ENERGY-ONLY AND CAPACITY MARKET MODELS AND THE ECONOMICS OF THE DUTCH POWER SECTOR

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Introduction

- The European electricity sector faces several challenges
  - Integration of renewable energy sources
  - Safeguarding of broader environmental objectives
  - Discussion related to the nuclear phase-out
  - Energy price evolution
  - …
- No "final" overall target market model
- Investment decisions and existing plant performance affected
- Concerns whether liberalised energy-only electricity market will deliver
  - eventually needed investments
  - investments in flexibility

Aim of analysis and approach

- Economic implications of ***generation adequacy*** in liberalised electricity market
- Empirical assessment of ***Dutch power sector economics***
- Two-step approach:
  - Theoretical and qualitative assessment of electricity market design options
  - Quantitative and qualitative assessment of a socio- and techno-economic scenario of the Dutch power sector
    - Applying long-term simulation model

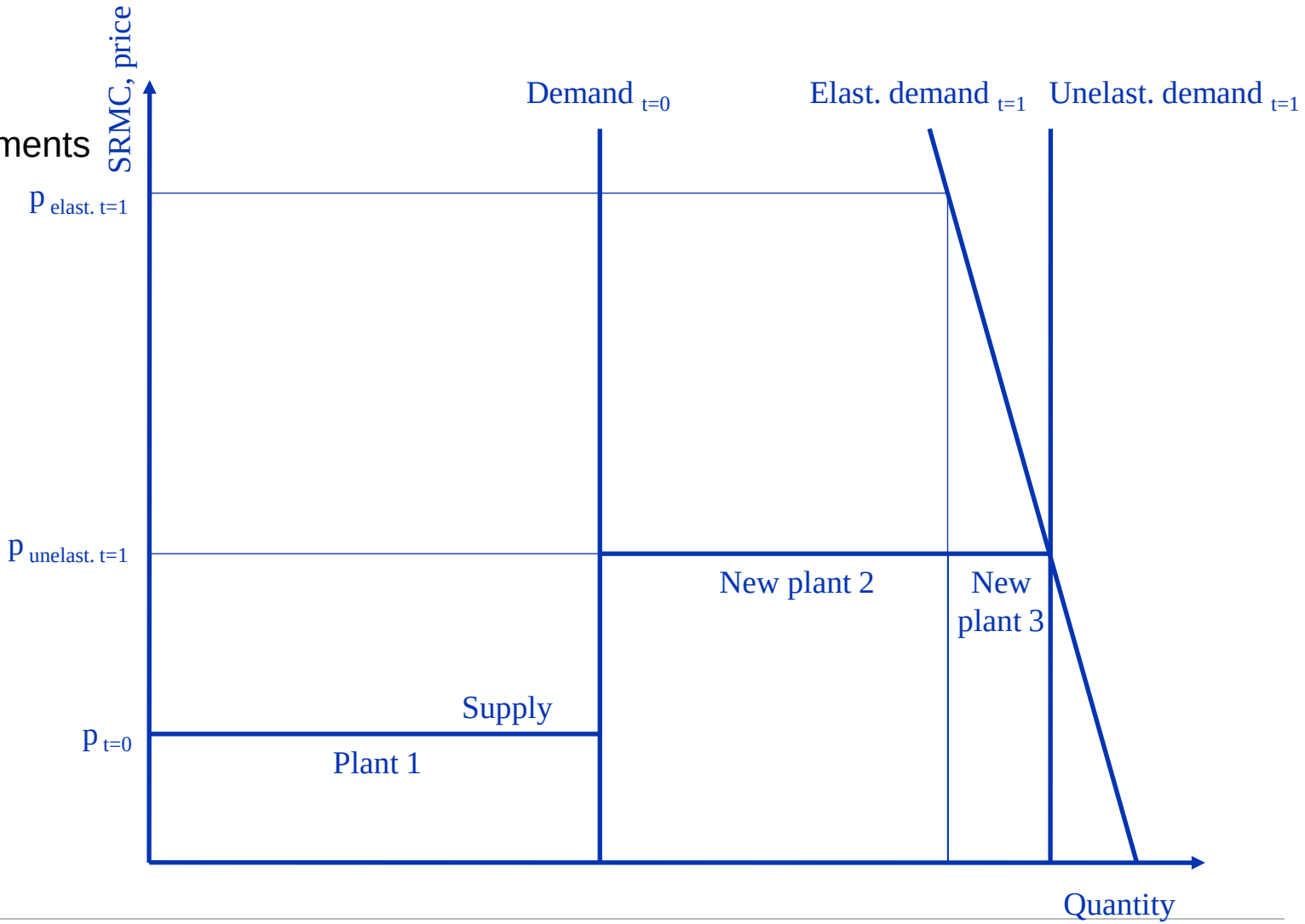
The economics of generation adequacy

- Theory of energy-only market:
  - Rewards energy sales
  - Competitive wholesale price equals SRMC
  - ***Price-elastic demand***: Prices spike as reserve margin gets lower
  - Generation adequacy ensured
    - Relying on scarcity

  - Market with ***price-inelastic demand***:
    - Price-setting plant earns no contribution margin
    - Prices not set by marginal utility of demand
    - Missing money problem

The economics of generation adequacy

- Example:
  - Lumpy investments



The economics of generation adequacy

- RES appear as game changers
  - Right-shift of merit order
    - That's the aim of RES policies… increase share of renewable energy
  - Times of low generation of intermittent RES
    - Flexible plants, storage – or demand side response – needed
  - Uncertainties with dispatch and revenues of backup capacities
    - Increases investment risk
    - Still need for backup

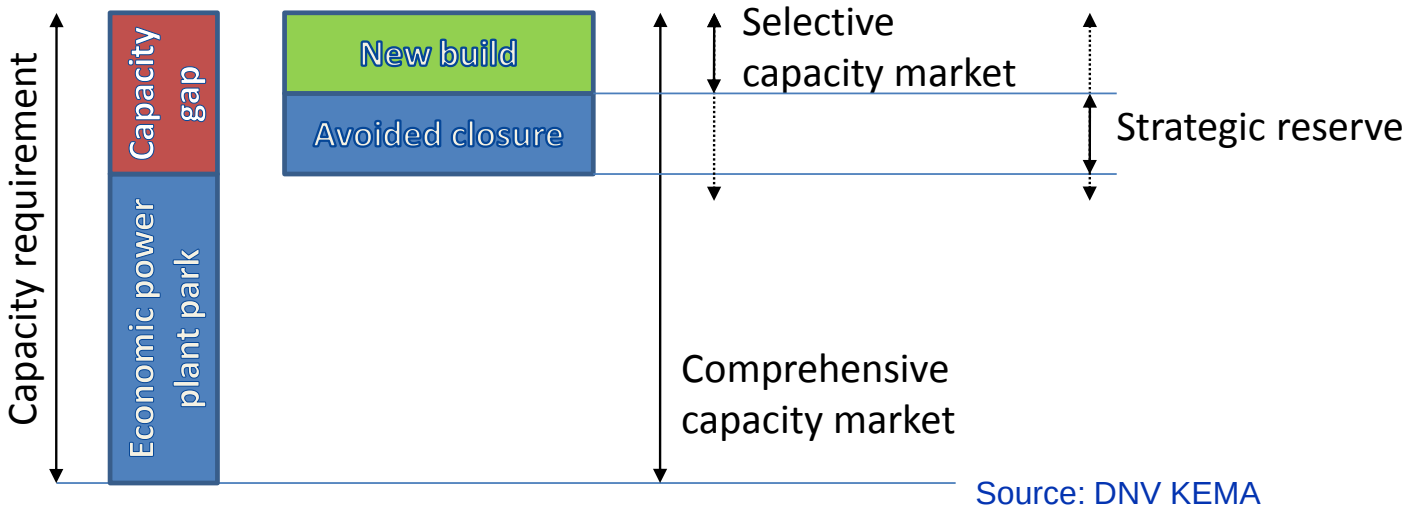
The economics of generation adequacy

- How can long-term financial viability be secured without sacrificing reliability
  - Extensions of the existing market design increasingly discussed
  - Incentivise operation of existing and construction of new flexible generation and storage
- Discussion centres around ***capacity mechanisms***
  - Rewarding available capacity
  - Capacity provider bids expected gap in contribution margin
  - Energy-only market remains pillar for covering fixed costs

$$Offer_{Cap} = \frac{\mathrm{E}\left[(p_{energy-only} - c_{var})q\right] - C_{fix}}{capacity}$$

Overview capacity mechanisms

- Quantity based mechanisms: Target capacity level which is auctioned
  - Capacity market
    - Comprehensive or selective
  - Reliability option
  - Strategic reserve
  - Operating reserve

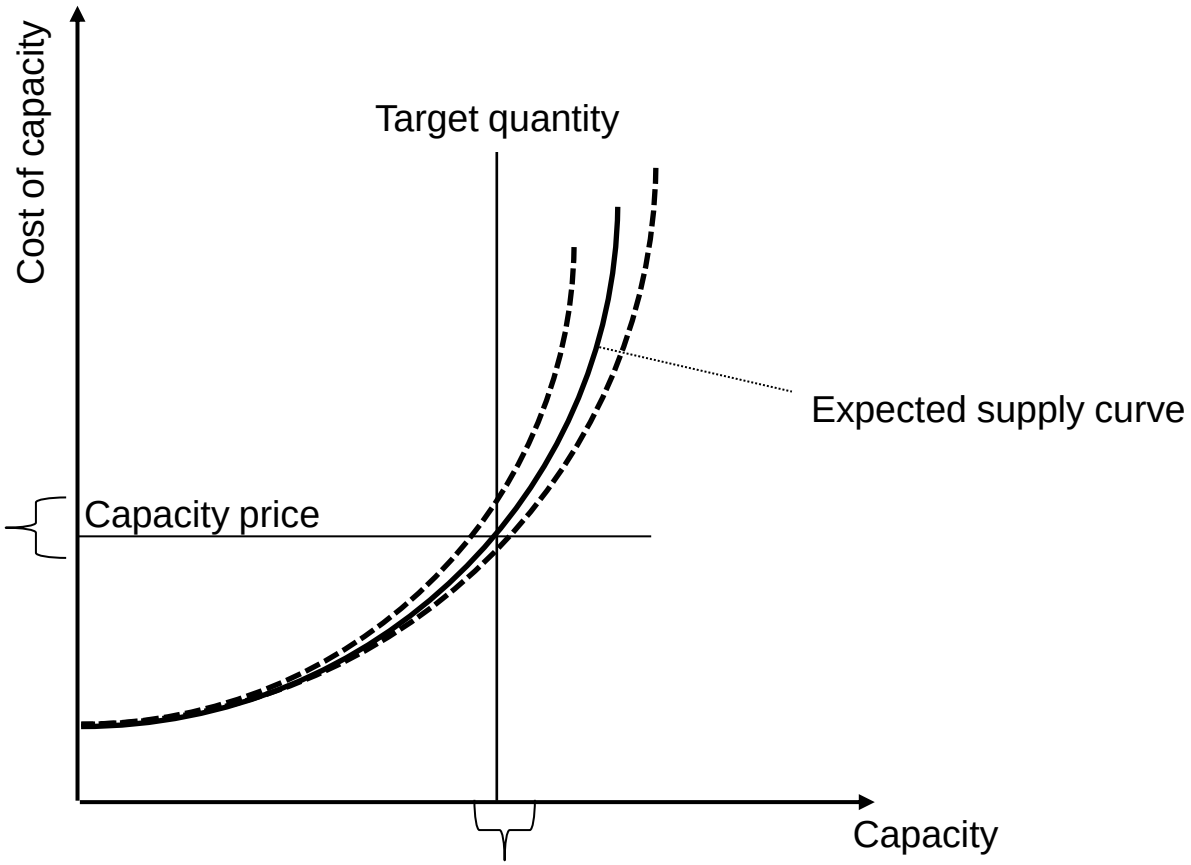


Source: DNV KEMA

- Price based mechanisms: Set capacity payment paid for capacity provision
  - Fixed capacity payments
  - Dynamic capacity payments

Overview capacity mechanisms

- Quantity vs. price based mechanisms

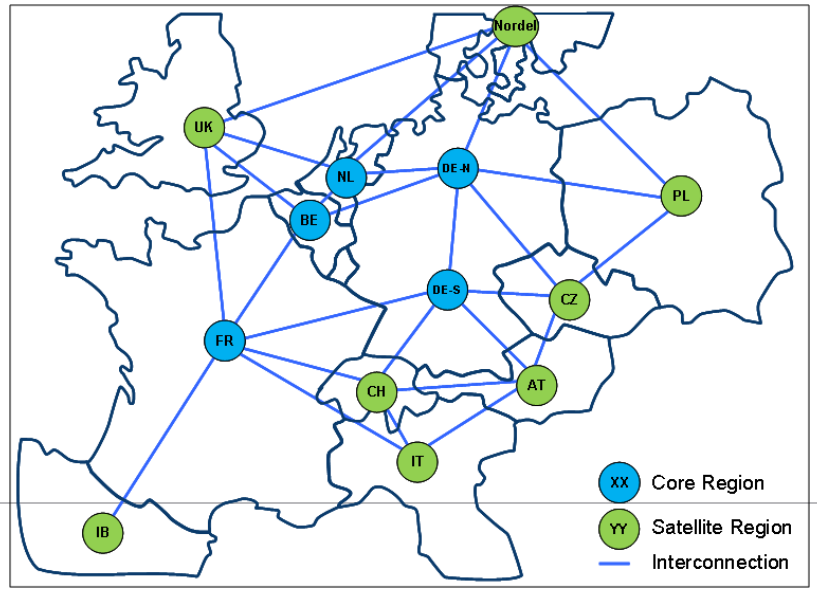


Empirical case study: Dutch power sector

- Bottom up simulation model
- Assess scenario with high RES share, high carbon prices, rather stagnating demand
- Storyline captured in sustainable development (SD) scenario
  - Based on 450ppm scenario of World Energy Outlook (IEA, 2011)

DNV KEMA market model of Northwest Europe

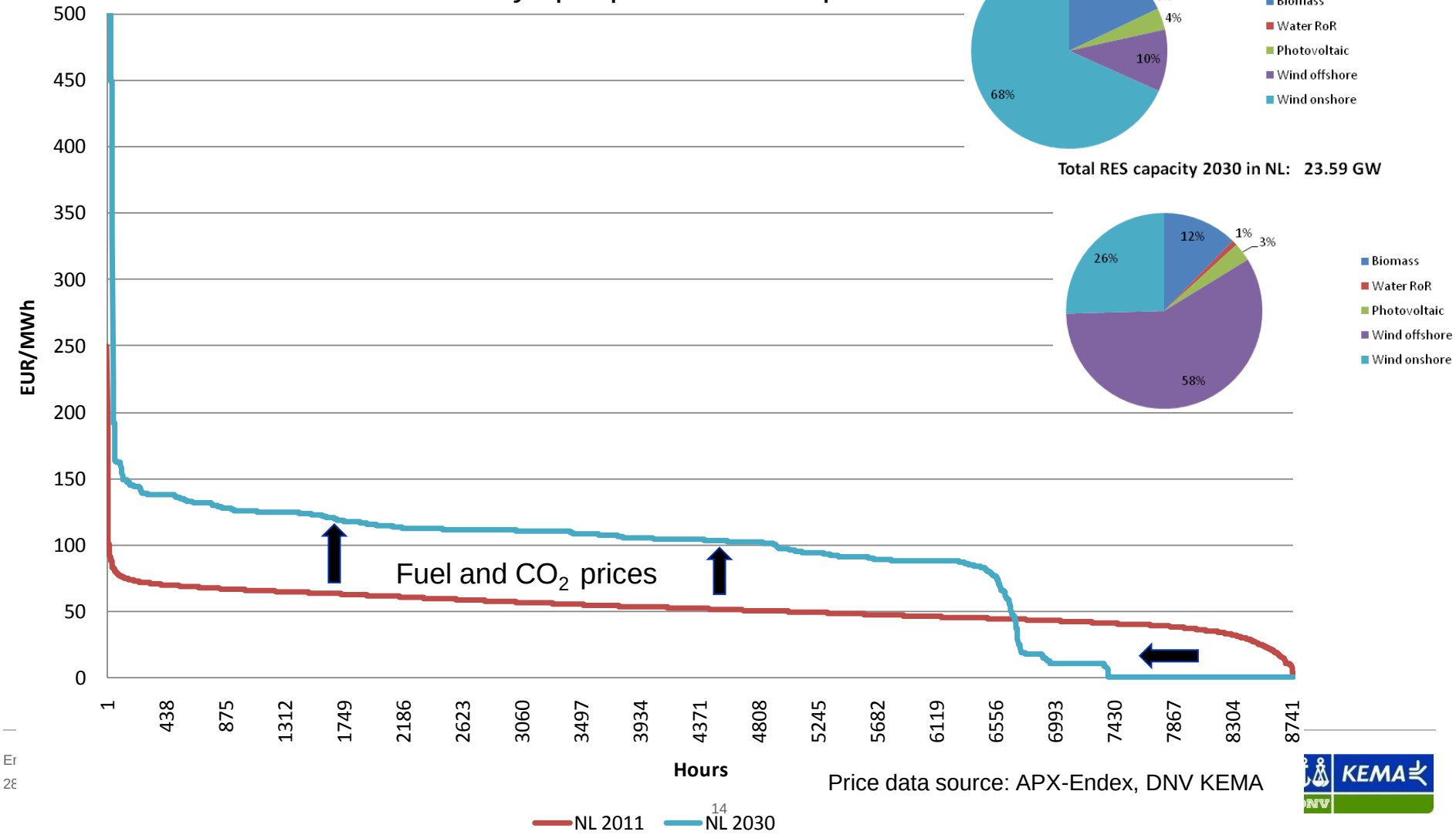
- North West European electricity markets:
  - Five core regions represented in detail; Eight surrounding satellite regions
  - Each region "one-node-region“
  - Market modelled as uniform price auction; SRMC are bid
  - Reference simulations for 2010 to calibrate model
  - Level of granularity: Individual power plants above 100 MW
  - Wind, PV generation patterns based on historic realisations
  - Generators smaller than 100 MW aggregated
  - Inputs and optimization approach deterministic ➔ No uncertainties about prices or intermittent RES
- Modelling software:
  - PLEXOS for Power Systems



Source: DNV KEMA

Simulation results

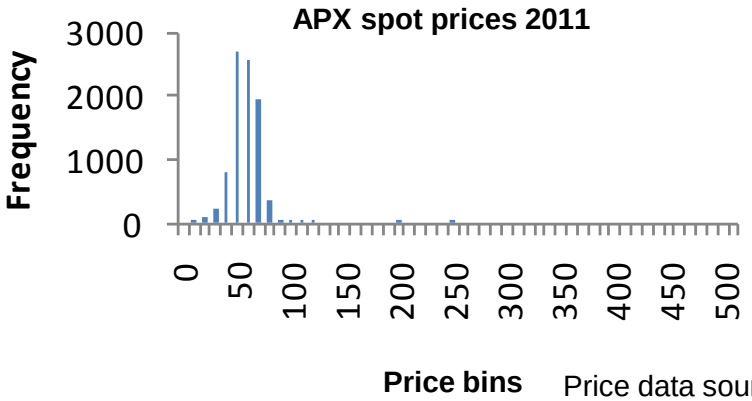
- Results of SD scenario for 2030:
  - Price duration curve of hourly spot prices: Sorted prices



Price data source: APX-Endex, DNV KEMA

Simulation results

- Results of SD scenario for 2030:
  - (Spot) price distribution: Load factors of conventional plants decrease



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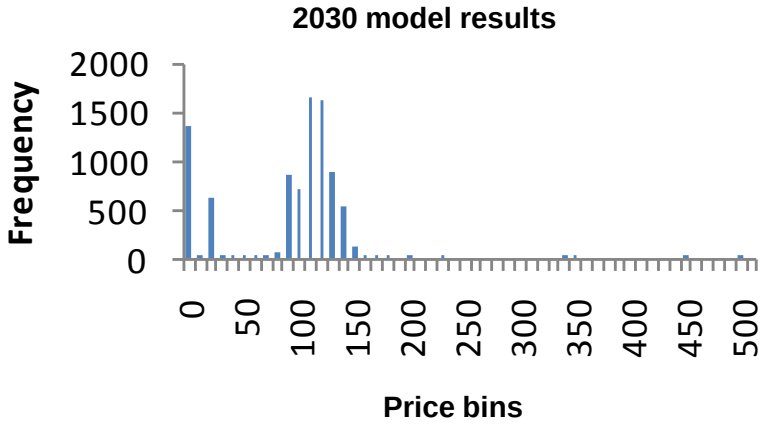


Price data source: DNV KEMA

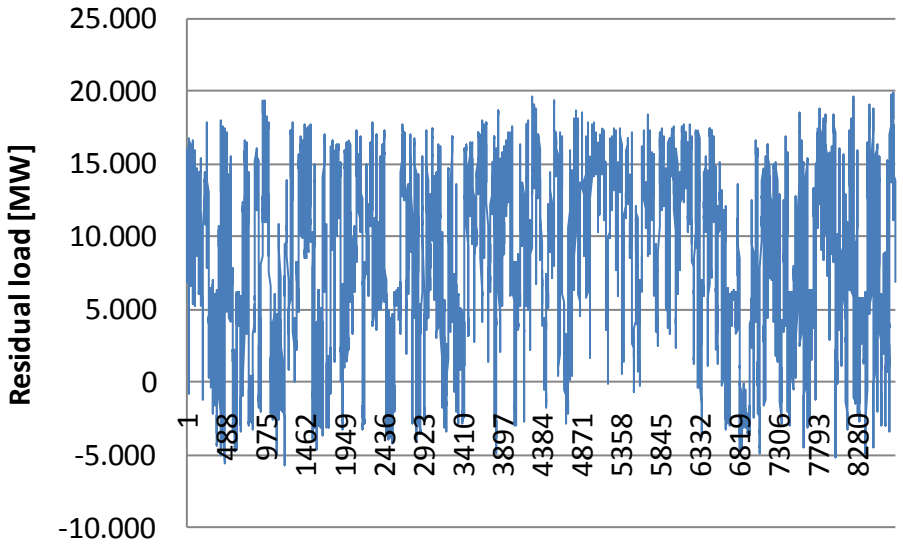
- More price spikes
- More “zero” prices
- Price volatility rises
- Skewness rises
- Kurtosis rises

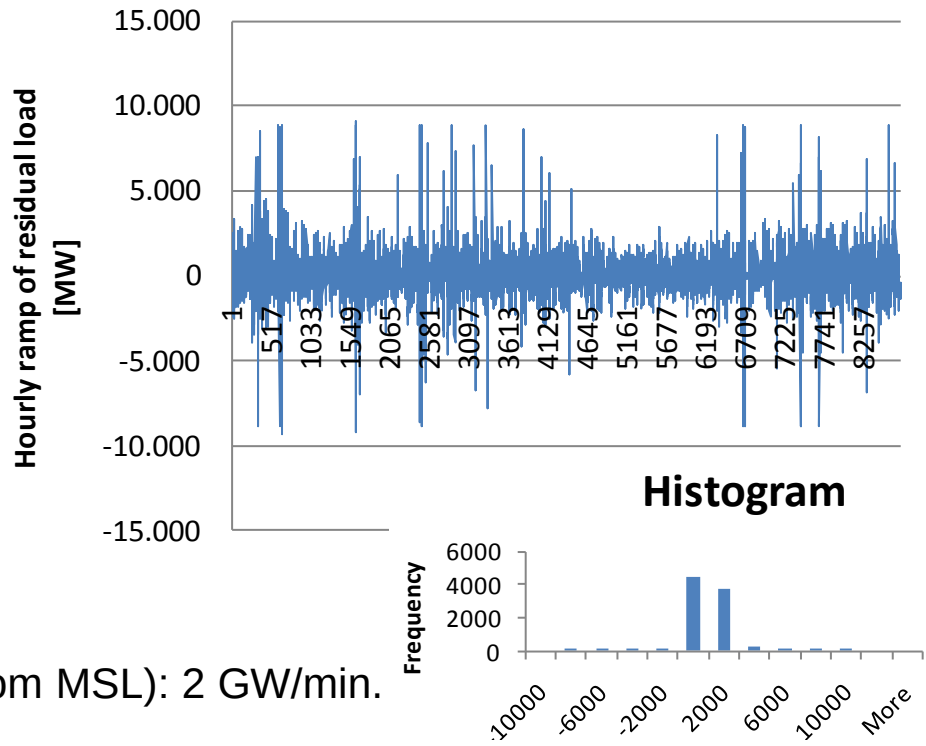
Capacity vs. capability

- Deterministic simulation
  - Sufficient ***volume*** of capacity
    - No new builds and no missing-money problems
  - But: Price distribution gets more extreme
- Stochastic effects of RES (not modelled)
  - Possibly insufficient ***capability*** of installed capacity – assuming ***price-inelastic*** demand!
    - Lacking flexibility
- In that case flexible (“capable”) new builds needed
  - Assuming similar security of supply level and no demand elasticity

Capacity vs. capability

- Residual load (Load - intermittent RES) and associated ramp:





- No security of supply issue in deterministic run
- Theor. ramp rate of conv. power plant park (from MSL): 2 GW/min.
- Stochastic effects:
  - Available ramp rate depends on generation state of plants
  - State of system vs. most adverse state of system

Capacity vs. capability

- New built CCGT:
  - 400 MW plant
    - Efficiency 60%
    - Ramp rate 7%$_{\text{nom. cap.}}$ /min
    - WACC 6.8%; 20 yrs. economic life time
    - IC 870 €/kW
  - Missing money within the SD scenario simulation for 2030
    - Capacity price of 87 EUR/kW for covering remainder of fixed costs needed
- Ensure power plants needed for system security are incentivised?
  - Proper market design
    - E.g. Selective mechanism
    - E.g. Technological pre-qualification, requirements for technologies and eligibility
    - Tendered quantity
    - Obligations for tendered capacity

Current market design

- Concerns relate to investor risks
  - Current market design cannot value flexibility fully
  - Modelling investor behaviour elusive...

- Backcasting point of view one:
  - Ambitious long-term CO_2 target imply full power sector decarbonisation
  - Wind and PV core technologies
  - Energy-only market model based on SRMC prices can not work
  - 2050 long way to go...

Current market design and ways forward

- Margins in EU power market comfortable – yet specific situations: BE, South DE
- Focus on current market imperfections before adding new elements and complexity
- EU target model: Market coupling, common transmission capacity calculation, balancing market integration, develop markets closer to real-time
- Price signals closer to real time: Utilise new information for flexible plants
- EU market integration / coordination helps with capacity concerns: Common reserve margin lower than individual ones (Baritaud, 2012):
  - Trade off between countries going alone and regional and integrated assessments
- Most relevant adjustment is flexibilisation of demand side
  - Smart meters, grids, end-use technologies: Real-time pricing... Co-benefits
- Capacity mechanisms could resolve any remaining missing money issues
  - If no demand side flexibilisation: Necessary in the first place if reserve margin worsens
  - Appropriate incentives for appropriate technologies vs.
  - Mothballing risk: Momentum towards strategic reserve

Outlook

- Before implementation of capacity mechanisms:
  - Thorough quantitative assessment of their needs and effects
    - Assess changes in total costs of electricity provision
    - Illusive task as effects on investments and spot market and real-time prices need to be determined
    - Furthermore, demand response, flexibility of the system (market places) and stochastic effects would need to be included and call for investigation

Thank you for your attention!

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