Transition Pathways for a Low Carbon Electricity System in the UK

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Outline

- Outline of ‘Transition Pathways’ project
- Applying the multi-level transitions perspective
- Exploring transition pathways with different governance patterns and roles of actors
- Outline transition pathways to a low carbon energy system in the UK
- Analysing and exploring the pathways
- Branching points

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‘Transition pathways’ project

- ‘Transition pathways to a low carbon economy’
  - Universities of Bath, Cardiff, East Anglia, Imperial College, Leeds, Loughborough, Strathclyde, Surrey and UCL
  - Funded by EPSRC and E.On UK (May 2008 – April 2012)
- Research challenges:
  - To learn from *past transitions* to help explore future transitions;
  - To design and evaluate *transition pathways* towards alternative socio-technical energy systems for a low carbon future; and
  - To understand the changing roles, influences and opportunities of *large and small ‘actors’* in the dynamics of energy transitions
- Key aims:
  - Select, develop and analyse a set of *potential transition pathways* for the UK energy system to a low carbon future, and
  - Undertake *integrated assessments* of the technical and economic feasibility and social and environmental potential and acceptability of these pathways

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TRANSITION PATHWAYS

Project methodology

- Write outline transition pathway narratives (version 1.1)
  - Review of UK and international energy scenarios
  - Stakeholder workshops (policy, business, NGOs)
  - Interviews with energy system ‘gatekeepers’
- Initial quantification of pathways
  - Demand implications
  - Supply mix implications
- Explore and interrogate pathways
  - Technical feasibility, e.g. electricity grid enhancements
  - Social acceptability, e.g. smart meter trials
  - Whole systems appraisal, e.g. life cycle carbon emissions
- Iterate pathways (Version 2.1)
  - Based on analysis and ongoing policy developments

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Transition pathways approach

- Developing and analysing transition pathways (socio-technical scenarios) for a UK low carbon electricity system
- Co-evolution of technologies, institutions, firms' strategies and user practices
- Examining how pathways are shaped by the actions of a range of actors
  - including policymakers, incumbent market firms and new entrants, consumers and civil society actors
- Combining quantitative (e.g. generation and infrastructure requirements) and qualitative analysis (roles of actors)
- Identifying potential branching points

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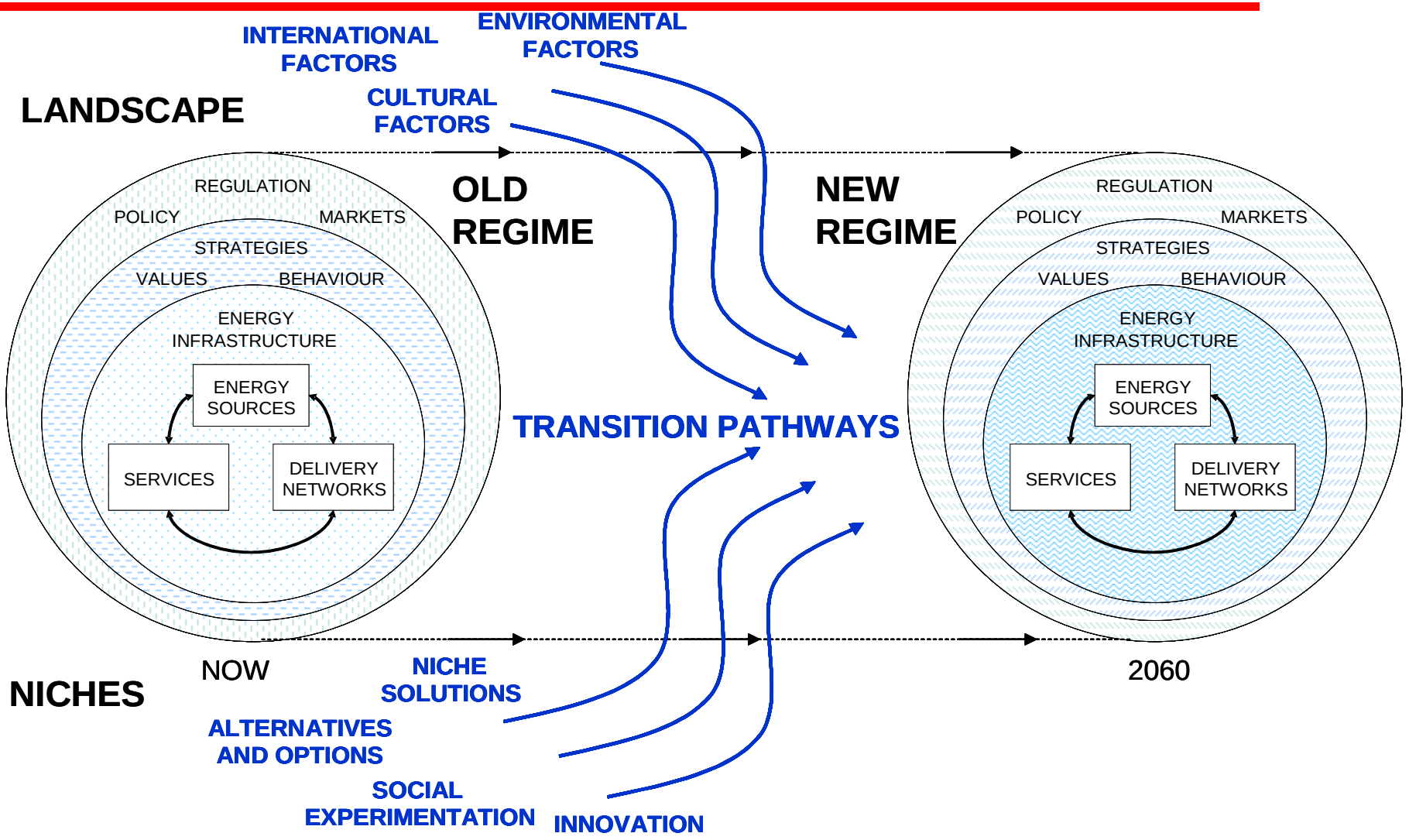
Multi-level perspective for transition pathways



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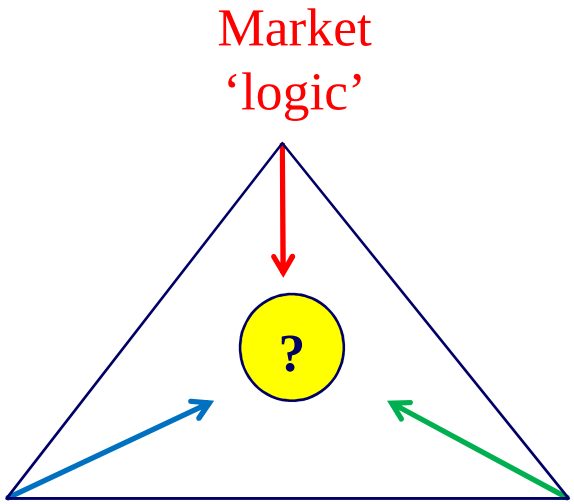
Insights from Past Transitions

- Scoping studies explored previous UK transitions and the insights for low carbon transitions
  - 1960s scale-up and roll-out of electric power plant by CEGB and industrial partners
  - 1960s transition/conversion from town gas to natural gas
  - C19 & C20: how gas and electricity industries sought to shape, stimulate and later re-mould and moderate energy uses
  - Why incumbents matter: end-C19 response of gas industry to the threat of competition from electric light (the *Sailing Ship Effect/ Last Gasp Effect*)
  - Insights from the Industrial Revolution: roles of relative prices, incentives & conditions for innovation; inertia, path dependency & lock-in; influence of General Purpose Technologies

The Action-Space Approach to Governance - 3 Key Actor Groups: Market, Government, Civil Society



Source: Jacquie Burgess & Tom Hargreaves – Transition Pathways Project

- Differing actor representations of others
- Choices depend on actors' competing 'logics' : messy, dynamic, interactive
- The action-space maps shifting relationships between actors
- Each actor's perspective *simplifies* that of other actors
- Via their *interactions,* each actor tries to '*enrol*' the others
- The dominant actor – the best 'enroler' - defines that period's action- space
- With corresponding influence on the pathway & its branching points

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Initial analysis of gatekeeper interviews

- Representations of 'public' by different actors
  - Market actors see the public as 'more or less rational consumers, sometimes in need of education to help them make rational energy management decisions'
  - Government actors see the public as both consumers and citizens
  - Civil society actors see the public as a complex and varied group, with multiple roles and identities
- Representations of government by different actors
  - Market actors see government as 'incompetent', so should set strong policy framework, then get out of the way
  - Civil society actors see government as 'biased' towards industry
  - Government: change from 'invisible government' to 'need for stronger action, as markets alone won't deliver radical changes'
- Which representation gains wider credence could strongly influence which pathway is followed

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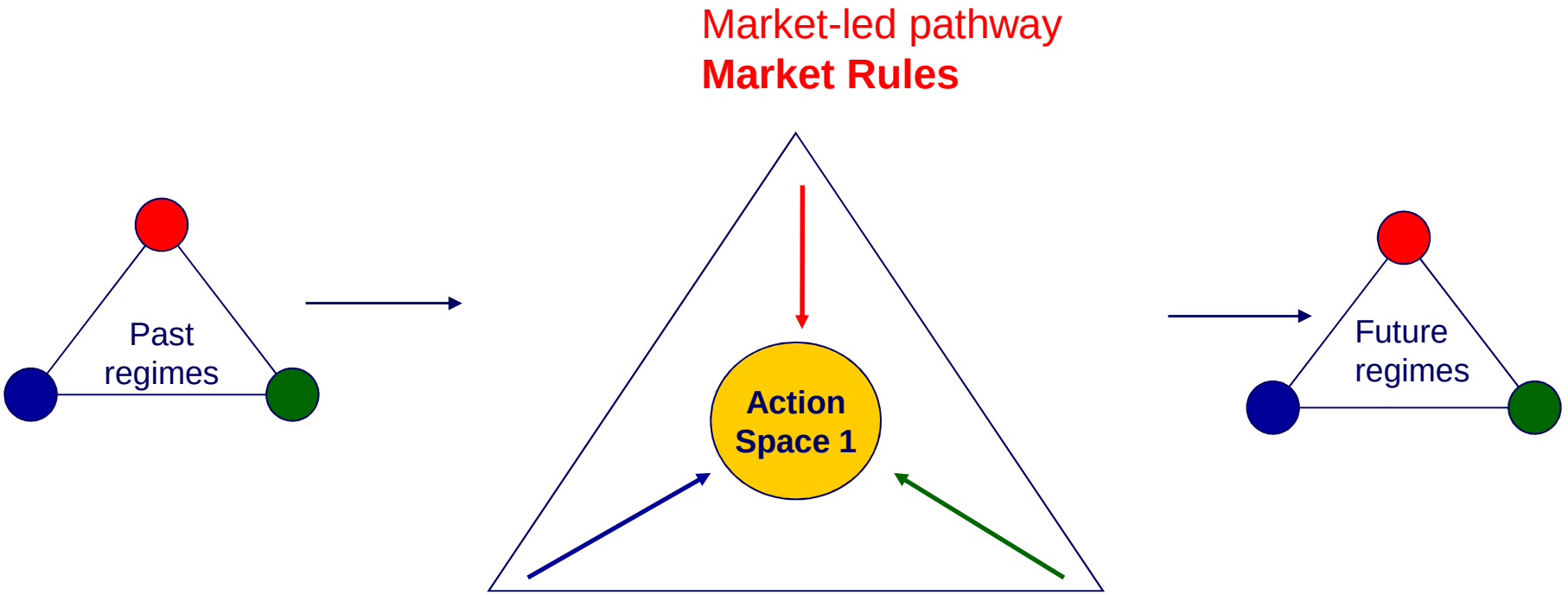
The Action Space for Transition Pathways



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TRANSITION PATHWAYS

Core transition pathways

1) ***Market Rules** v 1.1*:
   - Energy companies focus on large-scale technologies: nuclear power, offshore wind & capture-ready coal
   - Minimal interference in market arrangements
2) ***Central Co-ordination** v 1.1*:
   - Greater direct government involvement in governance of energy systems, e.g. issuing tenders for tranches of low-carbon generation
   - Focus on centralized generation technologies
3) ***Thousand Flowers** v1.1*:
   - More local, bottom-up diversity of solutions
   - Local leadership in decentralized options

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TRANSITION PATHWAYS

‘Thousand Flowers’ v 1.1: 2008-2012

- **1990-2008: Dominance of centralised systems**
  - Continued dominance of centralised systems for delivering electricity & gas
  - Small number of large firms, many part of international companies
  - Regulatory focus on ensuring competition & fair access
- **2008-2012: Pressures from landscape & niche levels**
  - UK Government leadership on addressing climate change
    - » UK Low Carbon Transition Plan published
    - » Feed-in tariffs introduced for small-scale renewable electricity & heat generation
  - Growing social movements for addressing climate change
    - » ‘10:10’ & successor campaigns achieve mass take-up
    - » Transition Towns movement demonstrates feasibility of small-scale solutions in many UK cities & towns

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TRANSITION PATHWAYS

‘Thousand Flowers’ v 1.1: 2013-2032

- **Climate change & energy security concerns lead to new drive for energy savings**
  - Changes to energy use habits & practices
  - Increasing obligations & demand for energy efficiency improvements leads to niche for energy service companies (ESCOs)
- **New focus on microgeneration**
  - ‘Virtuous cycles’ of change for decentralised options:
    - » entrepreneurial activities around a range of decentralized techs → advocacy coalitions of trade bodies & local NGOs → increasing legitimacy & further mobilisation of resources → investment in financial capital & skills & training
  - Further landscape pressures from natural disasters attributed to climate change & threats to gas supplies from Central Asia
  - Small number of technologies become ‘dominant designs’
  - Success of ESCO model with large number of smaller firms

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TRANSITION PATHWAYS

‘Thousand Flowers’ v 1.1: 2032-2050

- **Domestic & non-domestic microgeneration achieve high levels of adoption, meeting 50% of demand by 2050**
- **Greater ‘visibility’ of energy use through ‘smart meters’ & ‘smart users’ leads to changes in practices of energy use & stabilisation of overall electricity demand**
- **Centralized system becomes almost totally decarbonised**
  - but nuclear power & carbon capture & storage seen as expensive after costs escalated for initial new build & demonstration plants in late 2010s & early 2020s
- **Implications for technical & institutional design of centralized system**
  - Adoption of ‘smart grids’ & ‘virtual power plants’ to manage significant two-way power flows
  - Electricity trading arrangement re-designed, with new agreements for purchase of excess power from decentralized generation

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‘Market Rules’ v1.1 overview

Pathway aspect	Characteristics
Key technologies	**Coal and gas with carbon capture and storage (CCS); nuclear power; offshore wind**; onshore wind; imports; tidal barrage; wave and tidal power
Key concepts	Successful demonstration of CCS leads to high levels of deployment from 2020 onwards; **high carbon price makes CCS, nuclear and large-scale renewables economical to build**, and enables roll-out of retrofit of CCS to remaining coal and gas power stations; increasing electricity demand from heating and transport somewhat offset by technical efficiency improvements
Key actors	**Regime actors (large energy companies) dominate**; few new entrants
Key multi-level patterns	Landscape pressures (climate change and energy security) on regime actors leads to focus on carbon reduction and retrenchment around large-scale technologies; small-scale renewable technologies fail to emerge from niches
Key learning processes	Learning to achieve commercial deployment of CCS; **large energy companies see ‘high-electric’ future as a strategic business opportunity**, with increasing demand for electric heating and electric vehicles in a carbon-constrained world
Key infrastructure aspects	80% of generation still connected at high-voltage transmission level by 2050, with coal and gas CCS and new nuclear following siting of existing plants, and offshore wind concentrated around Scotland, implying need for high levels of transmission reinforcement

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TRANSITION PATHWAYS

‘Central Co-ordination’ v1.1 overview

Pathway aspect	**Characteristics**
Key technologies	**Coal and gas CCS; nuclear power; offshore wind**; onshore wind; tidal barrage; wave and tidal power.
Key concepts	Role of **Strategic Energy Agency** and use of **central contracts** to reduce the risks of low-carbon investment.
Key actors	Central government, through creation and direction of Strategic Energy Agency; large energy companies in delivery of large-scale low-carbon investment
Key multi-level patterns	Landscape pressures, particularly energy security concerns as well as climate change, lead to **greater role for central government, working closely with large energy companies**; niche-level activity focused on large-scale technologies, particularly offshore wind and CCS, with less focus on small-scale technologies
Key learning processes	Learning to achieve commercial deployment of CCS; co-operation but also tensions between government and large energy companies; increasing demand for electric heating and electric vehicles in a carbon-constrained world
Key infrastructure aspects	80% of generation still connected at high-voltage transmission level by 2050, with coal and gas CCS and new nuclear following siting of existing plants, and offshore wind concentrated around Scotland and in the North Sea, implying need for high levels of transmission reinforcement

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TRANSITION PATHWAYS

‘Thousand Flowers’ v1.1 overview

Pathway aspect	**Characteristics**
Key technologies	**Onshore wind; offshore wind; renewable CHP; solar PV**; imports; tidal barrage; wave and tidal power
Key concepts	**Move to ESCO business model**; **technological and behavioural changes lead to significant end-user demand reductions**; positive feedbacks lead to ‘virtuous cycles’ in deployment of small-scale distributed generation technologies; greater community ownership of generation, including onshore wind and biomass CHP.
Key actors	ESCOs (both new entrants and diversified existing energy companies); local communities; NGOs
Key multi-level patterns	Landscape pressures (climate change and energy security) on regime actors and government support for small-scale and community-level initiatives leads to focus on demand reduction and small-scale technologies; small-scale renewable technologies emerge from niches
Key learning processes	**Learning to achieve commercial deployment of range of distributed generation technologies**, with the emergence of a small number of ‘dominant designs’; large energy companies diversify into ESCO business model; focus on community-led renewable district heating schemes reduces the expected demand for electric heating, but rise in demand from electric vehicles
Key infrastructure aspects	50% distributed generation requires development of ‘smart grid’ technologies to handle two-way power flows; 50% still connected at high-voltage transmission level by 2050, dominated by high efficiency gas generation and offshore wind concentrated around Scotland and in the North Sea, implying need for significant levels of transmission reinforcement

Initial quantification of pathways

- Demand for electricity and fuels
  - Demand disaggregation by sector and end use
  - Greater detail on residential sector and on electricity uses
  - Annual demands along the 3 pathways
- Electricity supply characterisation
  - Generation mix, by pathway: capacity, output, capacity factors

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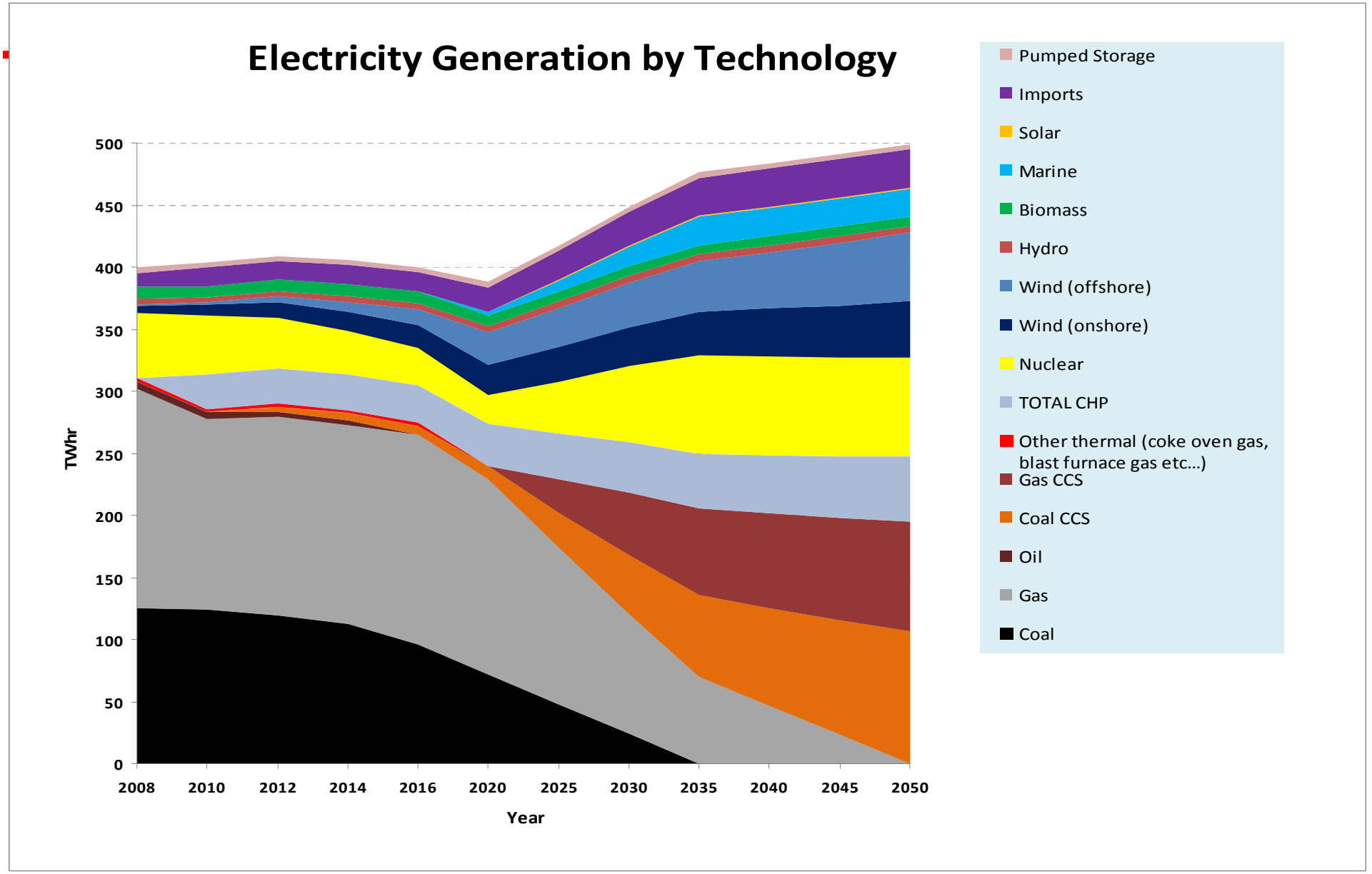
Electricity generation mix, 'Market Rules' v1.1



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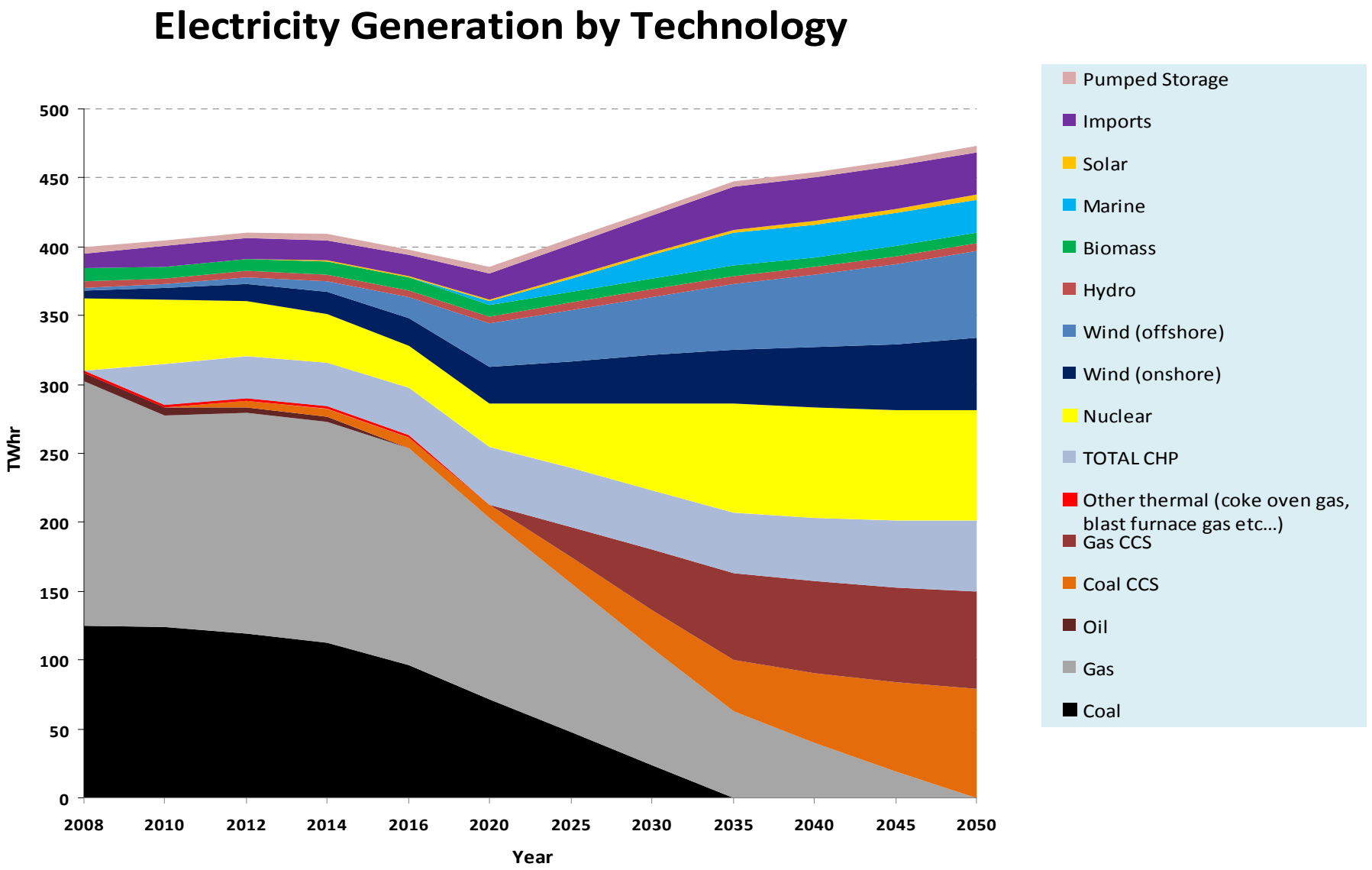
Electricity generation mix, 'Central Co-ordination' v1.1



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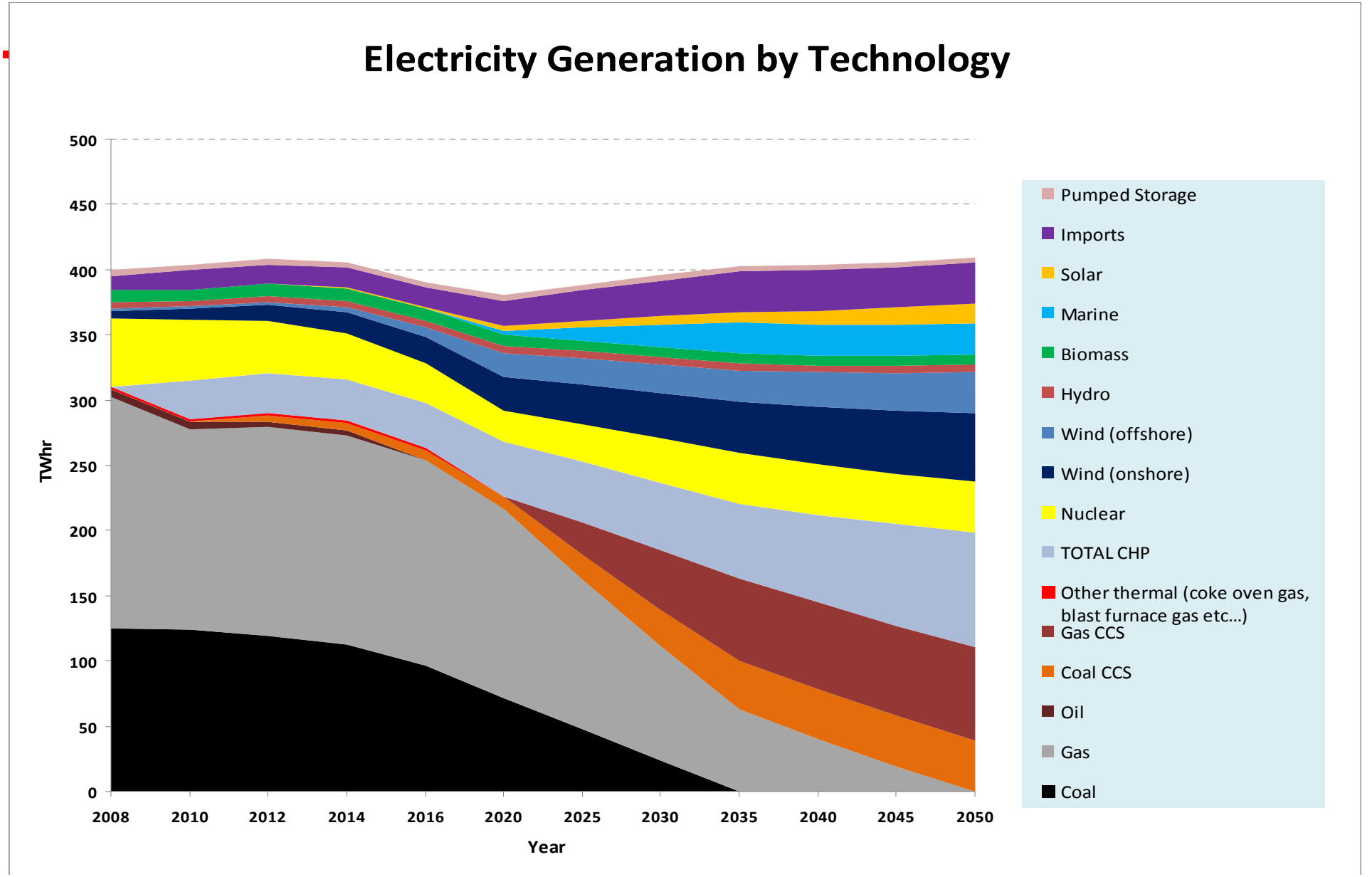
Electricity generation mix, 'Thousand Flowers' v 1.1



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TRANSITION PATHWAYS

The Visible Energy Trial

- **Aim:** exploring the potential of advanced real time displays (RTDs) to change domestic energy use.
- Partnership - UEA, Carbon Connections and Green Energy Options
- **The trial:** 282 households in East of England fitted with RTDs:
  - *Real-time data streaming, quarterly surveys, in-depth interviews*
- Initial findings:
- Social learning processes are negotiated in grounded *communities of practice* (i.e. households)
- Evidence of conflict and co-operation within households
- Negotiation and compromise around 'acceptable' energy use
- After a year or so, participants had formed understanding of their 'normal' usage and their necessary appliances, and would resist further measures to reduce energy use below this

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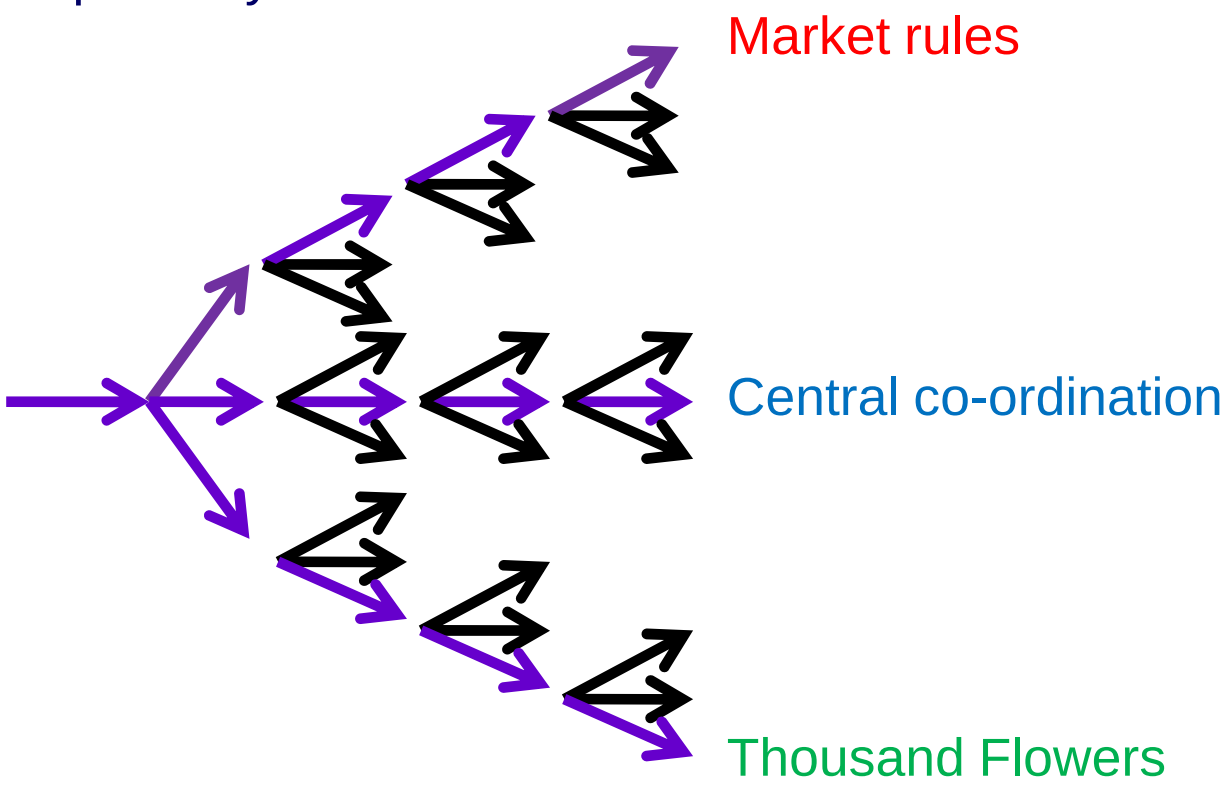
Branching point analysis

- Key points at which internal actions or external stresses lead to following or branching off a particular pathway
- Test pathway sensitivity, robustness & responses
- Explore branching points both generic to all three pathways, and specific to one pathway



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TRANSITION PATHWAYS

Classifying branching points

- Key technology fails to be technically/economically viable
- Governance framework fails to provide sufficient incentives for large investments needed
- Public acceptability of key technologies
- Competition between alternative governance models (e.g. households vs. local ESCos vs. big firm ESCos)
- Smart grids/smart meters change conditions for other technologies
- Acceptability and viability of local control
- Who controls the technology?

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TRANSITION PATHWAYS

Criteria for branching points

- Cost
  - Investment stimulated
  - Equity of costs
- Energy security
  - Technology delivery
  - Trust in energy companies and government
- Environmental and safety impacts
  - Carbon emissions
  - Local environmental and safety impacts
- Public engagement
  - Ability of actors to form advocacy/lobbying coalitions
  - Perception of risks and benefits
- Coherence of energy system
  - Coherence between different technologies
  - Coherence between different actors

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Value of 'Transition Pathways' analysis

- Specification and analysis of transition pathways and branching points could inform actions needed and consensus building for a shared vision
- Analysis shows implications of uncertainties, including
  - Future progress in different energy technologies
  - Role of ICTs to help facilitate change through a 'smart grid'
  - Role of changes in actors' habits, practices & wider social values
  - And how they might interact with techological change
- Shows pathways with different/shifting roles for government, market and civil society actors
  - how they might lead to alternative visions and realities of a low-carbon society

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- Nye, M, Whitmarsh, L and **Foxon, T J** (2010), 'Socio-psychological perspectives on the active roles of domestic actors in transition to a lower carbon electricity economy', *Environment and Planning A* **42**, pp. 697-714.
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- Special issue of *Energy Policy* planned for 2011.
- Further working papers and presentations available on project website: www.lowcarbonpathways.org.uk