EPSRC 'Realising Transition Pathways' Consortium: Key findings

'*Realising Transition Pathways*', a 10-university multi-disciplinary consortium within the *Research Councils UK Energy Programme*, has explored pathways to a low carbon electricity system and their roles in the UK achieving its GHG emissions reduction target of 80% by 2050. The pathways are achievable, but challenging, and will require concerted effort from central and local government, market and civil society actors. There are different ways to realise a low carbon electricity transition, but choices about governance arrangements are crucial, alongside, and interacting with, technical, economic, environmental and behavioural factors. Balancing the energy 'trilemma' of low carbon, energy security and affordability is not easy, but a whole systems and multidisciplinary approach to examining energy transitions can inform the difficult decisions that need to be taken. Detailed results have been published in a large number of papers and reports – some key findings are:

Stimulating investment in low carbon options: Analysis of historical energy transitions demonstrates that rapid change is possible, but not frequent, and requires a high degree of coordination of actions, driven by recognised need to change: e.g. as in the shift from town gas to natural gas. Today's potential low carbon investors are faced with uncertainty about national policy priorities, and there are structural constraints on low carbon investment, including immaturity of the sector and mismatches between fund manager and renewable energy investment timescales. The economic feasibility of generation in all pathways will depend on revenues from secondary markets/sources (e.g. capacity market, FiTs, tax incentives) although the ratio of the revenue needed from primary and secondary markets is case specific. Comparison with the situation in Germany demonstrates the valuable role that can be played by locally-focused institutions, where civic ownership was supported by a local banking sector.

Roles of different low carbon technologies: the temporal mismatch between low-carbon generation and demand profiles may lead to very low utilisation factors of dispatchable generation. This is likely to affect financing of gas-fired power stations, and hampers prospects for Carbon Capture and Storage, which will need to be fitted to fossil-fired generation to achieve long-term carbon budgets. In terms of sources of gas, despite exhibiting unwanted 'side-effects' and generating community resistance, shale gas fracking may contribute to attaining the UK's GHG targets if appropriate and robust regulations are enforced. The supply-demand balancing issues could lead to increasing curtailment of renewables and additional consumption of fossil fuel. This leads to significant potential for electricity storage; however innovation is needed to bring forward options for longer term storage.

Demand Side Response: another option for supply-demand balancing, DSR offers benefits to all parts of the energy system, estimated to amount to £5billion per year. As transport and heating services are increasingly electrified, there are new opportunities for DSR: e.g. research into social practices and service expectations combined with technical modelling shows that if householders would tolerate a drop in indoor temperature of 1°C for up to ten days a year, between 3 and 9 GW of peak supply capacity could be avoided.

Distributed energy: With strong demand reduction and management, 50% of 2050 final electricity usage could be met via distributed generation with emerging technologies, new infrastructures (including interconnections), and new institutions. A more distributed system will require regional energy strategies and local capacity building for city regions, municipalities, communities, and citizens. A distributed energy system opens up new avenues for energy transition finance, while challenging incumbent utility business models.

Upstream emissions: It is important to include upstream emissions (beyond UK borders) in a whole systems analysis (which neither DECC nor the Committee on Climate Change routinely do), as upstream emissions are significant in some cases. Life Cycle Assessment studies have shown an increasing uptake of bio-methane into the gas supply substantially reduces direct grid emissions and is critical in offsetting increases in upstream emissions.

Political and societal dimensions: Energy transitions are never smooth and always subject to contestation, negotiation and social change. New evidence and case studies of UK energy transitions provide practical advice on how sustainable energy transitions will depend on science and policy institutions becoming more responsive and adaptive to distributed societal actions.

Whole systems analysis: These and other findings have benefited from a whole systems and collaborative working approach, which combines quantitative and qualitative analyses for elaborating and examining pathways for realising a transition to a low carbon, secure and affordable UK energy system by 2050.