Institute for Public Policy Research

A DISTRIBUTED ENERGY FUTURE FOR THE UK

AN ESSAY COLLECTION

Edited by
Hywel Lloyd

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INTRODUCTION

Energy is essential for life and throughout history people have sought the fuel they need from their immediate surroundings.

In Britain, the Charter of the Forest of 1217 allowed people access to common land to search for and collect wood for fuel. Over subsequent centuries, facilitated by successive acts of parliament, the common land became private land. One consequence of this was to make citizens dependent on others for their energy and fuel supplies.

Today we might be aware of some hardy – and sometimes desperate – souls who source their fuel from the land, be they permaculture[1] forest dwellers or coal hunters on the shores of the north east. But they would be considered unusual in an age when, for the great majority, electricity and gas are readily available to power and heat our homes, workplaces and social spaces. Why, in this age, would anyone bother seeking their own fuel?

The UK energy system has evolved significantly over the last 200 years. Its first iteration (which we might call energy system 1.0) began with local, collective, and often municipally-led action to provide energy that would mainly benefit new city dwellers, as town gas and electricity emerged and was put to use. These innovations created a patchwork of local energy companies supplying a slowly increasing proportion of the (mostly urban) population, though many homes continued to use a hearth for heat, typically fuelled by coal. For country dwellers, access to electricity grew, while heat often continued to be fuelled by coal, or locally available supplies of biomass such as local wood fuels and peat.

Some energy supply companies were in private ownership and many were municipally owned, but in both cases much of the profits were retained locally given the majority were local enterprises serving their place. For local authorities, energy profits were a significant income (Parker and Manning 2013) – perhaps 15 to 20 per cent of their annual revenues. The second iteration – energy system 2.0 – saw gas supply managed locally through the creation of town gas, held in the once ubiquitous town gas holders.

Well before the energy system was nationalised in 1947, and now in its third iteration (energy system 3.0), the UK's electricity system was becoming more of a national, centrally controlled system. Innovation in the long-distance transmission of electricity provided opportunities to secure a network in the 1930s. A national gas grid emerged much later, in the late 1960s, initially to supply Liquid Natural Gas (LNG) to the north, then growing further in the 1970s to distribute North Sea gas.

For the last 40 years or so, the majority of UK citizens have accessed their energy supplies through the national systems for gas and electricity, served by companies that source and supply, and companies that transmit and distribute. What was once mostly in state ownership is now mostly in private hands (perhaps energy system 3.1), and even those citizens who are off the gas grid are served by companies that source, distribute and supply their gas, oil or coal from afar.

1 The development of agricultural ecosystems intended to be sustainable and self-sufficient – the forest garden is one of Britain's best models of permaculture.

So we have a functional, centrally managed, nationally and internationally connected energy system that supplies millions of people with gas and electricity at the flick of a switch, and others with their domestic oil tank, gas cylinders or coal sacks supplied by phone or online order.

Why then, would anyone bother seeking their own fuel when gas and electricity are readily available to all?

The answer is that doing so opens up prospects for innovation within the energy system – in light of the new challenges it faces – while providing opportunity, ownership and new economic benefits for consumers.

This set of essays explores how new energy technologies, different sources of energy, and new business and governance models can offer a more effective, efficient, low carbon energy system which can benefit all UK citizens.

We look at how designing and **creating a bottom-up, decentralised and distributed energy system** can meet the energy needs of the great majority of citizens with their 'fuel', benefitting themselves and their community, and the global community as well (by avoiding the worst effects of catastrophic climate change). It will be an energy system that is more resilient, more engaging of citizens and more appropriate to the challenges of the next century, while making the most of the local energy assets that the UK deploys to secure its energy future.

To begin that task, we set out a vision of what such a system might look like.

While it is generally agreed that the energy sector is in the midst of a transition driven by the trends of digitalisation, decentralisation, and decarbonisation, and potentially an emergent democratisation, it is unclear what such a vision means and looks like.

This essay collection seeks to lay out a vision of what could emerge, with essays addressing different aspects of the vision in greater detail. After all, the more substance we are able to give to our vision of the future, the more likely we are to be able to deliver it, or to improve it and deliver something even better.

THE VISION: ENERGY SYSTEM 4.0

A decentralised, distributed energy future for the UK, energy system 4.0, begins with the citizen, the home, our other buildings, the technologies of digital, wind and solar, and the concept of **near net neutrality.**

Near net neutrality brings together the three principles of: a) generating energy as close to its use as possible (reducing inefficiencies and emissions of distribution); b) maximizing the local benefit of energy infrastructure (reducing the extraction of wealth that can come with centralised systems, however they are owned); and c) efficient use of energy (to avoid unnecessary creation or wasteful use).

Together, the ambition to minimize unnecessary energy use and maximize energy harvesting moves us on from just seeking energy efficiency in the home, to turning homes themselves into power stations, in turn helping us realize the concept of near net neutrality.

As technology advances the role of home and local storage, smart meters and local grids will all play their part in delivering the near net neutral home, building, community and place.

Near net neutrality is the start of the energy story in each and every place. It reflects both the lie of the land and the nature, interests and work of communities in each place – and seeks to maximise the energy that each place and its people can generate, or harvest. In a near net neutral world, every building would have some energy harvesting technology fitted to it, appropriate to local circumstances. In some cases, associated land would also have energy harvesting technology, subject to proper considerations of other land uses – such as for food, nature, amenity, water and carbon management.

In many instances a balance will need to be struck between what is best done at the level of the home or building, and what is best done at the scale of the neighbourhood, locality, or town. It is in this consideration that the best solutions for heat (at scales beyond single buildings) and electricity (captured at many scales) will occur, and be integrated with other harvesting and generating opportunities. These will range from heat capture from industry, mine waters and deep geology, to green gas from anaerobic digestion (AD), hydrogen and other technologies (such as waste processing), and harvesting sites at scale where solar or wind farms are a better use of land than farms for food (and can co-exist with water harvesting).

In order to understand what is possible, and most appropriate, at the community scale requires community-wide governance at the appropriate level. For instance, a town or parish council will in some cases be more appropriate than a more distant district or county body. Urban unitaries, for example, which can govern 200,000 or more people can be too big to work out what is best locally.

Solutions will therefore require a sensible balance between neighbourhood planning and a perhaps more strategic district, county or unitary council scale planning. Any national framework for energy planning must offer flexibility (for local engagement) and incentivise subsidiarity over so-called economies of scale.

Within this decentralised, distributed energy future for the UK, we should seek to maximise the local opportunities for harvesting the power of the sun, the wind, and the land – and optimise its use. This is not a vision that seeks to create independent energy users, more one that empowers citizens and communities to be more self-sufficient while being part of a connected, inter-dependent system that offers security of supply and resilience in the face of changing demand and climate. Crucially, it recognises that some energy uses are greater and more intense than local supply can address.

The UK will still want to be a manufacturing nation; indeed some of the technologies that build this decentralised, distributed energy system require that we continue to manufacture the means to harvest and deploy these energy sources. There is no great advantage in seeking to maximize our local energy harvesting if we outsource the means.

THE ESSAY COLLECTION

In exploring this decentralised vision of the future of the UK's energy system, it is important to consider the challenges that need to be addressed as well as the opportunities offered. The first two essays in this collection help to identify those challenges from a system perspective, and from a user perspective. With the challenge of providing the everyday means for every 'prosumer' with practical and economic benefits in mind, the subsequent essays explore the potential and issues of this vision of transitioning to energy system 4.0.

Part two begins with an exploration of the household and the home, and how the nature of each will change as the system becomes more customer-focused, as prosuming becomes the norm, and as technology supports homes as power stations.

Part three then explores the implications for the sourcing, supply, management and distribution of electricity, for power, vehicles and other uses; and of heat, for warmth and comfort, noting that this vision of our energy future includes an expectation that local energy will be run as an integrated system, allowing the system to locally balance between power, heat/cooling and transport needs.

In part four, our authors begin to address the nature of the challenge, exploring how 'place' is key to realising the potential of such a decentralised vision. Local authorities are key and have a number of significant powers to deploy, whether they take an enabling or activist role. This local action is, in turn, set in a new UK-wide governance framework for decentralisation, one that is designed from the bottom up to put the prosumer and the customer first.

The conclusion provides a short overview of the breadth of all of the essays before looking to identify the next steps in public policy that would help realise this vision for the UK's energy system. We look forward to your thoughts and feedback on them over the coming months.

Finally, a summary overview of the collection – the vision and underlying essay exploration – is also available and can be downloaded at www.ippr.org/research/publications/a-distributed-energy-future.

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PART ONE: SETTING THE CHALLENGE

1. MEETING THE SOCIO-ECONOMIC CRITERIA FOR DECENTRALISED ENERGY NETWORKS

DR DUNCAN CONNORS

Decentralised energy production has immense potential to democratise energy use, by blurring the lines between producer and consumer and creating closer links between demand and supply. Instead of long distance transmission lines connecting gigawatt-sized power stations with the consumer (losing up to 10 per cent of the energy in the process), local energy and electrical networks would potentially be more flexible and able to respond to immediate needs.

However, this essay will argue that while the benefits of decentralised electric production are immense, the potential for economic disruption is equally sizable if the implementation of decentralised network generation does not reflect local conditions. In short, this essay argues that energy decentralisation is beneficial to society but that a 'one size fits all' methodology cannot work in all circumstances. Tailored and hybrid solutions that are good for sustainability, the environment and the economy might be the best overall solution even if they do not follow the decentralised energy network rule book to the letter.

Prevailing ideas and theories concerning the socio-economics of society have a habit of self-replicating across political boundaries and can become a one size fits all 'meme'.[2] By applying the concept of the meme in its political science, policy form, this essay will show that the implementation of a decentralised energy system has to be for the benefit of the economy and society, and not merely the top down implementation of a trend or buzzword. This self-replication of certain socio-economic trends as a 'complete solution' has caused immense socio-economic disruption – be it the failed attempts at Soviet-style planning in India, the imposition of free market rules on under-developed African economies, or the 'shock therapy' imposed on post-Soviet economies in Eastern Europe. Therefore, we have to be mindful that decentralised energy must happen for the right reasons and has to meet a number of criteria for its implementation.

Decentralising energy production and consumption is not a new an idea; during the last 30 years there has been a slow movement towards a more decentralised approach to energy and electricity production. The privatisation of the Central Electricity Generating Board (CEGB) and the National Grid in the United Kingdom allowed smaller players to enter the market, building a series of smaller gas fired power stations closer to the markets they were to serve and creating multiple commercial operators. This may have been just a small step on the path towards a decentralised grid but it was an important one. Indeed, the opening up of electricity generation to multiple providers that

2 In his book *The Selfish Gene, Professor Richard Dawkins put forward the concept of the 'meme', a self-replicating idea that permeates through social interactions and becomes part of the cultural zeitgeist.*

either dealt directly with the consumer or provided energy under contract to a utility company has made the recent implementation of large-scale renewable generation much easier than it would otherwise have been. However, while there are now multiple players and operators in the UK amenable to evolving decentralised generation, other nations have achieved the same goals in terms of local renewable energy through systems of planning and without the privatisation found in the UK. This is not to favour nor denigrate competing economic models, rather it is to emphasise that any energy solution must reflect local conditions and not be a solution based on the policy trends of the day, which then proves to be inappropriate.

That is the core message of this essay – that energy and electrical generation solutions in a decentralised system have to be beneficial to local conditions and fulfil both local (micro) and national and global (macro) goals. For example, supplying local solar and wind generation in an 'energy poor' developing nation would bring immediate benefits – from simply providing lighting to more complex benefits such as access to the world wide web, and even slow charging small electric vehicles to allow transport between communities. In that situation, the local energy demand is starting from a very low base compared to that in a developed nation and therefore small-scale, renewable technologies combined with energy storage will amply fulfil local needs and help build a local economy. Indeed, the sale of surplus energy can help generate commerce and the small electric vehicle could be a way of moving stored energy for sale over long distances without the need for a power distribution network.

However, there is a problem. What happens when the demand for electricity increases because of economic growth, and market mechanisms kick in? For example, the owner of the aforementioned electric vehicle may want to make more money but cannot with the low intensity renewable energy installation on the roof of their home; could a quick cost benefit analysis of funding the purchase of a petrol generator and fuel undermine the entire environmental raison d'etre of renewable energy? Evidence from India, with its unreliable electricity grid, suggests this is the case, and the market solution – thousands upon thousands of small generators operating in major cities to power air conditioning units – comes at an environmental and economic cost to the nation.

This brings us to the developed world and the United Kingdom. All systems have benefits and disadvantages and ergo, all systems of electrical production have both efficiencies and inefficiencies built into them. For example, the losses from electrical generation to the consumer in a developed nation are around 6 to 9 per cent, depending on the size of the particular nation and the distance the electricity has to travel to the consumer – an argument for decentralised energy production. However, there is an efficiency argument for large-scale, gigawatt-sized macro-generators as the economies of scale for large-scale power generators are much higher than small ones.

Nevertheless, concerns about global warming, pollution, finite resources and the 'geopolitics of energy', as well as the arrival of renewable technology, have led to a situation where local, decentralised smart grids are desirable and possible.

With the advent of domestic renewable electric generating systems such as home solar and wind, combined with vast improvements in energy storage, it is now possible for a householder to generate a good proportion of their electrical and heat needs at home. In theory, it is also possible to sell a surplus and either generate revenue or reduce the amount taken from the grid. This has a number of benefits. First, the householder will have lower utility bills (none at all in some cases). Second, there will be an environmental benefit as the national grid will shrink and there will be fewer large fossil-fuelled power stations in operation. And finally, there will be a fall in imported fossil fuels to feed the thermal generating plants. Therefore, the decision-making agency will shift from producer to consumer, who will make decisions at a micro level to reflect demand in real time.

For the above to be beneficial to all parties involved, technology must move forward, and with the needs of the local consumer in mind. The main challenge is no longer about producing solar panels or wind turbines that are affordable to the household consumer; prices for both systems have fallen dramatically over the past decade, as has the cost of high capacity batteries, and this is a trend that is likely to continue. Rather, the challenge lies in integrating a large number of consumers and producers within a local sphere who can trade surplus energy between one another without any party being short-changed, overcharged or left without. This will require smart, real time trading software that can adapt to circumstances as they evolve and a system of 'pooling' the surplus into a common resource that is sold anonymously via the time testing principle of 'willing seller, willing buyer'. Without such highly evolved systems, local trading will be time consuming for the householder, as well as unfair and socially fractious if a member of the community is left out through targeted buying and selling between houses. Luckily, the creation of open 'blockchain' technology that acts as a public ledger can remedy the majority of these problems, and with the implementation of smart, artificially intelligent systems that can be applied to electricity meters, it is unlikely that any member of a local energy trading scheme will be left out of the process and rendered energy poor.

For decentralised electricity generation to work we must ask the question: Can it provide for all the needs of the consumer and does it represent a better system than the current top-down macro approach? The answer is that society has a long way to go before developing a fully decentralised energy system, but that is not to discount the immediate benefit of small local and household generation in building resilience and reducing an unsustainable reliance on fossil fuel imports.

However, what is happening in the medium term is a hybridisation of smaller local generation with huge changes in the way macro grid-based generation works – which is now using an increasing amount of wind energy and putting forward storage schemes that will reduce the need for a fossil fuel or nuclear base load. There is also the issue of cost; would paying for household generation be considered a luxurious, additional cost compared to just paying the regular electricity bill? In short, society can only move to a decentralised energy model if it delivers economic and practical benefits to both consumer and producer, which in most distributed models is the same person.

If these criteria are not met and a *Field of Dreams* 'build it and they will come' mentality forces through changes before the market is sufficiently mature to take full advantage of decentralised energy networks, then we run the risk of producing another failed paradigm that will not benefit society in the way it was intended.

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2.
'KNOWING ENERGY': THE EXPERIENCE OF PROSUMERS LIVING ON A SOCIAL HOUSING ESTATE

DR NICOLETTE FOX

If you grew up in the 1970s, it was the ice on the inside of the windows that told you just how cold it was. You could feel the frosty panes and see the sun tracking round the house bringing warmth to cold quarters. Hear the wind whistling around the house killing off fledging fires, and smell the acrid soot being pushed back down the chimney. Knowing energy meant waking up your senses.

We learnt how to shape energy to our lives. Washing clothes on sunny days so they could dry crisp, perfecting techniques to keep the fire alive. And always, always, wearing layer upon layer as winter set in. But knowing energy was not just about keeping the home fires lit. It was also about knowing whether there were enough 50p pieces in the prepayment electricity meter to cook dinner or take the chill off a room. As a teenager it also meant squirreling coins away to avoid the embarrassment of a blackout with friends.

In many ways, the vision that introduces this essay collection offers a backdrop to an earlier energy life. For me and my family living in the country, we worked hard at earning our winter fuel, including waiting patiently for gas to reach our estate at the edge of a village. And yet when it arrived, along with the magic of central heating, our excitement was quickly tempered by the realization that this fuel too, had to be rationed.

I am fortunate that this is no longer my energy story. While sitting around a fire with my family was cosy, living on the edge of fuel poverty was far from it. Several decades on, fuel poverty is still with us and there are millions of people who have to make unpleasant energy choices (BEIS 2018). I experienced this first hand when I conducted a study of seven families who were given solar panels by their social housing provider. I followed their solar journeys over four seasons to see what difference producing and consuming – 'prosuming' – solar power made to their daily lives. How would the vision presented in this essay collection, of a distributed energy future with opportunity, innovation and ownership at its centre, stand up to scrutiny when applied to households living in a community with high deprivation indicators?

PROSUMING AND 'POSHNESS'

Firstly, without the intervention of the social housing provider, none of the households would have had the opportunity to use their own solar power. The cost of installing solar panels still runs into the thousands (Ingrams 2018), beyond the means of many households in the UK, let alone those living in a low-income community. A government report indicated that most households who have benefited from the 'feed-in-tariff', a government subsidy largely based on solar power generation, are from affluent households (DECC 2012).

However, this is not the complete picture. In recent years a number of social housing providers also took advantage of the tariffs before the rate was significantly reduced, to invest in solar panels for their tenants (Clark 2014; Vaughan 2016). This was the case for the families in my study and yet, despite the offer of free solar panels, many of the households initially simply didn't believe that solar panels could be for them. Solar panels were generally associated with affluence, ‘poshness’, not with their own community. As one told me:

> ***"When you watch programmes [they are] to do with posh [houses]. You just think about that sort of house, you don’t think about it on a council estate to be honest. You don’t do you?"***

ADAPTATION AND EXPERIMENTATION

Once convinced the solar panels were a genuine offer, all seven of the tenants had them installed on their roofs. But practising prosuming is not entirely straightforward. Solar production can vary depending on weather, seasons and changing daylight hours, and consumption is also affected by which appliances are used and when. On top of this, households have to work out how prosuming fits with domestic routines such as laundering or cooking, as well as with work and family life.

Yet to varying degrees, the householders in the study adapted and innovated. They experimented with everyday technologies and their daily routines to be able to draw on their solar power, if it could be fitted round their family and work lives. The prepayment electricity meter was at the heart of this innovation. For example, one woman used her meter to work out how much money her laundry was costing, prior to and after the solar panels were installed. Many of the families also used the meter as a casual but ongoing monitoring tool to help them keep track of whether prosuming was continuing to deliver the anticipated financial savings. As one man explained:

> ***"I’ve got the TV on, I’ve got the Sky box on, and I have been using electric all day, so you just want to keep pushing [the prepayment meter] … one day we used 20, 30 pence … we had the washing machine on all day!"***

Yet for those households who committed to practising prosuming for a year, the prepayment meter helped them to continue to make some savings during the winter. For example, over a number of weeks, one woman rigorously recorded her domestic routines, the weather and how much credit was left on her prepayment meter. It resulted in a 50 per cent reduction on her electricity bill for much of the winter, and some weeks this amounted to a saving of over £15. She achieved this by not only capturing what solar power was available, but also by being creative in how she changed her domestic routines to save energy. The result was significant to her family life but also her wellbeing, as her stress reduced as her finances improved.

In many ways, all the households became, to varying degrees, what Abi Ghanem and Haggett term ‘opportunistic’ energy users (Abi Ghanem et al 2011). But unlike in their study, the households in mine did not use it to justify high energy consumption. Instead they used it to improve their standard of living, particularly to reduce the strain of trading valued domestic routines off against another. As one woman told me:

> ***"When my partner, their dad, was here, my washing machine would be going and I’d be cooking a roast dinner on a Sunday. Well, when he left that stopped… ‘cos it would cost way too much money. So it would be like one or the other basically, I couldn’t do both. Whereas now I can do both and… it’s great!"***

COMMUNITY FOCUS

And what about issues of ownership? In my study the social housing provider had only been able to supply panels to around a fifth of the houses in the area. They had hoped to invest in more panels but, like many others, had to curtail their plans when the feed-in tariffs were reduced by the government (Howard 2015). While the households in my study were pleased to receive them, a number were also troubled that more were not available for others in their community.

There was also a feeling among a number of the households in the study that the government's feed-in tariff scheme was a much better fit for solar owner-occupiers than tenants on prepayment meters. For example, they made the surprising discovery that the solar panels only worked when there was credit on the prepayment meter. As one man said:

> ***"We ran out of electric and the solar panels didn't work. Nothing, we didn't have no electric ... I thought we should still have a bit of electric from the solar panels but obviously not."***

Questions were also raised about who owned the power that was generated. There was a feeling among a number of households that any excess solar power to their needs should remain within the community and not be sent to the wider electricity distribution network. As one man said:

> ***"The people that really need it that's where all the excess should go to. Or help reduce their bills some way or another... so basically everyone's helping everybody ... that way it's trickling back."***

KNOWING ENERGY IN THE 21ST CENTURY

When I was growing up, we only had access to instant heat when there were enough 50 pence coins in the meter. And yet, shockingly, in the 21st century, there are still many children living in households that are struggling to keep their electricity and gas meters topped up (Adam and Monaghan 2016). My study has highlighted that solar power could be one of the solutions to help address fuel poverty. Over a matter of months, most of the social housing tenants in my study shifted from believing that solar panels did not belong within their community, to becoming proficient prosumers and saving money on their electricity bills. What's more, a number of them developed a vision of the energy system they would like to see in the future – one that is focused on generating and sharing renewable power within a community. If, as this essay collection argues, we are to see a future where local energy is harvested, it is critical it becomes not just an everyday activity, but an everybody activity too.

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PART TWO: THE HOUSEHOLD AND THE HOME

3. CONSUMER PARTICIPATION IN FUTURE SMART LOW-CARBON ENERGY SYSTEMS

DR JEFFREY HARDY

Consumers of the 2030s will be at the heart of the low-carbon energy system. Whether they participate actively or passively depends on who, if anyone, is acting as an intermediary. In this essay I use decentralised and distributed energy systems to explore these issues.

WHY WILL CONSUMERS BE PARTICIPATING?

There are at least three reasons why consumers will be more participative than we (mostly) were in the 2010s.

The first is that the energy system, the thing that keeps us warm, fed, entertained, mobile and productive, will transform to one that is low-carbon. Near net neutral homes and places, harvesting as much energy as they can, will take us a long way towards the UK target to decarbonise 80 per cent by 2050 compared to 1990 levels.

The second is that the energy system itself will become more local, particularly the electricity system. This will be driven by the falling costs of key technologies including solar and wind power, and electricity and heat storage. Other technologies, such as electric vehicles including those that can drive themselves, will become commonplace. Thus, the electricity system will transform from a few large power stations meeting consumer energy needs to millions of energy generators, including 'prosumers' – consumers who produce their own energy, and therefore go some way to meeting their own needs.

The third is that these dramatic changes to the energy system will require (and encourage) consumers to be more flexible in their use of energy. This will be been driven by the millions of renewable electricity generators that produce power when the sun is shining and the wind is blowing. To take advantage of this 'free' fuel, consumers will be encouraged and enabled to be flexible in their demand through prices and through smart technology. Thus, the energy system will be constantly optimised to meet key outcomes of carbon, affordability and energy system stability.

Data is key to energy system optimisation. For consumer data, this requires transparent consent and a fair share of the reward for sharing data and doing the right thing for the system. Trust is crucial and this will be built through transparent, secure and democratic protocols – like distributed ledgers – that put consumers in control of their data. Data is also crucial for energy companies to better understand consumer preferences and values, to tailor energy offers to meet consumer energy needs.

HOW WILL CONSUMERS BE PARTICIPATING?

How consumers participate depends on their preferences. In the future, a range of options will be available – from the directly participative peer-to-peer energy to engaged local energy communities, through to passive approaches where consumers hand over the complexity of running a household to a company like Google or Amazon. An (extreme) example of each is summarised below.

Direct participation – peer-to-peer energy

This is the ultimate decentralised energy system where homes are power stations and all consumers are active energy traders. For these consumers, the supplier of today no longer exists – they deal direct with generators, consumers and prosumers. A combination of cheap solar panels, cost effective batteries, heat storage and electric vehicles means consumers can satisfy most of their energy needs, certainly in the summer months. Consumers choose to buy, sell or store power to maximise their benefit. Transactions are recorded and settled via secure public ledgers.

For these consumers, the grid is a backup for which they pay an insurance premium. Some consumers embrace the hands-on control, others employ third parties to manage the complexity and risk. For all consumers it makes sense to insulate homes and install smart devices that control home energy use to reduce demand and increase flexibility. Some consumers are selfish optimisers (they seek to maximise profit from their energy transactions) while others donate their excess energy to those in need.

Local energy communities

Communities could take back control of their local energy systems, creating local energy companies based on sharing economy principles. Here the whole community invests for the long term in energy infrastructure including local electricity generation, heat networks, energy storage and shared mobility, such as autonomous vehicles. Underpinned by smart data, monitoring and control, local residents are allocated an energy allowance which they could use or trade for energy, money or something else, like time or skills. Benefits of the community energy scheme, such as profits from trading with other communities, are reinvested locally in projects such as home energy efficiency measures and local amenities. Rather than a national trading market for energy, communities trade from the bottom-up, with other communities, seeking to maximise local energy consumption. The grid has become more of an insurance policy for when local energy isn't available.

Let someone else do the hard work

Here consumers outsource responsibility for running their household to lifestyle service companies. In return for a monthly lifestyle bill, the company keeps consumers warm, fed, entertained, mobile and productive – to an agreed service level. Homes are smart and full of monitors and sensors that constantly optimise the living environment. Retrofit services means homes are well insulated, minimising energy requirements. The investment is paid back over a long-term contract with limited upfront costs. Smart homes coupled with a deep understanding of consumer preferences and values means services are constantly optimised for consumers – for example devices in homes automatically respond to changing energy prices by changing their demand. Thus, consumers are highly participative in the energy system, without lifting a finger.

BENEFITS AND POWER TO THE PEOPLE?

While each example above results in something akin to a near net neutral home, the differences lie in how the benefits accrue and where the power lies.

In peer-to-peer, the power sits with individual peers. The benefits depend on how good the peer is at trading, how well equipped they are and how altruistic they want to be.

In local energy communities the benefits accrue to the local community, although communities vary in terms of financial and energy resource availability, so are not equal. Thus, power could lie with those communities with the greatest financial, energy and skilled people resources.

In the lifestyle service company example, consumers will benefit from enhanced levels of service and potentially from lower bills (if that is what they seek to optimise). The power depends on competition in the market to deliver those services; in a truly competitive market the power is with consumers, in oligopolies or even monopolies, the power likely resides in the companies themselves.

However the future turns out, there will be a strong role for policy and regulation to seek to maximise the positive outcomes and minimise the negative ones.

4.
THE 'BETTER HOME': HOW OUR HOMES COULD POWER OUR FUTURES

GILL KELLEHER

Taking a retrospective view from the 2030s, we can see that throughout the early 2010s, the UK was building and retrofitting its buildings inefficiently. At the same time, it was intending to invest in long-term infrastructure projects without being able to monetise the benefits that new, emerging and disruptive renewable technologies could provide when integrated into buildings (Ofgem 2017a, 2017b, 2018a; CCC 2018; IET 2017; ICL 2017).

Homes were being built to minimum performance standards, thus failing to protect those in fuel poverty in the long term. Moreover, energy policy price controls were being formulated and agreed under 'old fashioned' market frameworks and mechanisms (such as the RIIO[3] model), prolonging the use of fossil fuel heating into the future.

Such an approach, operating in silos and with metrics primarily based on financial measures, inherently excluded the benefits of whole building energy efficiency, and of integrated materials in the built environment from being actively reported against green house gas (GHG) targets. This in turn passed unnecessary costs onto government, consumers and businesses.

Continuing such an approach would be detrimental to the environment and public health, prolonging exposure to harmful pollutants from fossil fuel power and heat generation solutions and causing premature deaths and health risks (Defra 2018; Laville 2018), while failing to find solutions to meet the UK's fourth or fifth carbon budgets (CCC 2010, 2015).

Therefore the opportunity of ground-breaking regulatory action in 2019, as part of the government's Construction Sector Deal (DBEIS 2018a) and its Buildings Mission 2030 (DBEIS 2018b), brought a new focus to government strategies to unlock the benefits of smart disruptive technologies, like those being developed at SPECFIC Innovation Knowledge Centre (IKC) to turn buildings into 'active buildings', also known as 'buildings as power stations'.

An active building generates, stores and releases energy from the sun. It is:

> ***"a building which integrates solar generation and storage technologies for both electricity and heat within its construction, rather than being heated by gas, and which is controlled by an intelligent system to optimise energy management and comfort for inhabitants. Active Buildings aim to be net generators, and have the potential to utilise the surplus energy to 'trade' energy with the grid, surrounding buildings and electric vehicles."***[4]

Active buildings provide a different social economic proposition – they enable every householder to get a direct and immediate monetary benefit from the realisation of the energy potential of their home; and these benefits can be made available whatever your tenure. Homes and buildings are key to a decentralised energy future that seeks to balance and maximise harvesting from the sun.

3 RIIO (Revenue = Incentives + Innovation + Outputs) is Ofgem's performance-based framework to set network price controls.

4 See: https://epsrc.ukri.org/files/funding/calls/2018/iscftransformingconstruction/

New homes and buildings built in line with SPECIFIC's concept (see below) could help address fuel poverty, avoid the cost of reinforcing the electricity grid and demonstrate technology that could also be applied to the building retrofit market. This is all in addition to increasing energy security, reducing carbon emissions and improving air quality.

THE FINDINGS OF THE SPECIFIC PROGRAMME (UP TO 2018)

Active buildings are based on the approach piloted by the SPECIFIC Innovation and Knowledge Centre (IKC), a publicly funded partnership, based at Swansea University. This IKC is a unique testament to the foresight of the Engineering and Physical Research Council (EPRC), Innovate UK, European Regional Development Fund (ERDF) and Welsh Government to fund an industry partnership to work across building types and demonstrate what could be achieved by using the power of the sun to heat and power buildings: that is, turn them into 'buildings as power stations'.

Using its demonstrator programme, SPECIFIC works with industry and academia to demonstrate the wide-reaching benefits the approach offers while identifying critical market failures and the barriers affecting scale-up, and addressing the 'scientific-based' evidence gaps needed to create a fair, flexible energy system for all.

For example, in 2016, a partnership with Neath Port Talbot Council and SPECIFIC saw the creation of the Active Homes Neath project, the first innovative social housing development to be built by social housing group Pobl, using SPECIFIC's concept to dramatically reduce bills for tenants, and design out fuel poverty (no fuel costs = no fuel poverty) and associated carbon emissions. The concept used a combination of solar cells, battery storage and a revolutionary steel frame which draws solar-heated air through tiny perforations for heating and warm water. As such this is intended to be a building that goes beyond the concept of carbon neutral towards inherent over-production of energy.

The combination of photovoltaic cells[5] and battery storage means that the homes could harvest energy from sunlight and hold it until it is needed at times of peak demand. The potential savings over the next 40 years would be significant and such an approach would reduce peak heat demand and enhance energy system flexibility. Scaled up this would, in turn, reduce overall long-term infrastructure costs, by reducing the energy infrastructure required to supply homes using much less energy.

To investigate these cost savings further, an independent study (Bankovskis 2017) based on the Active Homes Neath project scaled up the potential savings that could be made if the technology and approach were applied to a million homes. It found that the average saving per household could be at least £600 (a cut of more than 60 per cent), not including any additional benefits from solar feed-in tariffs. Furthermore, there would be a decrease in carbon dioxide emissions of nearly 80 million tonnes over 40 years and a reduction of 3,000 megawatts in peak generating capacity – equivalent to the output of a very large power station.

The Neath project and other projects such as SPECIFIC's Active Classroom[6] and Active Office[7] are highlighting critical 'unfair' energy market issues that stifle innovation and scale up. These include the lack of an over-arching heat policy, associated market arrangements or any provision for a robust 'no regrets' heat de-carbonisation pathway that would take advantage of integrated solar thermal technologies such as these.

5 A photovoltaic cell is the constituent part of a solar farm, a layer of silicon semiconductor that converts light (and other parts of the radio magnetic spectrum) into electricity.

6 See http://www.swansea.ac.uk/campus-development/baycampus/keybuildings/activeclassroom/

7 See https://www.building.co.uk/the-active-office-an-energy-positive-building/5094223.article

These are critical barriers, important to overcome because approximately half of the global energy demand is for heating purposes.

They are also important to address because the UK's low carbon policies and Ofgem's regulatory reforms have been passing on 'traditional 'fossil fuel" (see Ofgem 2018b) network costs to consumers. They reflect a situation where only gas and electricity market arrangements are deemed to exist.

These arrangements mean that customer bills are based on a predict and provide, expenditures incurred 'plus' basis and do not monetise the way consumer bills were created, nor take account of the potential savings from alternatives to gas heating solutions outside of these traditional market arrangements.

Therefore, the value and business case of emerging technologies for heat and advanced storage systems – such as 'inter-seasonal' heating systems powered by solar energy – to become economically deployable are being missed. And so too is their potential role in supporting off-gas grid alternatives. In the short- to medium-term, policy and regulation could enable near to market solutions with the potential to displace the gas network rather than increasing dependency on gas going forward.

So will the UK government recognise this by quantifying and monetising energy efficiency, sources of non-fossil fuel generation, and storage using buildings? Doing that would inform its future policy reforms and enable active buildings to become a fundamental part of the UK's long-term decarbonisation pathway.

A new course would thus be set by creating fair, transparent market mechanisms for carbon and energy consumption and pricing. At the same time, 'no regrets' new build housing and decarbonisation targets could be achieved, lifting people out of fuel poverty, improving health and well-being, and reducing harmful air pollution from fossil fuel generation, transportation and industrial processes.

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PART THREE: THE FUTURE LOCAL ACTIVE ENERGY SYSTEM

5. LOCAL ELECTRICITY IN PRACTICE

DR SPYROS SKARVELIS-KAZAKOS

Arguably, the successful integration of more local energy generation requires significant changes in electricity distribution network operation (Cipcigan and Taylor 2007). Across the industry, distribution network operators (DNOs) have been drawing up plans and launching consultations on how they become distribution *system* operators (DSOs) (UKPN 2018). The essence behind this change is for DSOs to be able to control and operate equipment in the distribution network more actively, thus creating local energy markets, allowing more local generation to be integrated and increasing the reliability and resilience of electricity supply. There is a large body of research and innovation on the potential tools needed to achieve that, ranging from fundamental ideas to applied and tested systems.

ACTIVE NETWORK MANAGEMENT (ANM)

Currently, electricity networks are operated passively and, to an extent, reactively. Limited visibility and lack of control in large parts of the local electricity network create the need for more active tools to manage the real-time operation of electricity networks. ANM is a collective name for a set of tools and procedures that introduce real-time control of equipment, additional monitoring capabilities, and increased autonomy and automation of local systems (ENA 2015). It forms a fundamental part of the smart grid concept. Examples of ANM solutions would be to: increase generator output when there is excessive demand in a particular part of the network; defer flexible load consumption; or change transformer settings automatically to prevent voltage limit excursions (Manandhar et al 2014). ANM also offers regulatory and logistic advantages, as it may reduce the need for network reinforcement or essential upgrades, thus reducing waiting time for new generation interconnection.

ENERGY STORAGE

The electricity network traditionally contains very little storage. Most of the electricity that is consumed needs to be produced in real time. This balancing act is manageable when there are a few hundred generators throughout the country with straightforward power flows, but it becomes challenging when millions of small generators produce a complex array of local energy flows. Local energy storage has the potential to act as an energy sink and/or source, when necessary. In that sense, it can be used as a tool for ANM. This approach has been demonstrated in practice, for example, in UKPN's Smarter Network Storage project, where energy storage was used to defer network upgrades and offer new services to the system operator (Cooper et al 2015).

FLEXIBLE DEMAND

Flexible demand is another tool for ANM. It comprises any considerable demand asset that can be flexibly controlled when there is a need to do so. Deferring flexible demand can alleviate pressures in particular areas of the electricity network and can be used proactively or in real time (reactively). Typical examples of domestic flexible demands include deferring the washing cycle of a washing machine or controlling the charging of electric vehicles (Papadopoulos et al 2012). To an extent, electric vehicles can be used for providing power back to the grid, acting as energy storage devices. This is what is known as the vehicle-to-grid (V2G) concept (Grau Unda et al 2014).

INTEGRATED ENERGY SYSTEMS (OTHER ENERGY CARRIERS)

Finally, electricity is only one type of carrier for delivering energy. UK households consume more than one carrier – the second one being gas. In some cases, heat can be supplied by a district heating scheme. In the future, hydrogen may also be introduced. The household is therefore a hub, where multiple energy carriers meet and interact. For instance, a domestic combined heat and power (CHP) generator consumes gas and produces electricity and heat. If the CHP generator can be controlled by the DSO, then it can be used for ANM (Skarvelis-Kazakos et al 2016). There is great complexity in such interactions, but also great potential for flexibility and synergy.

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6.
DECENTRALISED HEAT

DR CHARLOTTE ADAMS AND PROFESSOR JON GLUYAS

Heat surrounds us in the earth, water and air we breathe. It is also created as a by-product of most processes and accounts for half of the UK's energy demand. In order to make better use of these heat sources, we need to redefine heat by changing the perception that it is felt warmth, and be more creative about where we source our heat in future. For example, we can take heat from a river at 4 oC or water from abandoned mines at 12–14 oC to provide space heating for adjacent buildings (Gluyas et al 2018). For future heat supply, reverting to old models – based on decentralised supply analogous to that of manufactured 'town gas' that predated the discovery of natural gas in the North Sea – could provide the answer. For example, instead of using gas in a decentralised network, heat could be sourced from – or stored with reasonable efficiency as – warm water beneath the Earth's surface, hosted by abandoned mines and aquifers and a range of other suitable subsurface geological formations. As the volume of water stored for heat recovery increases, so we can use ever cooler water to supply heat, thus reducing heat losses and improving efficiency.

Alternatives to using natural gas for heat come in many guises and at varying levels of readiness. They include options such as waste process heat, biomass, hydrogen and geothermal energy. These alternatives are all compatible with decentralised models of heat supply. What is clear however, is that to make best use of alternative resources, we also need to reduce demand by improving the fabric of our built environment and, where possible, embedding generation to turn individual buildings into power stations that meet or contribute to their energy demand. In the case of waste heat recovery and geothermal energy, existing technology is both proven and available to achieve this, and some attractive government incentives exist that promote the development of heat networks or pay out for kWh produced. However, shifting to decentralised heat supply will not succeed without joined-up policy support.

Adopting a decentralised heat system requires changes to the way heat is supplied, used and traded. It is also necessary to adopt a place-based approach to decentralising heat to maximise the potential of the resource attributes of the area in question, while being cognisant of the fact that heat is not as portable as electricity. Moving to a decentralised model for heat provision fits well with UK government aspirations (stated in the fifth carbon budget[8]) to supply 14–43 per cent of the total heat demand from our buildings using district heat networks by 2050. The difficulty in meeting this target is illustrated if we consider the domestic sector – if we assume build rates of 100,000 homes annually, connecting every new home to a heat network would take between 27 and 83 years.

This impasse is a direct result of planning policies and building regulations not going far enough to encourage developers to connect new developments to a decentralised heat network or embed generation within new developments. In future, planning policy should drive local authorities to consider their available heat resources to develop a heat plan that helps inform the planning consent process. Building regulations could be adapted to include much more energy efficient technology and embedded generation. Making changes to these two

8 See https://www.gov.uk/guidance/carbon-budgets#setting-of-the-fifth-carbon-budget-2028-2032

policy instruments alone could do much to future-proof new build homes and make them more compatible with the decentralised energy systems that will become more commonplace in future. There is also a business proposition in the potential that exists for the development of new heat markets and supply chains.

We need to start by re-thinking heat distribution to maximize the value of low temperature heat and make greater use of energy efficient heat pump systems to upgrade low enthalpy resources to useable temperatures. Consider the domestic setting where boilers heat water to high temperatures (80–90oC) before pumping it round radiators to heat rooms to 18–22oC. Switching to underfloor systems meant that circulation temperatures can drop to 30–40oC because there is a larger area available for heat dissipation (Adams 2016). Halving design temperatures has the potential to halve both CO2 emissions and energy consumption. At a larger scale, gas fired district heat networks are commonly designed to run at temperatures of around 100oC, but by designing a system that can operate with lower circulation temperatures, less insulation is required and losses are reduced. For example, running a heat network at 30oC instead of 80oC can reduce heat losses from 35 to 5 per cent.

These lower temperature heat networks have been successfully achieved in places like Heerlen in the Netherlands, one of several schemes where water in abandoned mines is successfully used to provide heating and cooling. In this example, around 200,000m2 of new and retrofit, mixed-use buildings are heated and cooled using a source at 28oC (Verhoeven et al 2014). A further benefit of this scheme is that energy spend is retained within the municipality, which has led to many socio-economic improvements for the region. In Copenhagen, 98 per cent of the city's heat is provided by waste heat from electricity production in a system that has been running since 1984.

The message is clear; we need to think creatively and embrace the existing opportunities of using alternative and waste heat sources. Instead of using the energy dense fossil sources that we have become accustomed to, we need to design heat supply systems and networks that can operate effectively using lower temperature sources, accept a wider range of heat inputs, and reduce our reliance on a centralized supply of natural gas.

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PART FOUR: THE BUILDING BLOCKS NEEDED TO DEVELOP THIS DECENTRALISED ENERGY FUTURE

7. THE IMPORTANCE OF PLACE IN ENERGY SYSTEM 4.0

DR KATY ROELICH

The vision of a distributed energy future (energy system 4.0) laid out in the introduction has allowed local, place history, the 'lie of the land' and the choices different organisations and communities have wanted to make come to the fore in the energy decisions made in and about their parts of the UK. This future recognises:

- The different drivers of decisions and engagement in energy that have occurred in each place – including those to make a place more resilient, to make a place more attractive to new residents or businesses, and to reduce fuel poverty, air pollution and carbon emissions. These drivers vary greatly between places and are shaped to a great extent by the nature of the place (Roelich et al 2018; Haf and Parkhill 2017). They are also substantially different to energy system 2.0 and this variety and difference has been taken into account in this future energy system.
- Different places have different resources available to them in terms of energy and harvesting. A simple example of this is that wind resources in urban areas are unlikely to be sufficiently stable to enable harvesting economically. Conversely, cities with energy from waste facilities have an ample heat resource and are more likely to invest in harvesting and distributing this heat. This future energy system allows for the uneven distribution of technologies that reflect locally available resources.
- The different history of a place and how this influences the likelihood and speed of project delivery. In previous work we have found that those places with energy infrastructure, for example a district-heating network, had institutional confidence in their ability to engage with the energy system as well as skills and competencies. As a result, they were more likely to plan additional heat networks. Once established in one technology or system area, this confidence can also spread to others and allow organisations to broaden their engagement in the future energy system.
- The culture of a place drives its decision-making and is also a powerful motivation for engaging with the energy system. An example of that is the institutional risk aversion that shapes how decisions are made in local authorities (Roelich et al 2018). The failure to deliver a service or 'break even' has far greater consequences than in the private sector, so risk is

a much more significant driver of decisions. This means that decisions are not made solely on the financial cost benefit of activities but also on the risk that activities pose to citizen services and to local authority budgets. Culture has also been found to motivate organisations and communities, for example using energy activities in overcoming historical disempowerment (Haf and Parkhill 2017).

The vision of a decentralised energy system (4.0) will be realised if the right policy and practice support is put in place. Such support needs to recognised, valued and work with the different motivations, the local histories, and varied lie of the land that makes up the range of British communities. For example:

- In accounting for and incentivising different local drivers, rather than just measuring carbon or technology deployment. This includes developing a new approach to accounting and valuation that is able to capture and assess non-monetary drivers on a more equal footing with monetary outcomes and to assess multiple drivers at once to enable comparison between very different projects.
- In enabling institutional diversity and the creation of organisations and institutions that reflect the drivers, resources and culture of a place.
- In providing a balance of incentives relevant to the resources of all places, rather than favouring technologies that are only relevant in places with specific resources, helping to ensure each ‘typology’ of place has received the necessary support so as to ensure no community has been left behind.
- By building the necessary institutional confidence by allowing and supporting experimentation and learning by different institutions and sectors – not least those newer actors, such as local authorities. Policy and support in this future would also use new forms of valuation that capture the benefits of intermediate activities in opening up future options, such as providing passive provision for future capacity, that will contribute to long-term outcomes to encourage incremental and reflexive change (Bale et al 2014).
- By encouraging the development of cultural capital and recognising how culture affects decision-making.

So what might this place-specific, near net neutral future look like in two contrasting places?

Firstly, let us consider an urban area with extreme fuel poverty and a history of heavy manufacturing. The place-specific drivers might be to retain the manufacturing sector and to tackle fuel poverty. In terms of local resources, this urban area already has a district heating system but it does not currently reach as far as the areas most affected by fuel poverty, and the local authority possesses skills and competence in operating the current system. A near net neutral solution might be to capture surplus heat from the manufacturing facilities, store it during periods where supply and demand are mis-matched, and extend the heating network to transmit this heat to properties including those in fuel poverty. The manufacturing sector therefore has a new source of income, meaning that they are better supported without providing subsidies and energy is harvested more effectively.

The second example is a deprived, rural community with a history of resource extraction, disempowerment and underemployment. The place-specific drivers are to attract income and enable self-determination in the community. In terms of local resource, the community is in a valley with a fast-flowing stream, a canal and has access to land on the hills surrounding the valley. The community is familiar with large engineering structures, having been surrounded by mining infrastructure for its living memory. A near net neutral solution here would harvest energy from the water (both heat and electricity) and wind resource and use this to supply as much of local demand as possible. Heat and electricity storage would be developed to meet the maximum amount of demand from local generation. In order to retain the financial value of this generation, a local supply company would be set up to sell energy directly to local residents and to export surplus to the grid. The physical assets would be managed and maintained by the local community to provide jobs and skills development to local residents and to improve their resilience and self-sufficiency.

In conclusion, place is a fundamental building block of this vision, and places are different in various ways. Understanding where each place and its community starts is essential to securing all the benefits of this decentralised energy system vision.

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8. WHO ELSE WILL NEED TO DELIVER? THE ROLE OF COMMUNITY AND LOCAL INSTITUTIONS

MARGARET TINGEY AND
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A more distributed energy system with scope for local innovation and flexibility, and making every building part of a networked clean, low energy, infrastructure, would have system benefits in line with policy for resilient and affordable supply. This essay reviews the potential for local authorities to participate in such a system, alongside neighbourhoods, community enterprises, social landlords and businesses, and outlines some necessary steps to ensure effective action for the social, economic and environmental prosperity envisaged.

WHY THE ENERGY SYSTEM NEEDS LOCAL AUTHORITIES

Local government is an established democratic route to engaging everyone in decisions about clean energy and low energy buildings, with the opportunity to share benefits as well as costs. Unlike most organisations, local authorities are committed to the area for the long term. Their planning powers, estates and responsibilities for housing, economic regeneration, transport and social care mean that they are uniquely placed to contribute, and are critical to meeting the UK's carbon targets. Many already have ambitious local energy strategies that aim to keep bills down, improve health and create jobs, as well as providing energy services.

WHAT ARE THE DIFFERENT ROLES THAT LOCAL AUTHORITIES COULD PLAY?

We consider three local authority roles in a near net neutral energy system: enabling, advising and investing.

Enabling actions focus on setting and enforcing high-energy performance standards on developments and prioritising clean energy supply locally. Local authorities may act as a partner in developments. Planning powers are key to setting standards in relation to buildings, renewable energy, energy from waste, energy storage and district heating. Local powers can be used for integrated spatial and energy planning, working with distribution network operators (DNOs) to optimise local generation, storage and demand side response. Local authorities may work through community planning partnerships, city region structures and 'city deals'; economic development strategies and procurement policies can bring clean energy investment into the area.

Advising is likely to have a range of dimensions including energy advice services to businesses, households and neighbourhood groups to raise awareness of energy costs and how to reduce consumption. Local authorities may provide targeted support to ameliorate fuel poverty as well as engaging with local groups and householders. Advisory services can be delivered directly, or in partnership.

The third role, **investing** in local energy, encompasses the most challenging activities, spanning building retrofit and energy services, generation and supply. Local authorities may run projects in-house, initiate municipal businesses, partner with community enterprises in cooperatives, and use joint ventures and commercial contracting.

In the following examples, we outline current initiatives illustrating each of these roles. The first two cover enabling and advising and the rest cover different models for investing. We draw these from our own research (Webb et al 2017) as well as that by others.

EXAMPLE 1. ENABLING ACTIONS: PLANNING AND COORDINATION

To be successful and mitigate the risks of 'developer flight', standards need to be coordinated across a region. **Scottish Cities Alliance** provides support to planning authorities who are developing heating guidance and local heat and energy efficiency strategies. The **Greater London Authority** spatial development strategy, *The London Plan*, includes minimum standards for district heating and acts as a key reference for local authorities (GLA 2016). **The Scottish Government's** *Energy Efficient Scotland Route Map* is a 20-year plan to 2040 that sets a common framework for mandatory energy performance upgrades in all existing domestic and non-domestic buildings and standards for new buildings (Scottish Government 2018a). It is a key part of the 2017 *Scottish Energy Strategy* (Scottish Government 2017a) and 2018 *Climate Change Plan* (Scottish Government 2018b). Local authorities are expected to work in partnership with government to ensure success, and selected local authorities are piloting integrated projects and costed delivery strategies.

In **Exeter**, planning policy requires new developments to connect to or establish decentralised energy networks, and public authorities work jointly (Exeter City Council 2012). Developments include Cranbrook and Skypark,[9] and in 2016, Dextco Ltd[10] was established by a group of local authorities and health bodies to secure a partner for district energy development in Devon. **Leeds City Council** has established a local development order to support a city-wide district heating network using heat from energy from a waste facility (Leeds City Council 2016). The **City of Glasgow Council** worked with the electricity DNO (Distribution Network Operator) in a detailed assessment of energy use in buildings, local energy sources and options for a low carbon energy system. The resulting strategy aims to reduce CO2 emissions by 30 per cent by 2020 against a 2006 baseline (Glasgow City Council 2013).

EXAMPLE 2. ADVISING ACTIONS: ENERGY SAVING AND RENEWABLE ENERGY ADVICE, FUEL POVERTY INITIATIVES AND ENERGY EFFICIENCY PROGRAMMES

Reading Council's Winter Watch[11] initiative with local health services is concerned with reducing vulnerability. Approximately 200 residents per year have been supported with emergency heating repairs, boiler replacements, advice on bills, and income maximisation through benefit checks. **Plymouth Energy Community**[12] is a community benefit society supported by Plymouth City Council. The local authority has provided grant and loan financing and rooftops for solar PV, and council staff are involved in day-to-day management. Plymouth Energy Community also offers an energy advice service and installs LEDs in schools. **Leicester Energy Agency**[13] is part of Leicester City Council and uses European funding to support energy efficiency improvements by businesses, community groups and householders. **Oxford Low Carbon Hub**, in partnership[14] with the local authority and universities, runs the OxFutures 'phase two' project (see example

9 See: http://www.exeterandeastdevon.gov.uk/cranbrook/
10 https://www.dextco.co.uk
11 See http://www.reading.gov.uk/winterwatch
12 http://www.plymouthenergycommunity.com
13 See http://www.energyagency.co.uk
14 For the full list of partners see http://oxfutures.org

5 for 'phase one' community energy) providing SMEs with free energy audits and financial assistance to implement recommendations. **Scottish Borders Council** works with social enterprise Changeworks, Home Energy Scotland (part of EST Scotland) and Resource Efficient Scotland (an agency of government) to provide energy advice for residents and businesses through the Peebles High Street 'hub' (Scottish Borders Council 2018).

EXAMPLE 3. INVESTING IN ENERGY: COUNCIL BUILDINGS, ESTATE AND SOCIAL HOUSING

Local authorities may invest in energy performance projects for their corporate estate and housing. They can manage these directly and may draw on specialist procurement frameworks. Finance sources include internal budgets, public sector borrowing, grants, energy company obligation, and developer contributions (such as Section 106 funding).

Cambridgeshire County Council was awarded EU funding to develop an energy performance contracting business.[15] The council drew on Public Works Loan Board (PWLB) borrowing initially to invest £15 million in a common investment fund for energy efficiency upgrades and renewable energy; the guaranteed energy savings and income from renewables cover repayment and fund an in-house Energy Investment Unit. A total of 40 schools and seven corporate estate buildings have been included so far; the council also developed a 12 megawatt solar farm, which secured a UK Contract for Difference in 2015. To date £20 million has been invested. The longer-term aim is to develop the investment fund to attract other public and private sector investment for Cambridgeshire's low carbon goals. **Greenwich Council** used a similar energy performance contract in a £14 million regeneration of the Barnfield Estate (577 homes). The council piloted the Greenwich Homes Standard Priority Investment Programme, which took a whole house approach to upgrades. Local authorities can also manage retrofits in-house through 'spend to save' funds. **Calderdale Council** LED street lighting programme, for example, is investing over £20 million to replace street lights and columns and is expecting to save around £900,000 and over 3,000 tonnes of CO_2 each year.[16]

EXAMPLE 4. INVESTING IN ENERGY: MUNICIPAL ENERGY SERVICES COMPANIES (ESCOS)

A municipal energy services company (ESCo) can provide long-term coordination and continuity of local energy development and a defined role for the council in shaping the remit and scope of the business. The ESCo provides a means to integrate local energy infrastructure, including energy from waste facilities (see for example **Sutton Decentralised Energy Network**[17]). Separate financial accounting creates a clear division of business responsibility for cash flows and ring fences revenues to secure their use for further energy developments. Independence from council reduces uncertainty caused by local electoral cycles and changing political control, as well as conferring some protection from restructuring. A municipal ESCo can accept social rates of return on investment, and there is scope for restructuring and/or selling the business at a later date.

Aberdeen City Council established **Aberdeen Heat and Power Ltd** (AHP)[18] in 2002 as a non-profit ESCo to deliver affordable heat 'for the benefit of the citizens of Aberdeen'. AHP develops, owns, operates and maintains gas-fired combined heat and power district heating (CHP/DH) centred on clusters of multi-storey tower

15 See https://www.mlei.co.uk
16 See http://news.calderdale.gov.uk/investment-for-a-bright-future
17 http://sden.org.uk
18 http://www.aberdeenheatandpower.co.uk

blocks (around 2,400 flats and 15 public buildings). The council buys heating and hot water from AHP, and supplies it to housing tenants under a heat with rent contract at a fixed weekly price. The council has representation on the AHP board and step-in rights should the company fail. AHP income is ring-fenced, and covers system maintenance and replacement costs, as well as further developments, and ensures the affordability of heat for tenants. The CHP/DH systems have been financed by combinations of central government grants, council Housing Capital Programme funds, ECO funding and loans from Scottish Government and the Co-op Bank. AHP have continued to extend their district energy business, and in 2013 established District Energy Aberdeen Ltd, a subsidiary company for heat supply to the commercial sector.

EXAMPLE 5. INVESTING IN ENERGY: PRIVATE SECTOR ESCO/SPECIAL PURPOSE VEHICLES (SPV) WITH A LONG-TERM CONCESSION CONTRACT

Local authorities can establish a long-term concession contract with a commercial utility for supply of heat (and power in some cases). An ESCo/special purpose vehicle (SPV) is set up by a parent company as a new company limited by shares, recovering investment from long term guaranteed energy sales to the council and potentially to other customers such as universities, hospitals and social housing tenants. The SPV structure limits financial risk to the parent company. Responsibility for upfront capital investment is allocated to the contractor, although contract terms may require an initial local authority financial contribution. Local authorities usually adopt this model as a route to externalise financial and operational risk and responsibility. The infrastructure may be extended and new connections secured without repeat procurement, but network expansion is frequently more challenging than may first appear because of the required level of commercial returns, and the necessity for guaranteed customer connections.

In 2010 Leicester City Council entered a 25-year concession contract with Cofely Ltd (now Engie) to create **Leicester District Energy Company Ltd** (LDEC)[19]. Services have been extended into the city centre connecting 30 council buildings, university campuses, and older island networks serving 3,000 social housing tenants have been upgraded. Council owned heat generation assets were transferred to LDEC who own, operate and maintain the new gas CHP/DH networks. The council retained ownership of some pipework, and equipment inside buildings already connected to the network, and is responsible for collecting heat payments. The concession contract has allowed the council to meet its objectives of carbon reduction, network renewal and extension into the city centre without upfront investment. Engie invested around £14 million; an additional £1 million was secured from Engie's parent company GDF Suez, which allowed GDF Suez to meet its energy efficiency obligations under the Energy Company Obligation (ECO) scheme.

EXAMPLE 6. INVESTING IN ENERGY: COMMUNITY RUN BUSINESSES

Local authorities can partner with community enterprises to support more inclusive and clean energy services. Local authorities can provide access to buildings, loan and sometimes grant funding, staff time and expertise. They can also use their 'trusted brand' identity to partner with community groups. Each party can access different funding opportunities as well as make joint bids. Supporting community energy is a route to local engagement and community responsibility for assets, as well as creating opportunities for training, skills development and empowerment.

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19 See https://www.engie.co.uk/energy/district-energy/leicester

In Oxford, the council has partnered with the **Low Carbon Hub**[20] as part of OxFutures, a four-year EU funded project, which resulted in £18 million investment into local energy projects. Solar PV was installed on council (city and shire), commercial and domestic rooftops, Osney Lock hydropower scheme was established and a small energy efficiency retrofit of homes was completed. A second phase of the project is offering energy audits to SMEs (see example 2). With the support of Edinburgh City Council, **Edinburgh Community Solar Cooperative** installed 1.38 megawatts of solar PV on 24 council schools, leisure and community centres.[21]

In Swansea, the council has supported training, skills development and community ownership of assets through **Swansea Community Energy**[22] that installed solar PV on schools and a care home financed through a mix of local authority and community investors. In Bath and North East Somerset, the council has a cooperation agreement with **Bath & West Community Energy**[23] and provided a £500,000 loan toward the 2.3 megawatt solar array at Wilmington Farm, which was combined with a share offer of over £2 million. Public Power Solutions, wholly owned by Swindon Council, engaged in a partnership with green economy investment platform Abundance to co-finance **Swindon Community Solar Farm** from a mix of public and community investment.[24]

Energy use is implicated in every area of public services and some cities and regions already have significant ambitions to develop a local energy system. In these cases, energy infrastructure and services are made central to capital investment, and municipal energy companies have been created to manage new business (Webb et al 2017). Bristol and Nottingham have set up municipal licensed gas and electricity supply companies, Bristol Energy[25] and Robin Hood Energy,[26] while a group of over 60 Scottish social landlords, local authorities and community organisations mutually own Our Power.[27] Warrington Borough Council has secured a credit rating from Moody's, and a £150 million CPI linked capital investment bond from the City of London; local authorities in Bristol, Cambridgeshire, Leeds, Oxford, and Greater Manchester have all invested in Programme or Project Delivery Units[28] to increase the scale and pace of low carbon infrastructure developments under a variety of business models. New City Deals and the 'localism' agenda create opportunities to integrate energy and carbon strategies into the programme of investment for city regions but so far 'devo deals' have included only limited resourcing for strategic local energy programmes (Scott 2012; Ward 2017; Webb et al 2017).

CONCLUSION

Ultimately, however new supportive policy, statutory powers and resources are needed to ensure effective action for the social, economic and environmental prosperity envisaged from a more decentralised energy system. The Committee on Climate Change report (CCC 2012), for example, proposed the introduction of a new statutory duty for local authorities to 'develop and implement low-carbon plans' (p9). Proposals for local authority energy powers to develop and implement a

20 https://www.lowcarbonhub.org
21 See http://www.edinburghsolar.coop
22 https://www.swanseacommunityenergy.org.uk
23 http://www.bwce.coop
24 See https://www.abundanceinvestment.com/investments/swindon-common-farm-solar and https://www.publicpowersolutions.co.uk/swindon-community-solar-farm-powers-up-thanks-to-unique-solar-bond-initiative
25 https://www.bristol-energy.co.uk
26 https://robinhoodenergy.co.uk
27 https://our-power.co.uk
28 These units (excluding Leeds) were integral to the European funding structures, which also included budgets for finance, legal and technical consultancy and require the local authority to set – and achieve – an ambitious energy investment target.

Local Heat and Energy Efficiency Strategy (LHEES) are being considered in Scotland (Scottish Government 2017c).

Proposals include a statutory local power for clean energy, with additional ring-fenced resources, and planning requirements for building owners to connect to district heating within designated concession zones. Pilot LHEES are being developed in several areas in 2018 and 2019 (Scottish Government 2017b). There is unlikely to be a single model for localised energy planning, development and management which works everywhere but we know from European practice (Hawkey 2015) that coordination between local and national governments, as well as specific powers and procedures for energy planning, supportive regulation, and access to low cost, long term finance are all critical to energy systems with a strong municipal component.

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9. GOVERNING FOR A DECENTRALISED AND DECARBONISED ENERGY SYSTEM

JESS BRITTON, RICHARD HOGGETT, PROFESSOR CATHERINE MITCHELL AND DR MATTHEW LOCKWOOD

Energy systems in Britain and around the world are undergoing fundamental and rapid change towards more decentralised systems, due to a range of different drivers. These include falling costs for small-scale generation and storage technologies, increased use of ICT in energy, business innovations and changing social preferences. Many of these changes are focused on the end user and provide new opportunities to create a smarter, more flexible and integrated system that generates value for the customer and the system as a whole (Mitchell et al 2016).

Much of this change is currently being experienced within the electricity sector, but the heat and transport sectors are also experiencing some transformation, with a growth in local heat networks, heat pumps and electric vehicles. These developments also mean that increased integration between heat, power and transport is inevitable.

In order to ensure that Britain does not get left behind, we need to rethink our approach to energy governance and provide a fit-for-purpose framework that enables the transformation to a decarbonised, flexible and secure energy system (Mitchell 2017). Transforming to such a governance framework is vital because of the risk that, as technology races ahead, infrastructure and regulations lag behind, thereby slowing (or even blocking) change. Additionally, while numerous decentralisation trends are important, some centralised technologies are likely to remain significant, such as interconnectors and offshore wind, so it becomes increasingly critical to govern the integration of technologies and markets at different scales.

Energy governance in Britain needs to reduce total energy demand, speed up change and recognize that in a decarbonised, decentralised energy system several issues become very important. In particular, policies to protect the vulnerable, the regulation of energy networks, system coordination, the balance between markets and regulation, and the changing role and influence of various different actors all need to be addressed.

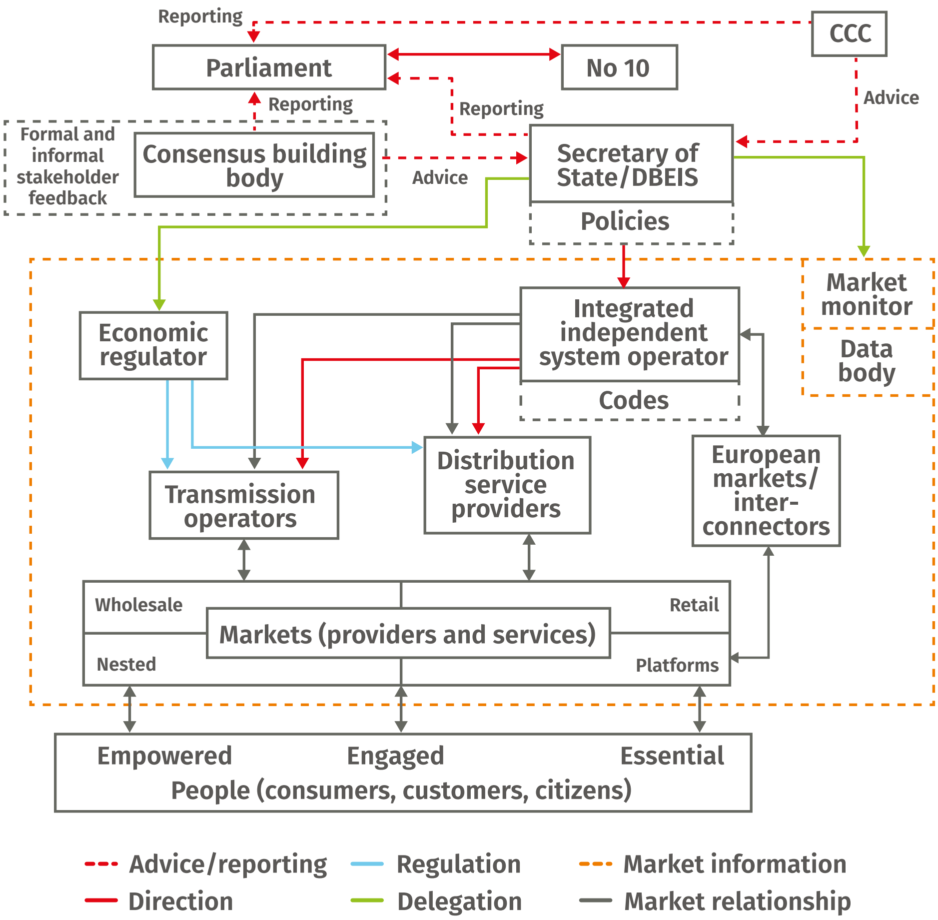
The key to enabling a decentralised, low-carbon, affordable system is restructuring energy governance to better integrate national and local, centralised and decentralised, and provide direction and flexibility, legitimacy and participation. To this end, the University of Exeter's Innovation and Governance (IGov) project has proposed a framework, which outlines four principles for governance to enable transformation. These are: 1) transparent and legitimate policymaking; 2) flexible, coordinated operation; 3) a people-centred approach; and 4) performance-based regulation (Mitchell et al 2016).

Based on these IGov principles, the framework proposes changes to some existing institutions as well as the creation of some new ones for the 2020s. Figure 1 illustrates the overall framework and the relationships between various elements. Specific changes include:

- the restructuring of Ofgem to become exclusively an economic regulator
- the formation of a Climate and Energy Policy Committee (CEPC) to provide stable political consensus on how the UK can decarbonise and enable a 'national conversation' on energy. The CEPC would work in parallel to the Committee on Climate Change, which would continue to track progress and establish greenhouse gas reduction budgets
- the establishment of a data body to collect and provide access to system data to support the delivery of policy goals
- the creation of a market monitor to track and report on market developments (independently of the economic regulator)
- the separation of transmission and system operation and the creation of a state owned Independent Integrated System Operator (IISO)
- the transformation of distribution network operators (DNOs) into 'active' distribution service providers (DSPs).

FIGURE 1

IGov fit-for-purpose institutional framework for the UK energy system



Source: Mitchell et al (2016)

Redesigning the function and regulation of distribution networks recognises that in a decentralising energy system, efficient coordination and utilization of resources best occurs at the distribution level. In Britain DNOs are currently being encouraged by Ofgem to become distribution system operators (DSOs). This involves them becoming more active managers of networks, and optimising demand, generation and other flexible distributed energy resources within their area.

We argue that the current approach to the DNO to DSO transition does not go far enough, given a business as usual regulatory mechanism, and status quo value chains and data ownership.

We propose that DNOs need instead to transform into distribution service providers (DSPs), which would take a more central (local) coordination – acting as a market facilitator, local market coordinator and balancer (Mitchell and Poulter 2018). This approach requires incentivising network operators to meet policy aims, facilitate local markets and flexibility, and coordinate action with local stakeholders to optimise the system.

This will necessitate different and new relationships with local authorities, communities and other local actors, and much more thought needs to be focused on how these relationships should be facilitated and formalised.

A decentralised energy system also needs to be focused on people by putting end users at the centre of the system design. This means optimising the system from the bottom up, starting with the household and businesses and working up to the national level (Hoggett 2017). In practice, this would mean focusing on energy efficiency and demand reduction, ensuring that energy system planning is inclusive of communities, neighbourhood planning and local authorities, and treating energy system data as a public good with data collection and access coordinated to deliver energy policy goals.

Some of the information and knowledge needed to optimise from the bottom up already exists, although it is dispersed and not necessarily easy to access and get value from. Finding ways to use this data more effectively to support local change would be beneficial. Examples include: network companies knowing their system constraints; accurate accessible data on off-gas areas; suppliers having data on customer demand; local authorities holding information on housing stock and tenure, transport infrastructure and forecast economic growth. We also have data from past energy efficiency schemes and existing energy agencies and NGOs that have been working for decades on sustainable energy locally, regionally and nationally. This data can help identify the possible options for bottom-up optimisation, although we will also need data and analysis higher up in the energy system to help direct change from the top down (Hoggett 2016).

Changing our approach to system transformation from the bottom up requires the political will to do so, as well as rethinking the relationships between local and national energy actors. Despite most energy infrastructure being fundamentally local, currently sub-national governance actors tend to play a very limited role in planning, delivering and optimising energy systems[29]. This means there is often a lack of knowledge and capacity in local authorities, and other local actors, to engage in energy. However, local governance in Britain is undergoing significant changes and an ongoing process of decentralisation has led to the establishment of devolved governments, Local Enterprise Partnerships, devolution deals, directly elected city mayors and the development of neighbourhood planning processes to engage local communities and councils in shaping the development and growth of their area.

These changes are causing many locations to look at the role they can play in local infrastructure and growth. Local actors are increasingly asking themselves how they can engage in the energy system to deliver multiple priorities relating

29 Although local authorities often played a much more central role in the early establishment of energy networks in the UK and elsewhere (Hannon and Bolton 2015)

to climate change, local economy, regeneration and community development. Some areas are grabbing the opportunities presented by decentralisation to link energy system decarbonisation to local prosperity. For example, Bristol City Council recently announced a call for partners to engage in a series of energy infrastructure investment opportunities worth £1 billion, with ambitious plans for energy efficiency and heat networks (Invest Bristol and Bath 2018). However, the lack of specific attention to scale and decentralisation in energy governance could lead to very diverse local approaches to decarbonisation, with some areas and communities being left behind. Larger, well resourced, often urban areas with a good track record on energy may do well in ensuring that their communities are engaged with, and prosper from, the energy transition – but smaller, more rural or less resourced areas could lag behind. Indeed, research has indicated that local authorities are taking very diverse approaches to sustainable energy (Webb et al 2017).

There is a need to bring together debates on energy system change and local governance change to explore how roles, relationships and institutions can change to support a decarbonised, decentralised energy system. How can the changing role of distribution be integrated with a reinvigorated role for local authorities? How can this best involve communities and neighbourhood planning approaches? Distribution providers will be central actors, but changes need to go beyond establishing local energy markets and framing citizens as individual energy consumers. Instead we need to recognize local collective energy system values as well as individual value – for example by exploring how smart energy data can create value for individual citizens and support wider social goals relating to system optimization, energy efficiency and improving public policy (Britton 2017).

Fundamentally, a decentralised approach to energy is about the type of houses we live in, where they are in the country, the places we work, local renewable resources, local networks and the aims and aspirations of local communities. It is only at this more local level that we can know what the best technical solutions might be, that we can engage people in meaningful conversations about the energy system and collectively choose the best technical, economic and social solutions.

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CONCLUSION

Delivering a decentralised energy future is predicated on addressing a number of challenges – from the physical nature of the changing system, to the behavioural engagement with citizens that is required to support them in the transition from a known system to an unknown, yet to be realised system.

Our authors highlight the importance of avoiding edict – of having a centralised approach to decentralisation, that is one in which planning, development, technology and the integration of energy assets is decided in Whitehall, rather than in each local area, as befits their history, the lie of their land and their priorities.

Our authors also reinforce the need to be customer and citizen led in the transition to decentralised energy. In making this transition, changes have to be seen to be of benefit to society, to consumers of all backgrounds and to each community according to its needs and priorities, and show their economic value. Given the inherent variety of the UK's communities, that must mean locally led approaches to realising social and economic benefit – and it must mean the transition leads, as Nicolette Fox says in chapter 3, to 'an everyday experience for everyone'.

Such an approach will require a focus on households and their homes, both as consumers and as producers. It looks likely that many will become more active in energy, while some will make use of trusted third parties to mediate their energy needs and data with suppliers. Trusted use of energy related data could offer wide-ranging opportunities for customers, be that to become prosumers, to be energy 'traders', to be part of local and community energy activity, or to access the support of lifestyle service companies to do all that is required for them.

In the main, households will also transition to homes that are fit for a decentralised energy future, on the one hand better equipped to use energy more efficiently (thus reducing demand), and on the other properly equipped to harvest, store and release energy (thus increasing and managing supply). An integrated approach to the heat and power needed in homes will be required which will present opportunities to transform the construction sector. For example, homes could be built off site, or built and retrofitted to designs that are energy positive, with changes to the fabric and equipment to deliver a near net neutral home or building.

A decentralised energy future will mean a greater role for, and use of, local energy assets – not least the active use and management of the local distribution networks for electricity and gas. These networks will have to become smart to enhance our understanding of how they function in real time, and in turn facilitate greater flexibility, connectivity (particularly of power station homes), and deployment of energy storage devices.

A local focus has always been necessary for heat and warmth; a decentralised approach makes this a higher priority for electricity and power, which in turn offers opportunities for greater local integration of electricity, gas and transport systems. This highlights the opportunity for a more creative approach to heat that would allow each locality to make better use of what is available locally (for instance accessing warm water where it occurs and geothermal where it can be sourced), while better aligning sources of heat with their use, encouraging more appropriate temperature use.

Our final group of authors emphasise that successfully delivering this vision of a decentralised energy system will require a different approach to that of a centralised system – on that recognises place, the actors best situated to deliver for each place, and a decision-making governance system that is designed for places to thrive, each according to their potential. They stress the key role of local authorities, and the need for a national energy governance system that reflects this emerging future. This in turn will change the nature of who does what, with existing and new functions differently distributed between consumer, prosumer, developer, and local network and system operators.

THE WAY FORWARD

In their publication of the latest *Future Energy Scenarios* (FES) (National Grid 2018), National Grid have created a new modelling framework by introducing a new axis that considers 'levels of decentralisation'. Modelling this in interaction with the 'speed of decarbonisation' leads to the creation of a new scenario, which they call 'community renewables' – a scenario that meets the UK's 2050 carbon reduction commitments. And as the FES notes, 'the more decentralised a system is, the more its supply and demand assets are linked to local networks and processes. Local energy solutions are developed to meet local requirements' (ibid).

Fulfilling the potential for a decentralised energy future for the UK requires a much greater sense of what is required locally, and what can be done locally. Key is a recognition that each place has its own combination of energy assets, challenges, capabilities and purposes. What drives one area may not drive another, and that purpose can only be determined locally, with due regard to their particular circumstances.

Clearly, with their long-term commitment to their place, local authorities should play a key role in securing the opportunities of decentralisation – be that through their planning and other enabling functions, or through investing and playing an active role in the future of energy in their area.

This requires a governance system that is designed from the bottom up, and allows local actors to act and influence both the design and operation of the energy system of which they are a greater part – whether they are consumers, prosumers, community and collective groups, or local authorities acting strategically for the long-term benefit of their communities.

NEXT STEPS FOR PUBLIC POLICY

As our authors note, a decentralised approach recognises that a one size approach to energy is no longer fit for purpose, nor fit for the purposes of the many and varied parts of the UK.

In the first instance, this prompts two requirements for UK public policy. The first is that the governance of the energy system should change, and the second is that places and their representatives (local government) should be actively supported in becoming part of a future decentralised energy system. We can take the opportunity we have to design the system that we want to have, therefore:

1. BEIS should now commission a programme of work to create the governance arrangements for a decentralised UK energy system. This system would include:
   - a leadership role for representatives of the local energy system (the devolved nations of the UK, the mayors of England, the combined and local authorities, and so on), while noting it should involve Ofgem and other incumbents relevant to a decentralised energy future

- a thorough consideration of the different opportunities, assets, capacities and purposes of the variety of places of the UK – not least on and off gas grid communities, sparse, rural, suburban and urban communities, and households of different tenures
- a consideration of business models and other approaches that allow the monetisation of the benefits of the many elements that secure a decentralised system, not least approaches that support the transition to and the growth of the prosumer. This would include understanding how to monetise the benefits of local supply and of increased energy efficiency. There will be more than one business model that is appropriate to this decentralised future, as there are trade-offs to be weighed up between where benefits accrue and who holds decision-making powers
- an exploration of the active roles required of future network operators in a decentralised energy system – for example in facilitating, coordinating and balancing local markets – and the implications for their transition.

2. The government support (from BEIS, MHCLG, Defra) for different aspects of the energy system transition should give equal priority to place-based solutions. This may mean, in the short term, that greater emphasis is given to place-based solutions over technology-based support. Such support would include:
   - confirming a formal role in the decentralised energy transition for local authorities, for example amending the Localism Act 2011
   - capacity building and access to energy finance for local authorities, and community energy providers
   - revisions to planning law to require local authorities to plan for local energy, particularly clean and community energy opportunities, along with the necessary financial support for this new role, to equip them to fully consider their energy assets, and how best to bring them forward in an integrated way
   - revisions to planning consent to prioritise connection to local energy systems, for example for heat supply from a local heat network.

Moving to a significantly decentralised energy system will create a range of opportunities. We have considered many in terms of householders, energy customers and local authorities, but there is also potential for considerable benefit to the construction and built environment sectors. While the energy sector is broadly recognised as decarbonising and decentralising, with primarily only questions of degree and urgency to be worked through (hence this essay collection), the trajectory for the housing sector is much less clear – in fact it is completely unclear whether it is decarbonising to any particular benchmark or decentralising, when housing policy is so driven by centralised new build targets.

It could be argued that for such a decentralised energy future to be fully realised, the housing sector also needs to clearly sign up to both principles, supported by a meaningful trajectory for both; for it is through new build and retrofit that housing becomes energy efficient, and opportunities for homes to be power stations is realised for everyone as an everyday activity. If left to those who can afford to retrofit energy harvesting equipment, we risk it being the preserve of a motivated few.

The government's Construction Sector Deal and Buildings Mission 2030 provide an opportunity to focus the housing and construction sectors more firmly on the benefits of smart disruptive technologies as opportunities for new business models, for new approaches to building and development, and for new approaches to meeting household needs of the future. As with the energy transition, digitalization is a key driver of this.

3. With the emphasis on place there is a growing urgency to transform regulations that address the existing and future state of homes and buildings. Transformations would include:
- revisions to building regulations to secure a high standard of energy efficiency in new build, and for retrofit
- greater support to local authorities and other actors in retrofitting existing housing stock for energy efficiency, as well as energy harvesting, including the development of new heat markets and supply chains.

As the National Grid (2018) highlights, a decentralised approach is one that could address the decarbonisation challenge we face, while also keeping the proverbial 'lights' on. This is because it is also an approach that engages local actors across the whole of the UK, something that could begin to re-balance the economy and provide more heft to the decarbonisation challenge.

Given the UK has managed many connected local energy grids before, the opportunity of this transition is to realise the benefits of a customer-focused, digitally enabled and decentralised energy system. An energy system designed and governed with the variety of places in mind will go a long way to realising the potential that the digital transition has to offer to each and every consumer, or future prosumer – be they on or off grid, or living in a sparse, rural or urban area – provided the issues and opportunities of their local area are given a proper voice and effective agency in the transition to the new decentralised approach.

For that we must design a system that empowers and supports all local actors to act.

REFERENCES

National Grid (2018) *Future Energy Scenarios*. http://fes.nationalgrid.com/fes-document/

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