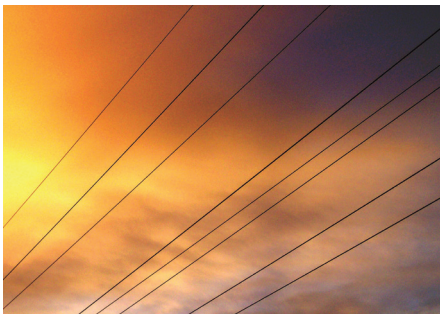


Review of UK Energy Policy

A UKERC Policy Briefing

November 2016



Summary of recommendations

This review takes stock of UK energy policy ahead of the Autumn Statement, Industrial Strategy and new Emissions Reduction Plan. Its main recommendations are:

1. An integrated, evidence based approach to the new Industrial Strategy and Emissions Reductions Plan. The Industrial Strategy should set out clear priorities and the mechanisms for realising benefits for the UK
2. A new White Paper on Heat and Energy Efficiency
3. A 'Gas by Design' approach to the future of gas that is compatible with carbon budgets and targets
4. A new approach to CCS commercialisation and deployment, in response to the Oxburgh report
5. An extension of the Levy Control Framework beyond 2020, and plans for auctions that include most large-scale electricity technologies and demand reduction in a single auction
6. Reform of the Capacity Mechanism so it gives equal treatment to all flexibility options, including demand side response and storage. This should be coupled with fairer treatment of energy storage
7. Strengthened vehicle emissions standards that drive a shift to low carbon, cleaner technologies and are designed to endure after Brexit.
8. A comprehensive programme of public engagement with energy system change at national and local levels. This should include mechanisms for the outcomes to influence policy decisions, incentives for bottom-up initiatives such as community energy, and measures to support shifts to more sustainable patterns of consumption.

Executive summary

Jim Watson, Paul Ekins, Lindsay Wright

The UK energy system is going through a period of rapid change. The implications of the vote to leave the EU and subsequent changes within government are largely unknown. Uncertainties about the future of the energy system were already high; these changes have compounded them.

This review takes stock of UK energy policy ahead of the Autumn Statement, the Industrial Strategy and the Emissions Reduction Plan that is expected in 2017. It is an evidence-based commentary covering the major components of the energy system and the links between them. The focus of the review is not only on progress with emissions reductions to tackle climate change, but also on synergies and trade-offs with other policy goals: security, affordability and (due to the recent creation of BEIS) industrial development.

The UK has a world leading policy framework for emissions reduction in the Climate Change Act, including legislated carbon budgets to 2032. This does not have to be affected by Brexit. In October, ten years on from his landmark report¹, Lord Nicholas Stern reiterated that clean, green development is the only route to global economic growth².

As the Committee on Climate Change have noted, there has been good progress with emissions reductions so far³. This has been driven by changes in the electricity system and reductions in energy demand, some of which have been policy driven. But this progress will not last into the 2020s unless policies are significantly strengthened in this Parliament. As we discuss in this review, priority areas for action include energy efficiency (see box), low carbon heat, the investment framework for low carbon power and citizen engagement.

Some policy changes during this Parliament, though understandable given the politics of deficit reduction and consumer energy bills, have had a damaging impact on investor confidence - and on cost-effective efforts to reduce emissions. They include the withdrawal of subsidies for onshore wind, cancellation of the Zero Carbon Homes standard and the termination of the carbon capture and storage (CCS) demonstration programme. The failure of the Green Deal energy efficiency programme has left a policy vacuum behind. The most recent Renewable Energy Country Attractiveness Index from Ernst and Young reported that the UK was at its lowest position ever on its international league table⁴.

If the new Emissions Reduction Plan is to succeed, there will need to be far greater buy in and cooperation across government. The Department for Business, Energy and Industrial Strategy (BEIS) is, in principle, better placed than DECC to deliver this: a bigger department with more clout. But the role of the Treasury, No. 10 and the Cabinet Office will also be crucial. The Plan needs to be developed with attention to both short- and long-term implications for affordability, security and industrial development opportunities. The co-benefits of reducing emissions, particularly in relation to improved health and air quality, strengthen the rationale for concerted action.

Energy efficiency: crucial, but neglected

There is growing international recognition that energy efficiency can contribute positively to all the objectives of the energy trilemma and that very often reducing demand is a more cost effective contributor to these goals than increasing supply¹.

The impact of policy on energy efficiency has substantially weakened in recent years, in particular with respect to electricity. The failure of the Green Deal was predicted by UKERC research² and the only remaining significant programme in the household sector does not address the main uses of electricity. In the commercial sector, the CRC Energy Efficiency Scheme has been substantially weakened and is due to be abolished in 2019. Alternative approaches to give electricity efficiency equivalent support to low carbon supply, eg Energy Efficiency Feed-in Tariffs³, have been rejected. And Brexit potentially threatens the process of updating product standards. The only significant innovation is the Electricity Demand Reduction Pilot, but our analysis of

this is that it is very small and not scalable⁴. The result is that the UK, having once been a global leader, now has one of the weakest policy frameworks for energy efficiency in the developed world.

Of course, energy efficiency has private benefits that justify private investment, but the public benefits of energy security and carbon emissions reduction merit policy support. A revitalised approach to energy efficiency is urgent, engaging the product supply chain. This includes electricity, where energy efficiency should be treated on an equal basis to supply in energy and capacity markets, drawing on experience from around the world.

One means for Government to achieve a strengthened cross-departmental focus on energy efficient, including commitment from Treasury, would be the development of a Heat and Energy Efficiency White Paper, which we advocate elsewhere in this report.

¹IEA. Energy Efficient Prosperity: The "first fuel" of economic development ²Rosenow J, Eyre N, 2013: The Green Deal and the Energy Company Obligation, Proceedings of the ICE = Energy, pp.127-136 ³Eyre N, 2013: Energy saving in energy market reform – the Feed in tariffs option. Energy Policy 52, 190-198. ⁴Liu Y, 2016: Demand response and energy efficiency in the capacity resource procurement; case studies of forward capacity markets in ISO New England, PJM and Great Britain. Energy Policy.

Policy on offshore wind offers some evidence that the Industrial Strategy and the Emissions Reduction Plan can be aligned. But an offshore wind factory and a new nuclear power station do not make an industrial strategy for energy. It needs to be much more systematic. Much of the evidence base for such a strategy exists⁵. The strategy can build on this evidence, and identify a portfolio of technologies and infrastructures where the UK's future energy needs, scientific strengths and industrial capabilities could overlap. It should also acknowledge the vital role the UK's financial, legal and consultancy sectors are already playing in low carbon investment⁶.

As the energy system changes, a battle of visions has emerged. There is much excitement about smarter electricity systems, electricity storage, and demand side response. Caution is required, but there are signs that radical change is possible. Some large players such as E.On are restructuring in anticipation. But arguments for a more traditional approach and the need for 'baseload power' are also strong. Government, Ofgem and National Grid need to open up markets to enable new players, technologies and business models, whilst remaining vigilant about security risks as the transition unfolds. They will also need to mitigate the risks posed by Brexit – particularly to investment (including in interconnectors) and consumer bills⁷.

By contrast, enthusiasm for electric heat pumps to deliver low carbon heat has waned. They could have a significant role, but quality of installation will have to improve and costs will need to fall. Some have advocated the alternative route of repurposing the gas grid through the use of hydrogen. This

would require the production of hydrogen without significant emissions, and reinforces the urgency of a new plan for CCS. But there is a danger of a swing to this alternative vision for low carbon heat before evidence has been established. We argue that multiple demonstrations are required, with adequate attention to learning about 'what works' in which contexts.

These changes have significant implications for energy consumers, driven, for example, by new products and services, the roll out of smart meters and the promise of affordable electric vehicles. But people are not just consumers: they are also citizens. Many have views on the direction of travel. They may also be owners of shares in energy co-operatives or prosumers, with their own generation. There is a strong need for a more comprehensive approach to public engagement which includes all of these roles. This requires a vision of the energy transition that encompasses social dimensions as well as information about technologies and costs. Difficult questions also need to be addressed about who pays, who the winners and losers might be, and the politics of change.

The Industrial Strategy and Emissions Reduction Plan are important opportunities for a more comprehensive and integrated programme of action: for investment, innovation and engagement. As well as ensuring that the UK continues to meet its fair share of international efforts to reduce emissions, they can emphasise the co-benefits of ambitious action: for health, industrial development and the wider economy.

A more coherent industrial strategy for energy

The new Industrial Strategy is the one of the most important tasks facing BEIS Ministers. It presents a clear opportunity to implement a 'mission oriented' approach to industrial development¹. Such an approach focuses on key societal challenges such as climate change mitigation rather than focusing on favoured technologies or firms, thereby mitigating risks of capture by incumbent industries.

It is important that there are clear criteria for the priorities that are advocated within such strategies. The government published a low carbon industrial strategy in 2009 alongside a low carbon transition plan. This strategy was wide-ranging and comprehensive. It also referenced several studies of UK strengths, weakness and opportunities. However, it was not clear how this evidence base was used, and the result was a long 'shopping list' of technology areas and projects rather than a set of priorities.

Significant analysis has already been carried out within government that could be used as a basis for a clearer set of priorities within the new strategy². This has been

complemented by analysis by the Research Councils UK Energy Strategy Fellowship³ and other public bodies such as the Carbon Trust and the Committee on Climate Change. This evidence base suggests a number of important criteria that should inform policy priorities, including:

- 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 (eg from UK-based components of supply chains)
- the stage of development of each technology; and
- the extent of existing scientific and industrial capabilities.

However, one drawback of this existing evidence base is that it tends to focus on discrete technologies. There is often less attention paid to system innovations that will be required (eg for smarter energy systems) and to new opportunities in financial, legal and other services.

¹Mazzucato, M (2013) *The Entrepreneurial State: Debunking Public vs Private Sector Myths*. Anthem Press. ²Low Carbon Innovation Co-ordinating Group (2014) *Coordinating Low Carbon Technology Innovation Support The LCICG's Strategic Framework*. London: LCICG. ³Skea, J., Hannon, M. and Rhodes, A. (2013) *Investing in a brighter energy future: energy research and training prospectus*. London: RCUK Energy Strategy Fellowship.

Electricity: harnessing rapid change

Nick Eyre, Keith Bell, Sarah Darby

Analysis by UKERC¹ and other organisations (eg Committee on Climate Change) shows that electricity should be decarbonised faster than other parts of the economy to meet carbon targets cost effectively. The electricity system therefore needs to be transformed over the next two decades. Change is already happening, sometimes more quickly than expected. In Britain, coal fired power generation is in rapid decline, with periods with no coal-fired generation, for the first time since the 19th century. 10GW of solar capacity has been installed in a few years, far faster than most predictions. In a traditionally slow moving sector, network infrastructure, business models and public policies are struggling to keep pace.

We identify four broad areas of challenge for electricity decision makers: generation investment uncertainty; capacity and flexibility issues; smart power; and implications for regulation.

Generation investment uncertainty

There have been major reductions in the costs of key renewable technologies – wind and solar. Globally, they are taking half of new generation investment and costs have fallen by 60% for PV and 30% for wind in the period 2010-2015³. The UK has some major strategic advantages, in terms of excellent resources and technological lead, notably in offshore wind. However, as we have already argued, investor confidence has been severely damaged⁴.

The Levy Control Framework (LCF) was introduced to control the level of subsidy to new, low carbon, generation technologies. Uncertainty about its future size is now the main constraint on investment in renewables^{5,6}. The decision to end support for onshore wind, the cheapest low carbon resource, adds to pressure on the LCF.

The decision to invest in the first new UK nuclear power station for 20 years has recently been confirmed by government. Nuclear decisions are inevitably controversial because of high costs, risks of accidents, and unresolved questions about long-term arrangements for radioactive materials. The Hinkley C design is widely seen as financially risky, because of construction delays, cost overruns and a lack of operating experience. The high price agreed for electricity generated from this project (£92.5/MWh) is likely to represent poor value for consumers.

One of the most unexpected decisions of this Parliament was the cancellation of the proposed £1 billion CCS demonstration competition. Whilst there are significant uncertainties about the economic viability of CCS, it could provide an important low carbon generation option and have a key role in decarbonising industrial processes. It could also enable manufacturing of novel fuels for heat and transport and, when combined with bioenergy, 'negative emissions'. The UK remains well-placed in terms of engineering expertise and geological resources to be a CCS leader. The recent report by Lord Oxburgh sets out a case for continuing

CCS investment⁷. It is urgent that the Government responds positively to this report's recommendations with a new plan for CCS commercialisation.

It is essential that future policy decisions are evidence based, taking cost effectiveness into account. Clarity on the size of the LCF beyond 2020 and a timetable for future auctions for low carbon capacity are urgently needed. The announcement of a further auction and confirmation of the coal phase out by 2025 are positive signs. But in future auctions, all mature technologies, including energy demand reduction, should be eligible on a level playing field so that the lowest cost projects are supported. First of a kind and immature technologies will continue to need dedicated arrangements.

Capacity and flexibility issues in a changing system

The shift away from fossil fuel generation to more inflexible technologies with very low short-run costs has led to falling wholesale market prices, making conventional generation less viable. Partly in response, a capacity market has been established to ensure adequate generation capacity. To date, capacity auctions have largely supported existing generation, with limited support for demand side options. Capacity market contracts have not been sufficient to prevent some plant closure.

However, adequate generation capacity is not the only important operational issue. These changes are also affecting power networks. For example, the rapid deployment of solar PV and other distributed generation is already requiring more active management by distribution companies. These pressures will increase with the deployment of more distributed generation and, potentially electrification of transport and heat. Significant electrification of vehicles now seems likely (see below). Electrification of heat would have a substantial impact on the need for generation capacity. UKERC research⁸ has shown that electrification is not a straightforward solution to heat decarbonisation (see below).

There is concern that these future developments pose risks to system stability that have not yet been adequately addressed^{9,10}. Our analysis is that the changes will place an increasing emphasis on flexibility¹¹ and that this needs to be

addressed at least as much as capacity. For the medium term, some schedulable generation plant (eg hydropower, CCGT and/or biomass) may need to be retained in key locations for the system to be operable and resilient¹².

An increase in the demand for balancing services is also likely, posing challenges for National Grid, which has limited visibility of demand and distributed generation. This has already led to some challenges for power system operation. At present, the markets for balancing services and capacity are too disjointed to support the most cost effective set of investments. One option to assist such coordination would be to establish distribution system operators (DSOs) at a local level.

Smart power, storage and demand response

These challenges require a smarter power system¹³ that makes use of the full range of options for exibility including generation, demand, storage and interconnection. The Ofgem and BEIS call for evidence on a smarter energy system demonstrates a willingness to use policy and regulation to support these options. Flexible demand (moving demand in time) will become more attractive as electricity prices vary more in real time. In principle, many of the balancing markets and the capacity market are open to this option. There has been good engagement of large consumers in some balancing markets. But it is essential that the capacity market is reformed to ensure equal treatment of supply and demand side measures – including to provide them with equal contract lengths.

A key enabler of demand flexibility in households and small businesses will be the roll out of smart metering. Nearly four million smart meters are now installed, with high levels of customer satisfaction and average energy savings of around 3% compared with legacy-metered customers¹⁴. However, there are still substantial issues to be addressed, relating to data security, privacy and the reliability of the equipment and associated processes. It is essential to maintain the customer feedback and engagement part of the roll out as crucial to the development of effective demand response.

The role of distribution companies will be increasingly important. The Low Carbon Network Fund (LCNF) has allowed these companies and others to undertake trials with novel approaches to network management. UKERC analysis of the LCNF¹⁵ shows that ‘active’ management of generation connected to the distribution network and flexible industrial and commercial demand should both be viable ‘business as usual’ options. Learning from insights gained through the LCNF and other demonstration projects needs to be a priority, to learn which technologies work best, and understand changes needed to system operation processes, skills and collaborations.

As the costs of batteries fall, storage is emerging as a potentially much larger player in electricity systems. Arbitrage in wholesale markets is not yet economic, but there are potential benefits in reducing grid constraints, delivering balancing services and in capacity markets. The potential is large, but storage needs a regulatory framework that allows storage providers fair access multiple value streams without facing separate charges for generation and demand¹⁶.

Implications for regulation and industry structure

The recent conclusions of the Competition and Markets Authority (CMA) confirm that retail markets have not been operating satisfactorily¹⁶ but do not propose radical change. It is far from clear that existing retail market structures can deliver the required levels of investment, innovation and engagement by decentralised actors. Many energy efficiency policies and the smart meter roll out operate via energy suppliers, even where the policy goals are inconsistent with suppliers’ business models. Our analysis is that this ‘supplier hub’ model is likely to prove inadequate¹⁷. A wider range of actors needs to be engaged, particularly for the installation of complex technical measures and through new business models.

There are also concerns that network operators are incentivised to over-invest in networks. System operation and networks are functionally separated in National Grid, but many would like to go further and see separation of ownership. Furthermore, there is increased interaction between distribution networks and market operations. This has led to international interest in the establishment of distribution system operators or DSOs¹⁸. The potential role and regulation of DSOs should be a policy priority¹⁹.

We need a more supportive framework for storage that allows providers fair access to multiple value streams without charging them twice – one for generation and another for demand

Gas by design, not by default

Mike Bradshaw, Paul Ekins

Natural gas plays a critical role in the UK's energy mix, and will continue to do so. But this role, and the scale of UK gas consumption, will have to change. A policy framework is needed to ensure that gas contributes to, rather than undermines, the low carbon transition.

Much of the discussion about the future of natural gas focuses on power generation, but only 27% of UK demand was consumed by power stations in 2015. The rest was used in households (37%), industry (23%) and services (12%)¹.

In 2015, natural gas accounted for 31% of the UK's primary energy production and 35% of its energy consumption. Natural gas production in the UK peaked in 2000 and in 2004 the UK became a net importer². A decade later, in 2015, the level of import dependence had risen to 42%. In 2015, 61% of the UK's gas imports came via pipeline from Norway, with an additional 7% from the Netherlands and 0.5% from Belgium. The exact origins of the pipeline gas that comes through the interconnectors from Belgium and the Netherlands is unknown, but increasingly it includes Russian gas traded on northwest European markets. These pipeline connections link the UK to the northwest European market and often price signals result in the UK exporting gas to the European mainland.

In 2015 the remaining 31% of UK gas imports arrived as liquefied natural gas (LNG) with 92% of that coming from Qatar. The GB gas system is now supplied by three LNG terminals: Dragon (Shell and Petronas) and South Hook (Qatar Petroleum and ExxonMobil) at Milford Haven, and the Isle of Grain (National Grid) in Kent. The total capacity of these three terminals is 47.8 billion cubic metres (bcm) per year, which is 70% of annual gas demand³.

When this is combined with domestic production and pipeline import capacity, the UK has more than sufficient infrastructure to obtain the gas that it needs; especially given that gas consumption peaked in 2004 and had fallen by 30% by 2015.

A price war over gas?

The level of LNG imports to the UK peaked in 2011 and then fell significantly with increased demand from Japan in the aftermath of Fukushima, and rising LNG spot prices; however, with Asian demand falling, along with the fall in the oil price and the new LNG production coming on line, there has been a relative return of LNG to the UK. As the LNG market is now moving into a prolonged period of over-supply—as a result of new production from Australia and the United States—it is likely the LNG spot prices will remain low for the rest of the decade at least. This may result in a price war in Europe as Gazprom seeks to preserve its market share. Thus, the UK will be well placed to benefit from both falling European pipeline gas and LNG prices.

What will low gas prices mean for UK shale?

The downside is that a period of prolonged low prices might accelerate the rate of decline in domestic offshore production. This will also challenge the economics of any potential UK shale gas production. Notwithstanding the recent Government decision in favour of Cuadrilla drilling in Lancashire, the scale of public opposition and the slow rate of progress to date means that a significant shale gas industry seems unlikely anytime soon. It is very unlikely to compensate for falling offshore production.

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We agree with the findings of the DECC/Ofgem 2015 Statutory Security of Supply report⁴ that: 'GB's gas system has delivered security to date and is expected to continue to function well, with sufficient capacity to deliver to meet demand.' However, while physical security may not be a policy concern in the near term, in the longer-term price security will remain a source of uncertainty. That said, market conditions are likely to remain benign for the rest of the decade, and gas consumption could rise as more coal fired power generation comes off the grid. It is in the 2020s that things could get difficult in terms of price security and there are at least three sources of uncertainty: first the impact of Brexit on the UK gas market and the status of the UK as a trading hub; second, changes in the European gas market as a result of the Energy Union and growing competition between LNG and pipeline gas; and third whether or not global oil and gas markets tighten as a result of the current phase of under investment in new upstream assets.

There are huge uncertainties about the future role of gas in the energy mix in the 2020s and beyond. It is essential to adopt a whole systems approach to understanding this role since the future of gas is tied to what happens in other sectors. In recent years, gas demand has been squeezed by the availability of cheap coal and by growing renewables capacity. The closure of remaining coal-fired power plants and most of the UK's nuclear stations will provide some additional gas demand, as might a slowing expansion of renewable capacity. The UK government intends to remove coal from the power generation mix by 2025, but has also abolished some subsidies for renewables.

This situation could be described as 'Gas by Default', with the role of gas in the power sector being shaped by problems elsewhere in the power generation system. However, in households and industry the future of gas demand is tied to improvements in energy efficiency and in the particularly challenging problem of decarbonising domestic heat. Thus, for these uses too, gas potentially plays a default role should other policies fail to deliver.

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The vital role of CCS

A 'Gas by Default' scenario poses major challenges for compliance with UK carbon budgets

However, research from UKERC^{5,6,7} and others shows that a 'Gas by Default' scenario poses major challenges for compliance with UK carbon budgets. While there may be some opportunity to replace coal with gas in the power sector, during the 2020s gas needs to be increasingly relegated to a role of providing back-up for renewable intermittency. This, in turn, makes the economics of building new capacity difficult. Our research demonstrates that by the late 2020s the commercial availability of CCS is also critical to keeping gas in the power generation mix. Without CCS, gas consumption in the UK could fall to 10% of current levels by 2050. However, CCS can allow higher levels of gas to stay in the energy system for longer.

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There needs to be significant progress in decarbonising domestic heat from the 2020s onwards. Here too CCS would allow gas to play a significant role as a large-scale source of low-carbon hydrogen. In a scenario where significant CCS is deployed, UK gas consumption could still be in the 50bcm range and be compliant with current emission-reduction targets.

A Gas by Design strategy

A number of actions are required by government to avoid the risks posed by a 'Gas by Default' future. This 'Gas by Design' strategy should include financial incentives in the near term to support sufficient new gas-fired electricity generation capacity and compensate for low load factors in the later 2020s and beyond. By the end of that decade CCS needs to be available to play an 'essential enabling role'⁸ to permit gas to remain in the electricity at higher load factors and, perhaps, relieve some of the pressure to decarbonise domestic heat in the 2030s. In addition to this, a more ambitious programme of energy efficiency is needed to put further downward pressure on gas demand in buildings – and to reduce consumer bills.

To avoid the risks posed by a 'Gas by Default' future, the government needs to plan for gas to play a 'Gas by Design' role in the UK's low carbon energy transition

The changing role of gas also poses challenges to the national transmission system and local distribution networks, alongside the need for new more flexible storage as existing storage capacity ages.

Heat: learning by doing

Janette Webb , Rob Gross

Heat for buildings comprises around 40% of UK energy consumption and a fifth of greenhouse gas emissions¹, but policy for heat decarbonisation, including the role of energy efficiency within this, continues to be challenging.

The UK DECC 2012 and 2013 Heat Strategy² identified a number of priorities. It considered the potentially high costs of electrification of heat and recognised heat as a systems problem, with no single technical solution. Among other things, the 2013 Strategy initiated:

- Further development of the Renewable Heat Incentive (RHI)
- A Heat Networks Delivery Unit (HNDU) which supports local authorities to analyse feasibility, and develop business models, and the subsequent Heat Networks Investment Project (HNIP) (England & Wales) with £320M capital funding from Treasury
- Analytical work, including examination of hydrogen, non-domestic buildings' energy use and whole systems modelling
- Funding for advanced heat storage demonstrators and decarbonisation roadmaps for heat-intensive industry.

Options for low carbon heat

There has been progress since then, but the Committee on Climate Change argues that 2030 carbon budgets for buildings will not be met in the absence of a long term integrated heat strategy³. This is urgently needed to keep total costs down and avoid 'stranded assets', while redressing the poor energy performance of much of the building stock and accelerating low carbon heat beyond its current 2.5% contribution to total supply.

Three main technical solutions for low carbon heat for buildings are prominent in the debate: repurposing of the gas grid to provide hydrogen; heat networks; and electric heat pumps. In principle there are complementarities between these, but interdependencies and trade offs are complex and need to be understood and addressed.

Assessments of technical and economic feasibility of gas grid conversion to hydrogen &/or biogas, on a regional or a UK-wide basis, are at an early stage. As yet there is only one active project, the Leeds Citygate⁴ project which modelled conversion of methane to hydrogen with CCS.

A review of this option commissioned by the CCC from Frontier Economics found that there is limited robust evidence about technical viability, financial costs and their allocation. There are also questions about the long-term use of natural gas that gas grid conversion implies. Finally, there are concerns about the carbon implications of inefficiencies in the CCS conversion process, and the necessity for an as yet unavailable and untried CCS industry.

For heat pumps, there is considerable evidence from other countries, where the market has grown strongly⁵. This shows that effective policy uses a mix of building and technology regulation and incentives. Incentives may be low cost loans, or in some cases one-off subsidies for early adopters, combined with grants for low income groups. Over time, subsidies can be replaced by regulation and loans. There is also an important role for taxation or regulation of less efficient alternatives. For building owners, upfront capital support appears more cost effective than on-going financial payments such as the UK's Renewable Heat Incentive policy. This evidence also shows that standards, certification and training are important in ensuring systems are well designed and perform as they should.

For district heating networks, long-term low cost infrastructure finance is very important. The Heat Networks Investment Project is a key step forward, with the pilot phase making investment available to local authorities, as direct investors and in partnership with private and community sectors⁶. However it will be important for the UK to avoid the 'stop-start' nature of previous schemes, leading to small scale 'islands' of development. The international evidence suggests that local authorities play a key role in heat network development. Zoning and planning are essential. Making heat recovery economically viable can be initiated through taxes which support fuel switching. High standards for energy efficiency, in for example, licensing of waste incineration or other combustion processes, have also been used successfully in countries such as Norway to stimulate rapid development of the industry⁷.

A strong governance process

A long-term strategy is needed that must address the implications of low carbon heating for home owners and tenants, as well as non-residential building owners. Implementing a change from highly accepted and valued gas central heating to something less familiar will be challenging. There are also likely to be circumstances under which choices about heating systems need to be made within a locality (eg by a Local Authority), rather than an individual household scale.

Work is also needed to support cross-sector appraisal, negotiation of strategy and decision points for the multiple possible solutions for low carbon heat. There are interdependencies and trade-offs between low energy buildings, reinforcement of electricity networks, new district heating

networks and gas grid conversion. The quality of the process governing these decisions will be key to effective policy and implementation, and to democratic legitimacy in allocation of costs and benefits. Uncertainties about the future of the gas network need to be addressed by the early 2020s and must not result in a hiatus in work on low carbon heat.

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A White Paper on Heat and Energy Efficiency

To achieve the necessary cross-departmental focus on low carbon heat, including Treasury commitment, we propose a new Heat and Energy Efficiency White Paper. This could review cost-benefit, tax and accounting frameworks and propose reforms so that they work cohesively to incentivise low carbon heat and energy efficiency investments. For the UK economy, such a White Paper could help ensure value creation through new markets for heat and energy saving technology, innovation, investment and services sectors, and in integrating low carbon buildings and heating into industrial strategy.

The White Paper could also address an important regulatory gap for heat – the absence of a public body with specific responsibility for heat. A heat regulator could assess governance, business and ownership structures for heat systems, and ensure equivalence in consumer protections and tariff structures. It would have responsibility for allocation of costs across energy networks/consumers, potentially ‘socialising’ the costs of heat network infrastructure as currently happens for gas networks. A heat regulatory body could be part of a restructured Ofgem. Since heat is already at least partially a devolved matter, and heating requirements and opportunities differ regionally, decisions on specific powers and responsibilities would need to be devolved as appropriate to national governments of the UK.

We need a new framework for regulating heat – which could be part of a restructured Ofgem

The White Paper should also set out how the increased take up of ‘low-regrets’ measures could be accelerated over the next 15 years, using incentives, affordable finance and regulatory standards. Action is also needed to define a framework for near zero emissions in new buildings in 2020.

There is also a need to establish during this Parliament the post-2020 governance process for achieving low energy buildings and decarbonised heat supply. This should include:

- Whole building and area-based retrofit, using results-based evaluation of energy performance
- Demonstrators and trials of different options for low carbon heat systems and low energy building solutions; an example is provided by the Energy Systems Catapult Smart Systems and Heat initiative
- A comprehensive programme for professionalising the building and heat supply trades to ensure best technical performance from investments.



Transport: integrating air quality and low carbon

Jillian Anable, Christian Brand

Transport remains the sector with greatest inertia in terms of carbon emissions reduction and presents particular challenges due to the many actors involved. Across the sector, increases in demand (in particular in urban freight) have been offset by increases in efficiency, with domestic transport GHG emissions of today being roughly at the same level as in 1990^{1,2}. Emissions rose in 2015 after several years of modest reductions.

There are sub-sectors of the transport system (freight, aviation and long distance travel) where growth in demand is strongest³ and these tend to be the areas with relatively little policy ambition and/or where technological solutions are most challenging².

Almost all policy eggs are in the electrification basket, and this in turn is focused almost entirely on plug-in hybrid and battery electric cars and vans. The uptake of electric vehicles (EVs) is increasing, but strategies to accelerate their introduction including the supply of charging infrastructure are still subject to trial and error. The availability of a competitive range of vehicles is still some way off. However, there are signs that the EV market is finally taking off, including 'pockets of success' at the national (eg Norway, Japan, China, the Netherlands), subnational (California) and local (eg Hong Kong, UK plugged-in cities) levels².

At the same time, one of the key components of the decarbonisation of vehicle travel to date – a shift to diesel cars – is under significant scrutiny due to air quality concerns and the VW scandal⁴. In addition to this, a lack of progress with electricity decarbonisation would significantly limit the emissions benefits of electric vehicles⁵.

Building the transport system of tomorrow

Transport policy needs to be more explicitly oriented towards creating the low-carbon transport system of the future and renewed policy focus on infrastructure investment (for example by reinforcing the power network to support the rapid scale up of charging points) is urgently needed. Such policy should aim to avoid some travel or freight movements altogether (eg through tele-working, smart logistics); shift travel activity to low carbon modes and mobility services (eg cycling and walking for short urban journeys and car clubs); and improve the emissions performance of existing modes and mobility services (eg via EVs or speed limit enforcement). All of these policies and measures require significant investment in ICT, cycling infrastructure, telematics and vehicle charging infrastructures.

Transport policy needs to be more explicitly oriented towards creating the low-carbon transport system of the future and renewed policy focus on infrastructure investment is urgently needed

Support for electric vehicles, whether they run on fuel cells, batteries or both, should be an important priority for the new Industrial Strategy. The automotive sector accounts for 10% of the UK's trade in goods, suppliers add £4.8 billion in added value and the sector as a whole turned over £60.5 billion in 2013 (KPMG and SMMT 2014). To facilitate market growth of EVs, the major manufacturers will need to accelerate the release of new EV models across all market segments. The final production of the Nissan Leaf takes place in the UK, and the low carbon vehicle market is a significant opportunity and economic activity⁶ (KPMG and SMMT 2014, Patrick, Killip et al. 2014). An industrial strategy should harness the UK's strength in regions with highly developed automotive clusters. The public (lower risk) and private (higher innovation) sectors should support innovative leasing and new ownership models across the vehicle life cycle to facilitate take up in difficult to reach market segments.

The Government also has a crucial role to play in creating a 'market pull' for low carbon vehicles via new emissions standards. It will be important to ensure that new vehicle standards that will apply after 2020 inspire trust and confidence, and provide strong support market development – particularly after Brexit when European standards may no longer apply. In addition to this, support for new rapid charging services is needed to facilitate adequate roll-out of rapid charging facilities across the UK. One estimate suggests the country needs ~2000 fast charging stations (roughly 10% of the number of petrol stations) to provide good coverage. This is technically and economically feasible.



Vehicle purchasing incentives also have an important role to play. This includes continuation of the lower tax rate for Benefit-in-Kind for company cars, or an equivalent capital support, for leased and rental fleets. It could be complimented by technology-neutral ‘feebates’ that have proven to be successful in transforming the market, eg in France⁵. Local and city authorities could provide further non-financial benefits (eg preferential parking and road access as in Norway) to provide high value benefits to end users at relatively low cost.

More fundamentally, policy needs to consider the implications of so-called ‘peak car’ – ie both the saturation of cars, and the potential decline in per-capita distance travelled by car. The potential for such structural changes in the transport system need to be explicitly acknowledged in policy making. After a plateauing and reduction in average per capita car use over the past decade or more, recent increases have been hailed as healthy in terms of economic growth, even though the causes are unknown. Research acknowledges the pattern of peak car use is uneven but it shows definitive evidence for travel demand reduction without a loss of welfare under certain conditions⁸.

Co-benefits of low carbon transport

Apart from a shift to EVs or hydrogen vehicles, promoting walking and cycling, and access to clean public transport are known to have significant co-benefits for health and improved air quality as well as emissions reduction. This provides additional policy rationales that go well beyond climate change mitigation. The health benefits of a more active lifestyle and the role active mobility can play are well established^{9,10}. Research has shown that urban environments with high levels of walking and cycling for travel typically represent a combination of many factors that help promote these modes¹¹. The most compelling argument, particularly for cycling, is that only via an integrated range of built environmental features (including infrastructure and facility improvements), pricing policies, or education programmes will result in substantive changes. We are heading in the right direction – the new London cycling superhighways being an example of progress in this area. But to achieve the levels of active mobility that have been seen for decades in the Netherlands, Denmark and parts of Germany, the UK should increase its ambition and accelerate implementation of the existing investment strategy in walking and cycling.

A social energy transition

Jason Chilvers, Nick Pidgeon

Most discussions about energy policy, including how to meet carbon targets, focus on costs, infrastructures and technological change. However, it is increasingly understood, including by government itself, that the transition to a low carbon energy system is a social challenge and will not be achieved without the meaningful engagement of wider society.

The transition to a low carbon energy system is a social challenge. It will not be achieved without the meaningful engagement of wider society

Failure to account for social values in decision-making can lead to public resistance to the adoption of low carbon policies and technologies¹, or otherwise risk ineffective implementation².

Societal engagement also opens up more options for carbon reduction, including shifting everyday practices to more sustainable paths³ and harnessing the initiative of citizens to develop bottom-up low carbon energy solutions⁴. The role of people and communities will thus be essential – as consumers, practitioners and citizens.

Energy policy initiatives that engage with the social dimensions of change have focused on two dominant areas of societal engagement. First is the area of behaviour change. Evidence shows well-designed behaviour change programmes can achieve energy savings of 3-10%⁵. Going further requires an understanding of how energy use is influenced by people's everyday routines and wider social factors⁶. Second, is the area of public opinion and consulting citizens on low carbon policies and technologies, often to gain 'social acceptance' for a particular technology that is seen to be desirable.

Deliberative and public dialogue approaches, where citizens and experts learn through the process and their views can feed into policy decisions, have seen some success in this regard as shown through the UK government-funded Sciencewise programme⁷. While there has been important progress, current approaches to societal engagement remain compartmentalised and siloed, focusing on engagement in specific parts of the energy system in a piecemeal way⁸.

Recent UKERC research⁹ has shown 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. These go beyond the behaviour change and social acceptance initiatives led by government and private sector institutions. This system-wide perspective provides new evidence on the interactions between diverse forms of engagement. It shows, for example, how citizens involved in policy consultations can go on to shift behaviours, or how a protest against shale gas development can morph into a community energy initiative.

As the new Emissions Reduction Plan is developed, it is important to draw on more comprehensive evidence like this to help overcome barriers to change and harness untapped citizen actions on an ongoing basis. UKERC's previous work¹⁰ has identified a range of social values that the public feel are important, including reduced resource use, efficiency, environment, security and autonomy. A recurring area of public concern centres on questions of fairness, equity and justice – about winners and losers and the processes by which decisions are made. This research suggests that energy policy respond to public values and visions of what is just more effectively, by attending to distributive and procedural concerns.

Justice and equity concerns, which are now more salient in the wake of the EU referendum, have led to a new phase of UKERC research¹¹ into who should pay for energy transitions and how. Early results from our nationally representative survey reveal that people do accept that they should pay for various goals associated with energy system change. These include increasing use of low-carbon energy sources, helping vulnerable and disadvantaged people pay for energy, funding programmes to reduce energy use, and ensuring reliability of energy supply. But they are only prepared to do so as part of a larger network of actors who also participate. On average, respondents say that the public should take on approximately 12% of responsibility for costs, whilst energy companies, the UK government and future UK residents should take on 45%, 32%, and 11% of responsibility respectively. Clearly, some of the costs that are met by government and companies will eventually find their way to citizens via taxation or energy bills. If there is to be public support for the transition, it is vital that we consider the fair and just distribution of costs.



The public feel they should pay for energy system changes, but they also expect other actors to be involved and for an equitable sharing of costs

What is clear is from this research is that our current ways of governing energy systems do not always account for equity issues or respond to social concerns¹². While political and scientific leadership is fundamental to the low carbon transition, an exclusively top-down approach will not work¹³. Evidence shows that transitions are always highly contested and involve multiple contending visions of desired futures¹⁴. Energy in the UK is no exception, even amongst those that accept the need for ambitious emissions reductions.

Government and industry must therefore be prepared to change course as a result of dialogue, to pay attention to issues such as fair access and sharing of costs, winners and losers, and which technologies are needed. This research also suggests that it will also be important to support a diverse range of ways for people to meaningfully engage.

The formation of BEIS provides an excellent opportunity to put this into practice, having brought previously disparate initiatives for public engagement with energy (eg Sciencewise, the Behavioural Insights Team, initiatives for community energy) more closely together. But any integrated approach to societal engagement in energy transitions must also reach beyond national government, and include stakeholders and engagement initiatives from across the devolved administrations, local government, business, academia and civil society.

Societal engagement should be whole systems, and reach beyond national government to include the devolved administrations, local government, business, academia and civil society

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