



Securing Power Supplies in the 2020s

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E.ON Engineering

E.ON Engineering is the 'Technology Centre' of the E.ON Group, the world's largest investor owned energy services provider, with sales of €69 billion and 88,000 employees.

We provide highly innovative efficiency and future-proofing solutions for electricity and gas-sector plant and equipment. We provide our customers with comprehensive expertise in the fields of energy modelling, energy plant operation and research and development.

Business Modelling

- Market Modelling
- Risk
- Optimisation
- Simulation

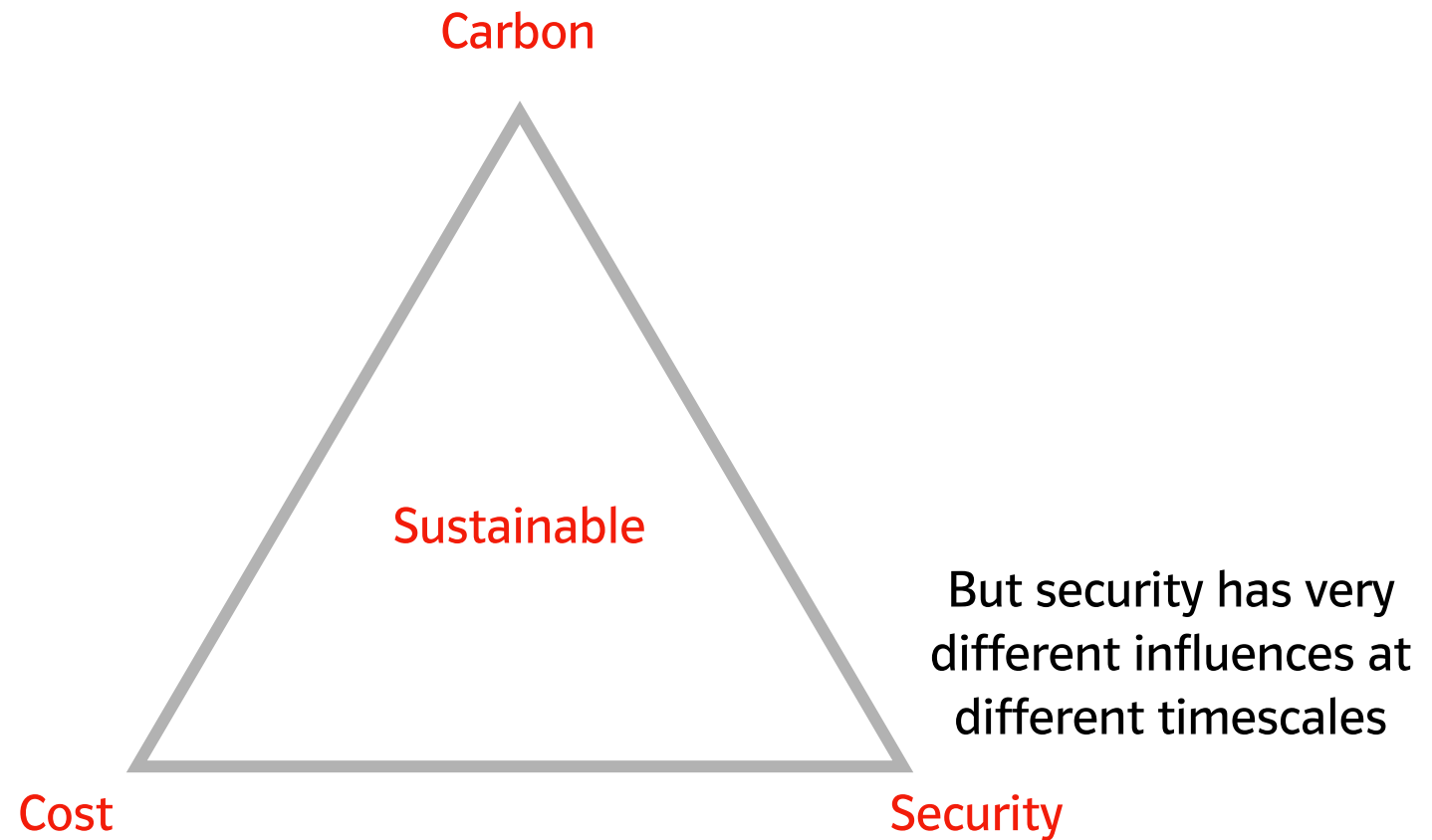


Development of mathematical modelling tools

Andy Boston

Andy joined the CEGB in 1985 and has worked within the electricity supply industry since then. He is technical head of Business Modelling and specialises in energy systems analysis, power markets and designing business simulation games.

The Trilemma



Timescales of Threats to Security

1 decade 1 year 1 month 1 day 1 hour 1 minute 1 second

Climate Change

Existing demand growth

New loads

Demand

Weather forecast errors

TV pick-up

Network

HV Grid constraints

LV Grid constraints

Circuit outages

Unexpected circuit loss

Generation

Insufficient planned build

Delays to new build

Wind forecast errors

Insufficient flexible dependable plant

Enforced closures

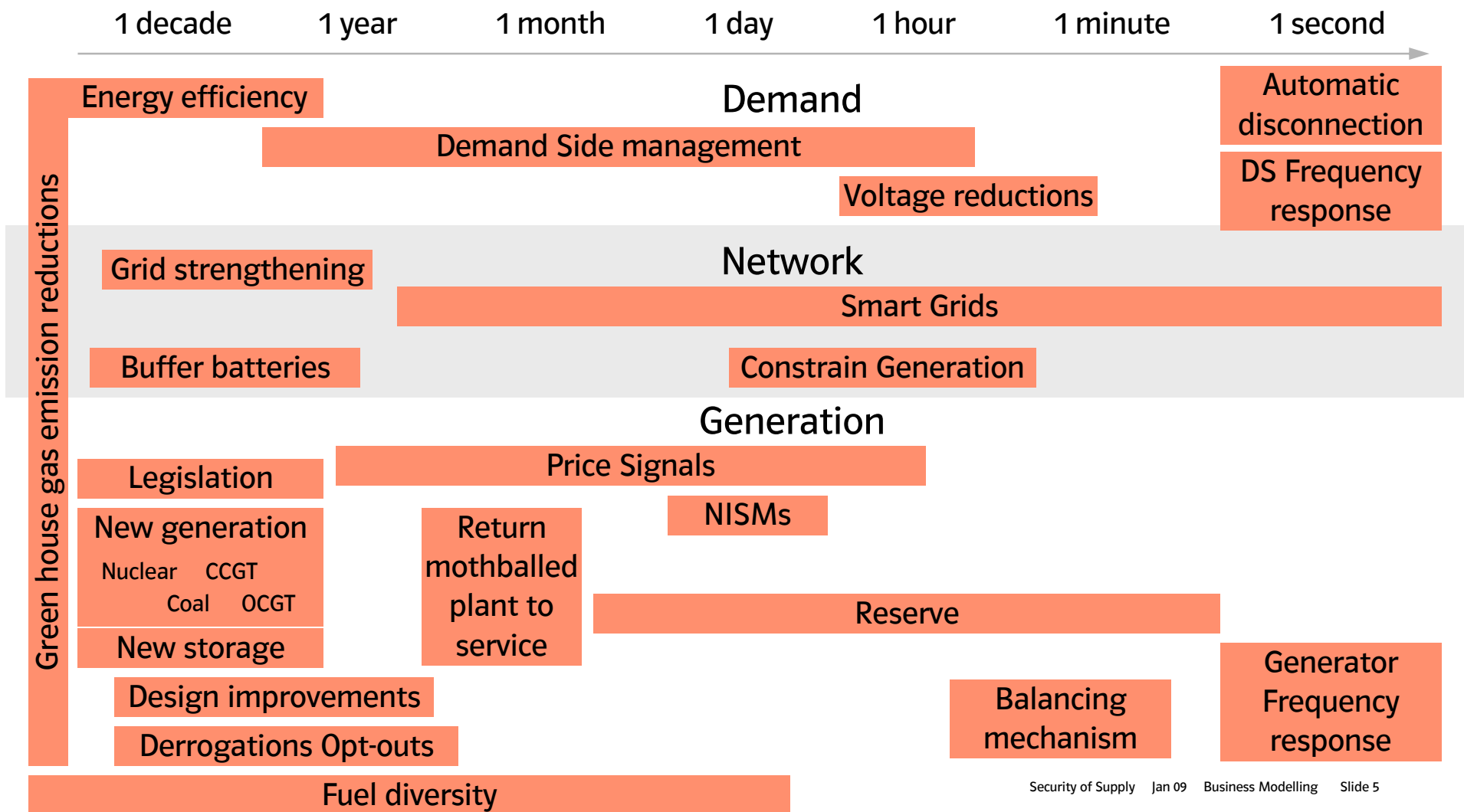
Long term breakdown

Short term breakdown

Unexpected unit trip

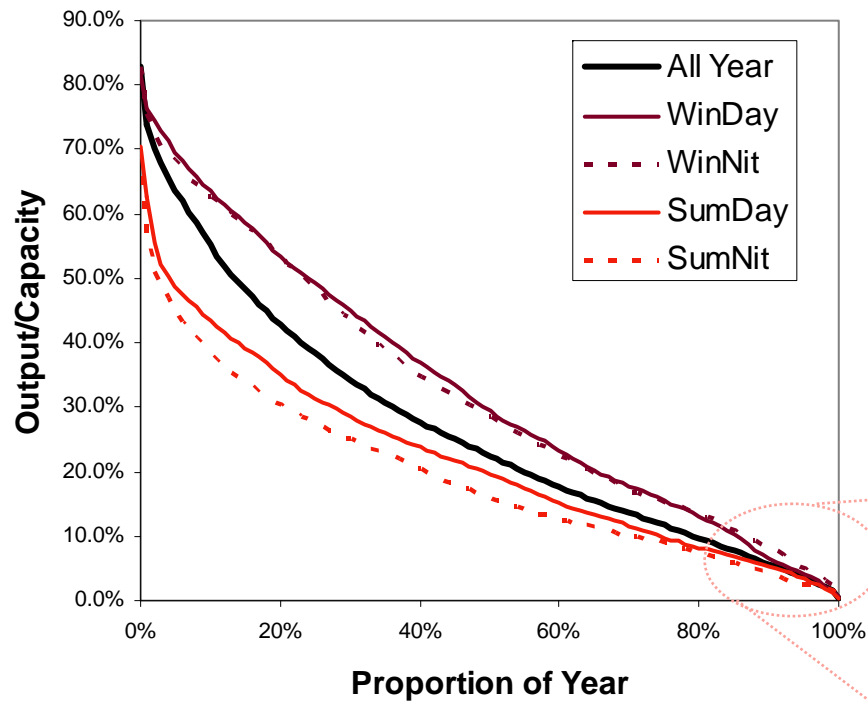
Fuel Supply Availability

Timescales of Mitigation Measures



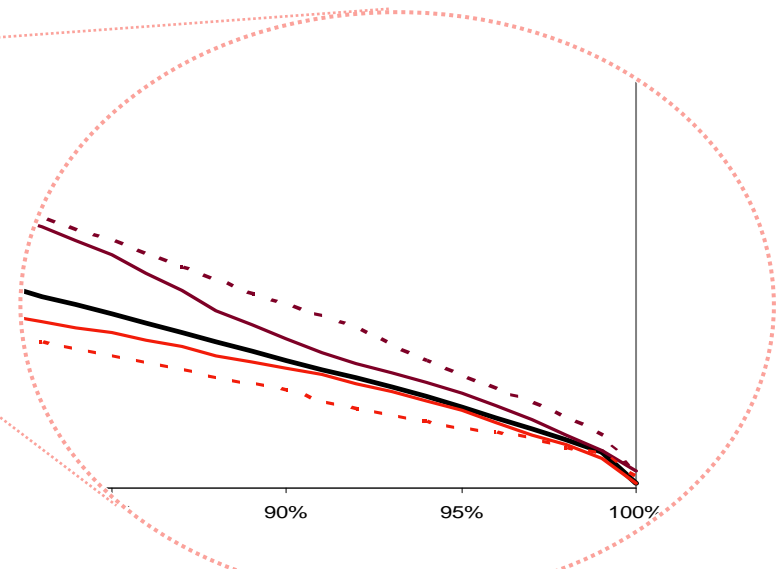
Wind Intermittency

Generation Duration Curve

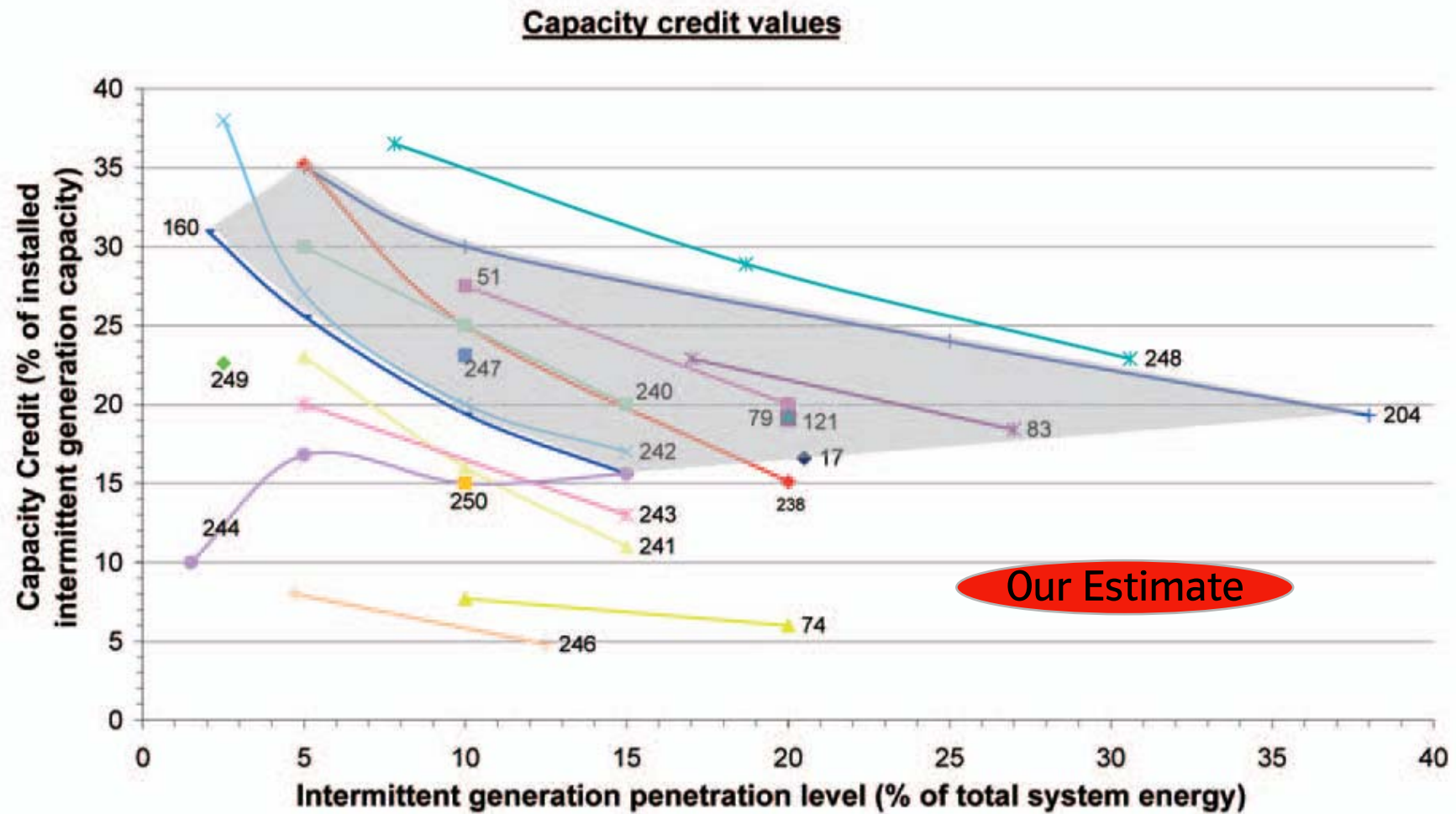


- Winter is generally windier than the summer, eg the median output for a winter day is 30% capacity, in the summer it is 20%
- Daytime is slightly windier than night, but difference is small and most marked in the summer
- However all curves drop to zero and converge at right hand end
- Conclusion: **Periods with no wind are equally likely at any time of year and any time of day.**

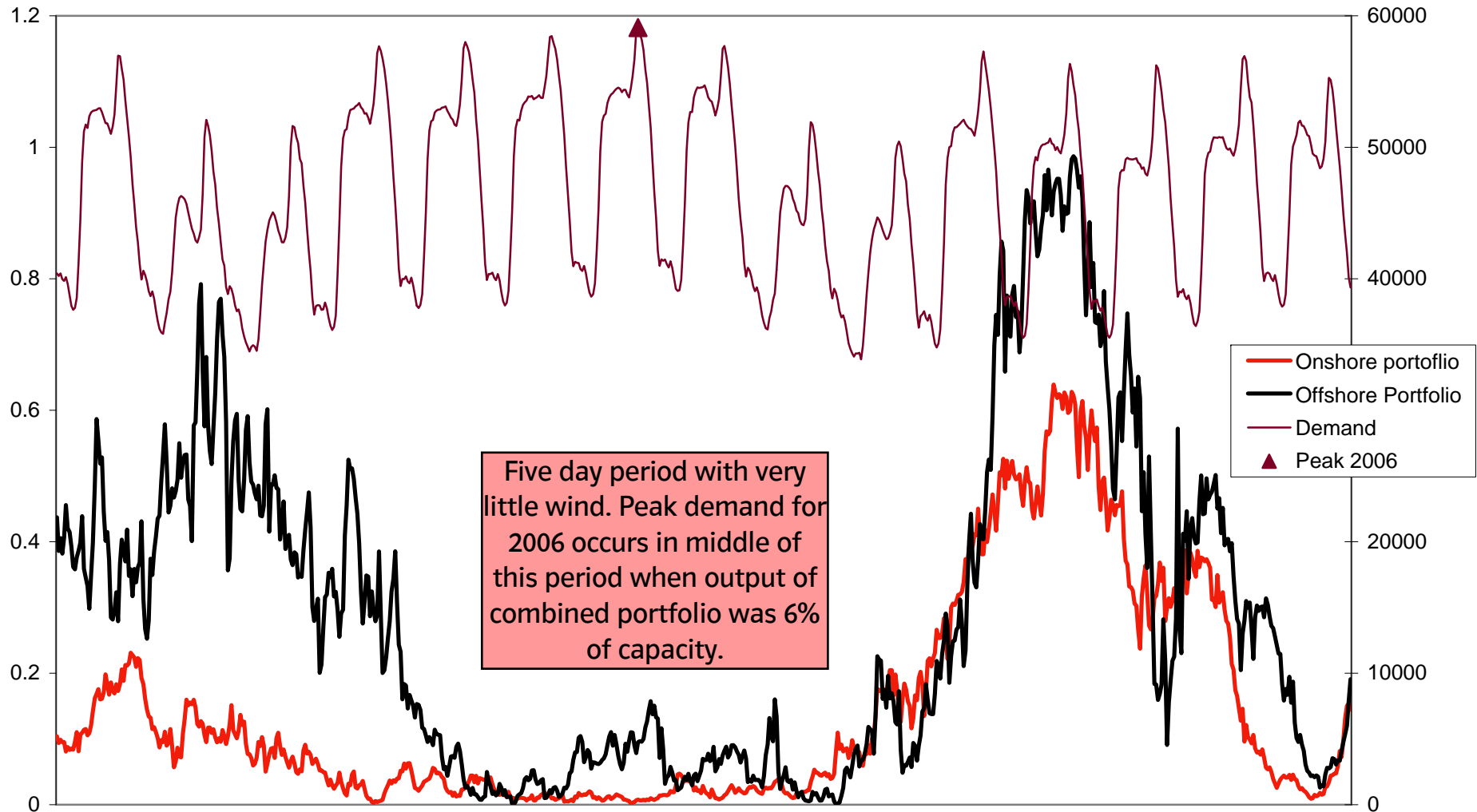
Loss of load calculations give wind a capacity credit of 8-10%



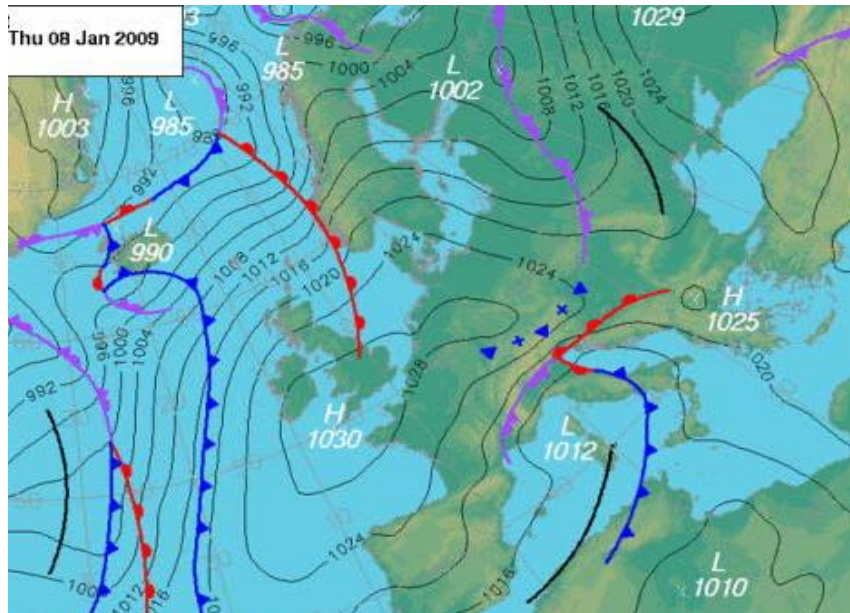
External Studies on Capacity Credit



Onshore and Offshore output for two weeks in February 06



Supply Reliability



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Ukraine refuses to ship Russian gas to Europe

Last Updated: Wednesday, January 14, 2009 | 9:45 AM ET Comments 154 Recommend 43
CBC News

Deliveries of Russian gas destined for Europe will not resume on Wednesday as hoped, according to the head of Ukraine's gas company, who blamed conditions set by Russia for the delay.

The most recent anticyclone coincided with gas supply interruptions.

It's not the first time supplies to EU have failed

BELARUS JAN 2007: Pricing dispute, Russia cut oil to Belarus and threatened to cut off gas

LITHUANIA JULY 2006: Russia shut an oil pipeline

UKRAINE, JANUARY 2006: Gazprom halt supplies in pricing dispute.

GEORGIA, JANUARY 2006: Blasts on gas pipelines in Russia, cut off supplies to Georgia and Armenia.

LATVIA 2003: Russia closed an oil pipeline

ESTONIA: Russia reduced refined oil exports when Estonia moved a WW2 memorial

Swedish Defence Research Agency :

"The number of incidents since 1991, i.e. cut-offs, take-overs, coercive price policy, blackmail or threats, is over fifty in total (of which about forty are cut-offs)."

Background

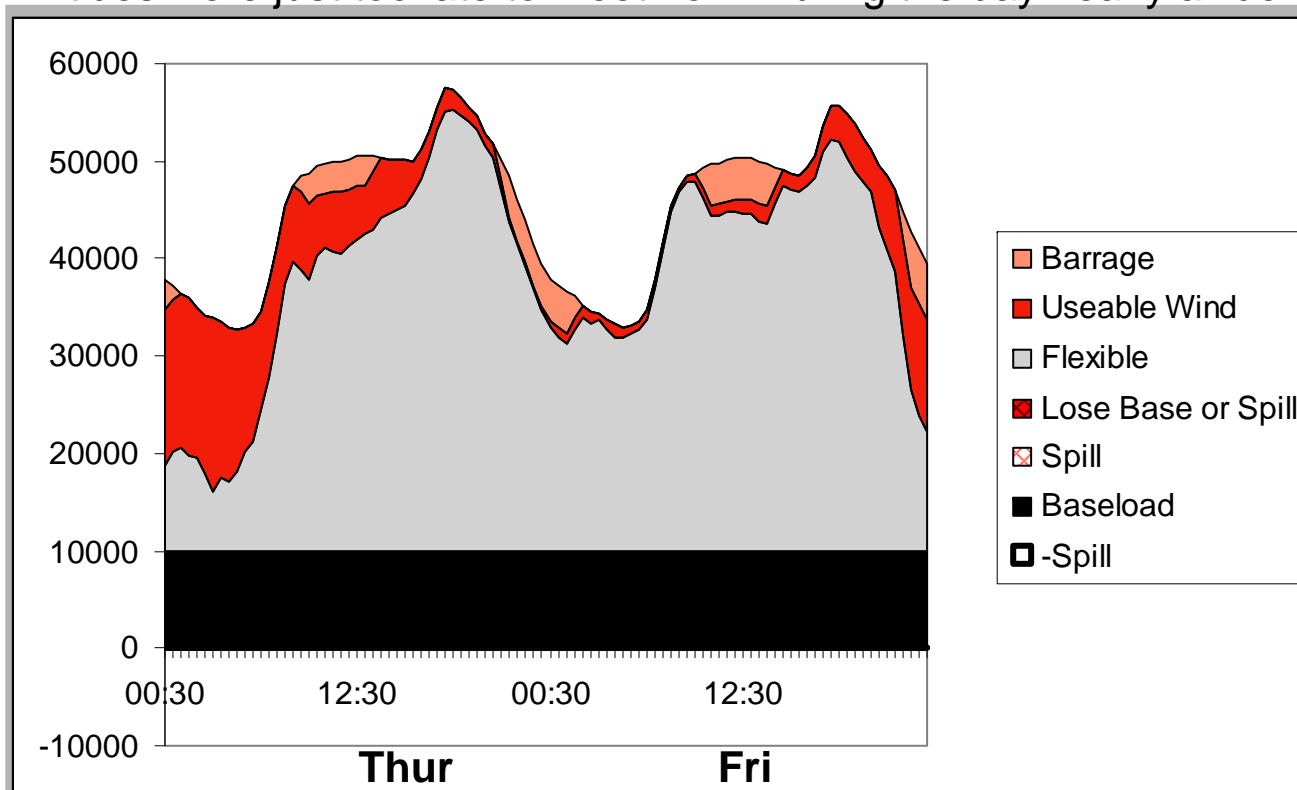
This is the story of a week in the life of a system operator in 2025. It is purely illustrative of the issues that will be faced by the electricity and gas system operators, and the utilities providing service to them. However it is based on a realistic simulation of the wind and tidal output onto a system with data from 2007 scaled to meet 38% renewables on the system.

Scene Setting – It's November 2025 and ...

- 30% of energy comes from wind (circa 45 GW)
- The Severn Barrage (8.6GW output on Spring Tides) is complete
- 10 GW of inflexible baseload (mainly nuclear) is on the system
- Remaining plant is mostly gas
- Neighbouring countries are experiencing similar weather so links cannot be relied upon to deliver security

Friday – A Cold Still Day

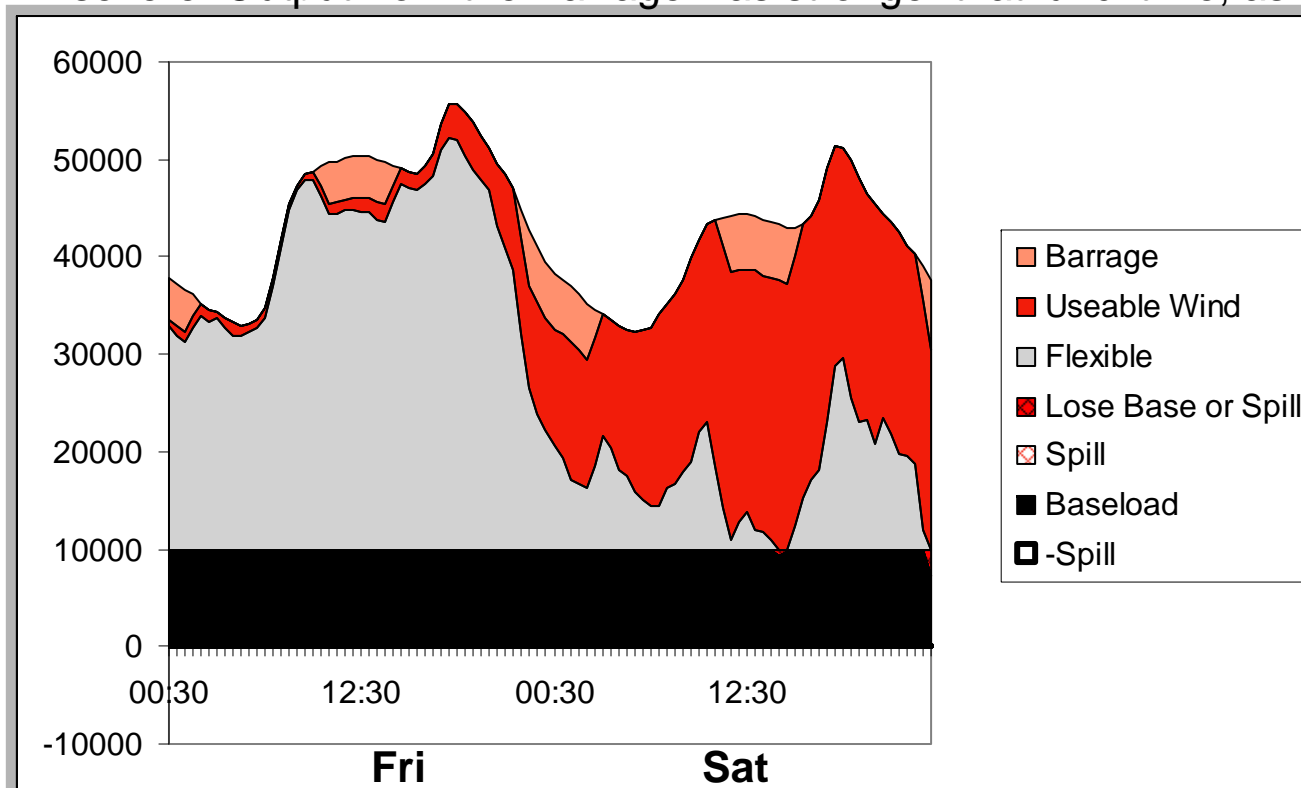
Friday started as a beautifully calm day. There'd been a touch of frost overnight with a bright, almost full moon high in the sky. With little wind much plant had been able to run through overnight and it was relatively simple to bring it up to full load for the morning peak, which the tides were just too late to meet now. During the day nearly all demand was met by thermal



plant with nuclear in the baseload. It was just like old times!
 However wind was picking up by the evening and a strengthening tidal output mean a lot of plant had to be shutdown before midnight

Saturday – The Wind Picks Up

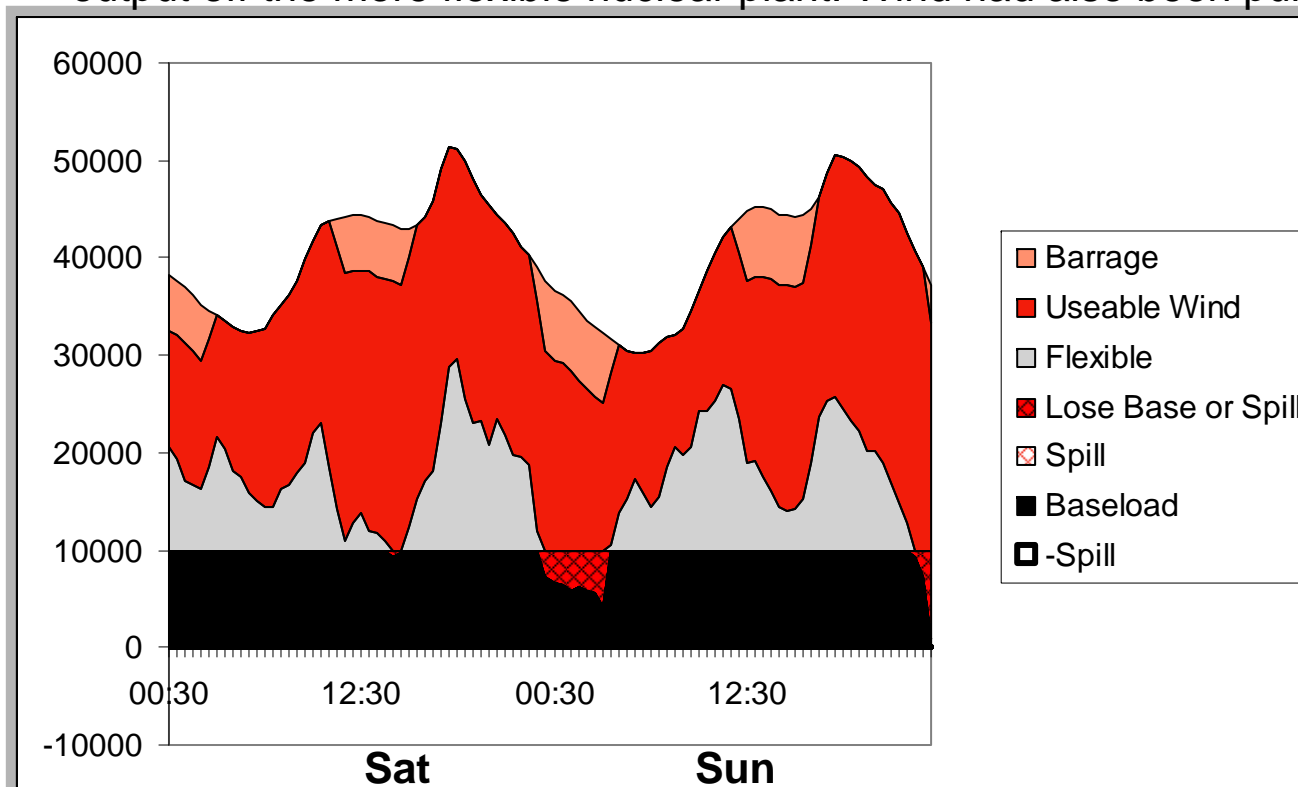
What a contrast to yesterday. The nightshift had had to contend with a short peak in output from flexible plant at 4am as more than 5GW of generation came off the bars with the rising tide. Thankfully it's not full moon yet otherwise the loss of the Barrage output would've been more severe. Output from the Barrage was stronger that lunchtime, as was the wind, meaning that



all flexible plant was off the bars by 3pm. Nearly 20GW had to be synchronised for the teatime peak but it all had to be off again by midnight. Fortunately some utilities had built flexible OCGTs which were able to do 3 starts today and stand in reserve in between

Sunday – Full Moon

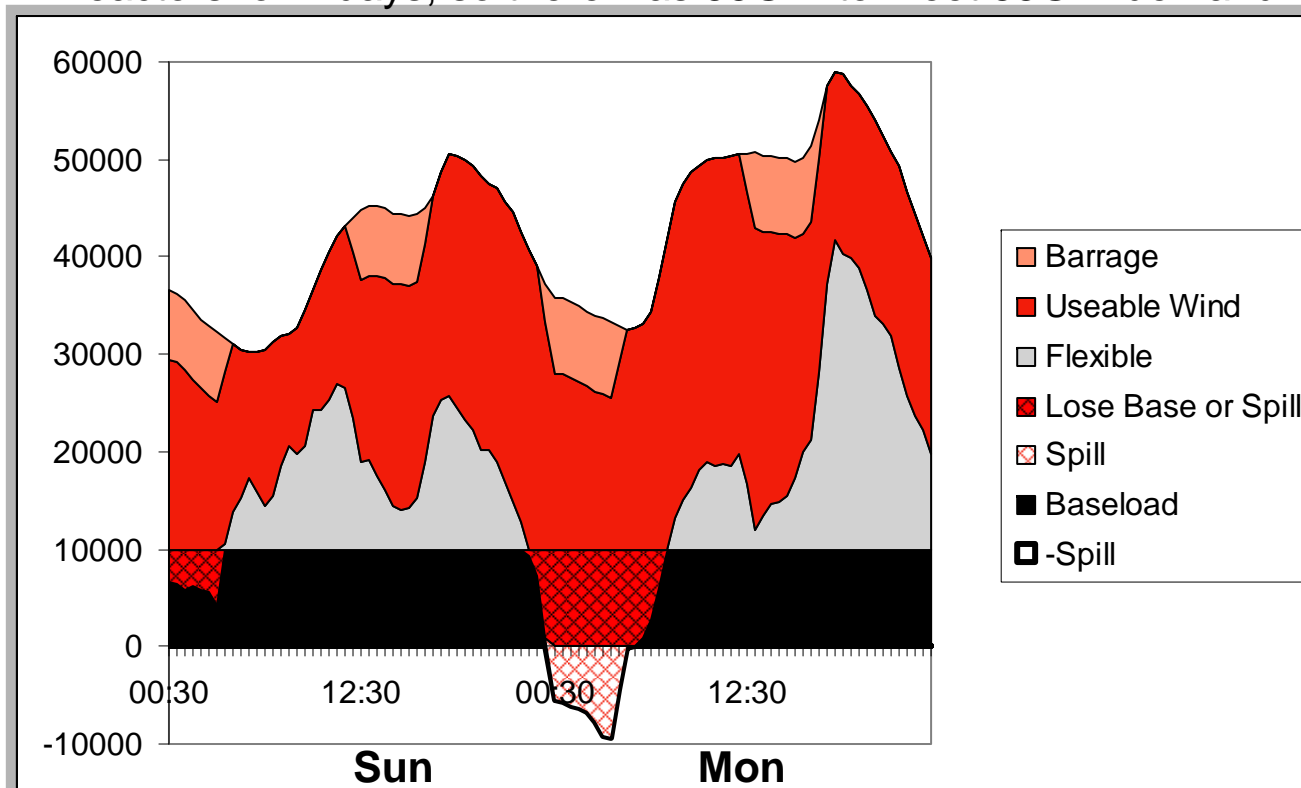
The situation got worse that night. The nightshift knew the barrage output would be stronger at 7GW but the strengthening wind had caught them off guard and now wind+tidal+nuclear was more than demand. However they managed it by accepting all the pumps bids and shaving some output off the more flexible nuclear plant. Wind had also been pulled back to do some frequency response.



response. The daytime was little better, 10GW of thermal plant had had to double two-shift around the Barrage output. They had charged a pretty penny for that, but delivered little energy over the day! It looked like Monday would be similar too!

Monday – Spring Tides and Winter Storm

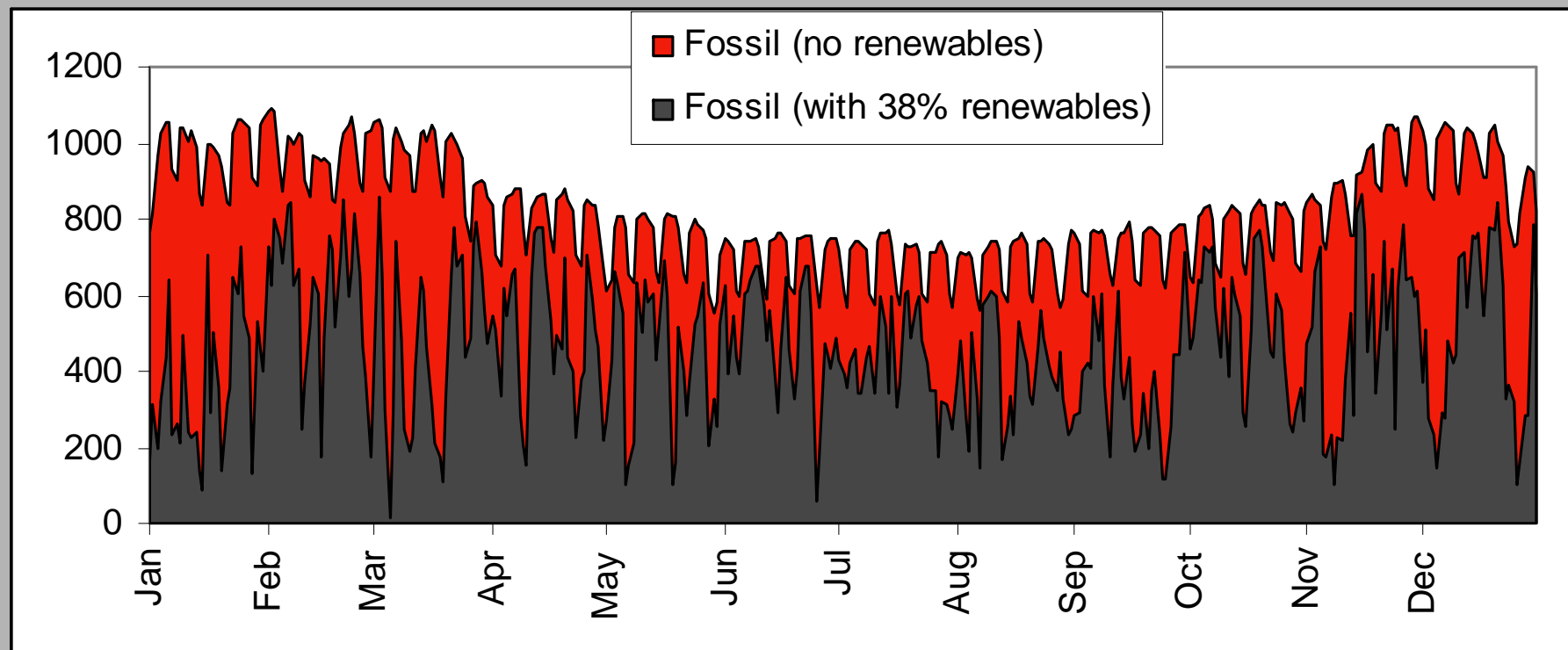
By midnight it was already clear this was going to be one of the most difficult days to manage. Wind had picked up to 35GW, nearly 80% of capacity, and the Barrage wanted to dump a further 7.5 GW on the system and needless to say, nuclear did not want to come off and poison their reactors for 2 days, so there was 53GW to meet 33GW demand!! Wind was forced to halve its



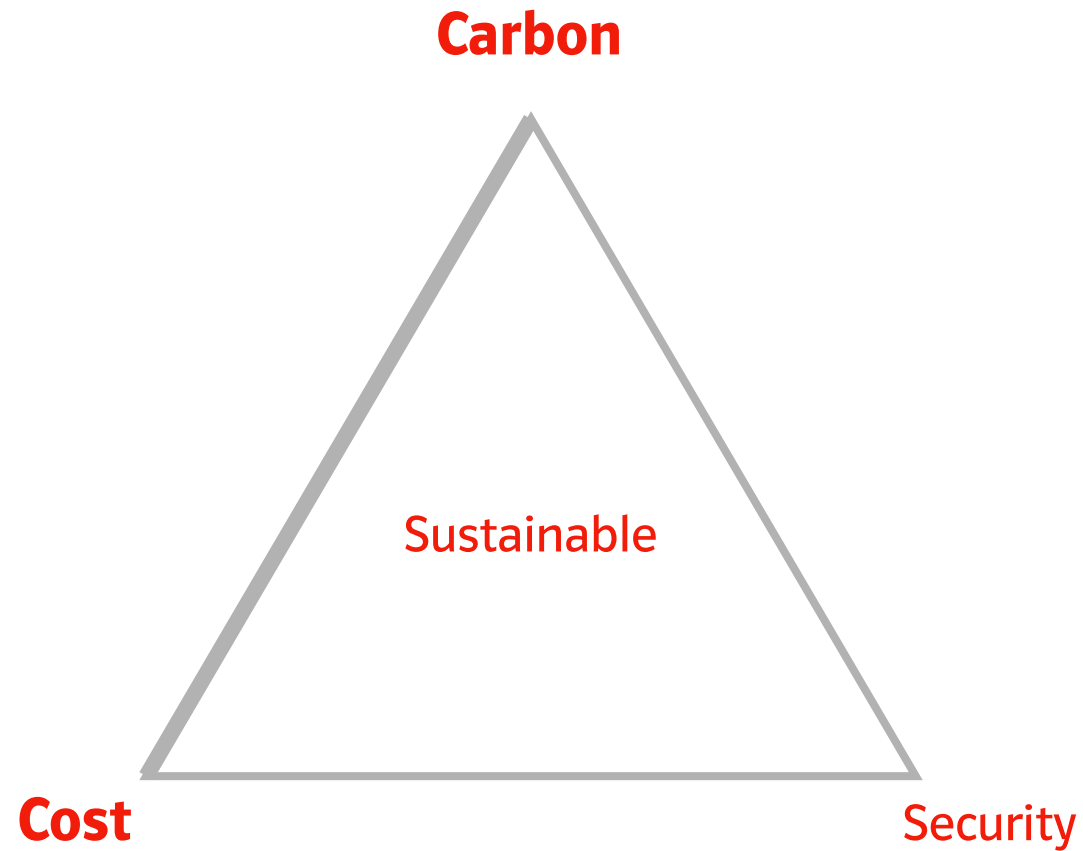
output. Teatime was even worse. The Barrage couldn't stretch its output any further and a weakening wind now meant 30 GW of thermal had to be synchronised for the peak, 20 GW between 3-5pm. Most of it was off again after 4 hours generation.

A Picture of the Year

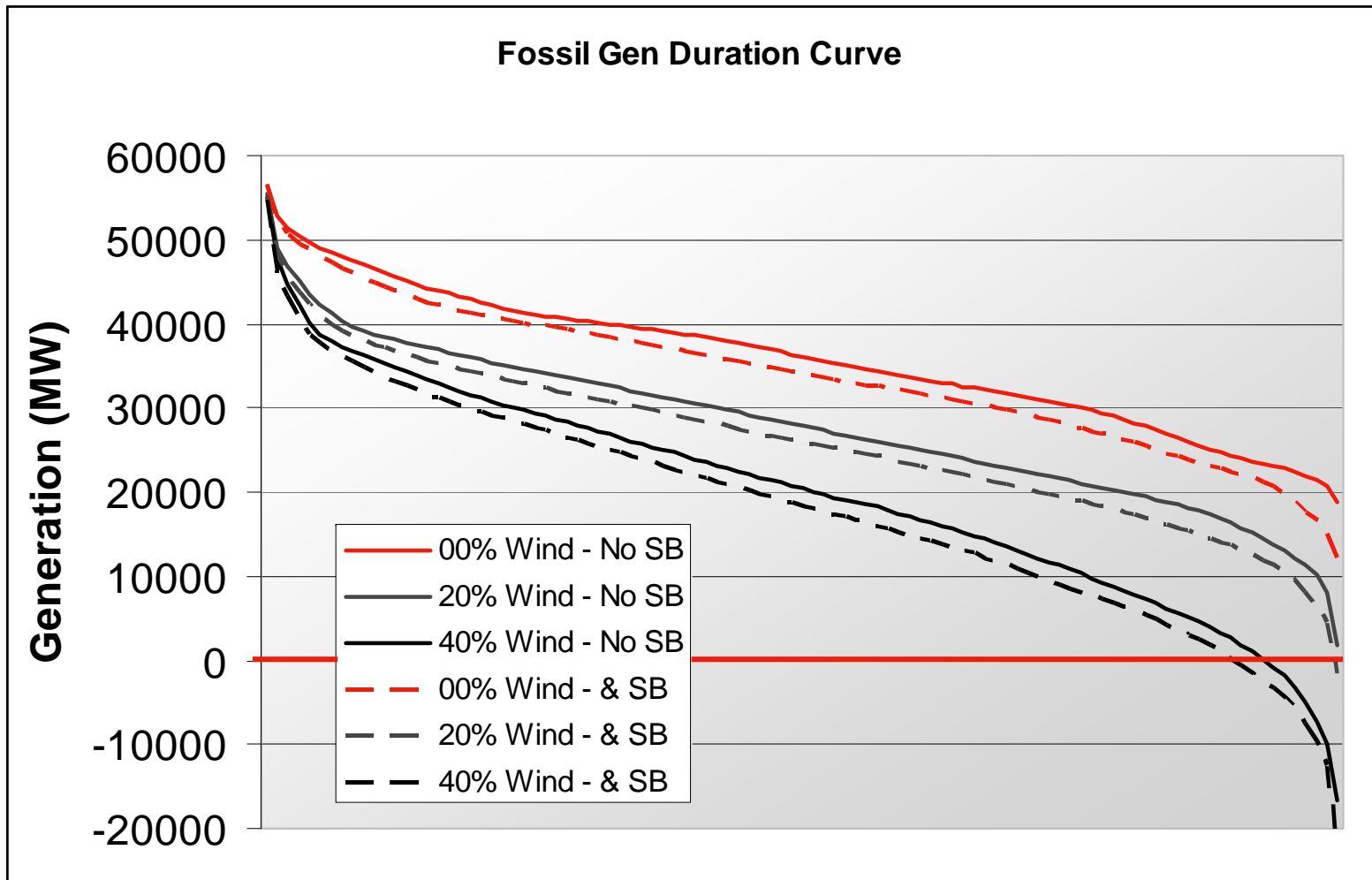
At the end of the year an analysis of generation demonstrated how much fossil output had been reduced. There were some large swings for gas demand, but these are on the timescale of a few days rather than a few hours. Daily generation (and hence gas demand) is illustrated below, it can be seen that increased wind in the winter almost levels monthly demand



The Trilemma



Fossil Duration Curve - 10 GW of nuclear



E.ON UK's Overview on the Energy Debate

Summary of main message of E.ON UK's manifesto "Carbon Cost and Consequences" 2008

- Integrated issues: Carbon Cost and Security have to be taken together
- Transparency and honesty: Need to clearly communicate scale and nature of challenge and implications for household bills
- Urgency: The timescale for decisions is short
- Diversity: To cope with price or availability issues with any one fuel
- Transition: Its going to take time