Requirements for expert judgment in electric power systems analysis

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Current issues in power systems

- Key driver - decarbonisation
  - Greater variability of supply, other issues such as integrating complementary technologies such as storage – more or less network?
- More complex trading – between people and countries
  - Larger computer models, more complex control strategies
- Doing things more efficiently
  - Using risk based approaches instead of traditional deterministic heuristics
- All of these require expert judgment
  - What does planning background look like?
  - How much data (in the traditional sense) do we have?

- Expertise in and acceptance of expert judgment
  - Expert judgment does not always get a good press
  - Limited statistical expertise in the industry

EXAMPLE: ADEQUACY ASSESSMENT

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Risk of absolute supply shortages

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Risk of absolute supply shortages

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Power shortage risks by 2015, Ofgem warns

Britain risks running out of energy generating capacity in the winter of 2015-16, according to the energy regulator Ofgem.

The regulator said coal-fired power stations would be closing sooner than expected

Its report predicted that the amount of spare capacity could fall from 14% now to only 4% in three years.

Ofgem said this would leave Britain relying more on imported gas, which would make price rises more likely.

The government said that its forthcoming Energy Bill would ensure that there was secure supply.

Ofgem blames the risk on coal-fired power stations being closed sooner than expected and EU environmental legislation.

The warnings come in Ofgem's first annual Electricity Capacity Assessment.

It comes three years after Ofgem's Project Discovery report, which warned that electricity shortages could lead to steep rises in energy bills.

It is now saying the highest risk of shortages would be sooner than expected because coal-fired power stations would be closing sooner than it had predicted in 2009.

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By SIMON ENGLISH, Business Editor

Published: 28th June 2013

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Adequacy assessment: formulation

- Snapshot margin of available generating capacity over demand

$$Z = X + Y - D = M + Y$$

  - X, Y: available existing and additional generating capacity, D: demand
  - Loss of Load Probability:

$$[\mathrm{LOLP}] = \mathrm{P}(Z < 0)$$

  - Expected Power Unserved:

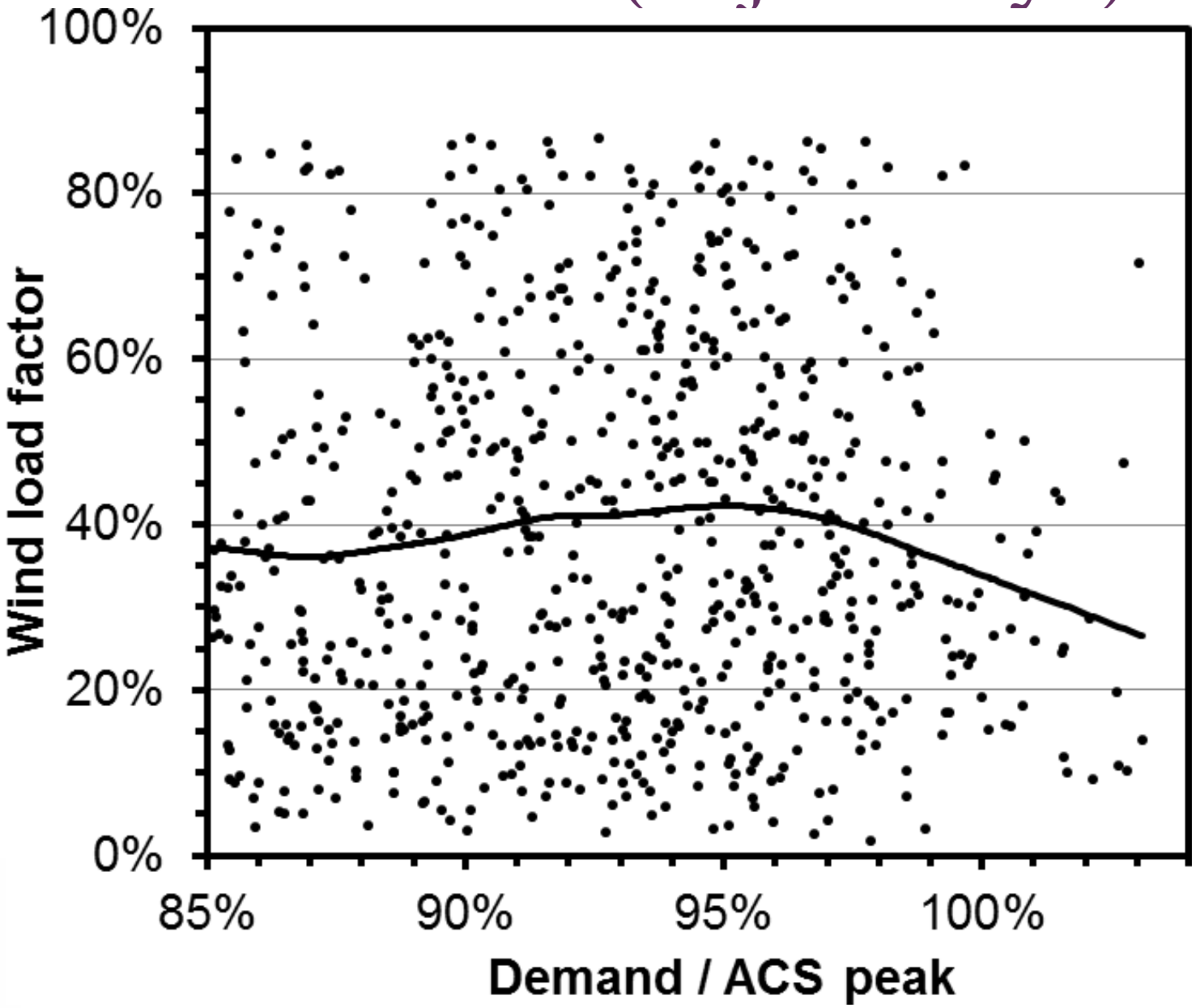
$$[\mathrm{EPU}] = \mathrm{E}[\max(-Z, 0)]$$

- Unified framework for annual peak and whole season calculations
  - X, Y, D: demand and available capacity at a randomly chosen time
  - Expectation values conditional on assumed state of knowledge

$$[\mathrm{LOLE}] = \sum_t \mathrm{P}(Z_t < 0) = n_{\mathrm{periods}}[\mathrm{LOLP}]$$

$$[\mathrm{EEU}] = t_{\mathrm{period}} \sum_t \mathrm{E}[\max(-Z_t, 0)] = n_{\mathrm{periods}} t_{\mathrm{period}}[\mathrm{EPU}]$$

Limited historic data (objectivity?)



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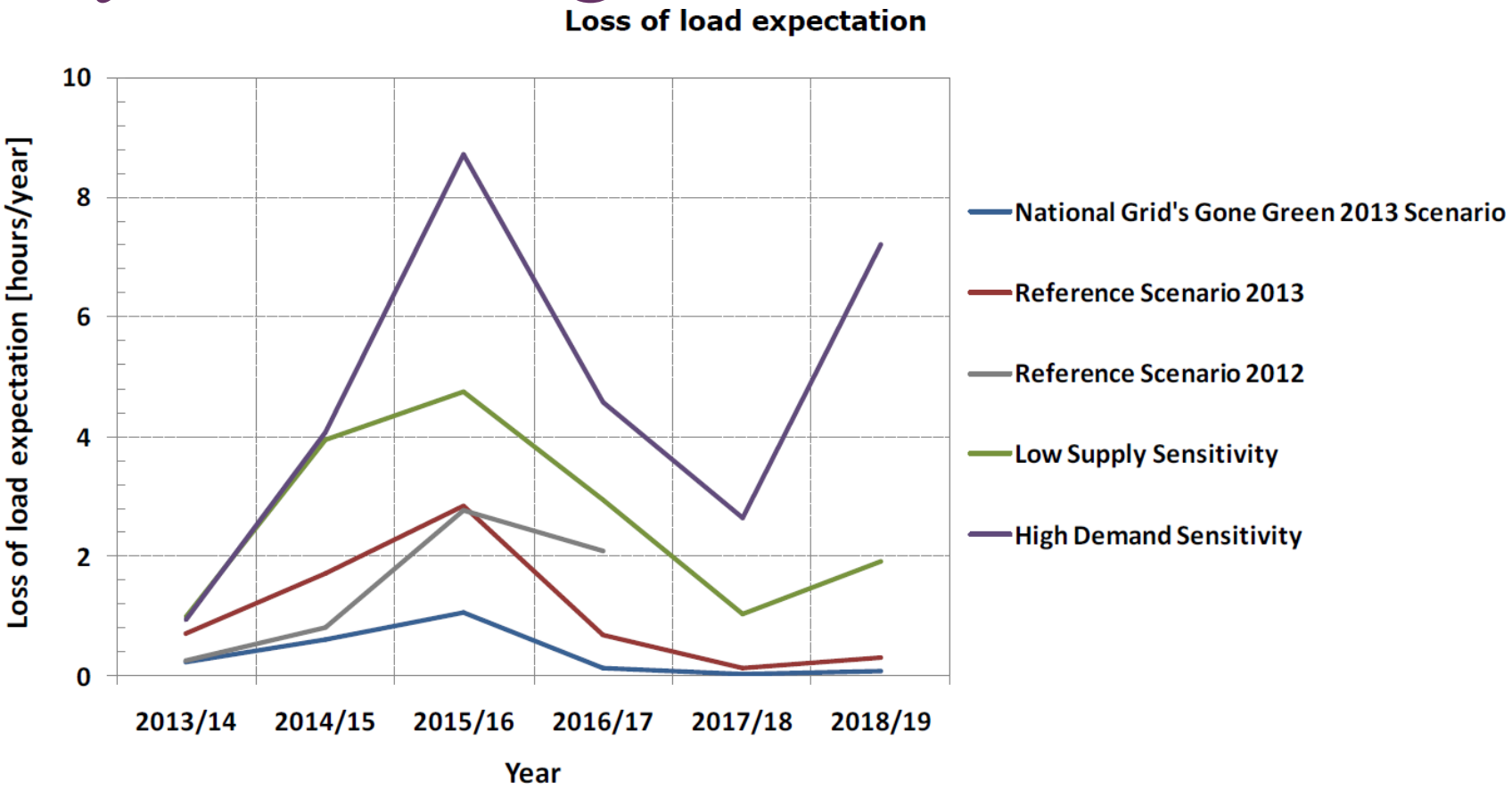
System background scenario



- What scenarios
- How to take decisions?
  - Assign subjective probabilities and define utility?
  - Look for solution which has most benign worst outcome?

Station outages

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Power returns following blackouts

Electricity supplies have returned to normal following countrywide blackouts on Tuesday, the National Grid has said.

Hundreds of thousands of homes and businesses across London, Cheshire, Merseyside and East Anglia lost power.

Blackouts were caused by Sizewell B nuclear plant in Suffolk and

Sizewell B provides about 3% of the UK's electricity

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Belt collapse shuts power station

The Longannet power station in Fife has been shut down after the main conveyor belt collapsed.

It fell onto a building below, which sits directly above a main gas pipe.

The incident took place at the plant at Longannet

The incident took place shortly before 1400 GMT on Sunday at the Fife plant. No-one was injured and the station was shut down temporarily.

The power station's owner, Scottish Power, said the closure would affect operations at the facility but should not affect supplies.

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France imports UK electricity as plants shut

Robin Pagnamenta, Energy and Environment Editor
Published at 12:00AM, July 3 2009

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France is being forced to import electricity from Britain to cope with a summer heatwave that has helped to put a third of its nuclear power stations out of action.

With temperatures across much of France surging above 30C this week, EDF's reactors are generating the lowest level of electricity in six years, forcing the state-owned utility to turn to Britain for additional capacity.

Fourteen of France's 19 nuclear power stations are located inland and use river water rather than seawater for cooling. When water temperatures rise, EDF is forced to shut down the reactors to prevent their casings from exceeding 50C.

A spokesman for National Grid said that electricity flows from Britain to France during the peak demand yesterday morning were as high as 1,000MW — roughly equivalent to the output of Dungeness nuclear power station on the Kent coast.

Nick Campbell, an energy trader at Inenco, the consultancy, said: "We have been exporting continuously from this morning and the picture won't change through peak hours, right up until 4pm."

EDF warned last month that France might need to import up to 8,000MW of electricity from other countries by mid-July — enough to power Paris — because of the combined impact of hot weather, a

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Climate change puts nuclear energy into hot water

By James Kanter
Published: Sunday, May 20, 2007

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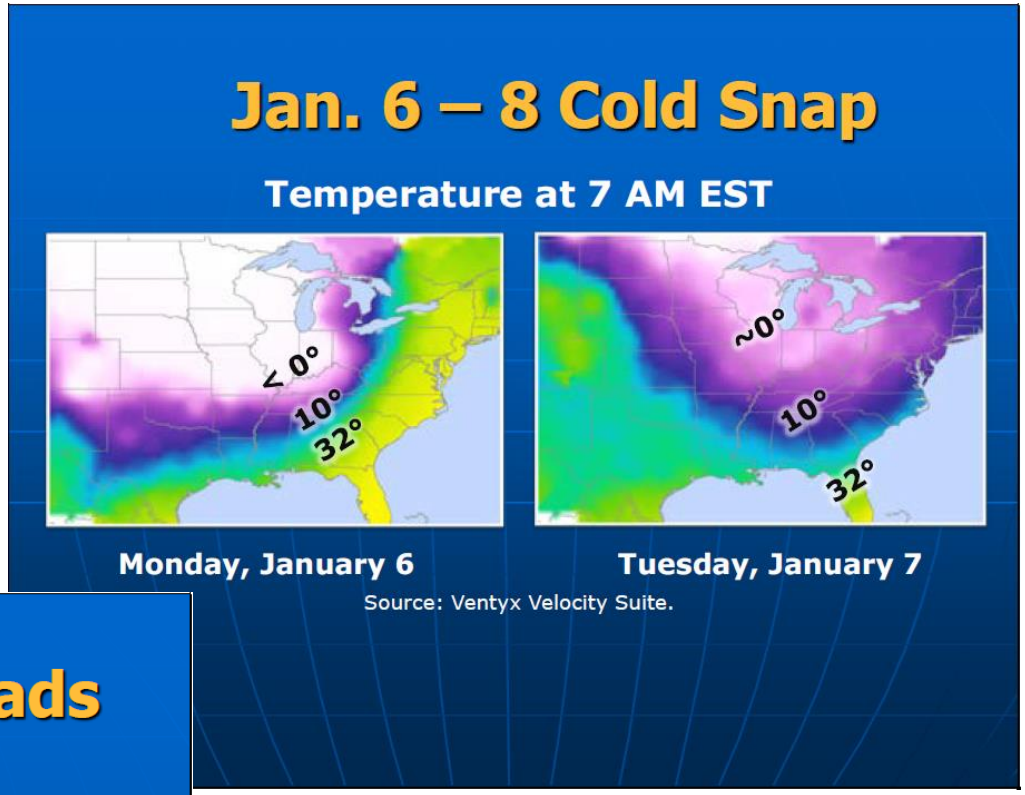
PARIS — Could climate change be the latest jinx on nuclear power?

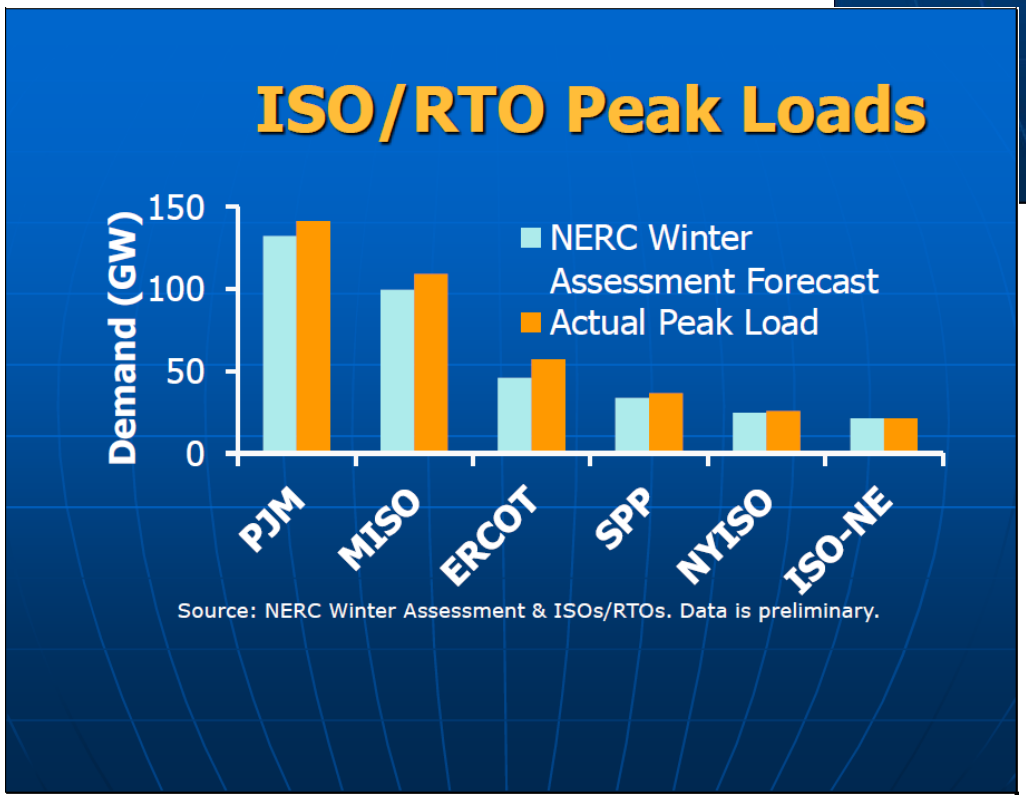
Long regarded with suspicion because of radioactivity, nuclear power suddenly has a revived image, thanks to the idea that many more plants could be built without worsening global warming. Unlike power plants fired by coal and natural gas, nuclear fission produces no carbon dioxide, the main greenhouse gas.

But there is a less well-known side of nuclear power: It requires great amounts of cool water to keep reactors operating at safe temperatures. That is worrying if the rivers and reservoirs which many power plants rely on for water are hot or depleted because of steadily rising air temperatures.

If temperatures soar above average this summer - let alone steadily increase in years to come, as many scientists predict - many nuclear plants could face a dilemma: Either cut output or break environmental rules, in either case hurting their reputation with customers and the public.

Cold weather





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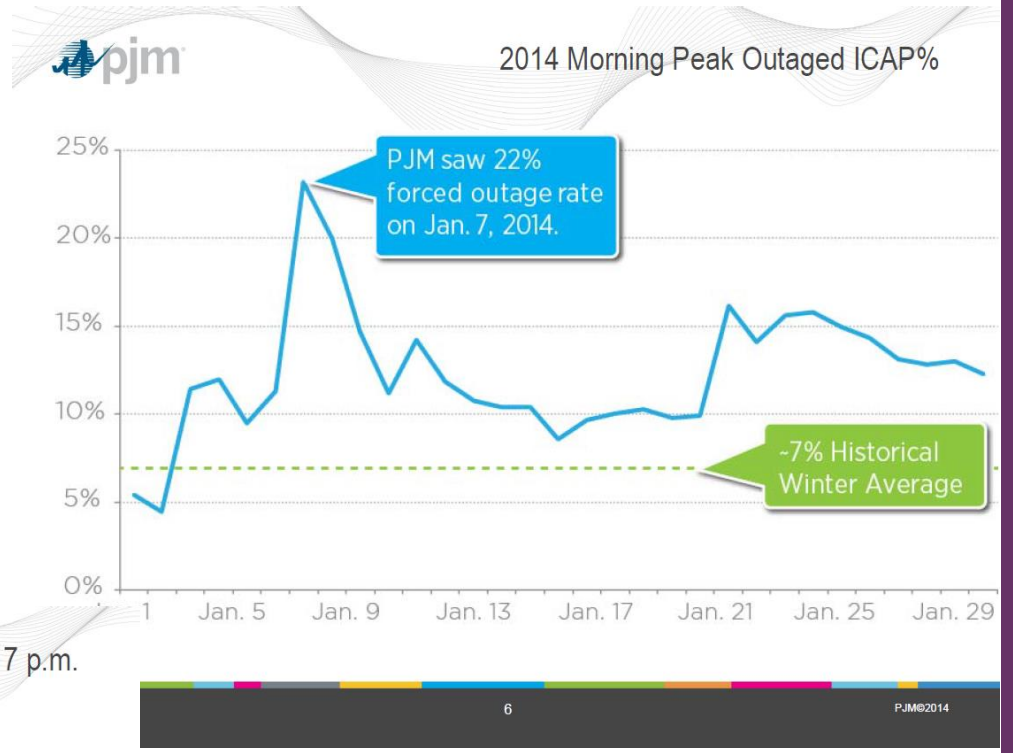

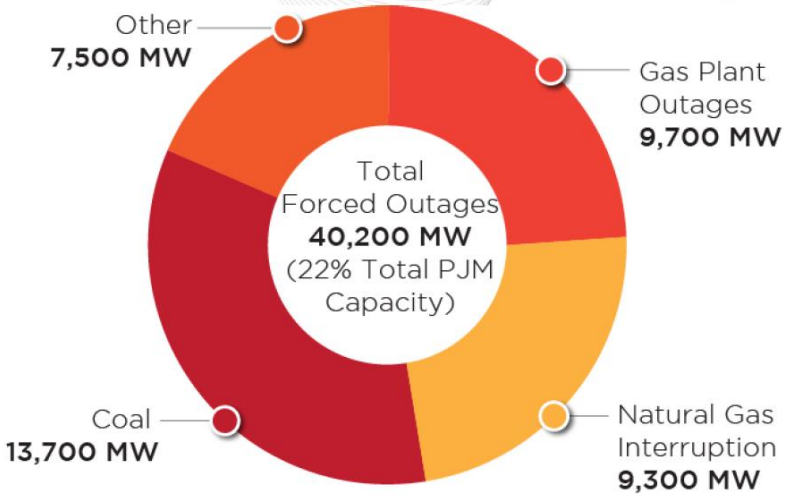

How to take decisions on HILP events

- Data
  - These events do not happen very often
  - And events of a given class may not be homogeneous (in basic nature, or in location e.g. of weather)
  - If weather is relevant, over what period might one assume stationary climate
- What are the possible consequences of extreme weather events?

- Major concern in N America that adequacy risk models which utilities use are largely meaningless in winter – how to do alternative statistical modelling and plan mitigation measures systematically?

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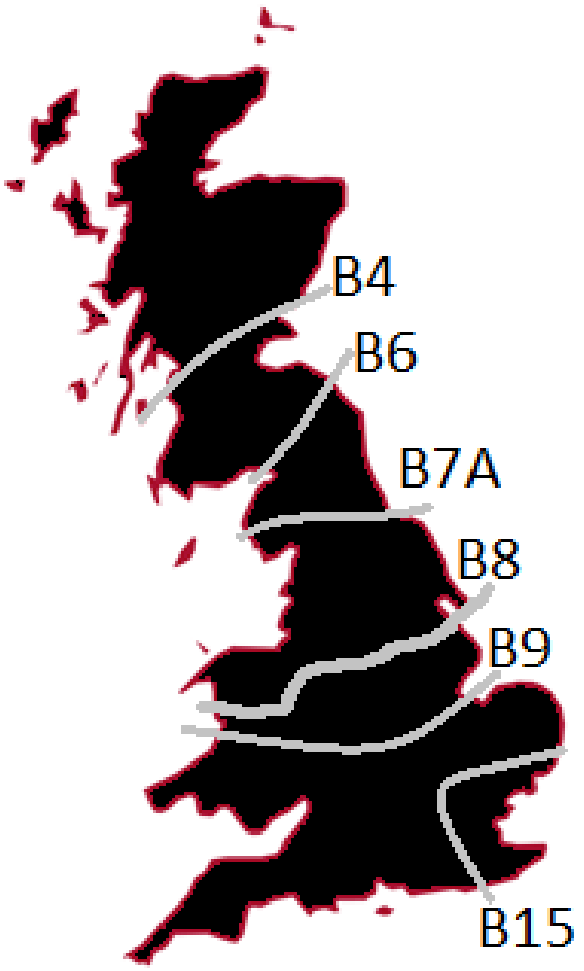
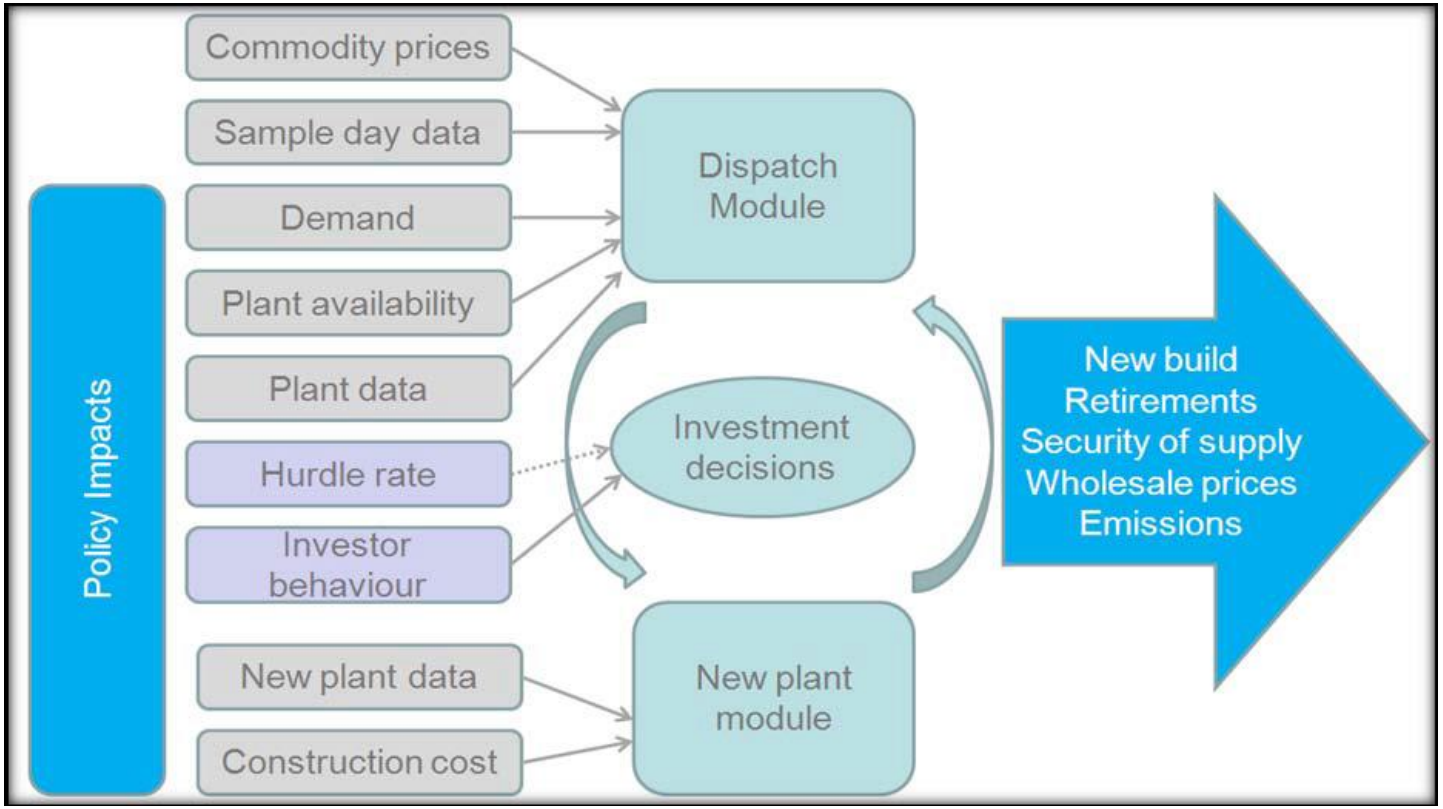
Network investment



- Network investment to achieve economic balance between capital costs and costs of finite network capacity constraining generation schedule
  - Uncertainties in location of plant, availability properties, demand growth, etc etc etc
  - Need to imagine being the system planner and quantifying that entity's uncertainty about system background
  - Fairly standard decision problem, challenges coming in computational complexity (use emulators?)
  - Watch this space: Antony Lawson (with Michael Goldstein)

Generation investment (e.g. DDM)



- How to project investment in generating plant
  - Design of markets, prices in capacity market
  - Need to imagine being market designer/operator, and make that entity's assessment of judgments of gencos!!
  - How to draw conclusions about real world?
  - Watch this space: Meng Xu and Amy Wilson

Conclusions

- Expert judgment is everywhere in power system planning
  - This is widely (implicitly) recognised when looking at development of scenarios against which to plan
  - It is less often thought of in terms of quantifying uncertainty in evolution of system background
  - Apart from people in this room, I see very few people in power systems talking about the methods discussed today!
  - Communication of higher mathematical/statistical methods can be difficult as skills are not widespread (particularly in industry) – but there are many genuinely useful techniques available (not just toys for people like me to play with!!)
  - There is very little analysis of relationship between modelling results and real systems

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- ‘Risk and Reliability Modelling of Energy Systems’ day, 12 November, Google *Durham Risk Day*