Distribution Network Planning

A ‘Real Options’ approach to support decisions on reinforcement versus post-fault demand-side-response (DSR)

Dr Rita Shaw – Tuesday 7th June 2016
Edinburgh University - International Centre for the Mathematical Sciences (ICMS)
Conference on ‘Energy Management: Flexibility, Risk and Optimisation’

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Agenda

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Introducing Electricity North West	Reinforce, or capacity from customers?
A real-options decision support tool	Summary and questions

Introducing Electricity North West

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4.9 million

2.4 million

25 terawatt hours

56 000 km of network ● £12.3 billion assets

19 grid supply points ● 66 bulk supply substations
363 primary substations ● 33 000 transformers

The GB electricity structure

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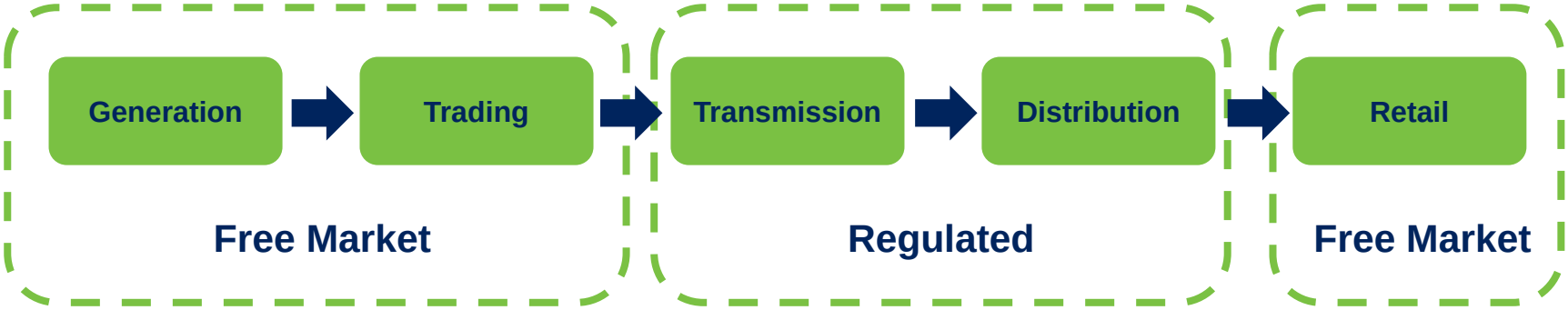
All participants regulated by Ofgem



ofgem Making a positive difference for energy consumers

RIIO regulatory framework

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RIIO =

Revenue = Incentives + Innovation + Outputs

ED1 = Electricity Distribution

14 DNO areas

Eight years

£1.8 BILLION Total to be spent on ENWL network 2015 - 2023

£24.6 BILLION Total to be spent on the GB distribution network 2015 - 2023

£10 Resulting annual average savings in consumer bills in RIIO-ED1

8% The power distribution part of a dual fuel bill

30% Network reliability increase since 2002

The lights are on – what's the problem?

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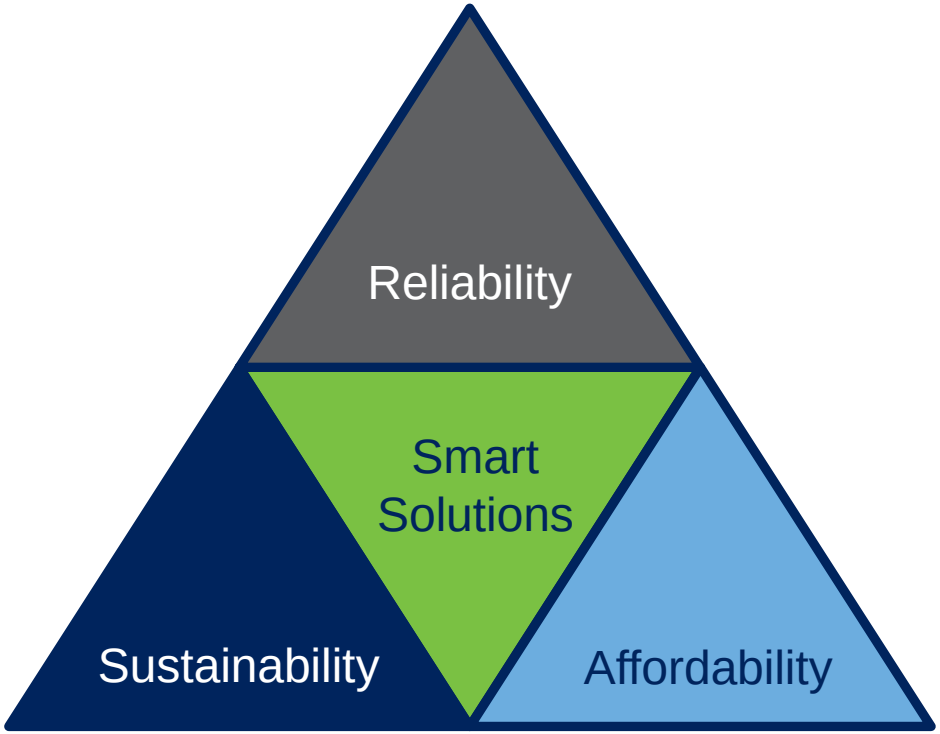
● The network operator 'Trilemma' ●



● Smart solutions are the key to unlocking this puzzle ●

Our smart grid development

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Leading work on developing smart solutions

Deliver value from existing assets

Customer choice

LCN Fund Low Carbon Networks — Five flagship products (second tier/NIC) £42 million

C2C

SMART STREET

Celsius

CLASS

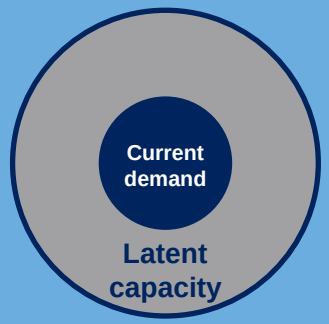
RESPOND

Capacity to Customers

Capacity to Customers unlocks latent capacity on the electricity network

Capacity to Customers

Technical innovation



New commercial contracts

Capacity to Customers	Technical innovation	New commercial contracts
Combines proven technology and new commercial contracts	Remote control equipment on HV circuit and close the NOP	Innovative demand side response contracts
Facilitates connection of new demand and generation without reinforcement	Enhanced network management software	Allow us to control a customer's consumption on a circuit at the time of fault
	Effectively doubles the available capacity of the circuit	

Trial complete ... now when do we use?

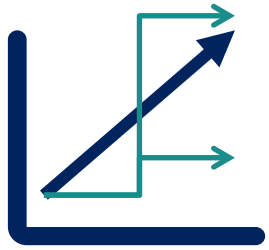
When is C_2C cost effective ...?

... or when should we reinforce?

Spend £ every year for capacity from customer

OR

spend £££ now to build capacity in new asset?



Answer depends on costs, capacity and views of future demand

Outlook for future demand

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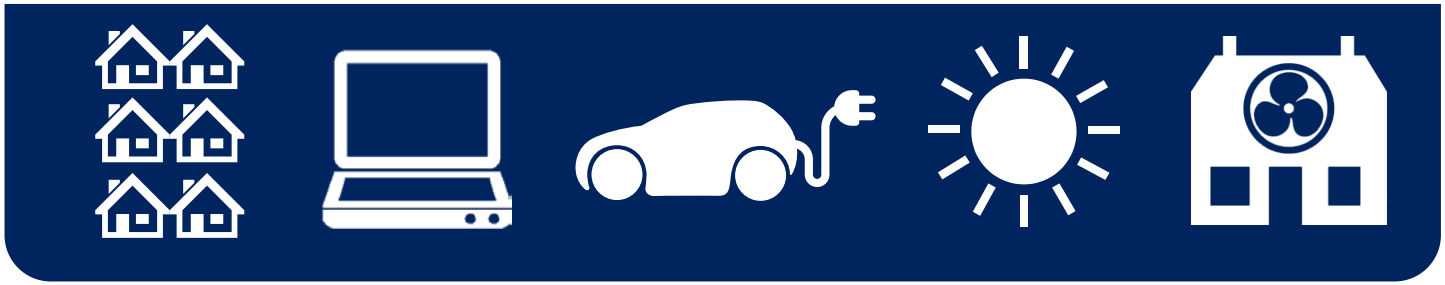
Why could demand go up?



Why could demand fall?

Long-term electricity demand scenarios

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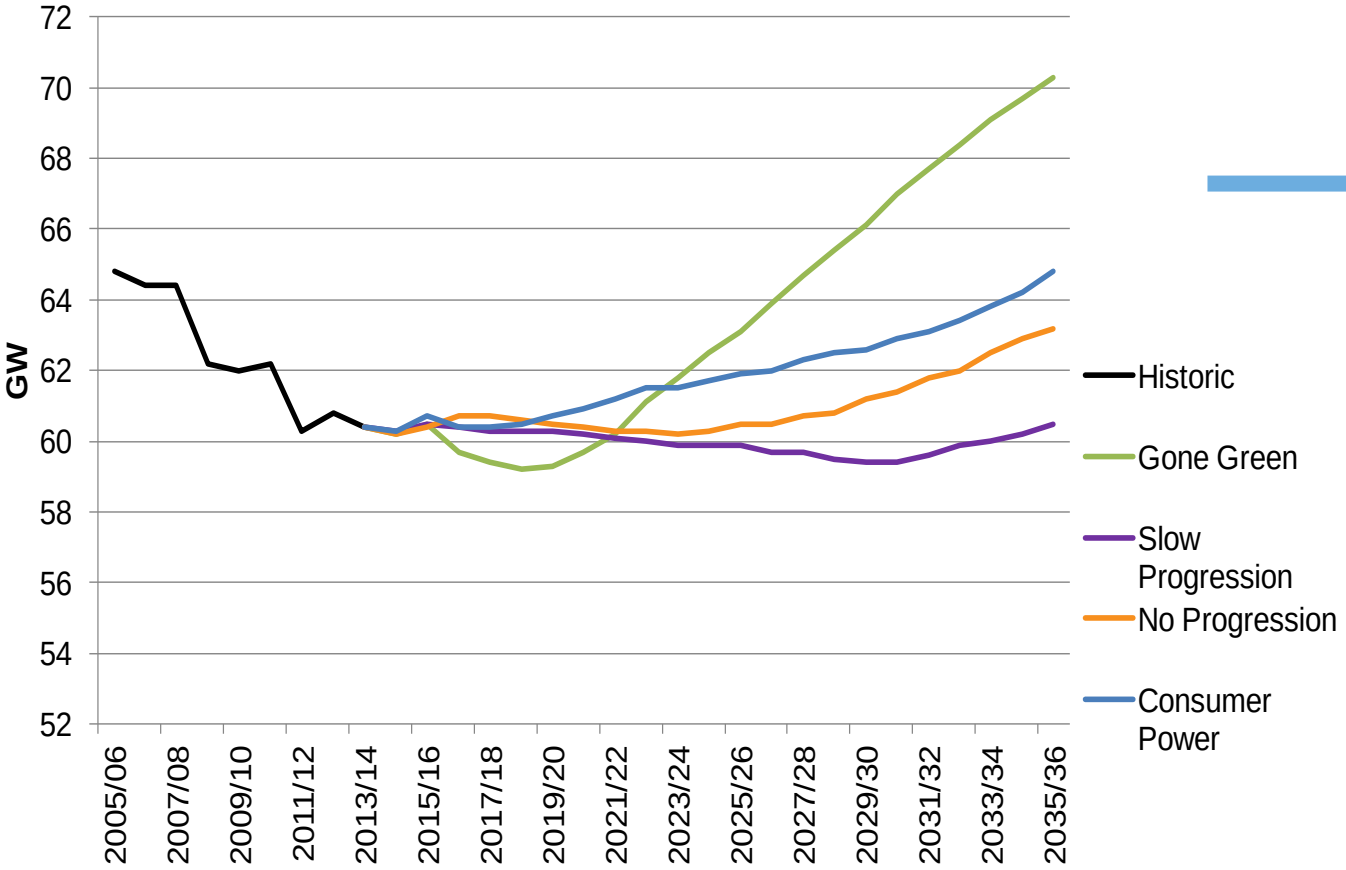
Average cold spell peak demand



Set of peak demand scenarios, tailored to a specific substation

Methodologies for annual update of long-term DNO load scenarios

e.g. National Grid Future Energy Scenarios – July 2015

The problem

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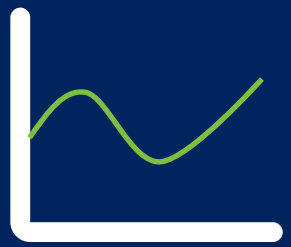
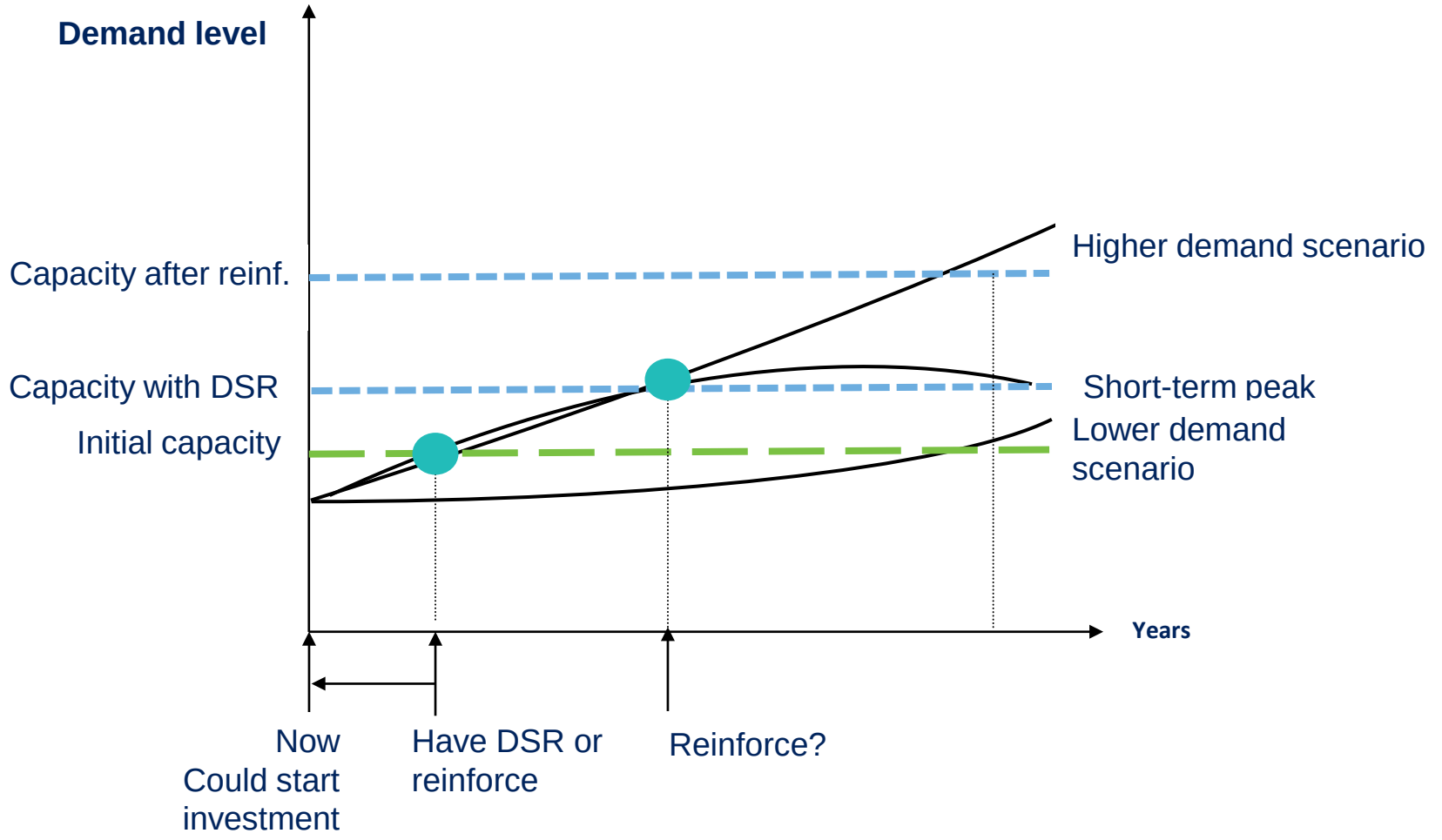
			
Uncertain scale and timing of future load	So uncertain scale and timing of capacity requirements	BUT capacity delivered in location-specific lumps. Sometimes large reinforcements, sometimes marginal release	(C_2C) DSR provides a new source of capacity

Objective – cost-effectively provide *just* the capacity required

DSR then reinforce if required



Is this new strategy cost-effective, and risk-appropriate?

Network Innovation Allowance project

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Demand Scenarios with Electric Heat and Commercial Capacity Options

Create improved demand forecasts and implement in a DNO-appropriate Real Options approach	Due to complete by end of 2016

Reports will be at www.enwl.co.uk/thefuture

A real-options approach (1)

- Traditional CBA / NPV approach assumes 1 view of future.
  'Real options' works with the uncertainty.

- RO values **flexibility** of decision-making under **uncertainty**
  - Branch of mathematical finance, relevant to engineering
  - Ofgem expressed an interest (initially in relation to GDNs)
  - Useful as traditional reinforcement is financially material and irreversible

- **Flexibility** in when and how we invest for network capacity
  - eg traditional large reinforcements, or marginal capacity release by DSR or incremental reinforcements

- Based on **uncertainty** in long-term peak demand scenarios
  - And sensitivity to volatilities in demand and in other inputs
  - Information is delayed

A real options approach (2)

Worked with University of Manchester on initial development of methodology and tool (Dr John Moriarty and Dr Pierluigi Mancarella)

‘Real options’ are useful for investments when...

- Flexibility exists
- Decision to invest based on uncertain information
- Uncertainty is financially material
- Investment is at least partly irreversible

Invest ● Abandon ● Defer ● Expand

A real-options approach (3)

Phase 1 report December 2013

“Flexible investment strategies in distribution networks with DSR: *Real Options modelling and tool architecture”*

Phase 1 report can be shared

Key findings		
A DNO-suitable approach *can* be implemented in Excel.	Can be based on annually-updated set of probability-weighted demand scenarios, plus demand volatility around those scenarios.	Many options exist for decision-metrics on cost and risk

Moriarty report – stages in RO model

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A	B	C	D	E
Identify significant future decision points in the investment project	Probability weights (or more generally, a probability measure) are constructed for the possible states of the world at those times, reflecting how likely the respective states are.	For each of these states, the information that would be available to management as a basis for their decision making is identified.	The decisions that would be taken by rational management in each of these states are identified, for example using a binomial tree.	*(one potential metric)* A probability weighted average is taken over these possible futures to arrive at the present project value.

A real-options approach (4)

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When would we use RO?

Scoping stage – find useful DSR scale and maximum price before approaching DSR customers

Before committing to investment – Justifying efficiency of load-related expenditure before commitment to DSR or reinforcement

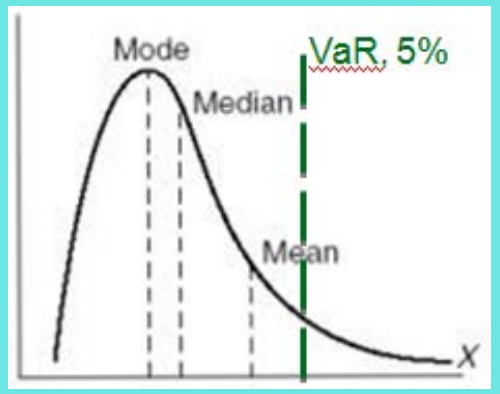
Applied to **every project** with DSR potential, **or to derive policy** –TBC

Options models provide the cost and risk metrics to support decisions about efficient investment

Should we do DSR, reinforce, or DSR then maybe reinforce?
How much DSR? When? At what price?
DSR while wait for demand increase?

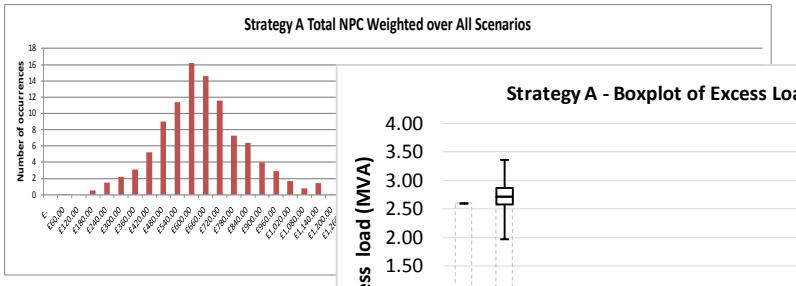
Large or small reinforcement?

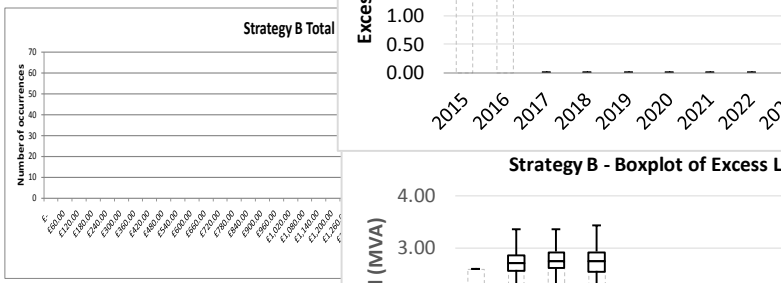
Like-for-like or oversized asset replacement?

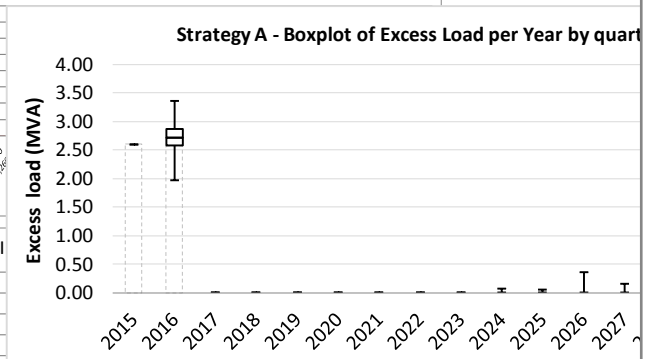


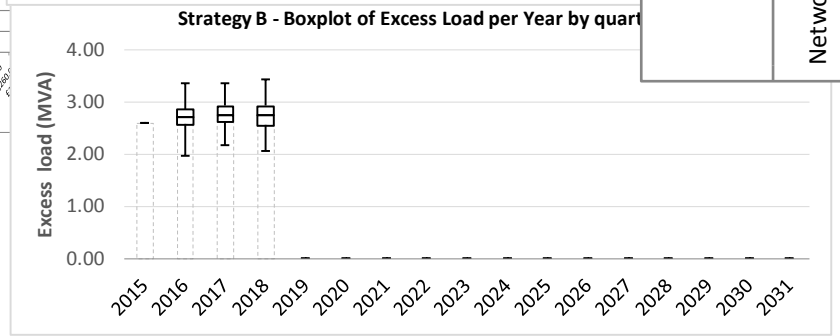
‘Real options’ methodology

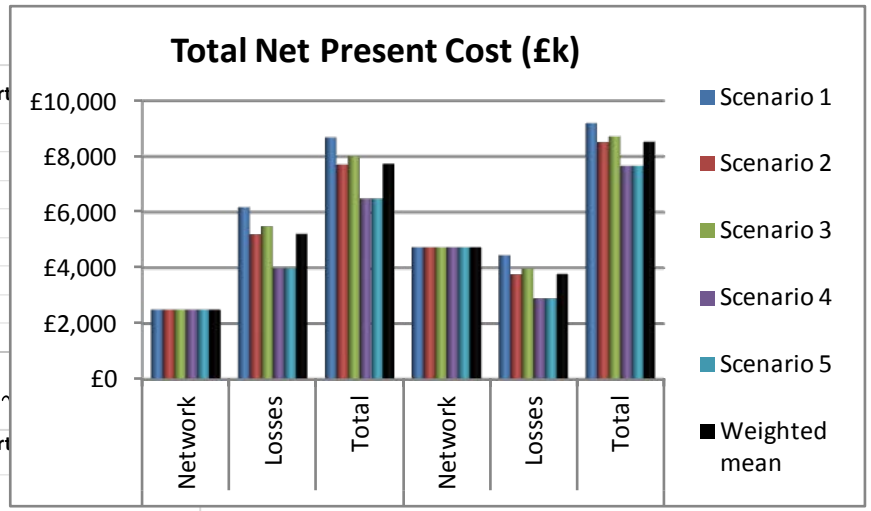
Working with University of Manchester to develop cost and risk metrics in a decision-support tool - *with business and regulatory perspectives*











Analysis of general reinforcement paid for by DNO and customer in general, not just connections reinforcement.

Objectives of our work

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Develop an options assessment method for strategic planning	Develop an informed position with Ofgem	Utilise the 'options' expertise at UoM to validate	Support C_2C for dissemination and BAU transition	Simple to apply v Reflects actual project

With appropriate recognition by Regulation and Finance colleagues

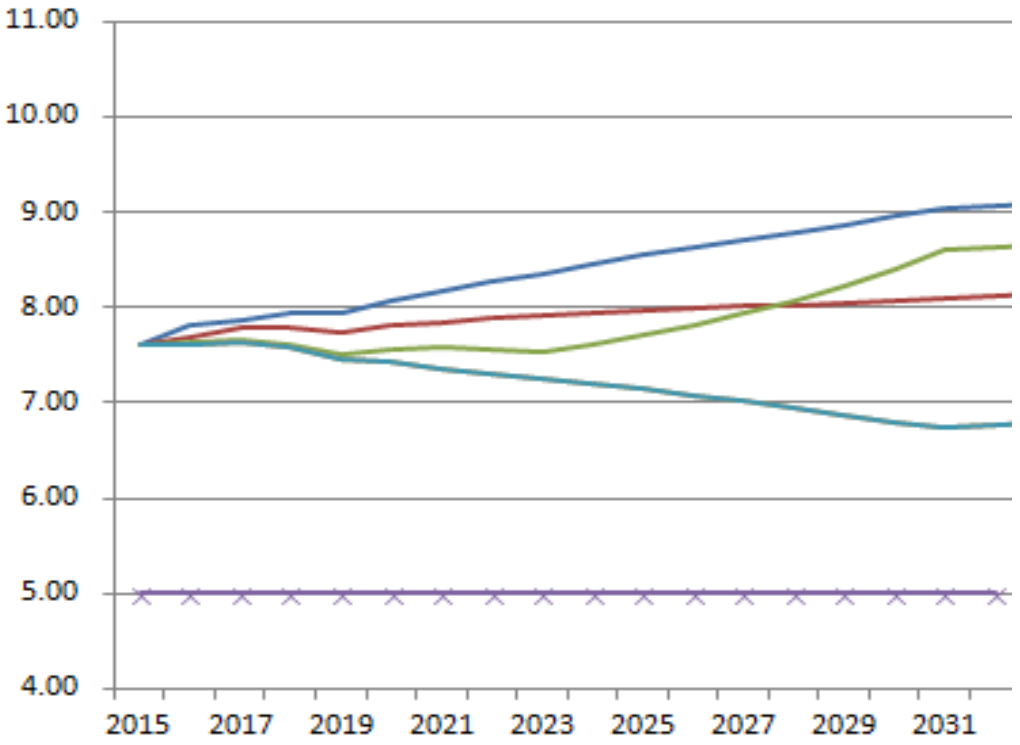
Real options – where we are now

Creating prototype model harder than we thought, **but now in use**

2 strategies, each with up to 3 interventions

Up to 5 demand scenarios, each with 2 x 100 Monte Carlo variations

Electricity North West developed UoM's early prototype



Currently structured into one 34Mb Excel model
Derive policy? Streamline for BAU stage after prototype complete?

RO model structure

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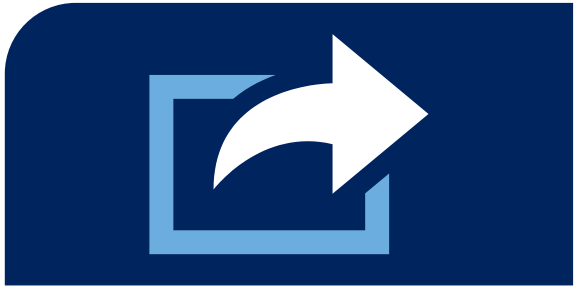


Inputs	Calculations	Summary metrics
Site demand forecasts Framework inputs Strategy A inputs Strategy B inputs	Strategy A Strategy B (repeated structure)	Cost and risk distributions Least regret cost and risk analysis Capacity output per macro-scenario Cash flow output per macro-scenario

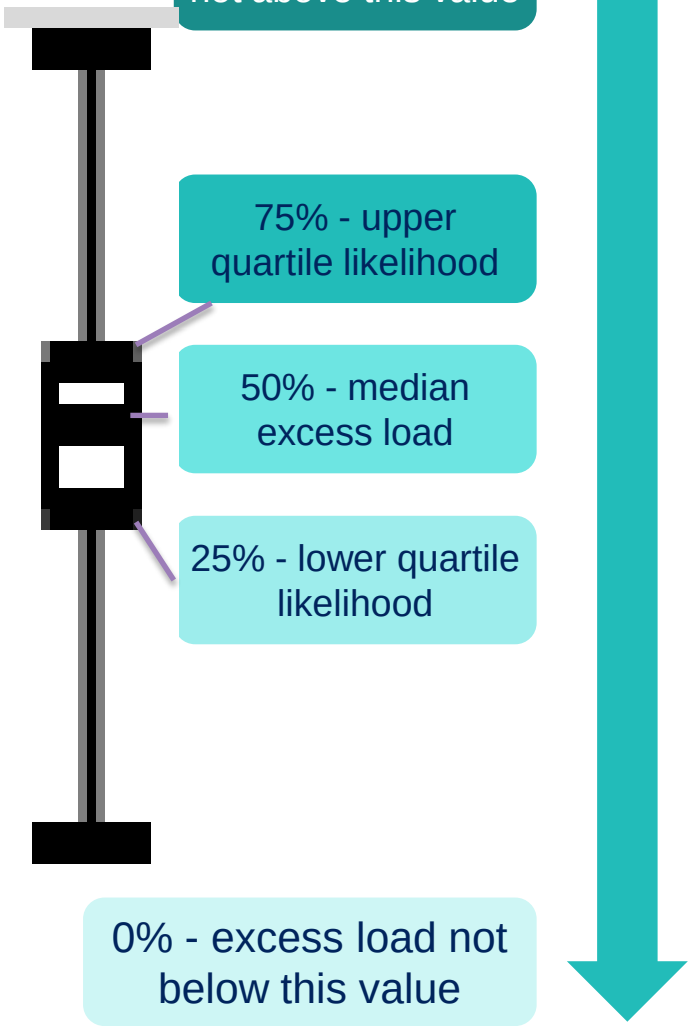
Comparing two strategies

Engineers define interventions and strategies, compare via model.
Model does *not* define the intervention strategies, or find optimal.

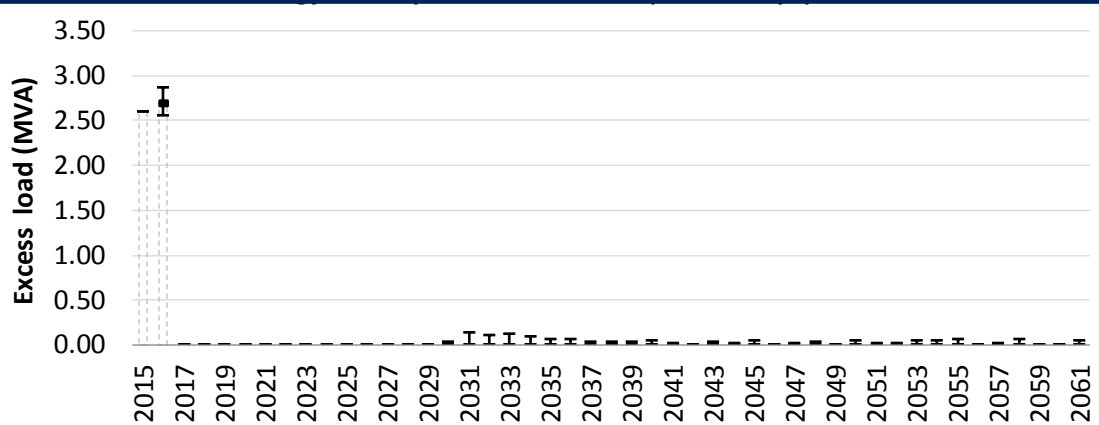
A – DSR then reinforce if required	*B – Reinforce*
Do nothing until Intervention 1	Demand Response
Intervention 2	Invest in Asset
Intervention 3	Do nothing
Intervention 1	
Trigger level as % of capacity	100%

When do I need to commit to a strategy? How much DSR do I need?
What does it cost? Is the network risk acceptable?

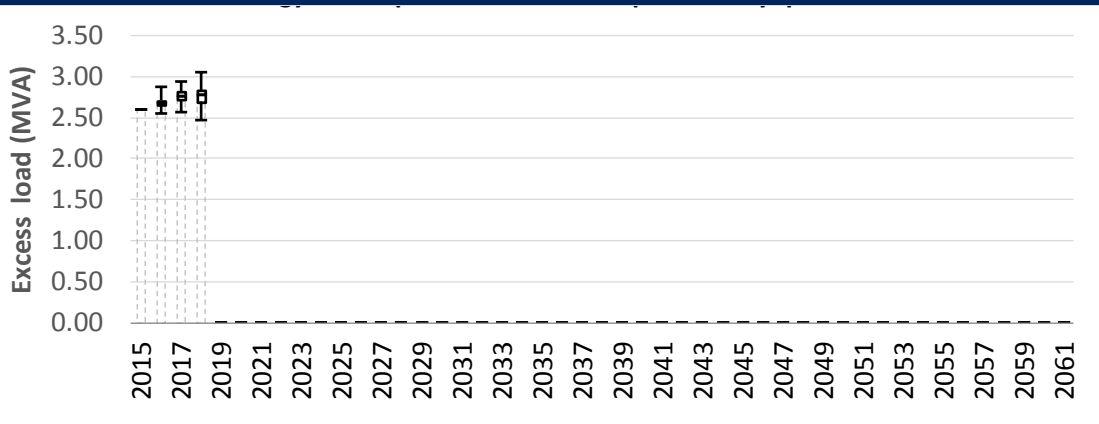
Representing risk of excess load



Strategy A – Boxplot of Excess Load per year by quartile



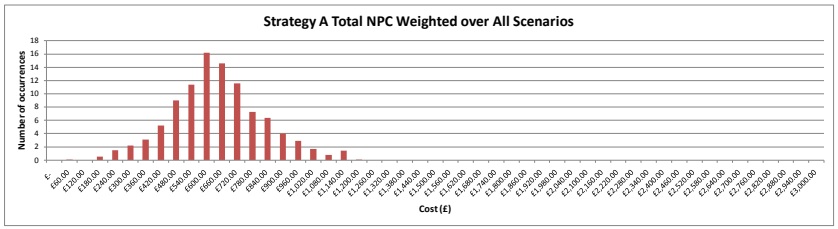
Strategy B – Boxplot of Excess Load per year by quartile



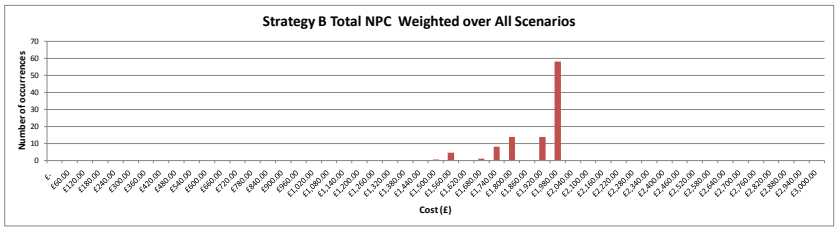
Example probability distributions

Net present cost

DSR



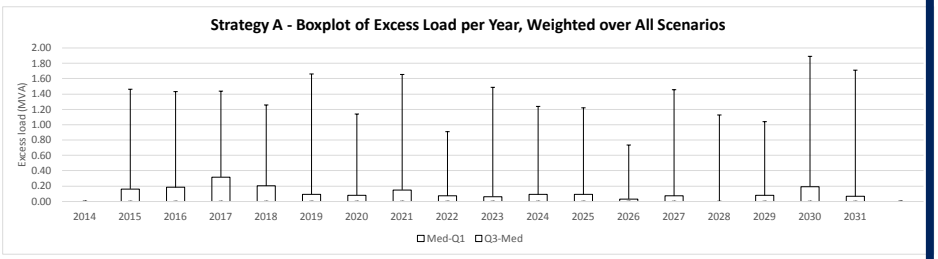
Reinf.



DSR is always cheaper, but with greater uncertainty in total cost (width of distribution).

Network risk over time (probability and scale of load exceeding capacity)

DSR



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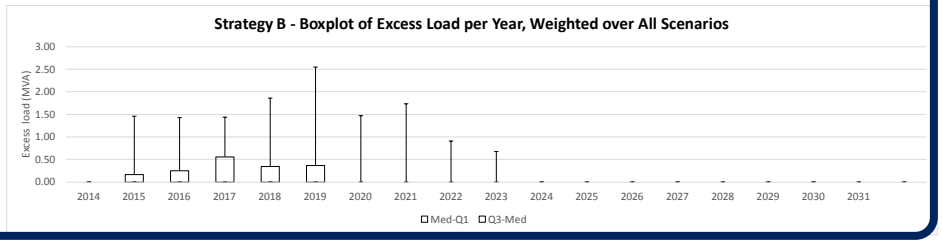

Reinforcement strategy carries network risk during implementation lead-time. Network risk is smaller with DSR, as DSR more quickly adjusted to network load, but occurs over longer timeframe.

At least two NPV financial views

The model rapidly presents two vital perspectives on cost

DNO commercial view	Regulatory customer-view based on the Ofgem Cost Benefit Analysis (CBA) framework for setting RIIO-ED1

Comparing strategies across views

		Total cost saving to customers *inc. losses* in Regulatory View	
		3.5% discount rate for 45 years, inc. RAB financing and losses	
		Yes	No
Cost saving in DNO commercial view Higher discount rate, Fewer years, Different incentives	Yes	Proceed, good for DNO business and customers	
	No		Do not proceed, no benefit for DNO or customers

Cannot imagine DSR which reduces losses, so irrelevant for DSR, but this is the case for low-loss transformers

Use of the model in practice

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Step 1	Set up inputs, sense-check capacity chart v. scenario
Step 2	Check residual excess load acceptable within the planning horizon for both strategies
Step 3	Compare the strategies based on commercial cost perspective
Step 4	Compare the strategies based on customer cost perspective
Step 5	Make business-decision on multiple criteria, may include outputs outside of the model

Hurdle

Real options – next phase

The future approach

Target of £10m against investment plan

First customer signed

Decision making process includes viability of DR option

Ongoing relationship management required

Implement through new managed connection agreement and retrofit automation equipment on agreed switch

Electricity North West personnel to approach customers to purchase post fault DR

Benefits

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Customer satisfaction

Stimulates the market for future commercial solutions to manage the network

Contribute to outperformance of RIIO-ED1

Facilitates a reduction in carbon costs of network reinforcement

Avoid costs and risks due to uncertainty of demand and connection of low carbon technologies

Want to know more?

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