# Building our Industrial Strategy

## Response to the Green Paper from the UK Energy Research Centre

Prof Keith Bell
Prof John Barrett
Prof Paul Ekins
Prof Nick Eyre
Dr. Robert Gross
Prof Jim Watson
Lindsay Wright

## ABOUT UKERC

The UK Energy Research Centre (UKERC) carries out world-class, interdisciplinary research into sustainable future energy systems. It is a focal point of UK energy research and a gateway between the UK and the international energy research communities. Our whole systems research informs UK policy development and research strategy. UKERC is funded by The Research Councils UK Energy Programme.

For information please visit www.ukerc.ac.uk
Follow us on Twitter @UKERCHQ

## Introduction

The development of a comprehensive industrial strategy for the UK is long overdue. The strategy is an opportunity to bring much needed coherence to economic and industrial policy, and to ensure that it works in tandem with the government's other policies and plans. It is particularly important that the strategy underpins the UK's transition towards a cleaner, low carbon economy. This will only be achieved if it is fully compatible with the Climate Change Act, and is integrated with the forthcoming Emissions Reduction Plan.

The Green Paper includes a welcome confirmation of the government's commitment to reducing greenhouse emissions to meet statutory targets, and to do so whilst meeting other important energy policy goals. Unlike previous statements of energy policy, we are pleased to see that the Green Paper adds a fourth policy goal alongside the familiar 'trilemma' of emissions reduction, energy security and affordability. Such an approach is common in many other countries, and the UK has been an outlier in the lack of focus on the employment and industrial benefits of the transition to clean energy.

To the extent that the UK government has developed industrial strategies in the past, this has traditionally focused predominantly on sectors. Whilst this sectoral approach has led to some positive developments, it risks supporting those industries that have the most resources to lobby for sectoral deals (BEIS Committee, 2017). As the Secretary of State argues in his introduction to the Green Paper, the job of industrial strategy must be to open up new opportunities, and not just to protect incumbents. The recent House of Commons BEIS committee inquiry on industrial strategy advocates an alternative approach. We agree with their proposal for a continuation of 'horizontal' policies to support industrial development and innovation, combined with a focus on specific 'missions' that are designed to meet societal goals (Mazzucato and Watson, 2016). The transition to a clean, low carbon energy system is a good example of such a mission. It has the advantage of cutting across traditional sectors and including significant scope to support the new technologies and business models that will be required.

When implementing the industrial strategy, the government will inevitably be faced with the need to prioritise particular missions, industries or technologies due to financial and other constraints. The trade-offs between sectors, challenges and regions will be partly political, but decisions should be taken on the basis of the available evidence. However, as the BEIS committee argued, the current Green Paper contains 'little discussion of the implicit tensions and conflicting demands that exist in policy making' (BEIS Committee, 2017). It also lacks an explanation of how the government is making decisions about which sectoral deals to focus on.

Previous industrial strategies have also lacked such an evidence base. For example, the government published a low carbon industrial strategy in 2009 (BIS and DECC, 2009). This was comprehensive in its coverage and referenced several studies of UK strengths, weakness and opportunities. However, the link between these studies and the priorities discussed in that strategy was not particularly clear.

For the transition to a low carbon energy system, significant analysis has already been carried out by government to establish an evidence base for a set of priorities (LCICG, 2014). This has been complemented by analysis by the Research Councils UK Energy Strategy Fellowship (Skea, Hannon and Rhodes, 2013) and other public bodies such as the Carbon Trust and the Committee on Climate Change. Taken together, this evidence base suggests a number of important criteria that should inform policy priorities. These include:

- the potential UK and global market for different low carbon technologies;
- the potential for cost reductions, including the effect of UK policy on such cost reductions;
- the potential value to the UK-based components of supply chains; and
- the extent of existing scientific and industrial capabilities.

Good examples of priorities that would advance the transition to a low carbon energy system include offshore wind, where the UK has considerable leadership in deployment, and UK policies have a significant impact on international innovation and costs); and smart energy systems, where the UK has been at the forefront of demonstration trials (Frame, Bell and McArthur, 2016).

However, one drawback of this existing evidence base it that it tends to focus on discrete technologies, and pays less attention to the system innovations that will also be required (e.g. for smarter electricity grids and for low carbon heating systems). Such system innovation will be a key feature of successful low carbon transitions (Watson, Kern and Wang, 2015). This is also a weakness of the Green Paper as it stands. Whilst it is right to highlight the significant opportunities in areas such as smart electricity grids and electric vehicles, the Green Paper pays too little attention to energy efficiency in homes and commercial buildings and to new systems for low carbon heating. There is also a gap in thinking about how the decline of incumbent industries such as offshore oil and gas will be taken into account, including any opportunities for existing skills to be transferred to newer industries for which they are still relevant.

## Responses to consultation questions

We have confined our specific responses to the four questions on energy.

## 27. What are the most important steps the Government should take to limit energy costs over the long term?

As the Green Paper notes, the costs of energy to UK consumers and businesses are not uniformly high when compared to those of other countries. Electricity prices for industrial consumers are at the high end of the European range. Large energy intensive consumers are already exempt from 80% of policy costs. Gas costs are more similar to those in many other European countries. Furthermore, as the Committee on Climate Change's most recent analysis shows, household energy bills (as opposed to prices) have actually fallen in recent years. Between 2008 and 2016, average household dual fuel bills have fallen by £115 due to price increases (including the effect of any policy costs) being offset by improvements in energy efficiency (CCC, 2017).

Action to reduce energy costs also needs to take into account the long-term goal confirmed by the Green Paper, which is to meet the targets in the Climate Change Act. This requires a largely decarbonised energy system by 2050. To achieve this will require further action to bring down the costs of low carbon technologies. Some low carbon electricity generation technologies are already approaching competitiveness with fossil fuels. This is even the case when the additional costs of integration into electricity systems are taken into account (see below).

Taking into account these trends, it is essential that a long-term approach to reducing energy costs (i.e. energy bills) for consumes is taken. Whilst reducing the size of policy costs on consumers may seem politically attractive on the short term, it would not help to solve the long-term problem of a carbon intensive energy system. This means further policy intervention to provide time limited incentives for innovation (linked to evidence of cost reductions) and energy efficiency measures to bring about further reductions in energy bills, even if supporting those innovations and measures leads to modest increases in prices. As we argue in our responses to Q28 and Q30 below, this requires further specific policy action to create and sustain markets for these measures.

As recent experience in the UK and world-wide has shown, the costs of most low carbon technologies have fallen significantly in recent years (IEA, 2016: 53). This has been the result of market creation policies in many countries. UK consumers have benefitted from these policies – and in some cases such as offshore wind, UK policies have had a significant impact on cost reduction trends. Important exceptions to this include nuclear power which has been characterized by steadily rising costs over time. Recent experience of new nuclear in Western Europe has been particularly poor, with large cost overruns and delays to reactor construction.

As the energy system changes, it will also be important to provide more incentives for electricity system flexibility to help minimize future energy costs. The National Infrastructure Commission argued last year that £8bn a year could be saved by 2030 through measure to increase flexibility – particularly interconnectors, demand side response and storage (NIC, 2016). Whilst the precise value of savings is subject to significant uncertainty, this overall conclusion fits with UKERC's evidence review of the costs and impacts of intermittent renewables on the electricity system (Heptonstall et al, 2017). Intermittency provides a particular challenge for electricity systems that were designed around large centralized fossil and nuclear generators. Our assessment shows that a more flexible electricity system is likely to be able to integrate intermittent renewables at a significantly lower cost. In UK conditions, this means an additional cost of £10/MWh for a share of intermittent renewables of up to 30%. Such renewables already provide around 14% of UK electricity, a proportion that is set to grow further in the next few years.

Finally, it is important that the approach to energy within the industrial strategy should not only focus on electricity. Sources of energy other than electricity account for a significant proportion of energy costs. They also include significant scope for innovation and job creation to bring down these costs over the long term, for example through the demonstration and deployment of low carbon heat systems and through further improvements in energy efficiency (see our response to Q30 below).

## 28. How can we move towards a position in which energy is supplied by competitive markets without the requirement for ongoing subsidy?

Our response to this question focuses on electricity. Shifting towards a more market-led approach to achieving a low carbon electricity system is sound in principle and may offer benefits in terms of efficient allocation of resources, price discovery and incentives for market-led innovation (Gross and Watson, 2015). There are a number of caveats to this.

First, as the implementation of Electricity Market Reform (EMR) has demonstrated, 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.

Second, there are considerable externalities associated with the use of fossil fuels. These should be internalised into their cost (e.g. through carbon pricing) before clean energy technologies are expected to operate without subsidy.

Third, it is important to acknowledge at the outset that there are limits to neutrality due to the differences between the low carbon options that this policy framework is designed to support. It is well understood that purely technology-neutral 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. For example, the cost reductions now being experienced by offshore wind would not have happened without specific technology support. Currently, tidal lagoons may be in a similar situation to the position for offshore wind a decade ago. It therefore makes sense for government to support the initial demonstration of this technology at full scale as recommended by the Hendry Review (Hendry, 2016). Moreover, markets are not generally efficient providers of network infrastructure – government's role in such provision is widely accepted, not least as part of the rationale of having a National Infrastructure Commission.

Finally, it is important to be clear which market opportunities are being sought and optimised – markets can take the form of auctions for capacity, provision of flexibility or other system services, or long term contracts. It is important not to conflate technology neutrality and market principles with a return to an 'energy only' market – even if it proved possible to put a strong carbon price or cap on emissions in place.

Any future reforms to the UK policy framework for electricity should consider a number of factors. We think that five are particularly important:

a. Whilst shifting away from subsidies is a laudable aim, it is important to take into account all subsidies when comparing cleaner, low carbon options with fossil fuels. Fossil fuel use (including in electricity generation) benefits from significant subsidies at present. Although the carbon price floor means that fossil fuel electricity generators pay for some of their external costs, the level of the price floor is lower than most estimates of the damage costs of greenhouse gas emissions.

b. Addressing market failures associated with carbon emissions and R,D&D is necessary but not sufficient. Whilst carbon pricing is necessary, in practice it is unlikely to be sufficient to drive new investments in low carbon generation (or indeed in enhanced levels of energy efficiency) in the foreseeable future. Carbon prices from the EU emissions trading scheme are too low and uncertain, and the carbon price floor is subject to too much political risk. Such uncertainties are compounded by the lack of clarity about the impact that Brexit might have. Therefore, long-term contracts are also likely to be required for such investments (e.g. Newbery, 2016). It is also necessary to continue to facilitate a strategic approach to the development of regulated assets such as the power grid, and any future heat, electric charging or CCS networks. Support for research, development and demonstration of emerging technologies will also continue to be important if emissions reduction goals are to be met. This applies in particular to the 'valley of death' between R&D and commercial deployment (see response to Q29 below).

c. A fundamental shift away from the EMR policy framework would be both risky and time-consuming. There are alternatives, such as the regulated asset base approach (Blyth et al, 2015) or other forms of auction (e.g. Helm, 2015). However, due to the risks to investor confidence (which is already fragile) and limits to the amount of time available to meet carbon targets, it would be preferable to adopt an evolutionary approach that works with the current set of policy instruments. Implementation of these policies can be adjusted significantly – and that will be required if policy goals are to be met. Time and again the energy industry and investment community have stressed the importance of longer term signals and policy clarity.

d. Any reforms should take a systems approach to implementation. This is partly reflected in the Green Paper's emphasis on the role of smarter electricity networks. The network infrastructure and systems impacts of different low carbon technologies are not the same. Intermittent renewables lead to specific challenges and policy questions about the costs and impacts of integration. UKERC recently completed an update of its 2006 evidence review on this subject. The key finding of this updated review is that greater electricity system flexibility is likely to significantly lower the costs of integration (Heptonstall et al, 2017). Notwithstanding the recent cancellation of the CCS commercialisation competition, achievement of the carbon emissions reduction targets post-2030 is likely to require carbon capture and storage (CCS). CCS deployment is partly dependent on the development of pipeline networks and storage sites. Reforms are also needed to ensure that the demand side of the electricity system is included in future. This means ensuring that contracts for 'negawatts' are possible if these turn out to be part of a least-cost portfolio (Eyre, 2013; Green Alliance, 2016)

e. Policy interactions will also need to be closely monitored and addressed where needed. It is hard to separate a discussion about reform of the implementation of specific elements of EMR (e.g. contracts for difference) from other elements, or from broader policies (e.g. for land-use planning). Falling wholesale prices are partly driven by the increase in zero-marginal cost generation, funded by long term contracts. This has reduced incentives for investment in new gas-fired power plants that may be required to balance supply and demand – and has therefore led to stronger incentives through the Capacity Market (DECC, 2016).

With these considerations in mind, the transition to a market that relies less on subsidies could have the following elements:

- We recognise the case for all low carbon technologies, including contracts for energy efficiency, to be moved into a single competitive auction over time. However, in practice specific arrangements are likely to be needed for particular technologies for the foreseeable future – especially those that are complex, capital intensive and characterised by high financial risks. A particularly strong case has been made by the Oxburgh report on carbon capture and storage (CCS) that these technologies require a more state-led approach to investment that still leaves significant room for competition to minimise costs (Parliamentary Advisory Group on CCS, 2016). In the context of the industrial strategy, CCS technologies are also a potential priority since they offer a way to decarbonise some industrial sectors for which there are few alternatives. They can therefore help make sure sectors compatible with the overall mission of a transition to low carbon economy.

- As the Committee on Climate Change has argued (CCC, 2015), visibility about funding for low carbon contracts is increasingly critical for investors developing new projects. The 2017 Budget announced a review of the Levy Control Framework. Whatever arrangements are put in place for the future, it is important that these provide more certainty into the 2020s, and learn lessons from the Framework's implementation. Rather than using short-term wholesale electricity prices to calculate the size of financial flows in future, a longer-term average price should be used to reduce the political risks and uncertainty. Any impacts on consumer bills should be calculated on a net basis in relation to this average price so that any falls in wholesale prices (which benefit consumers) do not simply drive an increase in the apparent costs of EMR policies to consumers (House of Commons Energy and Climate Change Committee, 2016).

- 'Subsidy-free' contracts for difference are worth further consideration. Such contracts would not provide additional funding for a low carbon project when compared to the lowest cost alternative (usually assumed to be a gas-fired CCGT). However, they would reduce political and other risks for investors – and this leads to an important debate about what 'subsidy-free' means in practice, and how such contracts would differ from fixed-price power purchase agreements. Further investigation is needed to assess whether this approach could undermine the ultimate aspirations for technology neutral auctions where contracts are simply awarded to the lowest price bidders.

- Even with technology-neutral contracts for difference, specific policies will still be required for emerging technologies. At present, this is handled by complementing RD&D support with contracts through a specific Levy Control Framework funding 'pot'. An alternative would be to allow emerging technologies to compete in the main auction, and to offer them additional forms of support that is required to reduce the risks of innovation, demonstration and scaling up. As discussed above, explicit criteria and evidence are required to decide which technologies should receive additional policy support.

- The Capacity Market can also help reduce the costs of the low carbon transition for electricity by explicitly providing incentives for the full range of sources of flexibility: flexible generation, storage, demand side response and interconnectors. As we argue in our response to Q27, the economic benefits of increased flexibility could be very significant. Any further reforms to the Capacity Market should retain the principle that balancing of supply and demand is best achieved and paid for on a system-wide basis. Proposals from others (e.g. Helm, 2015) that renewables generators in particular should self-balance would impose un-necessary costs on individual generators and the system as a whole. Reforms are also required to ensure that the Capacity Market is more neutral with respect to different sources of flexibility. Whilst there may be a rationale for different capacity contract lengths for supply and demand side investments (e.g. DECC 2016), offering equal terms to both would allow market participants to identify the most cost effective sources of capacity, and would thereby minimise the amount of subsidy required.

## 29. How can the Government, business and researchers work together to develop the competitive opportunities from innovation in energy and our existing industrial strengths?

Businesses, universities and the government all have important roles to play in the UK's 'innovation system' – including the specific innovation system for cleaner energy technologies. As we argue in the introduction to this response, the industrial strategy is an important opportunity to go further than previous sectoral approaches. There are good arguments for combining a mission-oriented strategy with more traditional 'horizontal' policies to support innovation and industrial development.

The transition to a cleaner, low carbon energy system is a good example of such a mission. Recent evidence shows that those countries that have been more successful in clean energy innovation have pursued a mission-oriented approach (Mazzucato and Semieniuk, 2017; Mazzucato and Watson, 2016). This goes well beyond the traditional economic prescription of correcting market failures (such as the failure of firms to invest sufficiently in R&D). Instead, government policies and organisations intervene in multiple ways to shape markets, and to reduce risks faced by the private sector.

It is welcome that the mission of transitioning to a cleaner, low carbon energy system has already been identified within the Green Paper as a priority. This mission includes a range of opportunities for building on existing UK industrial and research strengths as well as developing new industries and sources of jobs and growth (Skillings and Smailes, 2017). However, as we also note in our introductory remarks, it will be important to use an evidence based approach so that limited public money and policy attention can be prioritized effectively. Furthermore, any priorities will need to ensure that there are a wide range of potential beneficiaries – not just incumbent industries.

Implementing the industrial strategy effectively will also require further action to address some of the shortcomings of the UK's innovation system – particularly the under-performance in connecting an internationally leading research base with the successful commercialization of new products and services. This has been documented in detail, for example in the Dowling Review of Business-University Research Collaborations (Dowling Review, 2015), the House of Commons Business, Innovation and Skills Committee (BIS Committee, 2014) and, more recently, the BEIS Committee (BEIS Committee, 2017).

As these reports acknowledge, government has acted to try to address this structural problem. This includes the formation of Innovate UK and funding for a new network of catapult centres. Four of these catapult centres now include the transition to clean energy within their remits (Transport Systems, Energy Systems, Offshore Renewable Energy and Future Cities). However, even the most recent BEIS Committee report on industrial strategy concludes that it is too early to tell whether the catapults have been successful, and recommends that they be given more time to demonstrate impact before changes are made.

Whether or not the catapults help to significantly bridge between the academic research base and industry, they should not be developed or evaluated in isolation from other elements of the UK's innovation system for clean energy.

The implementation of the industrial strategy should therefore pay sufficient attention to a number of other issues, including:

- The need to reduce complexity. The Dowling Review identified the complexity of the UK's innovation system as a potential barrier to performance. Although some complexity is to be expected – and is also a feature of energy innovation systems in other countries – the UK's approach has been characterised by a series of overlapping institutions and support programmes that can be hard to navigate. The new Energy Innovation Board has an important role to play in helping to bring greater coherence to these institutions and programmes.

- Co-ordination between university research and industrial research funding. The Industrial Strategy Challenge Fund represents an important opportunity to provide greater support for firms developing clean energy innovations. A wide range of potential clean energy priorities have already been discussed, and funding has already been confirmed for some of these. This funding, and complementary programmes that support university research in the same area, need to have sufficient overlap with respect to the stage of technology development (or Technology Readiness Level) they support. This will help to facilitate collaboration rather than compartmentalisation. Sufficient attention is needed to the 'valley of death' between research and commercial deployment, where both costs and risks faced by the developers of new technologies often remain high. Offshore wind technology has recently crossed the valley of death, partly due to patient support from government and public sector innovation organisations over an extended period.

- The need for public sector institutions to have sufficient capacity to fund and support mission-oriented innovation. Evidence from agencies such as ARPA-E in the United States shows that this capacity includes having sufficient budget, autonomy from both short-term politics and incumbent business interests, and highly qualified staff (Hayley, 2017). In a fast-moving area like clean energy, these institutions need to direct financial support where it is needed to meet mission goals – and to learn quickly from both successes and failures.

## 30. How can the Government support businesses in realising cost savings through greater resource and energy efficiency?

We welcome the recognition that improved resource and energy efficiency can contribute to energy affordability and productivity goals. It is the cost of energy services, determined by a combination of energy unit prices and technical efficiency, which matters to final consumers. Historically, improved efficiency has been the largest single contributor to lowering the costs of energy services and there remains a very large potential for continued improvement. Energy efficiency activity has been seriously damaged by a number of policy changes since 2012, and these need to be addressed urgently (UKERC, 2016). We strongly agree with the analysis in the Green Paper (page 91) that there is potential in new business models as well as technological change, indeed the evidence indicates that the two are often closely linked.

As discussed in our response to Q28, we agree with the goal of eliminating structural subsidies in the energy sector, including for energy efficiency. However, there are a number of widely held misconceptions that need to be addressed in delivering this agenda:

- the majority of energy subsidies are for energy supply, not energy efficiency, and therefore tends to militate against energy efficiency rather than support it.

- it is important to differentiate between long term structural subsidies, such as carbon prices that are much lower than the social cost of carbon (see our response to Q28), and subsidies via taxes or energy bills that are designed to support innovation for a limited period of time.

- There are a number of important energy sector outcomes which represent public goods rather than private benefit, notably energy security and carbon emissions reduction. Socialising the cost of delivering these goals should not be considered as a subsidy. Moreover, where energy efficiency provides a more cost effective route to delivering these public goods than supply side options, it is in the interests of both business and households to structure policy to promote energy efficiency. Particularly in the electricity sector, current policy arrangements do not do this (UKERC, 2016), indeed there have been major reductions in the effectiveness in energy efficiency policies over the same period that energy supply subsidies have risen.

We suggest that the work on energy efficiency within the industrial strategy should cover both households as well as businesses. There are several reasons why this would be appropriate:

- there is significant overlap in technologies used in residential and non-domestic buildings, and therefore a coherent approach needs to cover both,
- energy efficiency supply chains, many with the potential to develop exports markets also operate across this divide.
- For the reasons set out above, improved energy efficiency across the economy can contribute to more efficient energy systems and therefore lower costs to both UK businesses and households.

There are a number of barriers to money saving measures in homes and businesses. These have been set out in both the academic literature (e.g. Sanstad and Howarth, 1994; Eyre, 1997; Brown, 2001, Sorrell et al, 2004), but also in a number of UK Government publications (e.g. Oxera, 2006; Stern, 2006). Barriers include:

- imperfect information to energy consumers,
- separation of costs and benefits (e.g. the landlord/tenant barrier),
- imperfect capital markets,
- tariff structures which do not reflect marginal costs,
- non-inclusion in prices of externalities, and
- bounded rationality (i.e. deviations from profit/utility maximisation).

Some of these can be addressed directly, e.g. through advice programmes to improve information, but others are quite deeply embedded features of energy markets and human behaviour. In the latter cases, alternative policy approaches are required and justified. There is good evidence that product and building standards are amongst the most cost effective approaches. For example, the largest single contributor to improved energy efficiency in the UK in recent years was the decision to require condensing boilers as part of the Building Regulations. We believe that an energy efficiency strategy should develop this approach and set out a long term trajectory of stronger energy efficiency standards in both new and existing buildings.

Energy efficiency standards have also been important in reducing energy costs in both electrical appliances and vehicles. The situation is more complex here than for buildings, as the current policy framework is determined at EU level, and therefore needs re-consideration in the context of Brexit. The proposed Repeal Bill will bring the relevant standards into UK law. However, significant improvements are planned at EU level and it will be important that UK energy users are not disadvantaged by such changes after 2019. In most cases, there will also be significant advantages for UK manufacturing in retaining alignment with EU and wider global product standards. The industrial strategy should therefore set out a mechanism for achieving this.

In the transport sector there potential for new business models and better urban infrastructure to deliver a range of benefits including cost saving, environmental improvement and the development of export opportunities. In this sector in particular, it will be important to define resource efficiency measures broadly, and for infrastructure choices to take energy issues into account.

There is considerable evidence that resource productivity improvements, including through public procurement, extended producer responsibility and industrial symbiosis, could make a significant contribution to growth in key sectors in the UK, particularly the construction sector (Ekins et al. 2017). Additionally, there is a strong link between resource productivity, energy demand and greenhouse gas emissions. This means that improved resource productivity could also make an important contribution to limiting the UK's emissions within the 4th and 5th carbon budget (Ekins and Hughes 2016).

Research undertaken by the Centre for Industrial Energy, Materials and Products (CIE-MAP) and UKERC has quantified the UK's cumulative emissions between 2013 and 2032 to analyse whether resource consumption strategies, in addition to existing and planned UK climate, can meet the UK's 4th and 5th carbon budgets. Resource productivity measures can bridge the UK's emissions shortfall for the fourth carbon budget and put the UK well on track to meeting its fifth carbon budget. In 2032, the end of the fifth carbon budget period, existing climate policies save 85 Mt, planned climate policies save an additional 52 Mt, resource productivity an additional 6 Mt to 10 Mt.

The majority of these savings are aligned with cost savings for the sectors analysed (predominately construction, services and food sectors). This means that a unique opportunity exists to align industrial and climate policy through improved resource productivity which can drive innovation and develop new markets. Historically, the fact that prices of materials have been low in comparison to labour costs, has been one of the major factors that resource productivity improvements have not been explored or adopted. With a low level of UK Government intervention, it is possible to create the "market" for resource productivity measures across key industrial sectors. We have summarised some of the key initiatives that we believe the UK Government should pursue:

1. The environmental case for resource productivity is strong and should therefore form part of the solution outlined in the Clean Growth Plan as well as the industrial strategy

Our conservative analysis of the role of resource productivity in climate change mitigation demonstrates annual reductions of greenhouse gas emissions of between 16 and 32 million tonnes by 2032. We recommend the inclusion of resource productivity within the Clean Growth Plan and believe this potential could be realised with Government support for assessment and benchmarking resource use at the national, sector and product level (documented below). Please see the enclosed policy brief describing the mitigation potential of improved resource productivity.

2. Measuring and managing embodied carbon emissions achieves savings in resource use, emissions and cost

Monitoring and targeting reductions in capital carbon (i.e. embodied emissions) at the organisational level can achieve substantial emissions and costs savings. With appropriate support, there is significant scope for best practice in embodied carbon management to proliferate within and transfer between sectors. The water industry is an excellent example where innovations in design motivated by ambitious project carbon targets helped Anglian Water halve capital carbon emissions and reduce capital costs by 20% in just 6 years. Other water companies, such as Yorkshire Water, are now adopting similar targets and management approaches. Meanwhile, numerous construction firms are adapting and applying Anglian's approach to the delivery of buildings and other infrastructure asset types.

3. Government should provide targeted support for assessment of embodied emissions and resource use in key sectors

The University of Leeds (one of UKERC's core partners) is working with Defra, BEIS and ONS to develop a national indicator of resource productivity which seeks to address a number of issues we discussed at the roundtable. Our preliminary results show a strong link between embodied carbon emissions and resource use, with the majority of impacts attributable to a small number of sectors. For instance, just 28 sectors account for 80% of the UK's carbon footprint and 68–82% of the material footprint for each of the 11 major resource groups we assessed. This suggests that targeted support for management of supply chain emissions and resource use in key sectors could drive substantial changes in national outcomes. The features of such sector specific support could be identified and incorporated into the sector deals proposed as part of the industrial strategy. Promoting measurement of embodied impacts is essential in establishing clear sector and product level benchmarks and would allow for the establishment of targets in the future.

4. Include embodied emissions or resource productivity targets within public procurement

There is a unique opportunity for Government to lead the way by integrating embodied emissions or resource productivity targets into briefs and tender documents on publicly funded projects. This 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.

## References

Department of Business, Innovation and Skills and Department of Energy and Climate Change (BIS and DECC) (2009) The UK low carbon industrial strategy. London: The Stationery Office.

Blyth, W., McCarthy, R. and Gross, R. (2015) Financing the UK power sector: Is the money available? Energy Policy 87: 607–622.

Brown, M.A., 2001. Market failures and barriers as a basis for clean energy policies. *Energy Policy* 29, 1197–1207.

Committee on Climate Change (2015) The fifth carbon budget – The next step towards a low-carbon economy. London: Committee on Climate Change.

Committee on Climate Change (2017) Energy prices and bills: impacts of meeting carbon budgets. London: Committee on Climate Change.

DECC (2016) Consultation on Further Reforms to the Capacity Market. London: Department of Energy and Climate Change.

Dowling Review (2015) The Dowling Review of Business-University Research Collaborations. Report to the Minister of State for Universities and Science. London: BIS.

Ekins, P. Keppo, I., Skea, J., Strachan, N., Usher, W., Anandarajah, G. (2013). The UK energy system in 2050: Comparing Low-Carbon, Resilient Scenarios. UKERC Working Paper. London: UK Energy Research Centre.

Ekins, P. and Hughes, N. (2016) Resource Efficiency: Potential and Economic Implications. Summary for Policy Makers. International Resource Panel. Nairobi: UNEP. http://www.resourcepanel.org/reports/resource-efficiency

Ekins, P., Hughes, N. et al. (2017). Resource Efficiency: Potential and Economic Implications International Resource Panel. Nairobi: UNEP. http://www.resourcepanel.org/sites/default/files/documents/document/media/resource_efficiency_report_march_2017_web_res.pdf

Eyre, N., 1997. Barriers to energy efficiency more than just market failure. *Energy and Environment* 8, 25-43.

Eyre, N. (2013) Feed-in Tariffs: the energy saving option. UKERC energy briefing paper. London: UK Energy Research Centre.

Frame, D., Bell, K. and McArthur, S. (2016) A Review and Synthesis of the Outcomes from Low Carbon Networks Fund Projects. Report by Supergen Hubnet and UKERC.

Green Alliance (2016) Beyond subsidy: how the next levy control framework can cut carbon at least cost. London: Green Alliance.

Gross, R. and Watson, J. (2015) Driving innovation through continuity in energy policy UKERC Working Paper. London: UK Energy Research Centre.

Hanna, R et al (2015) Innovation timelines from invention to maturity: a rapid review of the evidence on the time taken for new technologies to reach widespread commercialization. UKERC Working Paper. London: UK Energy Research Centre.

Hayley, B. (2017) Designing the public sector to promote sustainability transitions: Institutional principles and a case study of ARPA-E. Environmental Innovations and Societal Transitions. In press.

Helm, D, (2015) The first 100 days of Conservative Energy Policy. Energy Futures Network Paper No.13.

Hendry, C. (2016) The Role of Tidal Lagoons. Final Report.

Heptonstall, P., Gross, R. and Steiner, F. (2017) The costs and impacts of intermittency – 2016 update. London: UK Energy Research Centre.

House of Commons Business, Energy and Industrial Strategy Committee (2017) Industrial Strategy: First Review. HC616. London: House of Commons.

House of Commons Business, Innovation and Skills Committee (2014) Business-University Collaboration. London: The Stationery Office.

House of Commons Energy and Climate Change Committee (2016) Investor confidence in the UK energy sector. Third Report of Session 2015–16. HC 542 London: The Stationery Office Ltd.

International Energy Agency (2016) World Energy Outlook 2016. Paris: IEA.

Low Carbon Innovation Co-ordinating Group (2014) Coordinating Low Carbon Technology Innovation Support The LCICG's Strategic Framework. London: LCICG.

Mazzucato, M and Semieniuk, G (2017) Public financing of innovation: new questions. *Oxford Review of Economic Policy* 33(1): 24-48.

Mazzucato, M. and Watson, J. (2016) Written Evidence to the BEIS Committee Inquiry on Industrial Strategy. Brighton: SPRU, University of Sussex.

National Infrastructure Commission (2016) Smart Power. London: National Infrastructure Commission.

Newberry, D (2016) Policies for decarbonizing a liberalized power sector. EPRG

Working Paper 1607. Cambridge: EPRG, University of Cambridge.

Oxera (2006). Policies for energy efficiency in the UK household sector. Report for Defra. Oxford: Oxera.

Parliamentary Advisory Group on Carbon Capture and Storage (2016) Lowest Cost Decarbonisation for the UK: The Critical Role of CCS. Report to the Secretary of State for Business, Energy and Industrial Strategy.

Sanstad, A.H., Howarth, R.B., 1994. Normal Markets, Market Imperfections and Energy Efficiency. *Energy Policy* 22, 811–818.

Skea, J., Hannon, M. and Rhodes, A. (2013) Investing in a brighter energy future: energy research and training prospectus. London: RCUK Energy Strategy Fellowship.

Skillings, S. and Smailes, N. (2017) The Clean Energy Transition and Industrial Strategy. London: E3G and Energy Systems Catapult.

Sorrell, S., O'Malley, E., Schleich, J., Scott, S., 2004. The Economics of Energy Efficiency: Barriers to Cost Effective Investment. Cheltenham: Edward Elgar.

Stern, N., 2006. The Economics of Climate Change. London: HM Treasury.

UKERC, 2016. Review of UK Energy Policy. London: UK Energy Research Centre.

Watson, J., Kern, F. and Wang, X. (2015) ‘Energy Systems and Innovation’ in Ekins, P., Bradshaw, M. and Watson, J. (2015) Global Energy: Issues, Potentials, and Policy Implications. Oxford University Press.