

Transition Pathways for a Low Carbon Electricity Future: Exploring roles of actors, governance and branching points

Dr Timothy J Foxon

Sustainability Research Institute and
Centre for Climate Change Economics and Policy
University of Leeds, UK

‘Researching the transition towards a low carbon society’,

ACCIS Workshop

Aston University, 23 November 2010

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

'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

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

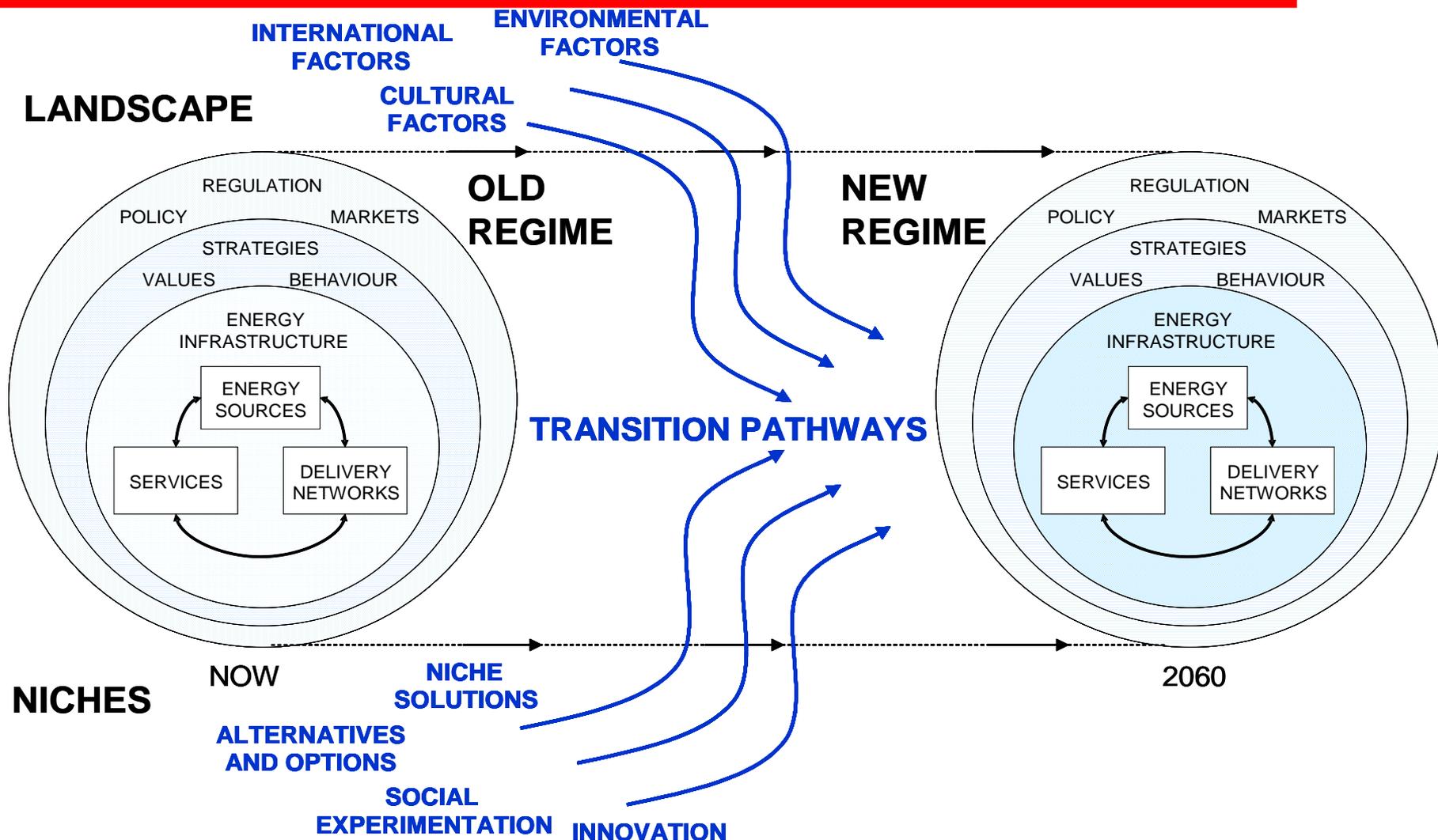
Dutch Transitions approach

- (1) Analysing historical dynamics of transitions using multi-level perspective (*Geels, Rotmans, Kemp*)
 - Landscape: broader cultural values and institutions
 - Socio-technical regime: prevailing set of practices, technologies, skills, institutions, infrastructures
 - Niches: Spaces partially isolated from regime where technological and social learning can occur
- (2) Transition management as process of governance (*Loorbach, Grin*)
 - Modulate dynamics of transitions through interactive, iterative processes between networks of stakeholders
 - Shared visions and goals; transition experiments
 - ‘Transition arena’: innovation-oriented stakeholders
- (3) Socio-technical scenarios (*Elzen, Hofman*)
 - Exploring potential links between various options and analysing how these are affected by strategies of stakeholders

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

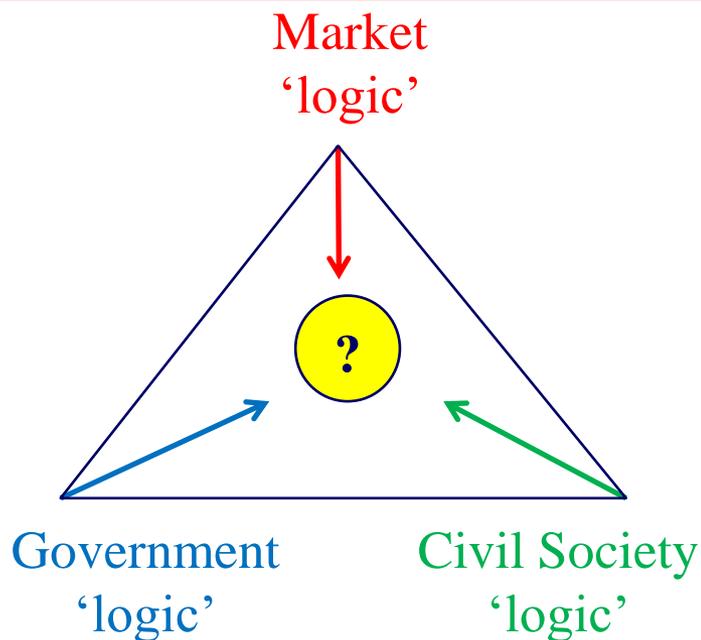
Multi-level perspective for transition pathways



Methodology for developing transition pathways

1. Characterise existing energy regime, its internal tensions and landscape pressures on it
2. Identify dynamic processes at the niche level
 - (actor-contingent) technology dynamics
3. Specify interactions giving rise to, or strongly influencing, transition pathways
 - co-evolutionary dynamics of technologies, institutions, firm strategies & user practices
4. Look for 'points of fulcrum'/branching points
 - Changes in motivation and behaviour of actors in response to changes at regime and landscape levels
5. Examine branching points in terms of technical feasibility and social acceptability
6. Assess shocks and surprises to system

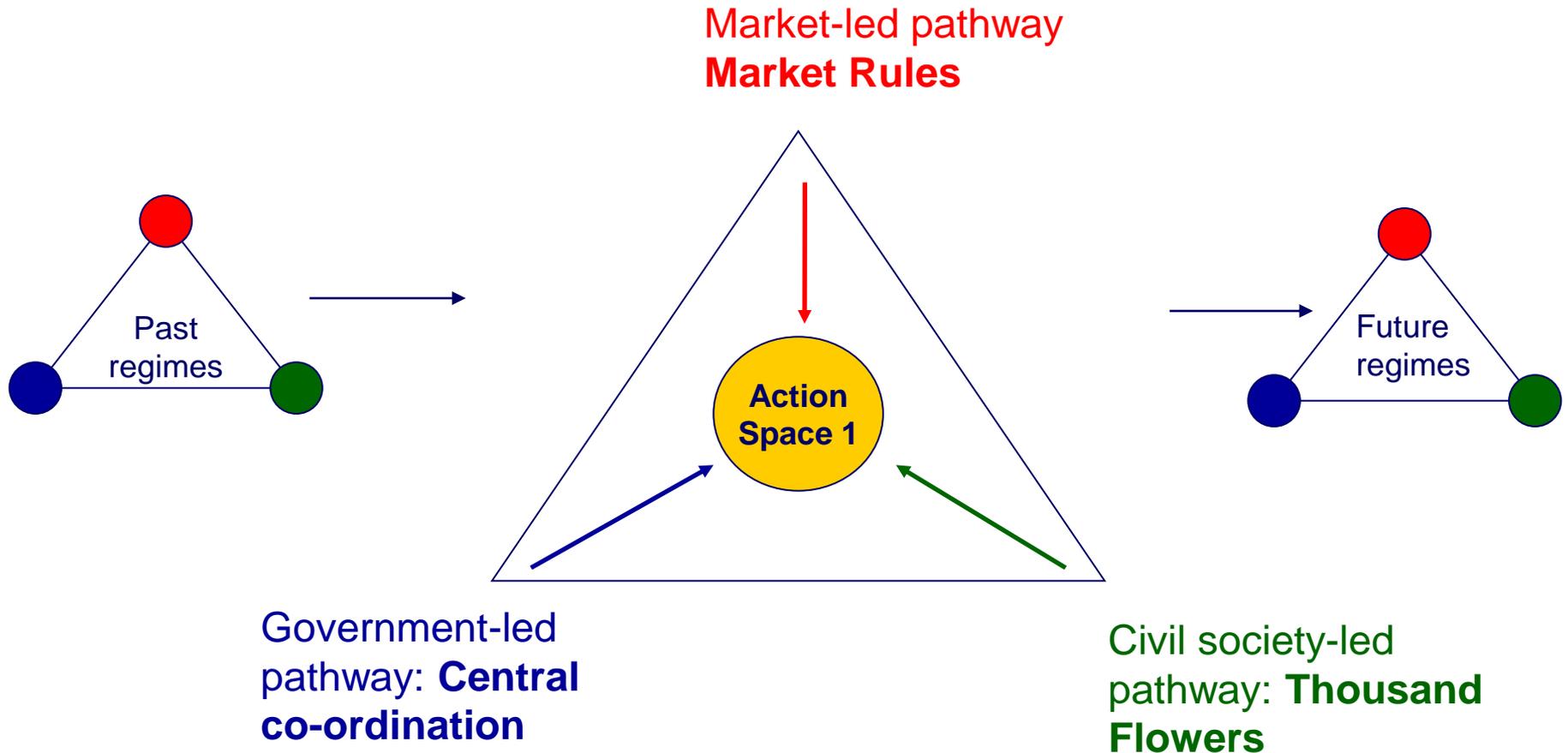
The Action-Space Approach to Governance - 3 Key Actor Groups: Market, Government, Civil Society



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

The Action Space for 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

'Market Rules' pathway v 1.1: 2008-2022



- ◆ **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
- ◆ **2008-2022: Climate change & security of supply lead large energy companies to focus on large-scale technologies**
 - New coal-fired power stations, designed to be 'capture ready', including three demonstration CCS systems in operation by 2020
 - One new nuclear power station in operation by 2020, with several others under construction
 - 19% of electricity generated from renewables by 2020, including 11GW of offshore wind
 - 'Generation gap' in 2015 just avoided, as large energy suppliers incentivise customers to use energy more efficiently

'Market Rules' v 1.1: 2023-2037

- ◆ **Evidence of climate change impacts lead governments to set stringent carbon reduction targets, but markets still seen as primary delivery mechanism**
 - More stringent caps set under European Emissions Trading Scheme to 2030, leading to high carbon price
- ◆ **High oil & gas prices, & instability in the main producer countries, mean that energy security concerns also continue to form a major part of the landscape**
- ◆ **These factors drive energy companies to further invest in large-scale technologies – offshore renewables, coal & gas CCS & nuclear power**
 - Security of supply concerns for many people, & job opportunities created, help companies to overcome local objections

'Market Rules' v 1.1: 2038-2050

- ◆ **Electricity supply almost fully decarbonised (40 gCO₂/kWh)**
 - Widespread take-up of electric heating (heat pumps) for 80% of all new heating installations
 - Electric vehicles predominate (25 million electric & plug-in hybrid electric vehicles in use by 2050)
- ◆ **Significant technical improvements in energy efficiency of electrical devices & the use of 'smart grids' to actively manage demand**
 - So, overall electricity demand only rises by an additional 10% between 2035 & 2050
- ◆ **Mix of large-scale low-carbon technologies**
 - 20 GW each of coal with CCS, gas with CCS & nuclear power
 - 60 GW of renewables capacity installed by 2050, mainly onshore & offshore wind, wave, tidal stream & barrage

'Central Co-ordination' 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: Government takes active steps to remove 'blockages' to deployment of renewables**
 - addressing transmission constraints by coordinating with National Grid for a major infrastructure investment programme (particularly to improve the North-South connections);
 - addressing the planning issues;
 - ensuring the supply chains & skills are in place

'Central Co-ordination' v 1.1: 2013-2022



◆ **New Strategic Energy Authority**

- remit “to ensure the government’s energy policy goals are met, including the role of energy supply in meeting carbon emission reduction targets; maintaining security of energy supplies; & alleviating fuel poverty”

◆ **Demand-side measures**

- Focus on technical efficiency improvements to appliances & building stock

◆ **Supply-side measures**

- ‘Technology push’ programmes for marine renewables, CCS & electric vehicles
- Large energy companies & engineering companies are key players
- Government issues contracts for 5 year tranches of low-carbon generation

'Central Co-ordination' v1.1: 2023-2037



- ◆ **Target of 80% decarbonisation of electricity supply by 2030, i.e. carbon intensity <80 gCO₂/kWh**
- ◆ **Renewables**
 - Onshore & offshore wind; wave & tidal power; Severn barrage
- ◆ **Carbon capture & storage**
 - All new coal or gas stations fitted with CCS
- ◆ **Nuclear power**
 - 10 new nuclear power stations in operation by 2030
- ◆ **Energy efficiency**
 - Smart meters enable dynamic management of demand, by end-users & Distribution Network Operators
- ◆ **Electric vehicles**
 - Also act as electricity storage devices

'Central Co-ordination' v 1.1: 2038-2050



- ◆ **Electricity supply almost fully decarbonised**
- ◆ **Focus on reducing emissions from heating & transport**
- ◆ **'Smart grids' are now in place to actively manage demand**
- ◆ **Electric heating & electric vehicles becomes widespread**

'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

'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

'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

'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

'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

'Thousand Flowers' v1.1

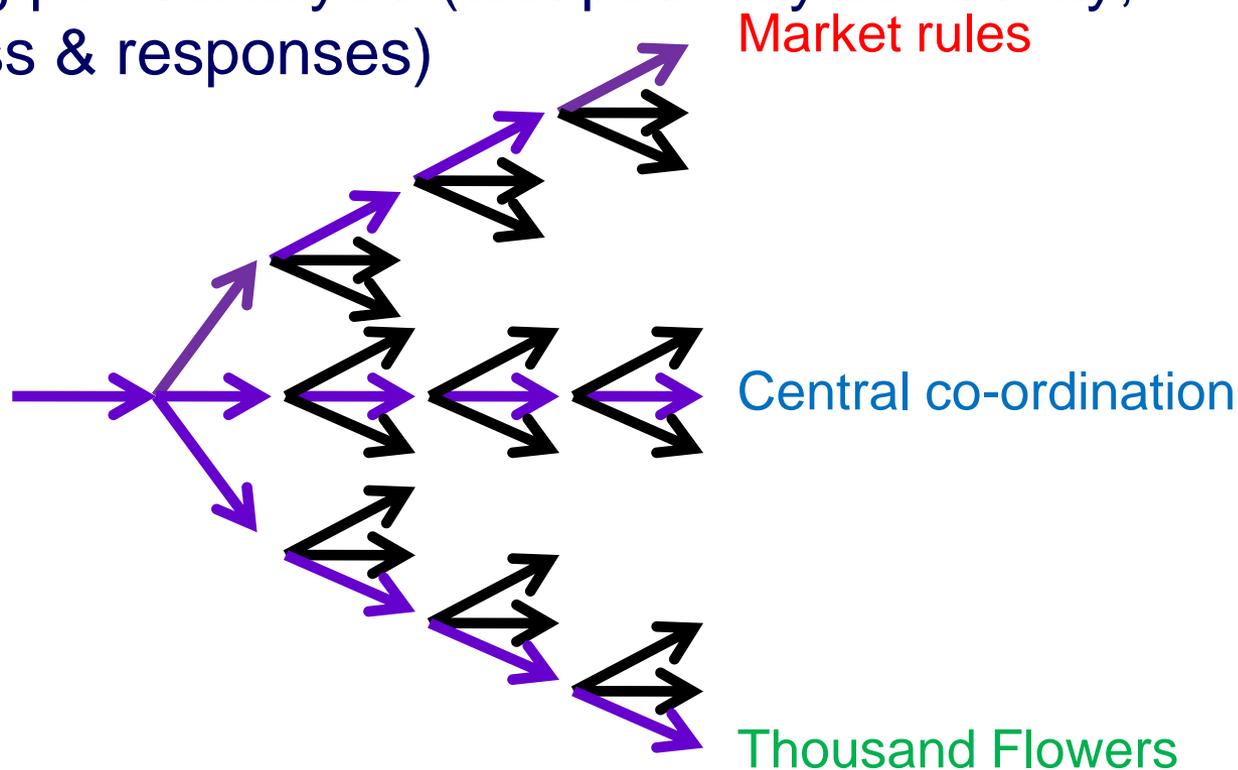
overview



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

Explore, interrogate & revise pathways

- ◆ Qualitative analysis
- ◆ Quantitative analysis
- ◆ Whole systems analysis
- ◆ Branching point analysis (test pathway sensitivity, robustness & responses)



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?

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

Conclusions

- ◆ Exploring what is needed to meet the scale of the challenge
 - inter-related nature of technological, institutional and behavioural responses, and how they coevolve
- ◆ 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 and qualitative analysis
- ◆ Identifying potential branching points
- ◆ See www.lowcarbonpathways.org.uk