‘Scottish Energy Strategy: The Future of Energy in Scotland’ Scottish Government, Edinburgh

Consultation response by the UK Energy Research Centre (UKERC)

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ABOUT UKERC

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Introduction

The Scottish Government's draft Energy Strategy is highly ambitious. In light of the essential global challenge of climate change and the need to transform energy systems, we believe such ambition is needed and should be replicated in other jurisdictions. In this sense, we believe the Scottish Government is taking a valuable lead. We do not seek to judge the political advantages (or disadvantages) of such ambition, but recognise that it has the potential to bring economic and social advantages – for example, the development of low carbon industrial capability with export potential and jobs, and improved air quality with associated health benefits. However, it is also important to ensure that the scale and pace of the transition minimises the additional costs for consumers. This can be achieved by supporting technological innovation that further reduces the costs of low carbon technologies, and by maximising investments in energy efficiency.

If such a strategy is to attract the necessary stakeholder investment and societal change, the set of targets and policies to achieve those targets also needs to be credible. Many of the comments we make below draw on the available evidence in order to help establish and maintain this credibility. Nonetheless, we recognise the extensive analysis and discussion that has informed the draft Energy Strategy. One of the very welcome aspects of the current consultation is the opportunity to suggest some modifications of the Strategy and the way it is presented.

We have taken into account the fact that the Energy Strategy consultation is one of a number of related consultations taking place concurrently. The others include a draft Climate Change Plan (the draft Energy Strategy and Climate Change Plans are described as 'freestanding companions'), as well as more specific consultations on local heat and energy efficiency strategies (LHEES) and regulation of district heating, the Scottish Energy Efficiency Programme (SEEP), onshore wind and unconventional fuels ('fracking'). Although UKERC is responding formally only to the Energy Strategy consultation, researchers associated with UKERC are also submitting to the consultations on LHEES, SEEP and unconventional fuels, and UKERC researchers have also provided oral and written evidence to the Scottish Parliament's consideration of the Draft Climate Change Plan and Energy Strategy (e.g. Winskel, 2017). We stand willing to offer further support to the Scottish Government and Parliament as the consultation and revision processes continue.

The draft Energy Strategy has high-level commitments to a 'whole systems' approach and a 'managed transition' to a low carbon future. These are welcome, and resonate with UKERC's own view of energy research and policy advice. We endorse the Scottish Government's efforts to develop an integrated and comprehensive understanding of energy system change, alongside the wider role of energy and climate change policy. Without this, policy and regulation are at greater risk of unintended and undesirable impacts, poor connectivity between aims and outcomes, and of failing to strike an appropriate balance between policy consistency and stability versus responsiveness and flexibility.

In practice, whole systems analysis and policymaking are both highly challenging, particularly at a time of high technical, economic and political change and uncertainty, and there are particular challenges in the Scottish context. As part of its efforts to better integrate policy, the Scottish Government has commissioned a whole system energy model: 'Scottish TIMES'. Within a set of constraints defined by the user, Scottish TIMES develops 'optimal' (i.e. least projected total system cost) future energy paths for the Scottish territorial boundary, with flows in and out of the Scottish system seen as imports and exports. In practice, energy supply and use in Scotland is highly integrated within a GB system, especially for both electricity and gas / heating infrastructures, and the UK economy. It is also affected by global trends that affect important energy trends such as the availability and cost of key technologies, and the price and availability of fossil fuels.

For example, the decarbonisation of power generation in Scotland has been achieved within the operation and development of the GB power system, including revenue support from bills paid by consumers across GB and the techno-economic balancing of supply and demand on a GB basis. A focus on Scottish Government action is welcome and highlights important responsibilities and actions that can be taken within Scotland. However, an under-emphasis on the mutual support that can be given by different regions – not only of the UK, but also Europe – risks imposing additional costs on energy users in any one region.

These cross-scale challenges apply to any modelling that is intended to inform policy. This is true of a model of Scotland as part of a wider system but also applies at finer scales, e.g. for cities and regions. We believe there is a continued need to develop models and other forms of evidence at different scales that are complementary, with each providing details at particular scales while also offering consistency across scales. A research priority is to better link Scottish TIMES and the UK versions of TIMES models (as part of a broader effort at improved multiscale modelling). Another research ambition is to create a multi-region UK TIMES model that examines Scotland within the UK context. Given the important limitations of optimisation models such as TIMES, it is also important that other forms of evidence are used to inform policy development and implementation.

Understanding the embeddedness of the Scottish energy system within the GB / UK system is especially important at a time of uncertainty over UK energy policy. Until parliamentary dissolution, the UK Government was expected to publish a comprehensive Emissions Reduction Plan in 2017. In its absence, some of the then UK Government's energy policy priorities are indicated in the Industrial Strategy Green Paper (HMG, 2017).

Here, the UK Government calls for a greater emphasis on affordability and economic growth, alongside decarbonisation. In some key areas – energy efficiency, low carbon heating and the development of carbon capture and storage – there is currently a lack of policy detail at the UK level (UKERC, 2016). There are also indications of an emerging difference in the pace of change, and perhaps direction, between Scottish and UK Governments. This is a concern for the affordable delivery of Scottish energy system change, given the interdependencies of Scottish and UK energy systems. More specific areas of concern are discussed later in this response.

In principle, a credible whole energy system analysis helps to ensure that the effects of particular policies in one sector on another sector are well-understood. When seeking to deliver ambitious targets, this becomes especially important as there will be important trade-offs; a model such as Scottish TIMES can allow these trade-offs to be explored and sensitivities better understood. It will be important for citizens and stakeholders to understand the impacts of a strategy for different sectors. Although the draft Climate Change Plan outlined the impacts on different sectors, it included only a single scenario with only one set of inputs and constraints, limiting discussion of trade-offs and the often difficult choices involved. It also risks the single trajectory presented as being interpreted as a 'forecast' of the likely nature of the future energy system, as opposed to an agreed pathway incorporating predicted – but ultimately unknown – extraneous variables. Retrospective analysis of UK energy futures by UKERC has shown that scenarios tend to reflect contemporary debates rather than a wider range of insights (McDowall et al., 2014), and the construction of a Scottish narrative based strongly in existing policies, such as continued use of North Sea resources, risks a continuation of this trend.

It is important to recognise that energy system models can underplay uncertainties and develop 'false confidence'. This is especially the case for optimisation models such as TIMES which assume 'perfect foresight' and do not capture real-world decision making by multiple actors or the politics of energy transitions. Some of these shortcomings can be ameliorated using a combination of complementary analyses, including other more specific models (e.g. of the housing stock or of detailed electricity system balancing). We encourage the final version of the energy strategy to include a structured exploration of pathways and uncertainties to meet Scottish energy policy goals under different assumptions about the future. This could include: sensitivities to different assumed availabilities and costs of low carbon technologies (such as with or without CCS); differing possible levels of demand reduction and energy efficiency; differing types of lifestyle and behavioural change; and differing fossil fuel costs and availabilities. For example, the BEIS Fossil Fuel Price Assumptions include a range of medium-term trajectories for oil, gas and coal prices that could be used to 'stress test' policies – including their costs (BEIS, 2016).

Systematic analysis of some energy system uncertainties has been carried out by the UK

Committee on Climate Change and UKERC among others (e.g. Watson et al., 2014), and while the results are strongly shaped by analytical assumptions and framing, such analysis allows for a system-wide consideration of where policy effort might be best directed and the timing of key decision points, according to some agreed understandings of the future.

Due to the very high capital costs and long lifetimes of many facilities, an energy system's infrastructure is especially vulnerable to 'lock-in' due to earlier decisions. Some of the transitions envisaged – not only in the draft Energy Strategy, but also elsewhere – depend on major changes to infrastructure, e.g. re-purposing the natural gas system and development of a system for the transport and storage of CO_2. The electricity system is especially sensitive to different pathways, either requiring significant expansion or becoming, to a large extent, stranded. There is now much prudent talk of 'low regret' commitments that minimise the possible adverse consequences of early decisions, either through options that can be easily adapted as information changes or simply by delaying decisions. We would like to see the capability of models such as Scottish TIMES used to illustrate the range of possible decisions and investments considered 'low regret'.

The underlying modelling also assumes, within the principles of cost minimisation, that all investment decisions are made in a universally coordinated and centralised manner. As we note above, such decisions are made by a wide spectrum of energy system actors. Furthermore, not all required powers are clearly devolved to the Scottish Parliament, nor will become so following the new responsibilities accorded by the Scotland Act 2016. In this respect, the Strategy would benefit from a clear introductory statement of which policy areas sit within the jurisdiction of the Scottish Parliament, and which will rely on engagement with identified UK and international bodies

In summary, while we welcome the Scottish Government's energy and climate policy ambition, and the opportunity to contribute to the consultation process – we would encourage the final strategy (and future versions) to include a richer and more integrated analysis, and interpretation of the possible implications of such analysis for policy. This is an important basis for strategy and investment, as well as realising the Government's ambitions for a holistic and managed transition. We would be happy to engage further with the Scottish Government on the future development of the Strategy, both in terms of direct Scottish policy concerns and in relating these to developments at UK and European policy, as well as international trends.

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Response to Specific Consultation Questions

In our response to the specific consultation questions, we often refer to the evidence presented in the draft Climate Change Plan as well as the draft Energy Strategy, as the former includes more detail on integrative whole systems analysis than the latter. Although they cover different timescales (the Climate Change Plan considers developments to 2032, the Energy Strategy to 2050), we recommend that the final versions of the documents offer a more consistent presentation of analysis.

We have responded to all questions apart from Q14. Wherever possible we have used publicly available evidence, with links provided.

Part A: Supply

Q1. What are your views on the priorities presented in Chapter 3 for energy supply over the coming decades? In answering, please consider whether the priorities are the right ones for delivering our vision.

Firstly, we note that the format of the consultation invites an essentially disaggregated analysis of Scotland's energy future, with supply and use discussed separately, and with a series of specific solutions and technologies discussed in turn, rather than starting with a more integrated whole systems discussion. This risks overlooking or underestimating the significant and growing interdependencies between energy supply and use. For example, on low carbon heat (identified as a priority concern in the draft strategy) an integrated analysis of supply and demand is critical for analysing the merits of different solutions. This is because reducing heat demand (either through policy measures or otherwise) has significant implications for the preferred type and level of investment in low carbon heat supply (Eyre and Baruah, 2014; MacLean et al., 2016).

Consideration of the future priority areas for Scottish energy supply should also take place against a recognition of the interdependencies between Scottish and GB / UK energy systems, the important role to date of the European Union policy and regulation in some areas, and the broader international dynamics of energy innovation and the cost and availability of technologies and fuels and their political and social acceptability. From a multi-level Whole Systems perspective this means understanding areas of alignment and divergence and, despite some emerging differences, there are still many areas of agreement / alignment between Scottish, UK and European policies and energy futures. For example, in our response to the UK Government's recent consultation on the Future of Heating (Lowes et al., 2017) we noted a broad consensus on the need to shift away from the current UK and Scottish high heat demand system, which largely relies on fossil fuel sources of energy consumed in poorly insulated buildings, towards a system that combines high levels of energy efficiency with low-carbon heat technologies and resources.

However, it is also important to note that in some areas the draft Scottish Climate Change Plan and Energy Strategy suggest a significant divergence between UK and Scottish policy in terms of the pace and direction of change. Scottish plans in key areas such as energy efficiency and buildings refurbishment, low carbon heat supply and carbon capture and storage appear to run several years ahead of UK Government timescales, and also ahead of the Committee on Climate Change's 5th carbon budget recommendations (CCC, 2015). This relates to the high overall policy ambition in Scotland, but also, to the concentration of effort (and therefore risk) in particular sectors of the Scottish economy.

The draft Climate Change Plan focusses its decarbonisation efforts on power generation with the anticipated arrival of a 'negative emissions' factor for the Scottish power system by 2027, based in part on Bioenergy-based carbon capture and storage (BECCS), and the residential and non-residential buildings stock (where the CC Plan pathway envisages a very rapid change in heat supply technology). This concentrated approach to system change carries concentrated risks. CCS, although still credibly seen as a key part of the least cost path to economy-wide decarbonisation, has suffered from successive false starts in the UK over the past decade, and BECCS has yet to be deployed at scale anywhere globally (Smith et al., 2016). (An ongoing UKERC research project, led by Prof Pete Smith, Aberdeen University, is carrying out a whole systems analysis of BECCS). The Energy Strategy identifies BECCS as an 'opportunity' to be explored (p37) while the Climate Change Plan has it as a key element of the pathway presented. This clearly highlights the benefit of illustrating alternative strategies which identify a role for CCS without the support of substantial bioenergy, or for CCS to fail to support the decarbonisation pathway entirely.

The emerging Scotland-UK policy divergence is particularly evident for the envisaged pace of the low carbon heat supply transition. In its 5th Carbon Budget advice, the Committee on Climate Change suggested that only around 1 in 7 UK homes and half of UK non-domestic buildings will be supplied by low carbon heating in the early 2030s, with strategic decisions on low carbon heat supply not being made until the early 2020s (CCC, 2015; CCC, 2016a). By contrast, the draft CC Plan pathway has 80% of Scottish domestic buildings and 94% of non-domestic buildings supplied by low carbon heating by 2032, with the transition compressed wholly into the years 2025-2032. This implies a deep intervention within the heat supply replacement cycle of house and business owners – some studies suggest consumer unwillingness to migrate to new sources of heat (Wales and West Utilities, 2015; CXC, 2016).

Although the Scottish Government sees the next several years as critical for demonstrating and analysing options on low carbon heating, there are no details provided in either the draft Climate Change Plan or Energy Strategy on Scotland's low carbon heating technology portfolio in 2032. This is understandable since there is considerable uncertainty about which low carbon heat supply technologies will be most cost effective in which contexts, or the pace with which change can be delivered (Watson et al., 2014). There is therefore the risk that the assumed levels of carbon savings from buildings heating will, from a policy perspective, lack credibility and, as a consequence, fail to build the confidence among investors necessary for their achievement.

While CCS and particular low carbon heating technologies may have critical roles in for decarbonisation efforts in Scotland and beyond, their development is still uncertain. There is likely to be limited scope for the Scottish Government to sponsor their development. However, anything Scottish government can do to accelerate the demonstration of different low carbon heat options would be welcome, especially if this can improve the overall evidence base on cost effectiveness, consumer responses and ease of installation. ClimateXChange and the UK Energy Research Centre convened a 'heat summit' in Edinburgh in September 2016, bringing together Scottish policymakers and leading UK researchers on heat transitions. The summit identified priority areas for research, policy and practice to support the decarbonisation of Scotland's heat supply and demand in the context of emerging Scottish policies (see CXC, 2016). UKERC also recently undertook a systematic international review of policies to promote low carbon heat supply (Hanna et al., 2016).

As already noted, to concentrate decarbonisation effort in particular parts of the economy that are subject to particular uncertainties seems to be a risky approach and it may be more prudent to devise a more balanced spread of effort across the economy, with more emphasis on sectors such as transport, land use and industry. For example, analysis and advice by the UK Committee on Climate Change on meeting Scottish emission targets to 2028-2032 (CCC, 2016b) featured a more evenly distributed pattern of emission reductions across the Scottish economy, with greater emphasis on demand reduction and less disruptive technological change than envisaged in the Climate Change Plan pathway. The CCC followed a bottom-up, sector-by-sector approach and had no access to the Scottish TIMES integrated whole systems model.

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Q2. What are your views on the ***actions for Scottish Government*** *set out in Chapter 3 regarding energy supply? In answering, please consider whether the actions are both necessary and sufficient for delivering our vision.*

Overall, we recommend that the Scottish Government develops its portfolio of support measures on energy supply according to a consistent and transparent set of criteria, so that effort and interventions can be justified in a balanced and evidence-based way. In the UKERC response to the UK Government's Industrial Strategy Green Paper (Bell et al., 2017a), we stressed the importance of an evidence-based approach to priority-setting, to ensure appropriate use of limited public money and policy attention, and we identified a number of criteria that should inform policy priorities. For energy industrial strategy, these include: the potential Scottish, UK and global market for different low carbon technologies; the potential for cost reductions (including the effect of policy on such cost reductions); the potential value to the domestic components of supply chains; and the extent of existing scientific and industrial capabilities. For an integrated energy strategy, policy support should also be judged against the likely contribution to domestic energy system futures (see also IEA, 2011).

Chapter 3 of the Energy Strategy identifies five priorities: continued support of oil and gas; demonstration of CCS; exploring new energy sources based on hydrocarbons; increasing renewables generation; and flexibility and resilience. The emphasis on continued support of oil and gas is understandable given the historic and continuing importance of the sector to the Scottish economy. However, this role has already declined significantly and the overall trend is for further reductions in the centrality of the sector to the Scottish economy. Furthermore, the Energy Strategy fails to acknowledge that significant proportions of global fossil fuel reserves will need to remain in the ground, even if CCS technologies are successfully commercialised on a large scale (McGlade and Ekins, 2015). This means that plans by individual countries and firms will need to consider whether some of their reserves should remain unexploited, rather than assuming that this 'unburnable carbon' is simply someone else's problem.

More attention is also needed on the decommissioning and repurposing of Scottish oil and gas facilities and expertise – and how to anticipate and address any negative consequences of decline for the communities that may be affected. There is also an opportunity to identify particular synergies between hydrocarbon-based and low carbon aspects of energy systems: for example, natural gas-based steam methane reformation using CCS may play an important role in Scotland's low carbon heat transition.

Although they have been associated with significant cost reductions, there may be a case for reforming arrangements for contracting for offshore wind and other renewable sources of electricity. For example, there is a need to include as many renewable technologies as possible within auctions (including onshore wind) to minimise costs. There is also a need to revisit the practice of indexing contracts to the wholesale electricity price (Bell et al, 2017a). Recent contracts awarded to offshore wind developments in Dutch and German waters have, compared with the previous round of auctions for Contracts for Difference in the GB, established very low prices for energy. It remains to be seen what prices the next GB Contracts for Difference (CfD) auction will deliver, though a number of commentators do not expect them to be comparable to the Dutch and German contracts, largely because the latter do not include the costs of connections to the main transmission network, but also because of the way, in GB arrangements, identification and development of sites and projects (including gaining of planning consents) is undirected and left to individual developers.

On flexibility and resilience: Renewable generation tends to be located in different places from fossil fuelled generation; power flows on the network change as a result, giving rise to a possible need for network reinforcement. For example, the CC Plan pathway envisages a need for £7bn spending on transmission networks by 2032. However, much new generation may be expected to connect within the distribution network and some growth in demand may be expected as a result of at least some electrification of transport and heat demand. These will give rise to a need to also reinforce the distribution network, though the extent depends on the precise location of new connections and their scale.

In common with other countries where the use of highly variable and somewhat uncertain sources of electric power is growing, the challenges associated with secure, stable operation of the power system are also growing, especially in locations, such as GB, with limited capacity of interconnections to other countries. Management of the variability and uncertainty of wind and solar and any necessary reinforcement to accommodate their power exports do give rise to extra costs, meaning that a simple, production-only, levelised cost of energy is an incomplete representation of the economics. However, as found by a recent review by UKERC on the costs and impacts of intermittency within the UK / GB energy system (Heptonstall et al., 2017), this additional cost is likely to be relatively modest. In UK conditions, additional costs of around £10/MWh are likely for shares of intermittent renewables of up to 30%. As noted in (Bell and Hawker, 2016), adding these to the likely costs of the lowest cost renewables is within the range of the uncertainty associated with the levelised cost of energy from

CCGTs (especially when the costs of carbon emissions are included) or nuclear power.

Although electricity is only part of the energy system, it remains fundamental to modern life. If not adequately managed, is also particularly sensitive to disturbances. Decades of good industry practice in delivering a safe, reliable supply of electricity need to be continued. However, it is also essential that the low carbon transition is accommodated as cheaply as possible. As noted in the E3G report cited in the draft Energy Strategy, Heptonstall et al. (2017), and National Grid (2016), sufficient flexibility and controllability of resources (e.g. generation, storage and flexible demand) are required to accommodate the fluctuations and uncertainty of the net demand after utilisation of available low carbon generation. Furthermore, the more flexible an electricity system is, the lower the costs of integrating renewables will be. The capacity market and various ancillary services markets exist to help the system operator manage the variability that is already seen.

However, in our recent submission to the Ofgem / BEIS call for evidence on a smart, flexible energy system (Bell et al., 2017b), we argued that the way in which different system operation services are procured needs to be changed to ensure a least cost for consumers. This is particularly so in respect of how particular equipment can deliver multiple services, the utilisation of distributed resources across the transmission-distribution divide and recognition of the locational value of schedulable generation, storage, interconnection transfer or demand, i.e. that for which the import to the main system or export from it can be planned with confidence over some period of time. Reforms to trading and access arrangements and the procurement of system services could be quite far-reaching.

In Bell et al. (2017b), we identified a set of principles to underpin this: competition and choice for consumers; safe operation of the system operated within relevant physical limits; enabling energy consumers' access to the system; minimisation of the overall cost of the system through suitable signals, such as locational prices or tariffs aimed at parties able respond to them; and scope for innovation. Depending on the level of ambition, the regulatory changes to deliver this could be quite complex. Given Scotland's tight coupling in both electricity system and market terms with the rest of GB, it is therefore unlikely to be something that could be delivered unilaterally from within Scotland; however, as has been shown in respect of debates around system resilience and black start, informed voices from within Scotland can make significant contributions to debate at a GB level in the best interests of electricity users across the whole of Britain, as well as in Scotland.

The location of schedulable sources of power will be especially important for Scotland in the coming years. It is important as a tool for the system operator to manage flows into Scotland under extreme weather conditions, when wind farms are either shutting down and starting up again as wind speeds vary around their high wind shutdown thresholds, or have shut down for a long period due to very high wind speeds. These same conditions also lead to a rate of occurrence of transmission and distribution networks faults that is significantly higher than normal. Schedulable sources of power in the right places that, when called upon, can operate reliably for a reasonable period of time are also important for the rare but entirely credible event of a regional or whole system black start. Without them, restoration times are significantly extended.

One particular recommendation in this regard would be that the location of such sources of power is taken into account in the capacity market. Scotland has particular geographical features that may dictate particular solutions to system problems. This is especially the case for remote, rural areas with quite low demand and weak connections to the main electricity system but high dependency on electricity. In such circumstances, the value of battery energy storage relative to alternative means of enhancing service resilience can be significant. As discussed in (Bell et al., 2016?), regulatory rules preventing network owners from owning and operating storage are a potential barrier to this. Lessons from recent projects such as one on the use of batteries in the Orkney isles may be useful in this respect.

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Q3. What are your views on the proposed target to supply the equivalent of ***50% of all Scotland's energy consumption from renewable sources by 2030****? In answering, please consider the ambition and feasibility of such a target.*

An important consideration when setting any targets is whether there are likely to be sufficient drivers for such targets to be met – either from ongoing market dynamics and/or government policy. Therefore, judgements about the feasibility of this target depend heavily on whether the policy and other incentives for renewables deployment are likely to be strong enough. The challenge for Scottish government is that it can set ambitious targets for renewables, but it does not have control over many of the policy mechanisms that could help to achieve such targets. Feasibility therefore depends on a view about the commitment of the UK government to further market creation policies. Whilst there are some policies in the pipeline (e.g. further auctions for Contracts for Difference), there is very little detail about UK policy beyond 2020.

Based on published analysis, it is difficult to develop an independent assessment of energy system portfolios for Scotland consistent with the 50% renewables target in terms of their economic, technical and societal feasibility. We feel that such an assessment can be useful in either informing some revision of a strategy or in helping to build confidence in it. Work by UKERC and others shows the importance of 'outsider' expertise and scenarios in challenging 'official' scenarios (McDowall et al, 2014; Winskel, 2016), and we therefore welcome the Scottish Government's intention to offer wider access to Scottish Government modelling and analysis later this year.

The '50% by 2030' of all energy (heat, transport and electricity) consumption (equivalent) to be supplied from renewables is described in the draft strategy document as 'capturing' the whole system view of Scottish energy futures. However, it is important that the pursuit of high-level targets is approached from a whole systems perspective, including demand side issues alongside supply side change. Modelling carried out for the Climate Change Plan suggests that between 44-50% equivalent of Scotland's demand could be generated by renewable sources, and that 11-17 GW of installed renewable electricity generation in Scotland will be needed by 2030 to fulfil the target, compared with around 7.5GW of installed renewable electricity capacity in 2015. Supply of electricity from renewable sources in Scotland already exceeds demand in Scotland for many hours of a typical year; utilisation of the supply therefore depends on adequate transmission export capability through Scotland and southwards through England to the main demand centres. Economic and efficient investments to facilitate the electricity market are licence requirements of the electricity transmission licensees but, aside from its role in respect of planning permissions, are outwith the control of the Scottish Government.

The cost implications of a supply-side strategy based on 50% of all demand from renewables relative to other means of decarbonising are not discussed in the draft Energy Strategy document. Separate modelling related to the 50% target was carried out by Ricardo E&E and UCL Energy Institute in 2016, commissioned by FoE Scotland, RSPB Scotland and WWF Scotland (Ricardo E&E, 2016). This presented a similar range of renewables penetration to that outlined in the draft energy strategy, for pathways consistent with the Scottish Climate Change Act. In Ricardo's analysis, between 44-48% equivalent of Scottish energy consumption in 2030 is supplied by renewables, including 40% of heat demand, 18% of transport demand, and around 145% of the demand for electricity within Scotland. It is important to note that this analysis used a 2-region energy system model based on the UK MARKAL model, which represented Scotland as a separate region to the rest of the UK so was able to examine decarbonisation pathways for Scotland within the wider UK context. (UK MARKAL has since been superseded by the UK TIMES model, from which Scottish TIMES was developed).

There has been no published comparison of results from Scottish TIMES and this earlier model, and beyond the high-level similarities there appear to be some very significant differences, for example: the much lower penetration of renewable heat in Scotland in the Ricardo study compared to the draft Climate Change Plan. Overall, while we welcome the Scottish Government's high policy ambition on renewables deployment, we call on the Scottish Government to publish analysis of the preferred and alternative ways by which the target might be most affordably met. Furthermore, there is a significant risk that the UK government policies required to incentivise continued renewables growth in Scotland will not be ambitious enough for the 50% target to be met.

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Q4. What are your views on the development of an appropriate target to encourage the ***full range of low and zero carbon energy technologies****?*

It is important that targets and support for energy technologies are set within a whole systems understanding of the evolution of the Scottish energy system. The energy system is ultimately needed to provide affordable, secure and environmentally sustainable services to society. Therefore, policy should be concerned with meeting these overall goals (and specific targets for greenhouse emissions reduction) whilst minimising costs and maintaining energy security. All other things being equal, a low carbon energy target would provide more flexibility than a renewable energy target. This would potentially provide a rationale for supporting a diverse range of emerging and more mature low and zero carbon energy technologies whilst avoiding the dangers of 'policy capture' in a technology-by-technology and sector-by-sector approach. However, the limitation we discuss above applies to such a wider target since policies to support other low carbon technologies are largely the competence of the UK Government, not Scottish Government.

At the same time, some technology-specific support is needed: in our recent submission to the UK Government's Industrial Strategy Green Paper (Bell et al., 2017a), we noted that purely technology-neutral support policies only bring forward those technologies that are closest to market, and fail to develop those which are currently less competitive but which may be required for deeper decarbonisation, or which may have the greatest long-term potential. Overall, there is a wealth of evidence from energy innovation research to suggest the importance of design variety and technology-specific support in early stage energy innovation, with a move toward technology-neutral support for more mature technologies (Watson, 2008; Gross et al., 2012).

For example, the cost reductions now being experienced by offshore wind would not have happened without specific technology support, both through explicit innovation funding and the creation of market-pull demand for offshore wind. It therefore makes sense for government to seek to directly support the initial demonstration of potentially key long term technologies such as BECCS and hydrogen. Scotland might be particularly suited to BECCS development and deployment, given the land availability for biomass and the proximity to CO_2 storage sites. In addition, given the strong role of regulation and the investor perceptions of regulated network companies as being low risk (thus giving low cost of capital), policy support has a particularly important role in network infrastructure innovation.

As discussed above in respect of renewables, there are a number of impacts that need to be taken into account, not least system operability and the potential need for significant upgrades to network infrastructure. This is equally true in respect of electrification of heat and transport, especially at a local, distribution scale where developments can be quite concentrated in particular areas. Alternatives to electrification of heat also have implications: the cost-effectiveness of district heating reduces rapidly as the density of heat demand reduces (and a low carbon source of heat is still required); most (though, we understand, not all) of the replaced gas distribution network can accommodate hydrogen (though not the transmission system which might still carry methane to large scale steam methane reform plant to make hydrogen that is exported directly onto the distribution network) although domestic appliances would need to be replaced. In other words, the interactions and impacts of different vectors need to be assessed across the energy system as a whole and at different scales (UKERC is carrying research on modelling at sub-national scale at the University of Strathclyde and University College London). One important implication of this is that analysis such as that afforded by a TIMES-type model can be very useful but is far from sufficient in giving strong evidence in favour of or against a particular energy strategy.

A systems framing is also important because recent UKERC research highlighted that the contribution of intermittent renewables in energy system change can only be understood by reference to the wider energy system context, and the capacity of the wider system to absorb intermittency through storage, demand management and response, and interconnection (Heptonstall et al, 2017). This is also evident in terms of the benefits of energy system decentralisation, with a technical shift toward local balancing of demand and supply with use of smaller scale storage and flexibility, and an organisational shift toward distributed system operation. The costs and benefits of decentralisation can only be captured by a systems framing, including multiscale modelling and evidence from local trials and demonstrations.

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*Q5. What ideas do you have about how we can achieve commercial development of **onshore wind** in Scotland without subsidy?*

It is widely recognised that developments of renewable sources of electricity in Scotland have made significant contributions towards decarbonisation of Britain's electricity supply. As part of the European Energy Union, it may be anticipated that its advantages would have been supported through development of EU-wide market mechanisms to incentivise development in cost-effective locations. However, there is a risk that Brexit will reduce the impact of such mechanisms in the UK (Froggatt et al., 2017). This could mean that the rest of the UK remains a particularly important buyer for Scotland's low carbon electricity for the foreseeable future.

The nature of the wholesale electricity market is being fundamentally changed by the growth of generation with low short-run costs that nevertheless need to recover still quite high long-run costs. To some extent, this has been recognised at a UK level by long-term contracts for low carbon generation. In respect of simple levelised cost of energy (LCOE), onshore wind remains the cheapest source of renewable electricity; it therefore seems perverse that onshore wind is excluded from such contracting arrangements.

However, the usual comparator technology for electricity generation (gas-fired CCGTs) receives compensation for some of the 'missing money' associated with low wholesale prices driven by low short-run costs: income from the Capacity Market. In respect simply of energy, this can be argued to distort the market, not least as wind is excluded from capacity payments even though – as shown in some recent analysis from ClimateXChange (Gill and Bell, 2017) – it contributes to reliability in respect of meeting peak demand (albeit in a relatively small way). On the other hand, various 'flexibility services' are of increasing importance in respect of operability and resilience of the electricity system; provision of such services can normally be expected to attract additional income. Any least cost pathway for Scottish and UK energy system change is very likely to include further onshore wind deployment, and we welcome the Scottish Government's consideration of 'subsidy-free' ways of supporting such deployment.

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*Q6. What are your views on the potential future of Scotland's **decommissioned thermal generation sites**?*

In the section above on flexibility and resilience we discussed the need for schedulable sources of power. These could be new thermal power stations as long as any carbon emissions from those stations is compatible with Scottish (and UK) climate change targets. Given that suitable land, sources of cooling water and grid connections already exist at them, the most obvious sites for these to be developed are those where old thermal plant has been retired. A future need to capture and store associated CO_2 emissions would require extra land for the capture plant and CO_2 transport facilities. Proximity to saline aquifers and depleted oil or gas fields would be an obvious advantage.

Where the sites maintain a useful locational position with respect to network infrastructure, these may also be suitable locations for storage deployments, such as electrochemical batteries supplying ancillary services to the system; one such deployment recently gaining a contract for Enhanced Frequency Response with National Grid is to be located on the site of the former coal and gas power station at Roosecote in Cumbria.

*Q7. What ideas do you have about how we can develop the role of **hydrogen** in Scotland's energy mix?*

We support the Scottish Government's intention to work with the UK Government and others on developing the evidence and strategy for hydrogen in the energy system, and for funding for innovative projects involving hydrogen. A recent White Paper from the Hydrogen and Fuel Cell Supergen Hub (Staffell et al., 2017) examines the potential roles of hydrogen in wider low-carbon energy systems. This includes UK energy system scenario modelling underpinned by UKERC research, and shows that the role of hydrogen in 2050 could vary from a small number of niche markets (e.g. HGVs and buses) to supplying most transport and heat demands. In the absence of dedicated scenario and pathway modelling, it is not clear whether these conclusions apply equally to Scotland, but there are significant GB-wide scale economies to infrastructure commitments and repurposing.

Hence there is a need to carefully consider the different ways that hydrogen can be most appropriately used in the Scottish and UK energy system across different parts of the system (heating, transport, power and industry), over different timescales, including more incremental and shorter term opportunities such as power-to-gas and fuel blending using existing transmission and distribution pipeline infrastructure, as well as more radical and longer term transformations such as 100% hydrogen replacement of natural gas based on steam methane reformation (and perhaps ultimately electrolysis) that may require transmission infrastructure replacement.

The 100% hydrogen option is now attracting significant interest from the Scottish and UK Governments, as a potentially lower cost and less non-disruptive way of decarbonising buildings' heating. There is a developing wider evidence base on low carbon heating, but much of this is desk-based assessment and modelling studies, and as the Government identifies, there is a need for demonstration projects to consider the hydrogen option in greater detail. Some trial and demonstration projects are now being specified but it will be some time before the evidence base is sufficiently enriched.

In the meantime, the most promising market for hydrogen technologies continues to be road transport. A fleet of hydrogen-powered fuel cell buses is already operating in Aberdeen. A transition to hydrogen vehicles would need to be underpinned by the development of a network of refuelling stations, which will be unprofitable at first due to a lack of customers. It might be possible for the first adopters of fuel cell cars to use refuelling depots, such as the bus depot in Aberdeen, until local refuelling stations are built. If the Government wishes to promote private hydrogen-fuelled road transport, then a plan to provide the basic underpinning infrastructure is required.

For now, the evidence base on the role of hydrogen in Scottish and UK energy system change is still unclear and emerging, set against other options. As with all other specific vectors, we consider the future of hydrogen to be best assessed within a whole systems framing, where different options for affordable and secure low carbon energy supply and use can be judged against each other, based on best available evidence. The draft Energy Strategy rightly describes the next 5-10 years as a crucial preparation time for hydrogen (and other low carbon heat supply options), with a need to develop a hydrogen 'roadmap'. We would also welcome a Scottish low carbon heat roadmap, including all emerging options.

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Part B: Demand, Use and Efficiency

Q8. What are your views on the priorities presented in Chapter 4 for ***transforming***

energy use *over the coming decades? In answering, please consider whether the priorities are the right ones for delivering our vision.*

Demand reduction and energy efficiency should be central to a whole systems view of Scotland's energy transition. As Chapter 4 of the draft Energy Strategy notes, there have been significant reductions in Scottish energy demand over the past decade, with total final demand in 2014 15% lower than 2006, and a very significant reduction of heat demand (of one-third) over the past decade, through a combination of technology changes (gas boiler replacement) and the effect of increased gas prices; UK-wide evidence suggests that this reduction has largely been driven by better insulation and boiler replacement (DECC, 2013).

Whilst the draft Energy Strategy and Climate Change Plan include some positive steps, they appear to pay insufficient attention to demand reduction and efficiency improvement. The Energy Strategy omits an integrated whole systems analysis of the benefits of demand reduction and efficiency improvements in terms, for example, of avoided investment in supply and network infrastructure expansion and reinforcement. The draft Climate Change Plan also lacks analytical detail on the contribution of demand and efficiency to system change. In some sectors, modelled demand reductions are modest. By 2032, electricity demand is forecast to increase by 30% (which may be partly due to the electrification of transport and other sectors) and domestic building heat demand to increase by around 8%.

Successfully harnessing the potential of demand reduction and efficiency offers important wider benefits for consumers and the economy (Pridmore et al., 2017), and potentially also in terms of the public acceptability of energy and climate policy. Recent analysis by the Committee on Climate Change found that while measures to deliver a cleaner, low-carbon electricity system added around £9 a month to the typical UK household energy bill in 2016, this was more than offset by a cut of over £20 per month due to reduced energy demand, mainly from the use of more efficient lights and appliances (CCC, 2017). Furthermore, average household bills fell by £115 between 2008 and 2016, partly due to this effect.

The apparent imbalance between demand reduction and decarbonisation of heat supply is a particular concern: the Association for the Conservation of Energy recently analysed a number of scenarios for emissions reduction to 2030, including the least cost path identified by the Committee on Climate Change (Guertler and Rosenow, 2016). Under all scenarios where emissions targets were met, demand reduction measures accounted for roughly half of the total emissions abatement related to heat, and decarbonisation of heat supply the other half. This result is reinforced by previous UKERC analysis of low carbon scenarios, which concluded that energy efficiency is a particularly important priority across scenarios that have different assumptions (Ekins et al., 2013). This seems at odds with the draft Climate Change's Plan ambition to completely decarbonise heat supply in 80% of residential buildings and 94% of non-domestic buildings over this period, whilst only reducing heat demand by 6% and 10% respectively.

As with supply, there are also significant differences between the Scottish Government's analysis, and independent analysis for Scotland carried out by the Committee on Climate Change (CCC, 2016b). This divergence is particularly evident on building energy demand expectations. The Government's draft Climate Change Plan suggests that improvements to building fabric through the Scottish Energy Efficiency Programme (SEEP) result in a 6% reduction in domestic (and 10% in non-domestic) buildings heat demand by 2032, despite the designation of energy efficiency as a national infrastructure priority with the expectation that 90,000 homes will be treated each year from 2018 to 2032.

A written Government response to the Scottish Parliament clarified this was set within rising overall expectations of buildings heat demand, of around 8% (without buildings fabric improvements, domestic heat demand would be expected to rise by 15% from now to 2032) (Scottish Parliament, 2017). By comparison, the Committee on Climate Change recently estimated that energy efficiency improvements, including walls and loft insulation, better heating controls and other insulation measures could provide a 15% reduction in energy used for heating existing buildings by 2030 for the UK as a whole (CCC, 2016a).

The reasons for this divergence of expectations on future heat demand are unclear. They may relate to specific aspects of the Scottish building stock and concerns and sensitivities about fuel poverty in Scotland. UKERC research (Eyre and Baruah, 2014) identified a tendency for under-ambition in energy demand reductions in many UK energy scenarios (including some produced by the CCC), so a key issue in further development of the Energy Strategy is to consider the scope (in scenario assumptions and real world policy delivery) for accelerated and deeper progress on heat demand reduction.

This carries important implications for supply-side changes, as demand reduction erodes the investment case for new heat supply infrastructure (and changes the preferred type of low carbon heat infrastructure) (MacLean et al., 2016). On the other hand, we are also conscious of the risks of what can be achieved by physical buildings efficiency measures in models (Kelly, 2016). This can lead to under-estimation of building energy demand and often poor performance in the construction sector with respect to specification and installation of facilities. This suggests the need for a comprehensive review of the evidence on buildings energy demand reduction and the role of policy with reference to Scotland, and the evidence base for the assumptions in the draft Climate Change Plan.

With respect to other end-use sectors other than households or buildings, it is important to bear in mind that energy consumption is a means to an end: it helps to deliver service demands such as mobility, comfort, education and health. In particular, whilst the Energy Strategy includes proposals to improve the energy efficiency of manufacturing and industry, it could do more to understand how the demand for goods and services drives industrial energy use. Failing to account for the link between industrial energy and final consumption from a supply chain perspective has implications for how transformations in energy use are framed. Unless this link is made, opportunities for resource efficiency to reduce energy demand could be missed.

For example, the production of materials such as aluminium, steel and plastic is very energy intensive and these materials act as carriers of industrial energy use as they are traded and transformed into products to meet end use services. Evidence for the UK shows that energy demand driven by household and government expenditure for materials and products is greater than domestic energy demand (CIE-MAP, 2017). However, due to the international nature of many supply chains, some of this energy demand will occur outside Scotland and the UK. It is therefore more difficult for the Scottish Government to implement actions to improve the energy efficiency of these supply chains.

There is an acknowledgement in the strategy that the Circular Economy can provide an opportunity for reducing emissions from industry (page 59), yet it is not clear how this will happen in practice. Whilst we recognise the constraints on the ability of the Scottish government to influence international supply chains, it could take the following actions to support this as a priority area:

- Partnerships with industry and academia to provide case studies, best practice, and pathways for realising the potential contribution the circular economy can contribute to delivering energy demand and emissions reduction targets. There is evidence that resource efficiency measures can reduce energy use/ emissions while improving economic productivity for industry and households (CIE-MAP, 2016; Barrett and Scott, 2012).

- Monitoring and targeting reductions in capital (which embodied energy) at the organisational level can achieve substantial energy/emissions and cost savings. With appropriate support, there is significant scope for best practice in embodied carbon management to proliferate within and transfer between sectors. A number of success stories have been reported in the UK construction sector for example, where companies have reported up to 40% reductions in embodied carbon combined with a 25% cost saving in just a few years (The Green Construction Board, 2014, WRAP 2014). The strategy highlights success in Scottish Water operations. An innovation fund could be directed at companies demonstrating transformative change in resource use at scale.

- Monitoring and measuring of energy embodied in organisations could be accompanied by a programme of leaders and laggards, where within five years standards are set on resource reductions, similar to energy efficiency targets, and all organisations within a sector are required to meet a certain performance standard.

- Leading the way by integrating resource productivity targets into briefs and tender documents on publicly funded infrastructure projects (particularly as a designated priority in SEEP). Billions of pounds of investment in Scottish infrastructure will place significant demands on energy use. Integration into the tendering process has already been done on high profile major infrastructure projects, such as HS2 and the Olympic developments, but has yet to become a routine requirement across the portfolio. By making such requirements routine, Government can demonstrate best practice, ensure a swifter dissemination of assessment skills, and drive supply chain innovation, whilst delivering more cost effective public procurement.

- Developing a better understanding of future household requirements in terms of goods and services, and the relationship with present and future energy demand. This requires an understanding of how consumption is structured and evolves and the complex relationship between energy production and end-user consumption. This is best done in partnership with research institutions who have or are developing the tools and techniques to do this.

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*Q9. What are your views on the **actions for Scottish Government** set out in Chapter 4 regarding transforming energy use? In answering, please consider whether the actions are both necessary and sufficient for delivering our vision.*

Scotland's Energy Efficiency Programme (SEEP) is described in the draft Energy Strategy as a cornerstone of the Scottish Government's Whole System approach to energy policy. The overall aims of SEEP, and the principle of a phased approach that enables supply chains to react effectively, are welcome, with an initial pilot phase before full deployment after 2022. We also broadly welcome the designation of energy efficiency as a national infrastructure priority. However, that is only meaningful if it is backed up by more detailed policies and measures to improve energy efficiency.

However, we note that SEEP is designed as a long term programme for the deployment of low carbon heat supply as well as efficiency/demand reduction, and that the Scottish Government is also consulting – through the Local Heat and Energy Efficiency Strategy (LHEES) consultation – on detailed regulatory powers (for example, on the regulation of district heating, with designated 'heat zones' and local 'concession areas' powers given to local authorities). We would welcome greater clarity on the relative emphasis over time within SEEP (and LHEES) on demand reduction and energy efficiency versus low carbon heat supply.

Within a national framework for their development and funding, local plans can take account of local conditions, e.g. access to the gas grid; high heat density or low; access to ground or water or waste sources of heat; access to biomass; levels of spare electricity distribution capacity; etc. However, there is also a risk of misaligned (in terms of the direction and pace of change) policies and regulations for low carbon heat across local and national government, with detailed regulations and spatial plans being drawn up at the local scale, with still major unresolved uncertainties at the national scale.

In practice, there will be an interaction between national and local transitions and powers. The capacity of local authorities and regional partnerships to develop and implement area-wide plans will depend on national coordination and resources, and there is a risk of a lack of an effective national framework to coordinate local planning and the systematic development of SEEP. Existing pilot projects, and their systematic evaluation, should provide lessons to inform the development of the necessary institutions.

The Heat and the City response to the local heat (LHEES) consultation (Webb et al., 2017) suggests that LHEES and SEEP present an opportunity for a more integrated approach to energy planning between local and national governments and delivery of overall energy strategy goals. A more integrated approach would support a greater alignment between local plans and national strategies, with localised preparation of SEEP and LHEES informing decisions at the national scale. SEEP and LHEES preparations in any one local authority area should not be considered in isolation, but in a coordinated national framework.

There is also a need for ongoing independent scrutiny of SEEP, as it seeks an integrative approach to demand reduction and supply, with close attention to the pilot phase in terms of measuring energy use (weather-corrected as appropriate) and assessing the cost effectiveness of the programme's demand reduction and efficiency benefits. The Existing Homes Alliance has estimated the overall cost of the housing component of the infrastructure priority at approximately £10.7bn up to 2025, including £450m per annum over ten years on average for public grants and loans.

There are a number of other more detailed issues raised in relation to the design of the SEEP programme. These are being addressed by the dedicated SEEP consultation, but we note here the need for a clearly defined programme with a substantial period of notice in advance of the introduction or tightening of regulations: this will increase acceptance by property owners and also provide the energy efficiency supply chain with signals that will drive the development and introduction of the most cost-effective technical options to deliver any given standard. Introducing incentives prior to standards (but with the intention to introduce standards clearly expressed) is also likely to increase acceptance, and can help smooth the profile of investment, supporting a more sustainable evolution of the local supply chain.

We also suggest that the Scottish Government work with the UK Government to review and strengthen energy efficiency policy. This should take into account the available evidence on 'what works' (e.g. Wade and Eyre, 2015) and explore options such as regulated investment in demand reduction by utilities, building renovation passports (as trialled in a number of other European countries), and improved links to the existing renovation market and to stimulate additional private investment in improving energy performance and up-skilling local supply chains. In some circumstances it may make sense to consider replacing high-carbon heat systems with low-carbon heat systems at the time as carrying out energy efficiency work as part of whole house retrofit packages.

By comparison with the buildings sectors, the carbon envelopes for both industry and transport as set out in the Climate Change Plan are relatively modest to 2032. For industry, this involves a 19% reduction in emissions by 2025, with no further reductions out to 2032. The Plan also involves demonstrating key technologies (including CCS and hydrogen injection) by 2030, but acknowledges that this will rely mostly on UK and EU support.

In its advice to the Scottish Government, the Committee on Climate Change (CCC, 2016b) also recognised the challenges of industry sector abatement but suggested that, out to 2032, upgrades and replacements to existing processes and equipment to improve their energy efficiency, combined with switching away from direct combustion to using biogas and biomass, was a more significant source of emission reductions than the use of CCS, although CCS becomes important after 2030 in CCC scenarios.

The draft energy strategy refers to the development of a Manufacturing Action Plan for industry sector decarbonisation, with the Scottish Energy Advisory Board (SEAB) seen as key source of industry expertise. Advice should also be sought from independent organisations (e.g. the academic research community), that spans the full range of technical, economic and social implications.

On transport, the Scottish (and UK) transport sector has stood out because of a lack of progress in emissions abatement since 1990, with vehicle efficiency improvements offset by demand increases. In terms of the carbon envelope in the draft CC Plan, the sector shows a gradual and modest decline (around 25% between 2017 and 2030), with a reliance on mostly technology-based measures – 'efficiency' rather than 'conservation' – such as accelerated e-vehicle adoption. In its analysis, the Committee on Climate Change suggested that Scottish transport sector emissions could fall by over 50% by 2030 against a business as usual scenario through measures such as conventional vehicle efficiency, adoption of ultra-low emission vehicles (ULEVs), reducing demand for car travel and improving the efficiency of freight operations. This suggests the need for greater consideration, in the draft Climate Change Plan and Energy Strategy, of more established technologies in the short term, and also demand-reducing and behavioural measures (see for example the measures identified in the Scottish Energy Taskforce Report, 2017).

The aim to induce change concerning the travel behaviours of Scottish citizens has been acknowledged for over a decade, with this objective being capable of delivering on a number of prominent societal issues. The National Transport Strategy of 2006 outlined a series of SMART measures covering personal travel planning, information provision and awareness raising, car clubs and car sharing, and active travel campaigns to promote sustainable mobility. However, the national level travel demand statistics have remained markedly consistent in the intervening time period, with such issues as mode splits for travel to work and school showing little if any positive trends. This may indicate that the current approach to encouraging behaviour change in the transport sector is ineffective in terms of its structure, or is under-resourced, and as a result unable to deliver improvements at a national scale.

The latest progress report on Scotland by the Committee on Climate Change (CCC, 2016c) states that stronger implementation is required concerning policies to reduce demand through shifts to public and active transport (e.g. cycling and walking). A re-design of the strategy through which to achieve stronger implementation which does not simply re-package existing measures seems prudent. Such a re-design could benefit from providing attention not only on means through which to encourage sustainable mobility but also methods that can discourage the use of cars. Such methods could include the potential introduction of Low Emission Zones and the expansion of car-free areas which would reduce the benefits of car based mobility and motivate citizens to consider alternatives.

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Q.10 What ideas do you have about what ***energy efficiency target*** *we should set for Scotland, and how it should be measured? In answering, please consider the EU ambition to implement an energy efficiency target of 30% by 2030 across the EU.*

As we argued earlier in our response, policy targets should not be considered in isolation from the policies and other market drivers that could help to meet those targets. Setting an ambitious target for energy efficiency can help provide a clear strategic signal of policy intentions and could align Scottish policy with the EU energy efficiency proposals. However, this would need to be matched by significantly stronger policies to support energy efficiency from both the Scottish and UK governments. As we note in our response to Q8, there is a lack of detail in the draft Climate Change Plan about energy efficiency and demand reduction – and we are concerned that the Plan is not ambitious enough. We have already set out some options for strengthening energy efficiency policies in our responses to Q8 and Q9.

Given that there is considerable potential for further energy efficiency improvements in Scotland, it makes sense for the Scottish Government to adopt the EU's 2030 energy efficiency target as an additional pillar of its energy policy. Whilst Brexit may mean that the UK is no longer bound by this and other EU energy policy targets, it represents a reasonable level of ambition – though Scotland could, of course, choose to go further.

As the European Commission makes clear in its proposals, it would mean a binding EU-wide commitment to a 30% improvement in energy efficiency. In practice, the Commission states that this would mean a 17% reduction in final energy demand across the EU when compared to demand in 2005 (European Commission, 2016). According to the draft Energy Strategy, Scotland's energy demand has already fallen by 15% between 2005-07 and 2014.

When measuring progress towards the target 2030, it is therefore important to recognise the distinction between energy efficiency and demand reduction. The main reason why the Commission expects only a 17% reduction in energy demand is that there is an expectation that EU economies will continue to grow between now and 2030. Progress towards the 30% target will therefore need to be measured against a counter-factual projection of energy demand to 2030 that does not include energy efficiency progress.

There are other ways of measuring such progress. For example, in transport, performance could be measured as energy demand per passenger-kilometres or tonne-kilometres (for freight). Domestic energy demand could be measured against household area or number of households. For industry and services, economic output could be more appropriate. This would identify additional societal factors that influence energy demand such as reduced household and vehicle occupancy rates. This changes the focus to energy service delivery and not a pure technical efficiency.

Monitoring will also need to take into account rebound effects, which will mean that reductions in demand due to energy efficiency will not necessarily be as large as predicted. Rebound effects can be direct; for example, if a car is more fuel efficient the owner may choose to drive further, offsetting any energy savings. They can also be indirect; for example, the savings from fuel costs of a more efficient car could be spent on other goods, which require energy to produce. And finally, a reduction in fuel demand could reduce fuel prices and increase fuel consumption in other parts of the economy. A previous evidence review by UKERC has demonstrated that such rebound effects are partial in most cases (Sorrell, 2007). Therefore, they should be taken into account in the design and implementation of policy – but not used as an argument for a less ambitious approach to energy efficiency.

The Scottish Government could also go further, and explore the case for a more ambitious absolute energy demand reduction target alongside an energy efficiency target. This would be easier to measure in that it would not require construction of a counter-factual scenario to compare actual energy demand in 2030 against. Given the progress that has been made in Scotland between 2005-07 and 2014, there is a strong case for building in an expected reduction in Scottish energy demand that goes further than the overall European Commission proposal.

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Part C: Local Energy

*Q. 11 What are your views on the priorities presented in Chapter 5 for developing **smart, local energy systems** over the coming decades? In answering, please consider whether the priorities are the right ones for delivering our vision.*

Local energy is the third pillar of the Scottish Government's energy strategy. Local, distributed energy is attracting international interest, reflecting the rapidly reducing cost globally of smaller scale power generation and storage, heat generation and residual heat recovery, the impact of IT on energy network management, and also a political trend toward regionalisation and devolution in some areas.

There are significant potential opportunities and benefits from localisation and decentralisation. These include greater community empowerment; local growth opportunities; reduced dependency on regulated utilities' processes that have, in many respects, failed to keep pace with network users' requirements; the freedom for groups of individuals to express their own preferences for particular sources of energy; a balanced, local resolution of adverse visual impacts versus benefits of different developments; and the clearer articulation of the interaction between supply and demand and the benefits of demand side flexibility.

However, there are also some concerns: a UK Parliamentary select committee recently argued that there are risks of inconsistency and piecemeal development, rather than the energy sector's established commitments to universal service and socialisation of costs and benefits across national populations (BEIS Committee, 2017). In our response to the UK Government's Industrial Strategy Green Paper, we noted that 'policy and institutional arrangements are subject to significant lock in and path dependency. Shifting away from the current system of complex governance arrangements may be more difficult that some may think, and impacts on investor confidence will need to be carefully thought through' (Bell et al., 2017a).

Perhaps even more importantly, 'local' or 'decentralised' does not necessarily mean cheapest, either for the individuals involved in a local scheme or for society as a whole (Winskel et al., 2014). In some circumstances, e.g. in a remote location with a long, weak electricity network connection, it can be a cost-effective means of unlocking local supply potential to meet demand, especially if community members' active engagement means that they also actively manage their own demand and its timing. In other locations, however, economies of scale, the low costs of an existing, almost fully depreciated network and an expectation of a high reliability with minimal impact on consumers' behaviour mean that 'local' or 'community' energy has limited value. There may be, instead, an apparent value to end consumers which is an artefact of the structure of energy tariffs, and in reality stems from a redistribution of costs between consumers rather than their reduction. In a similar way to district heating schemes, local or community energy schemes also tend to require a certain, minimum level of commitment from consumers, both in terms of numbers and duration. This places limits on consumer choice that may be unacceptable to some.

Many of the challenges that local energy faces in making significant contributions to energy affordability, security and sustainability are related to business models for demand reduction and routes to market for local generation (Hall and Roelich, 2015). Supporting local energy projects without addressing these two issues will not address the systemic constraints limiting the potential of local energy. More priority should be given to supporting innovative business models that capture value from demand reduction activities, to reduce the reliance on grants for these activities.

From a whole systems integrated perspective, assessing the pros and cons of energy system localisation and the development of local energy systems is challenging. As we noted above, while there are number of benefits, there are also concerns. Large integrated systems offer a number of economic, technical and societal advantages, especially in areas where scale economies are still significant (such as offshore wind and long distance interconnection).

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Q12. What are your views on the actions for Scottish Government set out in Chapter 5 regarding ***smart, local energy systems****? In answering, please consider whether the actions are both necessary and sufficient for delivering our vision.*

The Energy Strategy references a range of local energy initiatives, projects, programmes, companies and decision support tools such as the Scottish Heat Map and Scottish Enterprise's Energy Masterplanning, the Low Carbon Infrastructure Transition Programme (LCITP) and two long term independent assessments to monitor and evaluate social and economic impacts from Scottish local energy projects being carried out by ClimateXChange.

Ideally, the potential for local energy systems should also be assessed through multiscale modelling and evidence synthesis to complement the Strategy's focus on particular cases or examples. However, multiscale analytical methods and tools are still emerging. We recommend that Scottish government engage with these emerging developments (such as being conducted within the current UKERC theme on Energy Systems at Multiple Scales), and use such tools when they are available to carry out a more systematic assessment of the potential for local energy systems.

While there is some encouraging emerging evidence (in terms of the potential, for example, for 'smart' network operation to assist localisation and decentralisation) the evidence is still tentative and often based on modelling simulations and small local trials rather than larger-scale demonstration and deployment. For example, the National Infrastructure Commission's estimate of £3-8bn savings from a smarter electricity system is based on 'top down' modelling simulations (NIC, 2016). It does not take into account some of the emerging evidence from local trials, for example on the social constraints to demand side response. This suggests a need to recognise energy system modelling limitations, and to combine modelling and other forms of evidence.

The ESRC's What Works Centre for Local Economic Growth recently concluded that 'policymakers should be cautious in using local-level innovation policy … we know little about how this feeds through to greater innovation, better firm performance or longer term economic growth at the local level … traditional local cluster programmes have a very poor success rate' (ESRC, 2017). Therefore, there is a need to strengthen the evidence base as well as drawing on existing evidence. Policies should be designed to facilitate evaluation, with more systematic ex-post analysis (see also UKERC, 2016).

As the Energy Strategy notes, Local Authorities are expected to be key actors in planning for, and implementing, more decentralised energy systems. Consultations on both SEEP and LHEES & regulation of district heating reinforce this potential. Their planning powers and responsibilities, resources and knowledge mean that they have a necessarily long term social and economic commitment to the locality. They are also democratically elected bodies, conferring significant societal legitimacy (see Hawkey et al., 2016).

Recent UKERC/ETI analysis, mapping Local Authority engagement with energy across the UK, found Scotland had the greatest proportion of local authorities at the leading edge of clean energy and energy efficiency action, compared with England, Wales and Northern Ireland (Tingey et al.,2017), and many leading authorities have multiple modes of engagement. These include long-term concession contracts with private sector energy suppliers, joint public-private ventures, non-profit and social enterprises, as well as in-house teams. Currently this activity remains small scale, relative to Scottish energy consumption, and is at risk from continuing budgetary constraints. Nonetheless the range of activity and investment indicates much greater potential (Webb, et al., 2016).

Enabling Local Authorities to become significant partners in developing the Scottish energy strategy will however require investment in capacity and capability, in a long-term policy framework which confers increased powers (Tingey et al., 2017). An updated central energy efficiency fund dedicated to investment in localised energy provisions and services, with low interest, long-term loans, should be considered, as well as other fiscal measures to reduce investment risk. Local authorities, as well as other local enterprises supplying electricity will also need a simpler access route to wholesale markets.

There is also a need for financial appraisal methods to be further developed so that the wider social and economic costs and benefits of local energy projects are captured. Where there are significant wider benefits, they could help to make local projects more competitive with more traditional energy projects (Roelich 2015). Project or finance appraisal methods for government supported finance (e.g. capital grants, Scottish Investment Bank) or those supporting access to finance (e.g. Scottish Futures Trust) should be adjusted to account for multiple and long-term outcomes and ensure they are considered equally and throughout the appraisal process.

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*Q.13 What are your views on the idea of a **Government-owned energy company** to support the development of local energy? In answering, please consider how a Government-owned company could address specific market failure or add value.*

A recent UKERC paper noted how the advent of decentralised energy production, potentially large new electricity demands, smart metering and the possibility of demand flexibility, is changing the nature of the UK energy market (Eyre and Lockwood, 2017). It argues that while decentralised energy production, flexibility and trade does not necessarily imply decentralised governance, it becomes an option in the way that is precluded by central system operation. This opens questions about the potential roles of the state: through devolved administrations, regional institutions and local government.

In addition to these changes, the ambitions for a stronger role for local energy in Scottish Government’s plans imply that significant institutional change may be needed to ensure effective and coherent policy development, implementation and review. As we have argued in response to previous questions, Local Authorities are often committed to act on clean energy in principle, but have very limited internal technical capacity for planning, delivery and attracting finance. Reliance on relatively expensive external consultancy is pervasive, and leads only to marginal improvements in in-house capacity and skills; for example, technical-economic feasibility reports tend to raise new questions about risk and return, and leave a considerable gap between appraisal of investment options and viable business models.

However, the Energy Strategy is right to be cautious about the case for a new Government-owned energy company, and to ask how it could add value or address particular failures within the energy market. It also makes clear that such a company could take many forms and fulfil a range of possible roles – including acting as an energy supplier, investing in infrastructure and delivering government energy efficiency schemes. Whilst some Local Authorities such as Bristol have set up energy supply companies or are in the process of doing so, it is not clear what additional benefits would be provided by a Scottish Government owned supply company. Such a company could be a not-for-profit organisation, but it may not be able to offer cheaper prices and/or better service than other companies in the market. If the policy objective is to increase the diversity of energy suppliers within the market, and make it easier for smaller local suppliers to operate, then it may be more effective to reform regulatory frameworks and licensing conditions.

There are other roles that could be usefully carried out by an arms-length public body, 'energy company' or energy agency. This could create means to more rapid and less fragmented local energy planning and investment in a number of areas including:

- delivery of policy schemes (e.g. for energy efficiency)
- centralised procurement to reduce costs;
- potential for risk underwriting for investments;
- systematic technical-economic capacity for analysis and monitoring of progress towards policy objectives (see our response to Q16);
- database development and analysis; and
- training and skills development.

Many major economies use a government agency to achieve the types of outcomes proposed by Scottish Government, as in the example of the Danish Energy Agency. If there is reluctance to create a free-standing agency, business/government hybrid models could be adopted. DENA in Germany is an apt example (see: www.dena.de/en/about-dena.html). In addition, the First Minister has signed an MoU with the Governor of California, which also uses an Energy Agency structure to govern policy and planning, databases, guidance and investment. Given that many examples already exist, a first step would be to learn lessons from them, taking into account the differences in market and institutional structures between countries, and to consider how a similar agency could help meet Scottish Government policy objectives.

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Part D: Delivery, Monitoring and Public Engagement

Q. 15 What ideas do you have about how Scottish Government, the ***private sector and the public sector*** *can maximise the benefits of working in partnership to deliver the vision for energy in Scotland?*

We would like to emphasise three main areas where partnership working is particularly important.

First, there is a need for continuous engagement between Scottish government and energy system stakeholders from the public, private and third sectors as the Strategy is implemented. As we discuss in our response to Q16, there are some welcome proposals for reform of existing advisory structures such as the Scottish Energy Advisory Board in the draft Energy Strategy. Our view is that these structures should also include space for independent organisations that carry out research and analysis of the whole energy system. This will help to ensure that decisions are as evidence-based as possible, whilst recognising that these decisions will also be influenced by political priorities and trade-offs.

Second, the draft strategy document is right to cite the need for new skills and the transfer of skills between different sectors if the Energy Strategy's ambitions are to be successfully realised. The public sector can do much to invest in training and education and we would encourage that, at both apprentice/technician/fitter level and at a professional level in respect of different disciplines, especially engineering. However, such investment will only pay back if there is a concomitant willingness and commitment from industrial and public sector employers to a multi-year programme of recruitment, development and retention of apprentices, trainees and graduates. We would urge the Scottish Government to go further in trying to influence commitment to training and development on the part of industry.

Third, there is a need to anticipate the potential loss of a significant source of R&D and technology investment funding when the UK leaves the EU, including over £500m support from the European Investment Bank (EIB) support for offshore renewables in Scotland. European Structural and Investment Funds are also a source of co-financing for Scotland's Low Carbon Infrastructure Transition Programme (LCITP), providing match funding for investments in low-carbon infrastructure programmes and sustainability initiatives over the period from 2014-2020. EU funds and European Investment Bank (EIB) loans account for around £2.5 billion of the UK's energy-related infrastructure, climate change mitigation, and research and development (R&D) funding per year. Recent UKERC research argued that replacing these sources of finance should be a priority within the Brexit negotiations to come (Froggatt et al., 2017)

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*Q16. What ideas do you have about how delivery of the Energy Strategy should be **monitored**?*

In the face of multiple uncertainties, the Energy Strategy should be based on a holistic approach spanning shorter term and more incremental measures as well as longer term prospects, with decisions taken, as far as possible, by transparent reference to evidence. This is difficult to implement and maintain: the UK Committee of Public Accounts recently expressed concern about 'a culture of optimism' within UK government energy policy making, which 'gave a completely misleading picture … to Parliament and other stakeholders' (CPA, 2017). It argued the need to foster openness and transparency and do more to demonstrate value for money for consumers.

The draft Energy Strategy proposes that Scotland's advisory bodies should be refocussed on new strategic priorities, with a support network of industry- and consumer-led advisory groups, and an increasing role for Local Authorities, enterprise and skills agencies and supply chains. While this is welcome, we also recommend attention be given to independent whole systems interdisciplinary research and analytical capability – both within the Scottish government and in independent organisations. The energy strategy is being formed in a highly dynamic and contested period for energy futures, and in addition to sectoral, supply chain and technology-specific expertise, there is an important role for independent, interdisciplinary and holistic expertise able to synthesise and contextualise the emerging evidence base.

Here, the Government's commitment to whole systems analysis, and allowing wider access to the Scottish TIMES whole energy systems model is welcome, and should allow strengthened research-policy exchange. Scotland's energy systems interdisciplinary research base has tended to be fragmented and patchy, and there is an important role for interdisciplinary networks and centres such as UKERC and ClimateXChange in co-ordinating and capacity building the community as it develops in response to policy and stakeholder needs.

The Climate Change Plan and Energy Strategy (or an independent analytical body) could usefully differentiate between areas where supporting evidence is relatively robust and consistent (e.g. the increasing affordability of large-scale offshore wind, and opportunities for buildings efficiency improvements) and other areas where there is still considerable uncertainty and variability in the evidence base (e.g. on low carbon heating supply technologies and the benefits and costs of local energy systems). Simple presentation of evidence consensus and confidence are used by public bodies such as the Office for National Statistics and also DEFRA.

The Climate Change Plan includes detailed proposals and measures for policy monitoring and evaluation, and the setting up of a new governance body to provide advice to Government. While these proposals are welcome, improved monitoring and assessment cannot guarantee delivery of policy outcomes given the multiple uncertainties involved, many of which are beyond the Scottish Government's control. It is therefore important that distinctions are made between areas of policy that the Scottish Government has responsibility for and those where the UK government (or, for the time being, the European Union) plays a leading role. It is also essential that any new advisory body operates relatively independently from Government. An alternative measure might be to strengthen and formalise the advisory role of the UK Committee on Climate Change in its relations with Scottish Government.

Reference

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Q. 17 What are you views on the proposed approach to deepening ***public engagement*** *set out in chapter 6?*

We welcome the proposal for the Scottish Government to broaden its engagement with stakeholders and civil society across Scotland about the transition to a sustainable energy future. This mirrors increasing interest at UK government level. Over the past nine months, UKERC, BEIS and Innovate UK have led the development of a new Citizen-centred Low Carbon Transition (C3T) working group. The group comprises academic, policy, industry and third sector organisations, including ClimateXChange. The group has received Ministerial support, and is currently finalising an integrated public engagement strategy for the UK.

It is clear from the Scottish Government's draft Energy Strategy and Climate Change Plan that a good range of initiatives for public and stakeholder engagement in the low carbon transition are evident in Scotland, and have already played a role in forming the Government's energy strategy. We note, however, that the proposed 'approach to deepening public engagement' set out in chapter 6 is very brief and comes right at the end of the consultation document. There is increasing awareness and evidence that achieving low carbon energy transitions in a fair and effective way depends on the meaningful engagement of wider society (Chilvers and Pidgeon, 2016). This suggests that a more comprehensive approach to public and stakeholder engagement is required that is properly integrated into all aspects of the Scottish Government's energy strategy.

Research conducted by UKERC and the Science, Society and Sustainability (3S) Research Group at the University of East Anglia shows that approaches to public engagement with energy (for example, those highlighted in the consultation document: information provision and awareness raising, behaviour change programmes, community conversations, and deliberative processes to inform energy policy) do not occur in isolation but interact together as part of a wider interconnected system of public engagement with energy (Chilvers and Longhurst, 2016; Chilvers et al., 2015). This shows that an integrated whole systems approach to public engagement will be crucial to the success of the Scottish Government's energy strategy, which needs to join up and coordinate disparate engagement initiatives so they become more than the sum of their parts.

The value and importance of this whole systems approach to public engagement in this way has been demonstrated by a recent UKERC systematic mapping of UK public engagement in energy between 2010-2015 (Pallett et al., 2017). The review reveals the sheer diversity of ways that people are already engaging with the shift to a low carbon energy system: from investing in energy co-operatives to major field trials of smarter networks; and from developing low carbon solutions in Transition Towns to new forms of political mobilization and protest. In Scotland, the review showed a significant number of community energy groups and initiatives based in Scotland, as well as a richness of academic work around public engagement with renewable energy and district heating, and several examples of local government public engagement around energy issues. These forms of engagement go beyond government-led approaches to information provision, behaviour change and social acceptance initiatives.

The Scottish government's approach to public engagement could also learn lessons from a major UKERC research project led by Cardiff University between 2011 and 2013. It developed and executed a systematic methodology for engaging diverse members of the general public with the question of future energy system transition, hereafter referred to as the 'UKERC Public Values Project' (Pidgeon et al 2014; Demski et al, 2015, 2017). This project, which was novel in engaging people in Britain with energy system change for the very first time at the system-wide level, incorporated a significant element of in-depth field and survey work with members of the Scottish public. In our view this research provides one proven template for how the Scottish Government might begin to think about its future public engagement methodologies and strategies in future.

In January 2017 the UKERC team at Cardiff were commissioned by ClimateXChange to prepare a report to accompany the publication of the Scottish Government's draft strategy. We were asked specifically to draw out the Scotland-relevant findings from the UKERC Public Values Project, highlighting any differences there might be between these and the national UK results (see Demski and Pidgeon, 2017). In broad terms we concluded that citizens in both the UK and Scotland aspire, in common with each other, to a long term low-carbon energy future that is based upon greatly reducing society's reliance upon finite fossil fuels, and greatly increased efforts in reducing final energy use.

This vision was underpinned for people by a set of values to which they aspired, including such things as environmental protection, development of innovative energy solutions and technologies, reducing wasted energy, fairness in energy provision, while also respecting a degree of individual autonomy for people - all values that are already, implicitly or explicitly, present in the draft Scottish Energy Strategy. We also concluded from this project that, given the right resources and time to deliberate, citizens in Scotland, as elsewhere in the UK, are perfectly capable of engaging enthusiastically and in considerable depth with many of the difficult policy choices and trade-offs that the new Energy Strategy will pose for Scottish society. This direct evidence reinforces our view that the Scottish Government should be proactive in developing a programme of public engagement, based upon a genuinely systems-led approach.

There is a genuine question raised by the current consultation proposals in that they leave open the objectives of any future Scottish Engagement Strategy, and in particular what such a strategy might aim to achieve. There are many potential objectives ranging from simply informing or engaging people, through to providing social intelligence that can inform and shape policy, through to a direct critique of that policy. Here we would argue that the principle objective should be to secure 'public consent' for the coming sustainable energy transition (also Roberts, 2017).

Such an objective goes well beyond simply seeking 'acceptance' of any specific low-carbon technology (e.g. Carbon Capture and Storage systems, Bioenergy, Onshore Wind etc.) or demand-side policy. Rather, the idea is to foster a broad consensus or mandate from various sectors of the public as a whole, such that key policy players including government, regulators, industry, and community and other civil society groups can be confident that the direction of travel towards a sustainable energy system change holds genuine and broad assent. Political scientists often refer to this idea as a 'social contract' between citizens and government. The UKERC Public Values Project has demonstrated empirically that such a social contract can and should be the goal of policymakers in Scotland, and we would recommend that the Scottish Government pursue this as its principal objective in developing its future public engagement strategy.

To meet this objective, public engagement initiatives implemented as part of the Strategy could include emerging methods for mapping diverse forms of public engagement with low carbon energy transitions. These include systematic reviews, issue-mapping, network analysis and other 'digital methods' for gathering and analysis content from websites and social media platforms (for example, the Digital Methods Initiative, University of Amsterdam (see https://wiki.digitalmethods.net/dmi). Such approaches to mapping public engagement in 'real time' provide a broader and more comprehensive evidence base to inform policy developments and social change.

We are encouraged to see the consultation document stating the objective to: 'improve the design of programmes and initiatives through sharing ideas and listening to and feeding in the views of the public in designing policy'. But the current document provides little indication of how this will be achieved. An effective 'approach to deepening public engagement' will depend just as much on deepening the capacities of institutions and decision-makers to respond to the outcomes of public engagement processes in a responsible and publicly accountable way. This will require dedicated resources, training and work programmes targeted at enhancing institutional responsiveness to the social intelligence produced through an integrated programme of public engagement, for example building on the learning gained through a UK Government sponsored Sciencewise programme (see for example Chilvers, 2013).

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