Exploring UK Energy System Scenarios: Comparing Domestic Heating Futures

Dr Mark Winskel

Chancellor's Research Fellow
Science, Technology and Innovation Studies
School of Social and Political Science
University of Edinburgh

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Introduction

- Research Origins
  - Contributing to an ESRC project on *Heat and the City*
  - … while helping develop energy scenarios for the UK Energy Research Centre
- Substantive concerns
  - Changing scenarios of UK energy futures since the Climate Change Act
  - An emerging 'battle of the systems' between *building-level* and *network-level* heating technologies
- Meta-themes
  - 'whole systems' research / interdisciplinarity
  - role of long-term scenarios in policymaking
  - role of quantitative modelling in scenario exercises
  - research-policy exchange and expertise
  - 'good governance' (= accountability of public policy)

Outline of talk

- The return of energy futurology
- Mainstream accounts of UK heating futures
- Marginal accounts and comparative studies
- Discussion and Implications

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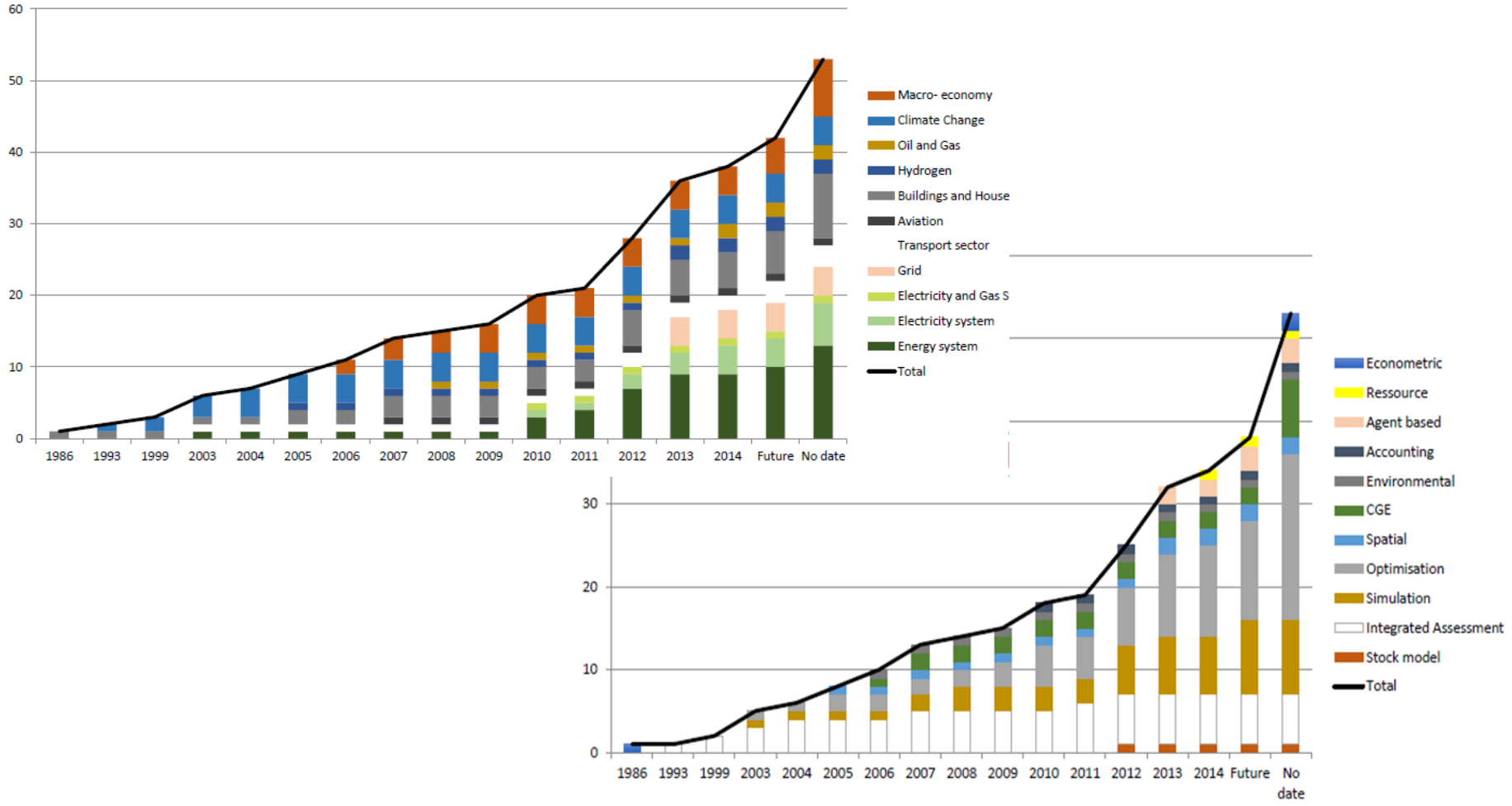
Energy modelling is a growth industry

UK Energy Modelling Capacity, by focus area and model type (Zeyringer, 2014)

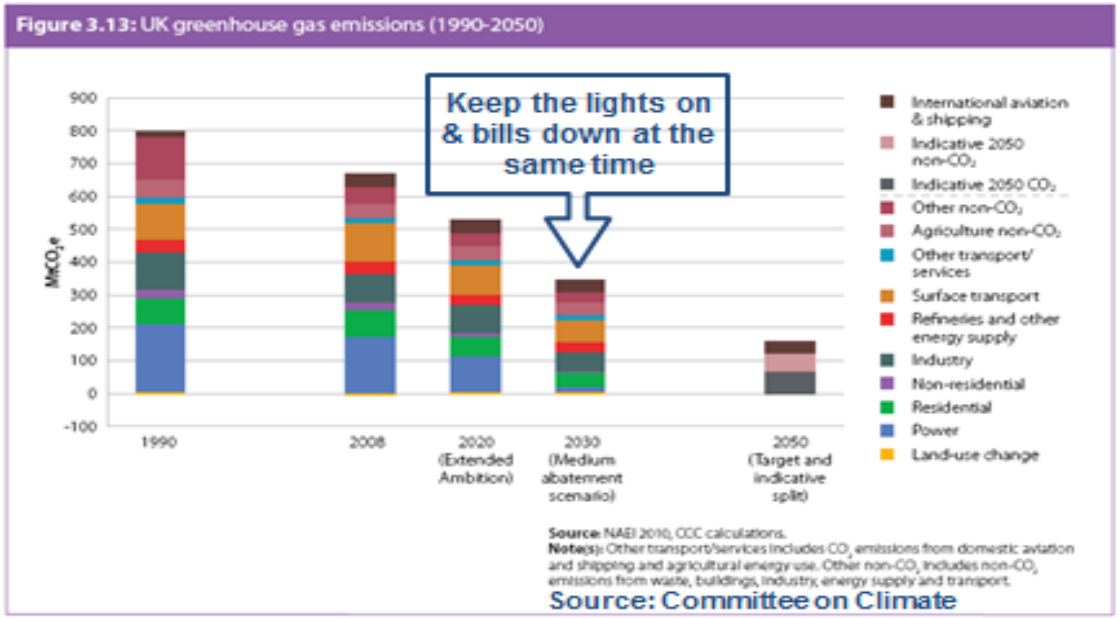


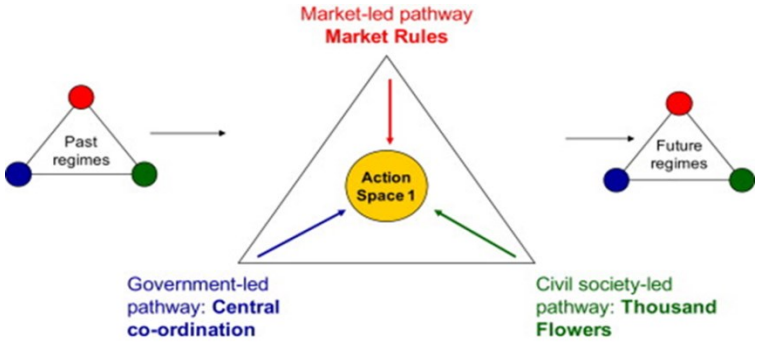
A scenario for any preferred future?

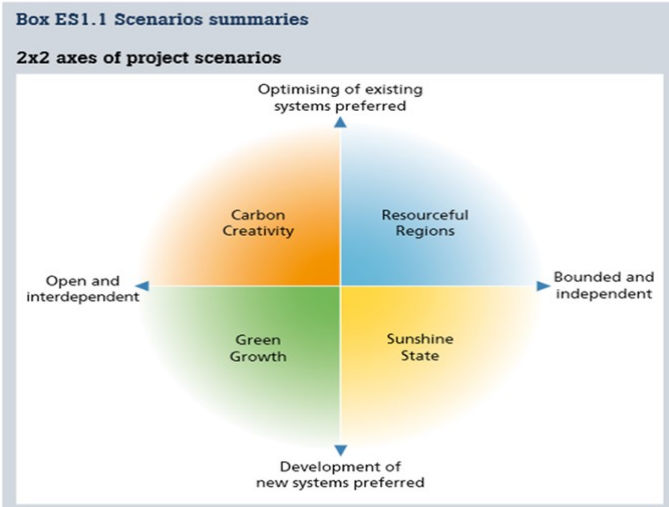
- Many ‘official’ versions of the future, from EC, UK government, Committee on Climate Change, Ofgem, Scottish Government, …
- Plus multiple ‘unofficial’ futures, from industry bodies, consultancy firms policy think tanks, environmental groups, consumer groups, academia …
- With more or less emphasis on:
  - *technology or behavioural change*
  - *… some technologies and behaviours above others*
  - *radical or incremental change*
  - *decentralisation or large system integration*
  - *public or private sector leadership*
- Reflects a fragmented research and policy infrastructure … for good and bad

So, why the return of scenarios?

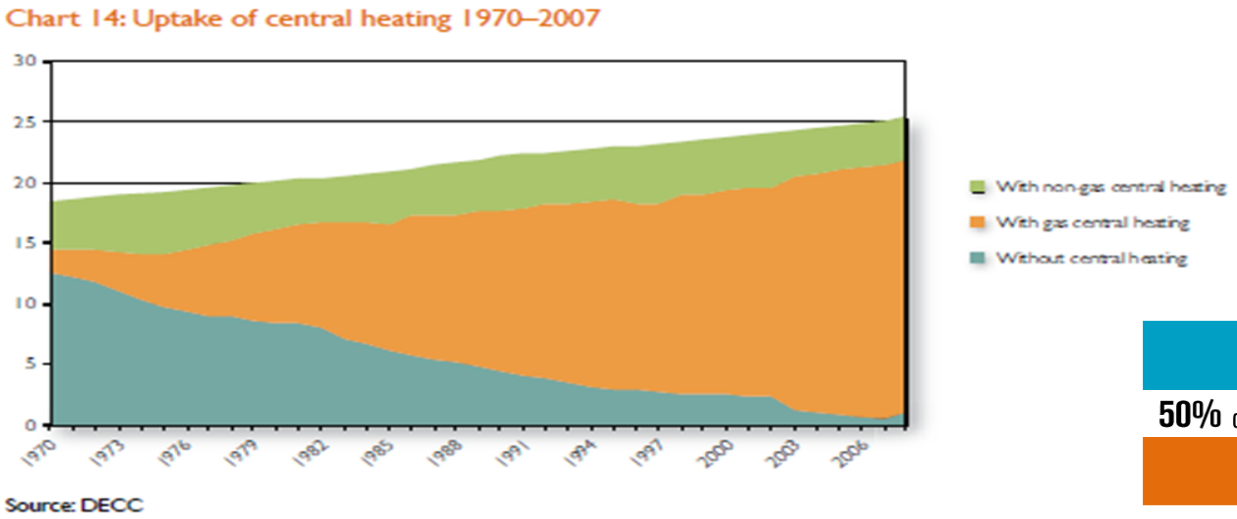
The UK's low carbon transition





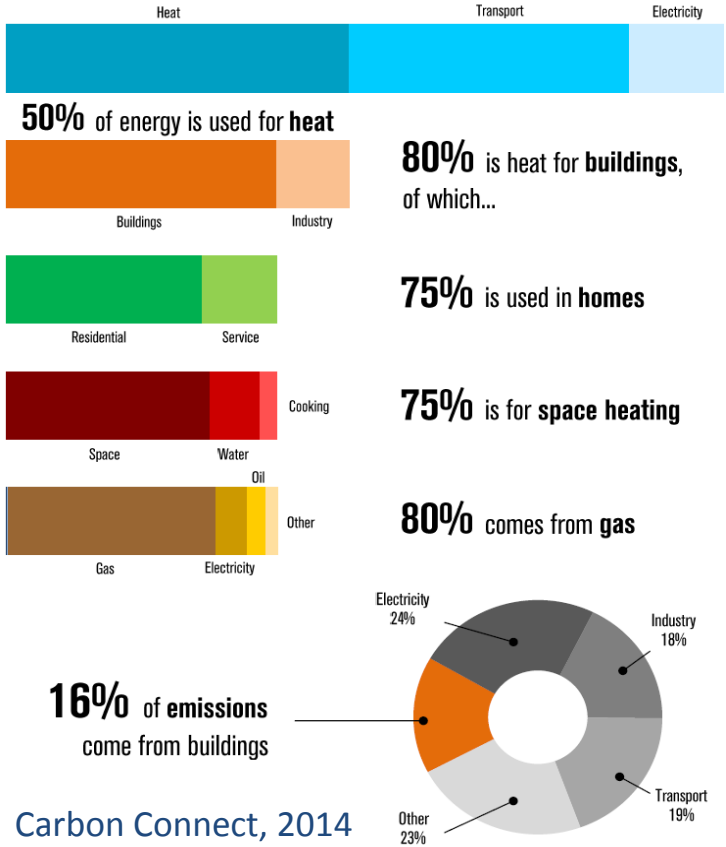


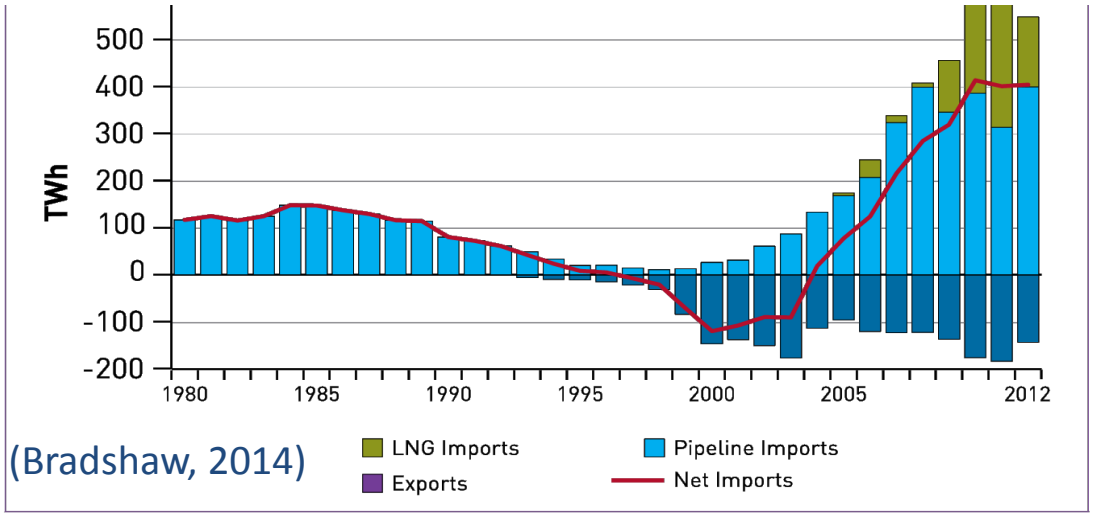
Material history of UK heat supply



Doubling of domestic energy bills in less than a decade since 2004
(Source: CCC).

The rapid emergence of a 'heat policy trilemma'





(Bradshaw, 2014)

Carbon Connect, 2014

Energy Policy Drivers

- **UK Climate Change Act** (2008)'80% by 2050' decarbonisation
  - implies a near wholesale shift away from unabated natural gas for buildings heating

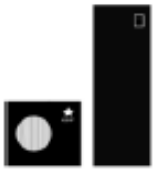
- **EC Renewables Directive** (2009) 15% of all energy from renewables by 2020
  - an rapid deployment programme of renewable electricity, especially windpower

- **EU Emissions Trading Scheme** (ETS) (2005) EU-wide limit on 'traded sector' emissions to 2020
  - relative UK policy emphasis on emissions from 'non-traded' emission (such as buildings heating)

'*you're not going to make your carbon budgets unless you do something about heat*' (DECC official, 2013)

Low carbon heating technologies

Electric Heat Pumps



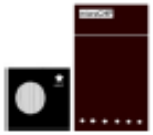
1. Will – under our base case - result in higher upfront costs and running costs than gas technologies
2. Requires an outdoor unit, hot water tank and typically some modifications to the heat distribution system (radiators + possibly pipework).
3. Will be more challenging in homes with very high heat demands (as a 3 phase connection will be required)

Electric storage heaters may be an effective solution for homes with very small thermal demands (e.g. new flats)

Micro CHP

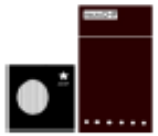
1. Carbon emissions critically depend upon assumptions for marginal electricity that is displaced
2. Have large (but uncertain) potential for cost reduction and performance improvement
3. Are a relatively straightforward retrofit (generally larger / heavier than a boiler & requiring hot water storage tank) – produce high flow temperatures.

Gas heat pumps



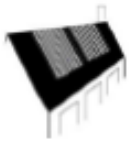
1. Are only emerging today, with high (but uncertain) potential for cost and performance improvements
2. Will bring similar (but slightly lower) retrofit challenges to electric heat pumps – potentially without requiring a hot water storage tank

Hybrid heat pumps



1. 50-60%* of heat demand from ASHP, rest form boiler
2. Flexibility in operation helps to avoid electricity system impact
3. Simpler retrofit than pure heat pumps

Solar Thermal



1. Relatively straightforward retrofit, providing south facing roof and hot water storage tank

District Heat

1. Requires a district heating connection into a house – and a hydraulic interface unit (like a boiler), without hot water storage tank.
2. Flexible heat source from energy centre (can be local or remote from residential customers)
3. No experience in UK in connecting existing owner-occupier homes to district heat networks (commercial risk in building new schemes).

Biomass

1. Some retrofit challenges - requires fuel storage (manually or automatically fed to boiler) and a larger heating appliance
2. Good fit with high flow temperatures in existing heat distribution systems.

(Delta EE, 2009)

The value of systems thinking and scenarios…

Understanding complex 'whole system' interactions

The heat challenge is a 'systems problem' … it cannot be fully solved by considering one part of the solution in isolation … the heat question is also the electricity question, the storage question and the infrastructure question

(DECC, 2013)

Efficient and accountable policy-making

Pathways illustrate some of the ways in which it is possible to allocate effort … [and] show different perspectives on how [policy] targets could be met

(UK Government, 2010)

Bringing the future into the present

Scenario exercises based on present-day knowledge and perceptions may under-represent the potential of emerging innovations to contribute to system change (Winskel et al., 2011)

Recent trend in energy scenarios: from central planning to 'co-production'

- Benefits of scenario exercises include opening-up dialogue, challenging prevailing thinking and creating plausible alternative narratives (McDowall et al., 2014)

- Many energy scenarios focus on high level trends and drivers, but lack institutional, organisational and regulatory detail (Hughes, 2010; Watson et al., 2014).

    - Volkery et al. (2014) need stronger connection between scenarios and decision-making, political context and institutional embedding

- Increasing attention on mixed methods and 'co-production'
    - e.g. Tompkins et al. (2014) offered a process based on stakeholder involvement, and centralised/localised and reactive/anticipatory futures

    - A challenge for independent, integrative whole systems research?

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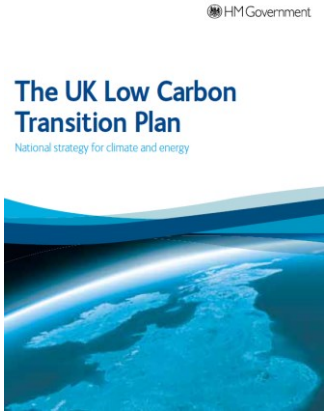
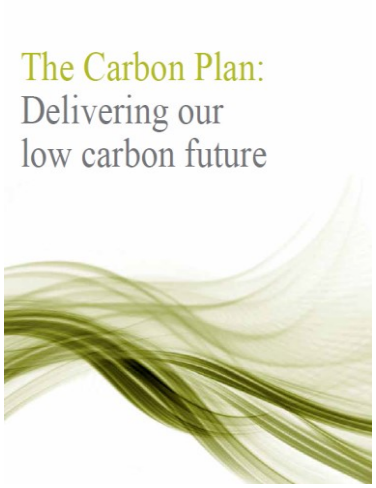
Mainstream UK heat policy-making since 2008

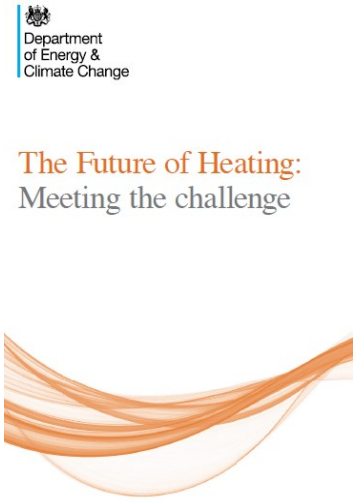
Climate Change Act 2008

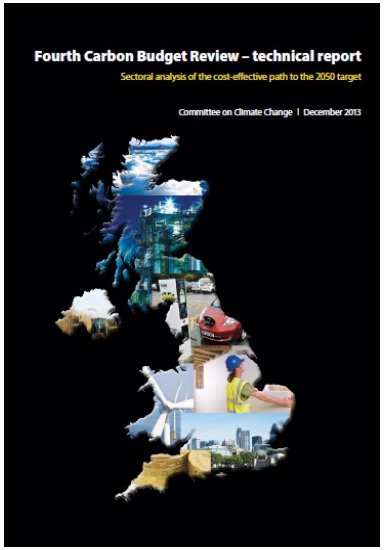


HM Government

2050 Pathways Analysis
July 2010





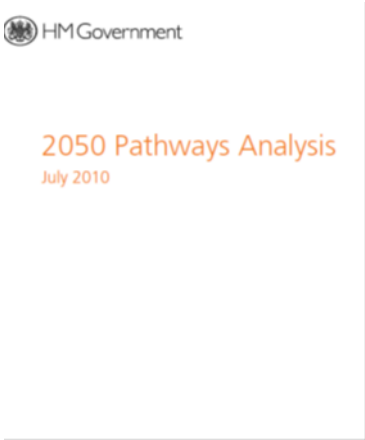


2050 Pathways Analysis, 2010

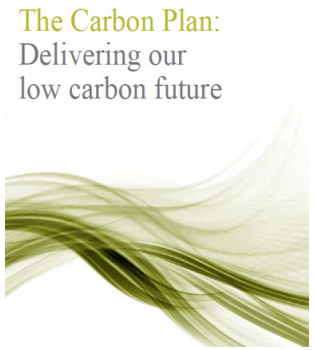
- Based on physical and engineering limits, not cost optimisation
- Helps establish the UK 'conventional wisdom' :
  - Rapid demand reduction
  - Decarbonised and electricity supply by 2030
  - Electrification of heating and gas, post 2030

'We should leapfrog over gas-powered combined heat and power and go directly for heat pumps'

David MacKay, DECC Chief Scientist, 2010



The Carbon Plan, HMG, 2011



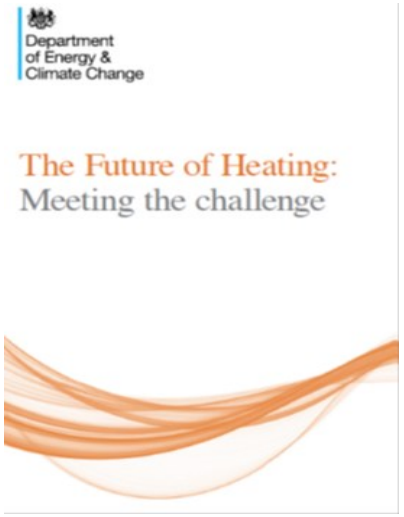
- A national-level vision of energy transition, using three system models and additional sector / network models
- Expectation of market-based technology selection
- Heat transition seen as a gradual process, taking many decades, with next decade as 'preparatory'
- Heat networks seen as viable in up to half of heat demand

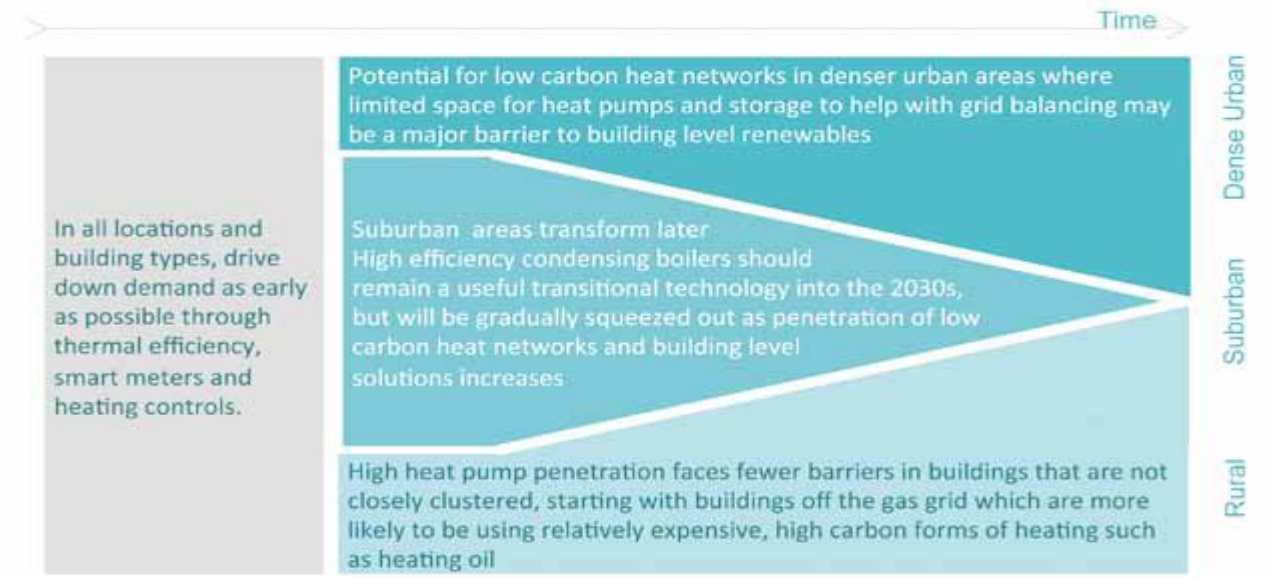
'A diverse portfolio of technologies, competing against each other for market share, can drive innovation and cost reduction'

'After 2020, heat pumps start expanding at scale, and heat networks expand form urban areas to compete with individual building-level technologies, so helping to keep costs down'.

DECC Future of Heating, 2012 and 2013

- A new emphasis on localism and diversity:
- *'a national transformation, and also a local one, with different solutions for different localities and geographies.'*
- More diverse sources of data and modelling, including industry workshops and field trials
- An emerging emphasis on hybrid technologies not included in earlier modelling





UK Committee on Climate Change (2008-13)

The MARKAL model … provides an indication of what could be achieved under ***optimal policy and decision-making****; by definition, deviation from this optimal solution will tend to increase overall costs* (CCC, 2008).

- Initial focus on meeting first three carbon budgets to 2022, using low carbon electricity and demand reduction
- For heating, an initial focus on biomass and solar thermal (2008), then heat pumps (2010), then a balance of heat networks and heat pumps (2013)
- More recent role for policy in 'keeping open' substantial contributions from both by 2050

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Building a Roadmap for Heat (Speirs et al., 2010)

- Commissioned by the Combined Heat and Power Association
- Highlighted weaknesses and blindspots of the 'all-electric' scenario:
  - No valuing of system diversity … tends to 'winner takes all'
  - Assumption of economically rational decision-making
  - Doesn't reflect local conditions and transitional technologies
- Adapted a CCC scenario to develop an alternative scenario, with greater technology diversity and infrastructure transformation

'decentralised energy, and major system changes, may be under-represented in existing scenario analysis'

Called for a policy focus on *diversity* rather than *optimality*

UKERC Uncertainties project (Eyre and Baruah, 2014)

Context

- Early UK explorations of heating focussed on the continuity and *reinforcement of trends*, with greater use of efficiency, CHP and on-site renewables.
- After 2008 a new *disruptive narrative* emerged: large scale conversion to low carbon electricity
  - optimisation models had limited detail of the UK building stock
  - results always treated sceptically in the building research community
  - Some moderation in the heat vision more recently, reflecting slower progress in HP deployment and rise of interest in DH and intermediate / bridging / hybrid technologies

Pathways for Heat (Carbon Connect, 2014)

- Industry sponsored study, compared six prominent UK buildings' heating scenarios to 2050
- System-wide national energy models unable to simulate the behaviours of users and investors, the impact of particular policies, and UK building stock and networks
- Detailed buildings or network models fail to model wider energy system interactions
- Need a better representation of local areas, consumer preferences and supply chain capacities.
- Need for greater transparency of scenario methods and more careful communication of results

'*there is a risk that their results are misunderstood because there is not enough context to understand their assumptions and limitations*' (Carbon Connect, p.7).

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Changing Visions: long term transitions and short term exigencies

- Dramatic recent expansion of activity in UK energy futurology, both from policy mainstream and margins
  - During this expansion, scenario content has changed very substantially
- Earliest mainstream energy scenarios had a short term outlook – focus on the next decade rather than decades-long transitions.
  - Reflecting interacting UK and EU policies
- The early 'all electric' vision was a simple techno-economic blueprint
  - neglected many social, institutional and behavioural issues
  - marginal voices not committed to it soon began to highlight its weaknesses
  - later scenarios have been less technologically radical, with greater diversity, mature technologies and hybrid combinations

Modelling Determinisms?

- Rise of the UK's all-electric energy vision was closely associated with techno-economic modelling, particularly MARKAL
- Early mainstream studies identified a determining role for modelling, around which policy (and wider society) should conform
  - reflected a need to establish the legitimacy of the radical vision embedded in the CC Act?
- Led to criticisms of 'spurious accuracy' and unable to withstand the contestations of liberalised political and research cultures
- More recently, trend to greater variety in analytical tools and evidence bases
  - With a role for policy to maintain diversity in the face of uncertainty

The role of modelling

- MARKAL as a durable 'boundary object' serving shared policymaker and researcher interests (Taylor et al., 2014)
- Present case suggests models can embody the views of both mainstream and marginal groups
  - focus of early scenarios were *upfront scenario design choices* as well as 'black box' modelling outcomes
  - more recent scenarios have been *designed* to exhibit technology diversity.
- But, early scenarios *did* lend a false confidence on the affordability and ease of system transition, and need for only temporary market intervention
  - simplification and over-optimism about low carbon innovation?

Changing Policy and Research Cultures

- Scenarios serve 'insider' institutional interests (e.g. Russell, 1993; Kern, 2012)
- In the present case: some biases and blind-spots in early mainstream scenarios, but also, a relatively fluid set of interests and preferred futures
- No simple supply-side bias: many scenarios emphasised energy efficiency and demand reduction – to an extent often not reflected in policymaking
  - suggests a role for scenarios as 'policy monitors'
- Erosion of any single vision for change reflects a shift from 'technocratic cores' to dispersed policy and research communities
  - Marginal counter-narrative scenarios were influential, suggesting a role for dissident visions and dissensus

Post-Technocratic Whole System Scenarios…

- Calls for 'pluralistic visions' (Stirling 2011, 2014) sidesteps the need for long term commitments (Walker, 2000) and accountable policymaking (Rutter, 2015)
- Alternative versions are partly *instrumental* (system definition and ordering) but also *normative* (governance and legitimacy)
- Studies which compare and synergise different scenarios offer important spaces for critical reflection
- Whole system scenarios will always be undermined by emergent uncertainties, shifting policy commitments and contested politics
  - an evidence-based 'optimal' path is a technocratic chimera
- Even so: a key part of good governance, in articulating, testing-out and comparing different claims about the future.

Thank You

M. Winskel (2016) ‘From optimisation to diversity: Changing scenarios of UK buildings heating’ in D. Hawkey, J. Webb, et al. *Sustainable Urban Energy Systems*, Routledge, London

mark.winskel@ed.ac.uk