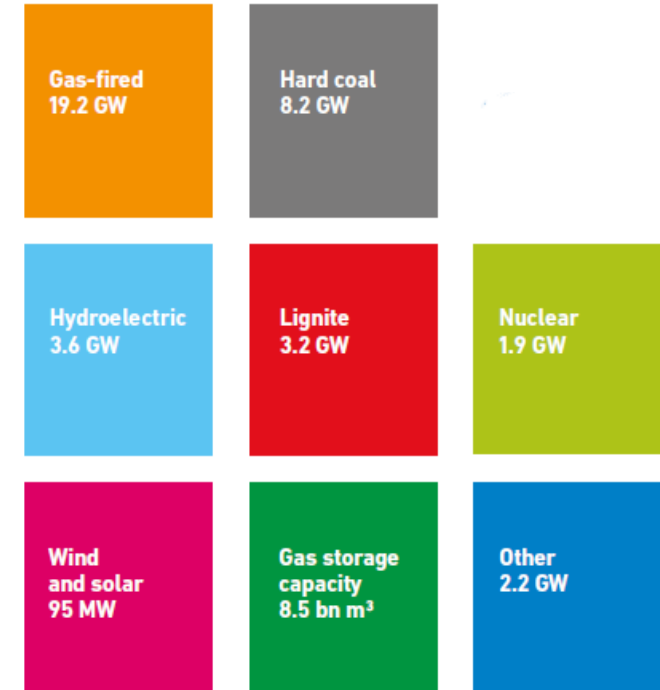
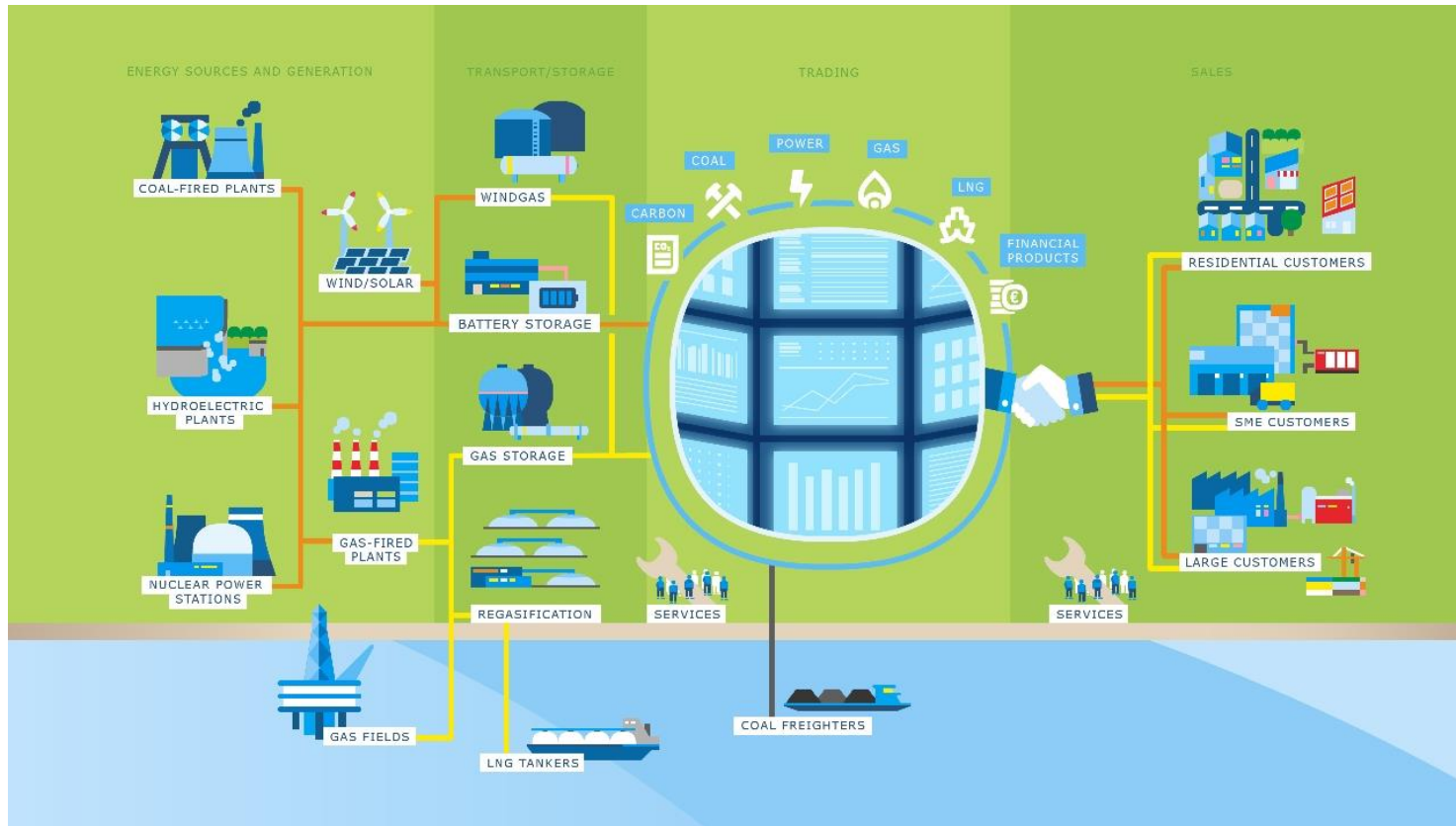




Modelling Transitions to High-VRE Systems

Colin Silvester, Christopher Bates and Arjun Chohan, Uniper

Uniper – A Company with a Century of Experience in Generation and Energy Markets



Scope of our power assets in Europe and Russia

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



© Bloomberg



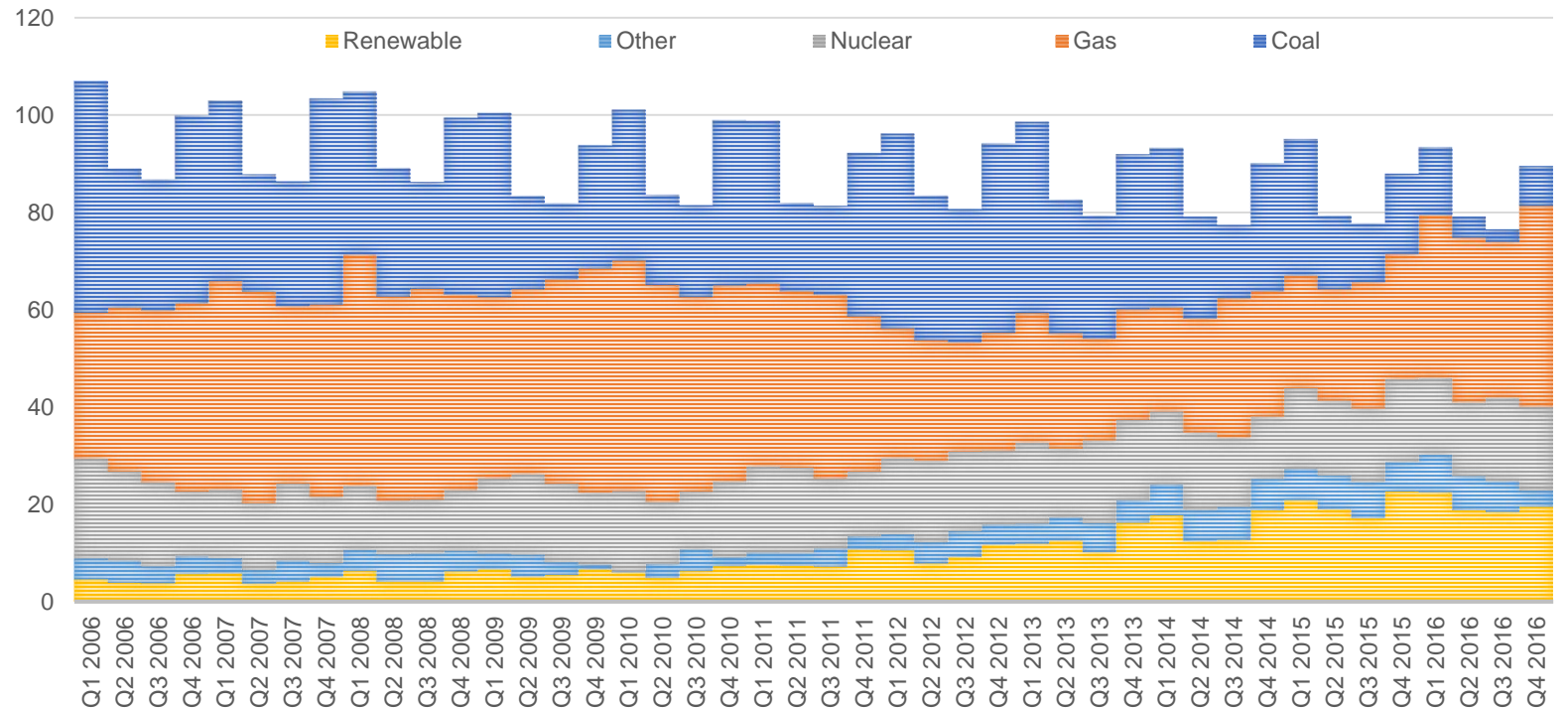
APRIL 22, 2017 by: **Pilita Clark**, Environment Correspondent

Britain has gone a full day without turning on its coal-fired power stations for the first time in more than 130 years.

Power price surges to record high on supply shortage fears

Prices for the hour to 8pm on Thursday evening traded at £999/MWh.

QUARTERLY UK GENERATION 2006-2016



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

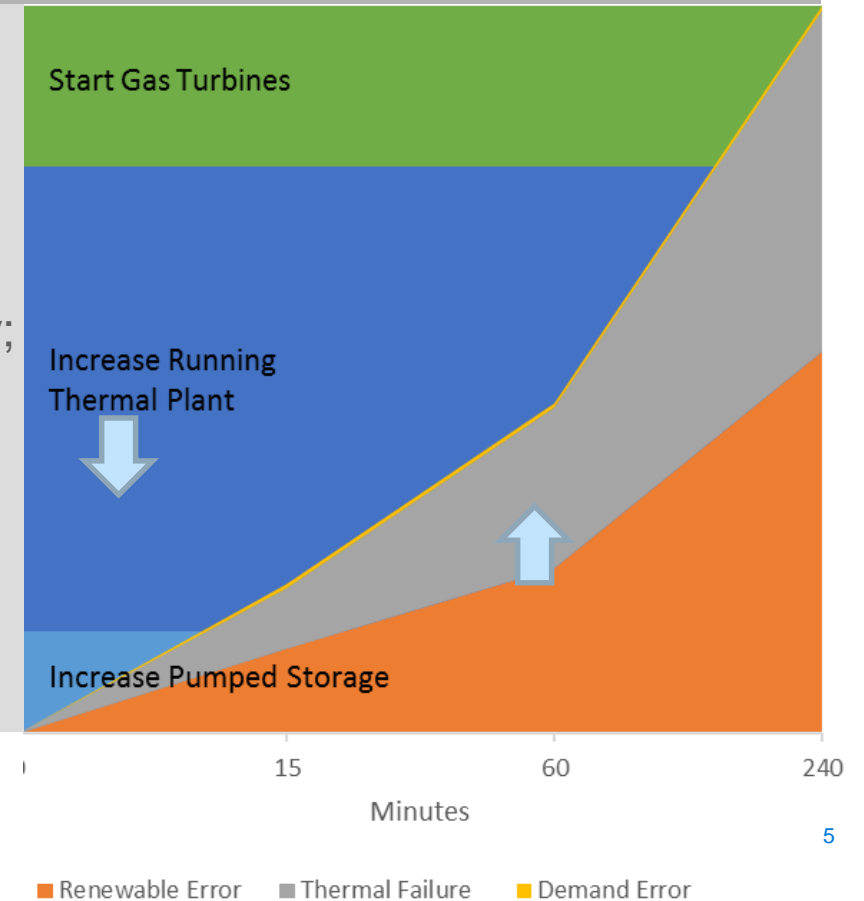
The Ancillary Services Challenge

Frequency Containment Reserve (FCR)

- Timescale seconds to minutes;
- FCR requirement increases as the inertia of the system decreases;
- FCR provision cost is mainly capacity element.

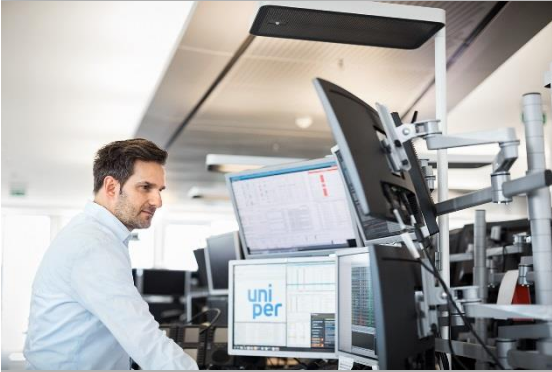
Frequency Restoration Reserve (FRR)

- 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

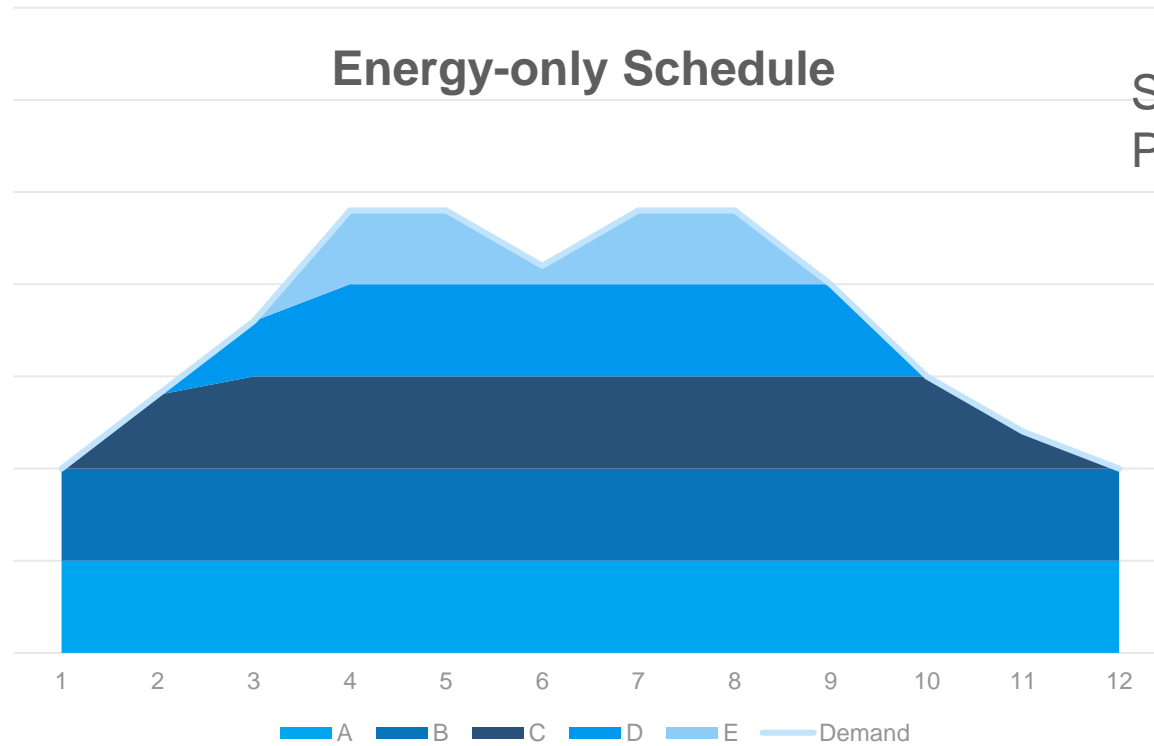


- In many European countries approach is to procure ancillary services through markets and bilateral contracts.
- Generators offer balancing capacity and energy with different response characteristics.
- TSO balances system at least cost.
- Variations from forecast cashed-out at imbalance prices.

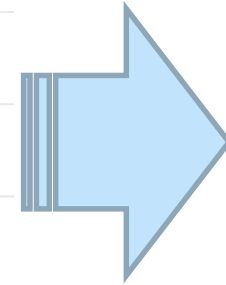
Transmission Constraints

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

Conventional Modelling Approaches



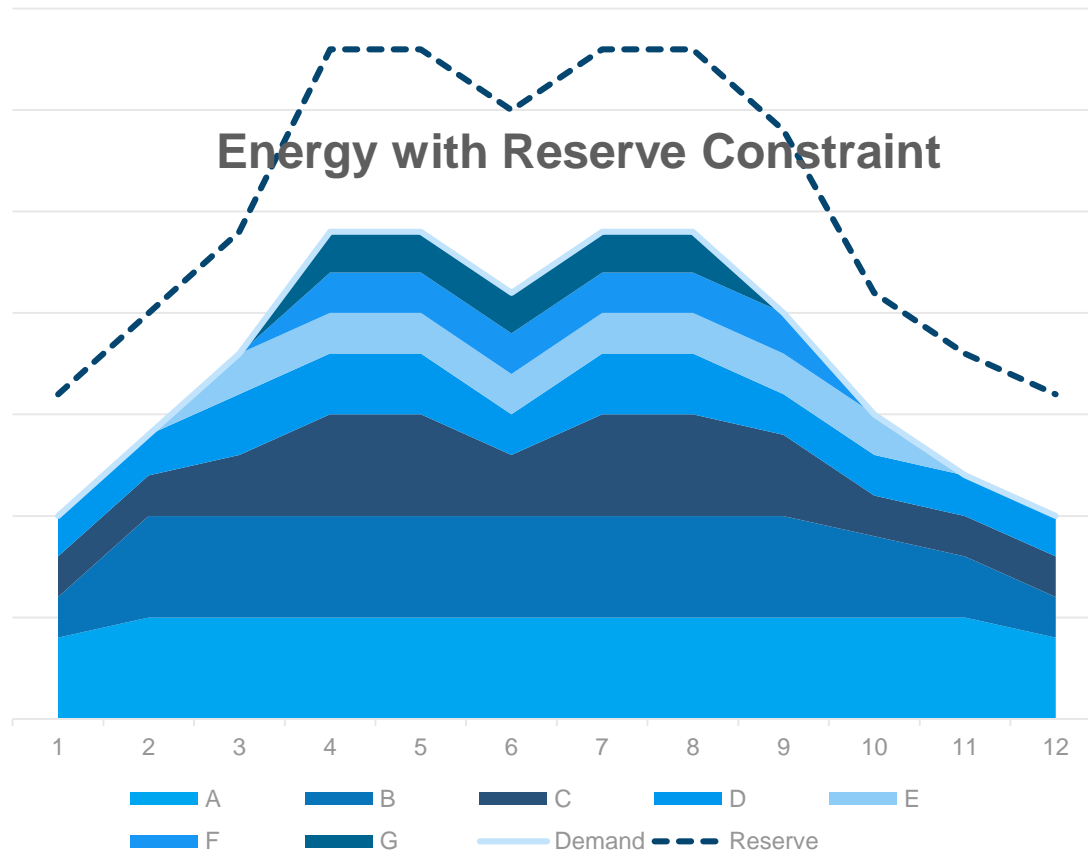
System Marginal Prices



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



✓ Larger number of generators are committed, providing spinning reserve

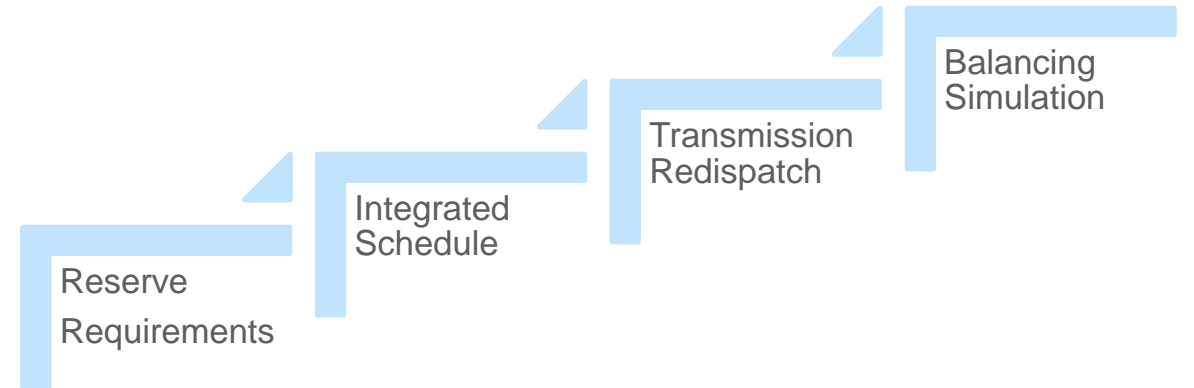
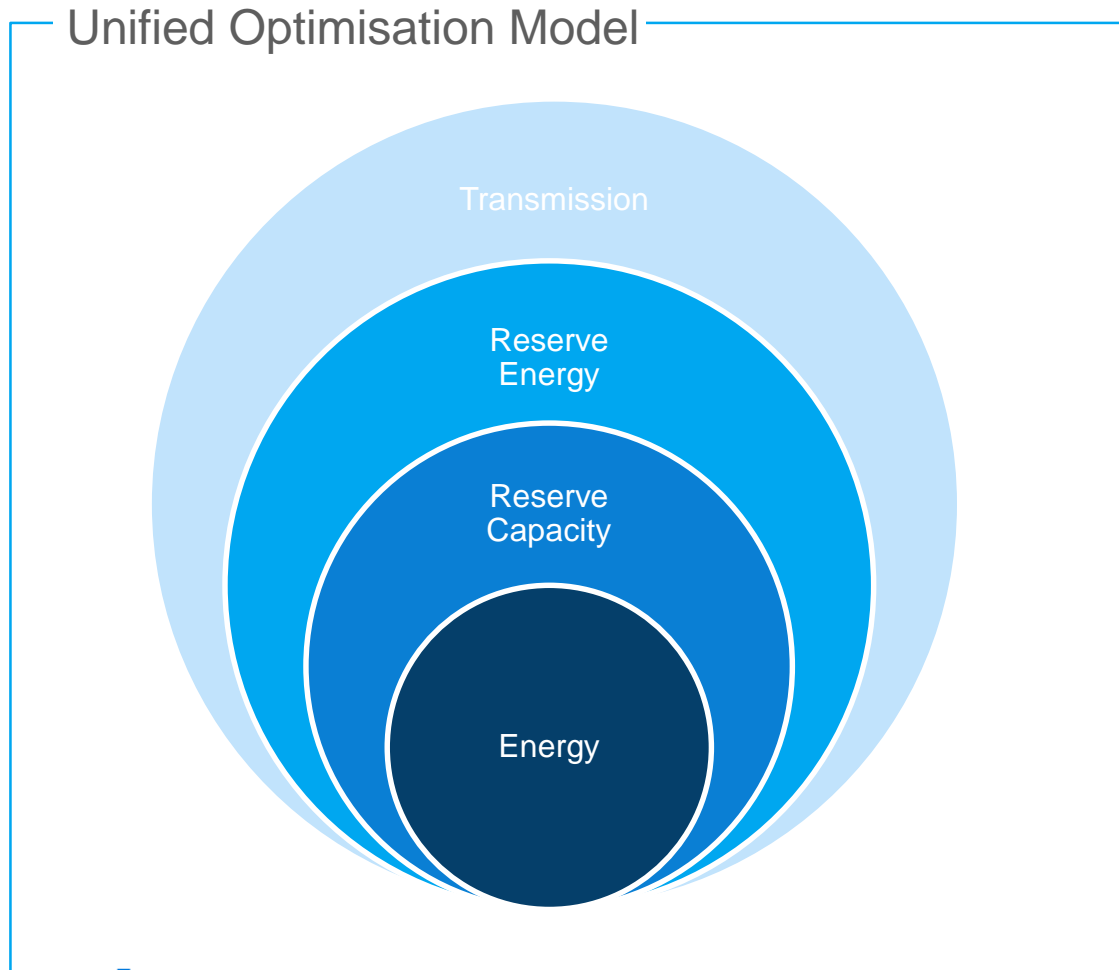
Ancillary Service Model
Energy prices used as opportunity costs in calculating cost of AS

✗ Models MW not MWh
No distinction between:

- Response rates
- Energy cost of reserve

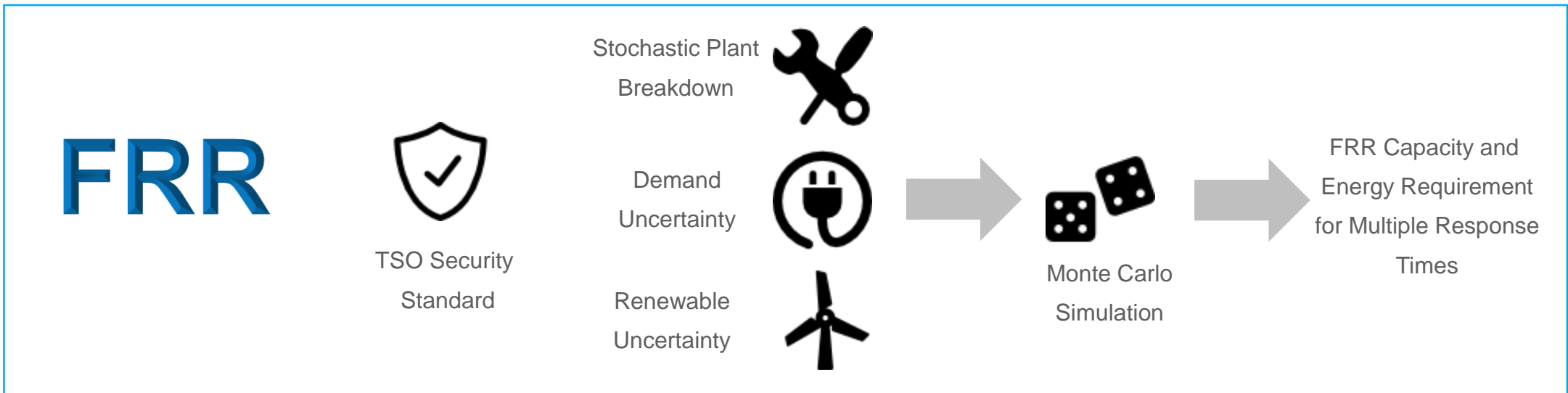
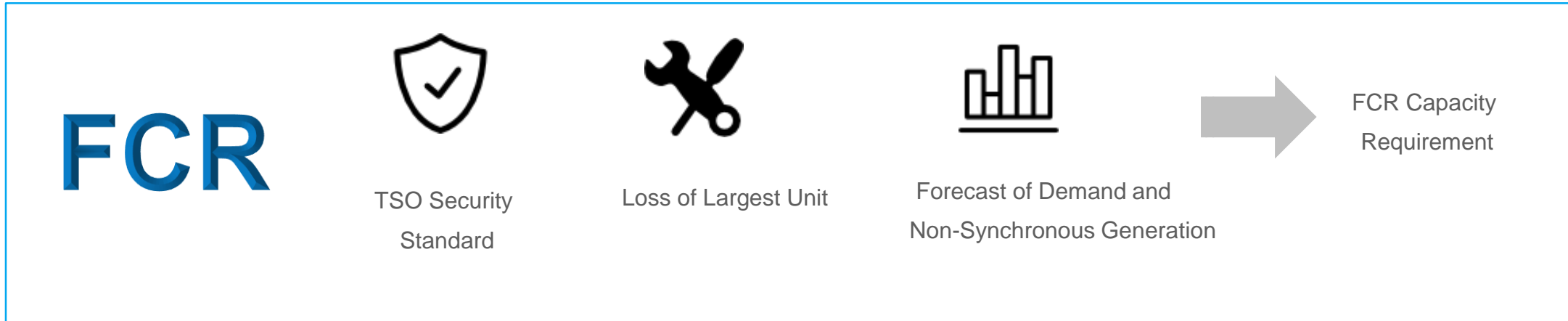
➔ Inefficient allocation of generators to reserve

Integrated Market Model

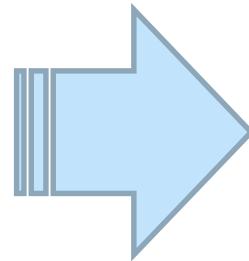
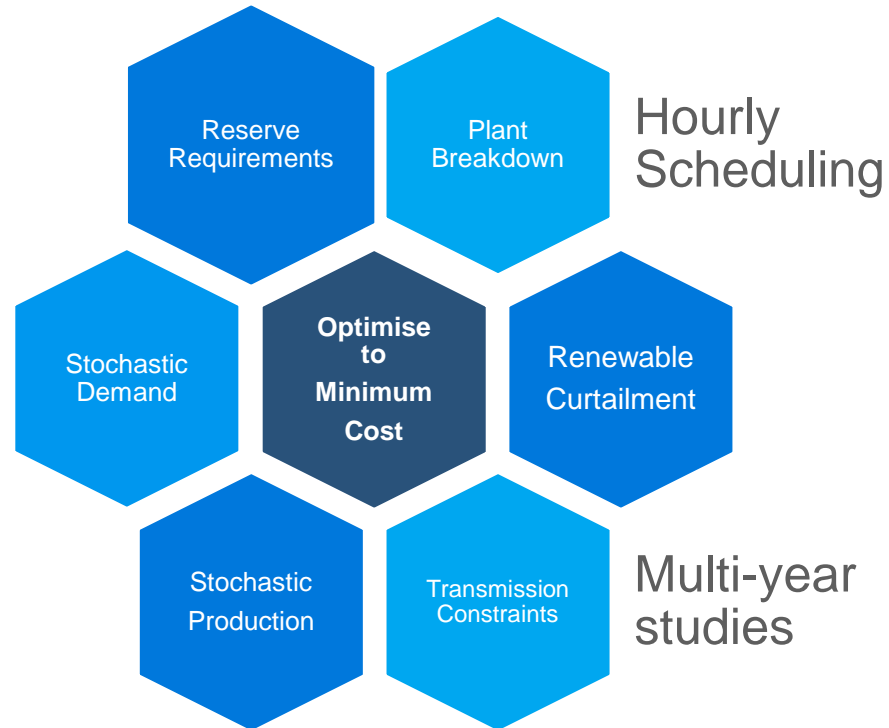


- Reserve Requirement Derived from TSO's security standard.
- Integrated model of energy, reserve capacity and balancing energy.
- Optional models of :
 - Redispatch for transmission constraints;
 - Outturn balancing actions, for separation of capacity and energy costs.

Calculating Reserve Requirements



Optimiser Features



- **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.

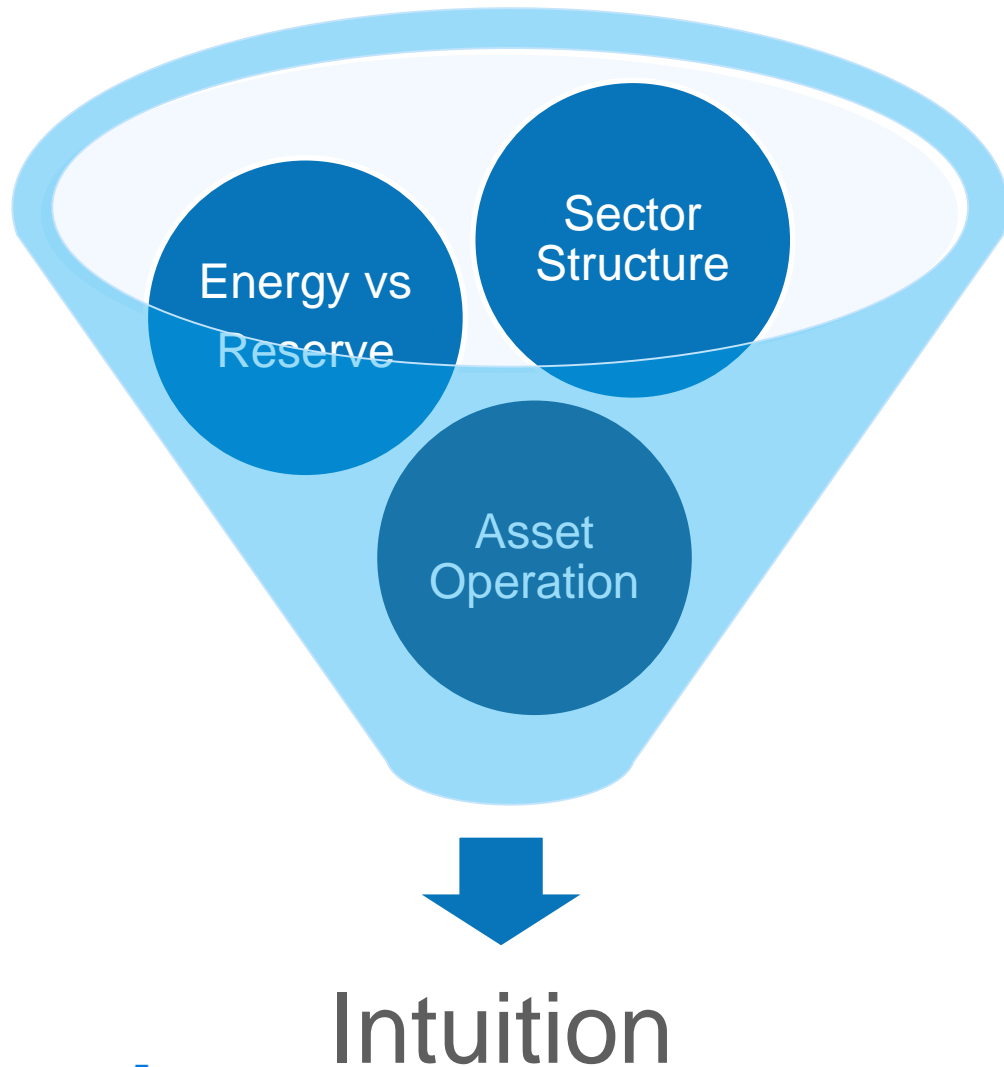
BALANCING

Increased curtailment of renewables to reduce costs for system balancing

IMBALANCES

Wind cost-rates for imbalance seen higher than for other plant types

Building Intuition Through Simulation



How do we Simulate ?

- 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.

Why Simulate ?

- 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:

Uniper SE
www.uniper.energy

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