Modelling Transitions to High-VRE Systems

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Uniper – A Company with a Century of Experience in Generation and Energy Markets
Impact of VRE on Thermal Generation in Europe

UK generates a day’s electricity without coal
Share of power from the fossil fuel fell to zero on Friday for first time since 1882

Power price surges to record high on supply shortage fears
Prices for the hour to 8pm on Thursday evening traded at £999/MWh.
Transition From Fossil to Renewables

Renewables incentivised by:
- Renewables obligations and Feed-in-Tariff subsidies;
- Declining CAPEX costs for wind and solar.

Fossil generation discouraged by:
- Tightening legislation on NOx and SO2 leading to ‘invest or close’;
- Carbon Fuel Tax;
- Reduced residual demand

Demand decline from:
- Energy Efficiency
- Weaker economic growth
- Self generation, especially domestic PV
The Ancillary Services Challenge

Frequency Containment Reserve (FCR)
- Timescale seconds to minutes;
- FCR requirement increases as the inertia of the system decreases;
- FCR provision cost in mainly capacity element.

Frequency Restoration Reserve (FRR)
- Timescale minutes to hours;
- Wind and PV limitations for full FRR provision;
- Typically provided by storage hydro and spinning thermal units;
- Renewables increase demand for reserve and reduce the supply;
- FRR provision includes significant capacity and energy costs.
Provision of Grid Stability

Managing Imbalances

- In many European countries approach is to procure ancillary services through markets and bilateral contracts.
- Generators offer balancing capacity and energy with different response characteristics.
- TSO balances system at least cost.
- Variations from forecast cashed-out at imbalance prices.

Transmission Constraints

- Approaches to dealing with constraints are:
  - Scheduling with regional flow constraints;
  - Unconstrained Schedule followed by redispatch.
Conventional Modelling Approaches

Energy-only Schedule

System Marginal Prices

Ancillary Service Model
Energy prices used as opportunity costs in calculating cost of AS

Reserve not allocated in energy schedule.
Reserve has to be secured by starting standing units
Expensive reserve
Conventional Modelling Approaches

- Energy with Reserve Constraint
- System Marginal Prices

Ancillary Service Model
- Energy prices used as opportunity costs in calculating cost of AS

- Larger number of generators are committed, providing spinning reserve
- Models MW not MWh
- No distinction between:
  - Response rates
  - Energy cost of reserve
- Inefficient allocation of generators to reserve
Integrated Market Model

• Reserve Requirement Derived from TSO’s security standard.
• Integrated model of energy, reserve capacity and balancing energy.
• Optional models of:
  • Redispatch for transmission constraints;
  • Outturn balancing actions, for separation of capacity and energy costs.
Calculating Reserve Requirements

**FCR**
- TSO Security Standard
- Loss of Largest Unit
- Forecast of Demand and Non-Synchronous Generation

**FRR**
- TSO Security Standard
- Stochastic Plant Breakdown
- Demand Uncertainty
- Renewable Uncertainty
- Monte Carlo Simulation

FCR Capacity Requirement

FRR Capacity and Energy Requirement for Multiple Response Times
Optimiser Features

- Reserve Requirements
- Plant Breakdown
- Optimise to Minimum Cost
- Renewable Curtailment
- Stochastic Demand
- Stochastic Production
- Transmission Constraints
- Hourly Scheduling
- Multi-year studies

- Generator Operational Plans
- Prices for Energy, Reserve and Redispatch
- Merit order for Balancing Actions
Key Output Characteristics

For a changing market our model shows:

**PRICES**
More expensive units running than in energy-focused models. Costs allocated to energy price and ancillary service income.

**RESERVE**
Realistic mix of spinning thermal reserve and hydro to cover frequent small volumes. High cost plant only at tails.

**BALANCING**
Increased curtailment of renewables to reduce costs for system balancing.

**IMBALANCES**
Wind cost-rates for imbalance seen higher than for other plant types.
Form teams of decision makers and strategists.
Each team represents a company acting in the sector.
Simulation of electricity sales, plant scheduling and system operator actions.
Teams optimise their performance and compare with other teams.
Experience the interactions of energy, reserve and balancing.
Understand how plants will run in the future.
Validate future sector structure and support feedback to lawmakers.
Give decision-makers ‘market intuition’ in a safe environment.
Seamless transfer from ‘learning’ to ‘doing’.
Applying Uniper’s Experience

Uniper is developing energyLens, a tool that combines our simulation event experience with our skills in detailed modelling of energy systems.

1. energyLens Executive

   Digital Intuition events combined with cutting-edge software, form the foundation for senior stakeholders. Supports adjustments of key market drivers and visualisation of headline results. Understand the current sector, take control and drive the future.

2. energyLens Strategist

   Made available on an ongoing basis for strategists within key organisations. Supports adjustments of inputs and inspection of outputs in greater detail. Drill into the scenarios with deeper offline analysis of market evolution.

Access energyLens across platforms, devices and locations

Fast, flexible and secure
Key Messages

Europe has been at the forefront of a worldwide transformation from thermally dominated to high VRE systems.

Ancillary Services are growing in importance to support the renewables transition.

Uniper has developed a modelling framework that gives an integrated view on the converging markets for energy and capacity.

Uniper has embraced simulation events to gain competitive advantage ahead of changes to the electricity sector.

We are now developing energyLens, a combined simulation and modelling platform for high VRE systems.
Thank you!

If you need any further information, please contact us:

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