts of renewables.
- Power trading: spot and forward market, OTC and exchange, physically and financially settled, contracts may be traded in the delivery period
- Fuel mix: nuclear, lignite, hard coal, gas, oil, hydro, wind, solar





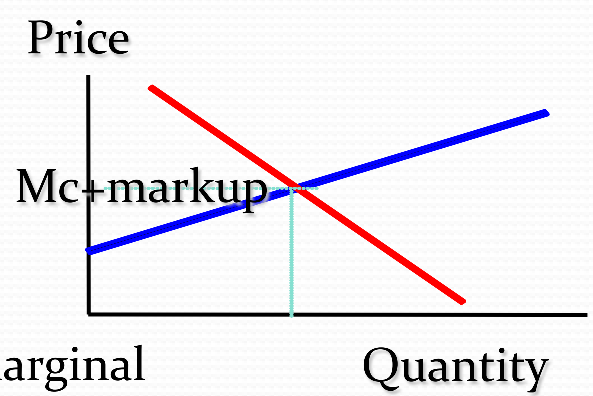


Typical Production Profile Germany (EEX)

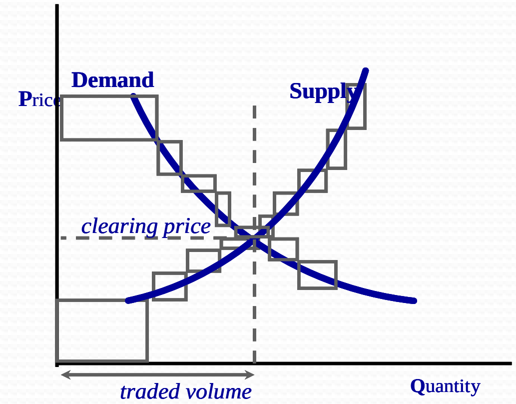


Fundamental Stack Model – Inputs and Outputs

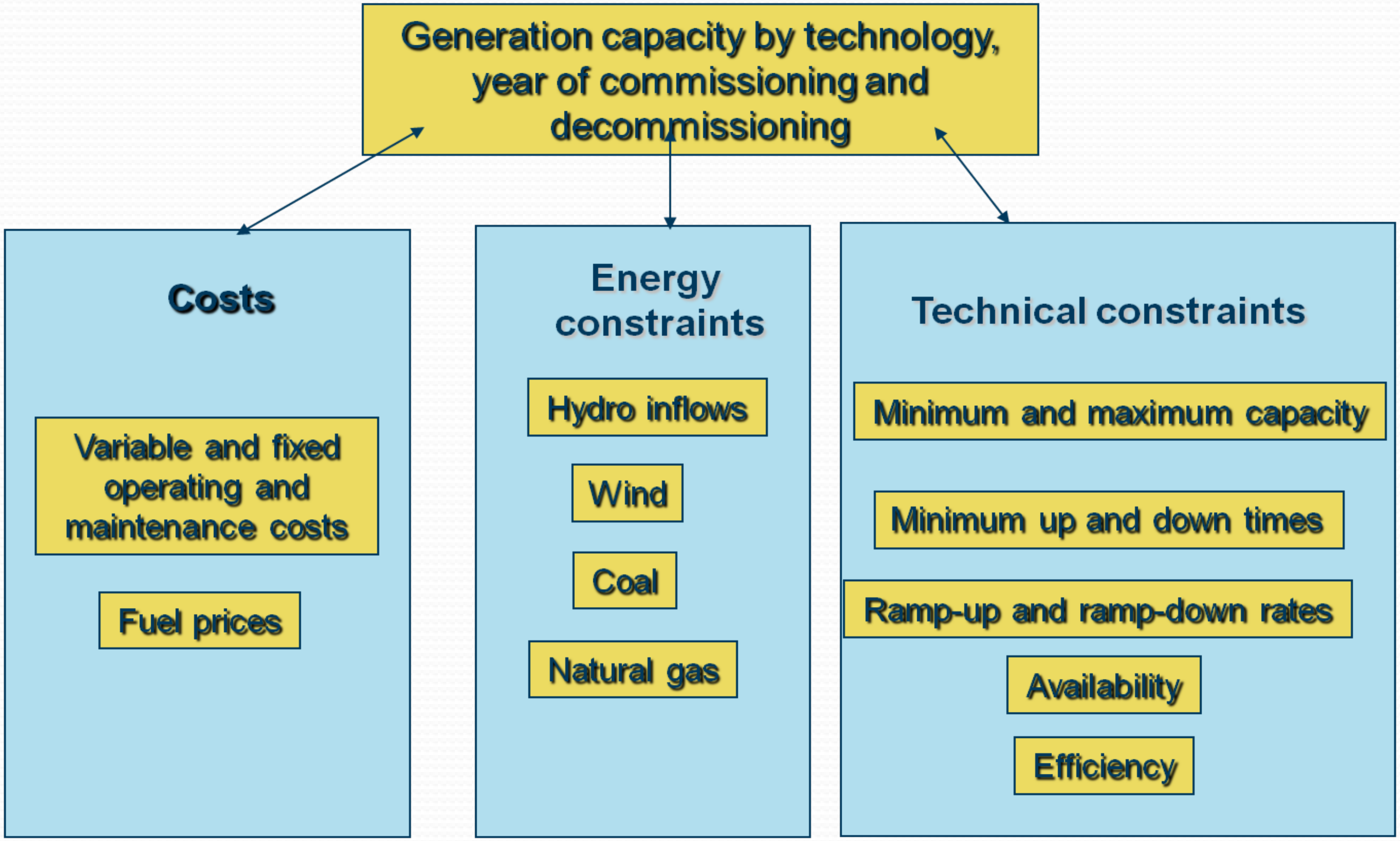
Inputs	Model	Outputs
•Supply • Demand • Fuel prices	Fundamental Model supply=demand	**Hourly prices**



Mc= marginal cost



Power Plant Characteristics



Fundamental Stack Model - Inputs

- In a fundamental model it is about supply and demand and price and volume in the spot market
- Inputs
  - Power plant data and availabilities
  - Hydro production forecast
  - Wind forecast
  - Solar forecast
  - Demand forecast
  - Fuel prices
  - Exports/Imports
  - River temperature (summer)

Fundamental Stack Model – Principles and Outputs

- **For every hour:**
- Supply = demand + exports-imports

↓

- Available thermal generation + hydro + wind + solar = demand + exports-imports

↓

- Sort plants for thermal generation according to marginal cost

↓

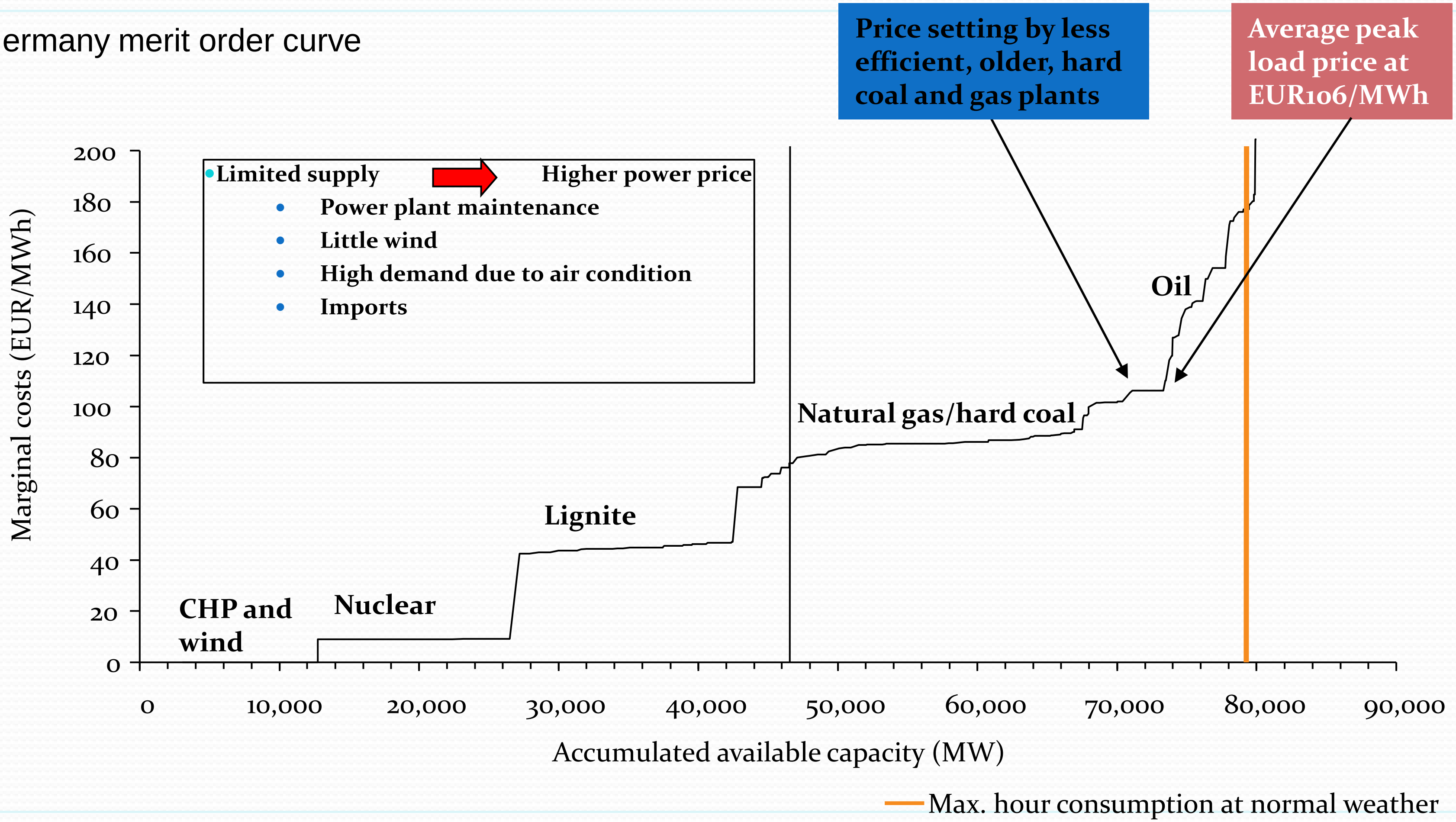
- What is the marginal cost of the marginal plant meeting the hourly demand level?

↓

- Market price = marginal cost of the marginal thermal plant +/- any markups due start/stop costs

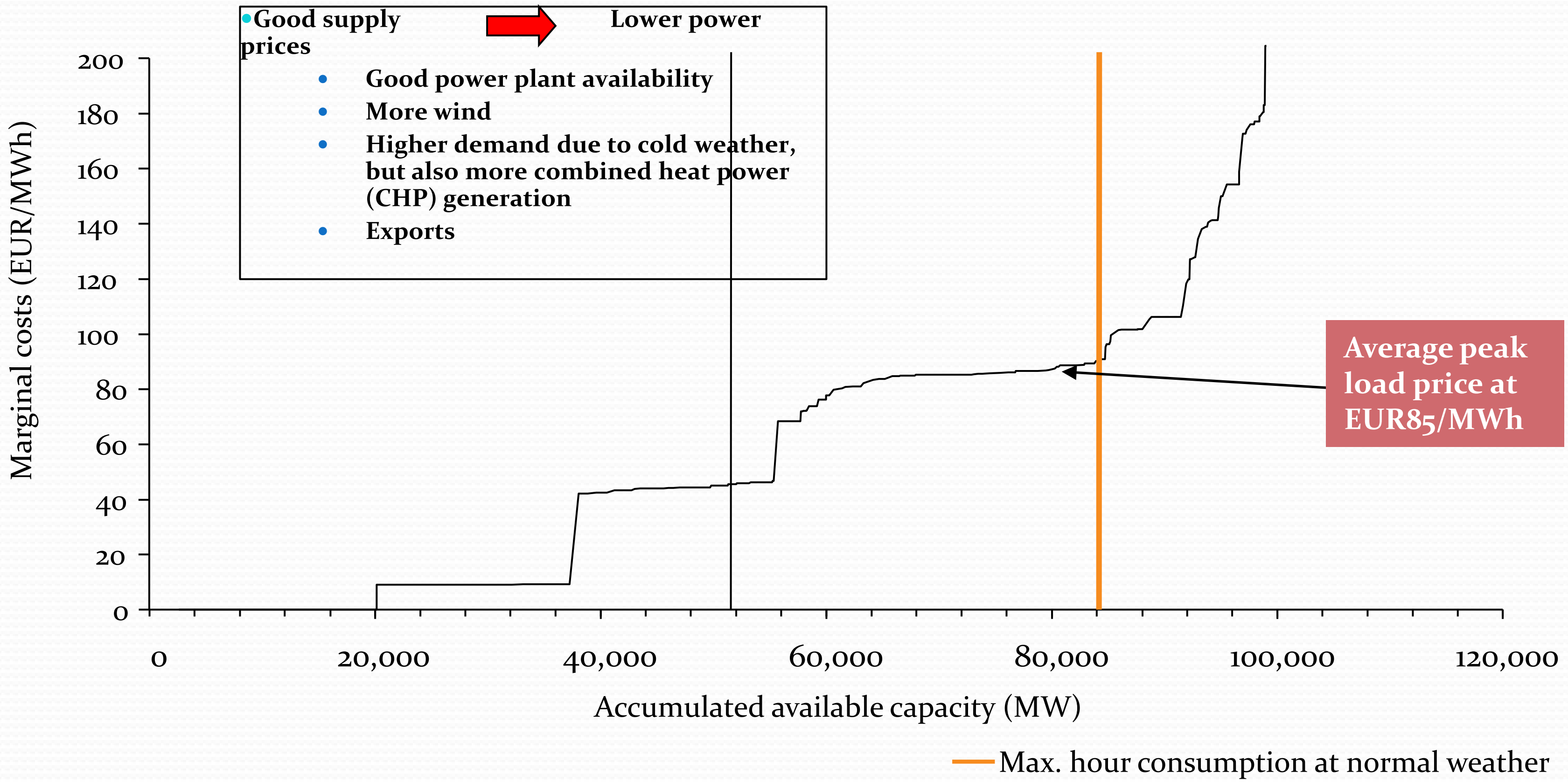
Stack Model a Weekday in July 2008

Germany merit order curve



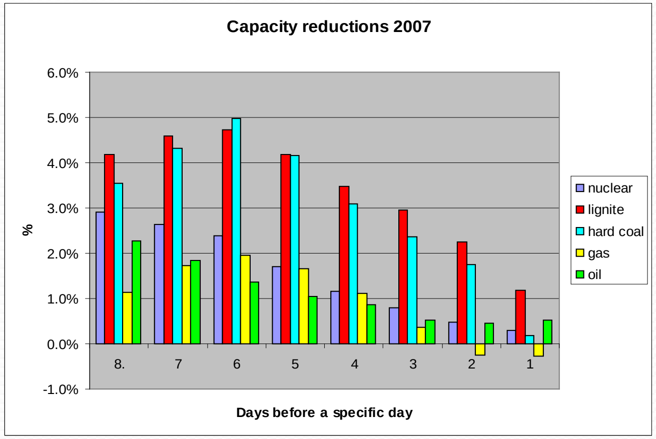
Stack Model a weekday in November 2008

Germany merit order curve



Power Plant Availabilities

- All German nuclear, lignite, hard coal, gas and oil power plants are represented on a unit basis with corresponding technical parameters. No aggregation.
- Average percentage power plant availabilities are estimated from EEX numbers and applied to all power plants.
- However since EEX numbers constitute only around 70% of installed capacity this may create deviations.
- Furthermore the availabilities are reduced to take into account that EEX numbers normally are reduced the closer to delivery.
- Lignite and hard coal plants show the largest reduction of capacity (around 3% eight days before delivery)



Reduction of Available Capacity – Cooling Problems due to River Temperature

The higher air temperature, the quicker the river water heats up. The lower the low, the less energy has to be added to heat the river.

In the range 23-25 degree Celcius, capacity reduction increases exponentially

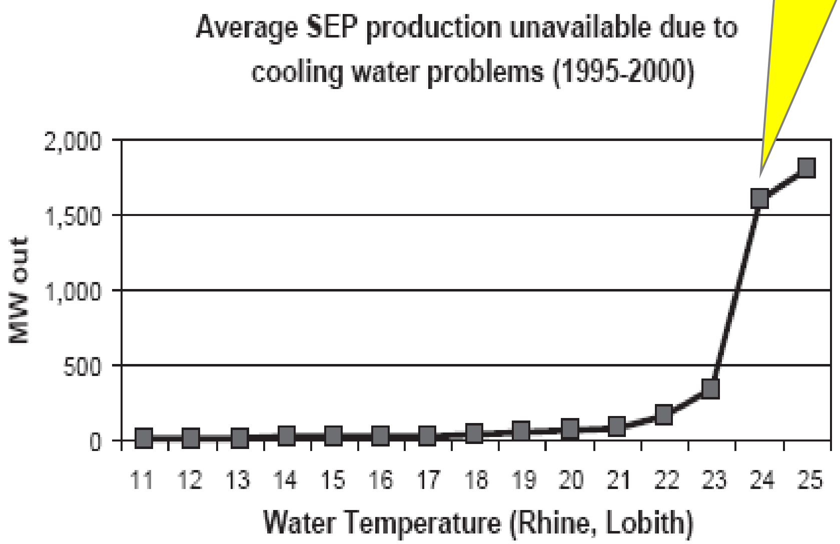


Fig. 2. Average production unavailable due to cooling water problems before deregulation.

Fundamental Analysis –Combined Heat and Power

- Combined heat and power (CHP) aggregated in a single plant:
  - Is assumed to be must run generation and price independent
  - One part includes generation from industrial CHP and assumed relatively constant throughout the year. The other part depends on heating demand and has the following temperature gradients:
    - 600 MW/degree Celsius   5 <= Celsius <= 10
    - 400 MW/degree Celsius   <5 and Celsius > 10 and turned off completely at 18 degrees Celsius

Generation of Renewables

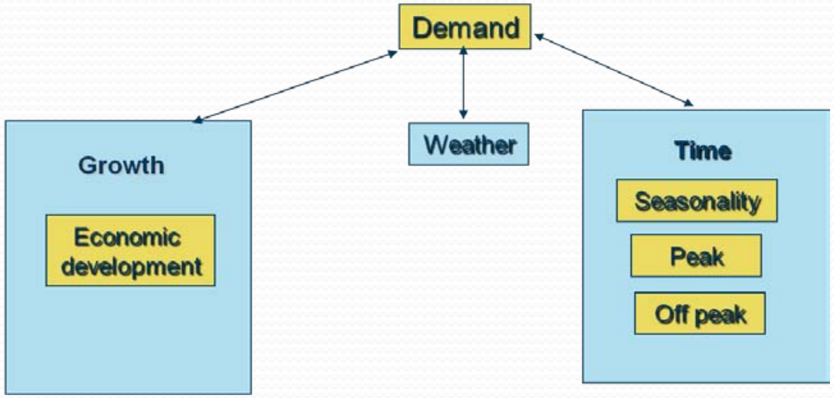
- Wind power (must run):
  - Utilize forecast from external providers with potential adjustment from discussion with meteorologist
  - Beyond two weeks: normal wind production adjusted for any generation capacity growth
- Hydro power (must run):
  - Most hydro in Germany is run-of river but imports depends on hydro in the Alps
  - Utilize forecast from external providers with potential adjustment from discussion with meteorologist
  - Longer term forecast assumes normal hydro production
- Solar power (must run):
  - Is important and exceeded 18000 MW in May 2011
  - Generation output depends on cloud factor and typically highest around noon
  - Complements wind: sunny days -> typically little wind

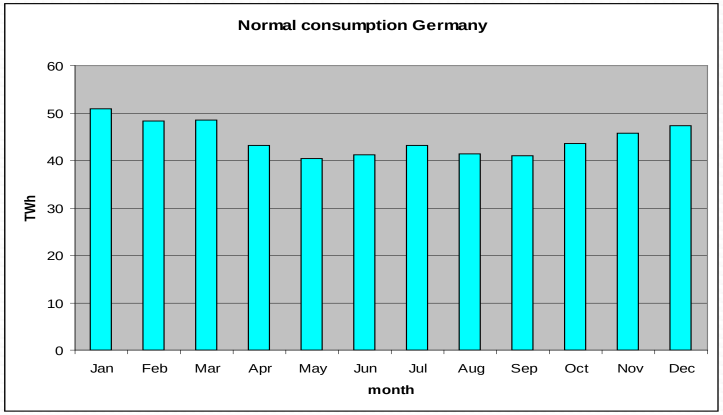
Marginal Cost and Mark-ups

- Forward prices for oil, gas, hard coal and carbon
- Gas fuel prices are based on TTF
- Lignite and uranium prices are assumed to be constant
- Marginal cost depends on power plant efficiency, operational and maintenance costs, transport costs
- Some peaking power plants run very few hours annually and thus require a power price covering the capital and start/stop costs to ramp up
- Bidding logic
  - Start-up costs can significantly increase marginal cost in peak periods while stop-costs can lower marginal cost in off-peak periods
  - In high demand periods, a demand increase must be served by unused capacity and thus start-up of a unit.
  - In low demand periods, a demand increase increases variable operating costs but saves a start-up in the next period since more capacity can be operated without interruption.
  - The bid price for hard coal plant = marginal cost – stop up cost/(unscheduled hours in one period *capacity)
  - Bid price for oil and gas fired peak units = marginal cost + start up cost/(scheduled hours*capacity)

Demand Forecasting

- Demand in Germany depends more on industrial demand and less on temperature driving heating demand as in France and the Nordics. May adjust the closest time periods to reflect temperature deviations from the normal. E.g. 1 degree colder weather than normal in the autumn may result in 500 MW higher demand.
- Point Carbon's demand forecast which considers annual and seasonal cycles and holidays:
  - Inputs are temperature, cloud cover, daylight factor, winter and summer time
  - Cloud cover is scaled from 0 to 8 where a change of 1 octa impacts demand with 600 MW/octa, no impact in the night
  - Temperature changes in the range 15-19 degrees have no impact, above 19 degrees the demand increases approximately 200 MW/degree (air conditioning) while below 15 degrees the sensitivities are larger up to 300-400 MW/degree. These are average sensitivities and changes from hour to hour with night sensitivities being larger than day time.





Imports/exports

- Model uses net exports to/from Germany
- For short term price forecast:
  - Use previous day's level adjusted for wind
  - Consider OTC prices for neighbouring countries: exports from lower price areas to higher price areas
  - Consider wind: more wind -> More exports
- For medium/long term price forecasts:
  - Use historic levels as a basis
  - Consider OTC prices for neighbouring countries: exports from lower price areas to higher price areas

Performance Day-ahead Model: Jan 2008 – August 2010

- Some possible measures:
  - Average deviation between the **in-house model** and the outturned day ahead price: 0.06 EUR/MWh
  - Mean absolute percentage error (MAPE)

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

  -
  - *A* is actual value and *F* is forecast value,
  - **In-house model** achieves MAPE= 6.8%

  - Directional:
    - forecast > previous day ahead price and day ahead price > previous day ahead price

    or

    - forecast < previous day ahead price and day ahead price < previous day ahead price
    - **In-house model** achieves 82% correct direction

Challenges

- Imperfect information
- Various German Stadtwerke not included in the EEX capacity numbers
- Varying wind and solar power forecasts
- Difficult to anticipate the “correct” level of capacity reductions
- Exports/imports and cross-border flows
- Negative prices