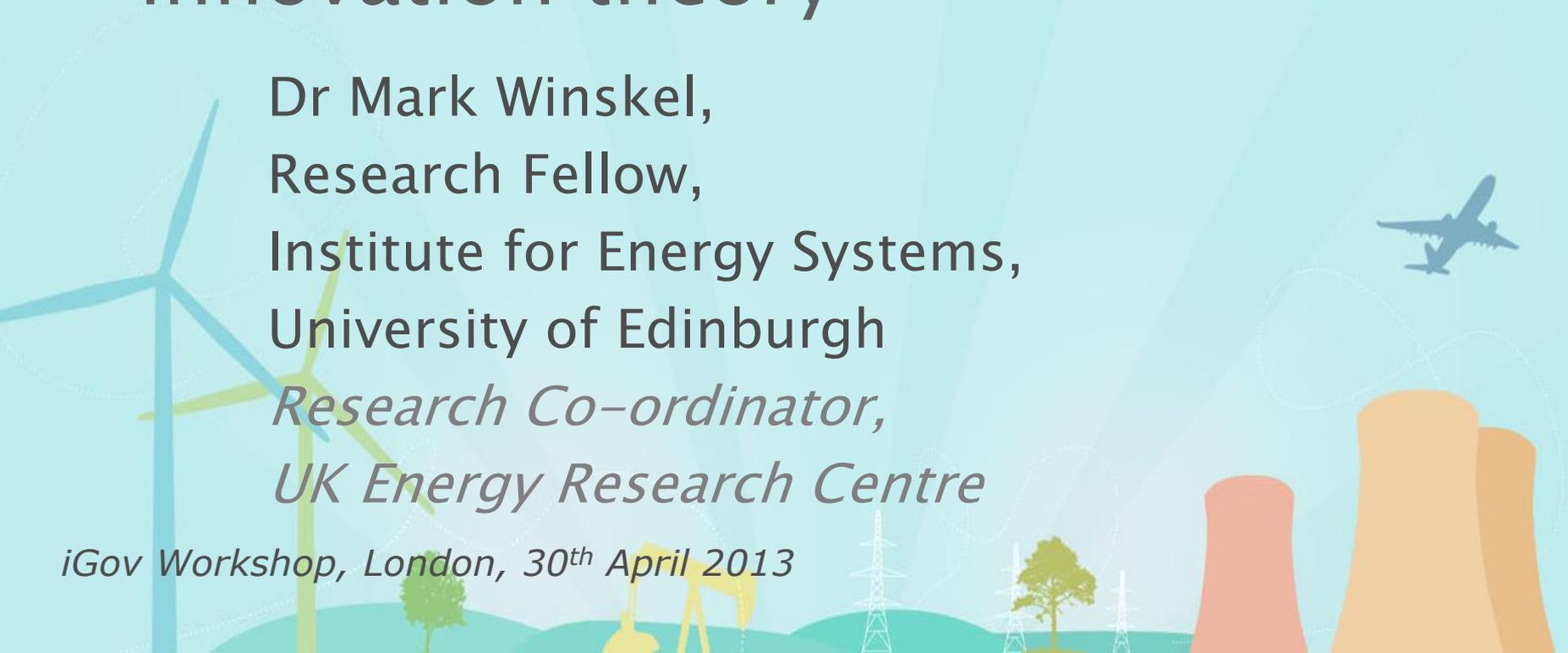


Accelerated energy innovation, and its implications for innovation theory

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Background, motivations

- Bridging between worlds of energy innovation policy, practice and innovation research / theory
- Bridging between disciplines, especially *innovation studies* and wider 'whole systems' energy research

Leading to...

- Reflection on sustainable energy innovation theory, especially the *multi-level perspective* and *technological innovation systems* theory
- Revisiting some old debates in technology studies, on constructivism and structuralism

The hypothesis...

- The terms of energy system change, and energy innovation have recently been transformed
 - Much more intense pressures for change, leading to the emergence of accelerated energy innovation
 - Wider emphasis on debt recovery and economic growth
- This has not been adequately reflected in sustainable energy innovation theory
- Need is for some renewal in energy innovation theory, and greater resonance with accelerated innovation dynamics in highly coupled systems

Outline

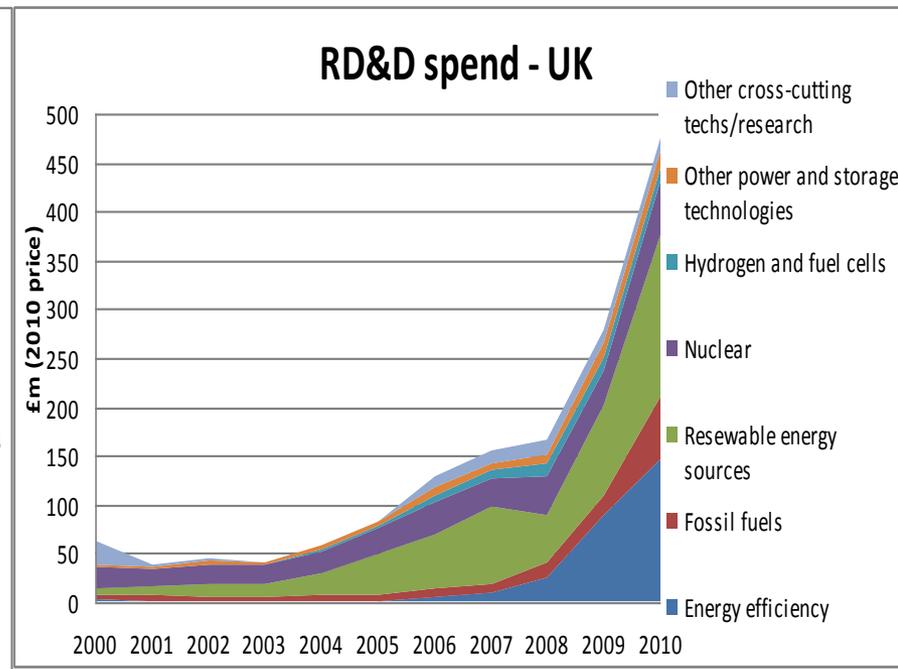
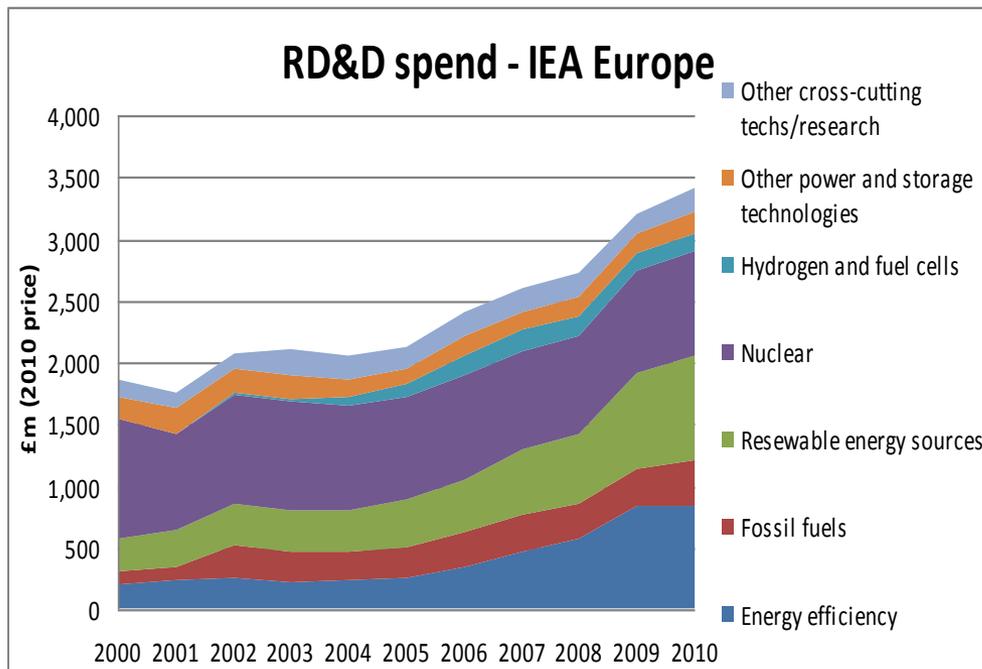
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- Trace the development of sustainable energy innovation theory over the same period
- Consider the resonances and dissonances between policy and theory
- Identify implications for energy innovation studies and theory

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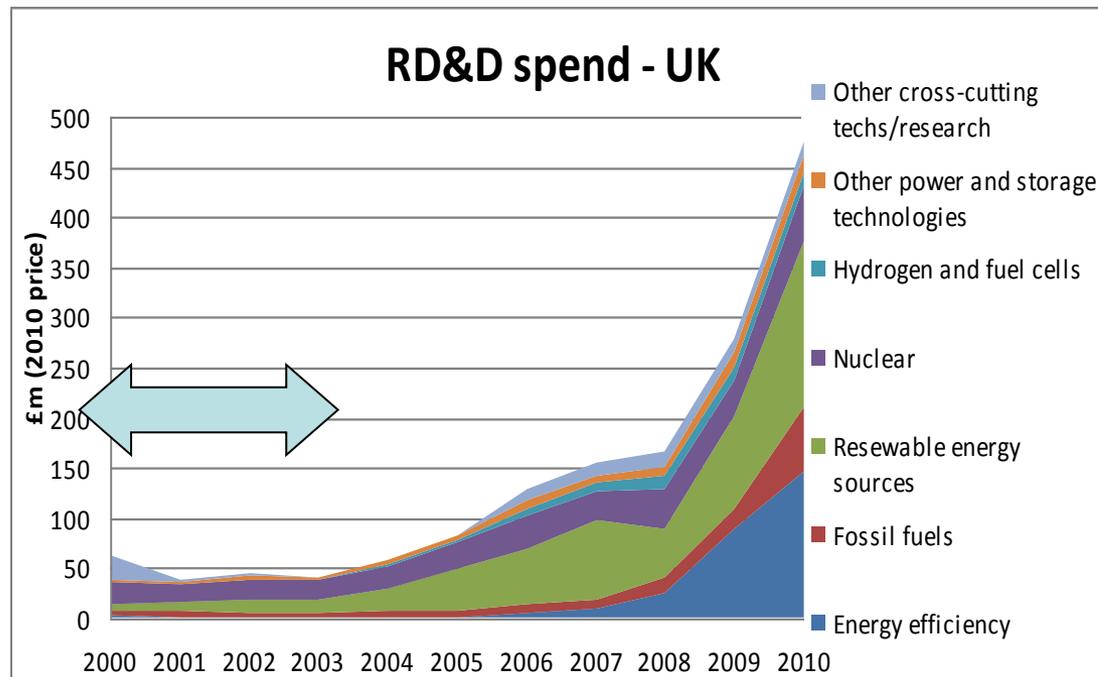
International Context: Global Trends

- In Europe, UK is an extreme case of ‘stop-start’, from very low base at the beginning of the 2000s to rapid acceleration from 2008 onwards



UK Energy Innovation: Early Efforts (2000–2004)

- collapse in energy RD&D funding after privatisation
- global trends, but experienced particularly strongly in the UK
- closure of most of the UK's national research infrastructure.
- a small and fragmented residual research base
- climate change driver emerges, but in a benign context: cheap, secure energy



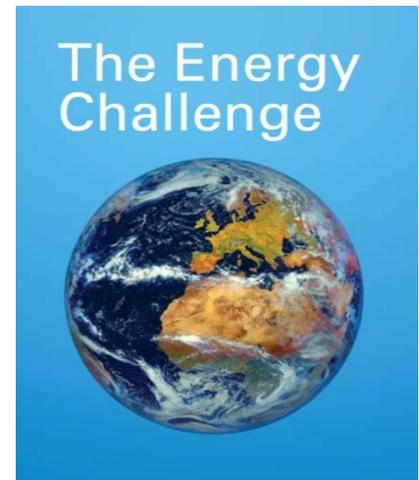
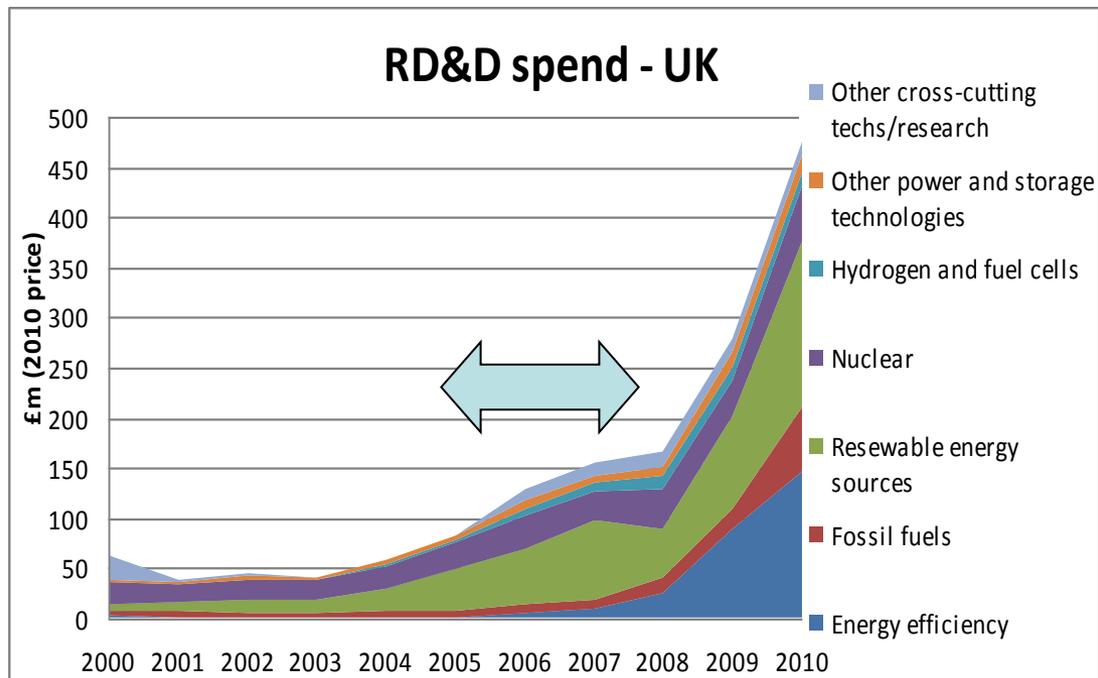
Early Efforts (2000–2004)

- modest / non-binding ambitions for decarbonisation and renewables deployment
- Energy innovation efforts increase, but gradually, from very low base
- new UK organisations and networks were grafted-on to a system still oriented to short-run market efficiency and technology neutrality
- emphasis on longer term RD&D rather than deployment
- a *niche-based* approach to energy innovation



Momentum Building (2005–08)

- End of benign times in the wider energy economy
- Global expansion of the fossil fuel economy, stalling of UK decarbonisation trend
- New UK supply security concern ...UK gas import dependency, volatile international oil and gas markets
- Still favourable macroeconomic context, and growing momentum in UK energy innovation system



Momentum Building (2005–08)

- Larger-scale interventions,
- stronger role for private sector in spending, and strategy
- greater emphasis on demonstration and deployment
- developing focus on big technologies (nuclear, CCS, offshore wind)
- Trend to more technology-specific support
- Growing number of organisations, each prioritising according to their remits



Technology Strategy Board
Driving Innovation

Acceleration (2008–12)

■ Step Change in Policy Targets

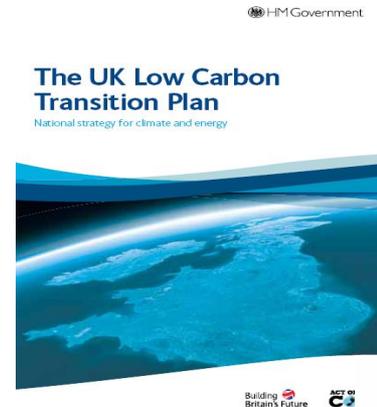
- UK and Scottish Climate Change Acts
- EC *Renewables Directive*

■ Corporate and political consequence

- From *long term scenarios* to short-term *plans and roadmaps*
- Planning reforms for ‘swifter delivery’
- Expanded domestic supply chains

■ Huge infrastructure investments

- £110bn in generation and transmission by 2020
- Equivalent to replacing $\frac{3}{4}$ of UK power generation assets by 2025



The Carbon Plan:
Delivering our
low carbon future



HM TREASURY

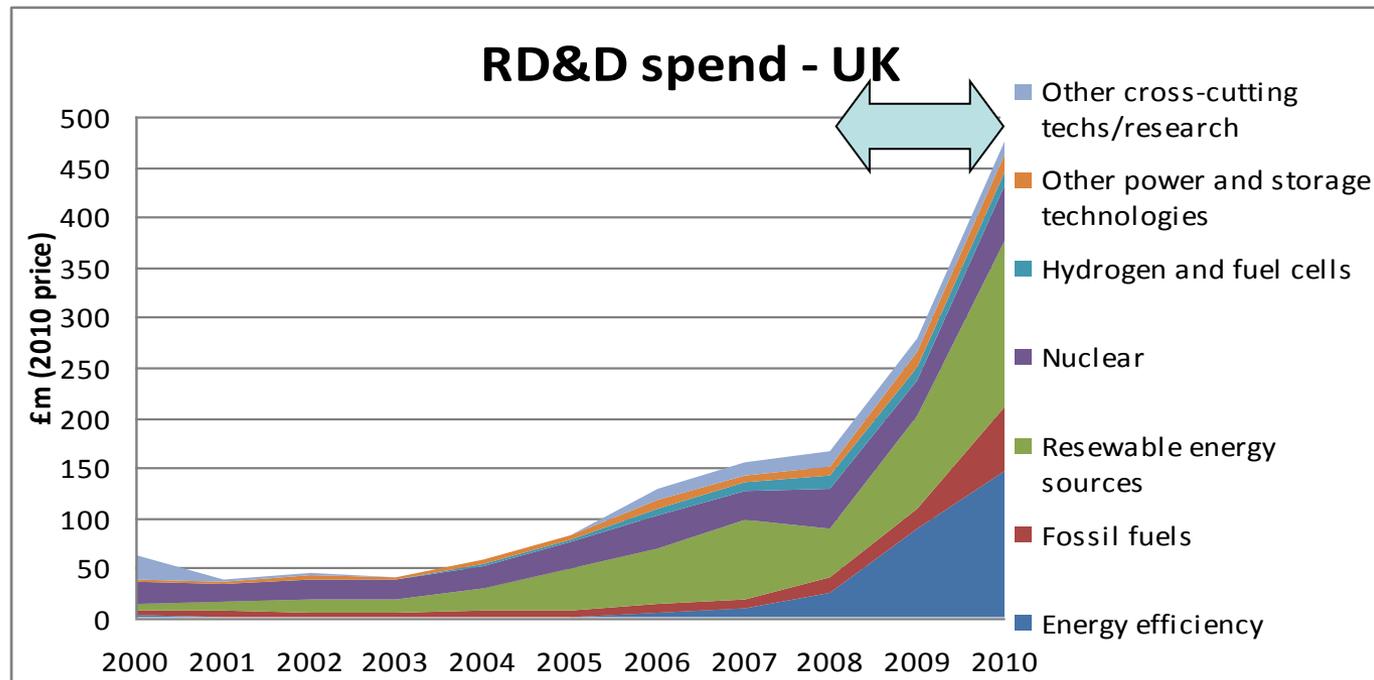


Infrastructure UK

National Infrastructure Plan 2011

Acceleration (2008–12)

- Rapidly growing energy RD&D spend across public sector
 - incumbent-oriented energy innovation programmes ... aimed at driving down the costs of large-scale technologies
- in the 2020s we will run a technology race, with the least cost technologies gaining the largest market share. Before then, our aim is to help a range of technologies bring down their costs so they are ready to compete (UK Government, 2011)*

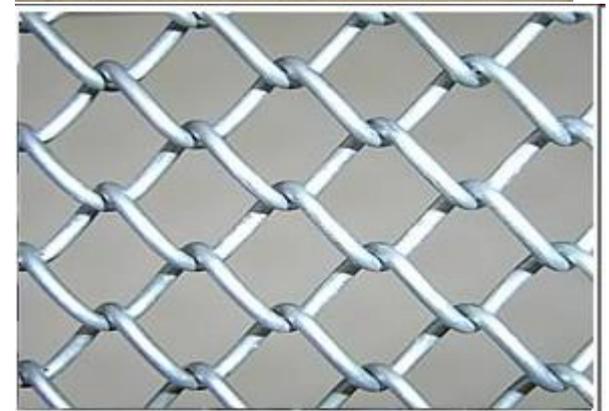


Acceleration: Regime Reinforcement

[we do] not believe that decentralised and community energy systems can lead to significant replacement of larger-scale infrastructure ...

there is no reasonable alternative to a massive re-investment in the UK's national, centralised system of electricity generation and transmission

(UK Department of Energy and Climate Change, 2011)



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Sustainable Innovation Theory

We start from a basic assumption ... [of] interactive learning between practice, policy, research and theory ... the interactive learning space 'dance floor' ... mutually learning, they constantly create and change configurations.

Sometimes practice is the driving force ... sometimes theory ... sometimes policy

(Smits et al., 2011)

Does this really reflect energy innovation policy–theory relations?

Sustainable Energy Innovation Theory

- Little interest in energy innovation studies in the 1990s and early-2000s
- During this period, emergence of constructivist-based theories of change in sustainable energy innovation studies
- System innovation described in *niche-led* terms: emergent, bottom-up and disruptive
- MLP traces lineage back to SCOT :
'regimes generate incremental innovations, radical innovations are generated in niches ... [so] system innovations start in ... niches'

(Geels 2004)

The limits of SCOT: a reminder

[Social constructivism] tends to concentrate on the early stages of radical technology projects, ignoring the greater part of technological change, where incremental changes proceed in a context of already strongly-articulated social and economic interests.

(Williams and Russell, 1988)

Later MLP: recognising the (greater) role of regimes

- Berkhout, Smith, Stirling (2005) need to challenge the niche-driven account
- Geels and Schot's 'transition pathways' admit a more proactive role for regime agency
 - Even so, major system innovations seen to initiate in niches
- Geels (2010; 2011) conceded MLP has tended to monolithic accounts of regimes, under-attending to 'internal tensions and conflicts'
 - ... and need to draw on other research fields: organisation studies, strategic management

Technology Innovation Systems

- Origins in evolutionary economics
- An essentially bottom-up account, with variation and selection via small firms, markets and networks
- Compared to NIS, ‘a greater emphasis on microeconomic aspects ... than institutional infrastructure’ (Carlsson and Stankiewicz, 1991)
 - Decades of formative phase interactive learning before upscaling
 - Successful innovation through ‘bricolage’ rather than ‘breakthrough’ (Garud and Karnoe, 2003)
- Since 2008, a functional framing which emphasises firm-level agency and entrepreneurship
 - Tends to a ‘point-source’ account of change

Non-radical, non-disruptive system innovation?

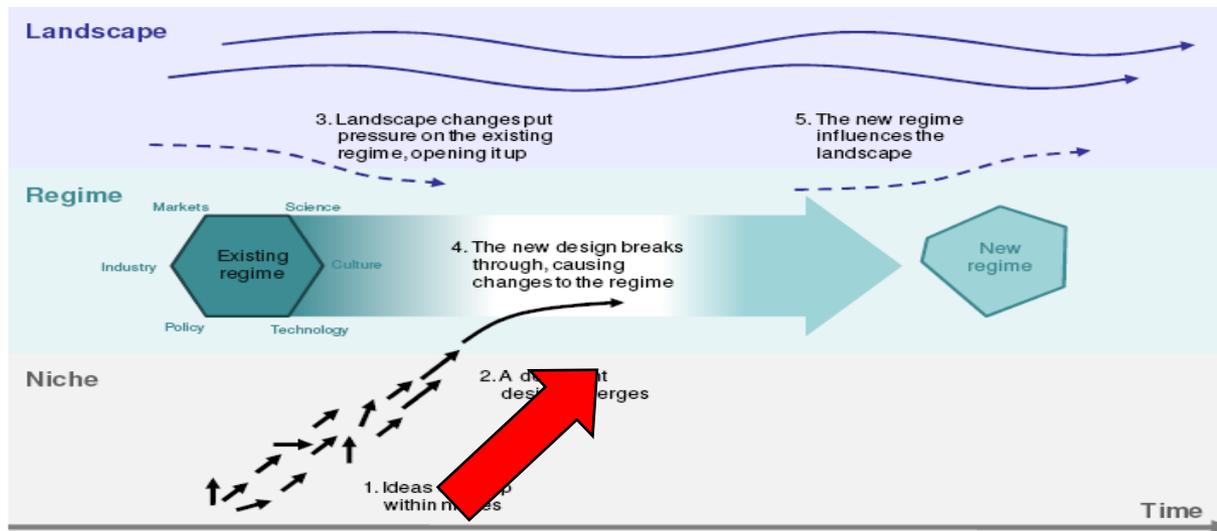
- Established technologies are a ‘moving baseline’ against which niches have to compete
- Incremental innovation has had major impact in US energy system: engine efficiencies, process efficiencies, capacity factors (Newell, 2011)
 - .. efforts at breakthrough innovations, such as on synthetic fuels, had much less impact.
- Fuel switching and improved conversion efficiency has had major impact on UK electricity emissions
- Incumbents can show surprising agility and preparedness to abandon embedded commitments
 - e.g. UK dash for gas

Alternative prescriptions for accelerated energy innovation

A burgeoning debate, with the ‘Manhattan Project’ (and Apollo) metaphor(s) invoked by proponents of *niche-led*, *regime-led* and *breakthrough* approaches...

Alternative prescriptions: niche-led (Mowery, Nelson and Martin, 2010)

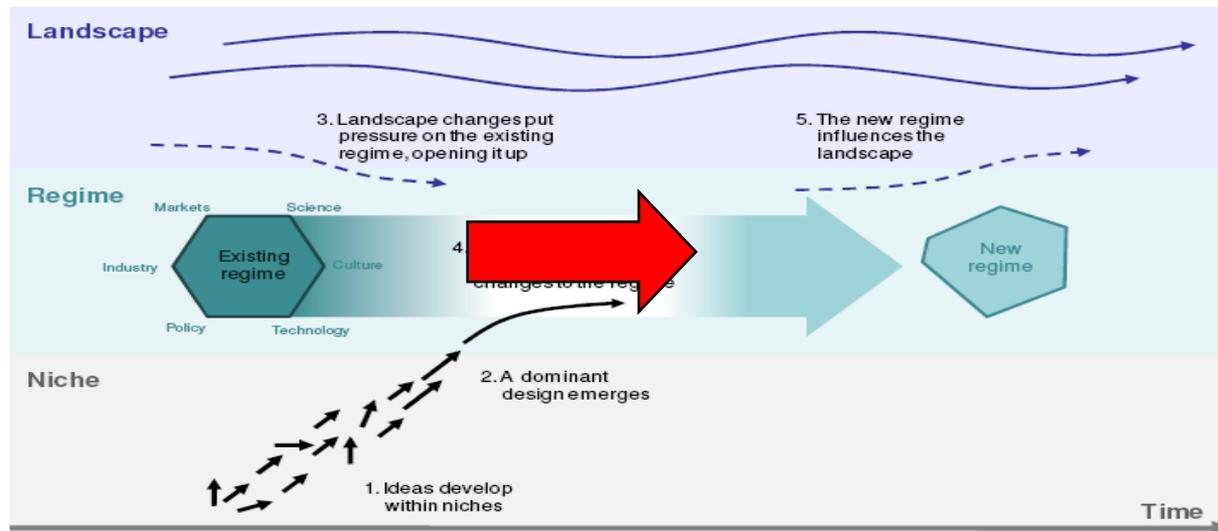
- need for a decentralised, diverse, emergent with long periods
- *'difficult if not impossible to plan or predict the structure of the overall R&D effort in any detail'*
 - shared by much of the innovation studies research community



Alternative prescriptions: continuity-led

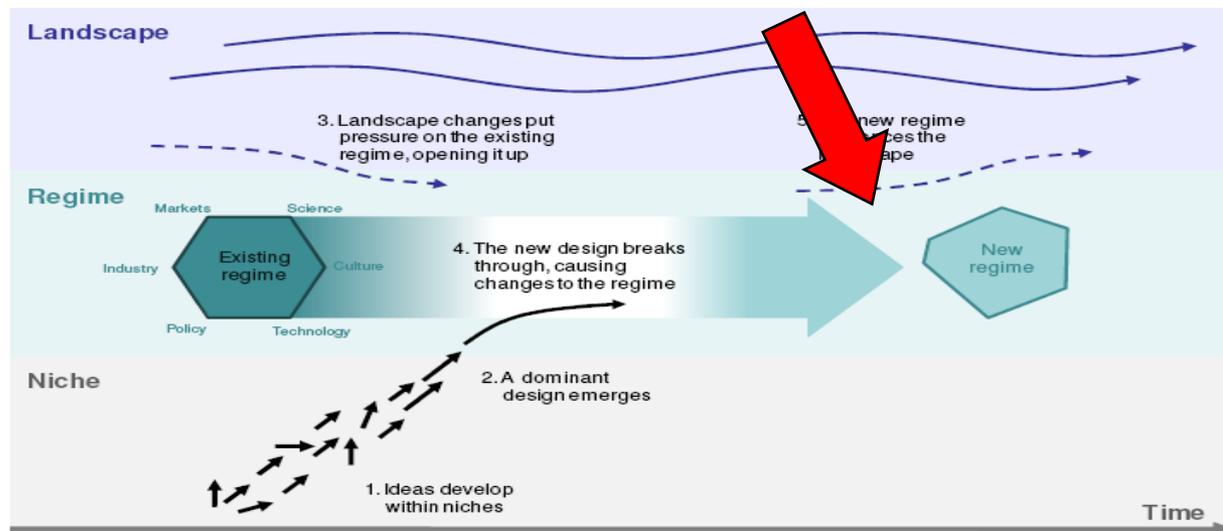
continuity approaches are likely to offer most effective responses to accelerated innovation imperatives (Unruh, 2002)

real ... opportunity lies in improving [known] technologies ... [we] cannot afford to place ... hopes on ... a radical technological transformation (Lester and Hart, 2012)



Alternative prescriptions: breakthrough-led (Perrow, 2010)

- Historically, central planning (and incumbent support) have been key elements in e.g. Brazilian sugarcane fuel and French nuclear power
- centralised top-down approach needed for large-scale generation technologies such as carbon capture and storage.
- Licensing to enable rapid international diffusion

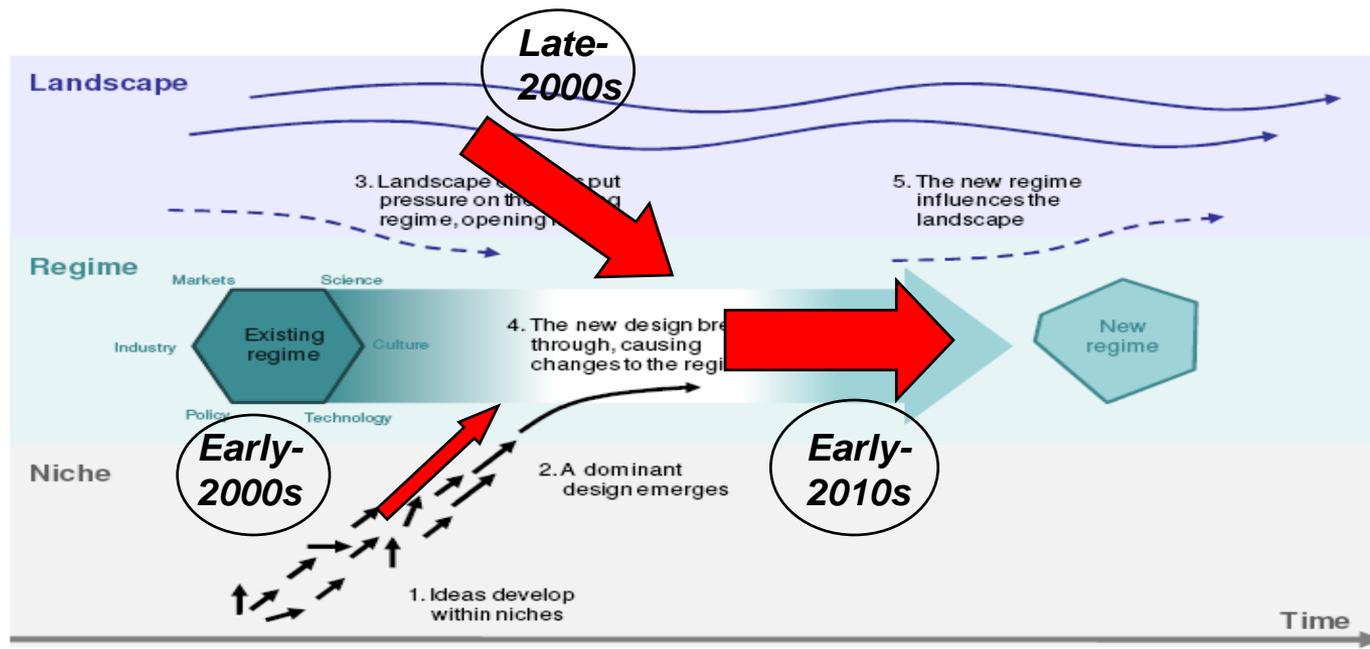


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Summary: changing energy innovation policy and theory relations

- For much of its recent history, energy innovation was a marginal, long-term endeavour
 - Niche-led innovation theories emerged during this period, and resonated with it
- Ambitious short term targets and fiscal austerity have provoked focus on continuity-based large-scale innovations, rather than radical or disruptive changes
 - Accelerated innovation is being mainly *regime-led*



Implications for Sustainable Innovation Theory...?

1. Reinforce niche-led framings of system innovation:
 - regime-led responses seen as the first phase of a sequence of transition types, with regime-overthrow to follow
2. Develop more structural / institutional framings
 - A richer, more nuanced account of regimes, with recognition (and detailed analysis) of the prospects of continuity-led *and* disruptive (niche or breakthrough) breakthrough dynamics for energy innovation and energy system change
 - Draw on insights from organisational studies, project management, risk studies, corporate strategy research literatures
 - all of which have now turned their attention to energy innovation

Conclusions

- Niche-led sustainable innovation theories offer original and important insights
 - Dynamic multi-level structuration
 - value of diversity and experimentation
 - risks of forced upscaling and early lock-in
- But, we need greater *ontological heterogeneity* in sustainable energy innovation studies
 - more fully engaging with the varied dynamics of regime-led accelerated innovation
 - their patterns, properties, strengths and weaknesses
- Revisit neglected themes in technology and innovation studies

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