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Long Term Electricity Network Scenarios Workshop

17th August 2007

Agenda - Morning

- 10.00 – 10.10 Introduction
- 10.10 – 10.30 Overview of the LENS project
- 10.30 – 10.50 Scenarios and energy modelling: complementary tools for decision making in energy futures
- 10.50 – 11.10 The development of LENS Scenarios
- 11.10 – 11.30 Q&A Session
- 11.30 – 12.10 Wider Context – four perspectives on scenario modelling for 2050
- 12.10 – 12.50 Lunch

Agenda - Afternoon

- 12.50 – 13.00 Introduction to breakout sessions
- 13.00 – 13.05 Split into groups
- 13.05 – 14.05 Breakout sessions:
- Group 1 – Identification of the key drivers and assumptions;
- Group 2 – Development of scenarios;
- Group 3 – Outputs of the LENS project.
- 14.05 – 14.20 Coffee break
- 14.20 – 15.00 Feedback session and Closing remarks

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Introduction and Overview of the LENS project

Robert Hull
Director, Transmission

Purpose for today

- The main objectives for today:
- To set out an overview of the Long Term Electricity Networks Scenarios (LENS) project;
- To facilitate academic and industry contributions to the scenarios debate;
- To seek views from industry and other key stakeholders on the potential approach to scenario modelling, the key drivers and project outputs;
- Identify the key issues and concerns for the next phase of the project.

Why are Ofgem undertaking this?

- **Response to Energy Review**
  - to give greater focus to long term investment and security of supply
  - to aid the consideration of strategic issues by the sector
- **Ofgem Corporate Plan**
  - to provide a strategic context for network price control reviews
  - to ensure price controls are compatible with long term outlooks
- **How**
  - develop a range of future scenarios for 2050/2025 around which to discuss longer term electricity network development issues with all stakeholders
  - the aim is to assist strategic thinking, **not** prescribe particular strategies
  - it is not a central planning process and won't "solve all the issues"

Background

- We published an open letter to kick off the project;
- Main objectives:
  - To provide a framework to facilitate contributions and debate.
  - To identify plausible outcomes;
  - To identify the network impacts of the scenario assumptions

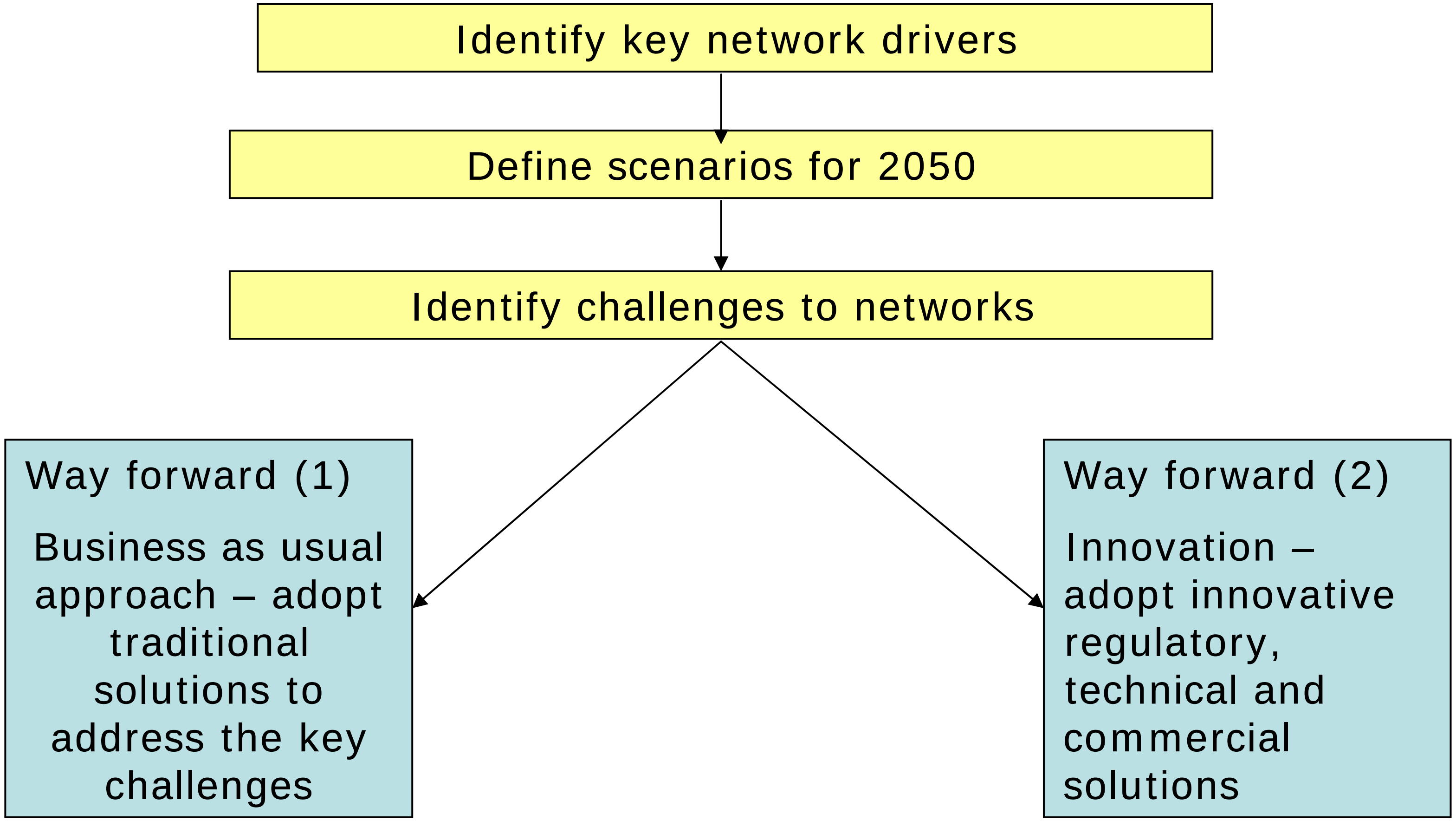
Approach

- **Choice of scenarios will be guided by the potential impact on electricity networks of a range of future issues, including:**
  - Government policy and market developments (including carbon)
  - Sustainable development and environmental challenges
  - Economic, social and demographic change
  - European and international commitments and/or initiatives
  - Potential significant shifts in the UK fuel mix
  - Renewable and distributed generation: local and remote from demand
  - Variability and controllability: both of generation and demand
  - Climate change and impact of apparent environmental trends
- **Recognise and build on existing/parallel work and expertise**
- **Not about picking winners and losers**

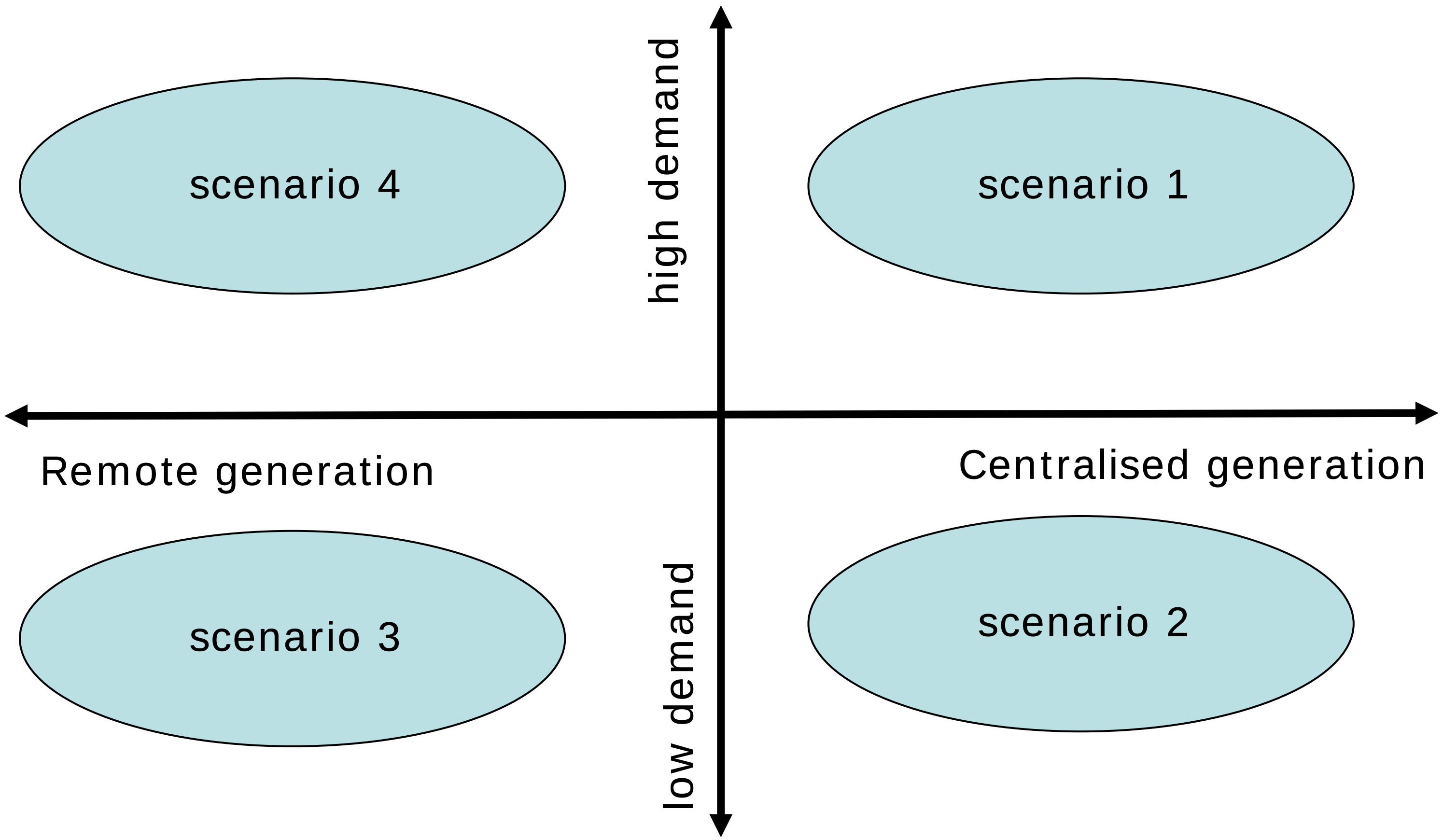
LENS: Open letter

- Open letter identified three phases to the LENS project:
- **Phase 1:** collation of robust raw data on electricity supply and demand outcomes from a combination of primary modelling of supply/demand and use of existing scenarios. The economic foundation for the scenarios will be provided by one of the major 'whole economy' models for energy.
- **Phase 2:** appraisal of the phase 1 raw data and the synthesis of four or five scenarios for the electricity sector in 2050. These will then be subjected to a 'backcasting' process to establish way-markers in 2025.
- **Phase 3:** analysis of the scenarios for 2050 and 2025 to establish a set of key issues for networks and for regulation of networks.
- **Consultation and a workshop will be included in each phase**

Key Stages


Identify key network drivers
Define scenarios for 2050
Identify challenges to networks
Way forward (1)
Business as usual approach – adopt traditional solutions to address the key challenges
Way forward (2)
Innovation – adopt innovative regulatory, technical and commercial solutions

Capturing key network drivers?



Network Challenges?

- Network Configuration
- Network Investment
- Planning/Ops Standards
- Asset Design & Standards
- Environmental Footprint
- Communications & IT
- Consents & New Build
- Asset Management Information
- Innovation Opportunities
- Resilience & Security

Issues to be identified to assist all the stakeholders, not “solved by Ofgem”!

Next steps

- Propose to develop our approach to the work programme in the light of responses to the open letter, view expressed at the workshop ad bi-lateral meetings;
- Expect to complete phase 1 – September/October 2007;
- Phase 2 work to begin – October 2007.

- **Industry engagement is important to develop an effective solution**

Scenarios and energy modelling: complementary tools for decision making in energy futures

Ofgem Stakeholder Workshop
17.8.07

- Nick Hughes, Dr. Neil Strachan
- Policy Studies Institute

Structure of presentation

- Aims and principles of scenario based thinking
- Background and historical development of strategic scenarios
- Scenarios for energy futures
- Approaches to scenario writing- key points to consider
- Modelling energy futures, and the link to scenarios

Aims and principles of scenario based thinking

- An instinctive human activity
- A response to the problem of uncertainty about the future
- An attempt to reduce the *risk resulting from uncertainty* by thinking through how the future could evolve

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Suggested definition

- A way of considering the future outcomes of near term decisions,
  - o Proactively- can we form the future?
  - o Reactively- can we prepare ourselves to be robust to most outcomes?
- …leading to three questions:
  - o What do we want?
  - o What is within our power to influence?
  - o Who is ‘we’?

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Background and historical development: Strategic decision making scenarios

- Herman Khan, RAND and the Hudson Institute
- “thinking the unthinkable…”
- The scenario planner has a “responsibility to be most interested in the many unpleasant ways in which things can go wrong”
- Scenarios on Nuclear War (1962) and The World in 2000 (1967)
- “Scenarios are attempts to describe in some detail a hypothetical sequence of events that could lead plausibly to the situation envisaged…it must of course relate at the outset to some reasonable version of the present , and must correspond throughout to the way analysts and/or policy makers… believe decision makers are likely to behave.” Herman Khan, The Year 2000: A Framework for speculation (!967)

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Strategic decision making scenarios (continued)

- Pierre Wack and Shell
- Redrawing the "mind map"
- Negotiating the period of oil shocks: "Shooting the rapids…"
- "The future is no longer stable… No single 'right' projection can be deduced from past behaviour. The better approach… is to accept uncertainty, try to understand it, and make it part of our reasoning" Pierre Wack
- "A tool for ordering one's perceptions about future environments in which one's decision might be played out." Peter Schwartz

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Using scenarios- relationship of possible futures to actual present

- How does consideration of the future affect what we do now?

- Peter Schwartz
- “The test of good scenarios is not getting the future right. In many ways, that is the easy part. The real test of a good scenario is: did I make better choices as a result of having looked at and understood both my environment better and the consequences of my actions?”

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Using Scenarios- Challenging the ‘mind map’

- Questioning commonly held assumptions about current systems
- **Pierre Wack**
- “We wanted to design scenarios so that managers would question their own model of reality, and change it when necessary, so as to come up with insights beyond their minds’ previous reach”
- **Herman Khan**
- They are “effective tools in lessening the “carry-over” thinking that is likely…”

‘Exploratory’ scenarios for energy futures

- Special Report on Emissions Scenarios (SRES) IPCC, 2000
  - Qualitative storylines derived from four scenario ‘families’ characterised by combination of four key drivers: environment vs economy; global vs regional
  - Quantitative modelling of scenarios using 6 global models to represent emissions levels in each scenario
- Energy for Tomorrow (Foresight, 2001)
  - Qualitative storylines derived from interaction of four key drivers: consumerism vs community; global vs regional
  - Stakeholder involvement
  - Scenarios have been used as basis for quantitative modelling in other studies

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Review of some recent UK Energy scenarios

- Treatment of uncertainty: normative or exploratory
  - Many scenarios are developed using normatively defined criteria, modfying uncertainty
- ‘Backcasting’
  - ‘The main distinguishing characteristic of backcasting is a concern, not with what futures are likely to happen, but with how desirable futures can be attained’ (Robinson, 1990)
  - UKSHEC Hydrogen Visions (Eames and MacDowall, 2005); Decarbonising the UK (Tyndall, 2005)
- Technical feasibility studies
  - Using demand assumptions and projected technology data to explore technical feasibility of various options
  - Energy, the Changing Climate (RCEP, 2000); Technical feasibility of CO2 reductions in housing stock (Bell, 2004)
  - A Bright Future (FoE, 2006); Decentralising UK Energy (WADE / Greenpeace, 2006)
  - Use of models to demonstrate feasibility by switching technical and policy options on and off

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Recent UK Energy scenarios- some observations

- Aspirational
  - Good at setting out (usually technical) milestones and achievements necessary to achieve certain emissions reductions
- Breadth of consultation
  - Some studies consult widely, others use expertise within smaller teams
- Treatment of uncertainty
  - Constrained end points do not necessarily consider ‘unpleasant’ possibilities
- Definition of key drivers and the degree of influence the scenario ‘recipient’ can have over these
  - Who or what is driving outcomes? Is this realistic?
  - Who are the scenarios for (scenario recipient)?
  - What is in and outside of recipients control?

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Approaches to developing scenarios and model runs

- Defining the recipient or user
- Defining a focal question
- Information gathering
- Identifying themes and drivers
- Seeing ‘branching points’ and tracing routes
- Writing storylines
- Modelling scenarios

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Modelling

- **Why do energy modelling?**
  - **Nature of policy question-** ie potential for long term deep GHG emissions reductions- drives model type
  - **Complexity of energy system:** Integrated models can demonstrate resource trade offs and system dynamics at levels of detail not possible with qualitative storylines
  - **Quantification:** quantification gives more specific answers to certain important questions (emissions levels, costs)

- **Risks** and possible remedies
  - **Uncertainty is not adequately characterised-** use of sensitivity analysis
  - **Temptation to switch inputs on and off to find 'right answer'-** need to develop coherent analytical framework to justify assumptions
  - **Interpreted as forecasting-** rather it is a **'what-if'** analysis. Scenarios can be used to demonstrate plausibility and internal consistency, as well as uncertainty and path dependency of assumptions behind data

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Energy model types

- Bottom up models
  - Eg. MARKAL & TIMES (IEA), MESSAGE (IIASA) etc.
  - Optimisation (for market efficiency) and simulation
  - Energy system focus
  - Technological detail
- Top down models
  - Eg. EPPA (MIT), AIM (NIES), E3MG (Cambridge) etc.
  - CGE or Macroeconometric
  - Macroeconomic effects- trade, government expenditure
  - Microeconomic effects- behavioural change
- Opportunities for 'hybridisation' increasingly being explored
  - Eg. MARKAL Macro, CIMS (Canada)

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MARKAL

- **MARK**et **AL**location dynamic optimization model
- 100+ users in 30+ countries under IEA ETSAP network
- A **least cost optimization** model based on life-cycle costs of competing technologies (to meet **energy demand services)**
- **Technology** rich bottom-up model (e.g. end-use technologies, energy conversion technologies, refineries, resource supplies, infrastructure, etc)
- An **integrated energy systems** model
  - Energy carriers, resources, processes, electricity/CHP, industry, services, residential, transport, agriculture
- Very large range of physical, economic and policy **constraints** to represent UK energy system
- Can incorporate external analysis ie energy service demand projections- use of scenarios to explain / justify

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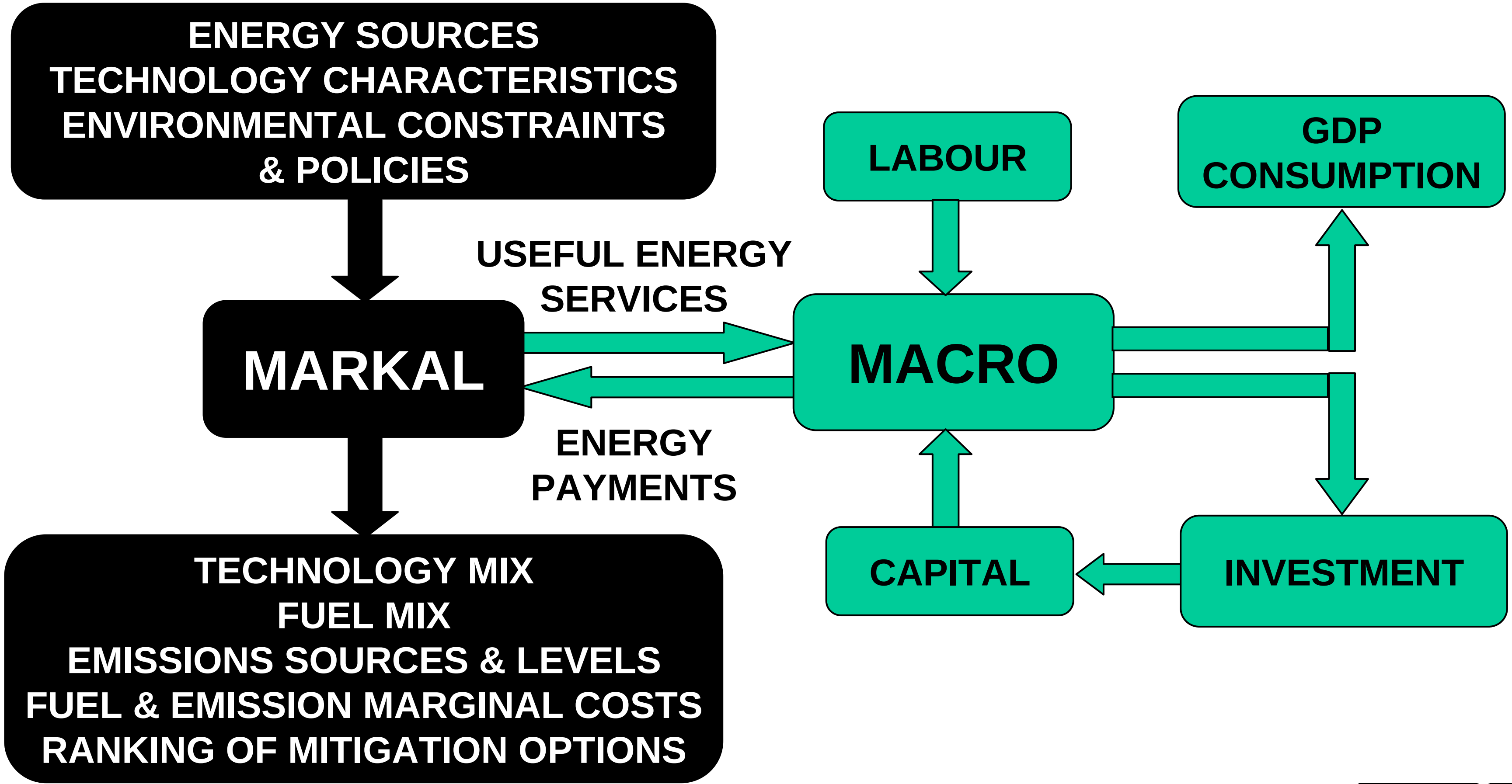
UK MARKAL Macro (M-M) model



UK MARKAL key input parameters

- System configuration – potential energy pathways and interactions
- Energy service demands - to a detailed sub-sectoral level
- Resource supply curves - imports and domestic production
- Global parameters - discount rate etc
- Temporal disaggregation – load curves for electricity, heat
- Macro parameters – GDP growth rates, demand elasticities etc
- Technology characterisation – capital costs, O&M costs, efficiencies, lifetime, availabilities, etc
- Emissions tracking - CO_2 by fuel & sector, SO_2 by technology
- Technology learning - vintages, exogenous learning rates
- Constraints – physical and policy driven
- Taxes, subsidies – by fuel, by technology

Running the UK MARKAL model

- MARKAL optimises (minimizes) discounted total energy system cost
  - MARKAL-Macro optimizes (maximises) total discounted utility
- Initial set-up to mimic UK energy system in year 2000
  - Depiction of existing infrastructures, installed energy technologies, current policies, physical constraints
  - Calibration to base-year final energy, CO_2 emissions and electricity generation
- Model then optimizes in 5-year time steps through to 2050
  - As existing technologies are retired, model selects new technologies and energy pathways based on relative costs, technology learning, constraints etc
- A full range of scenarios and sensitivity analysis is carried out in a systematic 'what-if' framework

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UK MARKAL principal outputs

- **MARKAL**
- Total and annual energy system costs
- Investments and capacity utilization of technologies
- Primary energy, final energy - by sector and/or by fuel
- CO_2 - by fuel, sector and end-use sector
- Average and marginal emissions prices
- Electricity generation mix– by fuel and by technology
- Imports, exports & domestic production of fossil & renewable fuels
- Use of processes and energy carriers
- Transport fuels, transport technology by mode
- Use of conservation
- Use of hydrogen (by production pathway)
- **MARKAL-Macro additional**
- GDP, consumption, investment, energy costs
- Change in demand services

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Relationship of scenarios to models

- Models are ‘what if’ tools: they operate on the basis of a range of assumptions

- Scenarios provide a feasible explanation of how such a range of assumptions might reflect a possible future which could feasibly evolve from the present day

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Possible issues to consider in developing and modelling long term electricity network scenarios

- Who are these scenarios for? (Ofgem, the electricity companies, UK government?)
- What is the question we want them to answer?
- What are the key drivers (legislation, long term national targets / frameworks, Ofgem policy)?
- What are the key branching points (What has to happen when; which decisions if taken or avoided will ‘lock in’ future developments to one pathway or another)?
- How can these be represented in models?
- What are the key interactions and outputs we hope to explore using quantitative modelling?

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Conclusions

- Scenarios should…
- define clearly the recipient, and the influencing factors within and outside of the recipient's control
- have a link to implications for current and near term policy or investment decisions
- explore alternative 'mind maps' rather than relying on existing assumptions about the system
- Scenarios can…
- aid understanding of the complex interactions between technology development, policy implementation, social and cultural factors, and key branching points
- Models can…
- be used to explore in greater detail the outcomes of scenarios in terms of key policy goals such as carbon reduction, as well as exploring complex whole energy system dynamics

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The Development of LENS Scenarios

Dr. Graham Ault

Scenarios approach

Define the recipient
Frame the focal question
Information gathering
Identify themes
Sketch possible pathways
Write scenario storylines
Model scenarios
Identify potential implications of scenarios on the focal question
Identify and develop potential strategies

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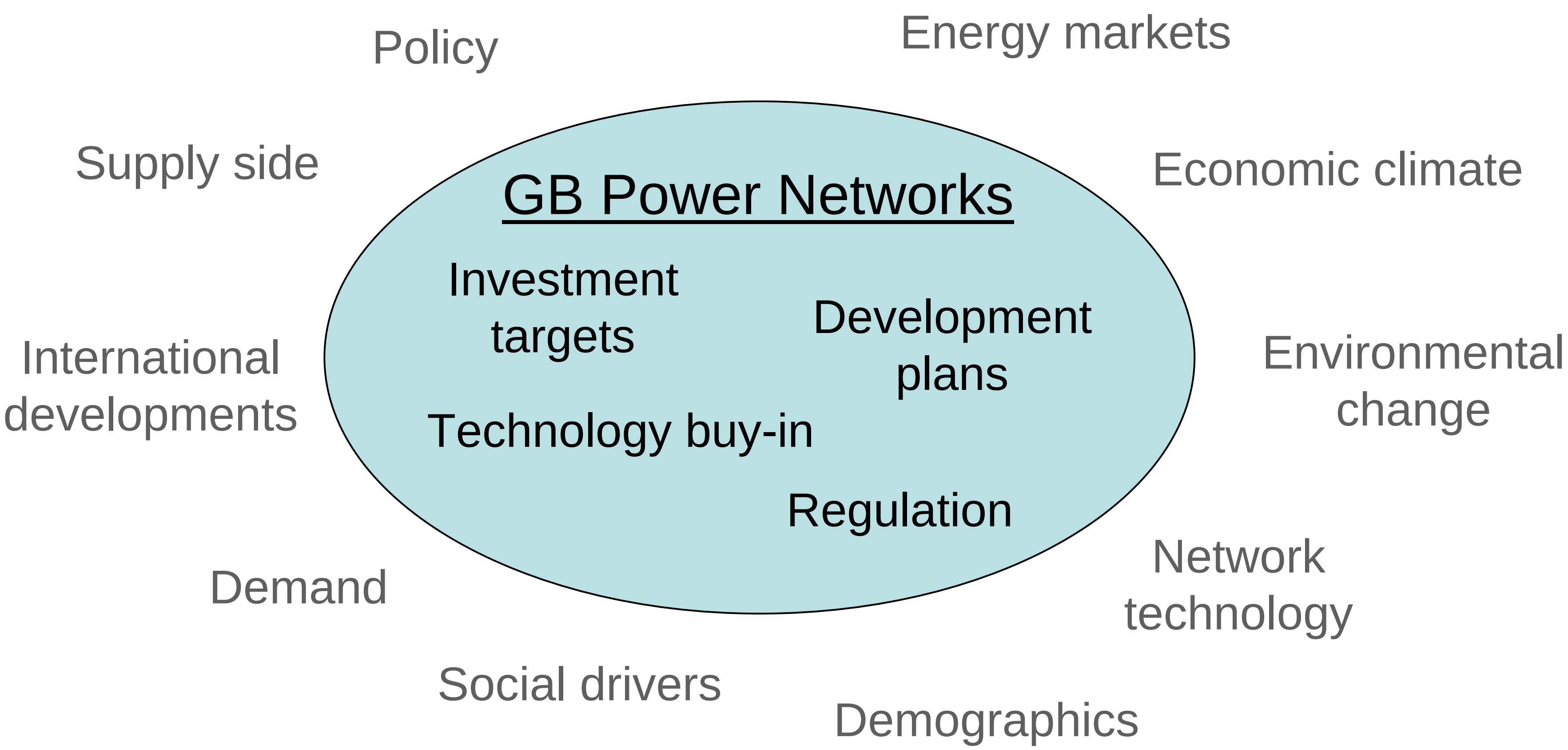
1. Define the recipient

GB power networks sector/stakeholders

2. Frame the focal question

- What would be the impact of external policy, markets, supply, demand and technology futures on the development of power networks?
  - What can be done to influence the 'external' landscape
  - What should be done 'internally' to achieve the best result?

Frame the focal question

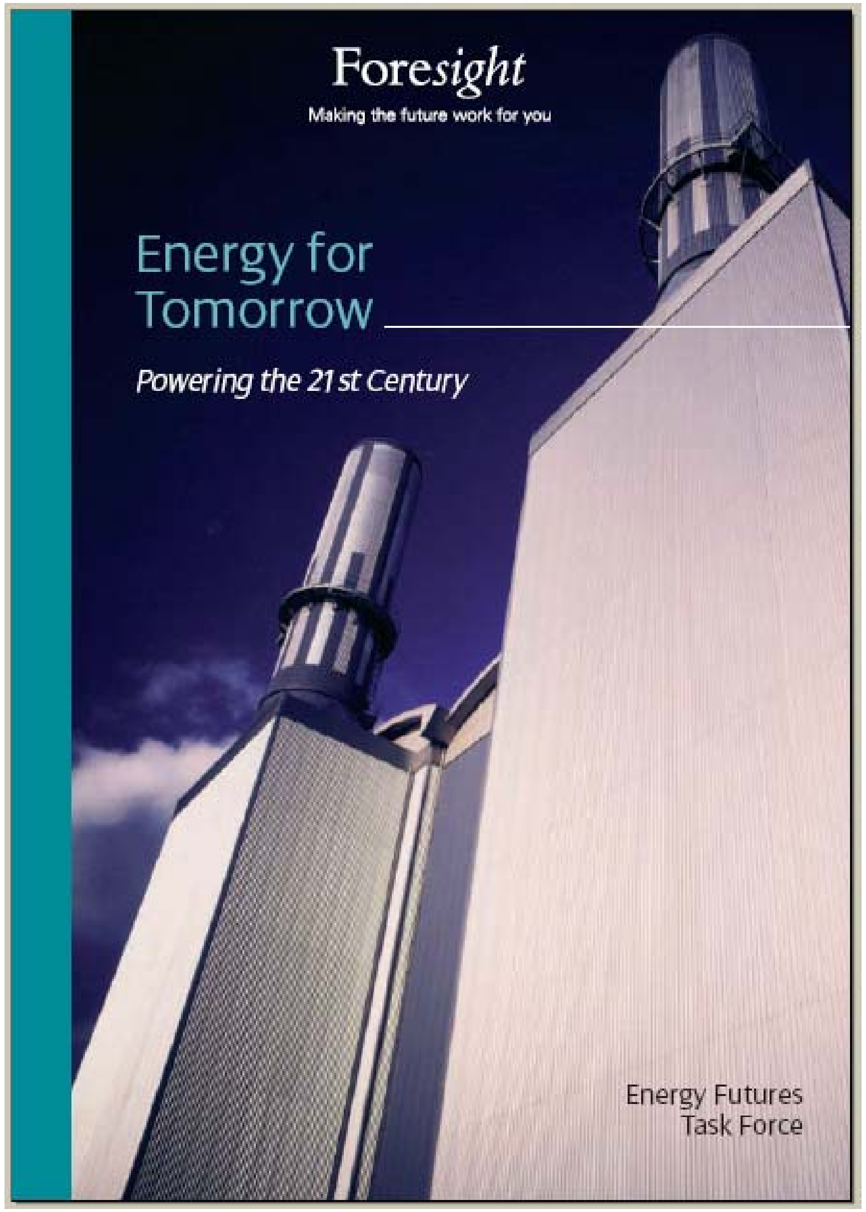


Scenarios describe external environment
Scenarios are **not** road maps, targets, plans, strategies, or blueprints

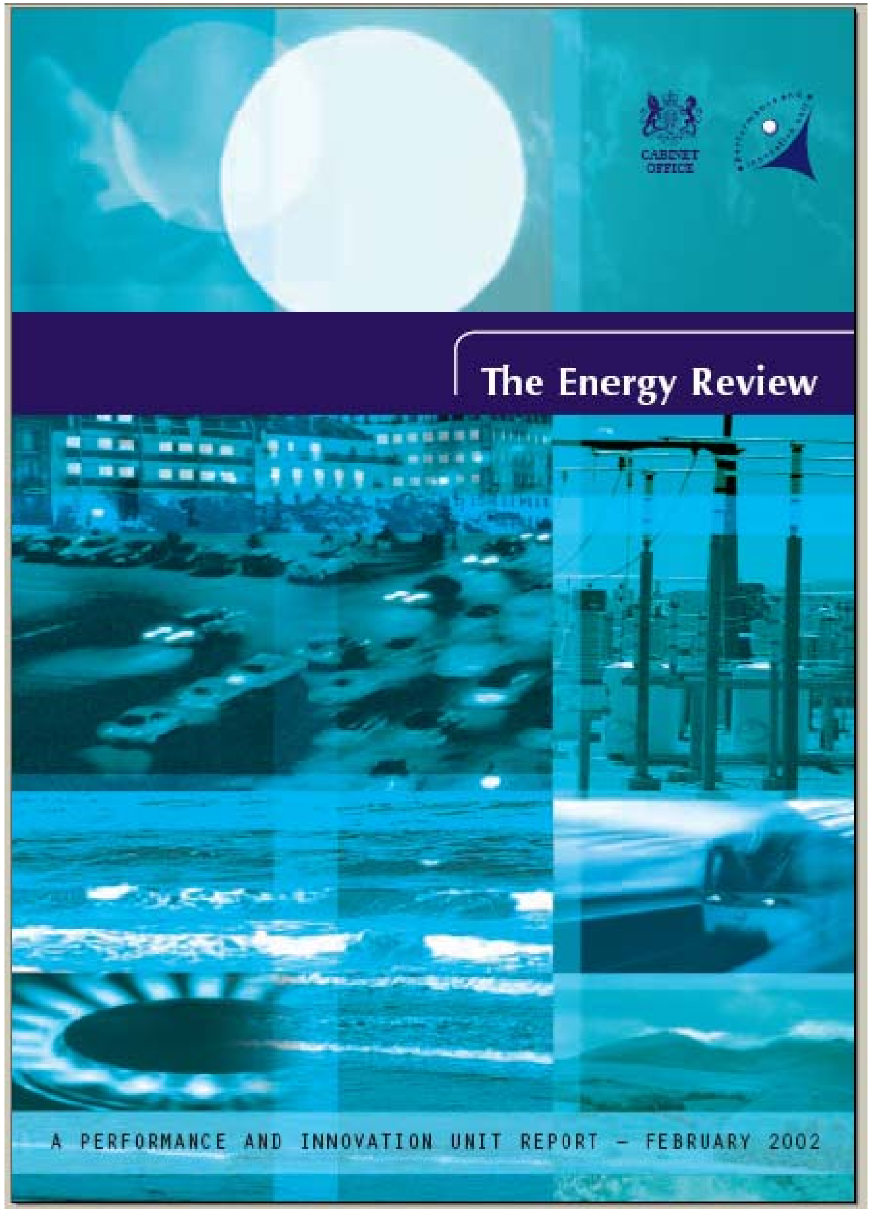
3. Information gathering

Review of recent relevant scenarios
Power networks stakeholder issues
Supporting modelling

DTI Foresight (2001)



- DTI started to push the use of scenarios for public and corporate planning in late 1990s
- Energy Futures Task Force set to work on energy scenarios
- Work resulted in four scenarios mapped onto Global-Regional and Consumerist-Community axes
- Picked up in 2002 PIU Energy Review



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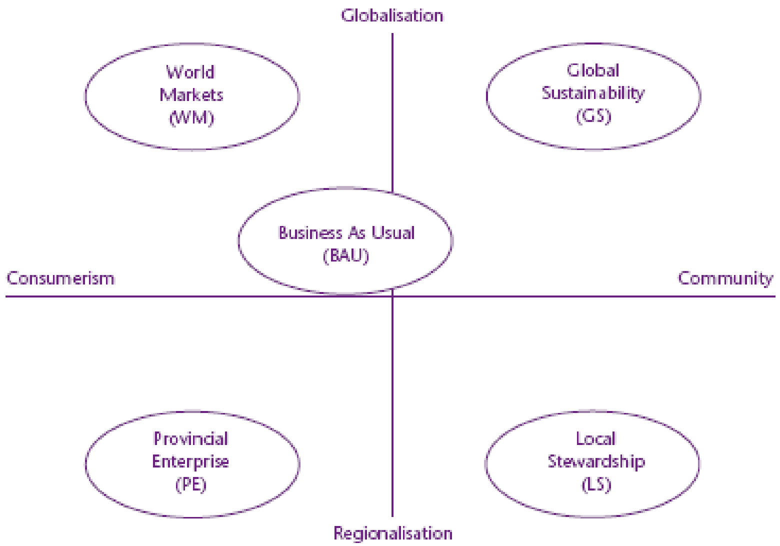
PIU Energy Review (2002)

Picked up from DTI Foresight
Put choices facing GB on energy policy in context of global energy scenarios



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Royal Commission On Environmental Pollution

RCEP (2000)

Table E.5

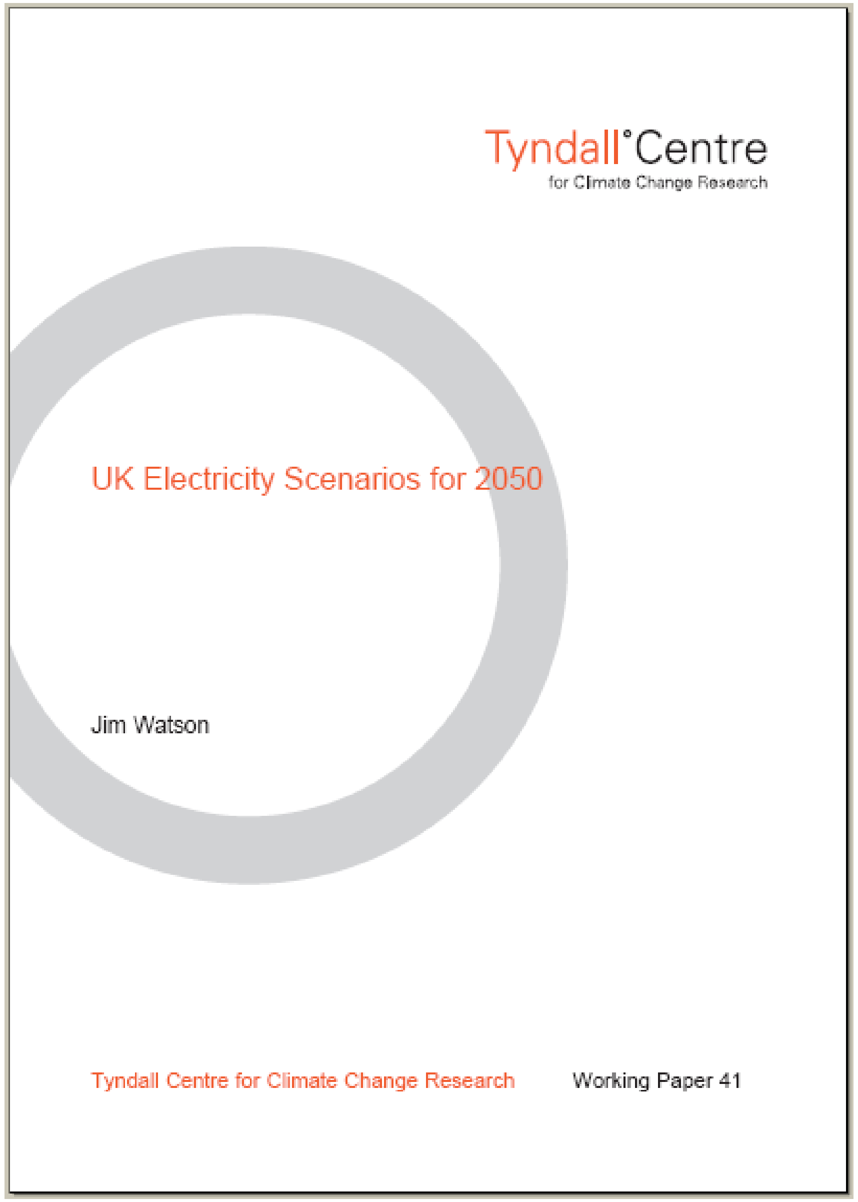
Outputs from energy sources in 2050 under the four scenarios

annual average rate (GW)

Source	present output	1	2	3	4
on-shore wind	0.10	6.5	3.3	0.2	3.3
off-shore wind		11.4	11.4	11.4	5.7
solar PV		10.0	5.0	0.5	0.5
wave		3.75	3.75	3.75	3.75
tidal stream		0.25	0.25	0.25	0.25
tidal barrage		2.2	2.2	0.0	2.2
total intermittent renewable sources		34.1	25.9	16.1	15.7
hydro existing	0.59	0.59	0.59	0.59	0.59
hydro new small scale	0.02	0.3	0.3	0.3	0.2
energy crops		10.2	10.2	1.8	1.8
agricultural and forestry waste	0.04	5.7	5.7	5.7	1.2
municipal solid waste	0.15	1.9	1.9	0.0	0.0
total renewable sources		52.8	44.6	24.5	19.5
nuclear power*	11.4	52	0	19	0
contributions from fossil fuels	266	106	106	106	106

*alternatively, the same amount of energy might be provided by fossil fuel baseload stations at which carbon dioxide is recovered and disposed of.

Tyndall (2003)


Tyndall°Centre
for Climate Change Research

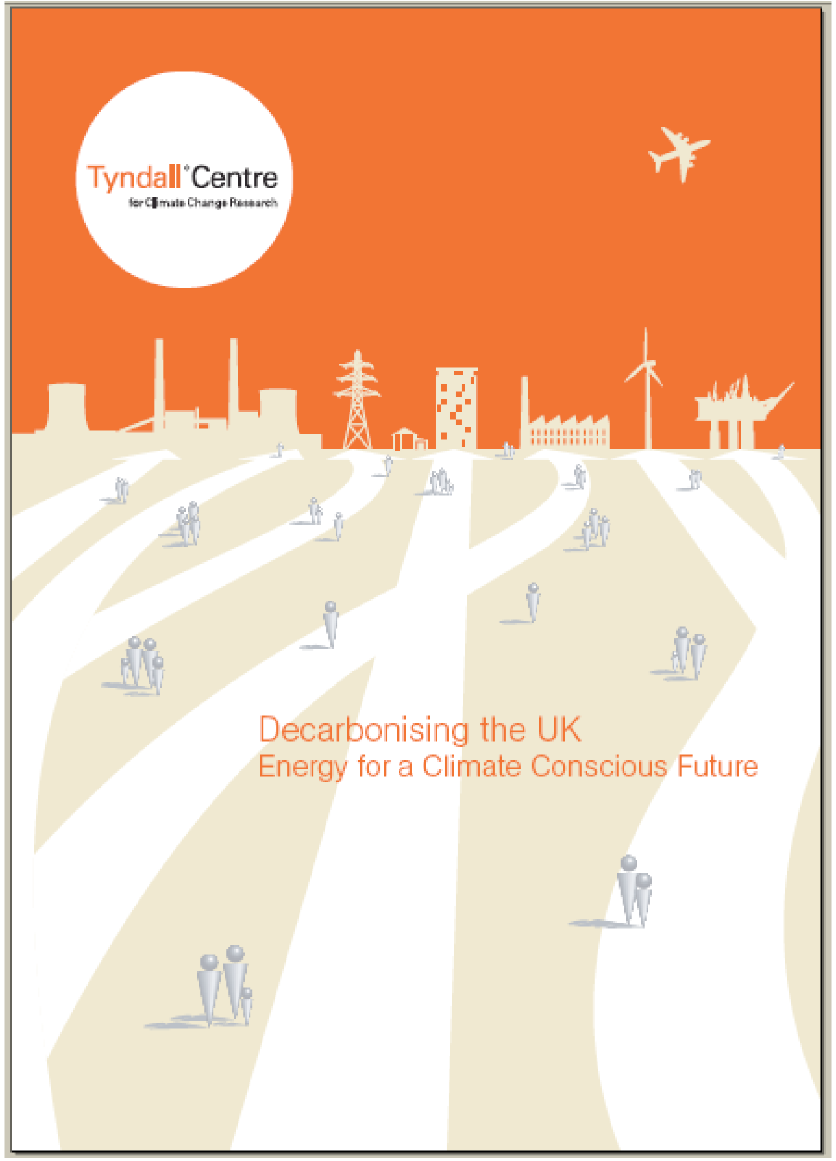
UK Electricity Scenarios for 2050

Jim Watson

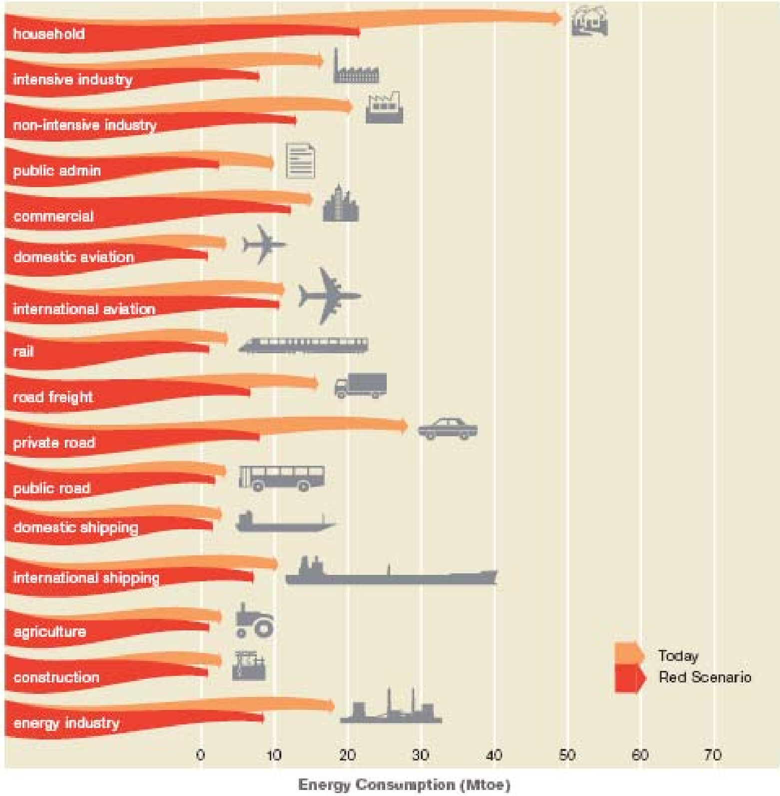
Tyndall Centre for Climate Change Research Working Paper 41

- Picked up the RCEP (2000) scenarios – constrained by 60% carbon reduction target
- Developed more detail on power generation mix
- Provides more realistic data for plant characteristics
- Assesses issues for RCEP generation mixes in meeting electrical demands

Tyndall: 'Decarbonising the UK' (2005)



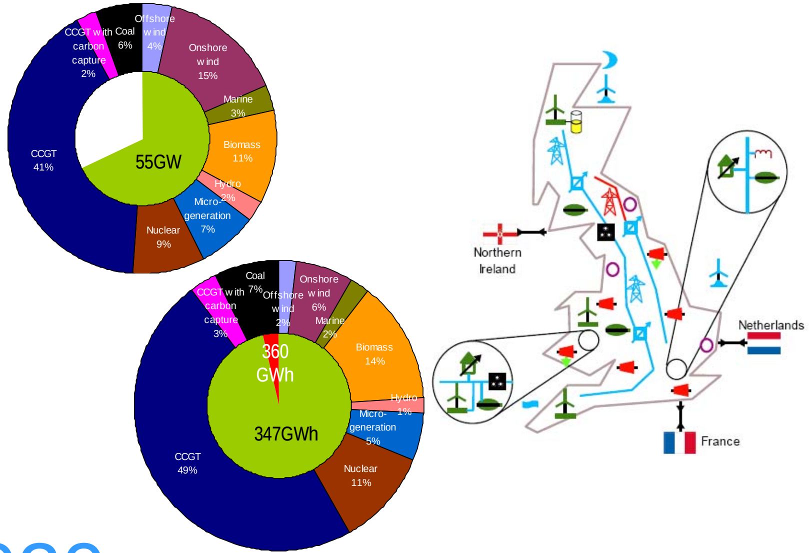
All UK energy sectors addressed through quantitative modelling



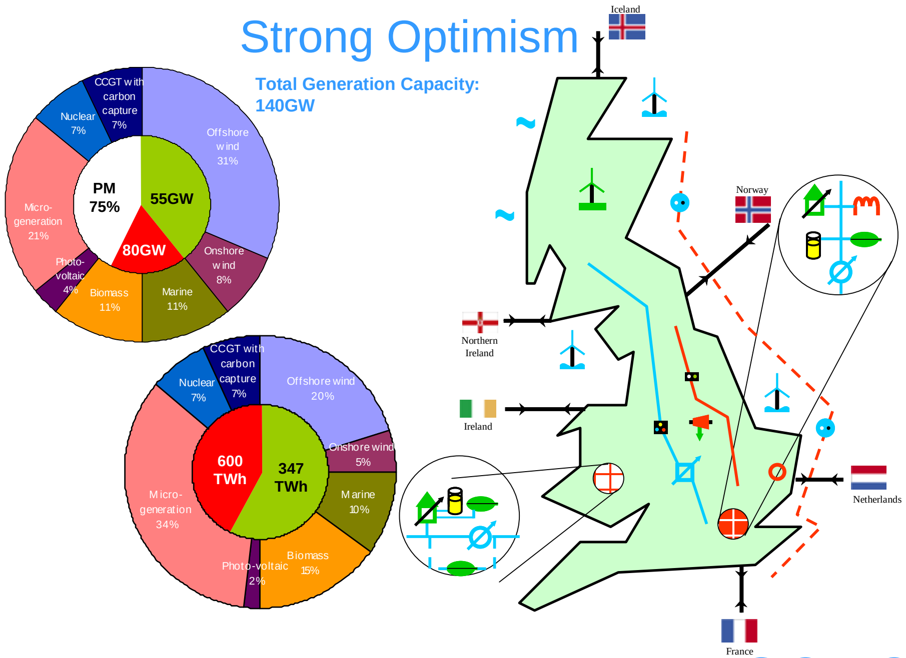
SuperGen ‘FutureNet’ Scenarios

- Scenarios for power system development in 2020 and 2050
- Relatively wide dissemination and use of scenarios in GB power sector

Environmental Awakening



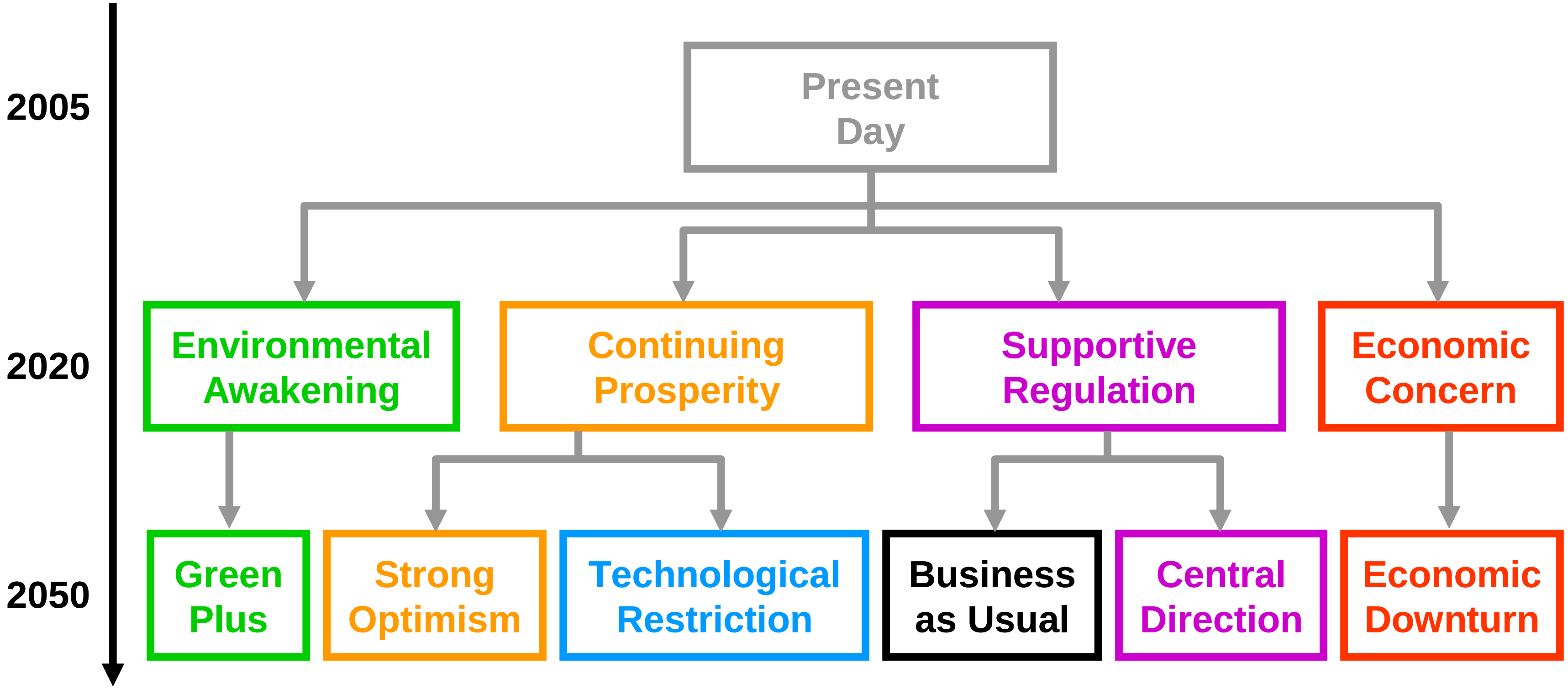
Strong Optimism



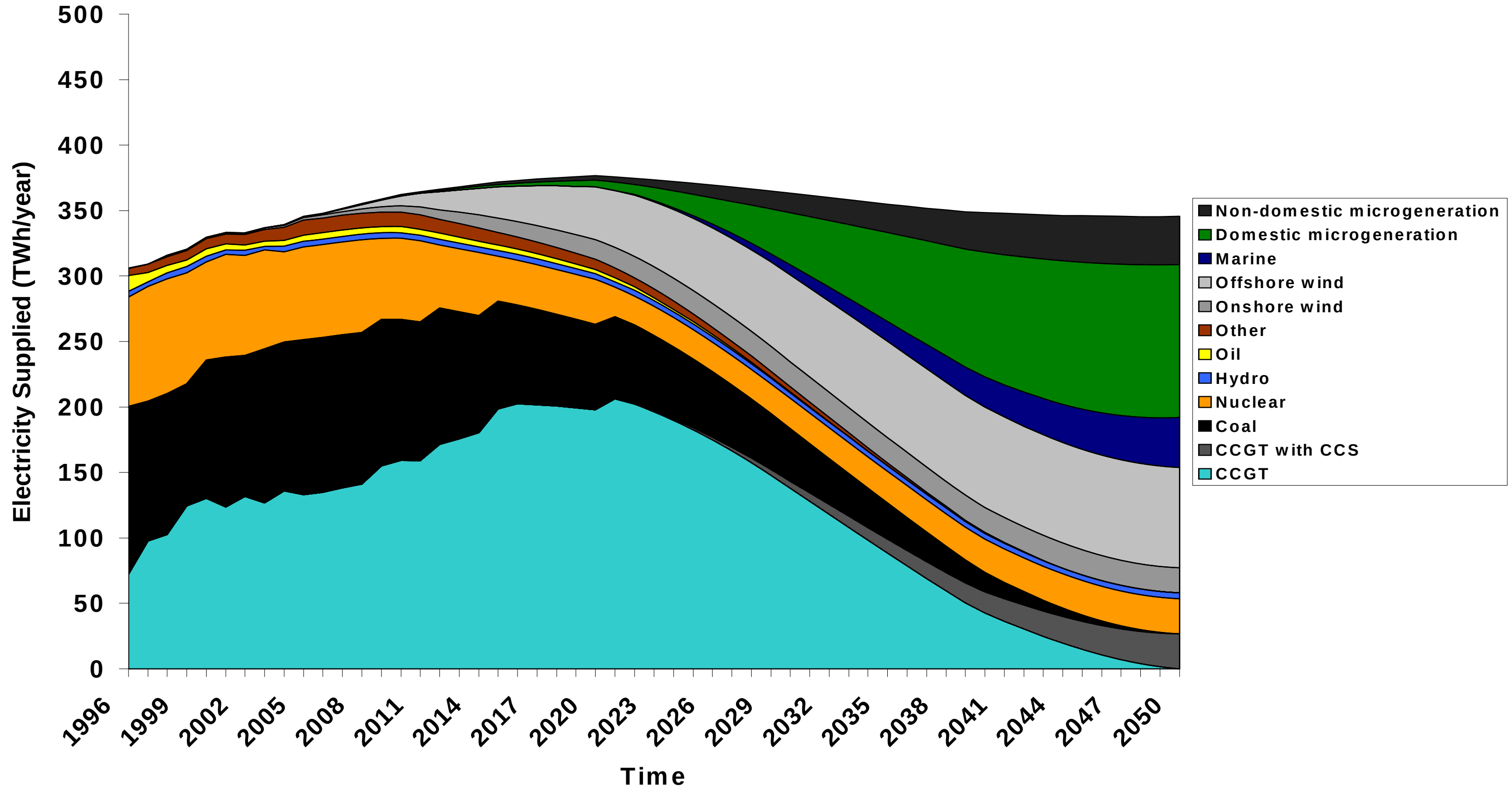
2020

2050

Relationship between 2020 and 2050 SuperGen 'FutureNet' Scenarios: Example of 'backcasting'



SuperGen HDPS Scenarios



Constrained by 60% carbon emission reduction by 2050

Focus on small scale distributed energy resources

Modelling outputs from the UK Domestic Carbon Model (Oxford)

Lower voltage power network impacts

Decentralising UK Energy (Greenpeace/WADE, 2006)

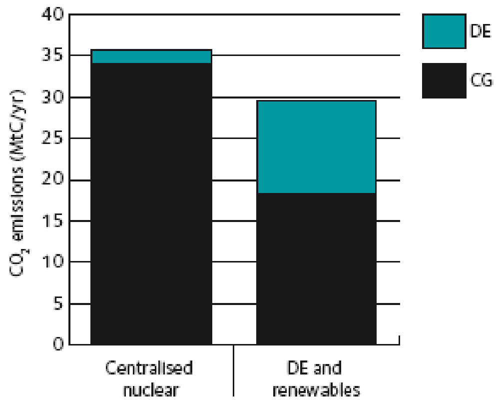


Figure 4: CO_2 emissions in 2023 – baseline scenarios (see section 3.2)

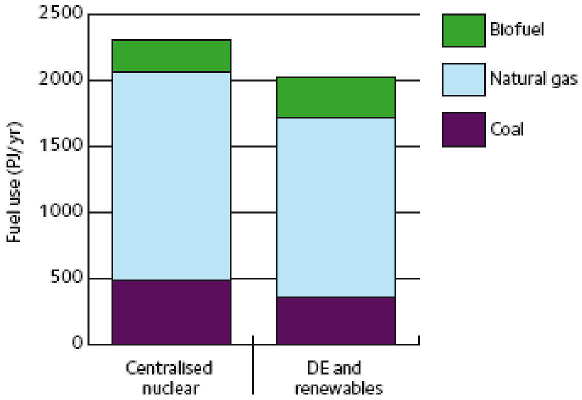


Figure 5: Total fuel use in 2023 by fuel type – baseline scenarios

Two scenarios: ‘nuclear scenario’ and ‘decentralised scenario’
Compared on: emissions, fuel use, retail cost, capital cost
Sensitivity undertaken for model input assumptions on fuel costs, demand growth, generation type exclusion.

Power networks stakeholder issues

Customer expectations / quality of supply / performance levels
Transport
Resources and skill requirements
Power plant / product markets
Technological development (networks and customer side)
New fuel sources (nuclear fusion, hydrogen, etc.)
Planning framework (local and national)
Regulatory framework
Demand growth and patterns of use (winter and summer peaks)
Centralised / decentralised generation development (and geographic location)

Power networks stakeholder issues

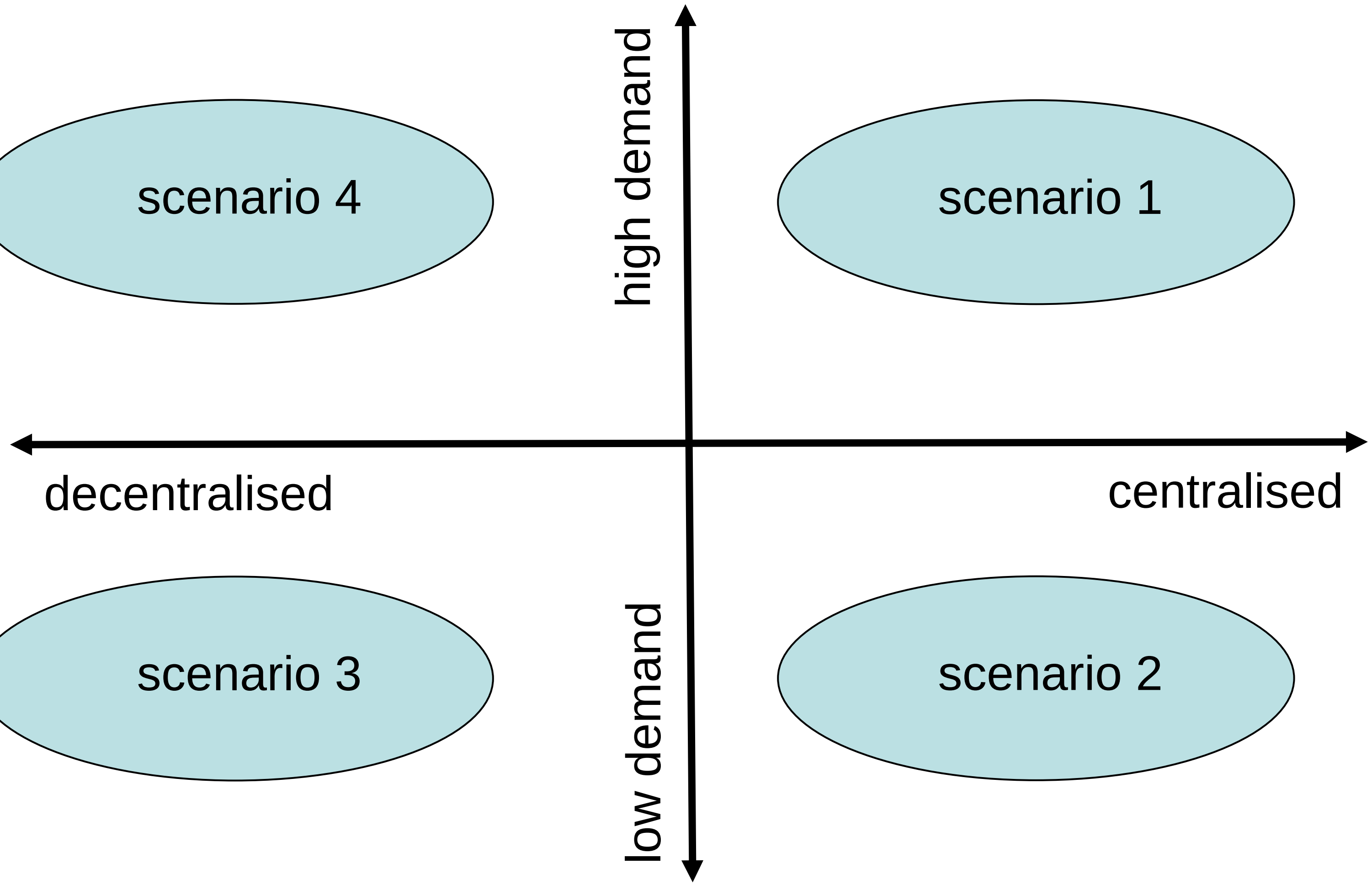
- Network security
- Societal and environmental pressures on network development
- Network resilience
- Health and safety
- Network access (load, generation and other customers)
- Role of distribution networks (proactive, reactive, support low carbon future, etc.)
- Smart metering
- Interaction of electricity networks with other energy networks

4. Identify themes
5. Sketch possible pathways
6. Write scenario storylines
7. Model scenarios

- Key themes (e.g. decentralisation of energy supplies)
- Driving forces (e.g. demand growth, environment)
- Path dependencies (e.g.)
- Modelling with MARKAL to quantify and test out the robustness and plausibility of emerging scenarios

- Outcome: initial 2050 scenarios

Key themes and driving forces: simple example illustrating benefits and drawbacks of a simple approach



8. Identify potential implications of scenarios on the focal question: Example illustration of generation technology and location – SuperGen 2020 scenarios

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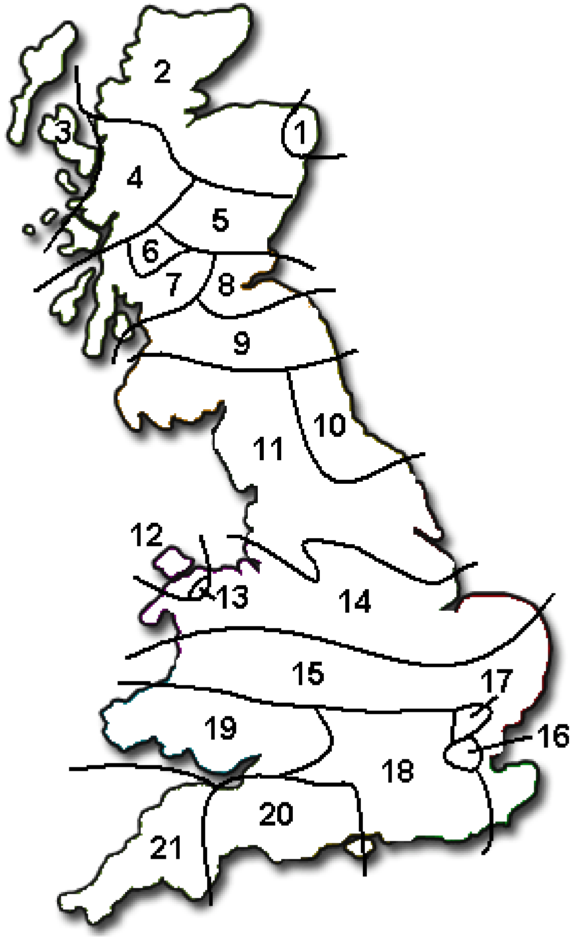
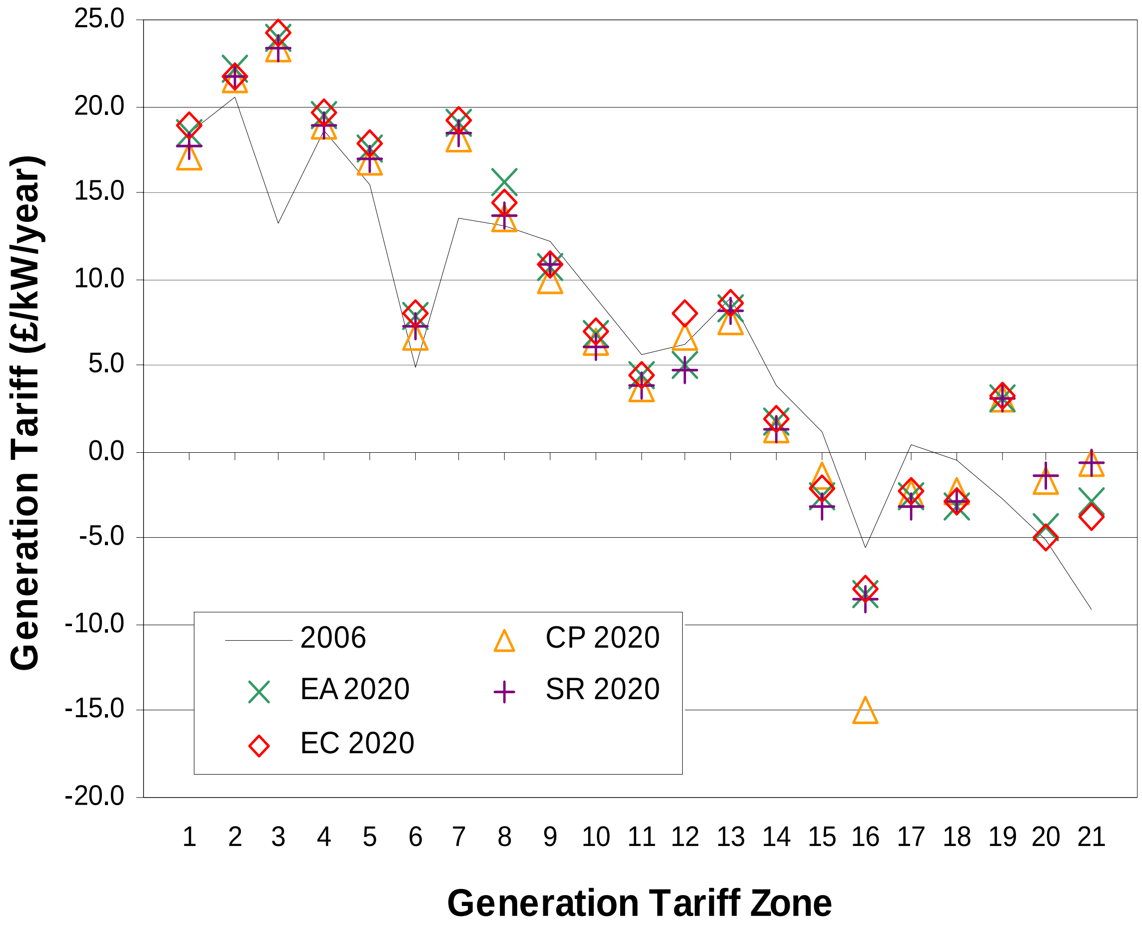
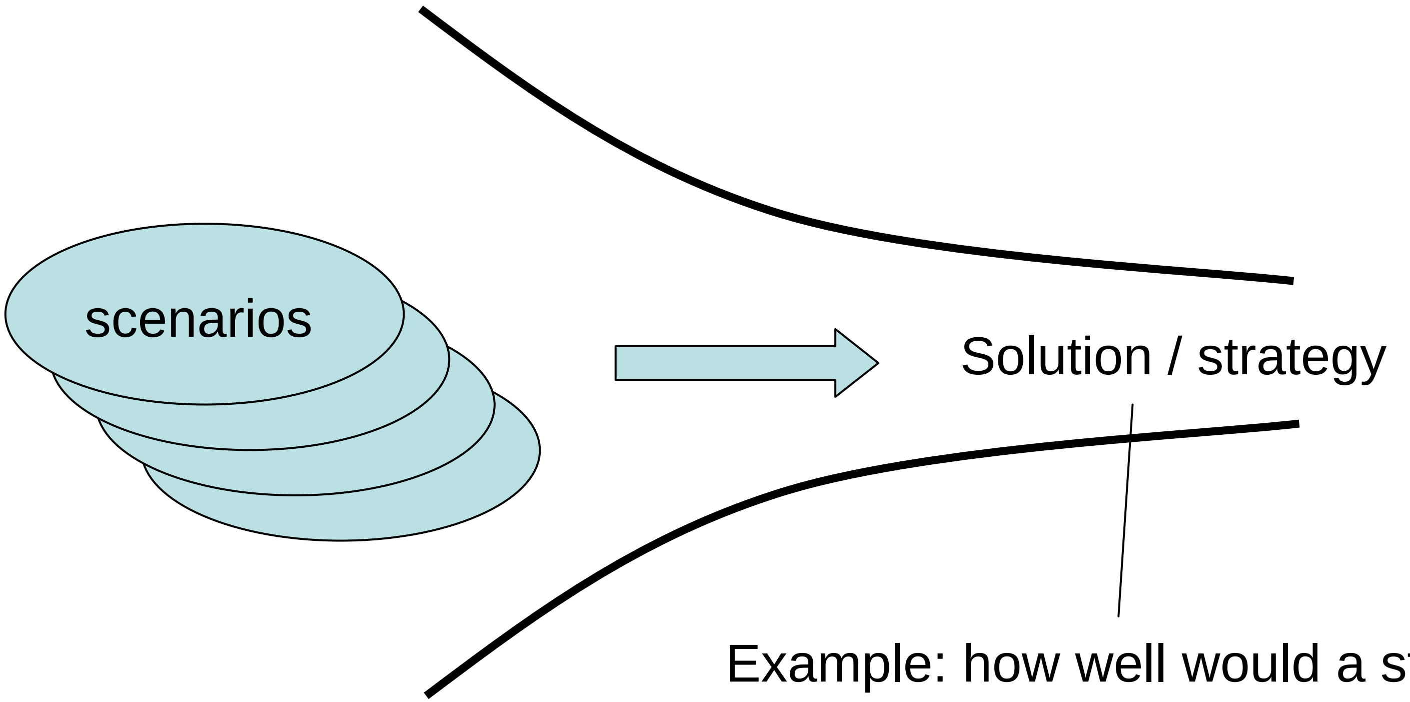
	Continuing Prosperity	Supportive Regulation	Environmental Awakening	Economic Concern
EHV: Variable output Generation (GW)	8.7	7.3	11.8	5.9
EHV: Reduction in Synchronous Generation (GW)	19.1	18.1	26.6	16.1
HV: Variable output Generation (GW)	4.0	4.0	5.1	2.6
HV: Asynchronous and Inverter Fed (GW)	3.5	3.5	4.6	2.1
MV: Variable output Generation (GW)	2.0	2.2	2.7	1.2
MV: Asynchronous and Inverter Fed (GW)	1.5	1.7	2.2	0.7
LV: Inverter Fed – Variable output Generation (GW)	3.0	0	6.0	0

8. Identify potential implications of scenarios on the focal question: Example of transmission pricing changes - SuperGen 2020 scenarios



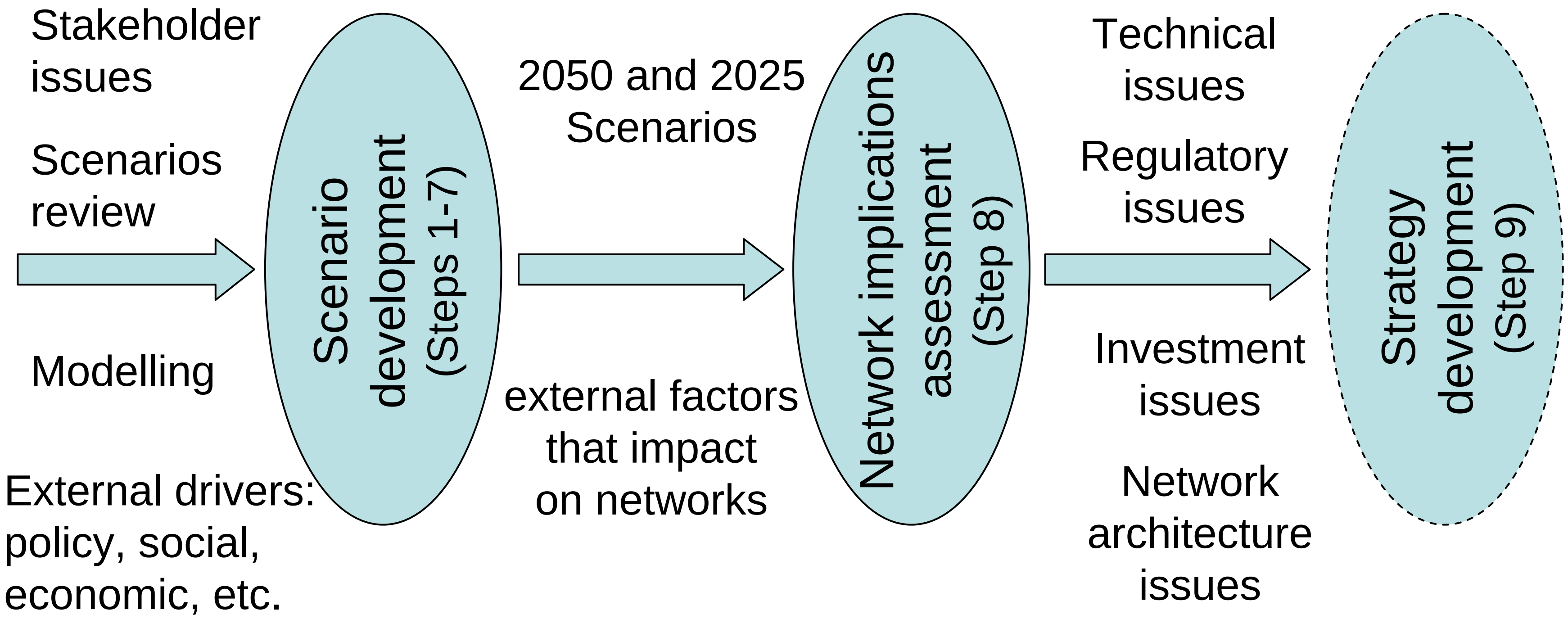


9. Strategy development: wind-tunnelling a solution



Example: how well would a strategy fare that focuses on developing DNO functionality for smart meters? Or a DPCR/TPCR settlement that allows for more risky strategic development of network capacity?

Overview of scenarios approach



Immediate next steps

Formulate detailed programme of work
Complete recent scenarios review
Collate inputs from letters of response and workshop
Scenarios process:

- Identify themes
- Sketch possible pathways

Then:

- Write scenario storylines
- Model scenarios

Q & A Session

Wider Context – four perspectives on scenario modelling

Electricty Networks Strategy Group

Horizon Scanning

Duncan Botting
Head of Technology & Business Development
ABB (UK)
Horizon Scanning Workprogramme Director
IET Power Systems & Equipment PN Exec

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What is Horizon Scanning?

- In the context of Electricity Networks:
- It is NOT a Central Planning activity
- It provides a platform for addressing strategic issues across the sector to be analysed and deliverable solutions brought forward
- Enables cross sector and government "joined-up" thinking to be delivered in a timely manner
- Ensures externalities are considered and included in planning and development of solutions
- Informs stakeholders by identifying options and addressing gaps in the liberalised supply chain decision making process
- Team members from a broad stakeholder base

ABB

ENSG HS has facilitated valuable "joined up thinking"

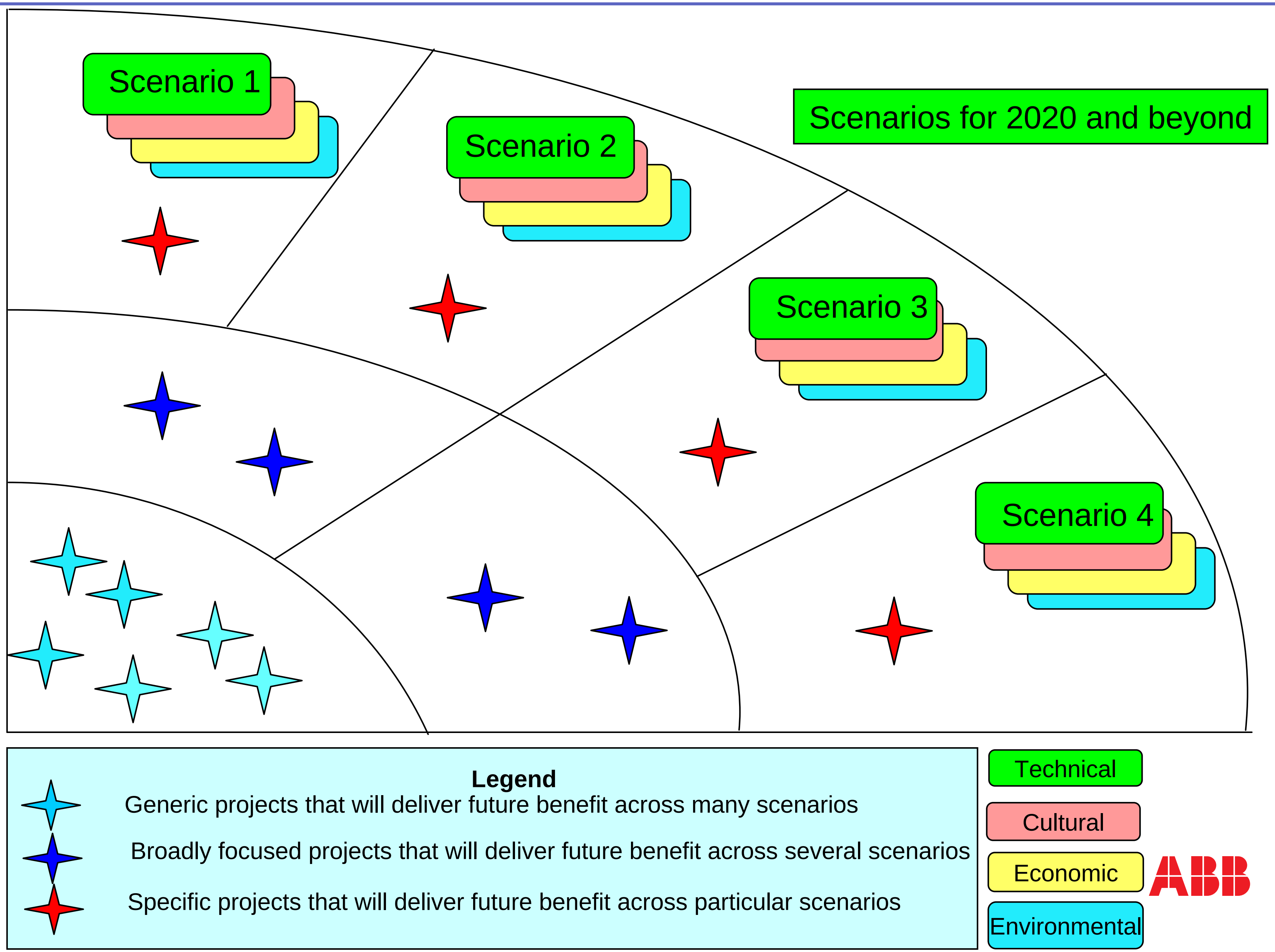
- Has helped to develop a shared vision and understanding across a diverse group of stakeholders
- Helped to develop a common vision identifying: **Flexibility**, **Credibility**, **Reliability**, **Availability** and **Capacity** all in an **Economical**, **Environmentally**, **Safe** and **Efficient** manner – taking account of:
  - Global Trends
  - Changing requirements
  - EU & Government Policy
  - Environmental
  - Regulatory requirements
  - Commercial models
  - Technical advances
  - Health & Safety

Horizon scanning is important for facilitating a shared vision and providing course correction

Horizon Scanning Deliverables

- Already Delivered:
- Technical Architecture Report
- Network Scenario work in conjunction with EPSRC (Supergen) and ITI Energy/ScottishPower
- International collaboration (e.g. SmartGrids (Eurpoe) Intelligrid/Gridwise (US), Super HVDC (China), IEA ENARD)
- Cross-sector information dissemination events
- The “Big Picture” Communications tool
- Work in progress:
- Future Networks Architecture – due to report in August
- “Big Picture – The next steps”

Projects to deliver future benefit in an uncertain world



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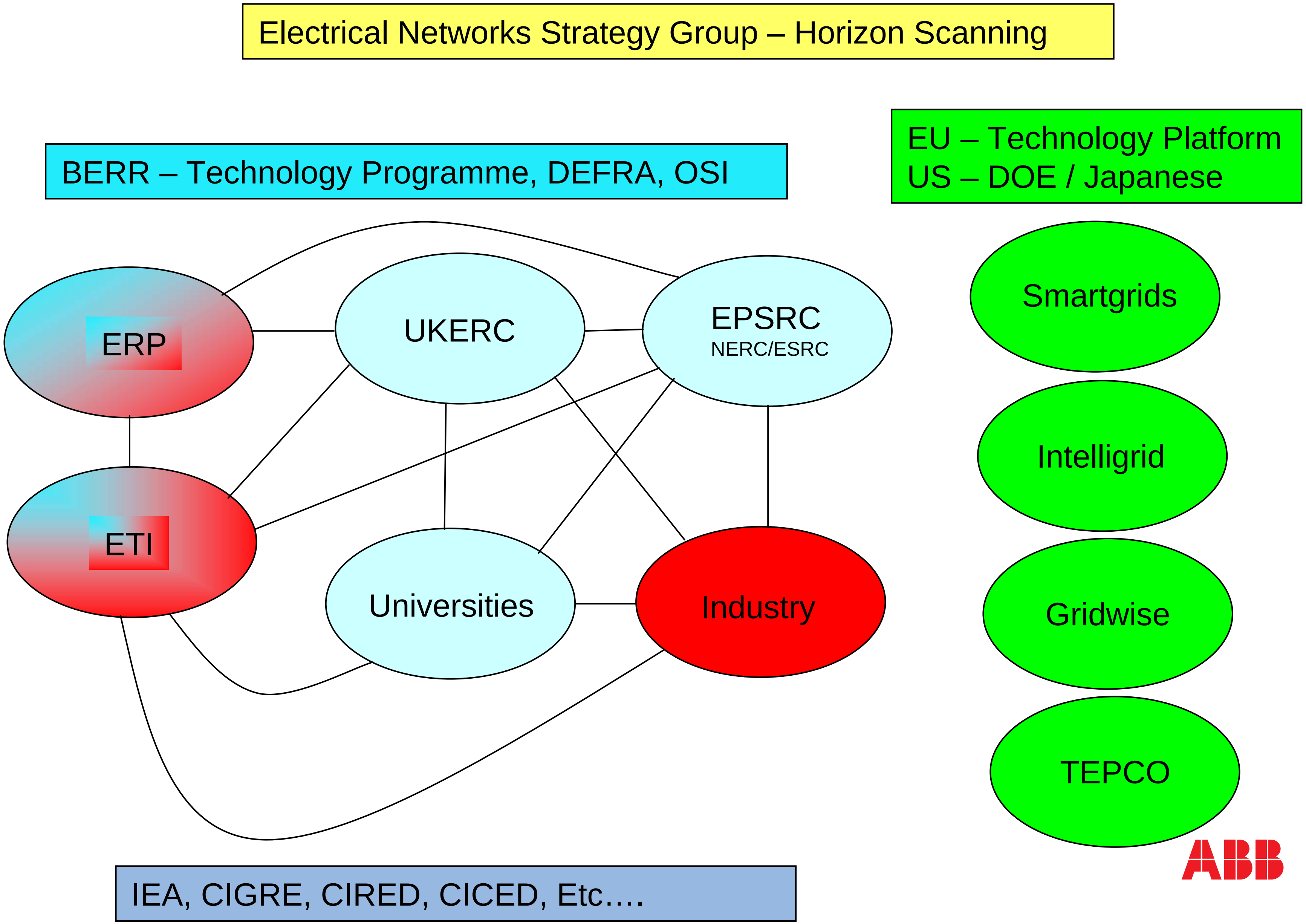
The “Electrical Energy RD&D Landscape”



Horizon Scanning project portfolio

- P01 - Long Range Scenarios for UK Power Systems – completed. The scenarios from this project are being used to inform the P02 project start.
- P02 - Network Architectures to progress towards possible Scenarios for UK Power Systems
- P03 – Future Projects - Not yet started.
- P04 – Existing and New Technologies and Infrastructures for the Future Networks Monitoring, Protection and Control (Sensing, Intelligence and Control)

  Following the final publication of current work associated with this project from PG2 (Active Network Management) the next step is to develop the future networks part of this project.
- P05 – Impact of Standards and Migration Planning
- P06 – International Activities on Future Electricity Networks
- P07 – Stakeholder Liaison

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Future Networks Architecture Project – P02

- The aim of the project:
- To propose network architecture solutions that would most efficiently meet the broad capacity estimates developed by the DWG PG1 – P01 project.

- An early, brief, personal interpretation of the key findings:
- Commercial and regulatory barriers may be more of a challenge than the technical barriers
- Many of the technologies required for future networks are available or in development, the application and deployment in legacy environments is an area which would benefit from greater research
- In order for future network architecture to be flexible enough to cope with any or a combination of scenarios, in a cost effective manner, a much greater emphasis on integrated solutions involving complete systems analysis and real-time interaction is considered important
- The traditional 'economics-based' network investment criteria (discounted cash flow etc.) will not support the development and application of suitable technologies unless there is a way of 'costing' more of the values that future network architectures are attempting to address

Some key points for consideration

In order to be useful scenarios need to be related to the current status

A clear objective of who/what is to be informed by the scenarios

They provide plausible outcomes but not accurate forecasts

There is a need to develop solutions which will cater for a variable range across multiple scenarios

How can the LENS project build on / coordinate with the HS group's work?

How can the LENS project best facilitate the appropriate economic, technical, environmental and cultural frameworks that will be required to meet the future challenges and timeframes?

How can the sustainable development of future network architectures be facilitated by this project?

ABB

Some insights into the future

- For example:
  - What impact will the transport sector have on networks of 2050?
    - Mobile generation from fuel cells in vehicles, large quantities of hybrid cars requiring charging, etc
  - What impact will European Networks, Offshore Grids, Energy Storage have in 2050?
  - The impact of demand side participation could require new and innovative trading and balancing in real time, this could be enabled by local power networks
  - Communications will be essential to the active networks and real-time optimisation and balancing of the entire system in 2050 – when and how will this be delivered?
  - Do we continue to implement tapered networks in the future considering the two-way power flows now being deployed?
  - Different skills will be needed to deliver networks of the future and to maintain the one we have
  - Etc, etc…..

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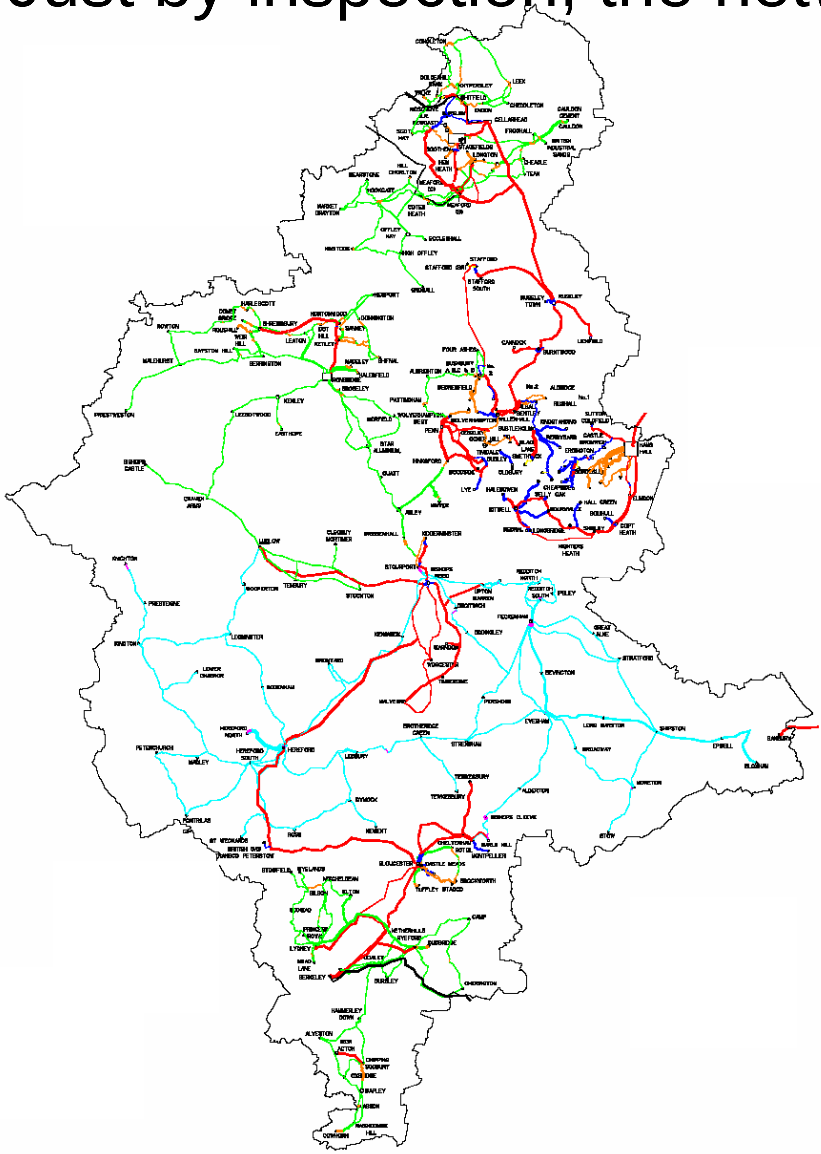
Developing Future Scenarios

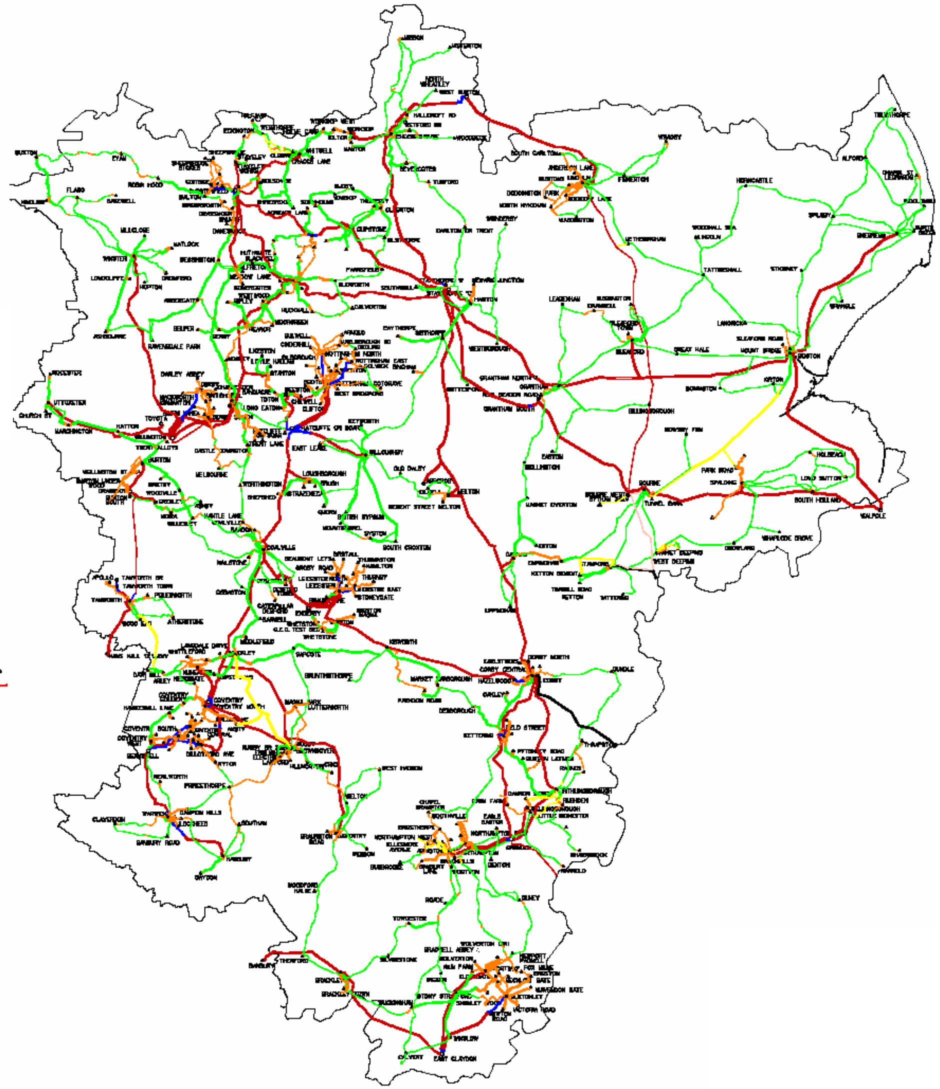
Jonathan Ashcroft

17 August 2007

e·on Central Networks

Just by inspection, the networks are visibly different





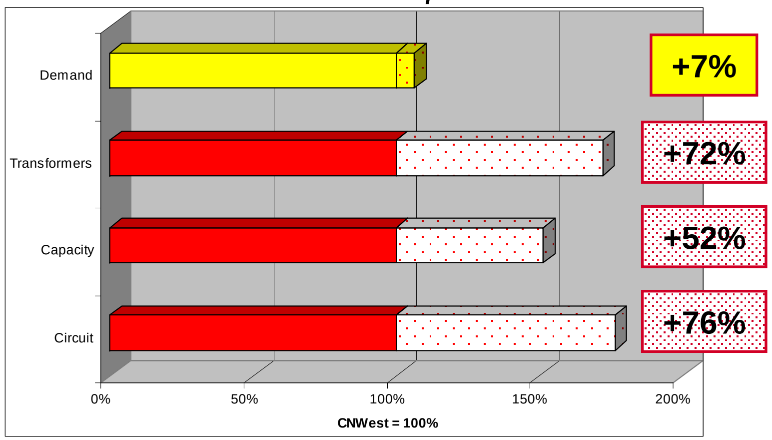
Current network characteristics, risks and issues

Network assets

- Connected customers in E & W are similar - 2.5M / 2.4M
- Both networks are P2/6 compliant
- Similar replacement spend profile based on asset condition
- But **East** has
  - 72% more primary transformers
  - 52% more primary capacity
  - 76% more primary circuit
  - 20% fewer customers / 11kv circuit

  i.e. **East has greater asset density and lower utilisation and is based on different design principles and standards**

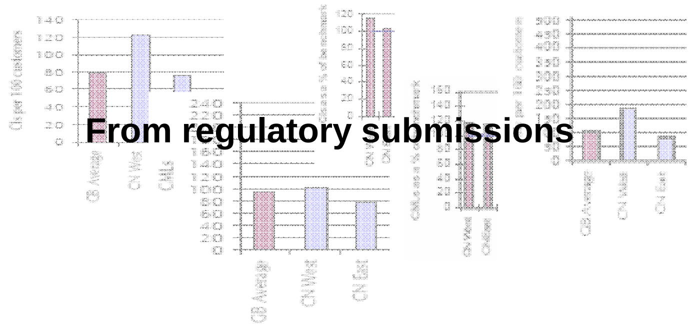
East network size compared with West



Network performance

West has up to

- 50% higher CI
- 25% higher CML
- 100% higher short interruptions
- 20% higher scale of fault impact



- *Should design principles for East and West converge?*
- *What are the appropriate design principles?*
- *Where should we apply them - new only or retrospectively?*

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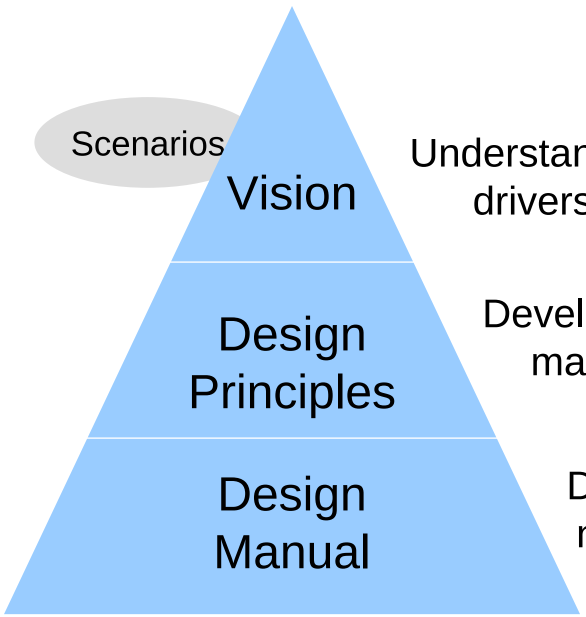
Developing a network design strategy

The network design strategy will

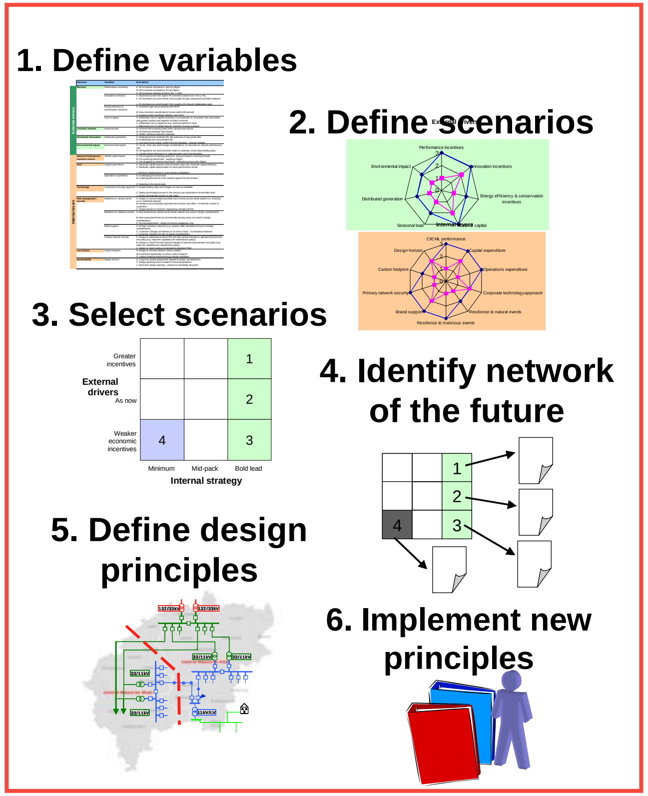
- deliver a set of design principles and rules (the manual) to maximise performance
- based on an understanding of the external drivers and responding internal strategies
- considering current conditions and future possibilities using scenario modelling



Understand effects of future external drivers and business strategy

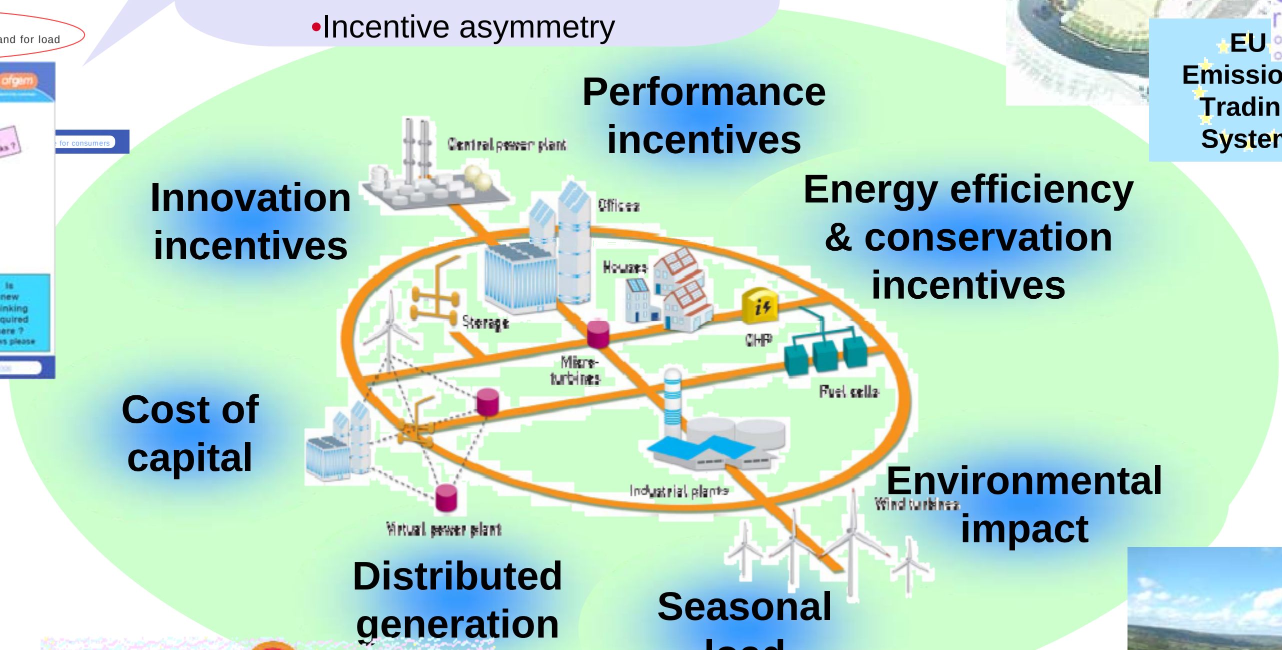
Develop design principles to maximise performance

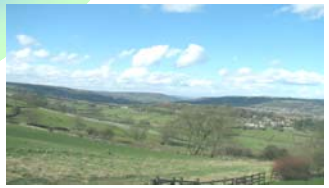
Define design rules for network planning and design



Emerging pressures driving potential future scenarios

- ‘Manage constraints’
- ‘Think Big’ – but be ready to justify
- Transmission Review Messages
  - Efficiency
  - Pay as you go for Load Related
  - Incentive asymmetry





Vision of the Network

Network Risk Prioritisation
•All risks understood and mitigated
•Design related to customer numbers / risks.
•Mitigation through hierarchy - configuration / automation / mobile generation
•No East / West rationale

Single Circuit Supplies
•High benefit – removed
•Medium risk – automation applied
•New design - exceptional

Flood Resilience
•Risk mitigated in accordance with predicted exposure – new and existing sites

Storm resilience
•Highest risk 10% of OH network fully resilient

Assets and Construction Standards
•International standards engagement
•Selective adoption

Remote Control and Automation
•Network wide
•Enhances base infrastructure performance e.g. 'second circuit outage'

Customers
•Key supplies protected >P2/6

Utilisation
•West migrating down to 66%.
•East migrating up to 66% - mitigating risk with automation

Malicious Acts
•Critical assets protected – hierarchy of measures based on risk

Distributed Generation
•DG incorporated at all voltages.
•DSO established.

Network Information
•Extensive for control, active networks, diagnostics, input to risk analysis

Second Circuit Outage
•High risk – removed
•Medium risk – automation applied
•New design – risk minimised
•New design – additional infrastructure where major risk during project build
•Extensive real time data / emergency cable ratings

Network Complexity
•Prioritised risk mitigation
•New design for operability

Losses
•Lifetime carbon content optimised
•Equal value to network performance

Seasonal Load
•Summer and winter loads / ratings applied

Central
Networks

Foresight Sustainable Energy Management & the Built Environment Project

Joanne Marsden

Long Term Electricity Network Scenarios (LENS)
Project Workshop
17 August 2007

Foresight's work

- Challenging visions of the future to ensure effective strategies now
- Science-based futures expertise, bringing together leaders in government, science and business

- Foresight is **not** about…

- Predicting the future
- Forecasting the future

Project outputs include:

- Reviews of cutting edge knowledge in relevant disciplines.

- **Visions of possible futures underpinned by a robust understanding of the key drivers.**

- Consequential actions owned by those capable of implementing them.

- Enduring networks to continue dialogue as the issues evolve.

Project aim

- To explore how the UK built environment could evolve to help manage the transition over the next five decades to secure, sustainable, low carbon energy systems that meet the needs of society, the requirements of the economy, and the expectations of individuals.

Project futures approach

- Developing scenarios to explore future uncertainties
- State of science reviews advances to inform the scenario development
- Technology road mapping activity to inform the scenario development

Transmission Scenarios

Andrew Hiorns, Strategy Review Manager
Electricity Network Investment
National Grid

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Transmission – Blue Print for the Future

Background

- 2020 government targets – Transmission system can facilitate progress.

- Scope of Study

- Utilise a number of scenarios.
- Identify range of future transmission requirements.
- Identify barriers to delivery of infrastructure required.
- Ensure short / medium term developments are
- consistent with long-term objectives.
- Develop a strategy to overcome barriers in a timely manner; a road map to the "right" transmission network.
- Review of standards and technologies required to accommodate.

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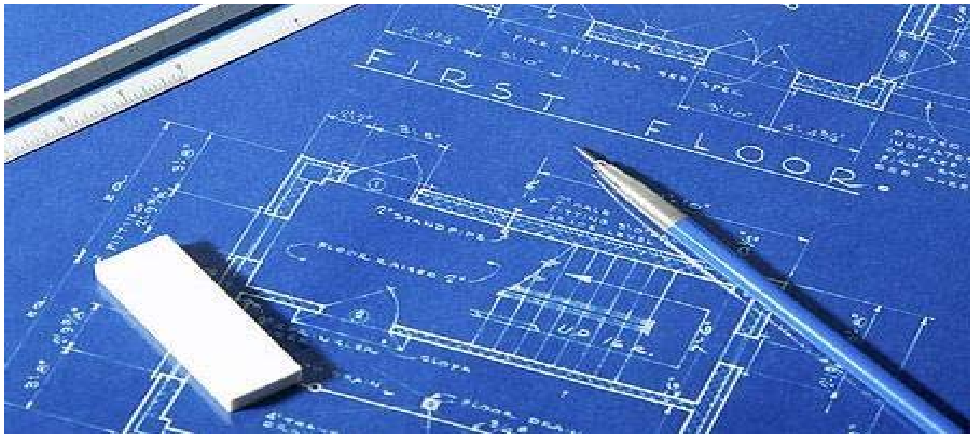
Why Scenario Planning?

- Plans implicitly based on key assumptions.
- Business model contingent on key events.
- Make the plan less “future – sensitive”.
- Ensure transmission system is equipped to perform under most viable long term scenarios.
- Not trying to *predict* the future.



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7 Key Uncertainties Facing Transmission

1. Environmental impact of the business and our operations.
2. The mixture of energy sources.
3. The proximity of supply to demand.
4. Consumer behaviors.
5. Growth in emerging markets.
6. Changing availability of resources.
7. Degree and nature of Government control.

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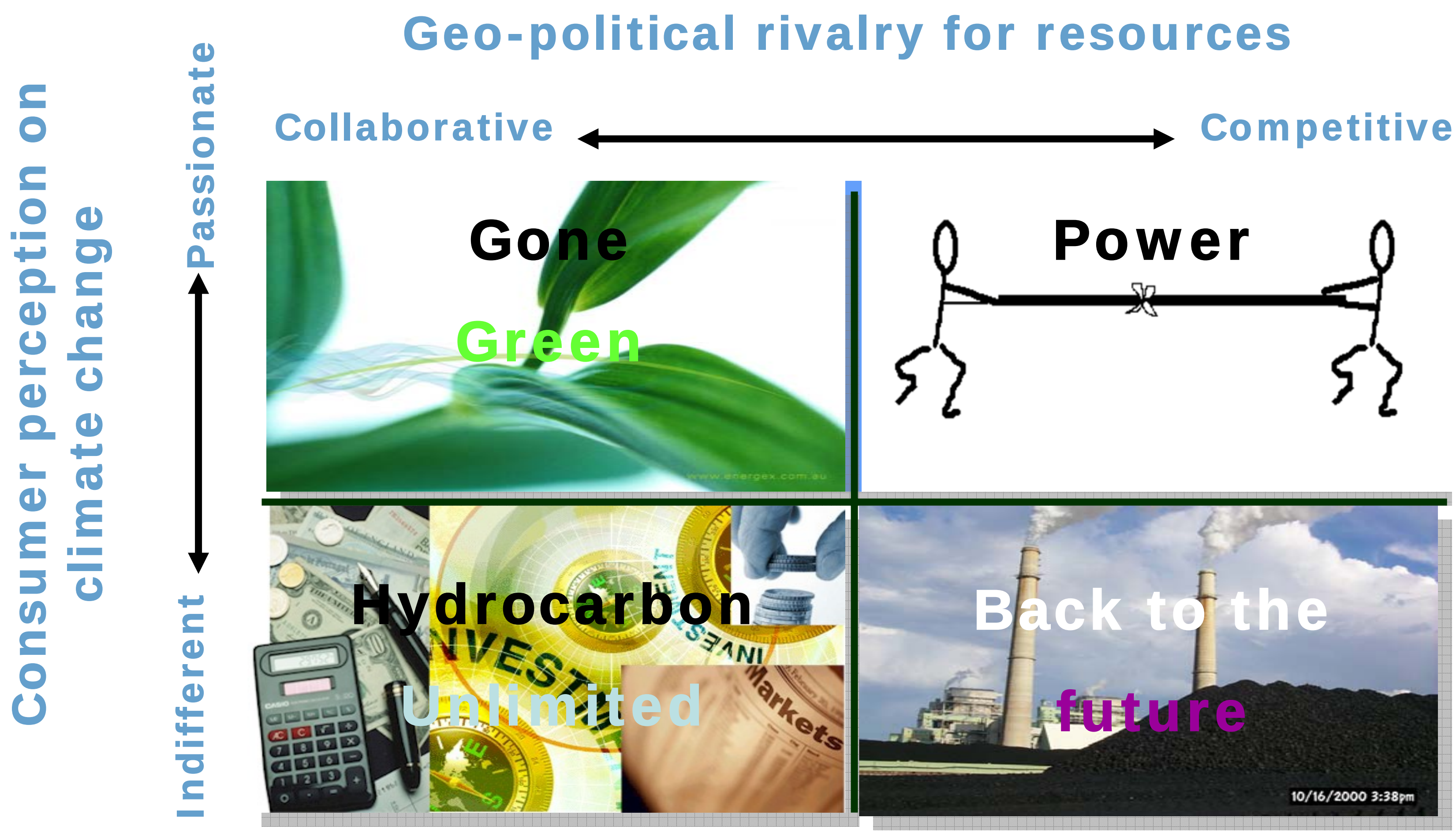
Plausible Futures



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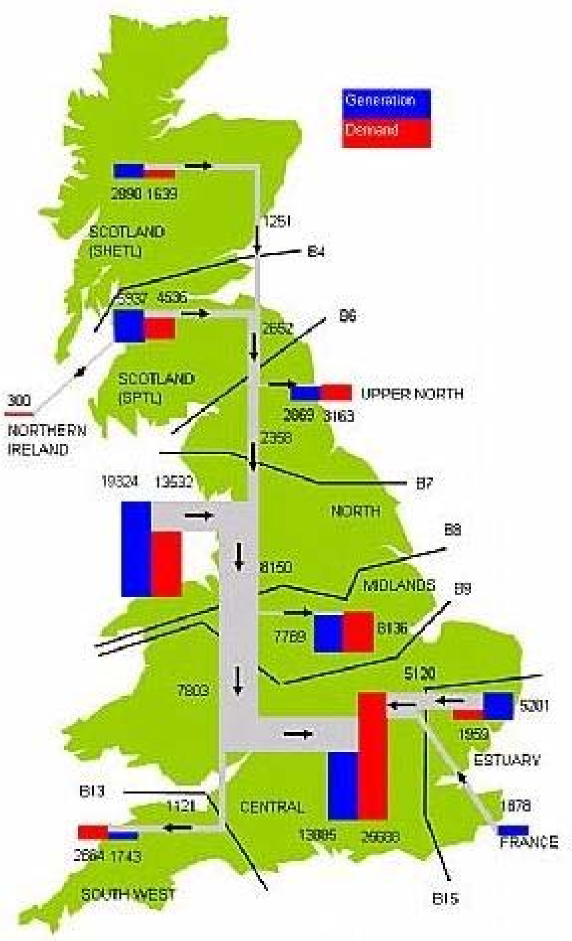
Why Do We Need Scenarios?



- Review appropriate standards and technologies available to accommodate these scenarios.
- Review commercial arrangements to ensure consistency with developing transmission capacity.
- Provide valuable support to long term asset replacement proposals.
- Model the transmission system to identify key areas requiring reinforcement.

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Summary

- National Grid recognise the challenges in meeting 2020 targets, and wish work with the industry in meeting these targets.
- Need to develop a long term strategy consistent with our short term plan to align transmission developments against.
- Complex task - future still very uncertain.
- Group established to review impact of scenarios.
- Transmission can facilitate these targets.

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Questions / Discussion

ofgem Promoting choice and value
for all gas and electricity customers

Introduction to breakout sessions

Robert Hull
Director, Transmission
Ofgem

Aims for the afternoon

- We have established 3 breakout groups. Each has a list of issues to help facilitate the discussions with each group.
- Groups have 1 hour to identify the top ten points;
- Feedback session will report on the key points and findings ;

Feedback from breakout sessions

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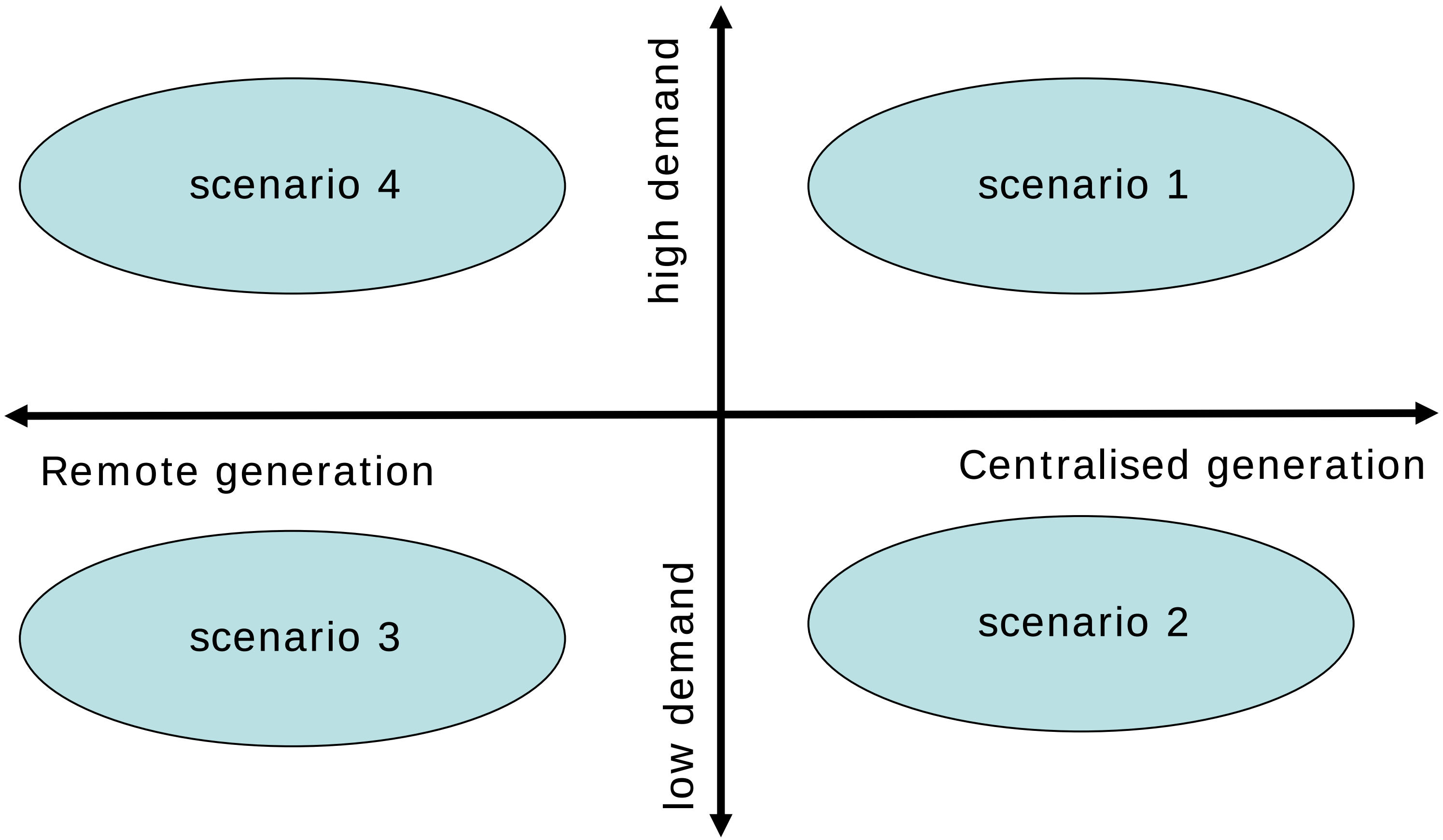
Closing Remarks

Robert Hull
Director, Transmission
Ofgem

Capturing key network drivers



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Promoting choice and value

for all gas and electricity customers