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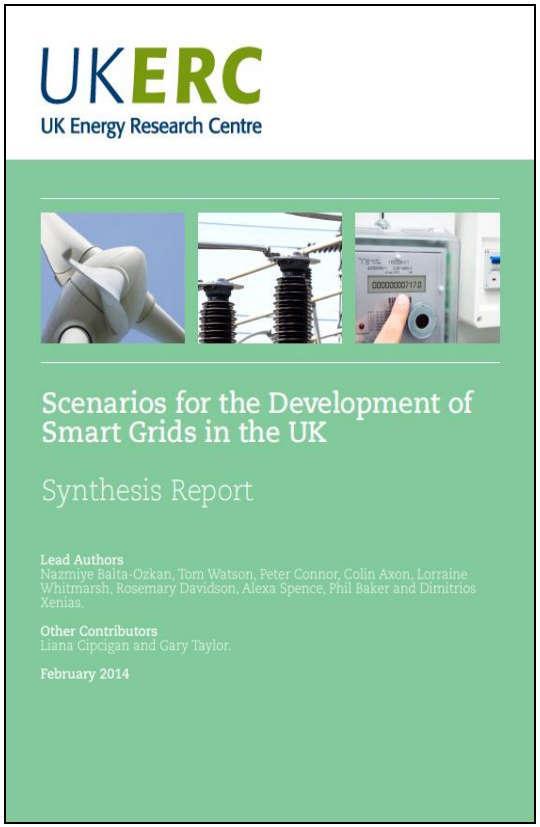

Envisioning Smarter Power Futures: UK Smart Grid Scenarios

Dr Peter Connor

18th September 2014

UKERC

University of Exeter

Outline

Context
Expert interviews
Online surveys
Expert workshop
Smart grid scenarios
Key messages

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Smart grids

- Contributions to UK energy and climate change policy goals
- Smart grids apply innovative technologies
  - Better planning & management
  - Actively manage supply & demand
  - New energy services
- Smart grids include many technological and non-technological options

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Need for smart grid scenarios

- Scenarios a framework to inform decision-making
- Scenarios are **NOT** predictive in any way
- A variety of approaches
- Our scenarios are
  - System perspective; socio-technical
  - Branching points rather than mere end points
  - Build on existing scenarios
- Our scenarios are not
  - Costed pathways
  - Technology roadmaps

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Objectives

1. Identify key steps likely to determine the future shape of smart grids at the upstream level and end user level; and
2. Develop a range of socio-technical smart grid scenarios, paying particular attention to:
    a) critical transition points within each scenario
    b) social and spatial differences within the UK energy system

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Research process

Extensive stakeholder involvement

- Identify

Step 1

Step 4

- Develop scenario pathways

Step 3

- Develop

- Analyse scenario building blocks

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Expert interviews: findings

- Predictability and uncertainty
- Planning and investment by DNOs
- Co-ordination
- Local grid issues
- Smart meter rollout
- Consumer engagement
- Skills shortages

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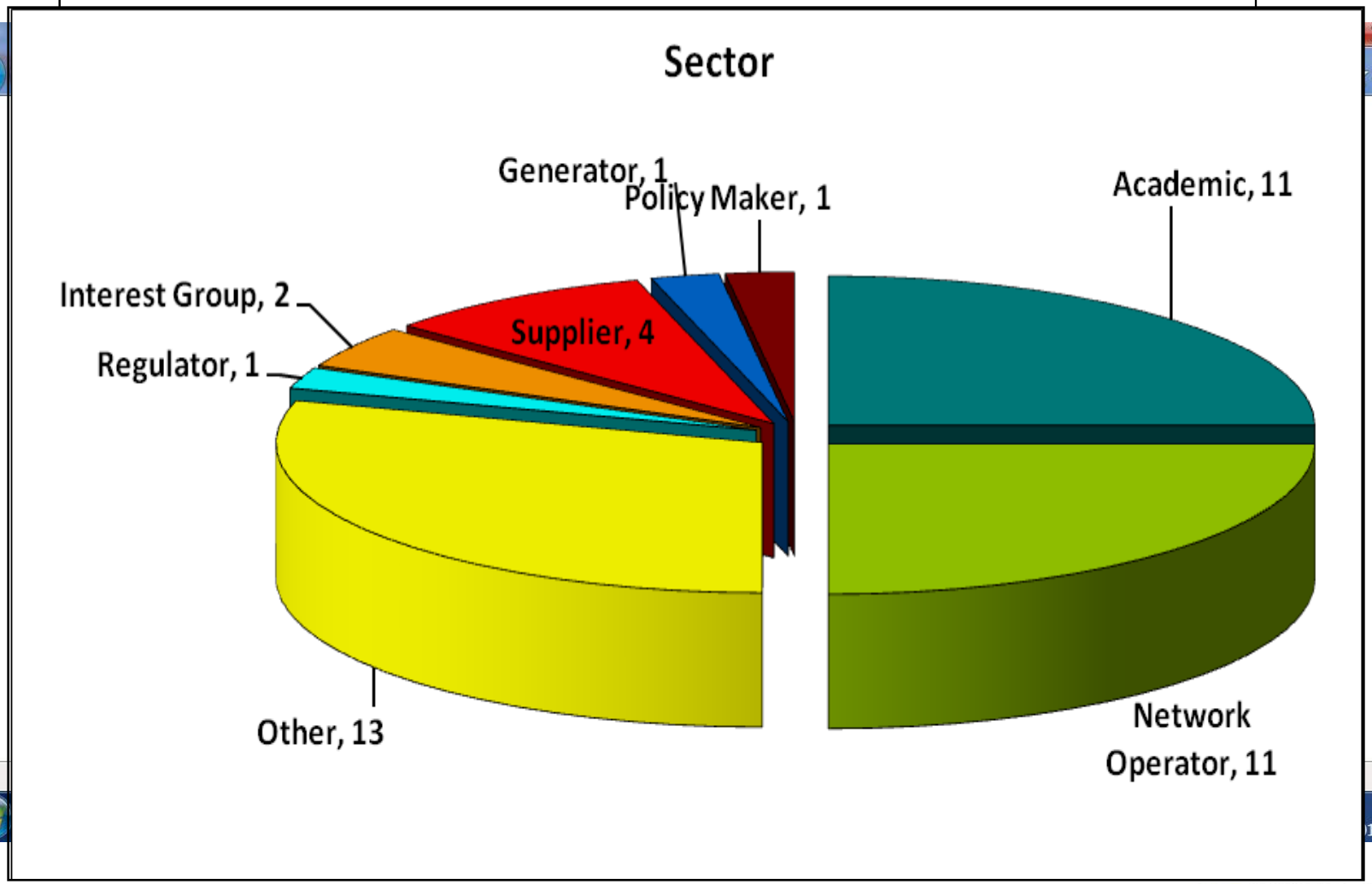
Online surveys



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Online surveys: findings

Top-cited benefits of smart grids	% of experts
Cost reduction in different levels of the system	39
Improved efficiency in generation, delivery and use of assets	39
Facilitation of renewable energy sources of electricity	24
Emissions reductions	24

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Online surveys: findings

Top-cited pitfalls of smart grids	% of experts
Costs or lacking/risky investment	42
Disengaged or uncooperative customers	27
Complexity or difficult-to-manage solutions	21
Data protection/privacy concerns	18

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Online surveys: findings

Smart grid essential functions	% of experts
Balancing a power grid with lots of RE	82
Increasing observability & controllability of the power grid	75
Enabling deployment of DSR technologies	74
Enabling active network management	73
Allowing integration of active loads	71
Facilitating energy storage	12

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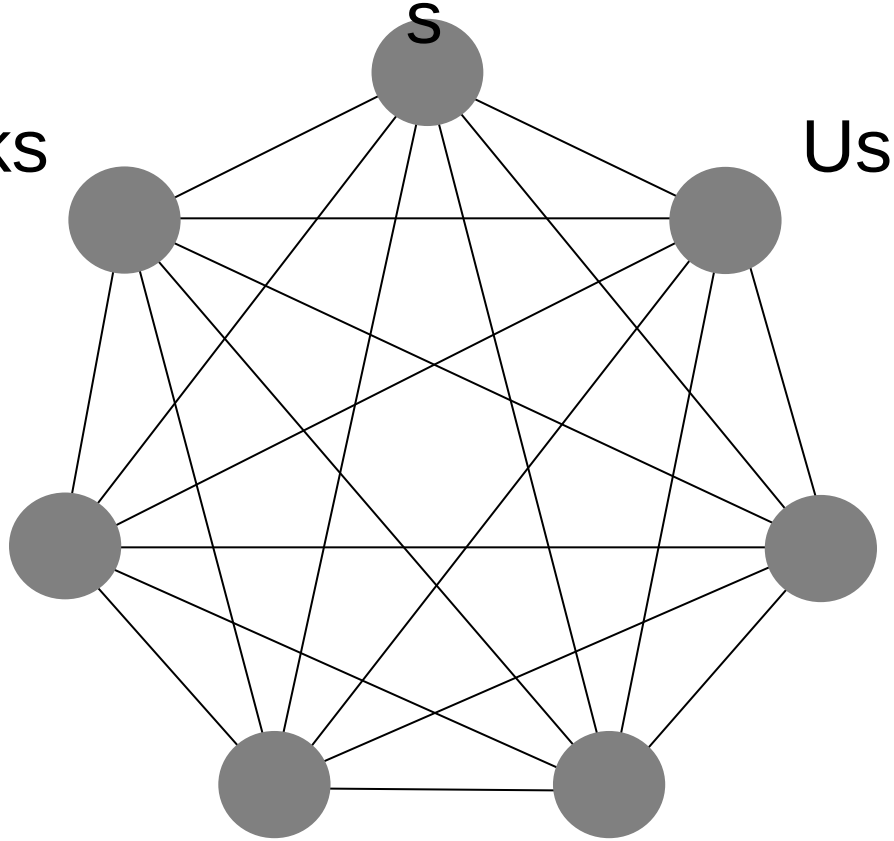
Scenario construction process



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Expert workshop: May 2013

- Test the endpoints of the scenarios as well as trajectories
- Add depth and timelines to the scenarios
- Some highlights:
  - Grid-scale storage deployment [2-17 years]
  - Consumers become active quite late
  - Regulation key role

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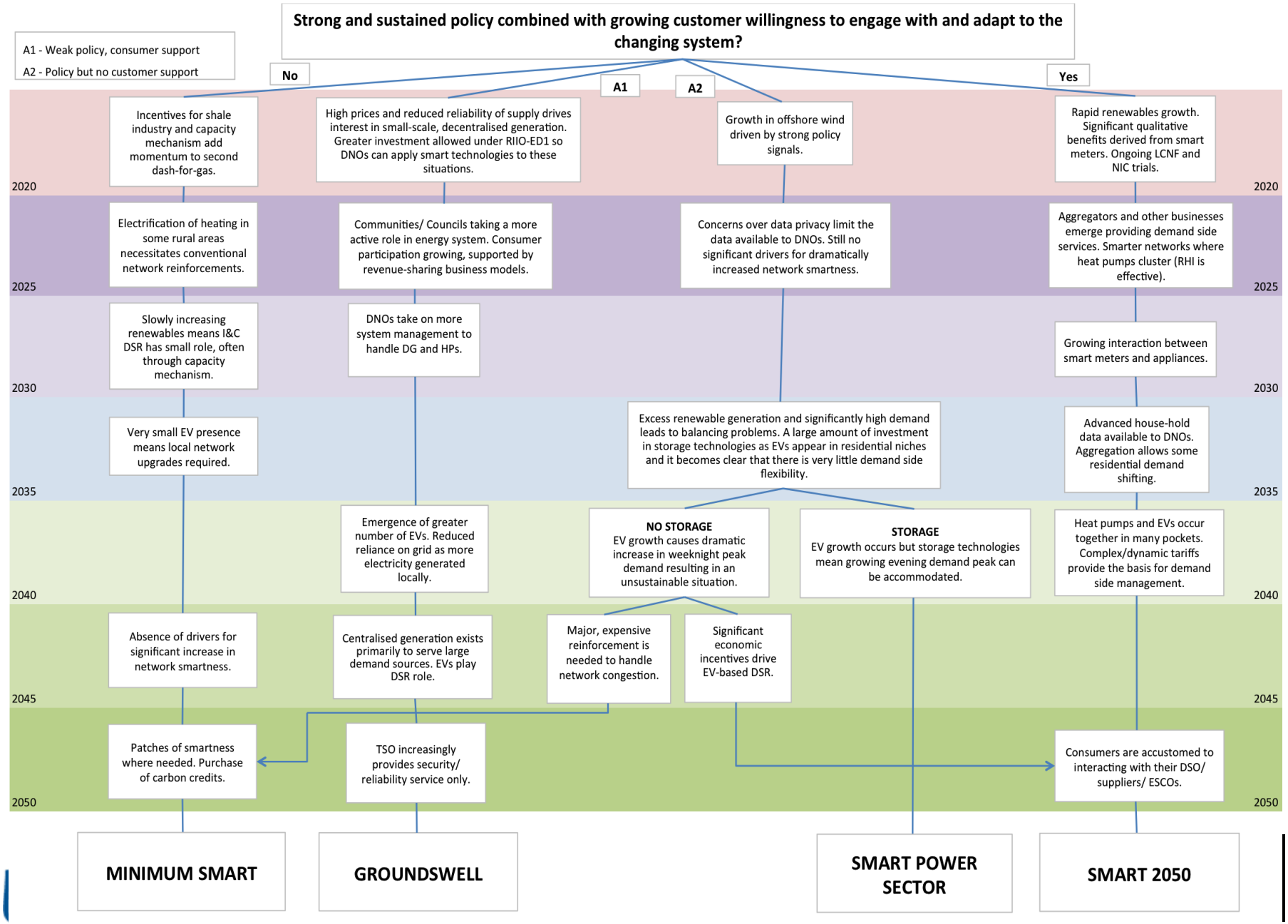
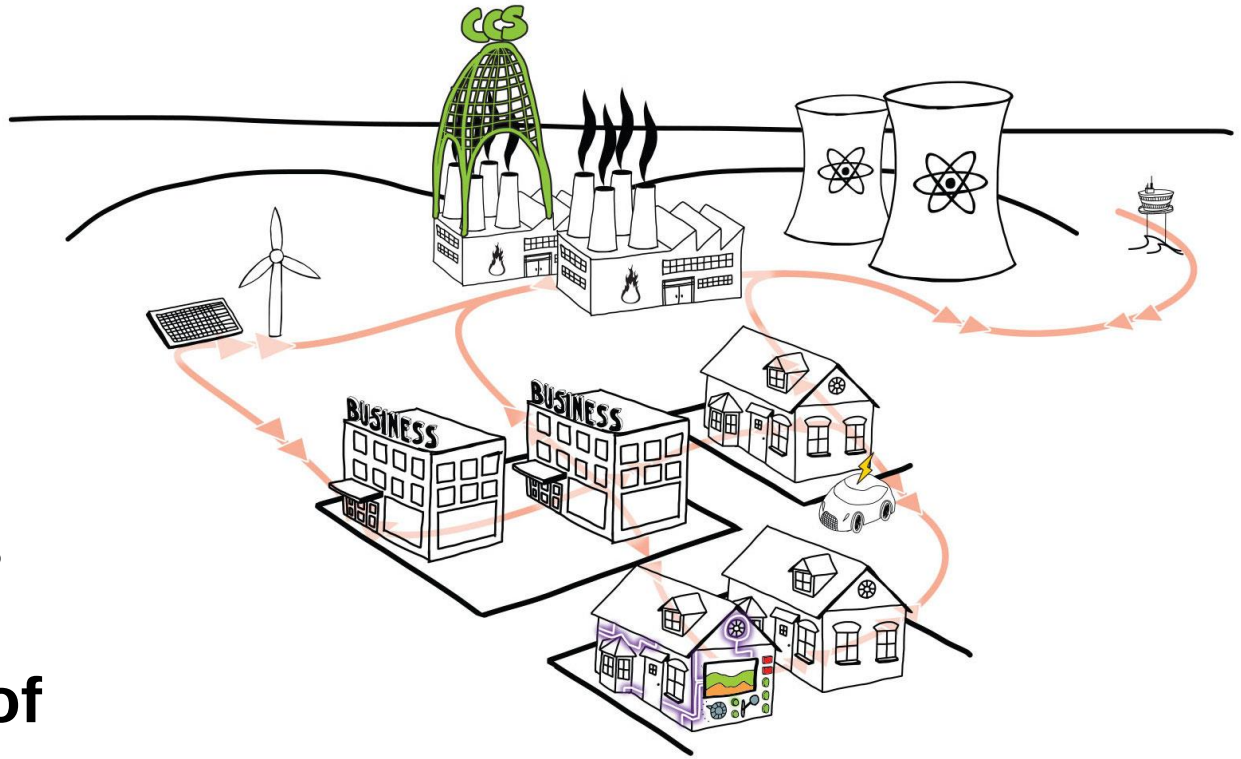

Strong and sustained policy combined with growing customer willingness to engage with and adapt to the changing system?
A1 - Weak policy, consumer support
A2 - Policy but no customer support
No
A1
A2
Yes
2020
2025
2030
2035
2040
2045
2050
Incentives for shale industry and capacity mechanism add momentum to second dash-for-gas.
High prices and reduced reliability of supply drives interest in small-scale, decentralised generation. Greater investment allowed under RIIO-ED1 so DNOs can apply smart technologies to these situations.
Growth in offshore wind driven by strong policy signals.
Rapid renewables growth. Significant qualitative benefits derived from smart meters. Ongoing LCNF and NIC trials.
Electrification of heating in some rural areas necessitates conventional network reinforcements.
Communities/ Councils taking a more active role in energy system. Consumer participation growing, supported by revenue-sharing business models.
Concerns over data privacy limit the data available to DNOs. Still no significant drivers for dramatically increased network smartness.
Aggregators and other businesses emerge providing demand side services. Smarter networks where heat pumps cluster (RHI is effective).
Slowly increasing renewables means I&C DSR has small role, often through capacity mechanism.
DNOs take on more system management to handle DG and HPs.
Growing interaction between smart meters and appliances.
Very small EV presence means local network upgrades required.
Excess renewable generation and significantly high demand leads to balancing problems. A large amount of investment in storage technologies as EVs appear in residential niches and it becomes clear that there is very little demand side flexibility.
Advanced house-hold data available to DNOs. Aggregation allows some residential demand shifting.
Emergence of greater number of EVs. Reduced reliance on grid as more electricity generated locally.
NO STORAGE
EV growth causes dramatic increase in weeknight peak demand resulting in an unsustainable situation.
STORAGE
EV growth occurs but storage technologies mean growing evening demand peak can be accommodated.
Heat pumps and EVs occur together in many pockets. Complex/dynamic tariffs provide the basis for demand side management.
Absence of drivers for significant increase in network smartness.
Centralised generation exists primarily to serve large demand sources. EVs play DSR role.
Major, expensive reinforcement is needed to handle network congestion.
Significant economic incentives drive EV-based DSR.
Patches of smartness where needed. Purchase of carbon credits.
TSO increasingly provides security/ reliability service only.
Consumers are accustomed to interacting with their DSO/ suppliers/ ESCOs.
MINIMUM SMART
GROUNDSWELL
SMART POWER SECTOR
SMART 2050

1. Minimum Smart

- **The defining theme in this scenario is a lack of drivers that push the development of a smart grid.**



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Minimum Smart (to 2030)

- Tensions exist between environmental and economic goals
- National smart meter programme is badly organised and negatively perceived by the general public. Trust in energy suppliers remains low
- Capacity concerns and the absence of a global climate deal spurs on growth of gas generation
- There is little need for demand side flexibility with large amounts of gas generation

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Minimum Smart (2030-2050)

- Smart technologies, on both demand and supply side, largely remain niche technologies
- Increasing the capacity of local transformers is generally sufficient to handle localised increases in power demand
- Gas as ‘bridging fuel’ has left a legacy of plants that are expensive to close so the UK attempts to meet climate obligations by buying increasingly expensive carbon permits.
- The distribution networks are largely similar to today

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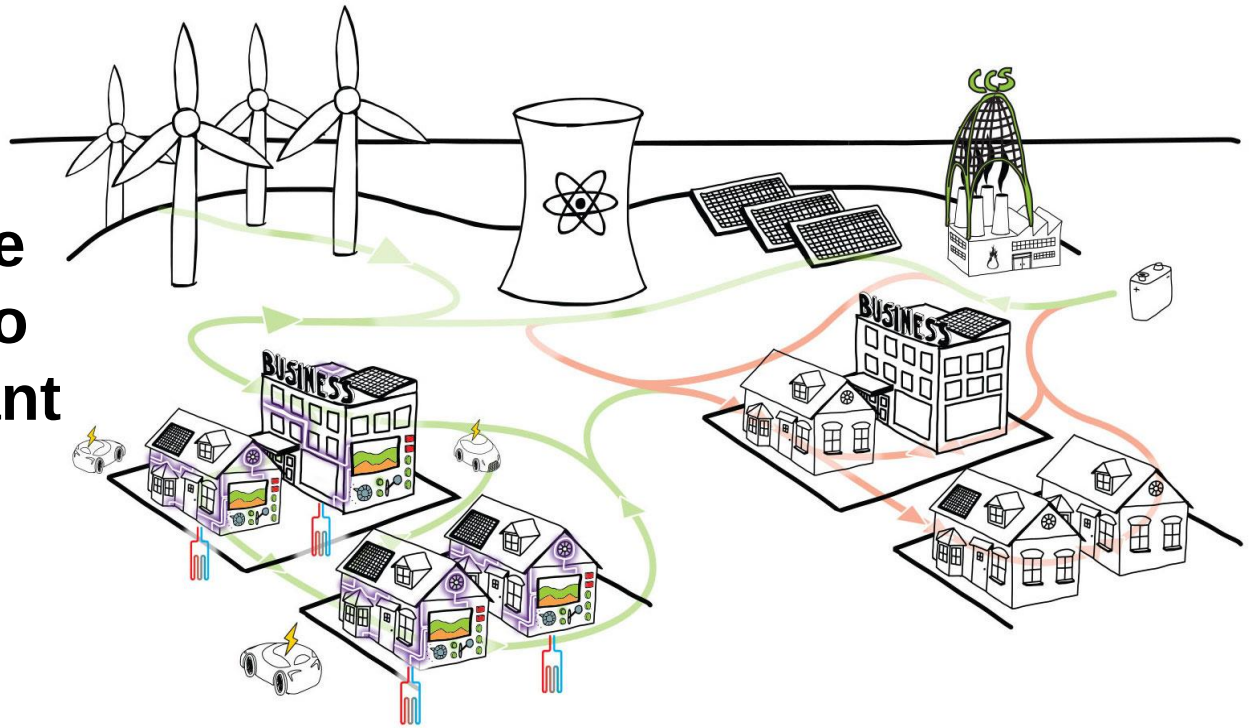
2. Groundswell

- **The key feature of this scenario is the significant public engagement with energy issues.**



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Groundswell (to 2030)

- Declining capacity margin, rising prices and effective smart meter rollout prompt interest in energy savings
- Well-designed regulatory framework encourages network investment in innovation (move to DSOs)
- Local authorities can play greater role; some partner with businesses; benefits flow to local communities
- Biomass CHP, PV on social housing and whole-block renewable heating all much more common
- Rapid growth of alternative tariffs and microgeneration

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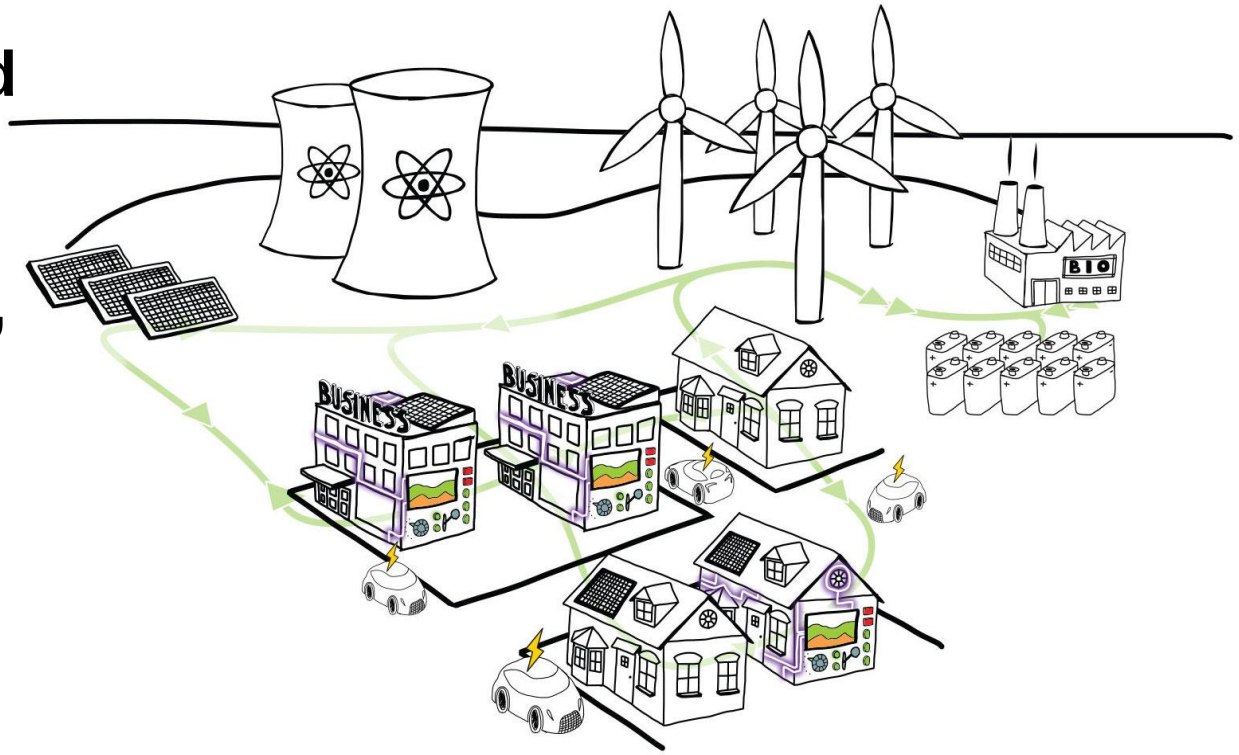
Groundswell (2030-2050)

- Rapid growth in small-scale generation and onset of demand management opportunities. Rural areas in particular generate a large amount of their own power
- EVs much more competitive and batteries can be used to smooth peaks; common in affluent suburbs
- DNOs control some smaller generators and so play a more active role in local balancing
- Mandatory CCS reduces flexibility although this is offset by strong integration with Europe
- Large-scale generation to meet needs of cities and industry; grid electricity acting as backup in areas

3. Smart Power Sector

- **Strong government-led commitment to energy and climate targets, although with consumer resistance to demand measures.**



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Smart Power Sector (to 2030)

- Negative press coverage of smart meters and data security fosters public scepticism and limits savings
- New nuclear but also large growth in offshore wind
- Some monitoring and control equipment appears in networks although in absence of microgeneration and large load increases it is not widespread
- Some EVs start to appear around 2030 as a charging infrastructure is developed

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Smart Power Sector (2030-2050)

- Very large amount of wind generation by mid-2030s although little demand side flexibility as consumer behaviour remains unresponsive
- Growth in demand from EVs leads to exacerbation of peaks, meaning flexiblility has greater system value
- Storage develops and although expensive it is the only way to meet very large evening peaks
- DNOs have to upgrade many local networks conventionally to handle greater residential demand but there is a large amount of network smartness where cost-effective, leading to notably smartness overall

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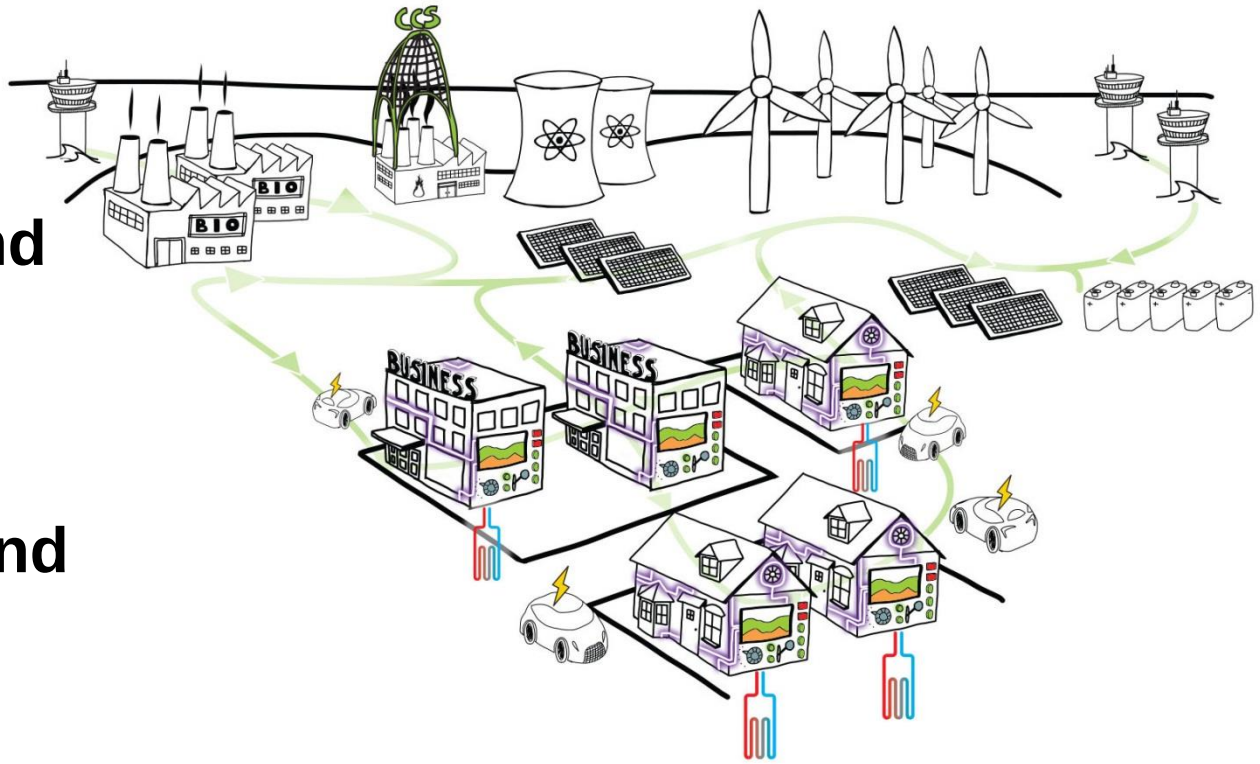
4. Smart 2050

- **Strong willingness and co-ordination between industry, the government and the public**.



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Smart 2050 (to 2030)

- International climate agreements drive decarbonisation
- Smart meter rollout successful and market entrants provide a range of new services (e.g. apps)
- Clear long-term policy supports renewables growth
- More engaged consumers lead a trend towards advanced consumer technology (e.g. in-home displays)
- Regulatory changes give DNOs greater flexibility when investing beyond RIIO-ED1; growing and heat pumps adoption drives network smartness

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Smart 2050 (2030-2050)

- Long-distance transmission across Europe acts to provide a flexible supply source as renewables continue to grow in the UK
- Adoption of air- and ground-source heat pumps in areas with EVs leads to new technologies and tariffs to reduce peakiness and spread load more evenly
- DNOs (or third parties) can access near-to-real-time data to assist with this, and communicate directly with customers to maximise benefits of demand flexibility
- Aggregators and energy service companies play a significant role in the residential market

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1. There is a need to develop ways of measuring progress
2. Equitable outcomes
3. Building trust
4. Benefits need to be clear
5. Manage risk, innovation and investment
6. Need to identify no-regrets solutions

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