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A RIIO-T1 Stakeholder Consultation Tool: An Electricity Scenario Illustrator



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Introduction

- Ofgem's RIIO framework requires network licensees to provide a well-justified business plan
- To develop such a plan we need your views on:
  - What might be the future requirements (scenarios)
  - How these might be met (responses by the network or others)
- Some parts of the plan (e.g. connections) are justified by the specific needs of individual customers …
- … but plans concerning the shared network infrastructure are more complex and require collective views.
  - To assist stakeholders, we have prepared a simple model to illustrate the benefits and implications of these works.

Our approach

- In our consultation (with workshops beginning end-March) we will describe:
  - The scenarios that we have derived
  - Our understanding of the implications for customers and other stakeholders
  - Our assessments of the transmission developments that can enhance value
- Recognising that stakeholders will wish to explore the details of our proposals by examining their own alternative scenarios/sensitivities and assessing the balance of trade-offs for themselves, this model is being distributed in advance of our consultation workshops.

Our understanding of high-level stakeholder requirements

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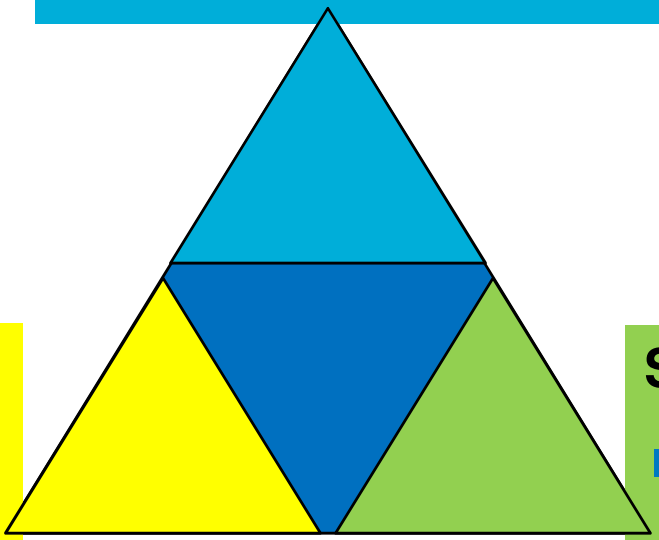
Security

- Acceptable reliability
- Resilience



Affordability

- Efficient operations
- Value for money developments

Sustainability

- Reduce CO_2
- Renewables
- Preserved amenity

In delivering, we must consider the key network trade-offs

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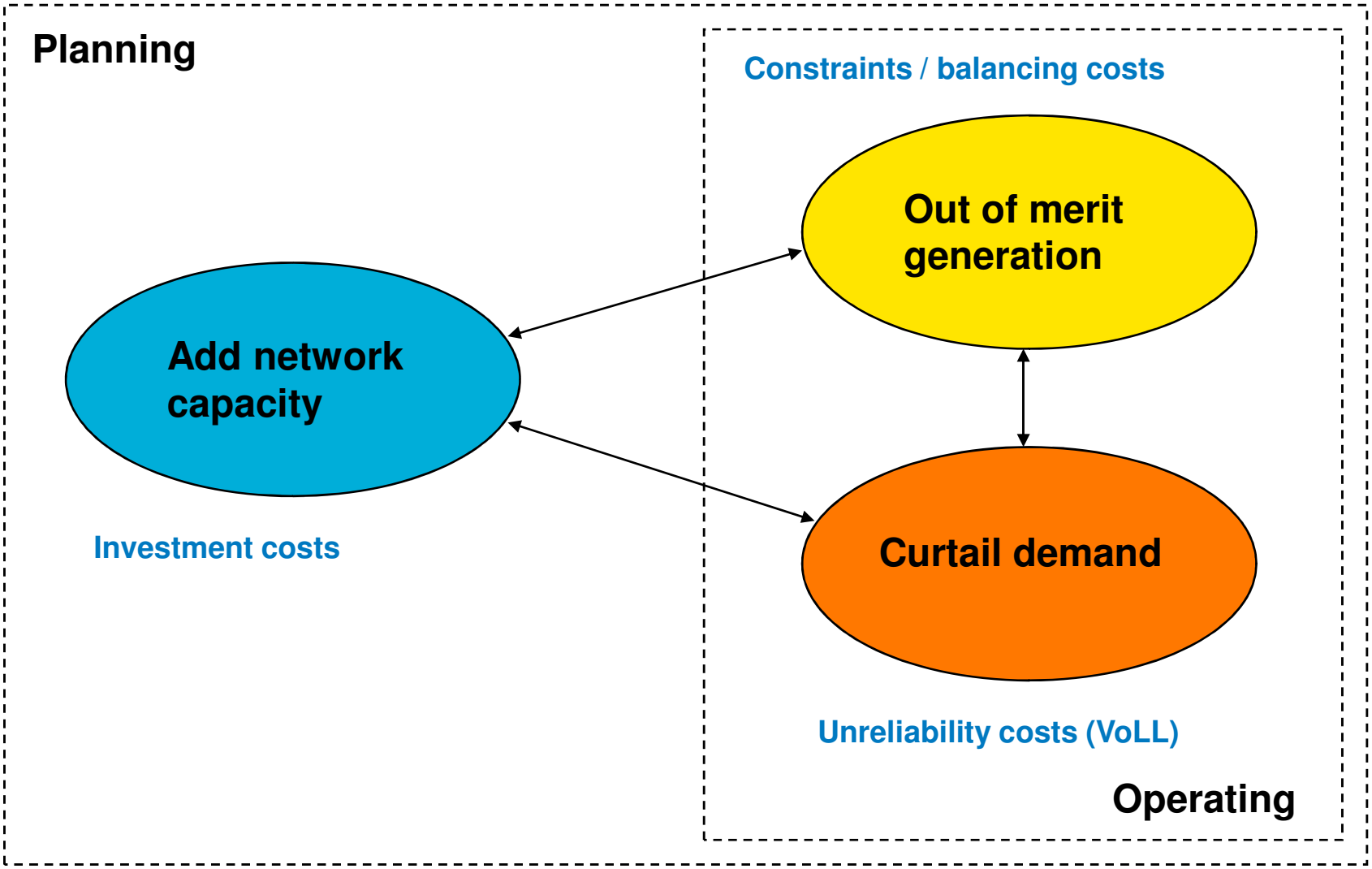

Generic issues we want to discuss with stakeholders

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- Unsupplied energy
  - What is the appropriate cost to be attributed to curtailed load? *
  - What is the acceptable risk for different severities of potential loss of supply events?
- Operational cost
  - How to appropriately assess the cost of network limitations?
  - What are the demand-side and other balancing alternatives? And when will they be available?
- Transmission investment cost
  - What are the desired characteristics of our identified reinforcement options?
  - Should others be developed

* Ofgem have indicated in their RIIO-T1 consultation on outputs that £16/kWh may be a suitable upper bound value. As a conservative starting point we have derived what may be a useful lower bound estimate by dividing GDP by energy consumed ≈ £4/kWh.

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Specific issues we want to discuss

- Have we got the right scenarios?
  - Reasonable generation/demand developments?
  - A good span of potential outcomes?
- Is our representation of future operation sufficient?
  - Consumer requirements and use patterns?
  - Fuel burn & CO_2 emission choices?
  - Wind variability & other plant availability assumptions?
  - Interconnection transfer & pump storage utilisation?
- Are the consequences of network limitations sufficiently identified?
- Are sufficient reinforcement options identified and their benefits appropriately explained?

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Overview: features & limitations

Electricity Scenario Illustrator

ELSI

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Model operation

The model can either examine the timeframe from the present until 2030 or a single year can be analysed. These two options are selectable from the buttons below.

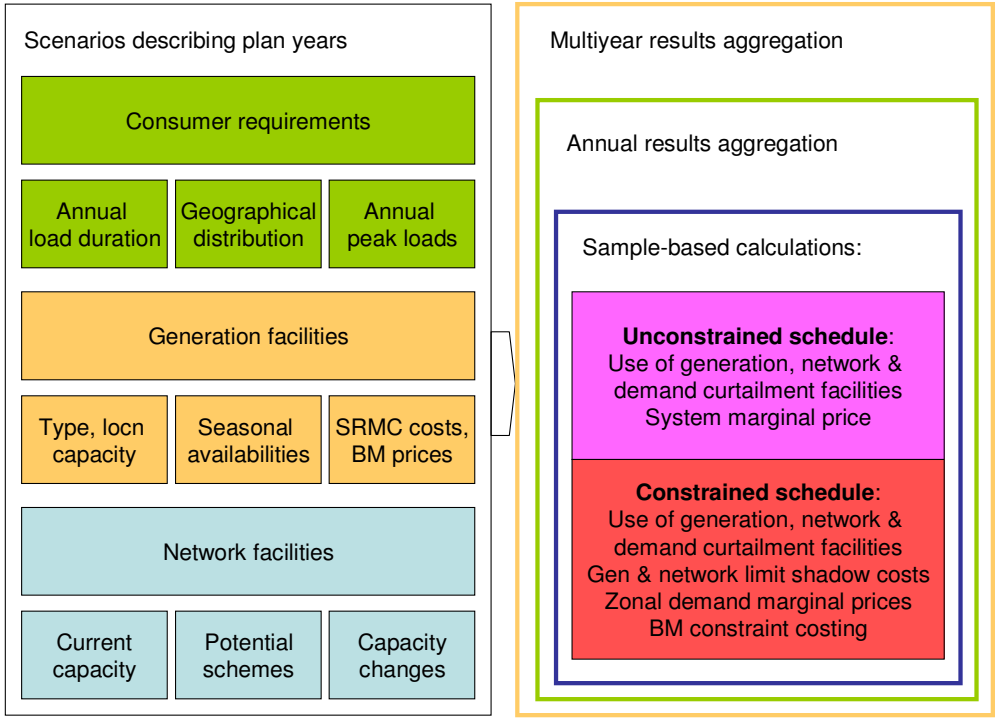
Run multiyear analysis | Run single year analysis | Multi year analysis | Selected year

The assumptions underpinning the analysis can be changed by selecting one of the existing scenarios from the button below. Alternatively new scenarios can be created and customised to model a particular view of the future. The currently selected scenario is GG June Updated

Select scenario | Create new scenario | GG June Updated | Selected scenario

The assumed firm network capability that is used in the simulation can be adjusted to values derived from normal (N-2) security criteria, relaxed (N-1) security criteria or some mix of the two here:

N-2 | Selected operational standards



Overview of the electricity scenario illustrator

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- The electricity scenario illustrator (ESI) simulates operation of generation and storage resources* to meet consumer requirements
  - For an extended period spanning the RIIO-T1 control
  - With transmission capacity* as currently established or extended by potential reinforcement schemes

* **Generation, storage and transmission investments are set by the user – the model only illustrates how, once established, these might then be used to meet consumer needs**

- If there is insufficient generation or transmission then demand is curtailed
  - This curtailment is costed at a Value of Lost Load (default = £4/kWh approximately equal to GDP per unit of electricity consumed)

- The model reports the sensitivity of operating costs to generation, storage and network capacity limits (e.g. in £/kW/yr)

Modelling and package approach

- The ESI is built to the principle "as simple as possible, but not simpler" and applies the 80/20 rule. E.g. seeking 80% of the answer from 20% of the potential detail.
- It is free and requires no additional proprietary product or licences other than a copy of Microsoft Excel
- All workings (outside a simple linear program code – see Appendix) are shown. Hence it should be easily customised and extended by users*.
- Scenarios based on Gone Green, Slow Progress & Accelerated Growth scenarios installed with illustrative cost and performance parameters (these chosen by package authors – no authoritative knowledge claimed!)

* Although National Grid will seek to assist users who are exploring RIIO-T1 issues with the ESI model, we cannot provide wider support for the code in this package.

National Grid has made strenuous efforts to ensure the package works reliably and functions acceptably for its intended purpose. However, we cannot provide guarantees that the algorithms and techniques are robust in all circumstances and results must, therefore, be used cautiously.

ESI features

- Consumer requirements represented by typical days for each season
  - **Currently each day represented by 4 demand blocks (peak, plateau, night trough & remaining pick-up/drop-off)**
  - **The typical days have been derived from the 2009/10 load data and these are scaled by forecast peak demand to model future years (other approaches possible)**
- Wind availability is represented by sampling (Monte Carlo) 10 yrs of historic daily wind speed data
  - **Default = 4 regions (Scotland, E&W onshore, offshore east, offshore west & south)**
  - **Seasonal daily profiles ensure diurnal and seasonal patterns are retained**
- Generation fuel & CO2 cost assumptions are separated from BM bid & offer price assumptions (to represent alternative scheduling approaches & costs)
- Transmission capability represented by Seven Year Statement boundaries (augmented with some 'local-issue' boundaries)
- Interconnector operation determined by marginal cost differences with remote systems (i.e. operation is cost minimising)
- Storage operation minimises daily operational costs given power & energy limitations and cycle efficiency (assumes wind accurately forecastable for this purpose)
- Random numbers are fixed (until deliberately randomized) to aid comparison of scenarios.
- Check of "peak demand with low wind" and "minimum demand with high wind" cases included each year

ESI key limitations (1)

- Generation dynamic limitations are not represented
  - (no ramp rate, minimum stable generation limits, etc)
  - Hence the model will underestimate generation operating costs
  - However, there are facilities for imposing generation flexibility reqs
- Availabilities of generation (other than wind) are (by default) represented at average seasonal values
  - this tends to underestimate the impact of network limitations
- Storage energy limits are enforced on daily schedules
  - potential for underestimating seasonal capabilities of some pump stores
- Assumes ideal curtailment of demand and immediate restoration
  - So potential for underestimating demand disruption
- Very limited (default, fixed price) modelling of European market and Ireland & Northern Ireland SEM

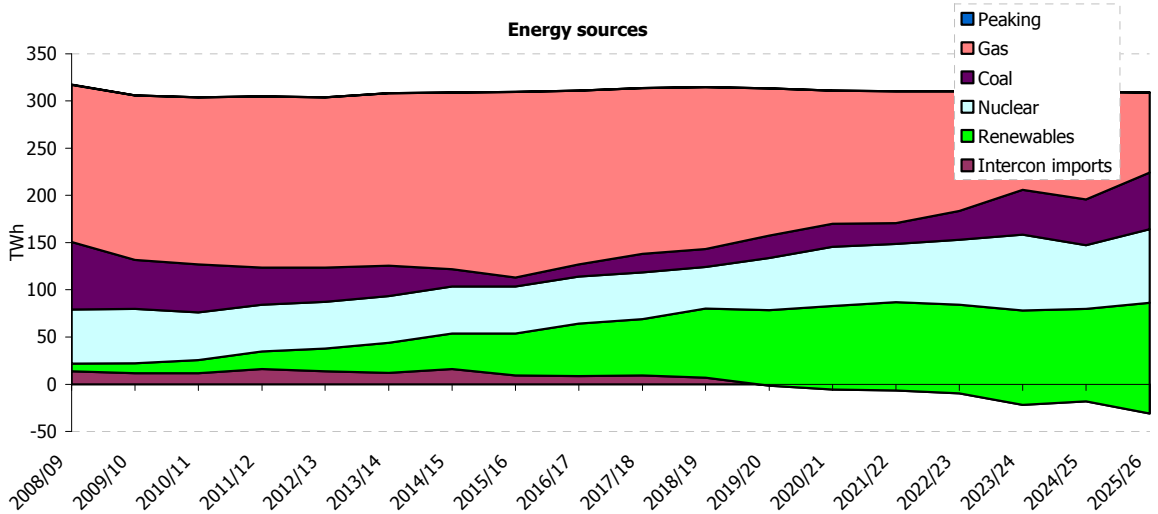
ESI key limitations (2)

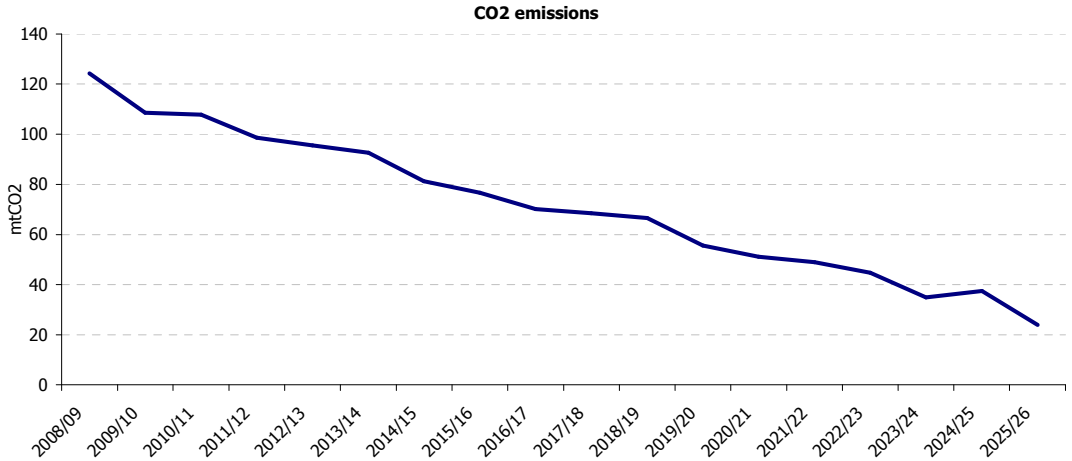
- Boundary representation of network capacity - reflects thermal, voltage & stability limitations after current control measures (i.e. protection, switching, QBs & other Smart controls)
  - Approximates effects due to actual power sharing across circuits
  - May require recalculation for radical scenario changes and fault-level issues
  - Generally overestimates effectiveness of running certain generators out of merit to alleviate constraints
- Simple modelling of network availability - temperature effects reflected in seasonal average capabilities
  - Network unavailability due to maintenance and construction outages neglected (assumes perfect generation/network outage coordination)
  - This will tend to underestimate actual network limitations
- The in-built scenarios are currently being updated to reflect recent developments. These changes will be incorporated in due course.
- The model does not calculate the reliability implications of transmission faults

Results available

- Production volumes:

(e.g. from Gone Green)





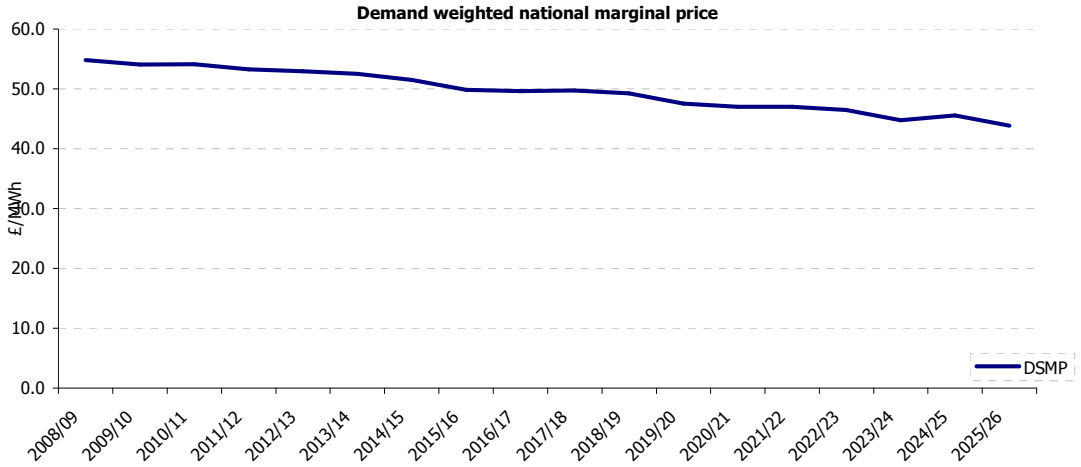
- CO2 emissions

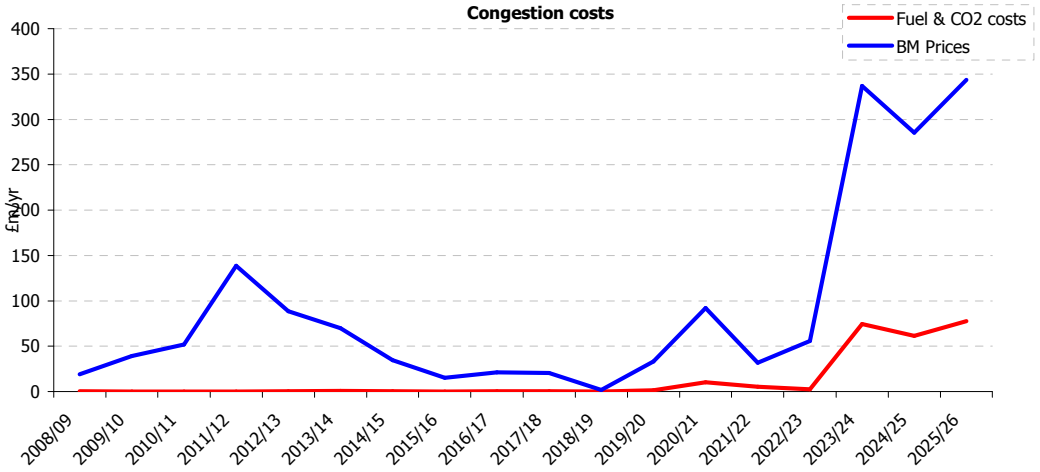
(e.g. from Gone Green)

Results available (continued)

- Evolution of prices

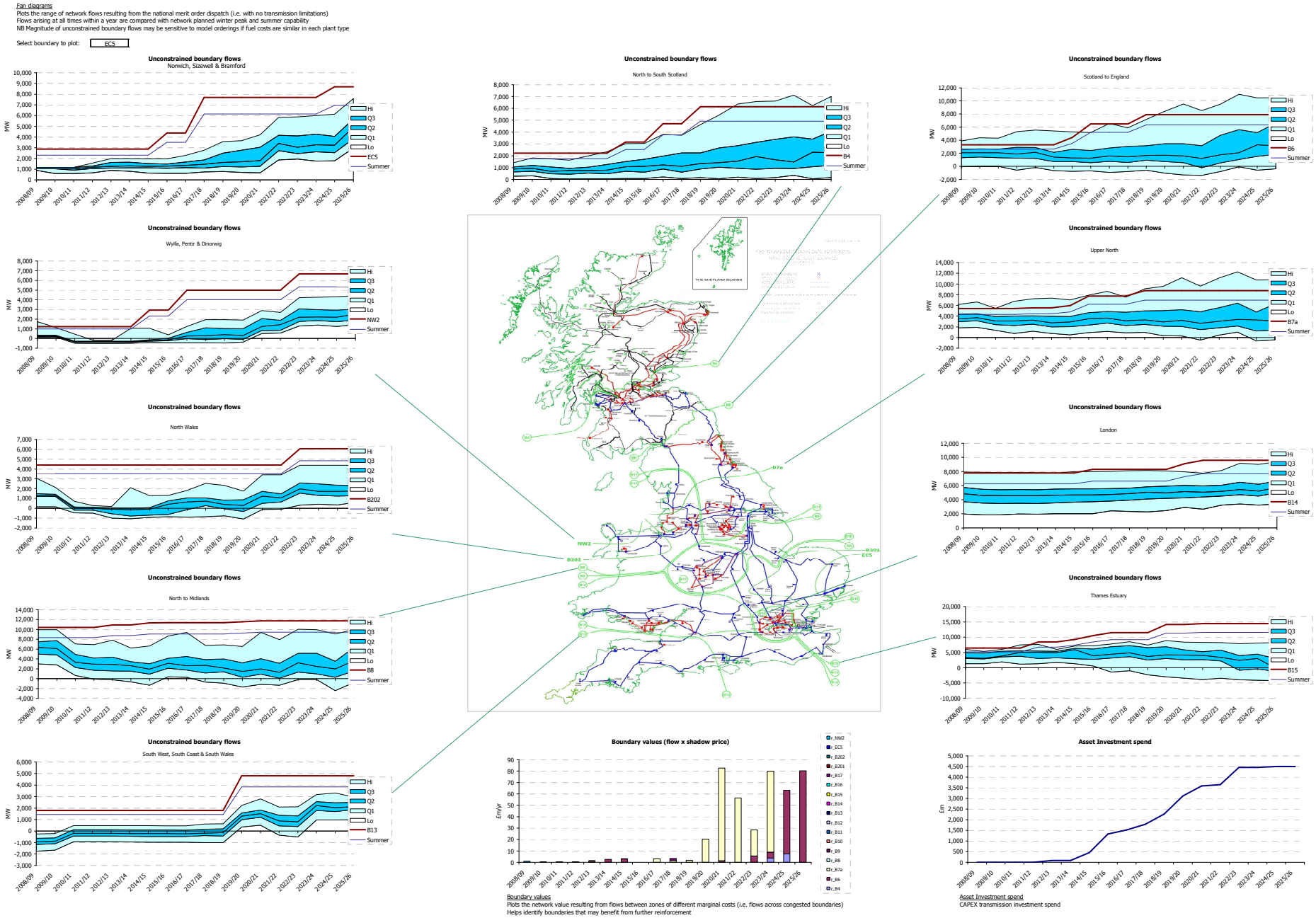
  (marginal cost of meeting demand with and without transmission limitations)





- Cost of network limitations

  (at fuel cost of redispatching generation and demand or at assumed Balancing Mechanism bid/offer prices)



Ranges of network unconstrained system flows, flow limits and cost/benefit information

Other results

- ESI also provides:
  - An approximate indication of the evolution of GB transmission losses and their cost
  - Indicative data on the total capital cost of selected reinforcement options (excluding financing during construction and other details)
  - Indicative data on the total length of new overhead lines required to establish the selected reinforcements
  - The marginal cost of energy in each zone (zonal price)
    - Annual demand weighted values
    - Spot values for each sample
  - The payments to generators
    - Assuming payment at zonal marginal price
    - Assuming payment at national marginal price

    (The difference indicating the value of firm access to a national market resulting from transmission reinforcements)

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Getting started

Electricity Scenario Illustrator

Getting started

- Open spreadsheet in Microsoft Excel
  - (2003 & 2007 editions tested but others should work)
- Enable macros when prompted (old Excel versions) or by using "options" in security warning banner at top of sheet (new Excel versions)
- The spreadsheet should open on the "Overview" page
- The results and input data pages are selectable (but detailed calculation sheets are initially hidden to reduce clutter)
  - Buttons at top left of sheet unhide calculations and workings
- "Run multiyear analysis" or "Run single year analysis" initiates a simulation of the chosen scenario
- Select the "Results multiyear" or other tabs to examine main results and details

Adding a scenario

- Click "Create new scenario" button on "Overview" sheet
  - (this ensures model required ranges are appropriately defined)
- Enter a name for your new scenario
- Select an existing scenario as a basis for your new scenario
- Click "Continue"
- Select your new scenario worksheet and modify
  - E.g. add generation of user-defined type
- On "Overview" sheet, click either
  - "Run multiyear analysis" or
  - "Run single year analysis"
- Examine results

Help

- If you need help running ESI or using any of its facilities please contact
  - William Kirk-Wilson on 01926-655424 or email: william.kirkwilson@uk.ngrid.com
- If you wish to discus potential developments to the economic modelling implemented in ESI please contact
  - Lewis Dale on 01926-655837 or email: Lewis.Dale@uk.ngrid.com
- If you need details on National Grid's RIIO-T1 consultation process please contact
  - Graham Frankland on 07796-993718 Graham.Frankland@uk.ngrid.com

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Appendix: Modeling details

Electricity Scenario Illustrator

Dispatch representations

- Load
  - Inelastic demand = peak demand x typical day block value (pk, plateau, trough, pickup/dropoff)
  - Curtailment represented by generator matching demand at price = VoLL
- Wind (& wave)
  - Dispatchable capacity = installed capacity x av. plant avail factor x wind availability (day sample)
- Other generation
  - Dispatchable capacity = installed capacity x plant availability factor (season average)
- Interconnection
  - Export = load matching dispatchable export capacity
  - Float = generator matching export load at price of remote market less cost of link losses
  - Import = generator of dispatchable import capacity at price of remote market plus cost of link losses
- Storage
  - Pump = load matching available pump capacity
  - Float = generator matching pump load
  - Generation = generator of dispatchable capacity
  - Cycle efficiency, energy storage limit, and daily neutrality represented for 4 linked day time steps
- Generation flexibility constraints can be represented by requiring a subset of (flexible) generation to exceed a specified minimum value

Linear program (LP) formulation

- The LP is a simple re-startable dual formulation using sparse matrix arithmetic:
  - LP variables are network & generation capacity sensitivity prices
  - LP constraints represent the requirement that dispatched generators must receive revenues greater than or equal to their short-run marginal costs (srmcs)
  - All (4) periods in a typical day are simultaneously optimised (so energy limits and cycle efficiency constraints respected)
  - Starting from a network unconstrained merit order solution, the LP seeks to minimise the cost of storage & network infringements
- To avoid unbounded solutions, generation SRMCs must be positive.
  - Balancing mechanism bids and offers can be negative prices if required. (These prices are applied as a post-processing calculation to the LP srmc –based dispatch)