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FAILURE TO MEET LONG-TERM UK CARBON REDUCTION TARGETS – A SYSTEMATIC ASSESSMENT

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OVERVIEW

Long term decarbonisation of the energy system is an integral part of the UK Government's strategy for the environment, energy and economy. The UK was the first G20 country to legislate [1] carbon dioxide (CO_2) reduction targets (of at least -34% by 2020 and -80% by 2050, relative to a 1990 baseline). A range of policy mechanisms [2] are now in place to put the UK on a path to meeting this target – an immense challenge that requires a fifteen fold reduction in emissions per unit of GDP. However, as the rhetoric on long-term CO_2 targets becomes ever tougher, there is widespread concern that these targets will be achieved – for example in a recent poll of energy experts only 9% thought the UK would reach its target of reducing CO_2 emissions by 80% by 2050 [3]. This paper systematically investigates this dichotomy.

Few energy-economists like investigating failure. There are comparatively very few energy-economic studies of very deep long term emission reductions [4]. Secondly, most modelling and scenario studies that do investigate such futures [e.g., 5,6] assume that this extreme exogenous constraint is met and then employ a "back-casting" process to investigate technological pathways, behavioural measures, costs, and uncertainties in meeting this target [7].

Scenario analysis of catastrophic failure is also not generally a popular subject choice, often viewed as defeatist or pessimistic [8]. However, challenging the existing and prescriptive world view can be extremely constructive [9]. Scenarios (and modelling) that break the assumption of meeting CO_2 targets can firstly challenge the consensus that implicitly exists around meeting targets, and secondly, identify protective and proactive strategies to anticipate failure to meet CO_2 targets from external and internal actors and drivers respectively.

METHODS

To systematically investigate failure to achieve long-term CO_2 targets, this paper utilises the UK MARKAL model – a partial equilibrium optimisation model that has underpinned UK policy analysis on the costs and pathways to meet such long-term targets [10]. The model maximises discounted economic welfare, taking into account evolving costs and characteristics of resources, infrastructures, technologies, energy service demands, behavioural price response and a range of taxes and policy mechanisms. As a perfect foresight model that assumes optimal behaviour, complete information, no market barriers and competitive energy markets, UK MARKAL represents a 'best-case' for the achievability and a lower bound for the costs of long-term energy policies. Systematically relaxing these assumptions explores the space between optimal solutions and the achievable pathways for such stringent CO_2 targets.

Credible failure scenarios are modelled via integrated sets of external and internal challenges. No attempt is made in this paper to assign probabilities to the failure of components, with resulting insights intended to be illustrative. The common mode failures are:

1. Key electricity technologies: As a principal low carbon vector for decarbonisation of buildings and transport sectors, prohibitive costs and/or public unacceptability of combinations of nuclear, carbon capture and storage (CCS), and offshore wind

2. Infrastructures: As a key enabling mechanism for a range of technologies, restrictions in the build rates of electricity, heat and hydrogen infrastructures
3. Timing: Delayed imposition of CO_2 targets due to political will or international consensus
4. Resources: As a price taker for energy imports the UK is vulnerable to prohibitive costs and/or unavailability of low CO_2 energy resources, especially biomass
5. Energy service demands: Higher demands for energy services combined with lower price elasticities to alter consumption patterns

RESULTS AND CONCLUSIONS

Initial insights illustrate that long-term CO_2 decarbonisation pathways are extremely challenging in terms of capital investment, low carbon resources, infrastructure and system operation. A full range of low carbon technologies and measures are required across all sectors. The power sector is an early and critical decarbonisation option, with overall negative emissions via a portfolio including biomass CCS. Resource constraint (e.g., on biomass) are routinely triggered, as are build rates of key infrastructures. Limits to energy conservation options and to energy service demand reductions are reached. High costs and very significant decarbonisation begins early to meet 2015-2020 interim targets (in a world where capital is yet to turn over and low carbon technology development is in its relative infancy). By 2050 marginal CO_2 prices rise to £290/tCO_2, with welfare costs (sum of producer and consumer surplus) rising to £B 36.0.

The integrated sets of drivers of failure, then investigates how if any of these model assumptions on foresight, competitive markets, and rational behaviour are relaxed, costs would increase further and indeed the feasibility of a solution would be questionable. Owing to the remaining paucity of decarbonisation technologies and measures, backstop technologies and emission permit purchases are employed to ensure the model solves. The resultant cost implications – and hence political feasibility – develops a hierarchy of failure scenarios.

Future extension to this work will include stochastic modelling to further investigate intertemporal and data uncertainties, and modelling to generate alternatives (MGA) to investigate structural uncertainty in the model. This will generate further insights into the causes and implications of failure to meet long-term CO_2 reduction targets and hence aid in the development of iterative policy making.

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