Transition pathways for a low carbon energy system: demand-side and supply-side measures

Tim Foxon

European Round Table on Sustainable Consumption and Production (ERSCP) 2012

Bregenz, 2-4 May 2012

Institutionalisation of low carbon targets in UK

Climate Change Act (2008)

Set 80% carbon emissions reduction target by 2050 into law

Requires govt to set five-yearly carbon budgets, based on recommendations of expert Committee on Climate Change

Carbon budgets set: 2008-12, 2013-17, 2018-22, 2023-27

Equivalent to a 34% reduction by 2020, 50% reduction by 2025

Low Carbon Transition Plan (2009)

Low-carbon transition 'will be one of the defining issues of 21st Century' (Ed Miliband, Climate Change Secretary)

Target of 40% of electricity from low carbon sources by 2020

The Carbon Plan (2011)

'Rapid decarbonisation of electricity required in 2020s and 2030s'

Electricity Market Reform programme, including 'Feed-in Tariffs with Contracts for Difference' from 2014

Notable features of UK Carbon Plans

Led by the Government to reach a social goal, namely reducing carbon emissions to mitigate climate change

- Key role for business in providing innovation and investment to deliver ‘low-carbon solutions’
- Focus on technological solutions, mainly ‘front-of-pipe’ solutions, e.g. low-carbon electricity generation through large scale renewables and nuclear power, and ‘end-of-pipe’ solutions, e.g. carbon capture and storage
- Demand reduction based on regulatory incentives on firms and consumer choice, e.g. Green Deal

Little discussion of the role of civil society in bringing about a low-carbon transition, or

What are alternative visions of a low-carbon future?

Transition Pathways: Consortium & Aims

Interdisciplinary University Consortium

- Bath, Cardiff, East Anglia, Imperial College, Leeds, Loughborough, Strathclyde, Surrey, UCL
- Funded by EPSRC & E.On UK (May 2008 - April 2012)
- Follow-on 'Realising transition pathways' project funded by EPSRC (May 2013 – April 2017)

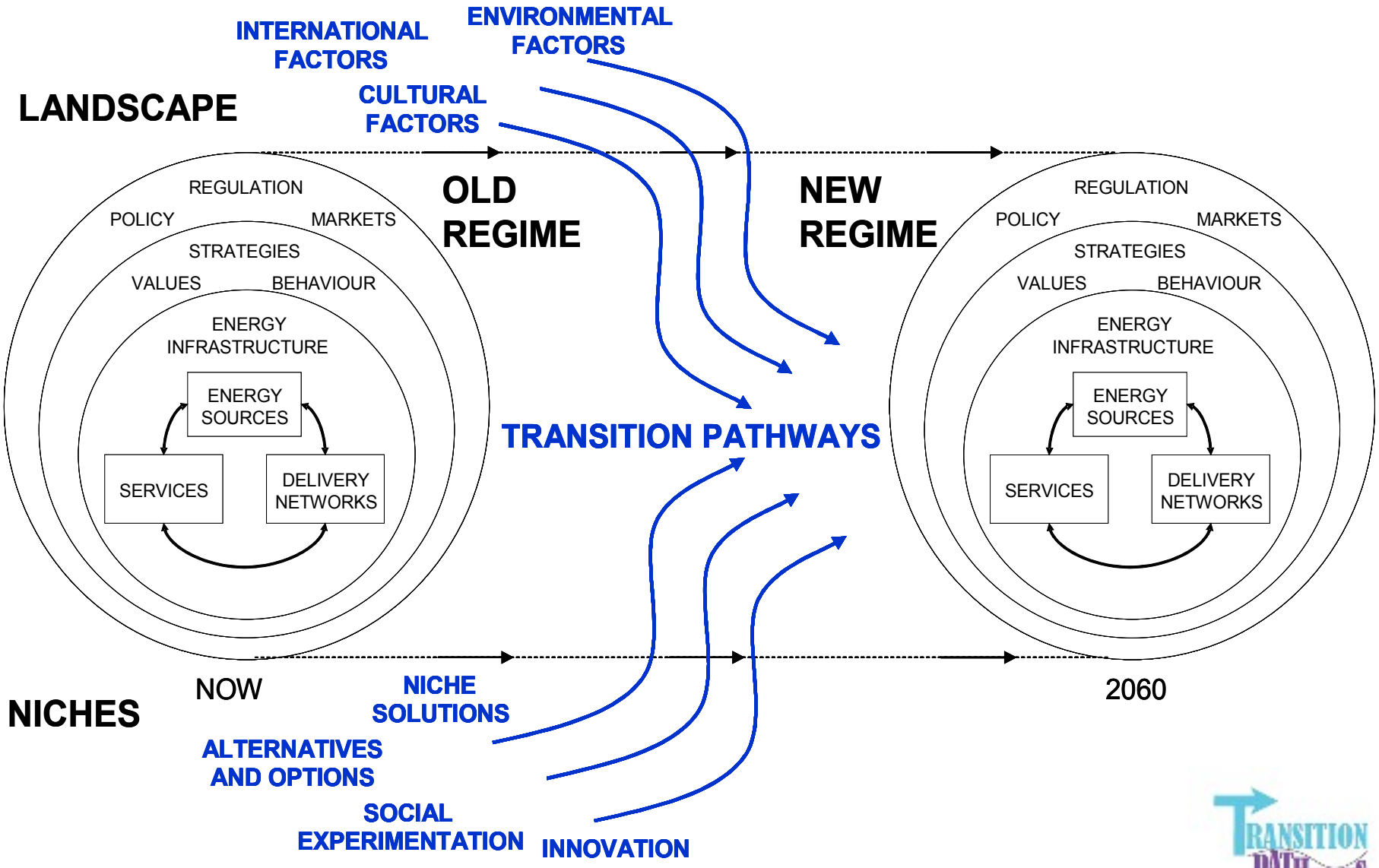
Key aims:

- Select, develop, analyse *transition pathways* to a 'more electric' low carbon future
- *Integrated 'whole system' assessments* of pathways' technical, economic, social & environmental implications
- Inform thinking & decisions on low carbon transitions & how to 'get there from here'

UK Context

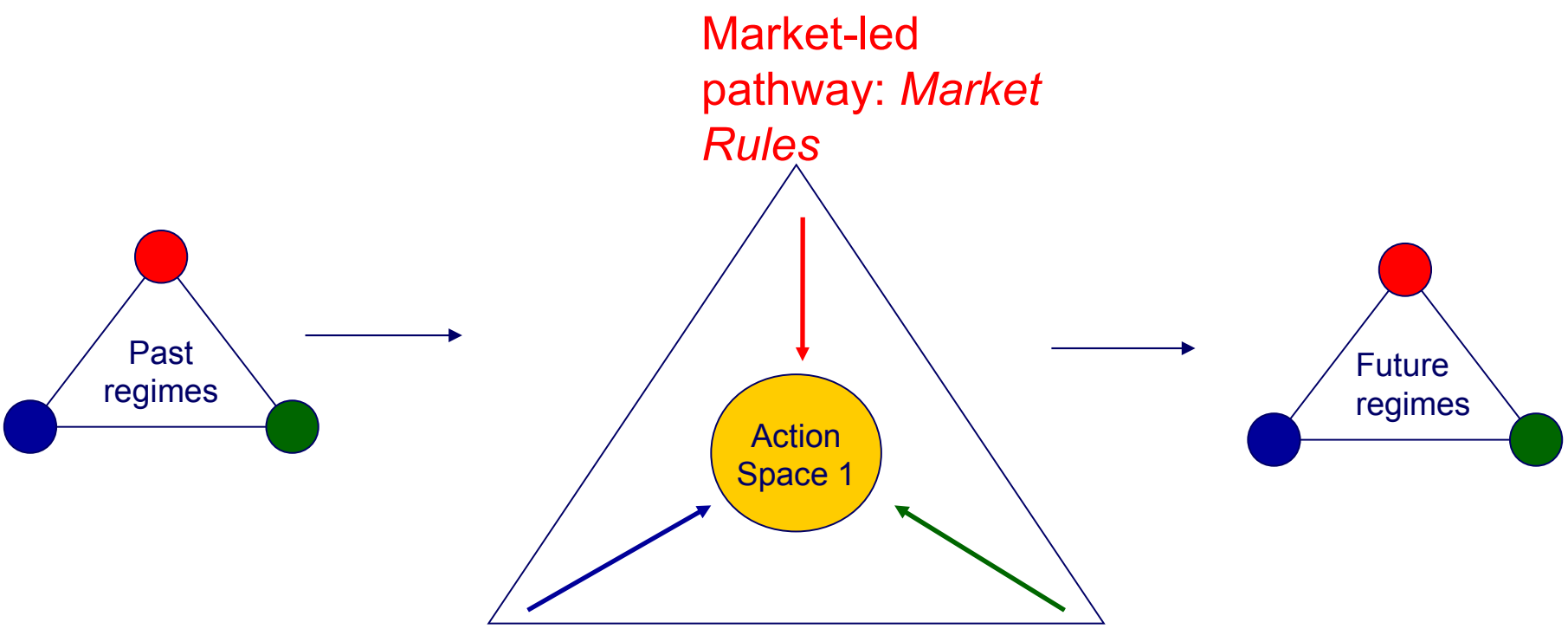
- Climate Change Act 2008: 80% GHG cut by 2050
- 'Trilemma': low carbon, secure, affordable energy

Multi-level Perspective on Transition Pathways

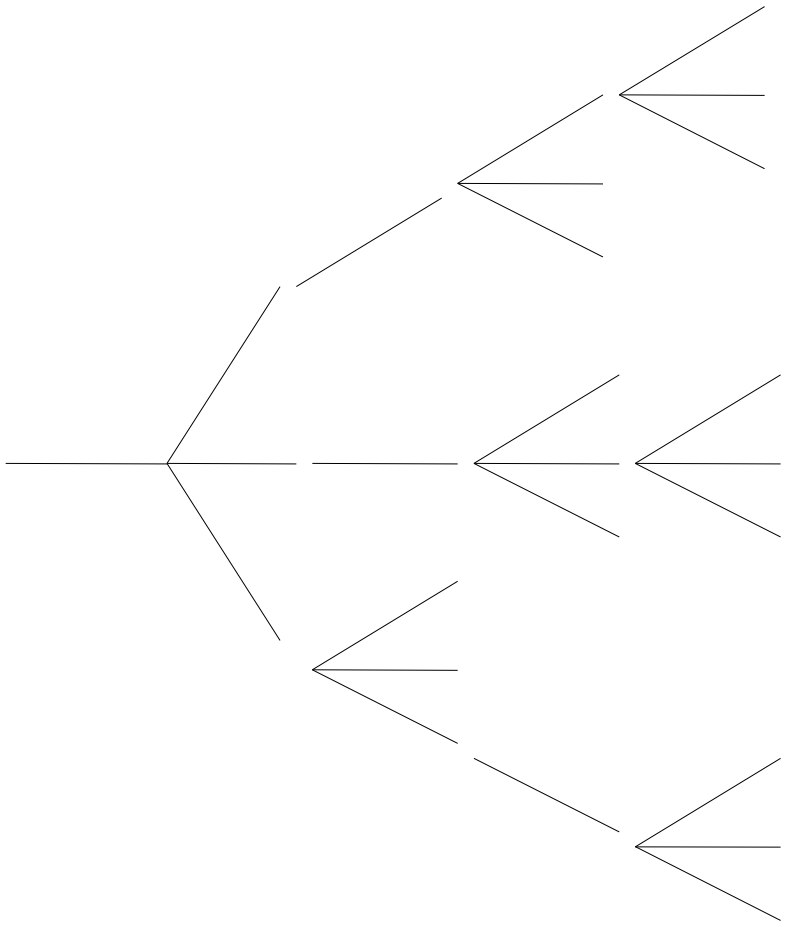


Source: Transition Pathways Team

The Action Space for Transition Pathways



Three Core Pathways & Governance Modes



Market rules

Central co-ordination

Thousand Flowers

Three Transition Pathways

1) *Market Rules*
   - Limited interference in market arrangements; high carbon price
   - Large companies dominate; big technologies in 'highly electric' future – inc. CCS-ready coal/gas, nuclear power, offshore wind
   - 80% generation linked to high-voltage in 2050: grid reinforcement

1) *Central Co-ordination*
   - Central government & Strategic Energy Agency commission tranches of low-carbon generation from big companies
   - Via large-scale centralised technologies
   - Cooperation & tensions between key actors

1) *Thousand Flowers*:
   - More local, bottom-up diverse solutions led by ESCOs (big & small), local communities & NGOs: closer engagement of end-users
   - Local leadership in decentralized options (50% share)
   - Key technologies: onshore & offshore wind, renewable CHP & solar PV; 'smart grid' technologies to handle power flows

‘Thousand Flowers’ pathway 2008-2050

2008-2012: Dominance of centralised systems

- Continued dominance of centralised systems for delivering electricity and gas
- Small number of large firms, many part of international companies
- Regulatory focus on ensuring competition and fair access

Pressures from landscape and niche levels

- UK Government leadership on addressing climate change
  - » UK Low Carbon Transition Plan published
  - » Feed-in tariffs introduced for small-scale renewable electricity and heat generation
- Growing social movements for addressing climate change
  - » ‘10:10’ and successor campaigns achieve mass take-up
  - » Transition Towns movement demonstrates feasibility of small-scale solutions in many UK cities and towns

2013-2032: Emergence of decentralised systems

Climate change and energy security concerns lead to new drive for energy savings

- Stronger product standards, e.g. LED lighting
- Increasing obligations and 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 and local NGOs
    - → increasing legitimacy and further mobilisation of resources
    - → investment in financial capital and skills and training
- Further landscape pressures from natural disasters attributed to climate change and threats to gas supplies from Central Asia
- Small number of microgen technologies become 'dominant designs'
- Success of ESCO model with large number of smaller firms

TRANSITION PATHWAYS

2032-2050: High levels of microgeneration

Domestic and non-domestic microgeneration achieve high levels of adoption, meeting 50% of demand by 2050

Centralized system becomes almost totally decarbonised

- but nuclear power and carbon capture and storage seen as expensive and unnecessary after costs escalated for initial new build and demonstration plants in late 2010s and early 2020s
- Reversion to electric heating technologies (2nd microgen revolution)

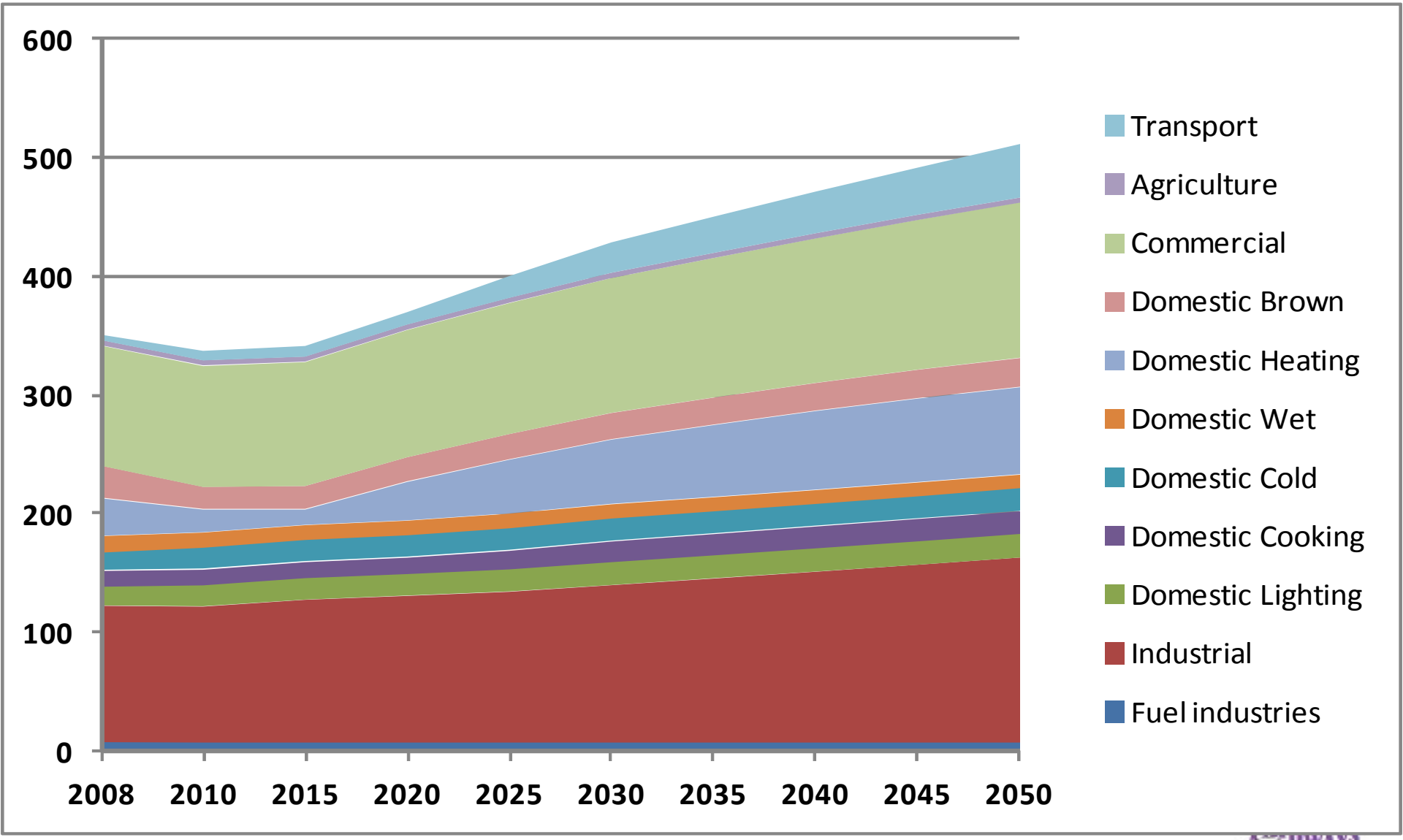
Implications for technical and institutional design of centralized system

- Adoption of 'smart grids' and '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

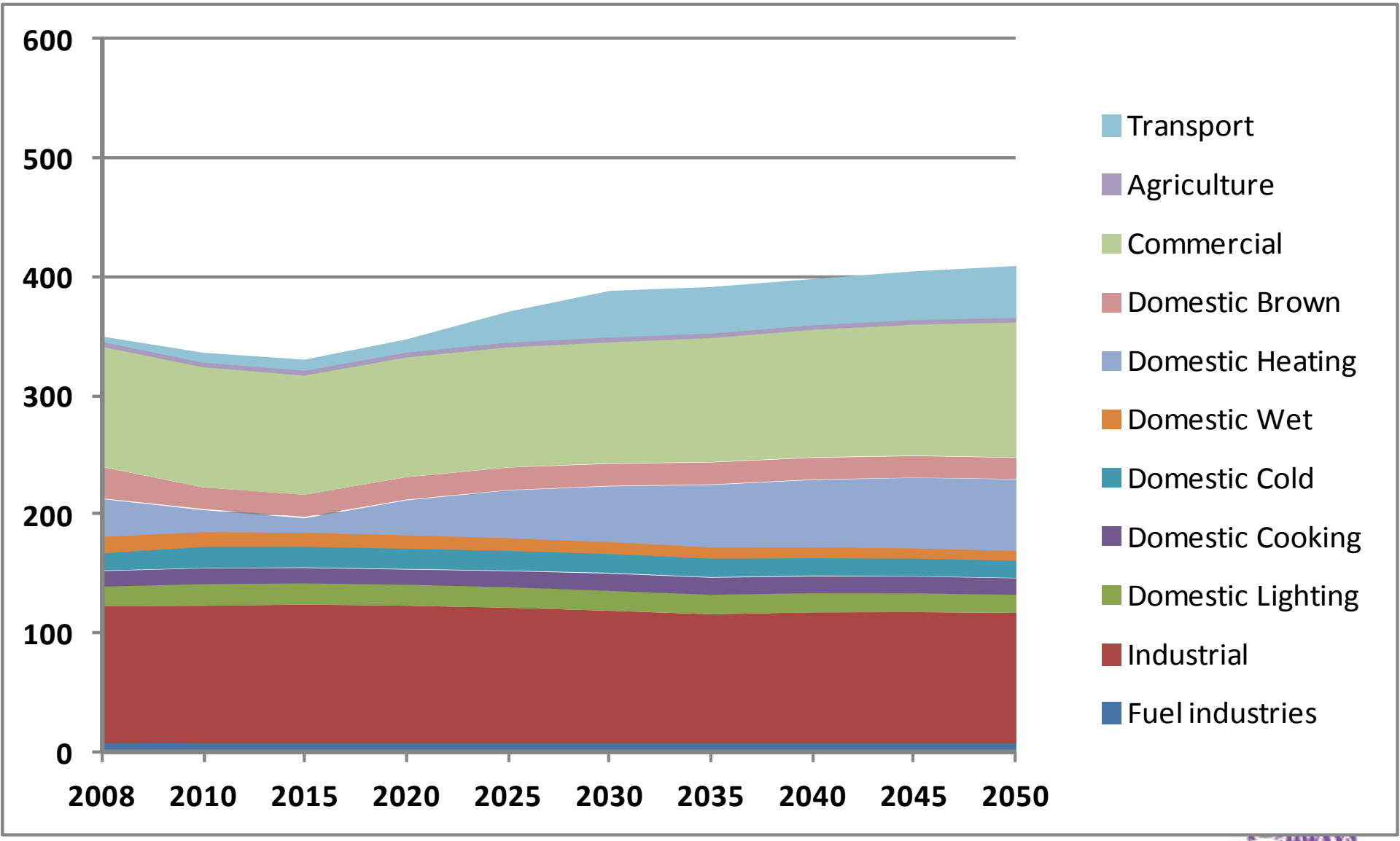
Results in carbon emissions from the energy sector reduced by 80% from 1990 levels by 2050

TRANSITION PATHWAYS

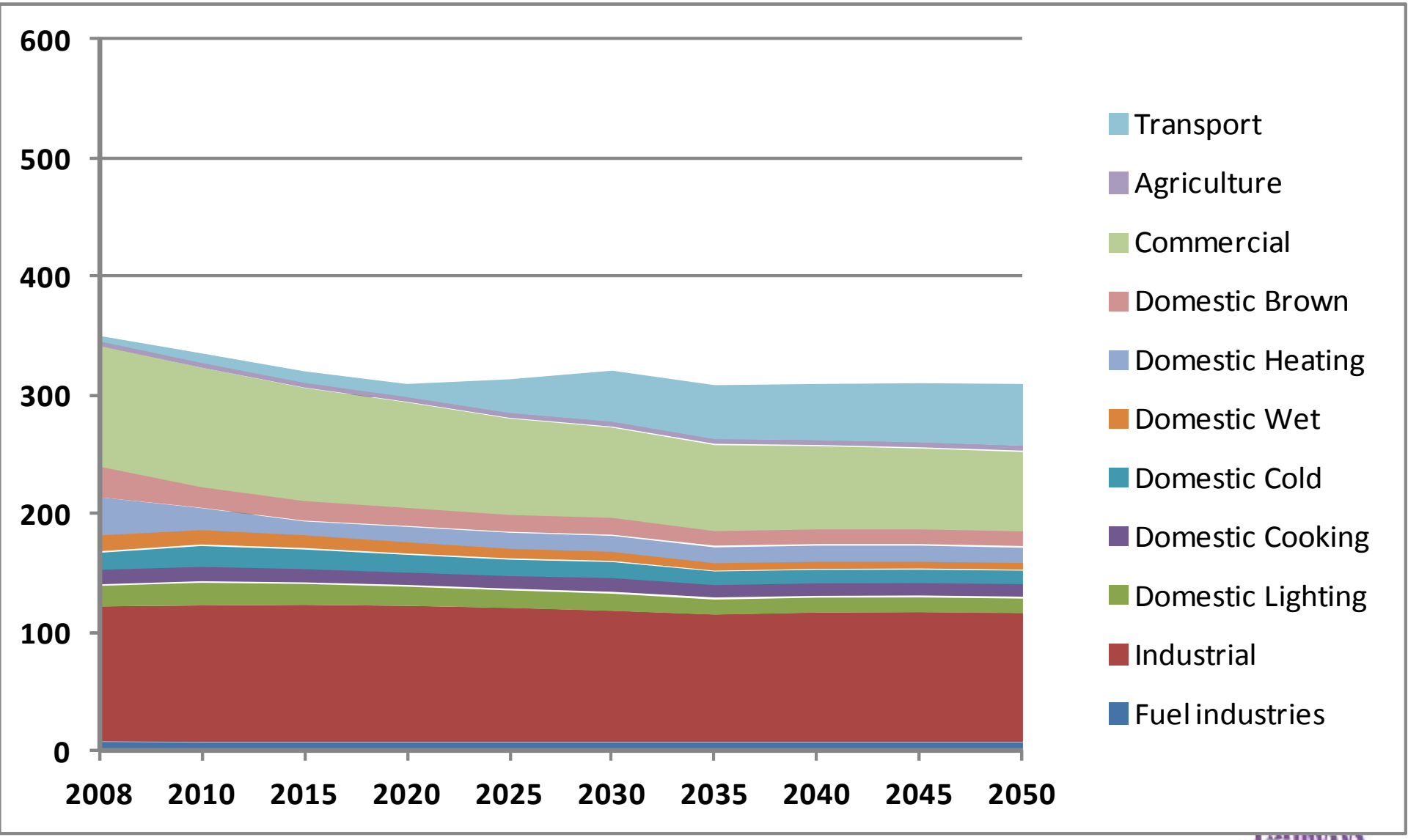
Market Rules electricity demand (TWh)



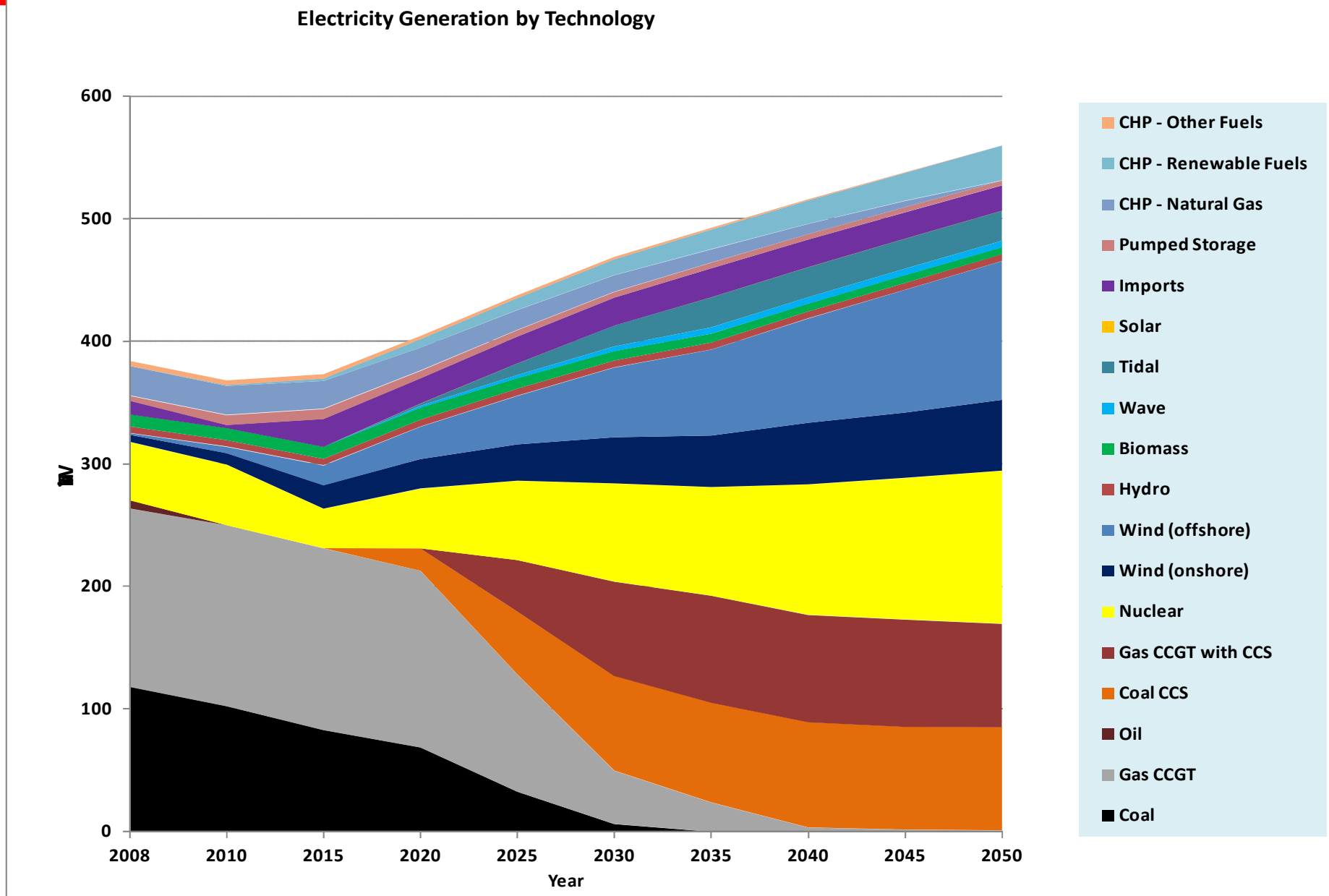
Central Coordination electricity demand (TWh)



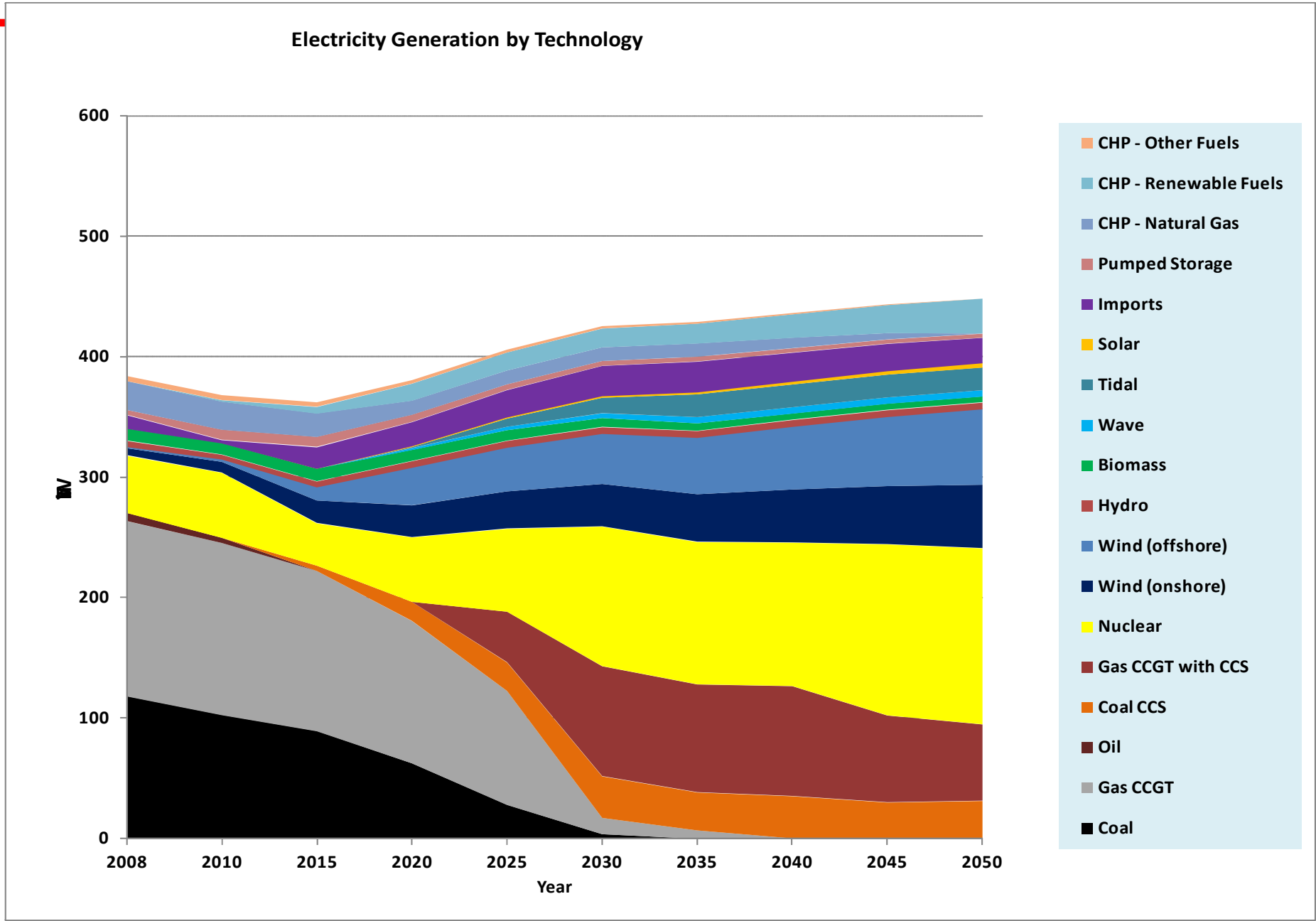
Thousand Flowers electricity demand (TWh)



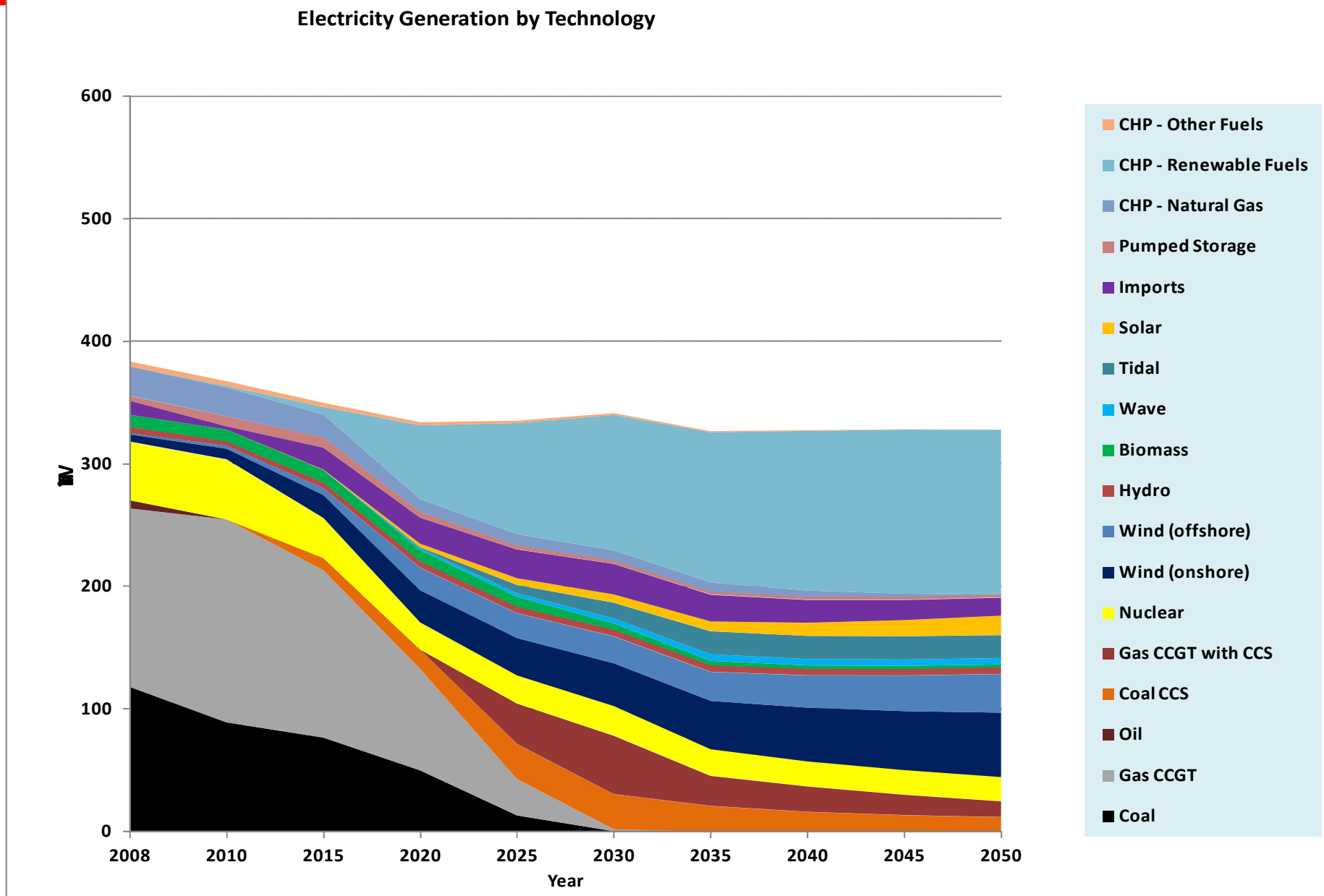
Electricity generation mix in ‘Market Rules’ pathway



Electricity generation mix in ‘Central Co-ordination’



Electricity generation mix in ‘Thousand Flowers’



Demand, Energy Use and Behaviour

Greater energy efficiency & use of non-electric heating sources (mostly CHP) in Thousand Flowers cuts peak demand to 38GW.

But with significant ‘excess’ generation locally at times of low electricity demand.

Load shifting through greater use of demand-side management, with widespread acceptance of automatic appliance control &/or deep behaviour changes, could address this,

But our longitudinal study of responses to visual energy displays showed how quickly households returned to pre-existing use levels.

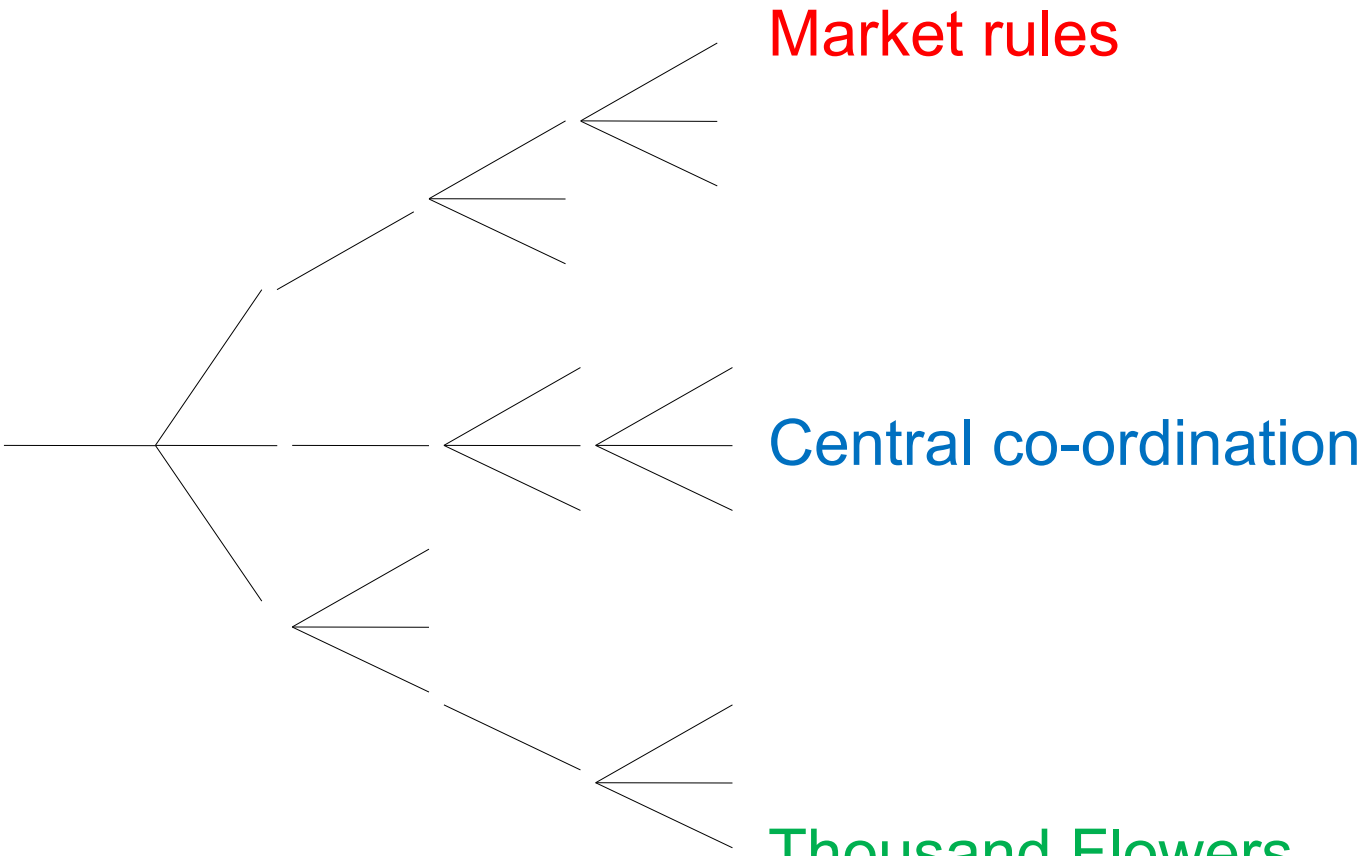
Most early adopters used displays to picture the household’s ‘normal’ energy use pattern - & tended to resist external appeals to change.

The closer engagement of end users with energy system governance in Thousand Flowers suggests one way to overcome these barriers.

Branching point analysis

Branching point analysis

- Test pathway sensitivity & robustness
- Informed by historical case studies



Potential branching points

Market Rules: CCS assessed commercially unviable by 2020

a) Market actors decide to continue investing in CCS, driven by expectations of large export markets for successful CCS technology;

b) Market mechanisms judged incapable of delivering CCS – branch to Central Co-ordination pathway;

c) Widespread scepticism about achieving low carbon targets & energy security concerns lead to renewed investment in unabated generation

Central Co-ordination: Strategic Energy Agency fails

a) Government proceeds to re-nationalisation of key electricity assets;

b) 'Bureaucratic interference and incompetence' blamed for failure – move back to Market Rules but with time delays & higher costs;

c) Lack of co-ordination leads to a 'two-tier' price driven electricity system

Thousand Flowers: 'Too much to carry' in terms of actions needed

a) Community groups take ownership of local electricity networks;

b) National govt. or big energy companies step in to manage problems

c) Patchwork of local problems, result in targets being missed

TRANSITION PATHWAYS

Challenges facing individual energy users/ households

Realising pathways requires households & energy users to play more active roles in energy service provision/use:

- Facilitating energy saving choices via more ‘visible’ energy use (e.g. smart meters) - but household dynamics influence responses
- Changes in habits/routines/lifestyles (e.g. reduced car use, increased car sharing)
- Changes in shared understanding of ‘proper’ energy use (e.g. awareness of increases in showering frequency)
- Increasing demand/new uses for low-carbon/more-efficient technologies (potentially leading to some rebound)
- Increasing policy action to ensure any energy use limitations are shared fairly across different groups

Dependent on wider social attitude changes, focusing on ‘quality of life’ benefits

Challenges facing social movements

Carbon targets imply radical changes to meet light, heat & power demands - inherently politically-charged

Social movements might play multiple roles:

- Lobbying government to introduce stronger targets, policies & measures, countering lobbying by big energy firms & others
- Demonstrating viability of alternative solutions
- Creating wider coalition of progressive energy users, generators & analysts
- Proposing alternative visions for a future low-carbon society

Suggests need for wider public debates on alternative visions & pathways to a low-carbon future

TRANSITION PATHWAYS

Value of 'Transition Pathways' analysis

Exploration of pathways & branching points informs actions needed & consensus building for common goals

Shows pathways with different/shifting roles for government, market & civil society actors

- And how they might lead to alternative visions & realities of a low-carbon electricity system

  Identifies challenges raised for different actors

Shows implications of risks & uncertainties, including

- Future progress in different energy technologies & portfolios
- Whole system sustainability challenges for technologies & pathways
- Role of ICTs to help facilitate change through smart grid/controls
- Demanding role of changes in actors' habits, practices & wider social values, & how actors might interact well or badly with technologies
- Role of policies & incentives

Selected Publications

Foxon, T J, Hammond, G P and Pearson, P J (2010), 'Developing transition pathways for a low carbon electricity system in the UK', *Technological Forecasting and Social Change* **77**,1203-1213.

Hammond, G.P., Harajli, H.A., Jones, C.I. and Winnett, A.B. (2012), 'Whole systems appraisal of a UK Building Integrated Photovoltaic (BIPV) system: Energy, environmental, and economic evaluations', *Energy Policy* **40**, 219-230.

Hargreaves, T, Nye, M and Burgess, J (2010), 'Making energy visible: A qualitative field study of how households interact with feedback from smart energy monitors', *Energy Policy* **38**, 6111-6119.

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**, 697-714.

Torriti, J., Hassan, M.G. and Leach, M. (2010). 'Demand response experience in Europe: Policies, programmes and implementation', Energy **35**, 1575-1583.

2 forthcoming special issues of *Energy Policy* in process, covering technical, social and environmental analysis of pathways, and insights from past transitions

Further working papers and presentations available on project website:

www.lowcarbonpathways.org.uk