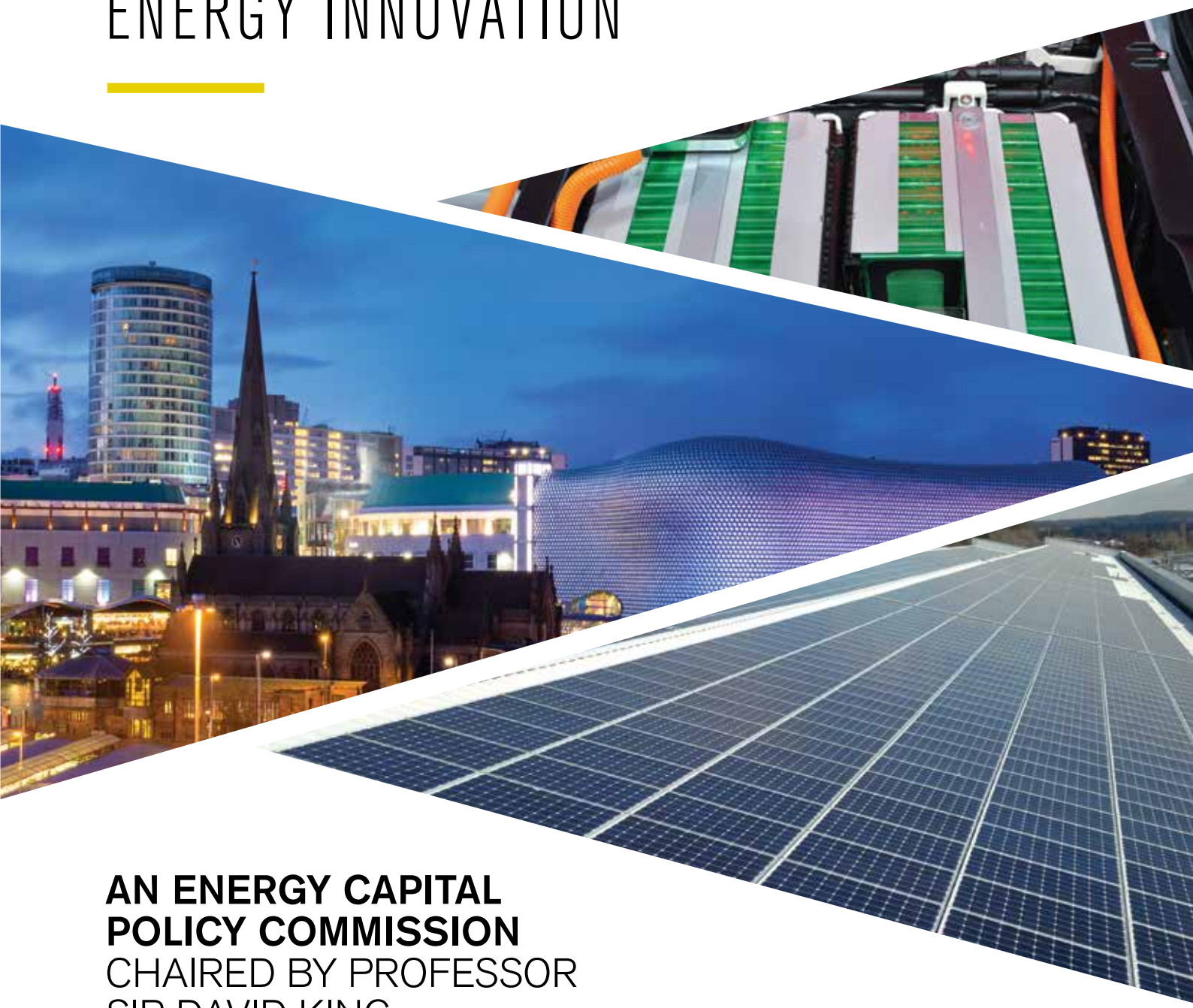
POWERING WEST MIDLANDS GROWTH

A REGIONAL APPROACH TO CLEAN ENERGY INNOVATION



AN ENERGY CAPITAL POLICY COMMISSION
CHAIRED BY PROFESSOR SIR DAVID KING

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FOREWORD

Economic growth across the West Midlands has been powered by energy and regional innovation for over 200 years. Black Country leadership of the industrial revolution was built on innovative use of local energy resources. The manufacturing industries and people of Coventry, Birmingham, Solihull and our surrounding counties have prospered and advanced as global energy and transport systems have become ever more accessible and integrated, and the region hosts many of the UK's leading energy research institutions.

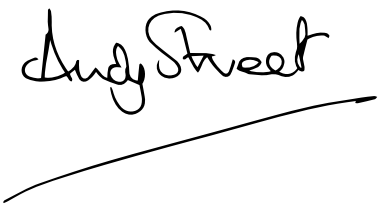
But future economic growth is about seizing today's global opportunities, not about dwelling on the successes of the past. The global energy system is changing profoundly, driven by technological change and the international response to the challenge of climate change. Our government's recent industrial strategy highlights the opportunities in clean energy globally, identifying 'Clean Growth' as one of the four Grand Challenges at its heart.

Delivering Clean Growth in the West Midlands means ensuring we can supply competitive power to underpin increases in productivity across our industrial base; it means ending fuel poverty for our most vulnerable citizens; it means building on our existing skill base to grow new industries; it means delivering this region's share of the UK's contribution to global climate change targets; and it means turning our innovations and research expertise into commercial successes for export worldwide.

These are challenging goals, but we know how to deliver to challenging goals and lead the world in the West Midlands, because we have done this before.

This report, by the Energy Policy Commission, which I set up as one of my first acts as Mayor last summer, sets out a framework which will liberate the fantastic diversity of skills and aspirations across this region. Energy Innovation Zones make it easier for industry, innovators and the public sector to come together to deliver the diverse clean energy infrastructure needs of our different cities and counties. Like the industrial revolution, they are an idea born in the Black Country and already being taken up nationally.

I look forward to working with the government and colleagues across the region to take forward the recommendations set out in this report.



Andy Street, Mayor of the West Midlands

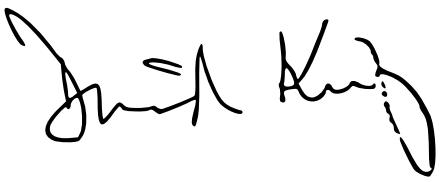
FOREWORD

Tackling climate change is one of the most pressing issues of our time. The Paris Agreement has set a path for limiting global warming to within two degrees, but the challenge remains immense. Britain has been in the vanguard and reduced its carbon emissions by more than 40% so far, through policies including the 2008 Climate Change Act, curtailing its coal generation, and developing the world's largest offshore wind capacity. The next steps are more difficult, however, because we now need to expand our efforts from electricity to heat and transport, which are inherently harder to decarbonise.

One of the most striking trends in clean energy over the past decade has been its localisation. All over the world, municipalities are increasingly active in clean energy innovation. And with good reason: many of the technical challenges of decarbonising heat and transport are inherently local; and local political leaders can tap into regional identity to build support for clean energy in a way that national leaders cannot. In Britain, some local authorities are pioneering ambitious clean energy programmes, but they are a minority; most no longer have the capacity or resources.

Energy Innovation Zones (EIZs) are designed to stimulate local and democratically accountable clean energy innovation to drive productivity, exports and growth. Their main focus will be to integrate proven low-carbon technologies across energy systems; develop the business models and market arrangements needed to support new approaches to clean energy, and overcome the regulatory and other barriers necessary for them to flourish. The benefits will include reduced emissions, bills and fuel poverty, and increased investment, exports and jobs. By taking a local approach to clean energy and productivity, EIZs will integrate the aims of the Industrial Strategy and Clean Growth Strategy with the government's devolution agenda.

The Energy Innovation Zone is a concept developed in the West Midlands that would allow the region to take control and ownership of the energy transition, building on the strong base already created through the Energy Research Accelerator and Energy Systems Catapult. Our Commission presents a compelling argument to invest in this locally driven model of clean energy transition. The thinking in this report represents a major step forward in the field, and I commend it to our stakeholders.



Sir David King, Chairman, Powering West Midlands Growth: A Regional Approach to Clean Energy Innovation, An Energy Capital Policy Commission

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EXECUTIVE SUMMARY

The West Midlands is uniquely positioned to lead the UK in taking advantage of the economic opportunities arising from the global transition to a clean energy system. The region's strengths include: strong and coherent political leadership committed to sustainability; the diversity of economic needs and scale of demand required to build competitive markets to support radical innovation; a world-class concentration of both academic and commercial expertise in the low-carbon energy sector; a massive programme of public and private investment in infrastructure planned for the next decade, and above all, the determination to secure long-term economic benefit from clean energy innovation.

This report makes the case for the creation of a small number of Energy Innovation Zones (EIZs) across the region, acting as pathfinders for an approach that might subsequently be adopted across the country as a whole. EIZs enable barriers – such as powerful institutional silos separating transport, digital, planning and energy – to be overcome within designated geographies. They create a risk-managed and commercial-scale context for the development of new local clean energy markets. They also provide a practical mechanism to help attract investment and muster local political support. At a national level, they can help ensure innovation is built into the government's strategic sector deals and other large-scale public investment projects.

THE WEST MIDLANDS POLICY COMMISSION RECOMMENDS THAT THE MAYOR OF THE WEST MIDLANDS SHOULD:

1. Ask the government to devolve power to the West Midlands Combined Authority (WMCA) to designate up to four pilot Energy Innovation Zones across the region, and work closely with local authorities, Local Enterprise Partnerships (LEPs) and other stakeholders to establish EIZs by the end of this year.

2. Ask the government to provide funding for a joint regional, government and industry working group – including lawyers and regulators – to detail a common governance model for these EIZs following the guidelines set out in this report.

3. Use EIZs as a framework to deliver the local industrial strategy, particularly in relation to clean growth, energy systems infrastructure and improving the competitiveness of energy intensive manufacturing firms. In particular, he should:
   a. Work with industry, universities, innovation agencies and local authorities to lead development of a clean growth sector deal for the region, drawing on support from Mission Innovation and the Industrial Strategy Challenge Fund
   b. Work with government, partners and appropriate regulators including Ofgem to ensure the WMCA is appropriately resourced to provide local democratic oversight and governance of EIZs – and innovative energy infrastructure investment across the region – through the board of Energy Capital.

4. Explore with government and the major energy suppliers the scope for allocating control of over £125 million of Energy Company Obligation (ECO) funding and associated carbon targets to the WMCA for investment in regional EIZs over the next five years. Investment of these funds should be at the discretion of the Mayor and outside normal ECO rules, but would still be obliged to deliver the ECO carbon target.

5. Ensure that the West Midlands Growth Company actively promotes the investment opportunities created by the pilot EIZs across the region.

6. Support the government and national innovation agencies, particularly the Energy Systems Catapult, in developing the EIZ model and rolling it out nationally, transferring lessons and best practice to other regions.

Background

The world is in the throes of an energy revolution. There is now no doubt that we are heading for a low-carbon energy system.[1] But two major uncertainties remain: whether we will decarbonise quickly enough to avoid runaway climate change; and the extent to which Britain will benefit from the $13.5 trillion clean energy investment required worldwide by 2030.[2] Securing good answers to both questions demands that Britain accelerates its energy innovation, and that now means taking a regional and local approach. We believe an important part of the solution is to create a network of *Energy Innovation Zones*, and that these should first be founded in the West Midlands.

The Energy Innovation Zone (EIZ) is a new concept designed to tackle the specific challenges of accelerating clean energy innovation in Britain today. An EIZ is a geographically defined area – a district, or even a whole city – in which innovators can deploy clean energy solutions under bespoke rules and conditions agreed between local authorities and national regulators. Unlike existing approaches, they will work not only to demonstrate new technologies, but also to turn them into fully commercial propositions. Their main focus will be the systems integration of proven low-carbon technologies; the business models and market arrangements needed to support new clean energy services; the regulatory and other barriers that must be overcome, and the policies needed for them to flourish.

EIZs are designed to stimulate local and democratically accountable clean energy innovation, which will in turn drive productivity, exports and growth. They will galvanise local energy innovation to develop solutions that reduce emissions and cost for the area; breed regional markets and supply chains that provide a platform for exports and growth; de-risk future investment, and inform new policies, standards and regulatory frameworks that could be applied in other regions and even nationwide. They will exploit local resources to satisfy local social and industrial priorities.

As a result, EIZs will, for the first time, fully integrate the aims of the Industrial Strategy, Clean Growth Strategy and the Ofgem 'Sandbox' with those of the government's devolution agenda.

The main benefits of EIZs include:

- Faster progress in the areas it is most urgently needed: transport and heat, where emissions have risen over the past three years, and system integration
- Lower emissions within the EIZ, and potentially lower energy bills
- Lower system costs through dynamic energy management and avoided infrastructure investment and stranded assets
- Local supply chains, jobs, skills and markets
- Clusters of innovative companies that accelerate work on system integration across sectors
- Improved productivity and faster growth
- New technical and other standards for innovative technologies that help establish new markets across the UK and abroad
- Funded through existing funding streams – no additional burden on the public purse

Energy Innovation Zones could be set up anywhere in the UK, but there is a strong case for starting in the West Midlands – where the idea was born. The region faces some acute energy, business and social challenges, but also enjoys distinct advantages that raise the chances of success. The West Midlands suffers some of the worst energy poverty in the country, a high concentration of energy-intensive manufacturing, and areas of electricity grid constraint and poor air quality. But it also hosts world-class universities, manufacturers and innovation agencies, and will need to build huge amounts of energy infrastructure over the coming decades. This combination of need, capacity and scale makes the West Midlands an ideal place to trial EIZs.

The West Midlands elected its first regional mayor in 2017, with new powers, an £8 billion investment budget and an ambitious vision for 2030. A benchmarking analysis of nine combined authorities conducted in 2017 ranked WMCA second for sustainability.[3] The West Midlands Strategic Economic Plan is based on unifying themes of *productivity*, *transforming lives* and *innovation*. EIZs would have a fundamental impact on all three. The energy aspects of the West Midlands industrial strategy are now overseen by Energy Capital, which convened the policy commission that produced this report.

Challenges and opportunities

By some measures, 2017 was the UK's 'greenest year ever'. Britain enjoyed its first full day without coal generation; more than half our power now comes from low-carbon sources; and our grid is fourth cleanest in Europe. These were among 13 green records set last year, which together represent a remarkable achievement.[4]

Progress is patchy, however. While renewables now generate 29% of our electricity, as recently as 2016 they supplied just 6% of our heat and 4.5% of our transport. So although UK greenhouse gas emissions have fallen more than 40% since 1990, on the current trajectory we will still miss our targets for 2030.[5] We have similar ground to recover in the other great energy-related challenges of our time: air pollution, energy cost and energy poverty. So we clearly need to accelerate our innovation in clean energy. To succeed, we must not only redouble our efforts but also change our approach.

Although the challenges are huge, so too is the opportunity. Fulfilling the commitments made in the Paris Agreement represents a global market worth $840 billion a year. The Industrial Strategy and Clean Growth Strategy recognise this as 'one of the greatest industrial opportunities of our time' in which 'whole new industries will be created'.[6] By one estimate the low-carbon economy in Britain could grow at 11% a year to 2030, four times faster than the rest of the economy, and deliver as much as £170 billion in exports.[7] In other words, accelerating clean energy innovation is not simply a matter of environmental responsibility, but also in our economic self-interest.

Barriers

Innovation works. In clean energy, innovation has reduced the cost of renewable energy so sharply that solar now undercuts coal in the Middle East, and offshore wind is starting to compete with gas in Northern Europe. This has led to exponential growth in renewable capacity around the world and transformed power markets in many countries. As already pointed out, however, most clean energy innovation has been in electricity, and progress in heat and transport has been much slower.

At the Paris climate summit, 22 of the world's richest countries founded Mission Innovation and promised to double their R&D spending by 2025 – implying a total of $10 billion per year. This is a major breakthrough and will feed the innovation pipeline for years to come. But R&D represents only the earliest stages of the pipeline – which extends from the initial invention right through to full-scale commercialisation of products and services. Many of the highest barriers to innovation exist at the later stages – particularly in the UK.

Britain is a highly inventive country, but has a weaker record in the later stages of innovation. Too often, British inventions have been commercialised by others: refrigeration, the computer, the internet, lithium-ion batteries, graphene. The government has recognised this problem and has begun to develop policy responses in the Industrial Strategy and Clean Growth Strategy. But innovation in clean energy suffers particularly obstinate barriers, which we believe require further attention.

Our system of energy policy and regulation has promoted some forms of innovation – for instance, among electricity network companies[8] – but over time has grown into a complex web. Detailed rules designed for the existing industry structure can be simply overwhelming for potential entrants, who don't know where to start. This gives a substantial advantage to incumbents who understand the detail and can frustrate radical change.

For example, UK electricity and gas supply licences run to 500 pages and industry codes to thousands more. While entry into the supply market has boomed, estimates of set-up costs range from approximately £100,000 up to £500,000–600,000, and the commercial challenge of attracting customers means that new suppliers may not be profitable from the outset.[9] As a result, new entrants have typically conformed to standard industry models in order to get off the ground quickly, rather than persist with radical ideas.[10] Aside from the overall complexity and cost of entry, some individual regulations also cause difficulty. Of course, many policies and regulations have been highly effective in supporting the growth of renewable energy in the UK – such as feed-in tariffs and contracts-for-difference. But many others inadvertently raise barriers that tend to stymie innovative approaches such as comfort as a service, aggregated domestic demand response, and third-party financed whole-house retrofits.

Other barriers include areas of regulatory or strategic uncertainty. One such is that UK energy policy and regulation deals with electricity, heat and transport separately. This means that areas with system synergies – such as the integration of heat and electricity production, electricity and transport, or waste and energy – receive less attention than simple 'single system' policy measures or none at all.[11] This barrier would be easier to overcome at a local rather than national level. Another is uncertainty over the future direction of UK policy on heat decarbonisation – whether it will rely primarily on the electricity grid or the gas grid. This raises the risk that early investments could be stranded by future policy decisions.

To accelerate clean energy innovation means we need to find ways to clear these barriers, and we believe the fastest and most effective approach will be local.

Why local?

One of the most striking trends in clean energy over the past decade has been its localisation. All over the world, municipalities are increasingly active in clean energy innovation: from Copenhagen and Munich to Bogota and New York. And with good reason:

- Energy resources and challenges differ from place to place, meaning solutions will also differ by location.
- Many of the most urgent problems require the integration of energy systems, such as heat and electricity grids, or the integration of energy into wider systems such as waste or transport, which must necessarily happen locally. Energy efficiency in buildings is an inherently local issue.
- Balancing electricity grids must increasingly happen at the local or regional level as the penetration of variable renewable generation rises. This requires local energy storage and local smart demand management – and is now made far easier by the digitalisation of clean energy equipment from wind turbines to domestic fridges.
- Local political leadership is vital to the success of clean energy investments, because it can help tap regional identity to build enthusiasm for energy innovation, overcome nimbyism and distrust of the big six utilities, and provide democratic accountability.
- Innovation is encouraged by the existence of clusters of companies working alongside each other in a given area.
- Wholesale reform of national energy systems is necessarily a long, drawn-out process, with a high risk of unintended consequences if carried out in haste. As the experience of many cities around the world has shown, a local approach could be nimbler and produce results sooner and with less risk.

In the UK, some local authorities such as Nottingham, Bristol and Cornwall are also pioneering ambitious clean energy programmes. But they are in a minority, and none yet integrates clean energy innovation and industrial strategy at the ambitious scale required. More generally, British councils lack the statutory powers and control over local funding streams enjoyed by their counterparts abroad, and after a decade of austerity, many simply do not have the resources or staff required. A study by UKERC (the UK Energy Research Centre) that assessed local authority engagement with the energy system found that only 30% of local authorities were 'energy leaders' or 'running hard', while 70% were 'on the starting blocks' or 'yet to join'.[12] One witness told us 'Each example of brilliance is swamped by hundreds of places that have done absolutely nothing'.

The government has recognised the importance of local clean energy innovation through its devolution deals with Cornwall and the West Midlands, and the new local energy policy launched by BEIS in 2017, which is designed to bolster the capacity of local authorities and Local Enterprise Partnerships. We welcome these initiatives but believe the way to unleash local potential fully is through Energy Innovation Zones.

The Energy Innovation Zone

EIZs are the missing link in the UK innovation ecosystem for energy. We have small-scale technology demonstrators and we have competitive national market structures, but we lack a supportive space in which to prove and deploy new *integrated approaches at scale*. The EIZ will:

- Demonstrate new clean energy technologies and approaches at scale in a competitive market defined and regulated to meet local needs
- Focus especially on integration between energy systems, such as electricity and heat, and between energy and other systems, such as transport and waste
- Concentrate on the new business models and market arrangements needed to support novel technologies and approaches
- Reduce or remove regulatory and other barriers to test new business models, which will in turn:
  - help define regulatory reforms needed to allow these new technologies and business models to flourish
  - de-risk future investments to roll out these new technologies across Britain and worldwide
  - provide a platform from which small energy innovators can grow to become national and international companies
- Protect customers from adverse consequences where innovation fails – especially those in fuel poverty
- Generate local political consensus around clean energy investment opportunities, giving investors and other stakeholders confidence that political risks will be minimised

The most visible activity of the EIZ will be to facilitate commercial-scale demonstrations of innovative clean energy technologies and approaches with real customers and infrastructure. The EIZ is not just an integrated technology demonstrator, but also provides a controlled environment in which innovators of all types can trial new services and business models, and policy-makers and regulators can ensure customers are not disadvantaged and evaluate what reforms are needed to allow these approaches to compete in the wider energy market.

The EIZ could provide a platform to support the development of potentially world-beating commercial enterprises in the areas of clean energy where innovation is most urgently needed – and faster than is likely under current national regulation. Our research and innovation institutions have already identified major areas of opportunity including:

- New enterprises supporting the acquisition, interpretation and use of smart energy data at scale to optimise the energy performance of entire cities or neighbourhoods
- New business models services emerging around the electrification of transport, and the integration of energy, transport and digital infrastructures
- Large-scale manufacture and deployment of competitive energy storage systems

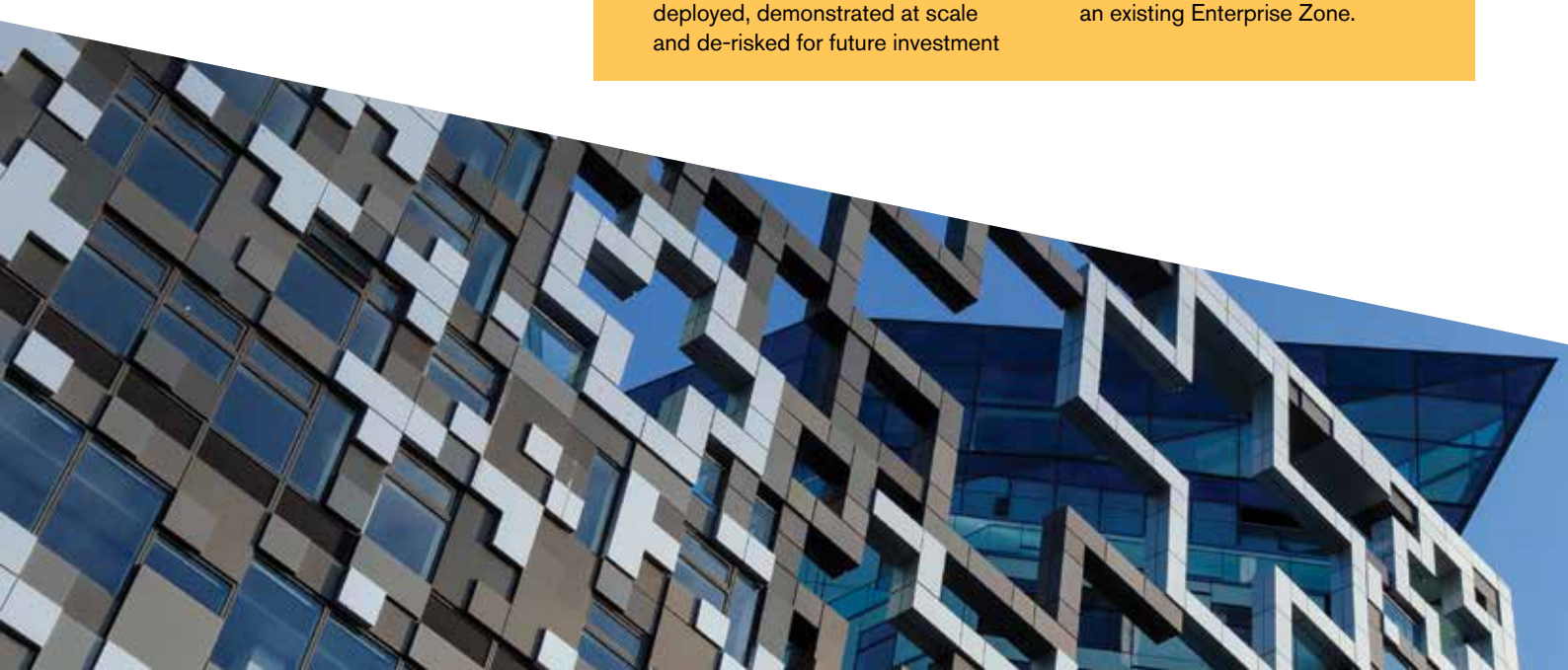
- New business and regulatory models that deliver competitive market outcomes in the customer and public interest in a more localised, clean energy future
- More efficient approaches to converting diverse waste streams into useful energy vectors, including hydrogen, and infrastructure to distribute and use the resulting energy, including heat, efficiently

In all of these areas, there is global potential for a new Google, Tesla or Amazon to emerge in the next 20 years, and EIZs will create platforms to increase the likelihood that these future giants emerge first and fastest in the UK.

The EIZ builds on the foundations of Ofgem's 'Sandbox' approach, under which an innovator can negotiate the relaxation of a specific regulation to allow it to demonstrate a novel business model. But instead of rule changes being negotiated on a company-by-company and rule-by-rule basis, with the details kept confidential to protect commercial interests, the EIZ would create a geographical space and legislative framework within which the amended regulations would be publicly known and apply to all-comers. This would create a competitive market rather than a single, small-scale demonstration. The EIZ would also lever the power of regional identity and resources in a way that Ofgem, as a national regulator, could not.

BOX 1: The Energy Innovation Zone: key features

- **Environmental and economic:** Aims to reduce emissions and costs, and stimulate growth and improvements in productivity, by speeding the progress of *clean* energy technologies and business models to market.
- **Competitive:** Creates a competitive market in clean energy infrastructure to meet local needs and priorities, and does not pick low-carbon winners; 'demand pull' not 'technology push'.
- **Regional:** Bridges the yawning gap between people and national energy markets, and taps regional identity to build support for energy innovation.
- **Democratically accountable:** Through local authorities and regional mayors.
- **Social:** Providing appropriate levels of protection for domestic customers, especially those in fuel poverty.
- **Collaborative:** Brings together universities, companies, local authorities and regulators. Lessons about local energy markets, regulation and innovation are shared regularly between EIZs and externally.
- **Independent** of major commercial interests in current or future energy infrastructure, and with transparent governance.
- **Innovative:** Creates a space in which new technologies can be deployed, demonstrated at scale and de-risked for future investment to take to market. Also supports technologies that have already been shown to work, but which need commercial-scale demonstration of the business model. Extends to SMEs the capacity to conduct commercial demonstrations at a scale only previously possible for incumbents with large balance sheets.
- **Clears regulatory and cultural barriers:** Where legislation allows, specific regulations are waived, amended or introduced to permit cost-effective commercial demonstrations. Different EIZs would flex different regulations depending on priorities – district energy, domestic heating, hydrogen, EVs etc. This may in turn lead to the development of new national regulations.
- **Flexible:** Size and focus varies according to local needs and priorities, but an EIZ should be large enough in terms of energy demand to support the development of supply chains, commercial clusters and regional markets.
- **Light on the public purse:** EIZs could be funded by reallocating existing funding streams such as the Energy Company Obligation (ECO), or through other innovative 'value capture' mechanisms, so avoiding the need for substantial extra public expenditure. EIZs could also – like Enterprise Zones – be financed through tax incentives, and in some places it might make economic sense to integrate an EIZ with an existing Enterprise Zone.



How would it work?

An EIZ would typically be proposed by an alliance of companies, business organisations (eg, Local Enterprise Partnerships), universities and the local and regional authorities. The geographical size of each EIZ would be determined by local policy priorities – which might be energy poverty in one area, industrial energy prices in another, and low-carbon transport infrastructure in yet another –established through consultation with and by the local authorities. The EIZ is strictly clean energy – meaning low-carbon and low-emission – but beyond that is technology neutral and does not pick winners. Instead, it develops a hypothesis about the barriers that have prevented the problem from being solved already, and defines a market in which a variety of low-carbon technologies and new business models compete to tackle the challenge identified. This may involve waiving or amending national regulations, where this is legally permissible, within the zone with the agreement of national regulators, whilst providing appropriate protections for end customers. The lessons learned would be shared regularly between EIZs, and externally through channels such as the Energy Systems Catapult, to maximise the benefits gained.

Funding

The EIZ is not primarily a funding mechanism, but it would require some funding. EIZ funding would not be to support individual projects, but to create markets through infrastructure, regulation and governance. This would then attract private sector risk capital to fund products and services, because the risks of deploying innovation in the EIZ context would be reduced.

EIZ funding could be provided in various ways. The conventional approach would be to award government grants matched or multiplied by private investment. The government recently set up UK Research and Innovation to invest £8 billion per year by 2020 to 'help translate excellent research into better business outcomes'.[13] The EIZ is intended to achieve exactly that aim.

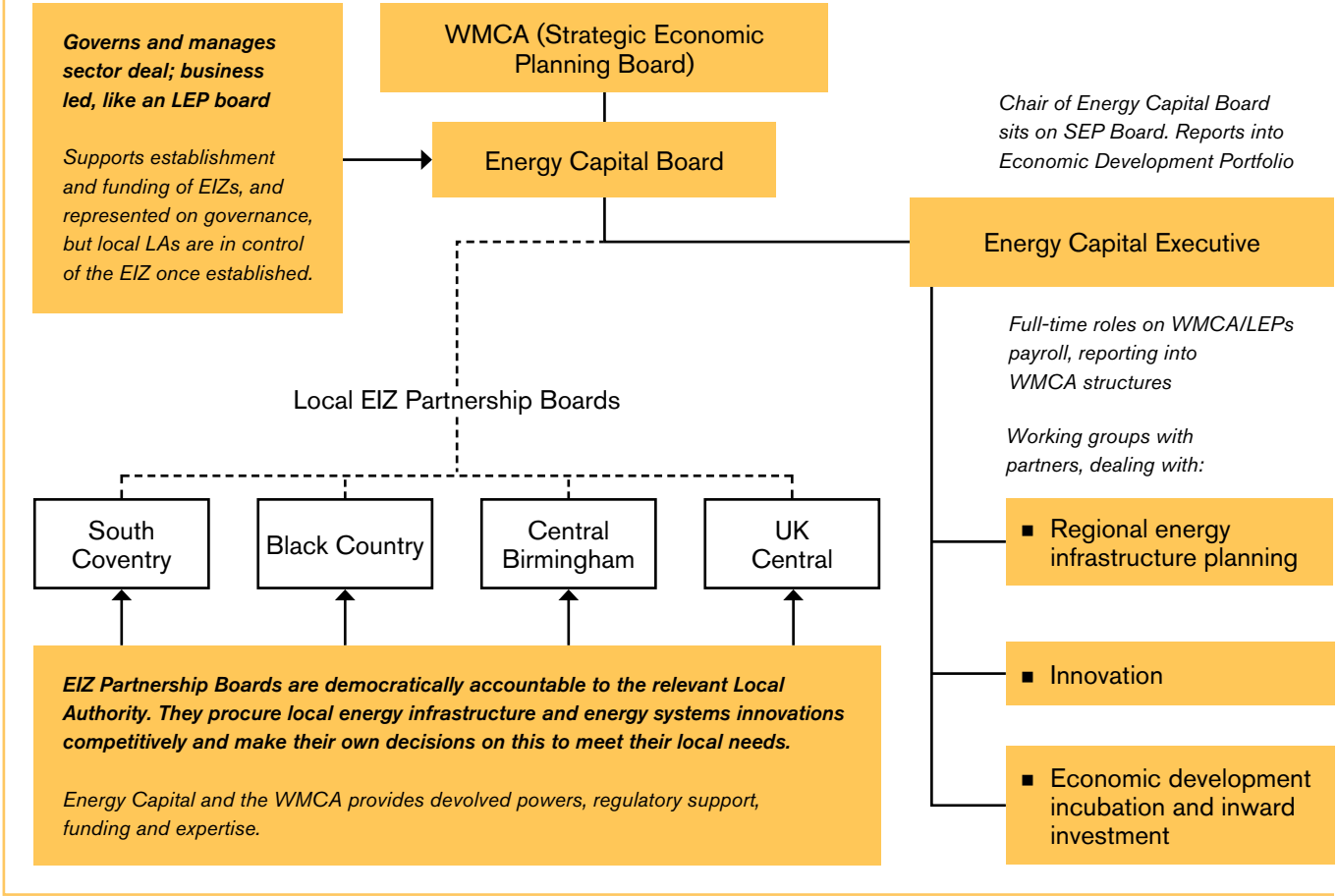
EIZs could also be funded through tax breaks, like the Enterprise Zones, or by developing innovative 'value capture mechanisms' that ensure risks and returns are borne locally. One such might be to divert some or all of the ECO funding generated within the zone to finance clean energy innovation that supports the scheme's objectives. The West Midlands' share of the ECO investment pot equates to between £175 million and £250 million, depending on the carbon price.[14] If even a fraction of this were diverted through the WCMA to appropriately specified EIZs, it could provide significant support for clean energy innovation and improve the outcomes of the ECO scheme.

Governance

Local and regional authorities will be essential partners of the EIZ. It is through them that the EIZ is democratically accountable to local people and their priorities. Public support is not just a political 'nice to have', but a critical condition for successful clean energy innovation. As Nottingham and Bristol have shown, local authorities can tap into regional identity to enlist local support for clean energy innovation in a way that national utilities cannot. Local authorities also control large property estates, vehicle fleets and waste streams that are vital to raising resource and energy system efficiency. Those local authorities that lack the capacity to manage ambitious clean energy innovation programmes themselves are likely to value the EIZ as a trusted arms-length organisation.

Regional mayors are particularly important – they have responsibility and budget for areas such as transport, housing and land, the integration of which is central to energy innovation, and for related areas such as productivity and skills. They are therefore ideally placed to coordinate resources across sectors at a regional and strategic level – although day-to-day running of the EIZ would fall to consortium members. More broadly, regional mayors would have a galvanising role as clean energy champions. This Commission is supported by the West Midlands Mayor, Andy Street, and has been recognised by the government under the region's second devolution deal. The relationships between the WMCA, local authorities, Energy Capital and EIZ are shown in Figure 1.

FIGURE 1: HOW EIZS RELATE TO THE WMCA AND LOCAL AUTHORITIES



Why West Midlands?

Energy Innovation Zones could be set up anywhere in the UK, but there is a strong case for starting in the West Midlands – where the idea was born. The region faces some acute energy, business and social challenges, but also enjoys distinct advantages that raise the chances of success. It is the combination of need, capacity and scale that makes the West Midlands the ideal place to trial EIZs. The West Midlands faces the same challenges as the rest of the country – only more so. It suffers some of the worst energy poverty in the country, poor housing stock, areas of high air pollution, a productivity gap of £15 billion a year compared to the national average, and a carbon gap of around 2mtCO_2e per year due to the density of manufacturing and motorways in the region. It also has a concentration of energy-intensive manufacturing vulnerable to some of the highest industrial electricity prices in western Europe, and areas of electricity grid constraint.

But the West Midlands also enjoys some formidable competitive advantages. It is:

- The largest regional economy outside London, and growing faster than Greater Manchester, Leeds City Region and the South East
- Britain's manufacturing heartland and home to world-class companies like Jaguar Land Rover, Aston Martin and Worcester Bosch
- A major exporter, especially of vehicles, and the only British region remotely close to trade balance with China
- Entrepreneurial, with more businesses registered than any other city bar London
- Centrally located, meaning 90% of the country's population is within four hours' drive
- Home to world-class universities and innovation agencies such as the Energy Systems Catapult

The West Midlands will build huge amounts of energy infrastructure over the coming decades, particularly around HS2 and Birmingham city centre, which represents a rare opportunity to innovate in clean energy at scale. The region already invests £2.5 billion per year in energy infrastructure and technology – not including buildings and transport[15] – and spends £10 billion per year on its energy bill, equal to around 10% of its Gross Value Added (GVA). If even a fraction could be diverted into distributed clean energy, the impact would be significant. This would not only boost clean growth locally, but also create new products and services for export into a global clean energy market worth $13.5 trillion to 2030.

Potential EIZs

The four potential EIZs described here have been proposed by local communities across the West Midlands, and so reflect local needs, opportunities and challenges. This is an essential feature and point of departure for EIZs: they are driven not just by climate change imperatives and technical opportunities, but also by local market and customer needs. This immediately distinguishes them from many innovation projects in the energy sector, and aligns them with the broad thrust of the clean energy revolution towards more customer-centric approaches. Each proposed EIZ presents distinctive opportunities for energy system innovation (Figure 2), and each is at a different stage of development. A detailed assessment of the economic potential of each EIZ is given in the Arup report that accompanies this one.

UK Central Hub

The UK Central Hub is an area that includes Birmingham Airport, the National Exhibition Centre, Jaguar Land Rover, Birmingham International Station and Birmingham Business Park. From 2026 it will also include the High Speed 2 rail station and the enormous mixed-use Arden Cross development. Each of the stakeholders has ambitious growth plans that will dramatically increase the level of employment and housing in the Hub area, but also support the wider West Midlands economy. As an EIZ, the wider significance of UK Central Hub is that it epitomises the energy challenges of a modern multi-modal transport hub.

Solihull Council formed the Urban Growth Company (UGC) to concentrate public sector investment on removing infrastructure constraints. UGC has already developed infrastructure plans for the area[16] and a 'value capture' framework of potential funding mechanisms.[17] It is now investigating potential constraints in the capacity of utilities to supply the planned developments, and has commissioned Peter Brett Associates (PBA) to analyse current capacity and potential demand over the next 30 years. Initial discussions with Western Power Distribution and National Grid suggest current spare electricity grid capacity amounts to 20–25MW at the Elmdon Primary Substation, but that planned developments may need a further 80MW, a shortfall of 55–60MW on a conservative estimate.

The conventional answer would be to build another primary substation and reinforce the local substations, requiring significant capital expenditure. Another would be to create an Energy Innovation Zone to encourage cheaper and more innovative solutions. The Hub has many energy-intensive users with large peaks and troughs in demand, and it may be possible to avoid or at least minimise capacity upgrades through innovative approaches.

Electric vehicles could present an even greater challenge to grid capacity. The Hub currently has around 40,000 car parking spaces, which could rise to over 60,000 in the next 20 years. No one yet knows exactly how much impact the planned development and electric vehicles will have on electricity demand at the Hub, but recent announcements by

FIGURE 2: CHARACTERISTICS OF POTENTIAL WEST MIDLANDS EIZS

Characteristics	UK Central	Birmingham (Tyseley)	Black Country	South Coventry
Distinctive need	Optimum energy for 21st-century integrated multi-modal transport hub	Optimised use of waste and energy systems infrastructure in dense urban environment	Minimised energy costs for intensive localised 21st-century manufacturing	Large-scale strategic greenfield housing and manufacturing, new transport systems
Potential clean energy innovations	Clean, integrated transport and building energy systems	Ultra-efficient waste to energy technologies. Ultra-low-carbon retrofit.	Localised high-quality power generation and distribution	Minimise impact of electric vehicle charging on networks
Indicative infrastructure requirements to unblock new markets*	Heat and electric vehicle (EV) Infrastructure	Heat and waste infrastructure. Mandatory building regulations for new developments.	Mandatory smart and sub metering supporting collective energy programme. Simpler connections.	Additional storage and smart controls in lieu of (or alongside) simple substation investment
Potential interventions and regulatory flexes to incentivise investment*	Incentives for accelerated deployment of EV and heat infrastructure. Innovative housing market regulation (eg, social rents).	Risk vehicle**. Regulations for competitive local heat networks.	Risk vehicle**. Strategic flex in energy charges. Legacy bank. Innovative housing market regulation (eg, social rents).	Incentives for accelerated deployment of EV and storage infrastructure

* Provisional
** A 'Risk vehicle' means a publicly owned entity taking the risk of new capacity investments and innovations and acting as a local integrated infrastructure systems planning body across energy, transport, waste and buildings.

car manufacturers including Volvo, Jaguar Land Rover, Toyota, Aston Martin and Peugeot indicate that the EV fleet is likely to grow quickly over the next few years. It is also clear that innovation in supply, control and use must be encouraged if we are to avoid the need for continual network upgrades in future.

The Hub also has large heating and cooling loads that could also be integrated with the electricity grid and wider systems such as waste. The scale and concentration of its electricity and thermal demand creates a huge opportunity for clean energy innovation and building efficiency that is probably unmatched in Britain over the next two decades. The Hub has just started a Heat Network Techno-Economic Feasibility Study, which is due to report later this year.

Tyseley and Central Birmingham

Birmingham city centre will undergo massive redevelopment over the next 15 years,[18] particularly around the HS2 Curzon Street station (£900 million), Smithfield (£600 million), Snow Hill, Paradise and Arena Central.[19] The area also suffers serious air pollution and the City Council is developing plans for a Clean Air Zone to start by 2020. This will require the construction of a substantial clean energy transport refuelling infrastructure including hydrogen and electric vehicle charging at scale. Part of the solution may be to use the industrial land available at Tyseley, 5km east of the city centre, to produce clean energy for the city centre and local communities, and power a new clean transport refuelling infrastructure. As an EIZ, Tyseley and Central Birmingham represents the challenges and potential of integrating waste, energy and transport systems in a dense urban environment with high levels of fuel poverty.

Tyseley is already the site of the city's energy-from-waste (EfW) plant, which burns 350,000 tonnes of waste per year to generate 25MWe. The 16-acre industrial site next door is being developed as Tyseley Energy Park, and already hosts a 10MWe biomass generating plant and private wire electricity supply, and the depot for a fleet of rent-by-the-hour electric taxis. A clean energy refuelling station is being built to provide EV charging, hydrogen and CNG for the city's bus fleet and refuse vehicles. Future plans include recycling waste heat from the EfW plant, which could be used locally or potentially through a heat pipe to the Birmingham District Energy Scheme in the city centre.

Key energy challenges and opportunities for an EIZ based around Tyseley and the city centre include:

- Integrating energy and transport infrastructure developments at a time of rapid change in both sectors
- Optimising use of the city's 350,000 tonnes of waste that currently passes through Tyseley annually, ensuring neither waste nor energy market regulation inhibits delivery of sensible outcomes
- Making use of the latest clean technologies already being developed and deployed by the Universities of Birmingham and Aston at Tyseley and elsewhere
- Making best use of the city's planning powers to optimise the energy performance of new and existing buildings as more than £2 billion of construction investment flows into the city
- Ensuring the local community is fully engaged in the major changes proposed, and actively contribute to the success of the zone

The stakeholder group for this EIZ includes the Birmingham City Council Planning and Regeneration Team, along with key city centre development stakeholders; ENGIE; the University of Birmingham, and Webster and Horsfall.

Black Country

The Black Country Enterprise Zones comprise a portfolio of sites in Dudley, Wolverhampton, Walsall and South Staffordshire (i54), spread over 120 hectares. Their purpose is to attract advanced manufacturing in the Black Country by offering competitive advantage to manufacturers who locate there, especially targeting aerospace, automotive and other high added-value engineering. As an EIZ, Black Country illuminates the challenge of minimising energy costs for energy-intensive manufacturing as the system decarbonises.

Several major manufacturing companies are already based on the i54 site, including Jaguar Land Rover, Moog, Eurofins and ISP. This enterprise zone is known as one of the most successful in the country, and total investment of more than £1.5 billion is expected across the Black Country over the next 15 years.

A key competitiveness issue for the Black Country is the cost of energy, and in particular the energy used in metal processing. This is because in competitor countries such as Germany, energy-intensive industries are exempted from the charges associated with the energy transition, such as subsidising renewable generation, which are paid only by domestic customers. This approach would not be politically acceptable in the Black Country, however, because of its high levels of fuel poverty. The role of the EIZ would therefore be to reconcile these competing and legitimate concerns through clean energy innovation.

There are specific opportunities for local generation and supply in the Black Country, and in particular a cluster of waste-to-energy firms is developing close to the Darlaston sites that need to be integrated with the LEP's plan for the region. Private sector investment in this type of activity could be encouraged through simplification of supply exemptions; support for manufacturers in managing relationships with the DNO; local incentives for energy from waste technologies; and the public sector taking an active role in matchmaking between potential generators and industrial energy users.

In addition, given the high density of similar SME metal processing businesses – with more than 250 across the region – there is scope for the Black Country to pioneer the collective use of smart energy data in optimising energy efficiency, for example by subsidising or mandating installation of smart sub-metering in industry connected to a common software platform; supporting collective purchasing and investments in storage and generation, and recouping this investment by a long-term levy on businesses within the region.

Coventry South

Coventry South covers Whitley, Bagington and the area around Coventry Airport, incorporating land in both Coventry and Warwickshire. This area is well served by transport networks, and significant growth is planned through developments such as the £250 million Coventry and Warwickshire Gateway scheme, and the £500 million development of Whitley South – a 60-acre engineering technology hub next to Jaguar Land Rover's global headquarters. As an EIZ, Coventry South represents the challenge of delivering clean energy to large-scale development of housing, manufacturing and transport.

There is little spare capacity in the local electricity network, yet demand is forecast to rise significantly over the next decade. Coventry Central and Coventry South are reaching the limits their circuits can supply, requiring major reinforcement works to raise capacity. The City Council has investigated options such as a new 132kV bulk supply point to the south of Coventry and a new super-grid transformer, which would involve substantial capital expenditure. Network companies are generally prevented from building capacity ahead of demand, meaning that some other organisation – for example, a development company – would need to pay for it and then recoup the investment from users over time. This represents a major financial risk and could inhibit development.

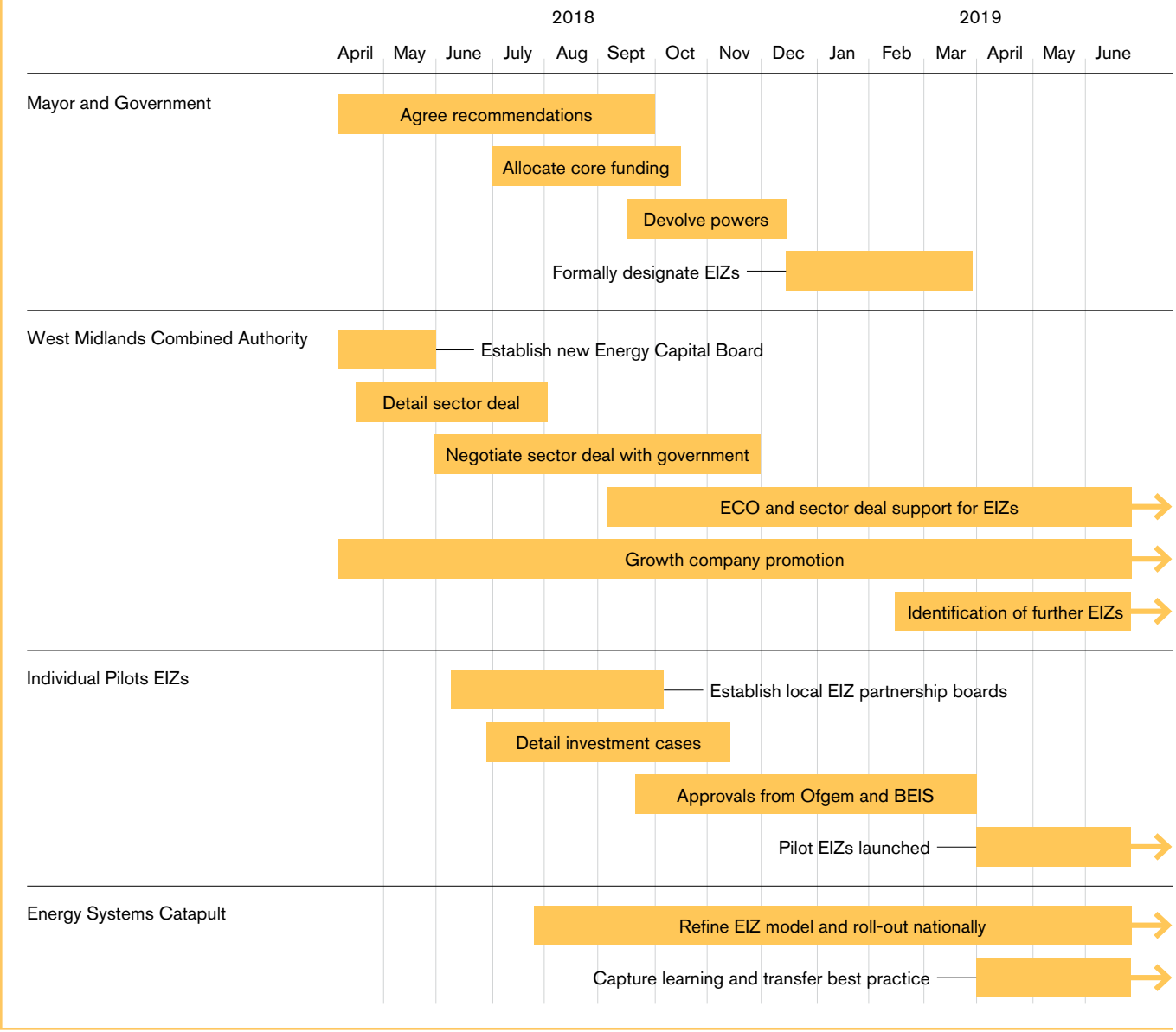
Other areas of planned expansion in Coventry and Warwickshire are Gaydon and Ansty. Jaguar Land Rover and Aston Martin have plants at Gaydon, which suffers grid constraints that would limit the growth plans of these and other companies. Ansty has shown considerable growth in recent years and has potential for large development in the future. Both sites need to ensure adequate power supply to enable future development.

Like UK Central Hub, these areas of economic growth and grid constraints need to develop timely and cost-effective clean energy solutions, which an EIZ could facilitate.

Next steps

If our proposals are accepted by WMCA and government, we suggest the Mayor should work with leaders of the relevant local authorities, LEPs, regulators and other stakeholders so that the first EIZs are ready for launch by the end of this year. A high-level Gantt chart of the necessary work is shown in Figure 3 below.

FIGURE 3: HIGH-LEVEL TIMELINE TO LAUNCH OF FIRST EIZS



1. ENERGY CHALLENGES AND OPPORTUNITIES

By some measures, 2017 was the 'greenest year ever' for the UK, which set a slew of records for clean energy.[20] In April, Britain enjoyed its first full day without coal generation since the industrial revolution. Wind and solar set daily output records, and for the year as a whole, low-carbon generation produced more electricity than fossil fuels: renewables 29%; nuclear 21%; gas 40%; coal 7%.[21] Britain's grid is now the fourth cleanest in Europe and seventh in the world.[22]

The haul of green records was a striking achievement, driven by the plunging costs of wind and solar generation worldwide and British energy policy – especially renewable support and carbon pricing – but gives no cause for complacency. All the records were for *electricity*, but in other sectors renewable energy is far less advanced. As recently as 2016, renewables supplied only 6.2% of our heat and just 4.5% of our transport energy.[23] It is therefore clear we need to accelerate and expand our innovation across a much wider front.

Clean energy innovation is vital not only to tackle the profound environmental and social challenges we face, but also to exploit the enormous opportunities of the energy revolution that is already under way – and which could be turbo-charged by digitalisation. Meeting the commitments of the Paris Agreement is estimated to require the energy sector to invest $13.5 trillion dollars by 2030.[24] The UK Industrial Strategy and Clean Growth Strategy recognise this will create entirely new industries and markets – and a major opportunity for British manufacturing. In short, redoubling our clean energy innovation is not only a matter of environmental and social responsibility but also in our economic self-interest.

Climate change

For all the progress made in Britain and elsewhere, carbon dioxide concentrations are at their highest level for 3 million years, and in 2016 emissions rose at the fastest rate for a decade.[25] Each of the last three decades was successively the warmest on record[26], and 2016 was the hottest year in modern times, with average global temperatures more than 1°C higher than in the late 19th century.

Under the 2015 Paris Agreement, almost all countries committed to limit global warming to less than 2°C and to strive for 1.5°C. The challenge remains immense. Analysis by the International Energy Agency (IEA) shows that on current policies and commitments, CO_2 emissions will not peak until 2050 and global average temperatures will rise by 2.7°C by 2100, and then continue to rise.[27] According to the IEA, it is still technically feasible to achieve a carbon-neutral energy system by 2060 but 'the gap between this pathway and current efforts is immense and unlikely to be bridged without an unprecedented acceleration of action on a global level'.[28]

A separate analysis by Bloomberg New Energy Finance suggests that meeting the 2°C target requires the energy intensity of global GDP to fall at 2% per year to 2030, a rate that has been achieved only twice in the past 25 years, *and* the carbon intensity of energy to fall by almost 2% annually over the same period, faster than any year since 1990.[29]

Britain can rightly regard itself as a world leader in policy on global warming. The Climate Change Act of 2008 set a legally binding goal to reduce CO_2 emissions by 80% by 2050 compared to 1990 levels, along with a series of interim carbon budgets to keep us on track. UK emissions have fallen 42% so far. Four-fifths of the reduction has come from the dwindling use of coal, which has almost run its course.[30] Emissions from buildings and transport are on the rise, however, and transport is now Britain's largest source of carbon emissions (transport emitted 26% of the total in 2016, energy supply 25%).[31] On current policies, the Committee on Climate Change estimates Britain will miss its fourth and fifth carbon budgets by 10-65MtCO_2e, which it describes as a 'significant margin'.[32]

There is a risk, therefore, that simply carrying on with our current strategy will end in failure. At home and abroad, we need to both redouble our efforts and change our approach. This will not only ensure we hit our environmental targets at home, but also improve our competitive position in clean energy markets worldwide.

Air pollution

Climate change is a real threat to humanity, but fossil fuels are already killing millions of people. Transport is recognised as one of the hardest sectors in which to reduce for CO_2 emissions, but vehicles are also largely responsible for the toxic air pollution that afflicts cities worldwide. The nitrogen oxides (NOx) and particulate matter (PM) emitted by diesel vehicles in particular are key ingredients in the outdoor air pollution that causes 3.7 million premature deaths each year[33], including more than 500,000 in the EU.[34] In Britain, the government estimates that each year NOx and PM cause between 44,750 and 52,500 premature deaths and cost society between £25.3 billion and £29.7 billion.[35] These numbers may in fact under-represent the health impact of emissions from transport and energy production.[36]

The government has largely devolved the problem to local authorities under the Localism Act 2011 and revisions to the Environment Act 2008, and has instructed five city authorities – Birmingham, Leeds, Southampton, Nottingham and Derby – to implement Clean Air Zones by 2020. All will prevent the most polluting vehicles such as old diesel buses, coaches, taxis and lorries from entering the most polluted areas at particular times of day, or charge them for doing so, and the Birmingham scheme will also cover vans.[37]

Excluding the most polluting vehicles from city centres at peak times should help reduce people's exposure to NOx and PM, as would tougher vehicle emissions testing to prevent the cheating by manufacturers exposed during 'Dieselgate'. But neither will eliminate transport emissions of NOx and PM emissions, for which there is no safe level of exposure.[38]

Dieselgate highlighted the need for greater innovation in transport by exposing the potential contradictions of clean energy policy. Diesel could not, as the manufacturers had claimed, deliver fuel economy (and therefore lower CO_2) at the same time as low NOx and PM emissions. The introduction of EVs will help, but to reap the full benefit, they must be powered by low-carbon electricity. Since the government has devolved much of the responsibility for tackling air pollution to local authorities, it would make sense for government also to support local innovation to help develop the solutions that reconcile these policy objectives.

Energy costs and energy poverty

The prices charged by energy suppliers, in particular the standard variable tariffs (SVTs) that most people pay, have been a source of bitter complaint for many years, and now those complaints have official backing. In October 2017, Prime Minister Theresa May described the energy market as 'broken'[39] and promised to 'end rip-off energy prices once and for all'.[40] Her conference speech announcement that the government would legislate to require the regulator, Ofgem, to cap energy prices for the 60% of customers still on SVTs, wiped billions off the value of energy company shares.[41]

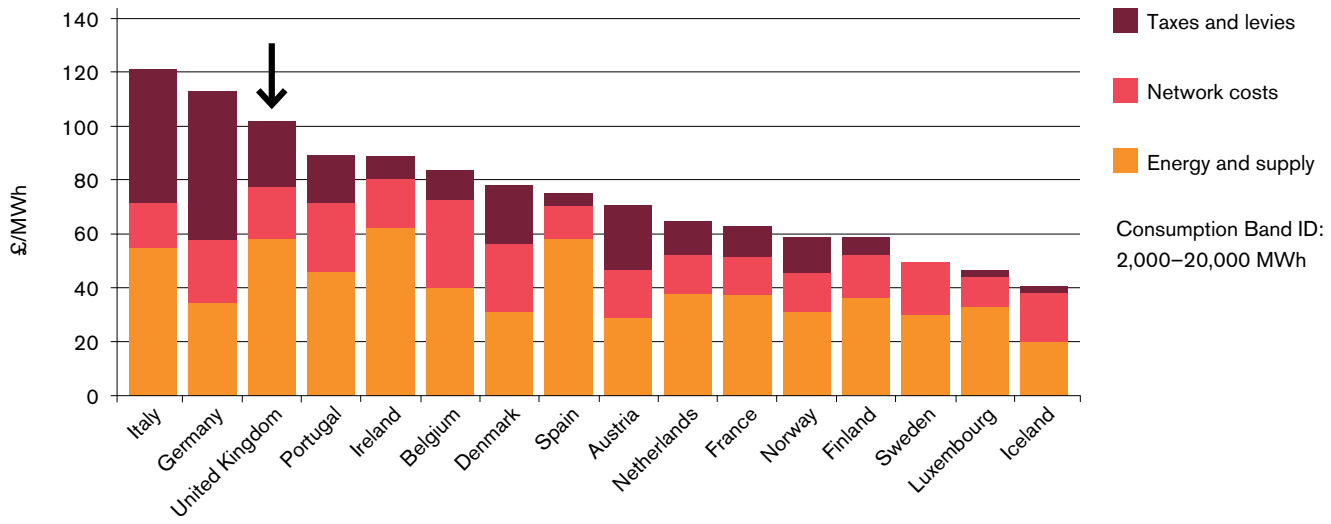
The Committee on Climate Change points out that energy *bills* have in fact fallen since around 2008, as rising efficiency has reduced energy consumption and offset the increase in prices.[42] [43] But energy prices are still a problem for industry, especially sectors exposed to foreign competition, and to consumers, especially those in fuel poverty.

Energy costs for industrial users are high by international standards, particularly for the largest users (see Figure 4). In traded sectors such as steel, cement and chemicals, high energy prices undermine their international competitiveness. The West Midlands in general, and the Black Country in particular, has a concentration of energy-intensive industries for which this issue is critical.

For domestic consumers, energy prices are in the middle of the range for EU countries (see Figure 5), but Britain has a persistent problem with energy poverty. In 2015, 2.5 million households in Britain were fuel poor – or 11% of the total, up 0.4% on 2014.[44] Fuel poverty contributes to 25,000 excess winter deaths in England each year, and the Committee on Fuel Poverty reported that progress towards the government's 2030 fuel poverty targets is too slow.[45] Studies have shown that higher energy efficiency in buildings could greatly improve the health of inhabitants, so reducing some of the burden on the NHS.[46] A household is defined as fuel poor if its energy costs are higher than average, and if its disposable income would fall below the poverty line should it actually spend the money needed to meet those costs rather than suffer the cold. Fuel poverty is therefore typically a function of energy prices, low income and poor home insulation. Low incomes and poor housing stock mean that the West Midlands suffers some of the worst fuel poverty in the country – 13.5%.

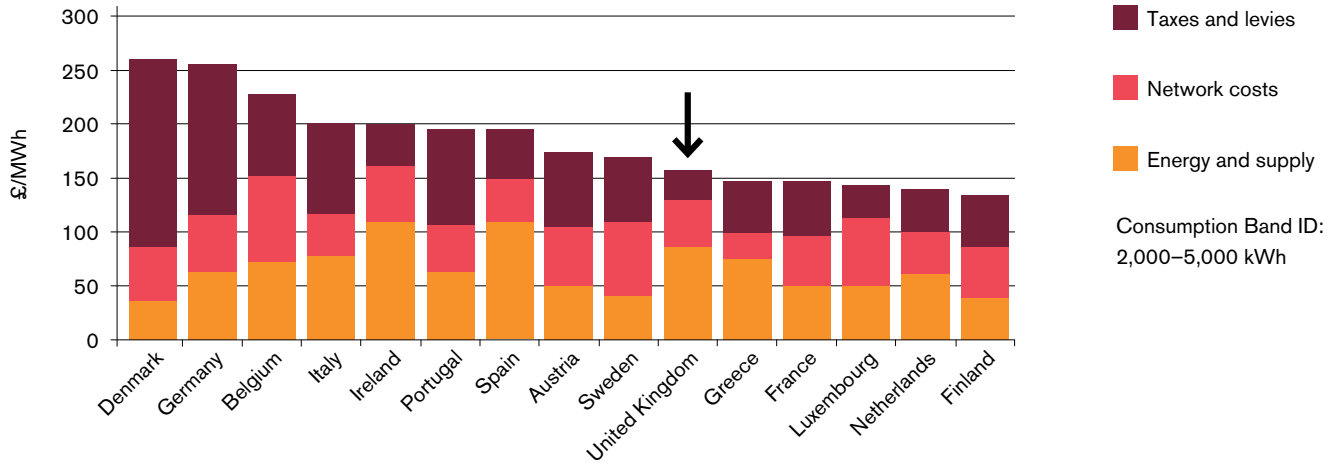
The combination of energy-intensive industries and high levels of fuel poverty means the West Midlands is especially sensitive to energy prices and in greatest need of local innovation to meet these challenges. There is a clear need to develop a policy to deal with fuel poverty separately from energy prices, and to innovate to provide new solutions to these problems.

FIGURE 4: ELECTRICITY PRICE COMPONENTS FOR MEDIUM INDUSTRIAL CONSUMERS



Source: Cost of Energy Review[47], Eurostat database

FIGURE 5: ELECTRICITY PRICE COMPONENTS FOR HOUSEHOLD CONSUMERS



Source: Cost of Energy Review[48], Eurostat database

System integration

The task of meeting the challenges of the energy transition is complicated by the increasing need to integrate across different energy systems, and between energy and other systems. The problem is not simply that progress in decarbonising heat and transport lags that in electricity generation, but that future progress in each sector will increasingly depend on the others. One legacy of the fossil fuel era is that electricity, heat and transport have been regarded as almost entirely separate energy sectors, each with its own fuels, technologies and infrastructure. But in the future, it simply will not be possible to achieve the necessary level of emissions and cost reductions required if we stick to these conventional silos. The ability of EVs to reduce CO_2 emissions depends largely on decarbonisation of the electricity grid, for example.

Integration across energy systems is needed not only to export low-cost, low-carbon electricity into other energy services like heat and transport that have so far proved harder to decarbonise, but also to help balance electricity grids as they absorb an ever higher proportion of intermittent renewable generation – for instance through smart heat pumps and EV charging. Tighter integration of energy systems into wider systems – such as municipal waste, and waste heat recovery – is also vital to increase resource efficiency and reduce emissions and cost.[49]

Since renewable and waste energy resources are inherently local, this integration will also need to happen at the local rather than national level. And because resources and infrastructure differ between regions, it follows that the innovation required to exploit them will also differ. The future clean energy system of the West Midlands, for example, will probably look very different from that of Cornwall, as we explore in section 3.

The opportunity

Although the challenges are huge, so too is the opportunity. There is now no doubt about the direction of travel: we are heading for a low-carbon energy system. The Paris Agreement was a major milestone, and to deliver it the energy sector needs to invest $13.5 trillion between 2015 and 2030 according to the IEA.[50] The Paris signatories' commitments do not yet match the scale of the task, but with the agreement's five-yearly reviews, investment should ratchet higher – driving an annual global market of around $840 billion.

More than $8 trillion is needed globally for transport and buildings, where there has been less progress so far than in the power sector, and where many of the technologies and business models have yet to be established. The opportunities for clean energy innovation are therefore enormous. The countries or regions that develop innovative solutions to the remaining challenges – especially in low-carbon heat, transport and system integration – will not only reduce their own emissions and energy costs, but also create products and services to export into booming markets worldwide.

The government has recognised through its Industrial Strategy and Clean Growth Strategy the low-carbon energy revolution as 'one of the greatest industrial opportunities of our time' in which 'whole new industries will be created'.[51] By one estimate cited in the Clean Growth Strategy, the low-carbon economy in Britain could grow at 11% a year to 2030, four times faster than the rest of the economy, and deliver between £60 billion and £170 billion in exports.[52] An innovation audit of the West Midlands found that 75% of the region's future market opportunities are in low-carbon energy, transport and buildings.[53]

Clean energy innovation

We therefore need to redouble our efforts in clean energy innovation – both to meet our environmental and social challenges, and to capture the opportunity of the clean energy revolution. This was recognised at the climate talks in Paris in 2015, when world leaders founded two organisations. Mission Innovation is an alliance of 22 of the world's richest countries, which have committed to double their spending on clean energy R&D within a decade – implying more than $10 billion per year by 2025. The Breakthrough Energy Coalition is a group of 28 private investors led by Bill Gates who have promised $2 billion early stage investment into technologies that emerge from government-funded research in Mission Innovation countries.

Both initiatives are timely and important, but they are just the start. R&D is only the first stage of the innovation process – which stretches all the way to commercial deployment of products and services – and government R&D spending represents only a fraction of the investment needed to support innovation. Total investment in clean energy – which has averaged $300 billion a year since 2010[54] – needs to triple to $840 billion, and much of the increase will necessarily involve innovative technologies and business models.

In Britain, the government has acknowledged we need to 'drive a significant acceleration in the pace of decarbonisation' to achieve our fourth and fifth carbon budgets, and that this means intensifying our efforts on transport and heat. It has refocused on clean energy innovation through Clean Growth Strategy, with £2.5 billion investment in low-carbon innovation to 2021. The broader Industrial Strategy will also play a major role, through its Grand Challenges, Sector Deals and the National Productivity Investment Fund.

Like Mission Innovation, the new strategies are a major step forward, but not the whole solution. As we show in the next section, clean energy innovation in Britain faces a number of structural barriers we need to overcome to secure the fastest possible clean energy innovation and the best returns on public investment.

2. BARRIERS TO INNOVATION

Photo: Tony Hisgett

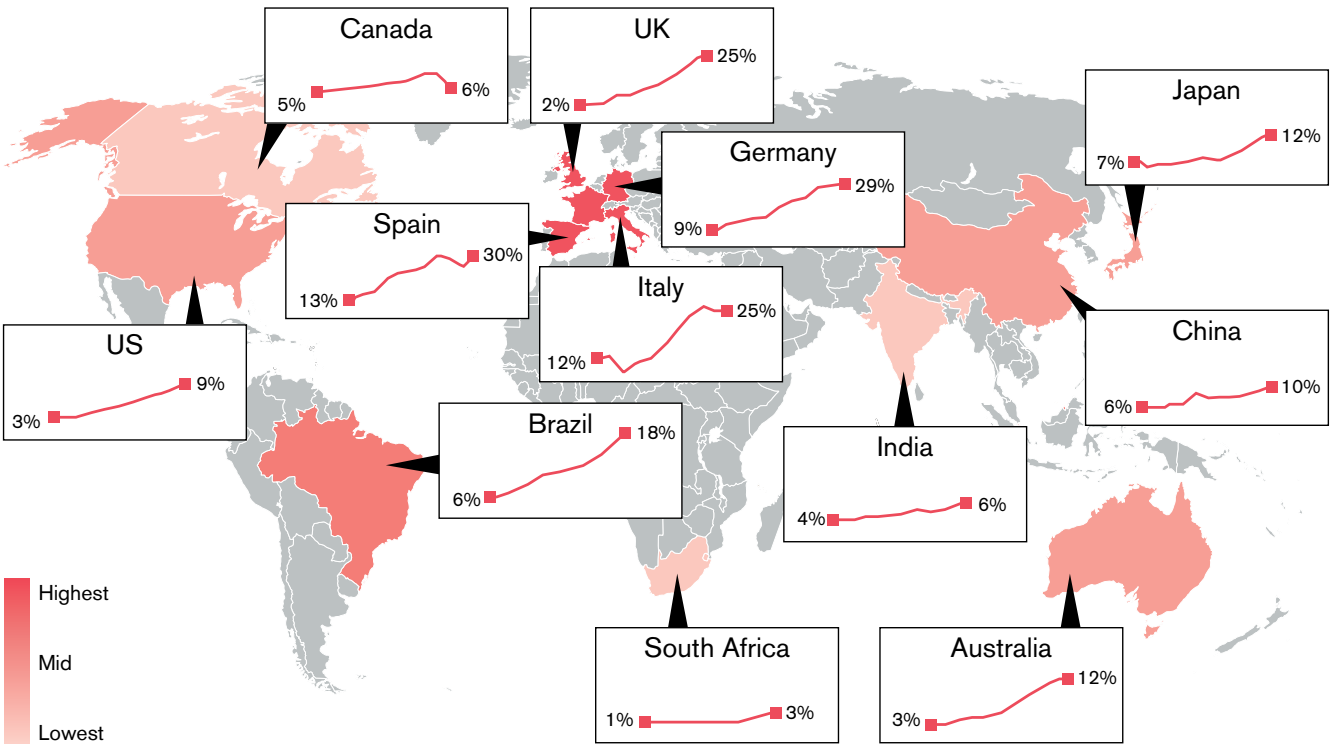
Innovation is fundamental to transforming the world's energy system – and it is already beginning to do so. Nowhere is this clearer than in the growth of renewable electricity generation and storage. Innovation has driven down the cost of solar energy, by 80% so far this decade, for example, making it cheaper than coal in many parts of the world. In the North Sea, recent offshore wind auctions have seen winning bids cheaper than gas and subsidy free. The cost of lithium-ion batteries has fallen by two-thirds since 2010, and sales of electric vehicles are rising sharply.[55]

Government support is vital to secure the fruits of innovation: from grants to support early stage technology development, to market support mechanisms that create demand-pull and economies of scale (see boxes). The UK now has the world's largest offshore wind park – and substantial turbine manufacturing capacity – thanks in part to its contracts-for-difference auction scheme and initiatives such as the Offshore Wind Programme, which helped reduce the cost of offshore wind energy by a third between 2012 and 2016, four years ahead of schedule.[56]

The plunging cost of clean energy technologies is having profound effects on the shape of the energy system. The speed of the growth in renewable capacity has continually wrong-footed many forecasters[57], and the proportion of electricity generated by renewables has reached levels undreamt of just a few years ago. By 2016, Britain and Italy were generating 25% of their electricity from wind and solar, Germany 29% and Spain 30% (Figure 6).

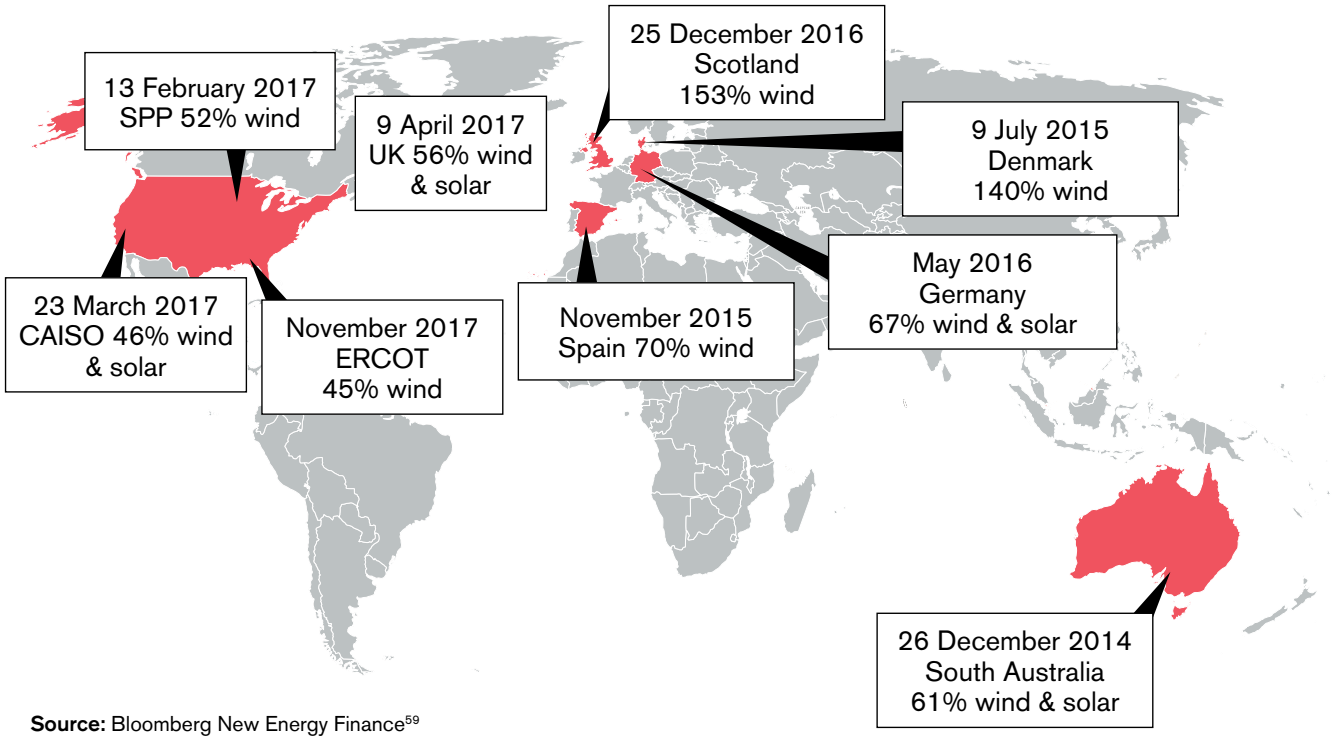
Peak renewable generation in these countries is far higher (Figure 7). On a sunny and windy Sunday in April 2017, the UK for the first time generated more than half of its electricity (56%) from renewables for an entire day. On Christmas Day 2016, Scotland generated the equivalent of 153% of its demand from wind alone. In Germany and Spain, renewable generation over a single day has reached around 70% and in Denmark 140%. In three US regional grids, it has ranged 45–52%.

FIGURE 6: RENEWABLE ENERGY AS A PROPORTION OF POWER GENERATION IN VARIOUS COUNTRIES, 2006–2016



Note: Excludes large hydro
Source: Bloomberg New Energy Finance[58]

FIGURE 7: PEAK DAILY RENEWABLE PENETRATION IN VARIOUS COUNTRIES



Source: Bloomberg New Energy Finance[59]

The speed and scale of renewable growth is not only starting to reduce CO_2 emissions from power generation but also upending energy markets. Global coal demand has now peaked, according to analysts at Bloomberg New Energy Finance, forcing seven coal mining companies into bankruptcy over as many years. The scale of solar generation in Germany has destroyed the traditional business model of large, centralised generating companies, forcing them to mothball even recently completed fossil-fired power stations. Several incumbents have demerged their renewable and fossil operations, and German utilities have written down $66 billion from their balance sheets since 2010. Global demand for large gas turbines has fallen to around 110 per year, compared to manufacturing capacity of about 400, forcing the industry to shed thousands of jobs in 2017.[60]

The rapid growth of solar and wind, caused by their plunging costs, is throwing up new challenges: how to balance supply and demand in systems with much more variable supply; how to accommodate distributed generation on a system developed to deliver power from remote, centralised generators; and how to overcome local constraints on grid capacity. These problems demand innovative answers including storage and demand side management that are beginning to be developed.

In short, the growth of renewables has shown that innovation has the potential to utterly reshape how we produce, trade and consume electricity. But decarbonising the power supply is arguably the 'easy bit' of the problem. The question then is how to enable innovation to do its work equally well across the entire energy system.

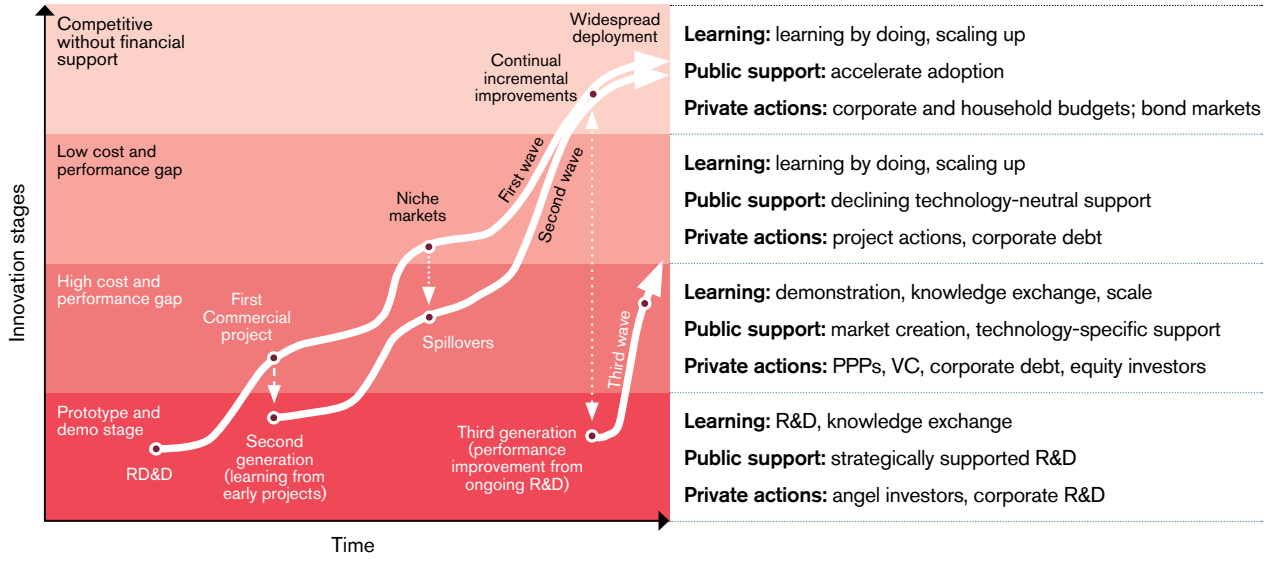
BOX 2: But what exactly is innovation?

Innovation is often confused with invention, but it is a much broader concept. When Archimedes, according to legend, leaped out of the bathtub yelling 'Eureka!', he had clearly made an important intellectual breakthrough, but running naked through the streets of Syracuse was a long way from demonstrating any practical application of his new knowledge. The same is true of any inventor in his or her laboratory or garden shed. In a market economy, if clean energy technologies are to make any difference to the world – by reducing emissions and cost – they will need to be bought or accessed by millions or billions of people. *Innovation therefore includes the entire process of transforming discoveries and inventions into commercial products and services that people want to buy.*

Innovation includes the entire process of transforming discoveries and inventions into commercial products and services that people want to buy.

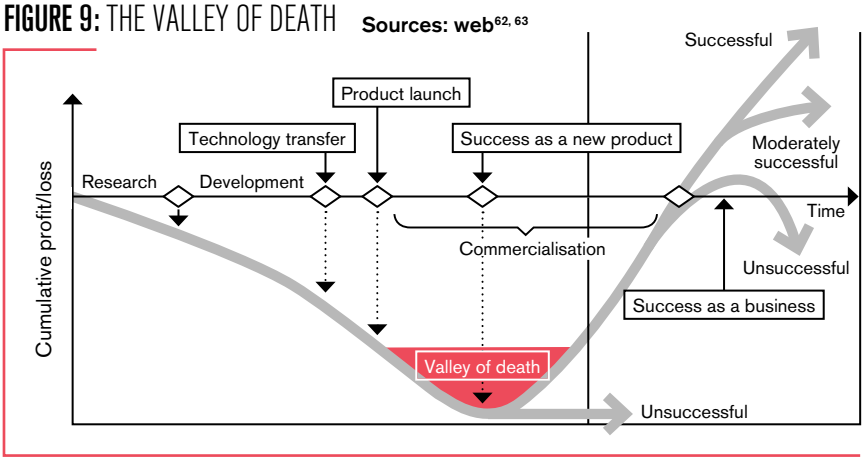
The journey from bright idea to commercial product travels through many different and overlapping stages, summarised as RDDD&D: research, development, demonstration, deployment and diffusion.[61] To turn a physical invention into a commercial product, the inventor or company must: build a prototype; prove it works; demonstrate it in real-world conditions; optimise the design to improve its performance and reduce its cost; build or secure small-scale manufacturing capacity; develop the supply chain for components, and the skills for manufacturing, installation and servicing; create the market, and scale up to mass production. The process is dynamic and iterative, with lessons learned during demonstration and deployment feeding back into product development (Figure 8). Where the 'invention' is a new service or business model, the process is broadly similar.

FIGURE 8: STAGES OF INNOVATION **Source:** IEA[62]



Each of these stages may involve different actors – universities, SMEs, manufacturers, commercial partners – and different investors from angels, to venture capitalists to corporate investors and equity markets. The funding required rises with each stage, and more often than not the journey ends in failure. This often happens in the 'valley of death' between launching a commercial product and the business achieving break-even (Figure 9), when funding requirements are highest.

FIGURE 9: THE VALLEY OF DEATH **Sources: web**[62, 63]



BOX 3: Public support for innovation

Innovation attracts government support because it advances social objectives such as decarbonisation and because it is fraught with levels of risk that the private sector cannot bear alone. The nature of government support differs according to the stage of innovation. During the early stages, it includes funding for fundamental research by universities, and grants for SMEs to produce prototypes and undertake demonstration projects – so-called 'technology-push'. At the later stages, commercialisation is supported by 'market-pull' mechanisms such as feed-in tariffs (FiTs) or contracts-for-difference (CfDs), which subsidise deployment until mass production reduces costs to the point where the technology is competitive without public support.

Such policies have been widely adopted and strikingly successful in bringing down the costs of solar and wind to the point where they are commercially competitive and innovation highly industrialised. Solar now has a 'learning rate' of 24–28%, meaning that the cost of solar energy falls by around a quarter with every doubling of capacity. For wind and lithium-ion batteries, the learning rate is 19%. As a result, although global investment in clean energy has held steady at around $300 billion per year since 2010, the amount of capacity that investment procures each year has almost doubled from 88GW in 2010 to 160GW in 2016.[64]

To maximise the economic benefits of innovation, it is important that every country supports all stages of innovation. A country that provides only technology-push, will find that its inventions are commercialised and manufactured abroad, while a country that provides only market-pull will suck in technologies manufactured abroad and fail to develop its own intellectual property. Neither will reap the full benefits for growth, exports and jobs.

Public support for clean energy has typically been a matter of national policy, and support schemes usually tailored to individual technologies. As the energy challenges evolve, the nature of public support will need to change too, to become more integrated across technologies – and more local.

The shortcomings of global energy innovation

Although innovation is proving a powerful driver of change in electricity generation, it has been far less effective in other areas of energy such as transport and heat. In its latest assessment, the International Energy Agency (IEA) concludes that current national plans – including commitments made under the Paris Agreement – are 'not consistent with achieving global climate mitigation objectives', and that 'many technology areas suffer from a lack of policy support, and this impedes their scaled-up deployment'.[65]

Analysts at Bloomberg New Energy Finance estimate that worldwide government spending on clean energy R&D rose 25% to $5.5 billion in 2016, perhaps reflecting commitments made by members of Mission Innovation (see section 1), but that corporate spending fell 40% to $3.5 billion.[66] Similarly, the IEA's most recent estimates of investment in the broader category of RD&D show that governments invested $19 billion in 2015, companies $6 billion, and venture capital funds $2 billion.[67] To put this in perspective, in 2017 the world's 25 largest corporate R&D investors – a list dominated by internet, automotive and pharmaceutical companies – spent $222 billion on R&D alone.[68]

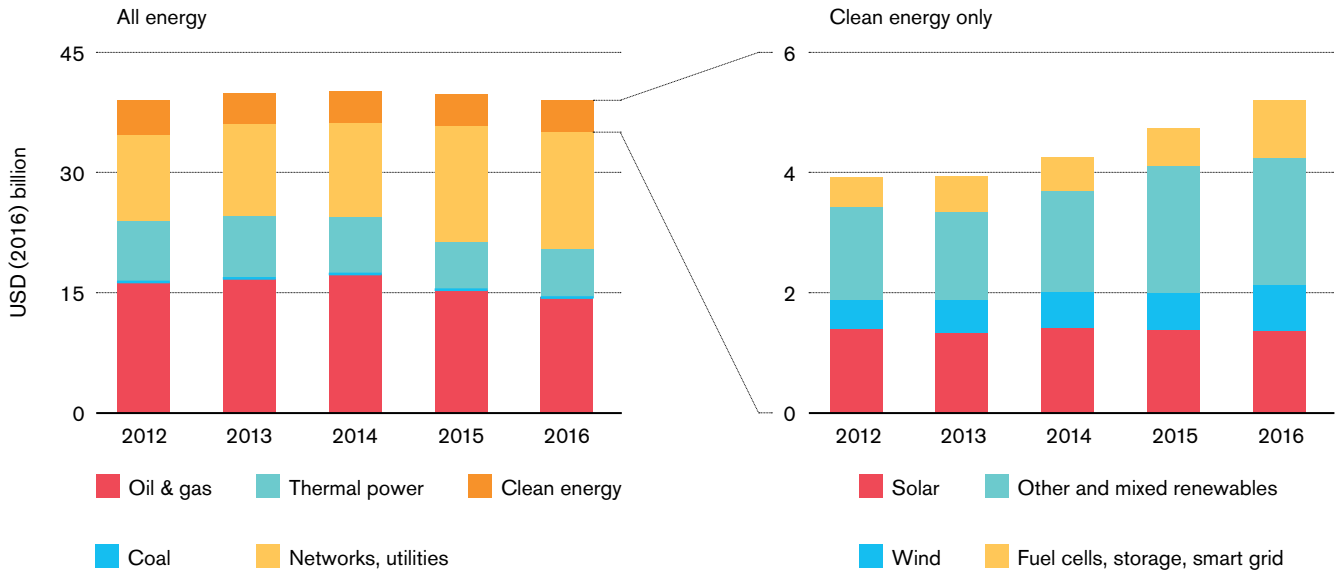
The immediate cause of the fall in corporate investment in clean energy R&D in 2016 was the highly competitive environment for wind and solar companies, but there are also other issues that are longer term and more fundamental. First, the energy industry as a whole invests far less in R&D than other sectors – car manufacturers spent five times more than oil and gas companies in 2015, for example. Second, clean energy R&D is tiny compared to fossil fuel R&D (Figure 10). And third, even the biggest clean energy companies are now spending more on share buybacks than on R&D (Figure 11).[69]

If overall investment in clean energy innovation is evidently inadequate, it should come as no surprise that progress within individual technologies has been patchy so far. In its latest detailed assessment, the IEA concludes that of 26 technology areas it evaluated, only three were on track to deliver a sustainable energy transition. Of the rest, eight were significantly off-track, including advanced biofuels, buildings and heat – which accounts for 50% of final energy consumption and remains largely fossil-fuelled. Renewable heat needs to grow 32% from 2014 to 2025 to be consistent with limiting global warming to 2°C.[72]

The IEA argues that governments should not only redouble their efforts – 'policy support for technology should be accelerated at all stages of the innovation cycle' – but also change their approach. Support for clean energy should be more *integrated* and more *local*:

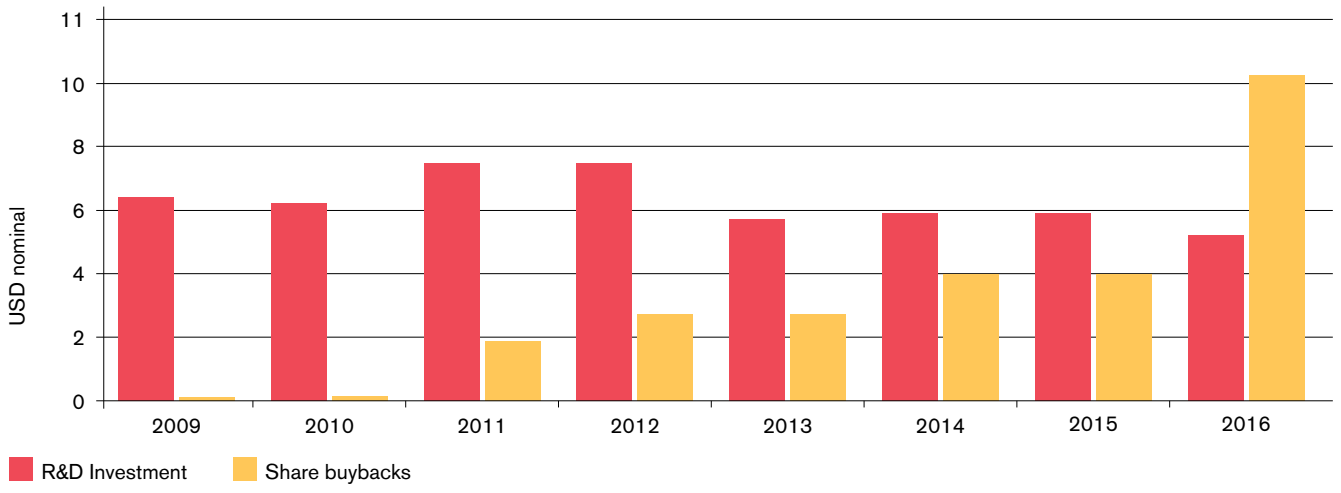
> 'Success depends not only on individual technologies but also on how the overall energy system functions. The most important challenge for energy policy-makers will be to move away from a siloed, supply-driven perspective towards one that enables systems integration. Effective planning tools, supportive regulatory frameworks, and increased policy dialogue are essential…
>
> '…Market designs and regulations should leverage the opportunity brought by increased access to energy information to enable new energy transaction models. More efficient institutional dialogue and co-ordination should be established between national, regional and local governments as well as with other energy stakeholders to accelerate the energy sector transformation and to discover novel solutions.'[73]

FIGURE 10: REPORTED R&D SPENDING BY ENERGY COMPANIES BY SECTOR



Source: IEA[70]

FIGURE 11: SPENDING ON R&D AND SHARE BUYBACKS OF TOP 20 CLEAN ENERGY COMPANIES



Note: Clean energy companies defined based on Bloomberg Industry Classification System (BICS) sectoral classifications.
Source: IEA[71]

Innovation in the UK

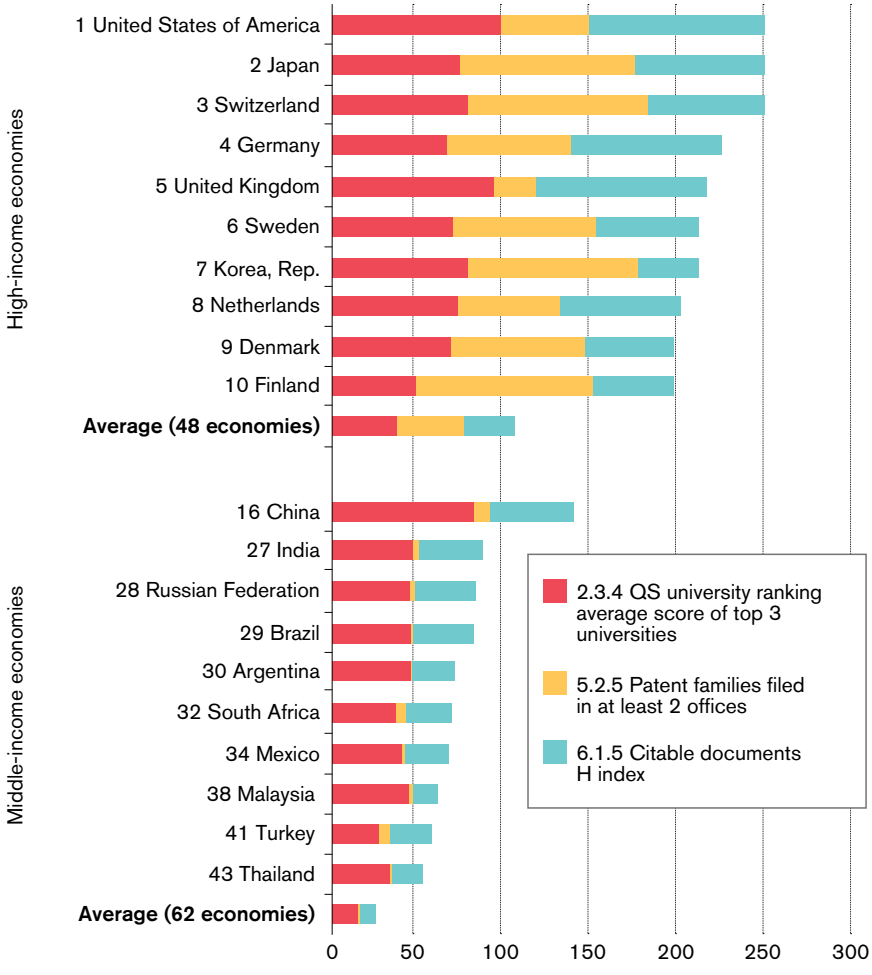
Britain can be rightly proud of its long list of world-changing inventions: refrigeration, the jet engine, the computer, the internet. But its record in innovation – commercialising those breakthroughs – has been weaker. Too often, as the Industrial Strategy recognises, British inventions have been commercialised by others. More generally, of the 25 largest corporate investors in R&D in 2017, only one, AstraZeneca, was British, and only Siemens was primarily engaged in the energy sector.[74]

> 'There have been major breakthroughs made in UK universities and research labs bought up by global businesses – from magnetic resonance imaging in the 1970s, lithium-ion batteries in the 1980s, monoclonal antibodies in the 1990s and genetic sequencing in the last decade. All of these are pioneering UK ideas being developed elsewhere or bought by businesses from overseas. Within R&D, the "D" for development needs a particular boost.'
> **UK Industrial Strategy**

There are many notable exceptions, of course, such as ARM Holdings, the Cambridge spin-out that designs the chips that power 95% of the world's smartphones – although it was bought by the Japanese company SoftBank for £24 billion in 2016.[75] But the general picture is confirmed by the Global Innovation Index 2017 – produced by Cornell, INSEAD and the World Intellectual Property Organization – which shows Britain's innovation performance has worsened in recent years, falling from second place in 2015 to fifth in 2017.[76] The UK continues to rank joint first with the US for the quality of its universities' research, but fell back to 28th in knowledge absorption and 38th in knowledge diffusion. Britain's position – marginally behind Germany – is shown in Figure 12, which also clearly shows our weakness in patent filings.

Britain's relative weakness in commercialising its inventions is widely recognised[78], and solving it is one of the aims of the government's Industrial Strategy – along with other persistent problems including low levels of investment, poor productivity and wide regional disparities.[79] These problems are compounded in the field of clean energy innovation by some additional and obstinate barriers.

FIGURE 12: GLOBAL INNOVATION QUALITY RANKINGS BY COUNTRY, 2017



Source: GII 2017[77]

Barriers to energy innovation in the UK

Progress on clean energy in the UK reflects the patchy global picture: renewables provided almost 25% of UK electricity in 2016 (29% in 2017), but only 6.2% of our heat and just 4.5% of our transport energy.[80] Some other countries such as Denmark and Norway have made far greater progress on heat and transport, however, and in the integration of energy systems to increase their efficiency. So why has Britain not matched this achievement?

Britain already has an extensive network of innovation institutions – Innovate UK, the Energy Systems Catapult – that support early-stage technology development and demonstration. The government recently set up UK Research and Innovation to invest £8 billion per year by 2020 to 'help translate excellent research into better business outcomes'.[81]

It also seems there is no shortage of *potential* clean energy innovation projects. By one estimate, local authorities in England are 'sitting on' clean energy innovation projects worth a combined £500 million because they do not have the capacity to carry them out – others put the figure even higher. A study by the University of Edinburgh found that of Britain's local authorities, only 5% have invested directly in more than three energy projects and 52% have yet to invest in any.[82]

The fact that Britain provides extensive support for clean energy innovation, but that many potential projects remain 'stuck', suggests the existence of obstinate barriers – particularly to late-stage energy innovation.

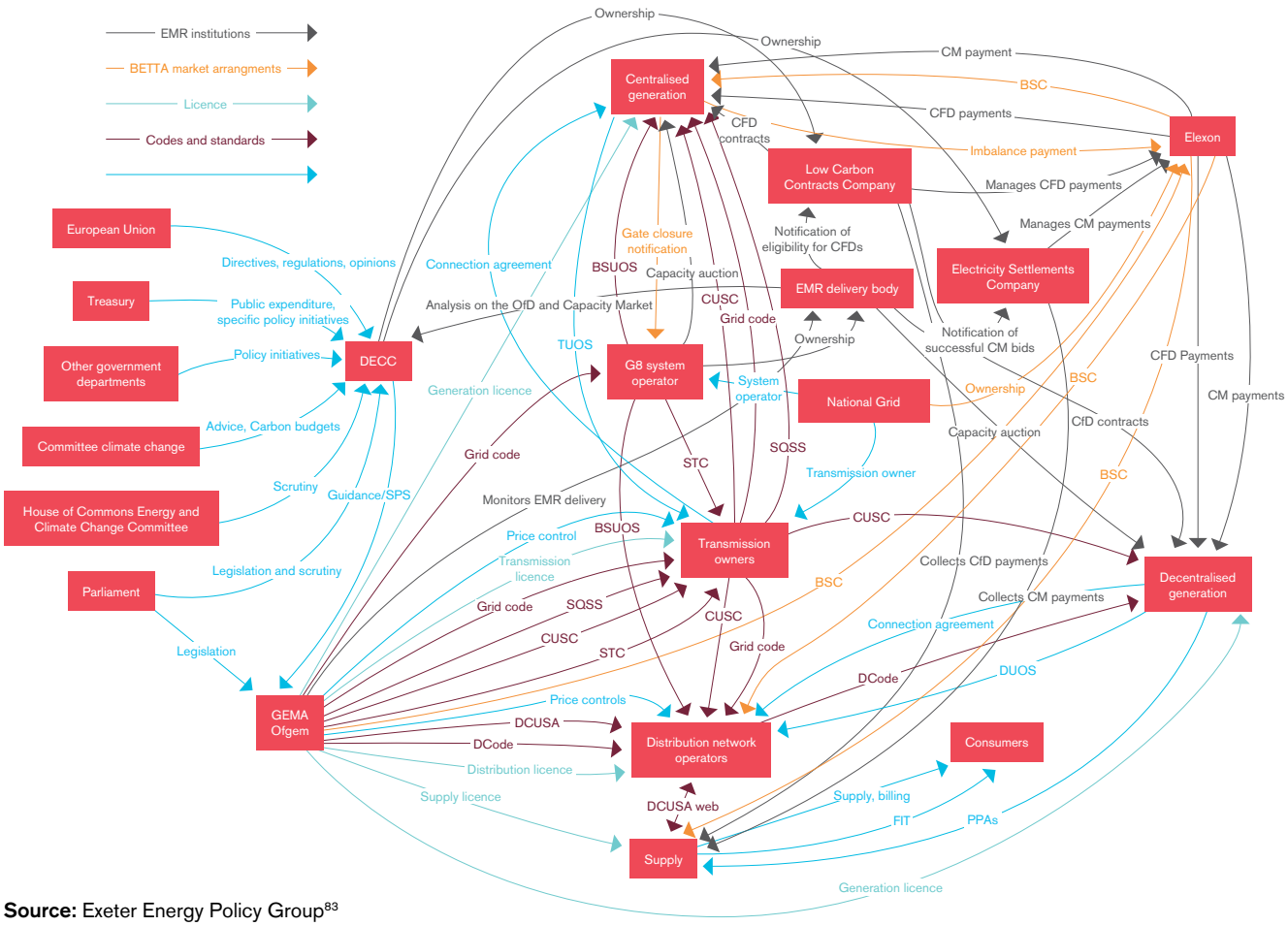
The Commission gathered evidence that suggests the key barriers are the complexity and governance of market rules; the unintended consequences of some individual rules and areas of uncertainty; and a lack of capacity and resources among local authorities.

> 'Evidence suggests the key barriers are the complexity and governance of market rules; the unintended consequences of some individual rules and areas of uncertainty; and a lack of capacity and resources among local authorities.'

Regulatory complexity and cost

It is already widely recognised that regulation of the electricity system in Britain is extremely complicated. The system has been successful in promoting some types of innovation – for instance, among network companies – but raises a major barrier to other forms of innovation. Rules and industry codes have proliferated over the years, and this complexity makes it expensive for challengers to enter the market. Figure 13 shows the institutions and relationships governing electricity.

FIGURE 13: REGULATION OF THE UK ELECTRICITY MARKET; INSTITUTIONAL RELATIONSHIP IN THE ELECTRICITY SYSTEMS



Source: Exeter Energy Policy Group[83]

The *direct* cost of securing an energy supply licence is low: Ofgem charges just £450 for a licence to supply electricity and the same again for gas. But the licence runs to 500 pages, and associated industry codes occupy thousands more. This means applicants must invest in expensive systems, personnel and professional advice to demonstrate compliance before securing a single customer. Ovo Energy spent £400,000 entering the GB market, for example, First Utility £600,000 securing licence approval and a further £750,000 getting the company going, and Bristol Energy Company cites start-up costs of almost £1.6 million.[84] [85] In evidence to the Commission, Councillor Lisa Trickett of Birmingham City Council, which plans to set up a local energy company, expected start-up costs of £2.5–3 million.

Over the past decade, the number of UK energy suppliers has risen from 20 to around 60, but almost all operate on essentially the same business model – selling energy in units of kWh. The big incumbents have lost 20% market share but competitive pressures have not been sufficient to ensure fair prices for customers who fail to switch, and so far there has been no large-scale disruptive entry to the market. The incumbents themselves have little incentive to innovate in ways that would cannibalise their existing businesses and sunk costs, unless or until they see real prospect of such major change. They also dominate the industry working groups that consider any prospective rule changes, where vested interests tend to stymie change. SMEs daunted by the idea of navigating the system alone may partner with an incumbent, but this means their innovative disruption is tamed. So complex is the system that Martin Crouch of Ofgem testified 'The biggest barrier is not knowing what the barrier is'.

A recent report supported by the Energy Systems Catapult, *Reshaping Regulation*, agrees that 'the current regulatory regime has been inundated with codes of practice that have added increased complexity to the system and further disincentivised innovation and new entrants', and argues cogently for fundamental reform of the entire system of energy regulation.[86] We agree this is vital, but fear the scale and complexity of the task and the high risk of unintended consequences from hasty reform mean this process will necessarily be lengthy. But time is short. In the meanwhile, we need a speedy and low-risk solution to unblock local energy innovation – which will in turn help develop new regulatory frameworks that could be applied nationally.

As noted previously, we have seen much more progress in decarbonisation and innovation in the regulated electricity sector than in the relatively less regulated heat and transport sectors. This suggests there may be some areas in which the *absence* of regulation is unhelpful. There is significant opportunity in heat networks, and the industry has recognised that it is held back by the lack of regulation and consumer protection. It argues that a regulatory framework on the lines of that in place in the electricity and gas sector would enable risks to be mitigated, reducing the cost of capital and encouraging investment.[87]

Other specific barriers

Besides the overall complexity of energy regulation, there are also individual rules that inhibit innovation, and important areas of regulatory or policy uncertainty that have the same effect.

The Commission heard that one major problem is that UK energy policy deals with electricity, heat and transport separately. This means that areas with system synergies – such as the integration of heat and electricity, electricity and transport, or waste and energy – receive less attention than simple 'single system' policy measures or none at all.[88] EIZs are intended to concentrate on integration across systems and sectors, and could therefore provide policy-makers and regulators with significant insights.

Another related barrier is uncertainty over the strategic direction of heat policy. The government has yet to announce whether decarbonisation of heat will be achieved mainly through electrification or through the gas grid. For innovators, this increases the risk that newly built assets could be left stranded by future policy decisions.

Among specific policies, the workings of the Energy Company Obligation (ECO) have been criticised for causing some unintended consequences. ECO is a levy added to retail electricity bills that the major suppliers are required to spend on energy efficiency measures to achieve specified reductions in CO_2 emissions. The suppliers have tended to pursue the lowest cost efficiency measures and avoid much needed higher cost measures such as solid wall insulation (see Box 10, page 44). In addition, the supplier obligation creates an oligopoly in a naturally competitive market, which reduces the incentive to innovate and can lead to poorer quality outcomes.

Another barrier is raised by clauses of the Renewable Heat Incentive (RHI) that deter third-party financing of heating equipment, which is in turn holding up the launch of some 'comfort as a service' business models. The government has consulted on this problem and plans to introduce legislation to solve it this year, but at present it remains a barrier (see Box 14, page 60 for detail).

Some of the assumptions that underpin energy regulations in Britain also inhibit innovation. One such is the use of standard profiles for domestic energy demand, which prevents companies from aggregating the flexibility of millions of households to help balance the electricity grid. Similarly, the use of 'deemed output' for micro-generators, under which generators of less than 30kW are paid a fixed amount funded by a levy on bills, means there is little incentive to develop aggregator business models for domestic solar systems and micro-CHP. Real-time metering of all domestic generation would solve this – although the new DCC smart meter communications system does not have the functionality.

No doubt we could add many more examples to this list, but it is already long enough to suggest that a wide range of barriers inhibit innovation and later stage demonstrations, particularly in the areas of heat and system integration where progress is needed most urgently. Since some of these barriers are embedded in national legislation it may not be possible to solve all at a local level, but others would be amenable to the EIZ approach.

3. LOCALISING CLEAN ENERGY INNOVATION

One of the most striking trends in clean energy over the past decade has been its localisation. Whereas climate and energy initiatives were once led largely by national governments, today some of the most exciting are driven by local authorities: from green roofs in Hamburg to gas-powered bus rapid transit in Cartagena; from EV chargers in Oslo to free home insulation in Newcastle; and from smart public lighting in Almada to palm frond recycling in Phoenix.[89 90 91] Cities as far-flung as Malmo and Vancouver have committed to going 100% renewable, and the Australian Capital Territory to do so by 2020.[92] Nor are they working in isolation: local authorities have banded together in international networks such as C40, which represents the world's largest cities, and the Global Covenant of Mayors[93], with almost 7,500 members worldwide, to set themselves ambitious targets and swap ideas. Localisation, you might say, has gone global.

There are many practical and positive reasons to conduct clean energy innovation and infrastructure investment at the local level:

- Energy resources and challenges differ from place to place, meaning economically efficient solutions will also differ by location. Cornwall has large geothermal and solar resources but widely dispersed rural housing, for example, while the West Midlands has larger resources of municipal waste and waste heat, dense urban housing, big business and an industrial tradition. The clean energy system that works for one region is therefore unlikely to work for the other; tailoring the system to local conditions is likely to achieve better reductions in emissions and cost.
- Many of the most urgent problems require the integration of energy systems, or the integration of energy into wider systems, which must necessarily happen locally. Examples include the development of hybrid heat pump systems, integrating waste heat from a biomass or industrial plant into a heat network, and recycling organic waste through a gasifier or anaerobic digester.
- Balancing local and regional electricity grids will become increasingly challenging with the continuing growth of variable renewable generation and new forms of potentially 'peaky' demand such as EV chargers and heat pumps. Bloomberg New Energy Finance forecasts that renewables will provide more than half of Britain's electricity by the mid-2020s, causing much greater volatility.[94] Most renewable generation is connected to distribution grids rather than the national grid. Where significant renewable clustering has or is likely to create grid constraints, it may be more economic to balance supply and demand locally rather than make additional network infrastructure investments. This has been made far easier by the advent of digitalisation (see Box 4 below).
- Local political leadership is vital to the success of clean energy investments, because it can help tap regional identity to build enthusiasm for energy innovation, overcome distrust of incumbent energy suppliers, and provide democratic accountability. Polls show that people have far greater trust in local authorities than in energy companies.[95] Britons are overwhelmingly in favour of renewable energy in principle, but often object to development in their own neighbourhoods. In Denmark and Germany, local authorities have overcome objections to wind farms by offering shares to those who live nearby, and by 2013, around three-quarters of Danish wind turbines were community-owned.[96]
- Wholesale reform of national energy systems is necessarily a long drawn-out process. As the experience of many cities around the world suggests, a local approach could be nimbler and produce results sooner and with less risk, which could then be applied elsewhere and even nationwide.

BOX 4: Digitalisation and local clean energy

Balancing electricity supply and demand at a local rather than national level is a significant challenge, but has been made far easier by the advent of 'digitalisation'. The recent emergence of low-cost digital technologies including sensors, internet and wireless communications, and powerful analytical algorithms allow the development of local energy management services that simply were not possible in a manual or analogue world.

'Big data' has long been used to optimise individual assets such as gas turbines or wind farms, but the biggest opportunity will be to create local networks of energy producing and consuming equipment that respond to real-time data on weather, supply, demand and price. This will allow not only the precise technical control of individual assets, but the creation of local markets that lead to locally optimum outcomes.

Local price signals will prompt heat pumps to consume electricity when renewable generation is high, for example, and batteries to discharge when demand is highest. This will increase energy efficiency, reduce emissions and cost, and reduce the amount of new transmission and distribution infrastructure that needs to be built. It will also make it possible to absorb more intermittent renewable generation than otherwise, along with new 'peaky' loads such as EV charging.

Analysts at Bloomberg New Energy Finance forecast that the global market for digitalisation in energy will reach $64 billion by 2025. The largest segment will be home energy management systems, worth $11 billion, designed to help a new breed of 'prosumers' – householders who own solar panels, batteries or EVs – to manage peak power prices or trade energy with their neighbours.[97]

Digitalisation and machine learning will become all the more important in integration across systems – home heat and electricity, for example – where devices such as hybrid boiler-heat pumps need to evaluate conditions in gas and electricity markets simultaneously (see Box 14, page 60). Dynamic energy pricing for heat pumps is already available in Finland and other Nord Pool countries.[98]

The arguments for local energy innovation are as true for rural as for urban areas, but cities are particularly important because of the scale of their energy consumption and emissions. The 90-plus mega-cities in the C40 network account for 25% of world GDP. More generally, cities consume around two-thirds of the world's energy and cause 70% of its emissions.[99] Not only do cities account for most of the problem, argues C40, but they also hold many powerful levers to solve it:

> 'Competitive advantages allow individual cities to pursue a subset of strategies that will lead to meaningful emissions reductions at the local level. Cities can be nimble in implementing policy changes, but are also readily accountable to their citizens, local businesses, schools, and institutions for the success or failure of their actions. To this extent, cities are a test-bed for larger action: policies and programs that work – environmentally, economically and politically – have powerful potential to effect change globally. Cities with common profiles can network, collaborate on solutions and disseminate best practices that bring actions to scale in other similar cities.'[100]

Local authorities and clean energy in the UK

In Britain too, local authorities have been recognised as potentially powerful actors in the development of clean energy. They are 'the only organizations unavoidably committed'[101] to their areas for the long term, and have responsibilities and powers over many areas vital to the development of clean energy: housing, planning, waste, transport and regeneration. They would be the natural choice to lead local energy innovation and integration in the UK, as they are abroad, but here their ability to fulfil this role has been weakened by several factors.

Several cities and counties across the country are developing innovative clean energy strategies. Pioneering local authorities such as Bristol and Nottingham have set up municipal energy supply companies with lower cost tariffs for local residents, and set up self-financing clean energy project development teams that bring in revenue for their authorities (see Boxes 5 and 6). Others, including Southampton, Birmingham and Newcastle, have developed district combined heat and power (CHP) schemes. Cornwall secured government support for its plans to develop geothermal energy and low-carbon heat in its devolution deal (see Box 10). Leeds has an ambitious hydrogen project. Britain's 38 Local Enterprise Partnerships (LEPs) have received funding from BEIS to produce local strategic energy plans.

BOX 5: Nottingham

Nottingham is one of several councils that have shown how much can be achieved on clean energy and energy efficiency within the existing framework – but its experience also illustrates some barriers to innovation.

In 2015, Nottingham became the first local authority to launch its own energy supplier. Robin Hood Energy is a-not-for-profit organisation intended to help tackle fuel poverty. It is not the cheapest supplier, but its 50,000 customers, 12,000 of whom live in Nottingham, have on average saved £137 against the average standard variable tariff offered by the big incumbents. The company also operates a 'white label' service for other councils, such as White Rose Energy in Leeds, taking its customers to 118,000 in total.

Nottingham has also built an in-house energy team to develop a wide range of renewable energy and energy-efficiency projects both in the city and around the country. So far it has installed solar panels on more than 4,000 homes and dozens of larger scale projects such as carports at council buildings. It has also fitted external wall insulation and other efficiency measures to around 5,000 council houses, and another 1,000 private homes with a financial contribution from the owners. It has also delivered wind turbine and fuel cell projects.

The energy team has around 30 project managers and 30 installers, and aims to generate a return of 5% above its costs on each project. Funding streams include EU sources such as Horizon 2020 and ERDF, and British sources such as Innovate UK. The team already more than covers its costs and therefore contributes to council coffers.

Much of Nottingham's excellent work could be described as best practice rather than fundamentally innovative – but it has also innovated. For example, the council developed the EEMonitor, a proprietary wireless energy meter and pre-payment device to help residents in social housing control and budget their energy use.[102] The device was designed for Nottingham's large district energy network, which provides heat, hot water and electricity to 5,000 homes and 100 commercial buildings, and is now also installed in district heating schemes across the country.

Nottingham has also pioneered the Energiesprong ('energy leap') approach to whole-house energy efficiency retrofits developed in the Netherlands. Energiesprong is both a building standard and a funding model. It aims to make houses net-zero-energy by adding thick external insulation and a new roof with integrated solar panels, along with new energy equipment such as heat pumps. The capital cost is paid by the building's owner – typically a council or other social housing provider – and recouped over 30 years from several sources. These include residents' energy payments, income from renewable energy generation, and avoided maintenance costs. Under the business model, the residents' payments should be lower than their current energy bills.

Nottingham has retrofitted ten homes already and is seeking funding for a demonstration with 230 homes. But Energiesprong's British organisation says that one potential barrier is the right-to-buy scheme, since landlords worry that they could invest heavily and then find that residents buy their newly improved homes, potentially leaving investors with a loss (see Box 15 for more detail).

BOX 6: Bristol

Bristol is another council taking vigorous action on greenhouse gas emissions and fuel poverty. Like Nottingham, it has set up an in-house energy team and a local energy supplier. The Bristol Energy Company now has around 111,000 customers[103], and aims to return a profit to the Council within four years, although it was recently reported to have made a loss of more than £8 million.[104] The company estimates that households switching to its local tariff save £190 on average,[105] and if everybody did so the savings would total more than £21 million.

The Council began to develop its strategy in 2005, and started to put it into practice from around the turn of the decade. In 2011, it introduced a new planning framework to minimise the energy demand of new developments and integrate renewable energy. Since then, the 30-strong energy team has:

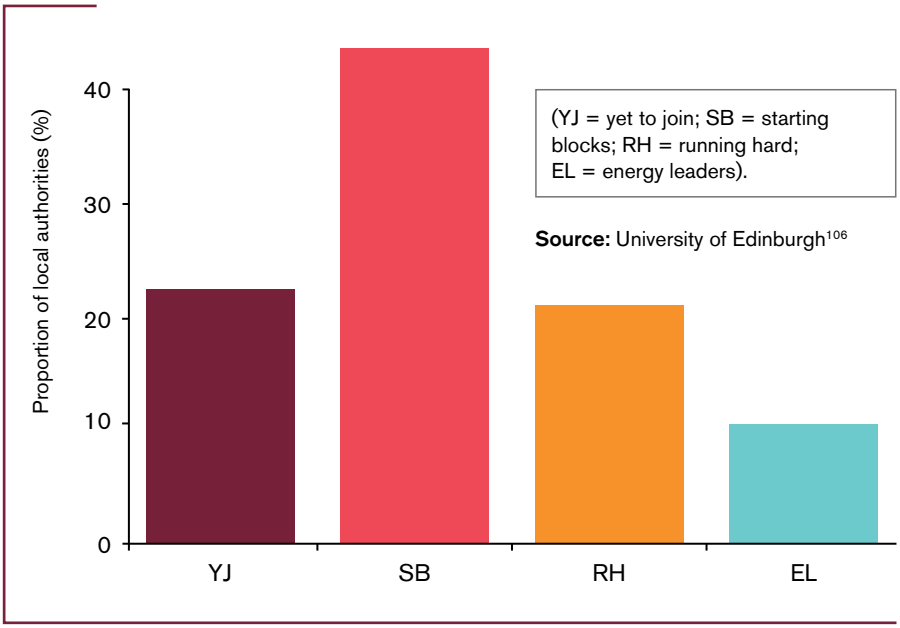
- Installed two wind turbines at Avonmouth, 700kW of solar panels on the city's schools and hundreds of EV charging points
- Begun to build district heating schemes in Redcliffe and Temple and the city centre, with an initial budget of £13 million
- Launched a Warm Up Bristol scheme to install external insulation on high-rise blocks and 3,100 low-rise homes
- Upgraded 22,000 streetlights, and improved the city's bus and cycling infrastructure

Bristol was awarded European Green Capital in 2015. In an interview with the Commission, Bill Edrich, Commercial Director of Bristol City Council, said that none of the technologies being installed is new, but what is innovative is 'stitching them together'. He said the only barrier is the enormous investment needed to expand the city's programmes to match the scale of the challenge.

Bristol estimates that the minimum investment required to achieve its target to become carbon neutral by 2050 is £1 billion. The council has around £900 million in public debt and can borrow no more. For this reason, it plans to issue a prospectus to raise £1 billion in asset-backed financing – in which private investors provide the funds against the security of the physical assets they create, with no financial exposure for the public sector. The prospectus will invite potential investors to discuss with the Council any new business models or legal arrangements they would need to make this work. We believe one way to achieve this would be through an Energy Innovation Zone.

But these examples are the exception. A study by UKERC that assessed local authority engagement with the energy system found that only 30% of local authorities were 'energy leaders' or 'running hard', while 70% were 'on the starting blocks' or 'yet to join' (Figure 14). One witness told us 'each example of brilliance is swamped by hundreds of places that have done absolutely nothing'.

FIGURE 14: CHARACTERISING LOCAL AUTHORITY ENGAGEMENT WITH ENERGY SYSTEMS



Source: University of Edinburgh[106]

The biggest barrier for local authorities is their lack of capacity.[107] After a decade of austerity, many simply do not have the resources or staff to develop ambitious clean energy programmes. Birmingham City Council, for example, has reduced its payroll from 50,000 to 10,000 with a final target of 7,000. Like many councils, it has also disbanded its sustainability team.

Energy is particularly vulnerable to austerity since local authorities have no statutory responsibility or core funding for the subject. In an era of scarce resources, discretionary spending tends to be cut first and hardest. The UKERC researchers found that austerity and frequent changes to national clean energy support schemes were significant factors in slowing down and scaling back local authority investments in clean energy. Interviews and workshops with local authorities produced the following list of barriers:

- Energy provision is discretionary in local government, and resources for discretionary activity are shrinking.
- Energy and sustainability teams were being scaled back often resulting in assembly of a project team from scratch for each initiative. This disrupted institutional memory and pathways for energy developments, making knowledge and expertise more fragmented.
- Internal technical expertise for energy projects is declining and transaction costs of commissioning and contracting can be significant.
- Hence there is no established 'problem owner' for clean energy and energy productivity.
- Austerity in public finances is creating uncertainty over the future of council building stock resulting in delayed or downsized energy efficiency investments.
- Energy policy support for local initiatives was also experienced as unreliable; references were made to setbacks stemming from:
  - Failure of the UK Green Deal
  - Unanticipated and rapid reductions in Feed-in-Tariff rates for small-scale renewable energy
  - Reduced funding and eligible activities from the Energy Company Obligation (ECO) scheme for energy and heating improvements in housing also limited the capacity to plan a programme of retrofit
  - Scaling back of the Carbon Reduction Commitment
  - Removal of the Code for Sustainable Homes in England, zero-carbon housing targets and allowable solutions.[108]

Another major barrier to local authority innovation in clean energy is procurement. The Commission heard evidence that both private companies and local authorities find the process bureaucratic, fragmented and inefficient.

From the companies' perspective, BEIS told us that within one county council area, five district councils had each procured LED street lighting separately, although the total value of the contracts was less than £2 million. One major contractor has now reportedly stopped applying for such contracts because they are too small, over-specified and take too long to agree.

From the councils' point of view, we heard that the rules of procurement are so tight that they are bound to accept the cheapest bid, meaning they usually go with the biggest company even when an SME might offer what the local authority considers better value. According to Councillor Lisa Trickett, 'local authority procurement is the death of innovation'.

The mismatch between the size of local authority projects and the needs of infrastructure investors is also a significant issue. The UKERC study looked at almost 450 local authority projects, of which only five were worth more than £10 million.[109] Yet £10 million is the minimum investment threshold for the Green Investment Group (formerly Green Investment Bank). This suggests that infrastructure investment of potentially hundreds of millions of pounds is being frustrated by a lack of suitably sized projects.

Given the range and height of these barriers, it should come as no surprise that many local authorities are struggling to fulfil their potential role as leaders of clean energy development. BEIS surveyed 55 councils and found a combined £500 million energy projects 'stuck' because they did not have the capacity to carry them out – or perhaps even people with the necessary skills to write the business case. The deep-rooted and specific difficulties faced by British local authorities strengthen the case for a new approach to accelerate local energy innovation.

The Commission also heard evidence that some councils are now driven far more by the imperative to introduce clean air zones and avoid fines for air pollution than by the decarbonisation agenda – for which they have no statutory responsibility. The two objectives are far from contradictory, but this does emphasise the need to develop integrated solutions that satisfy both national and local priorities.

International comparisons

Although there are many inspiring examples of clean energy innovation by cities and local authorities around the world, none provides a cut-and-paste solution for Britain. This is because in many cases municipalities in Europe, the US and elsewhere have far greater statutory responsibilities, powers and independent sources of funding than their counterparts in the UK.

Energy market governance has diverged sharply between Britain and Europe since WWII. In Britain, the electricity and gas industries were first nationalised and later privatised, creating a system where local authorities have little influence. In Europe, by contrast, most countries retained a decentralised approach in which municipalities are deeply involved in local energy markets. There is no single model, but municipalities can act either as owners or regulators of local utilities or grids, and may have powers and funding models that help them invest directly in infrastructure such as district heating (see Boxes 7, 8 and 9 on pages 42–43).

Energy markets are of course liberalised across the EU, but public or co-operative ownership of utilities is still seen as a powerful lever. In Munich, for example, the municipal utility is undertaking a €9 billion investment programme to supply all of the city's electricity from renewables by 2025 (see Box 8 below). Hamburg has bought back its power grid from Vattenfall and plans to do the same with its heat network in 2019.[110] One hundred and seventy German local authorities have 'remunicipalised' their grids since 2007.[111]

In the US, each state regulates its own energy market through a Public Service Commission, and cities often have some form of leverage over their energy supplies, and local tax revenues to invest. New York State is undertaking a fundamental but slow-moving reform process (see Box 9), and South Australia looks set to follow a similar route. But it is individual cities or communities that have made the most progress. Fifty US cities are committed to going 100% renewable, and five have already achieved that target for electricity, including Aspen, Colorado.[112]

Municipalities in other regions tend also to have more power than their British counterparts. In Latin America, for example, Bogota funds expansion of its TransMilenio bus rapid transit network by diverting half the 25% local tax on petrol – fund-raising powers not shared by local authorities in the UK.[113] In 2016, Mexico City issued a $50 million green bond to fund energy efficient lighting, and transport and water infrastructure.[114]

British local authorities can borrow from public markets, which can be cheaper than drawing on the Public Works Loan Board, but rarely do so, partly because their individual borrowing needs are usually too small. In 2014, the Local Government Association set up the UK Municipal Bonds Agency to help local authorities borrow on better terms by pooling the needs of several councils to create a single large bond, although it has yet to issue its first one.[115]

Because we start from an entirely different place constitutionally and culturally, adopting such approaches would mean reforming not only our entire energy system, but also the wider relationship between national and local authorities – which would take far too long. What international comparisons do demonstrate conclusively, however, is the power of local action to accelerate clean energy deployment and innovation, and to outstrip national targets.

> 'Countries can [also] empower their cities to achieve such goals by freeing them to regulate their own power supplies. Mayors in some cities, including Chicago, Seattle, Helsinki, and Toronto, enjoy various forms of leverage over their energy supplies. Some own their own power, others own the distribution system, and still others have the authority to sign contracts with any independent power generator they select. The Chinese government has given major cities, such as Shenzhen, expanded powers to swap out coal for cleaner forms of energy. In Denmark, Copenhagen is now on the path to full carbon neutrality, aiming to reach zero net emissions within a decade.'
> **Mike Bloomberg, President of the Board of C40**[116]

> '[Cities] are capable of making decisions at the right scale and the right speed, and can be quicker than national governments in taking the next steps in the energy transition.'
> **Alix Bolle, Energy Cities**[117]

BOX 7: Copenhagen

Copenhagen has set itself the challenge of becoming the world's first carbon-neutral city, meaning that by 2025 net emissions from energy generation and consumption, transport and the municipal administration should amount to zero.[118] This target is highly ambitious – 25 years ahead of the national one – and the city has already cut C02 emissions 38% since 2005 and 11% since 2014. In common with other Danish municipalities, however, Copenhagen enjoys some major advantages that give it a head start.

One advantage is Denmark's long history of developing district heating schemes, and in Copenhagen 98% of homes are already connected. Since oil shocks of the 1970s, district heating has typically been fuelled by coal or gas, but with the network already in place, it is relatively easy to replace fossil fuels for cleaner sources such as biomass. Copenhagen converted its Avedøreværket combined heat and power station to biomass in 2016, meaning that half the city's district heat now comes from carbon-neutral fuels.

Another advantage is Denmark's system of public utilities. Copenhagen owns HOFOR, which supplies gas, water, district heating and operates wind farms, and Ørsted (formerly DONG) which supplies electricity only, also including wind. Like all Danish municipal utilities, both operate as commercial companies – subsidy is forbidden – but as the sole shareholder, the city can give them strategic direction. HOFOR will replace another coal-fired CHP plant with biomass at Amagervaerket, making Copenhagen's district heating system entirely renewable by 2020. It also plans to build 360MW of wind turbines, including large offshore farms, to help make the city's electricity supply carbon neutral by 2025 and offset its transport emissions. None of this requires direct investment by the city.

While much of Copenhagen's climate plan is being delivered by its utilities, the city does also invest directly, for example in its world-leading bicycle infrastructure, and its Energy Leap programme to raise the efficiency of commercial buildings.

Capital investment by municipalities is supported by Kommunekredit, a communal bank owned by Denmark's local authorities. Its bonds are guaranteed by the local authorities jointly and severally and are rated AAA. In 2017, Kommunekredit issued its first green bond, raising €500 million to invest in district heating, energy efficiency, clean transport and water management.[119]

Danish politics generally strives for consensus, and there is strong and widespread popular support for action on climate change. It does also suffer from nimbyism, however, which Copenhagen has adopted smart measures to overcome. Objections to the Middlgrunden near-shore wind farm just outside Copenhagen's harbour were assuaged by offering local people the chance to invest in it themselves, for example. And the roof of the new state-of-the-art CHP waste incinerator at Amager Bakke has been designed to double as an artificial ski-slope![120]

Not everything has been easy for Copenhagen's climate plan however. Two other offshore wind farms have been stymied by local objections, and the city's plans to introduce a congestion charge were blocked by neighbouring municipalities and the national government. Nevertheless, it is clear the city has greater powers and resources than those available to local authorities in the UK.

BOX 8: Munich

Like Copenhagen, Munich enjoys some important advantages – including ownership of the main local energy supplier. Stadtwerke Munchen (SWM) is Europe's largest municipal utility, a conglomerate that owns the wires and pipes; supplies electricity, gas, water and telecoms, and also operates metro, bus and tram services. It operates in a liberalised market on an entirely commercial basis, with revenues of €6.5 billion in 2016,[121] but the city sets its strategic direction.

Since 2008, when the city joined the Covenant of Mayors, SWM has pursued an ambitious energy transition strategy. It plans to generate all its electricity from renewables by 2025, and all its district heating energy by 2040[122] – largely from geothermal.

SWM has invested heavily in renewable generation including solar, hydroelectric, biomass, geothermal and wind. It cannot generate all the renewable electricity it needs locally, so has invested not only within the city limits but also across Europe. The company owns a large-scale solar park in Spain, onshore wind in Norway, Sweden and France, and even has stakes in huge offshore wind farms including Sandbank (288MW) in the German North Sea and Gwynt y Mor (546MW) in Liverpool Bay.[123] [124] [125]

The company has also developed a virtual power plant made up of decentralised renewable generating plants with a total capacity of 80MW and large industrial consumers that operate as a single system and allows the utility to predict loads precisely.[126]

SWM is already well on the way to achieving its 2025 target. Having invested around €3 billion so far, it now generates around 50% of its electricity from renewables, and says it will invest another €3–4 billion to reach 100%.[127] Its district heating expansion will cost several hundred million Euros.

BOX 9: New York

In 2014, the governor of New York State, Andrew Cuomo, launched 'Reforming the Energy Vision' (NY REV), which is intended to transform the electricity grid from a top-down system dominated by a handful of utilities into a dynamic platform in which third-party providers help balance supply and demand locally and ease grid constraints. While NY REV is indeed a fundamental reform programme, which should enable the state to accommodate more intermittent renewable energy than otherwise, we believe its relevance to our inquiry is limited.

The electricity system in New York State is tightly regulated – perhaps even more so than in the UK. Utilities have traditionally been paid on a cost-plus basis: the cost of capital expenditure has been passed through to customers with a regulated rate of return for the utility charged on top. This has typically encouraged utilities to tackle grid constraint and balancing problems through conventional solutions such as building wires, pylons and sub-stations, rather than more innovative approaches such as energy storage and demand management. The flagship project of NY REV is the Brooklyn-Queens Demand Management Program (BQDM), under which ConEd will defer for a decade the construction of a new sub-station by investing in a variety of demand management and storage technologies.

NY REV is meant to change the way utilities are rewarded so as to encourage them to invest in 'non wires' solutions. Eventually, reformers hope that two-thirds of utility earnings will come from transactions and meeting specific policy targets, and only one-third from cost-plus investment. This necessarily involves a great deal of detailed negotiation over rate design – which has led to criticism that the process is slow.[128] 'That is true, but necessary if we want to get it right', Margarett Jolly, a director of ConEd, told the Commission in an interview.

NY REV illustrates the difficulty of reforming a large system – New York is a state of 19 million people, the size of a medium-sized European country – where the risks of getting it wrong are simply too high for haste. Since national energy market reform is necessarily a long drawn-out process, we believe there is an important role for nimbler, local energy innovation – supported by the Energy Innovation Zone.

British policy: devolution, energy and innovation

During the last century, Britain became one of the most centralised states in Europe. Since 2010, however, the government has embarked on a broad policy to return decision-making powers to local areas through a series of regional devolution deals, city deals and growth deals. These have given the new city-region mayors and Local Enterprise Partnerships the powers to develop plans to boost local growth. Devolution has begun to include aspects of clean energy through:

- **Cornwall devolution deal**. This is the only regional devolution deal so far to include substantive plans for clean energy. The main elements included government support for Cornwall's development of its geothermal resource; a second Enterprise Zone to support low-carbon heat; and energy efficiency measures.[129] Elements of the deal point towards important features of the Energy Innovation Zone (see Box 10 overleaf).
- **The second West Midlands devolution deal**.[130] Announced in November 2017, this supports the West Midlands Policy Commission on work related to this report, including £120,000 for local energy strategy development and contributions from BEIS and Ofgem officials. The second devolution deal also refers to a potential £1.12 million funding for Midlands Engine LEPs for which West Midlands Combined Authority projects could be eligible.
- **BEIS Local Energy policy**. BEIS has a developed a local energy policy to bolster the capacity of LEPs and local authorities through five new regional BEIS offices. The government awarded 38 LEPs a total of £1.6 million to develop energy strategies in 2017. A further £2.7 million will be released in 2018 to help LEPs and local authorities to identify clean energy opportunities and work-up proposals to the point where they can attract investment.

Although devolution is beginning to include energy policy, much of the Industrial Strategy and Clean Growth Strategy will be delivered through national initiatives such as the grand challenges and sector deals, and national bodies such as the newly formed UK Research and Innovation. We believe the impact of these policies could be greatly reinforced by further devolution of powers and funding around clean energy innovation.

The question then is how best to achieve this. Since local authorities' powers and capacity are limited, and since international examples are not directly transferable to the UK, we believe we need to develop a new and distinctly British approach. For the first time, this would fully integrate the strategic objectives of the Industrial and Clean Growth strategies with those of the devolution agenda to develop a new take on local energy innovation: the Energy Innovation Zone.

BOX 10: Cornwall devolution deal

In 2015, Cornwall became the first – and so far, only – region to secure a devolution deal that includes substantive measures on clean energy innovation. These reflect problems and resources specific to the area, and include the development of geothermal energy, marine and thermal Enterprise Zones, and a home efficiency scheme tailored to local architecture.

Cornwall's geothermal resource is big enough in principle to supply a fifth of UK electricity demand, but the hot rocks are buried several kilometres deep and the technology is relatively immature, making early projects expensive to develop.[131] Under the devolution deal, the government provided no new money for geothermal, but agreed to consider introducing a subsidy mechanism if Cornwall could prove the resource itself. This unlocked an £18 million deal to fund the United Downs Deep Geothermal Power project, comprising £10.6 million from the European Regional Development Fund, £2.4 million from Cornwall Council and £5 million from the private sector.[132] The pilot plant will provide baseload generation of 1MW, and drilling is under way. Cornwall believes the technology could eventually turn the region into a net energy exporter and transform its economy.

Officials in Cornwall say the most important aspect of the deal was the agreement to let the county modify the national Energy Company Obligation (ECO) energy efficiency scheme to meet local needs. ECO obliges energy suppliers to improve the energy efficiency of houses and reduce fuel poverty through measures such as insulation and boiler replacement. The scheme incentivises suppliers to reduce carbon emissions using cheaper methods such as loft and cavity wall insulation rather than more expensive ones such as solid wall insulation. But Cornwall has high levels of fuel poverty (14.5%), and a high proportion of houses with solid walls (41.5%).[133] In the two years following the introduction of ECO, only *three* solid walled houses in Cornwall were insulated under the scheme. The new ECO Flex scheme allows Cornwall to choose which houses to prioritise for energy efficiency improvements under social criteria including poverty and health.[134] Fewer houses will be treated overall, but action will target those most in need.

The devolution deal allows Cornwall to set up a low-carbon thermal Enterprise Zone to make use of waste heat, although the location has not yet been decided. Potential sites include the United Downs project and a recently completed energy-from-waste plant near St Dennis. It also transferred control of the Wave Hub[135] demonstration facility at Hayle from the government to Cornwall and allowed the county to set up a marine enterprise zone around it, which is now active. The deal also included plans to ease Cornwall's highly constrained electricity grid through batteries and other measures – although these are less advanced.

By tailoring energy policy to local resources (geothermal) and needs (energy poverty, solid wall insulation), and by adjusting national regulation to match local priorities (ECO Flex), the Cornwall devolution deal points towards some important features of the Energy Innovation Zone.


RESIDENTIAL
COVENTRY ROAD
A45
RETAIL
INDUSTRIAL
RETAIL / BUSINESS AND INDUSTRIAL
5
WEBSTER & HORSFALL FACILITY TO REMAIN
RESIDENTIAL
RESIDENTIAL
4
CENTRE OF EXCELLENCE
RESI
SPEEDWELL ROAD
3
2
INDUSTRIAL
INDUSTRIAL
EXISTING WASTE TO ENERGY PLANT
MILL POND
1
GRAND UNION CANAL
INDUSTRIAL
OPEN SPACE
VEOLIA EfW
LEAT
INDUSTRIAL
INDUSTRIAL

4. THE ENERGY INNOVATION ZONE

The Energy Innovation Zone (EIZ) is a new concept designed to tackle the specific challenges of accelerating clean energy innovation in Britain today. We have shown that clean energy innovation is going far too slowly to achieve either our environmental targets, particularly in heat, transport and system integration, or take advantage of the global economic opportunities identified in the Industrial Strategy (section 1). We have also shown that Britain, while highly inventive, has been weaker at commercialising its own inventions than some other countries, and that clean energy innovation in this country faces a range of specific barriers (section 2). We have argued that for technical, economic and political reasons the later stages of clean energy innovation are better undertaken at the local level, and that in many cases British local authorities are less well equipped to lead this process than their counterparts abroad (section 3). The single intervention that would begin to tackle all of these issues at once is the Energy Innovation Zone. If introduced, EIZs would for the first time fully integrate the aims of the Industrial Strategy, Clean Growth Strategy and the Ofgem 'Sandbox' with those of the government's devolution agenda.

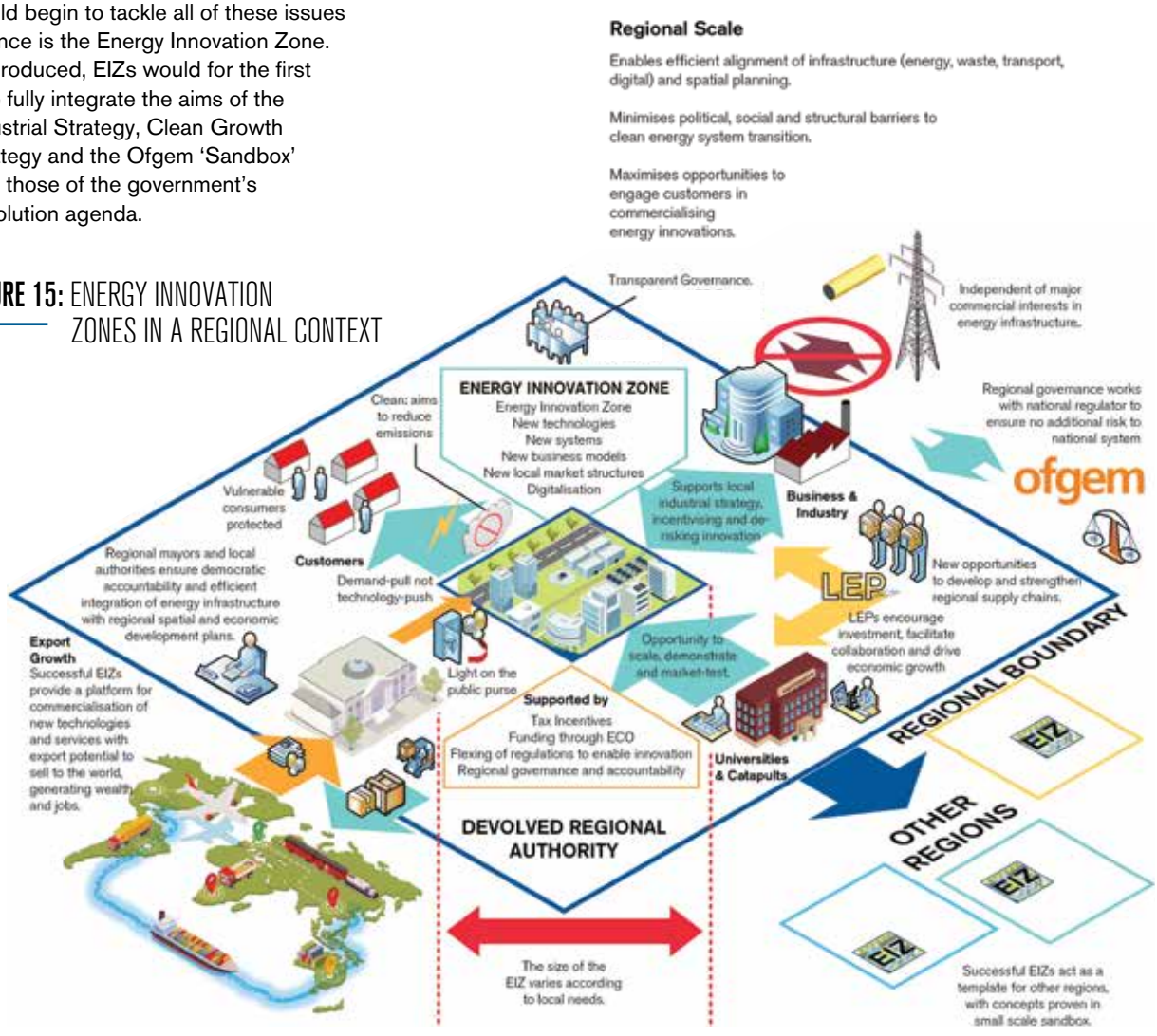
BOX 11: What is the Energy Innovation Zone?

EIZs are designed to stimulate local and democratically accountable clean energy innovation to drive productivity, exports and growth. Unlike existing approaches, they will work not only to demonstrate new technologies, but also to turn them into fully commercial propositions. Their main focus will be the on the systems integration of proven low-carbon technologies; the business models and market arrangements needed to support new approaches to clean energy; and the regulatory and other barriers that must be overcome for them to flourish.

The EIZ recognises that decentralised energy, digitization and system integration will revolutionise markets and dramatically reduce emissions and cost, and the need to integrate energy, waste and transport. It will embrace local and regional identity to bridge the yawning gap between people, innovation and national energy markets: individual EIZs will be big enough to create or serve a local market, but small enough for people to relate to.

The EIZ will galvanise local energy innovation and attract external investment to deploy solutions that reduce emissions and cost for the area; spawn regional markets and supply chains that provide a platform for exports and growth; de-risk future investment; and inform new standards and regulatory frameworks that could be applied in other regions and even nationwide.

FIGURE 15: ENERGY INNOVATION ZONES IN A REGIONAL CONTEXT



BOX 12: Key features

Key features of the EIZ include:

- **Environmental and economic:** Aims to reduce emissions and costs, and stimulate growth and improvements in productivity, by speeding the progress of clean energy technologies and business models to market.
- **Competitive:** Creates a competitive market in clean energy infrastructure to meet local needs and priorities, and does not pick low-carbon winners; 'demand pull' not 'technology push'.
- **Regional:** Bridges the yawning gap between people and national energy markets, and taps regional identity to build support for energy innovation.
- **Democratically accountable:** Through local authorities and regional mayors.
- **Social:** Providing appropriate levels of protection for domestic customers, especially those in fuel poverty.
- **Collaborative:** Brings together universities, companies, local authorities and regulators. Lessons about local energy markets, regulation and innovation are shared regularly between EIZs and externally.
- **Independent** of major commercial interests in current or future energy infrastructure, and with transparent governance.
- **Innovative:** Creates a space in which new technologies can be deployed, demonstrated at scale and de-risked for future investment to take to market. Also supports technologies that have already been shown to work, but which need commercial scale demonstration of the business model. Extends to SMEs the capacity to conduct commercial demonstrations at a scale only previously possible for incumbents with large balance sheets.
- **Clears regulatory and cultural barriers:** Where legislation allows, specific regulations are waived, amended or introduced to permit cost-effective commercial demonstrations. Different EIZs would flex different regulations depending on priorities – district energy, domestic heating, hydrogen, EVs etc. This may in turn lead to the development of new national regulations.
- **Flexible:** Size and focus varies according to local needs and priorities, but an EIZ should be large enough in terms of energy demand to support the development of supply chains, commercial clusters and regional markets.
- **Light on the public purse:** EIZs could be funded by reallocating existing funding streams such as the ECO, or through other innovative 'value capture' mechanisms, so avoiding the need for substantial extra public expenditure. EIZs could also – like Enterprise Zones – be financed through tax incentives, and in some places it might make economic sense to integrate an EIZ with an existing Enterprise Zone.

What will Energy Innovation Zones do?

EIZs are the missing link in the UK innovation eco-system for energy. We have small-scale technology demonstrators and we have competitive national market structures, but we lack a supportive space in which to prove and deploy new *integrated approaches at scale*. The EIZ will:

- Demonstrate new clean energy technologies and approaches at scale in a competitive market defined and regulated to meet local needs
- Focus especially on integration between energy systems, such as electricity and heat, and between energy and other systems, such as transport and waste
- Concentrate on the new business models and market arrangements needed to support novel technologies and approaches
- Reduce or remove regulatory and other barriers to test new business models, which will in turn:
  - help define regulatory reforms that ensure that the interests of energy customers are protected, and identify changes needed to allow beneficial new technologies and business models to flourish
  - de-risk future investments to roll out these new technologies across Britain and worldwide
- Generate local political consensus around clean energy investment opportunities, giving investors and other stakeholders confidence that political risks will be minimised

The most visible activity of the EIZ will be to facilitate commercial-scale demonstrations of innovative clean energy technologies and approaches with real customers and infrastructure. The EIZ is not just an early-stage technology demonstrator, but also provides a controlled environment in which innovators of all types can trial new services and business models, and policy-makers and regulators can evaluate what reforms are needed to allow these approaches to compete in the wider energy market. From an innovator's perspective, the path from highly subsidised demonstration project to investable proposition is often blocked by regulations designed for and by incumbents. The EIZ will clear these and other barriers, and de-risk new technologies deployed within the zone.

Some of the clearest ways to reduce emissions and cost involve integrating across energy systems, and integrating waste streams into energy production – such as municipal waste gasification, and waste heat recovery. These are harder to achieve because they often require collaboration across sectors and between companies that have never worked together before. An EIZ might therefore concentrate on supporting and demonstrating the technologies and business models needed to solve these problems and make best use of available waste resources. All EIZs would require strong local political support.

BOX 13: EIZs and the Ofgem Sandbox

Ofgem has already recognised one of the underlying problems we are trying solve with its 'Sandbox' arrangement, under which an innovator can negotiate the relaxation of a specific regulation to allow it to demonstrate a novel business model. In the first round, in February 2017, Ofgem received 30 applications, and approved five projects to trial various innovative tariffs and peer-to-peer energy trading platforms with some form of regulatory relaxation for up to two years.[136]

Ofgem's Sandbox is an excellent first step, but we believe too limited at this stage to solve this problem by itself.

Each Sandbox project is a bespoke arrangement negotiated between the regulator and a single company or consortium, rather than a general dispensation; the details of the regulations that have been flexed are kept confidential to protect commercial interests, and the projects have so far been of a limited scale.

The EIZ would build on the Sandbox approach by creating a legislative provision and geographical space with an agreed set of regulatory waivers or adaptations in which innovators compete to achieve locally determined goals. Instead of regulatory flex being negotiated on a company-by-company basis, with the details kept secret, the EIZ would establish regulatory waivers or changes that would be publicly known and apply to all-comers within the zone. This would create a competitive market rather than a single, small-scale demonstration. The EIZ would also lever the power of regional identity and resources in a way that Ofgem, as a national regulator, could not.

This combination of regulatory flexibility, open platform and local focus will encourage the development of regional markets with the potential to stimulate both local supply chains and products and services for export. The results will also help policy-makers and regulators understand what permanent reforms are needed to support innovation in the region and across the country.

How would it work?

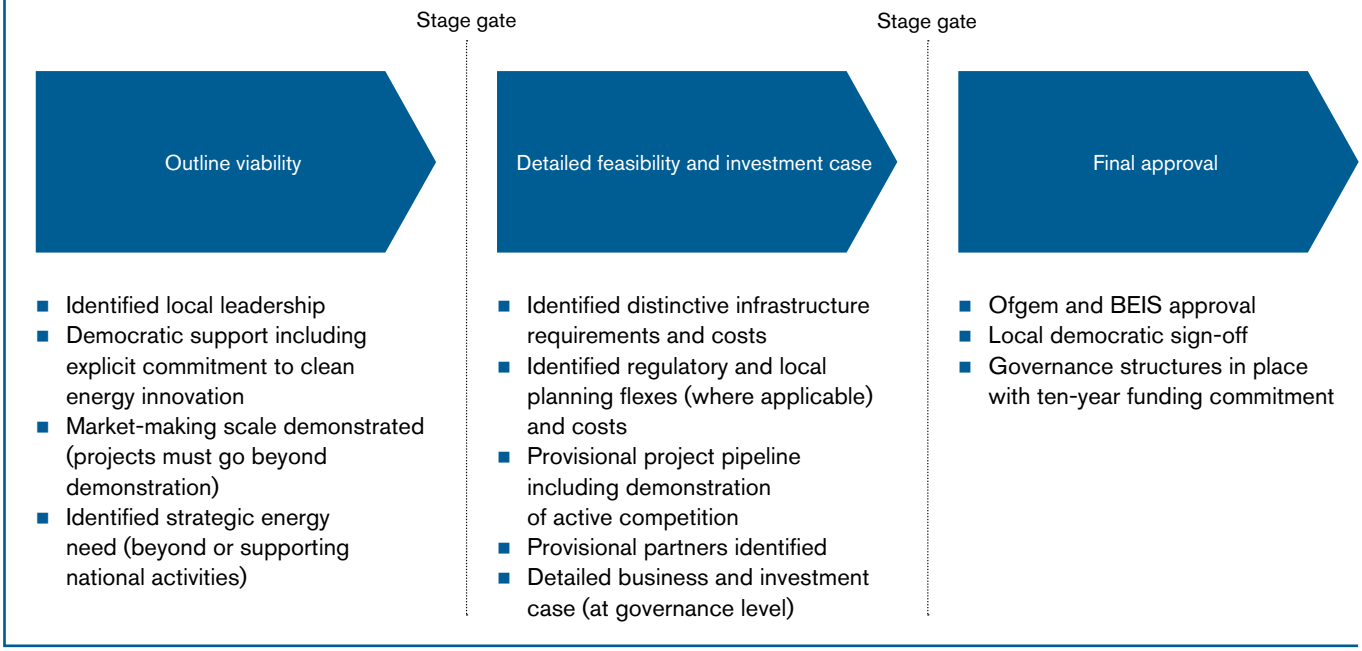
The Energy Innovation Zone (EIZ) is intended to support clean energy innovation to accelerate the reduction of emissions and cost in a particular area. It would typically be proposed by an alliance of companies, business organisations such as Local Enterprise Partnerships, universities and the local and regional authorities. The precise make-up of this group would differ from place to place, and the only essential sponsor would be the local authorities, through which the EIZ would be democratically accountable. In the West Midlands, this would be the Mayor and the West Midlands Combined Authority. The EIZ would also work closely with sub-regional local authorities, regulators, national government and investors. The process for setting up an EIZ could look like that described in Figure 16.

The geographical size of each EIZ would be a function of its purpose, and that would be determined by local priorities. These would be established through consultation with and by the local authorities. The priority might be energy poverty in one area, industrial energy prices in another, and low-carbon transport infrastructure in yet another – or some combination of these and other priorities. The role of the EIZ is to foster clean energy innovation to meet those challenges within its boundary.

Except for specifying clean energy – meaning low carbon and low emission – the EIZ is strictly technology neutral and does not presume to prejudge the answer to each problem. Instead, it develops a hypothesis about the barriers that have prevented the problem from being solved already. This hypothesis would then be tested and refined through further consultation and legal review, then developed into a proposal to be agreed with regulators and national government. The EIZ does not pick winners, but defines a market in which a variety of technologies compete to tackle the challenge identified.

The proposal would differ from place to place, but would probably include a request to suspend, vary or introduce specific regulations within the zone – which might affect not only energy markets but also infrastructure, planning, transport and waste – and identify potential funding streams (see *Funding* on page 64). Examples of regulations that might be flexed include ECO rules, arrangements for district heating, and local authority roles. Some forms of flexibility may be bespoke to individual consumers, such as accepting demand management schemes or limitations on use of connections in return for lower connection costs.

FIGURE 16: PROVISIONAL EIZ PROCESS



Size and purpose

We propose the following four initial EIZs for the West Midlands (see Appendix 1 for detail), which give an idea of the potential variety in size and purpose. These are at varying stages of development, but all meet the fundamental criteria of being locally proposed, led and democratically accountable, and willing to explore distinctive innovative solutions.

FIGURE 17: FOUR INITIAL EIZS FOR THE WEST MIDLANDS

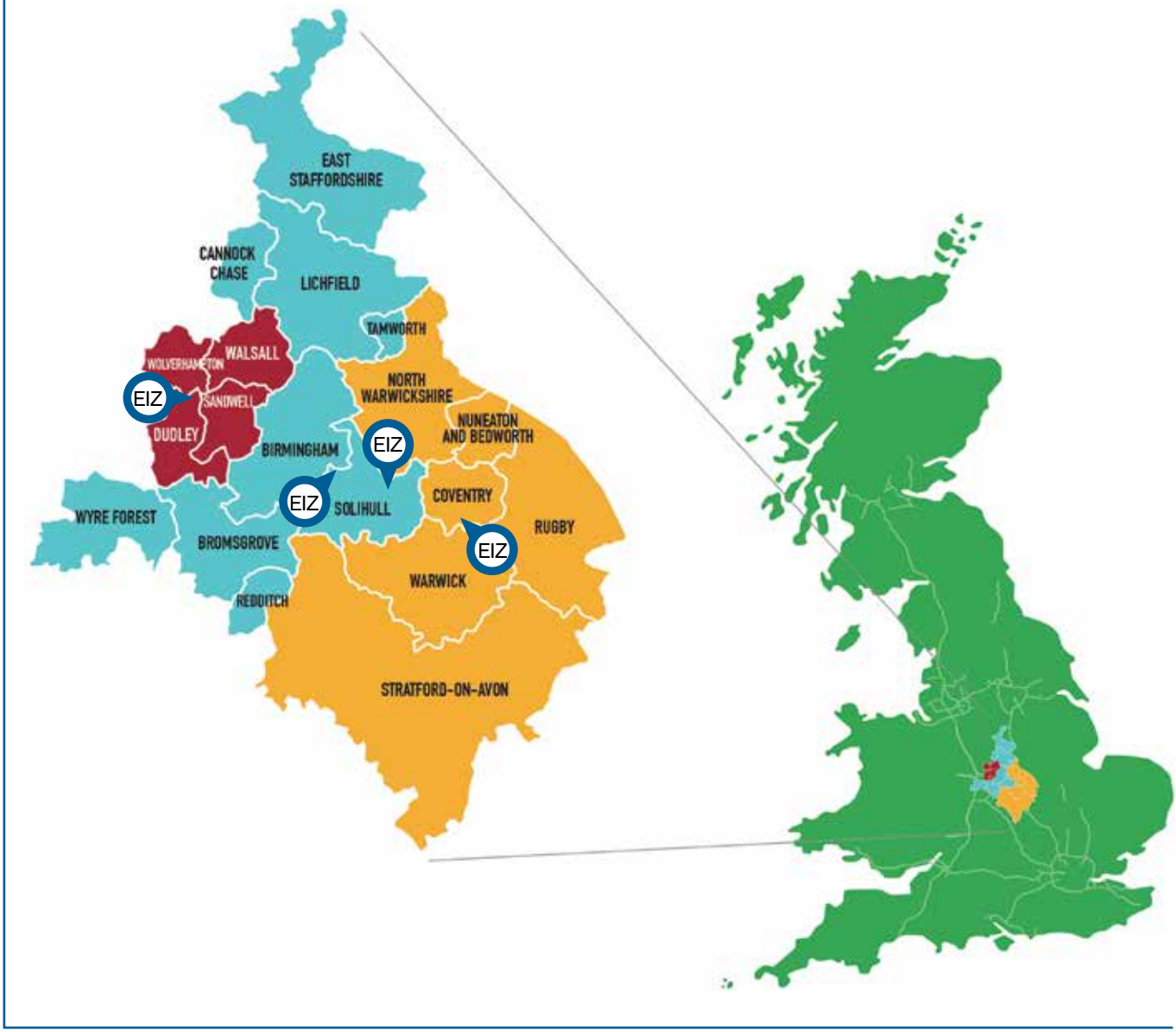
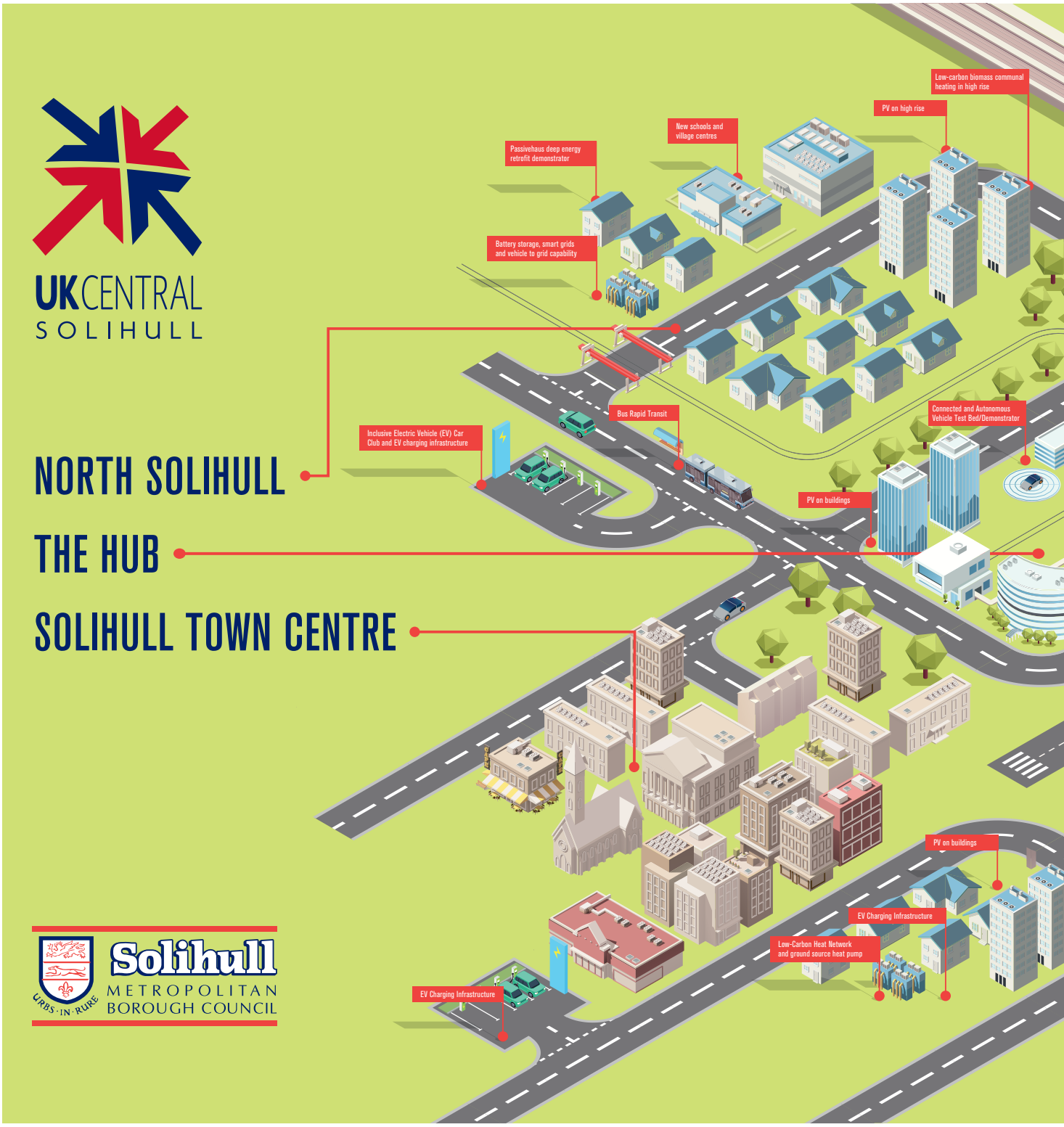


FIGURE 18: UK CENTRAL HUB

Covers five sites clustered around Birmingham International Station, including Birmingham Airport, the National Exhibition Centre, Birmingham Business Park, the Arden Cross development and Jaguar Land Rover's Solihull plant. All are heavy consumers of energy, and demand is forecast to rise steeply with the development of HS2 and the surrounding sites. UK Central Hub is one of the most concentrated multi-modal transport interchanges in the UK, and represents a unique opportunity to create new transport and energy infrastructure to allow the delivery of a nationally significant commercial development. The Urban Growth Company, which is coordinating the development, is concerned about the timely construction of the required grid capacity, and has recently started to investigate the technical and economic viability of a heat network.



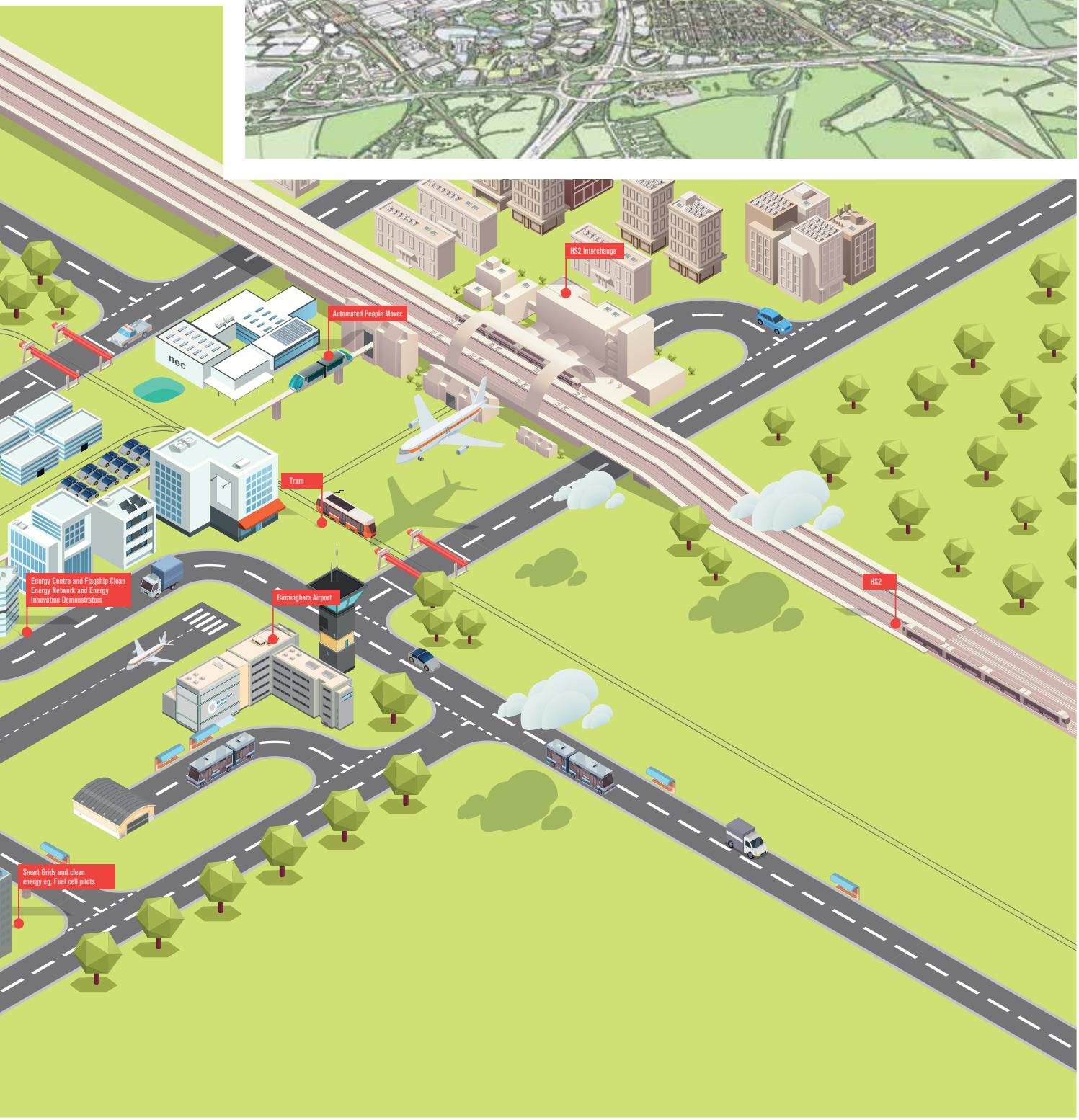
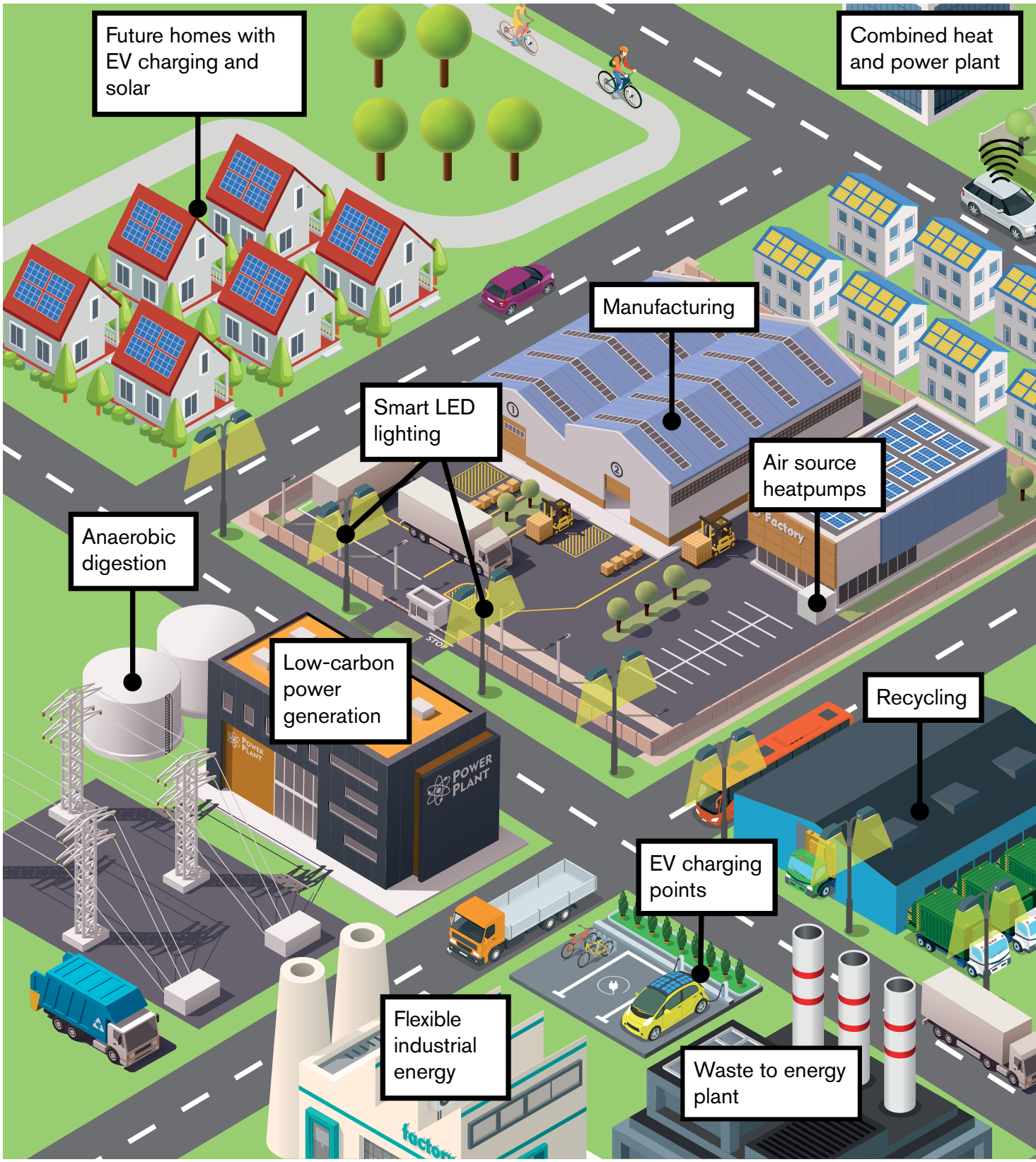

HS2 Interchange
Automated People Mover
nec
Tram
Energy Centre and Flagship Clean Energy Network and Energy Innovation Demonstrators
Birmingham Airport
HS2
Smart Grids and clean energy eg, Fuel cell pilots

FIGURE 19: SOUTH COVENTRY

Covers Whitley, Bagington and a wide area around Coventry airport. This area is well served by transport networks, and significant growth is planned. There is little spare capacity in the local electricity network, yet demand is forecast to rise significantly over the next decade. Other areas of planned expansion in Coventry and Warwickshire are Gaydon and Ansty, which are also grid constrained. Like UK Central Hub, these areas of economic growth and grid constraints need to develop timely and cost-effective clean energy solutions, which an EIZ could facilitate.



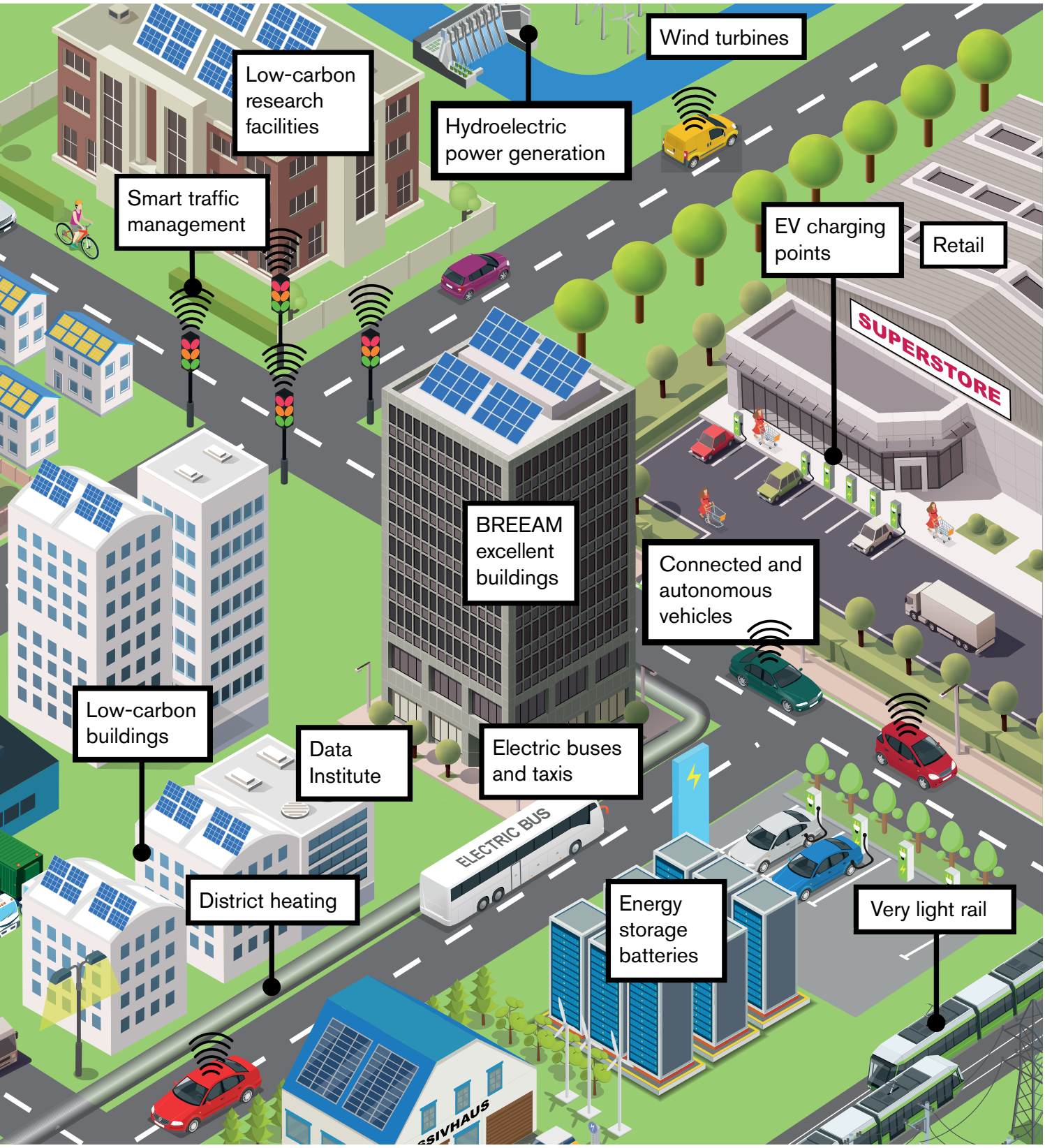
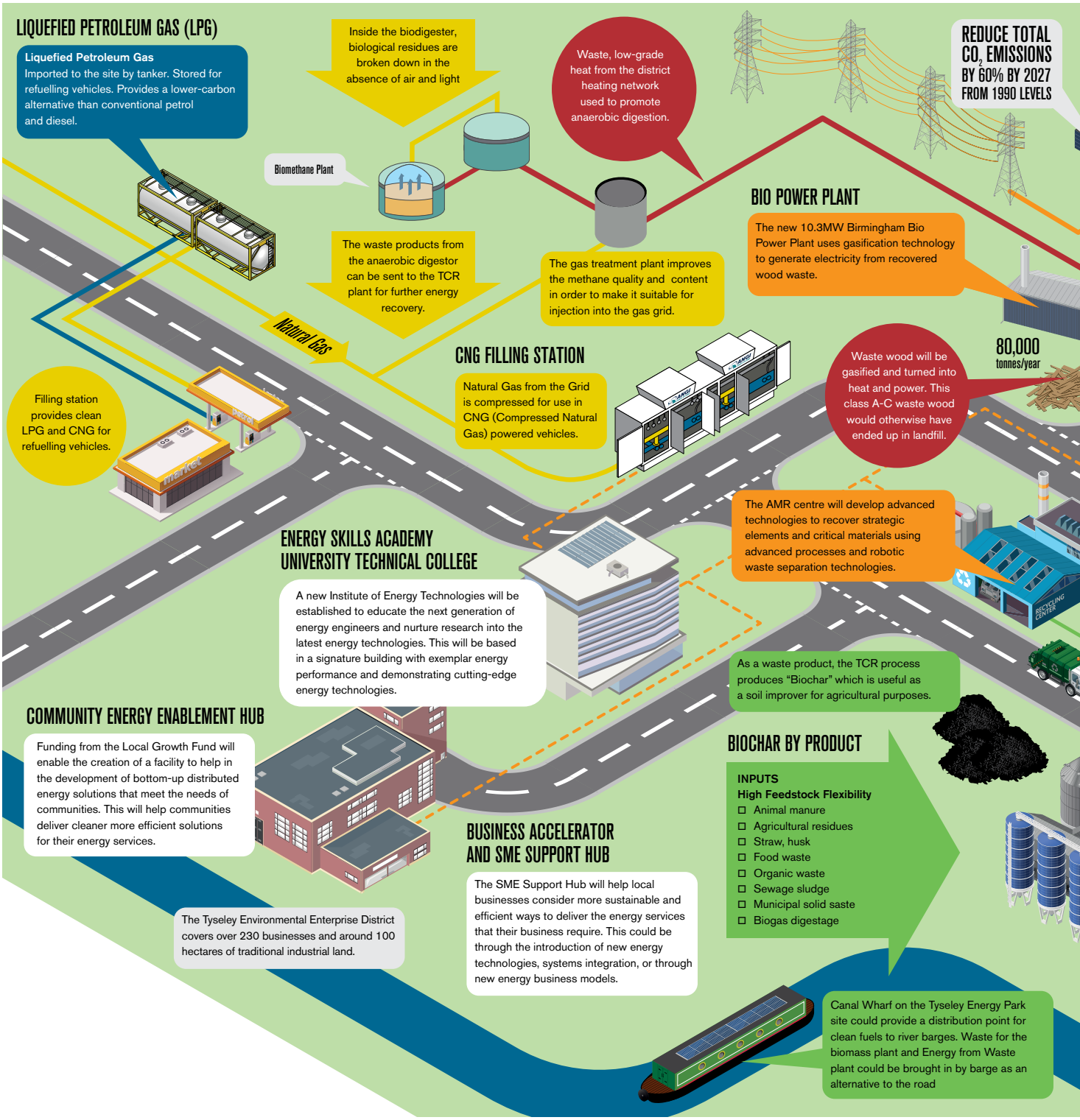

Wind turbines
Low-carbon research facilities
Hydroelectric power generation
Smart traffic management
EV charging points
Retail
SUPERSTORE
BREEAM excellent buildings
Connected and autonomous vehicles
Low-carbon buildings
Data Institute
Electric buses and taxis
ELECTRIC BUS
District heating
Energy storage batteries
Very light rail

FIGURE 20: BIRMINGHAM

Birmingham City Centre, including Tyseley Energy Park – Birmingham suffers a constrained electricity network, some of the highest levels of fuel poverty in the country and poor air quality. But there are also major opportunities: more than £1 billion of regeneration around a new HS2 terminal; expansion of the city centre heat network; the mandatory introduction of a Clean Air Zone by 2019; and the development of an innovative energy park at Tyseley. The site's owners have already built a 10MW biomass plant and private wire electricity supply, and aim to turn it into the city's hub for waste reprocessing and low-carbon transport fuel, with production and refuelling facilities for hydrogen, biofuels, EVs and natural gas. There are also plans to recycle waste heat from the 25MW energy-from-waste incinerator next door into the city's heat network.



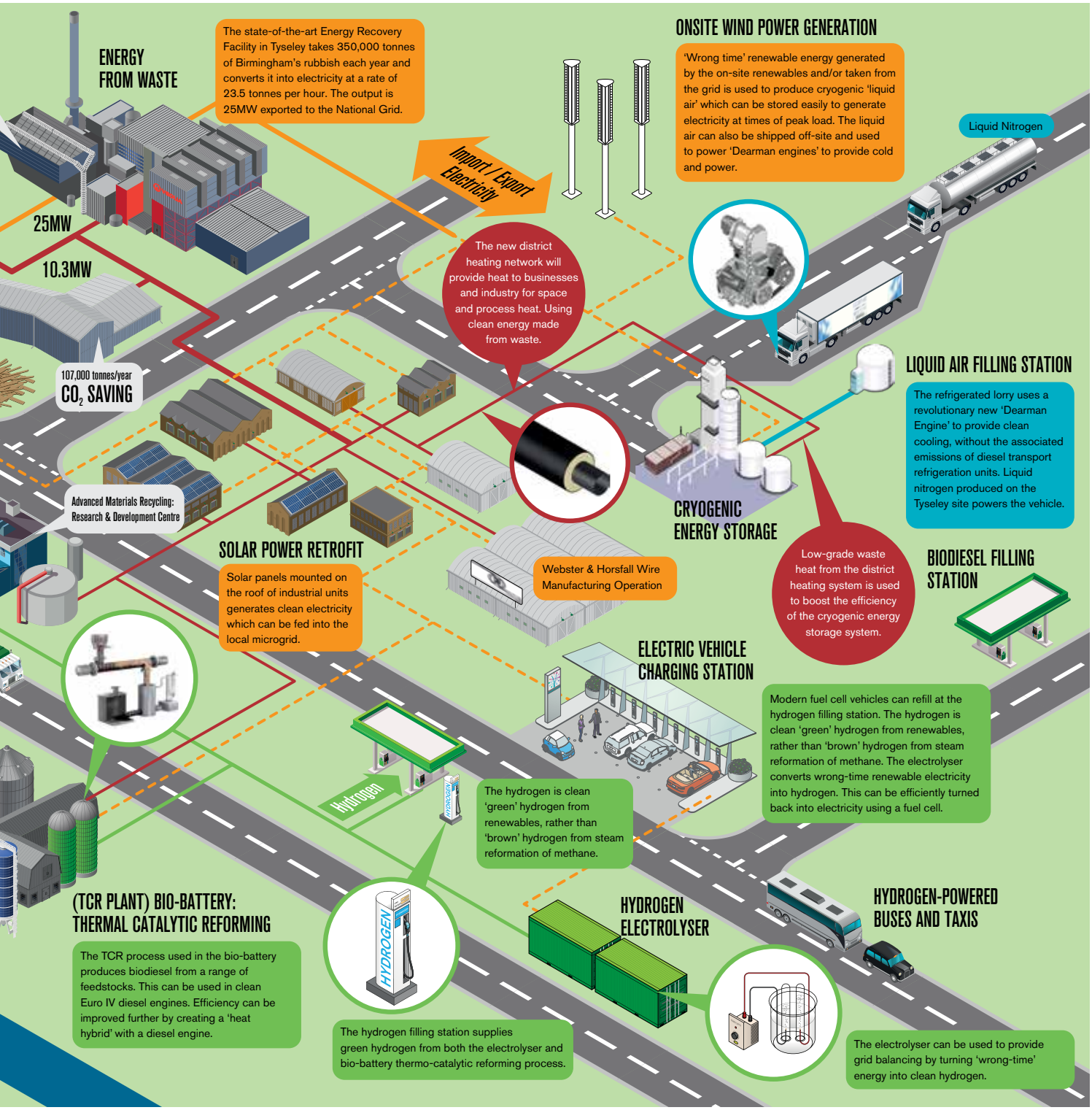
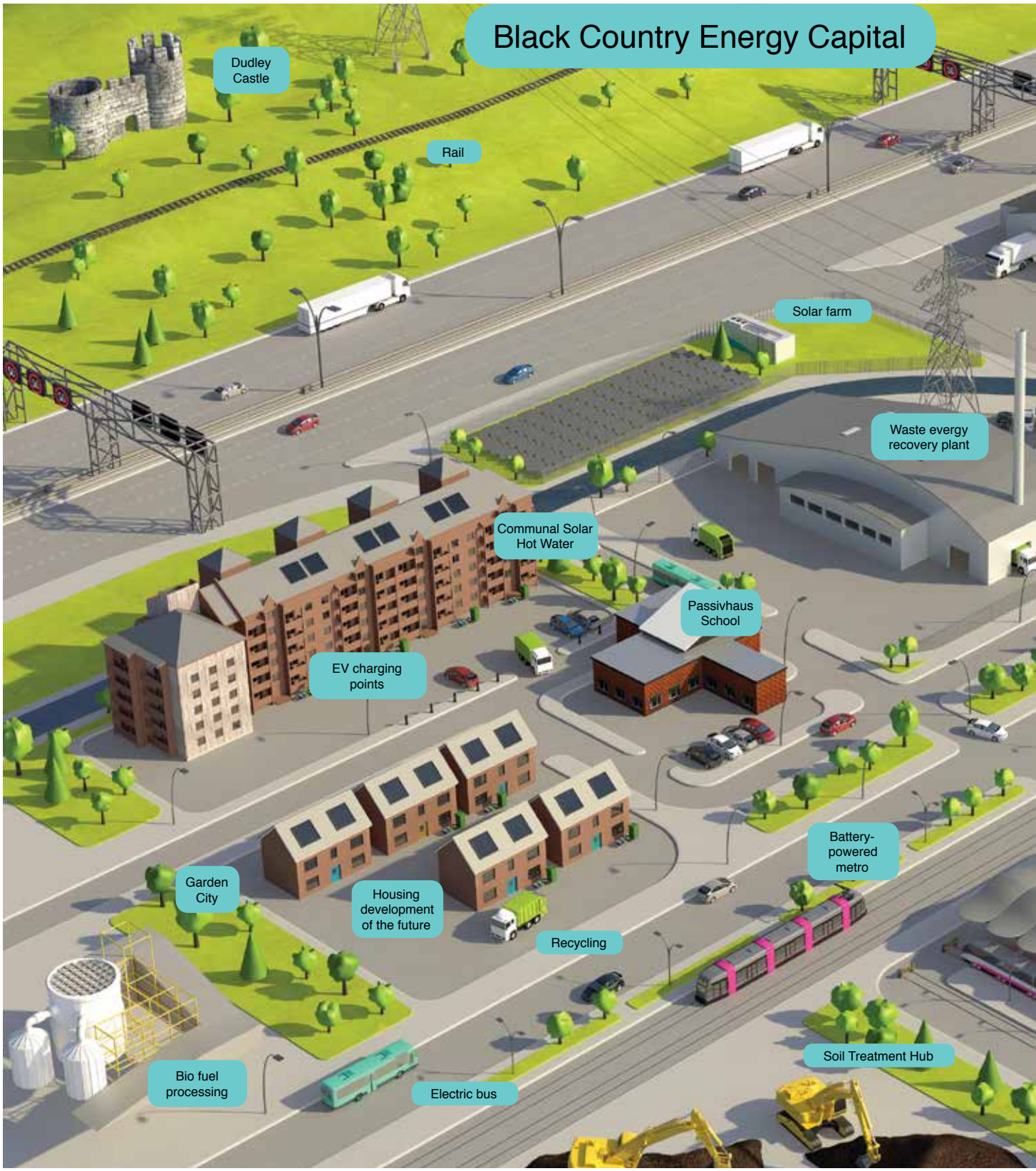
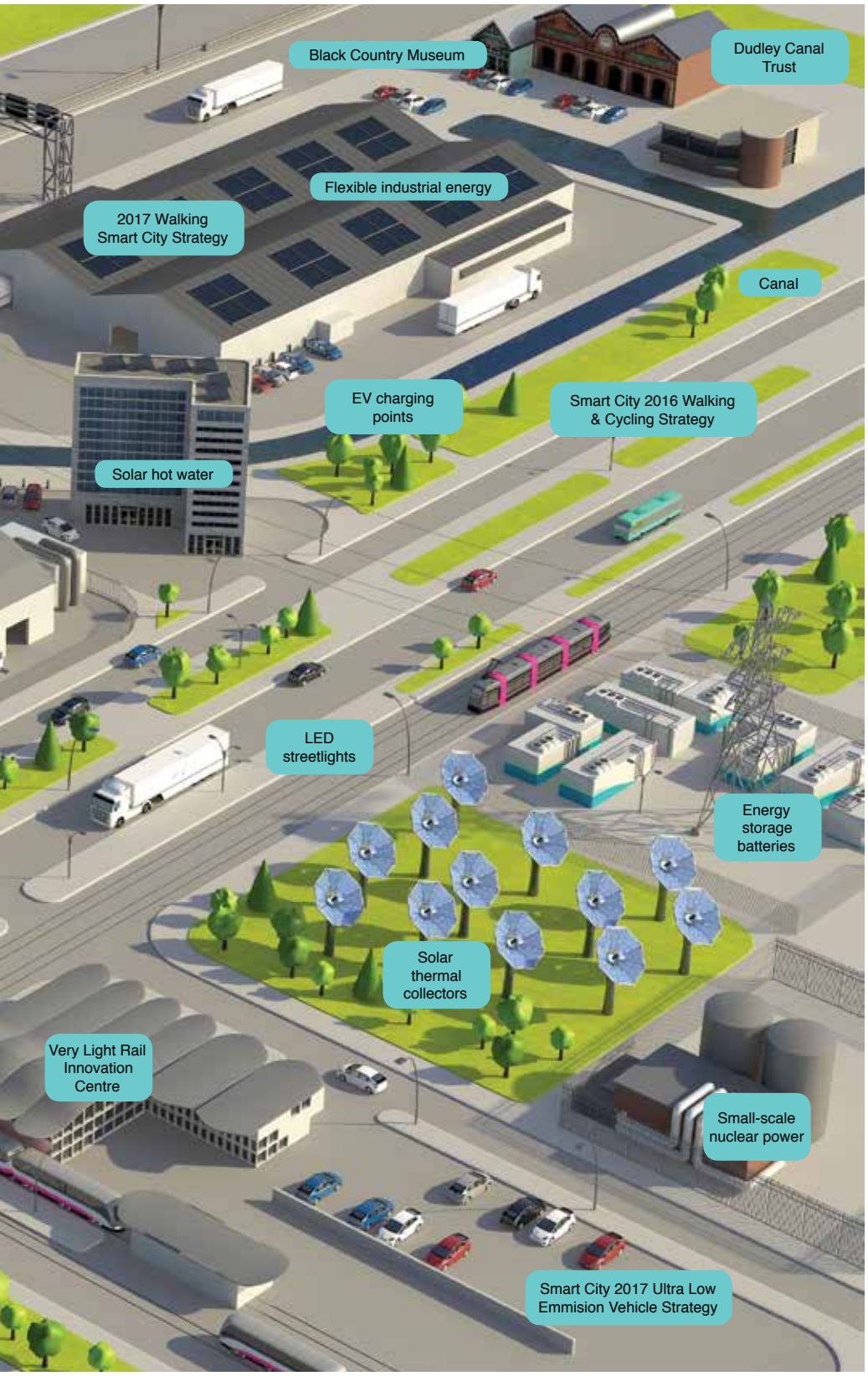

ENERGY FROM WASTE
The state-of-the-art Energy Recovery Facility in Tyseley takes 350,000 tonnes of Birmingham's rubbish each year and converts it into electricity at a rate of 23.5 tonnes per hour. The output is 25MW exported to the National Grid.
25MW
10.3MW
Import / Export Electricity
ONSITE WIND POWER GENERATION
'Wrong time' renewable energy generated by the on-site renewables and/or taken from the grid is used to produce cryogenic 'liquid air' which can be stored easily to generate electricity at times of peak load. The liquid air can also be shipped off-site and used to power 'Dearman engines' to provide cold and power.
Liquid Nitrogen
The new district heating network will provide heat to businesses and industry for space and process heat. Using clean energy made from waste.
107,000 tonnes/year CO_2 SAVING
LIQUID AIR FILLING STATION
The refrigerated lorry uses a revolutionary new 'Dearman Engine' to provide clean cooling, without the associated emissions of diesel transport refrigeration units. Liquid nitrogen produced on the Tyseley site powers the vehicle.
Advanced Materials Recycling: Research & Development Centre
CRYOGENIC ENERGY STORAGE
Low-grade waste heat from the district heating system is used to boost the efficiency of the cryogenic energy storage system.
SOLAR POWER RETROFIT
Solar panels mounted on the roof of industrial units generates clean electricity which can be fed into the local microgrid.
Webster & Horsfall Wire Manufacturing Operation
BIODIESEL FILLING STATION
ELECTRIC VEHICLE CHARGING STATION
Modern fuel cell vehicles can refill at the hydrogen filling station. The hydrogen is clean 'green' hydrogen from renewables, rather than 'brown' hydrogen from steam reformation of methane. The electrolyser converts wrong-time renewable electricity into hydrogen. This can be efficiently turned back into electricity using a fuel cell.
Hydrogen
The hydrogen is clean 'green' hydrogen from renewables, rather than 'brown' hydrogen from steam reformation of methane.
(TCR PLANT) BIO-BATTERY: THERMAL CATALYTIC REFORMING
The TCR process used in the bio-battery produces biodiesel from a range of feedstocks. This can be used in clean Euro IV diesel engines. Efficiency can be improved further by creating a 'heat hybrid' with a diesel engine.
HYDROGEN
HYDROGEN ELECTROLYSER
HYDROGEN-POWERED BUSES AND TAXIS
The hydrogen filling station supplies green hydrogen from both the electrolyser and bio-battery thermo-catalytic reforming process.
The electrolyser can be used to provide grid balancing by turning 'wrong-time' energy into clean hydrogen.

FIGURE 21: BLACK COUNTRY

Covers the I54 and Phoenix 10 Enterprise Zones. The Enterprise Zone covers the Jaguar Land Rover plant and business park next to the M54, and land to the south of Junction 10 of the M6. The Black Country, to the west of Birmingham, comprising Dudley, Sandwell, Walsall and Wolverhampton, has a high concentration of small energy-intensive manufacturers in the automotive and aerospace supply chains whose main preoccupation is high industrial electricity costs compared to their global competitors.





From these examples, it is clear the EIZ could vary significantly in size. The important point is that the EIZ should be large enough to create or serve a market in which commercial propositions can be tested on real customers and infrastructure; but also small enough that local people and politicians can relate to it. Their boundaries will also need to make sense in the context of local and regional energy infrastructure.

If EIZs are sized optimally, and supported with appropriate infrastructure and expertise, they will create competitive local markets at a scale that encourages survival of the fittest among competing technologies and business models. This will ensure innovations are judged by their ability to service real customer needs rather than simply by their competence in securing subsidies or navigating regulations, neither of which is necessarily a good foundation for global competitiveness. In this way, EIZs will help local authorities, investors, regulators and government take the decisions needed to accelerate clean energy innovation.

Benefits

The EIZ is designed to foster clean energy innovation to produce both environmental and economic benefits. By accelerating the progress of novel technologies and business models to market, we believe the main benefits will include:

- Faster progress in the areas it is most urgently needed: transport, heat and system integration
- Lower emissions within the EIZ, and potentially lower energy bills
- Lower system costs through dynamic energy management and avoided infrastructure investment and stranded assets
- Local supply chains, jobs, skills and local markets
- Clusters of innovative companies that accelerate work on system integration across sectors
- Improved productivity and faster growth
- New technical and other standards for innovative technologies that help establish new markets
- Greater customer engagement and therefore more efficient energy markets

The EIZ will also:

- De-risk future investments and open new technologies and business models to global investors
- Establish products, services, business models and IP for export
- Test and demonstrate regulatory reforms needed to support clean energy innovation in a safe space that could be more widely applied
- Provide a platform from which small energy innovators can grow to become national and international companies

If established in the West Midlands, we believe EIZs will help give businesses in the region access to lower-cost energy to support productivity and growth, and make the region one of the most attractive locations worldwide to base and grow innovative energy technology businesses. The EIZs would also help maximise the benefit from national investment in the region's academic institutions of around £200 million to date.

Heat, transport and system integration

EIZs are clean energy technology neutral, but will naturally focus on the areas where the need is most urgent: transport, heat and system integration. Heat accounts for around 40% of our energy consumption, and is therefore central to reducing emissions, bills and fuel poverty, yet in 2016 scarcely 6% of our heat was produced from renewable energy.[137] Some of the main ways to improve heating efficiency include recycling waste heat, integrating heat and electricity networks, and whole house retrofits. All these approaches are inherently local, and could be tackled more effectively within an EIZ (see box 14).

BOX 14: Potential EIZ hybrid boiler project

One example of an EIZ project that could help clear barriers to clean energy innovation would be a commercial-scale demonstration of hybrid boiler-heat pumps. These devices are made up of a novel combination of a condensing gas boiler, air-source heat pump and smart controls, which can switch between gas and electricity according to real-time energy prices to achieve the optimum cost and emissions reductions. The smart system can also exploit the thermal mass of the house to time electricity consumption in such a way as to relieve pressure on the grid at peak times.

This approach has already been demonstrated at small-scale with 75 households in Bridgend. The Freedom Project was led by PassivSystems, which developed the smart controls, along with Western Power Distribution and the local gas distributor Wales & West Utilities, which funded the scheme with £5.2 million of Network Innovation Allowance.[138] An interim project report found that hybrid gas-electric approach to home heating would save more carbon than electric only, and that in 2030 savings across the energy system could exceed £1.3 billion.[139] But there are several major barriers that remain to be cleared before this technology could compete in the energy market.

Because the hybrid consists of a boiler and a heat pump, it is naturally more expensive to buy than a conventional boiler, and most consumers would never choose one voluntarily. One answer could be an energy services model, in which the equipment is bought, maintained and controlled by a company, which provides an agreed heat and hot-water service to the householder for a monthly fee. The company would also receive payments for demand response services in the electricity market, so making the technology more competitive.

This approach has been successful in solar with widespread 'rent-a-roof' schemes. But in heat, there are still major obstacles, as Colin Calder, founder and chief executive of PassivSystems, explained to the Commission. First, to develop a competitive heat-as-service offering with hybrid boilers, a company would need technology-neutral access to all eight value pools in the electricity market, which requires new markets to be created. Second, the workings of the Renewable Heat Incentive deter third-party ownership of the equipment by pension or infrastructure funds, making it difficult to scale-up such a business. The government plans to introduce legislation on this issue, but at present it remains a barrier.

It is exactly these kinds of barriers that the EIZ is intended to clear. The task is urgent, and the benefits could be huge. As Mr Calder pointed out, there are only three boiler replacement cycles before 2050, when we need to be net carbon neutral, and at present there are no competitive alternatives to the condensing boiler. The EIZ would be strictly clean energy technology neutral, but would help create the market in which innovators can demonstrate such business models at scale.

BOX 15: Energiesprong home retrofits

Another potentially barrier-clearing project would be the large-scale demonstration of the Energiesprong ('energy leap') approach to whole-house energy efficiency retrofits developed in the Netherlands. This could make a major impact on energy poverty in Birmingham, which has thousands of poorly insulated Victorian homes.

Energiesprong is both a building standard and a funding model. It aims to make houses net-zero-energy by adding thick external insulation and a new roof with integrated solar panels, along with new energy equipment such as heat pumps. The capital cost is paid by the building's owner – typically a council or other social housing provider – and recouped over 30 years from several sources including residents' energy payments, income from renewable energy generation, and avoided maintenance costs. Under the business model, residents' payments should be lower than their previous energy bills.

Nottingham City Council has already piloted Energiesprong with ten homes and hopes to conduct a much larger demonstration with hundreds of houses. But Energiesprong's British organisation says that one potential barrier is the right-to-buy scheme, since landlords worry that they could invest heavily and then find that residents buy their newly improved homes, potentially leaving investors with a loss. Since right-to-buy is enshrined in law, an EIZ project would need to find some mechanism by which landlords or investors could recoup their capital should the resident exercise their right to buy. With this assurance, investors might then back a project to demonstrate the approach on thousands of homes, and volume production would reduce costs and improve the business case. If the demonstration were successful, the risk reduction mechanism could then be deployed elsewhere.

The value of a large commercial demonstration, is that it brings economies of scale. Energiesprong UK says the price to retrofit 100 houses is £70,000 each, whereas the price for 3,000 is just £45,000 each – at which point the business model begins to work.[140] A key feature of the process is that the external cladding and new roof are manufactured remotely, and then fitted by crane in less than a week, with little disruption to tenants (see video[141]). This both increases the efficiency of the process and creates work for local manufacturers. Nottingham City Council carried out a pilot project with ten homes in 2017, for which the cladding and roofs were manufactured by LoCal Homes in West Bromwich – within the proposed Black Country EIZ.

The Energiesprong approach has huge potential, because Britain's social landlords spend £5.2 billion on property maintenance a year, and tenants spend around £4.2 billion in energy bills. There are almost 5 million homes rented from social landlords in the UK. If 5% of these could be retrofitted to Energiesprong standards, the investment cost – ie, spending on local manufacturing and services – would amount to £11 billion, but this would produce annual savings of 4TWh and more than 775,000tCO_2e, and the retrofit would last 40 years.[142] Energiesprong UK claims that for every 5,000 homes retrofitted, its approach would close two power stations, create 5,000 jobs and save the NHS £105 million.

Again, the EIZ would not pick winners, nor fund demonstration projects, but rather create the conditions in which such business models could be demonstrated at scale.

Strategic utility corridors in an EIZ

One of the challenges of major developments such as UK Central Hub is building the energy infrastructure in time. Power, gas and heat networks need to be built early enough to avoid holding up the development, but not so early that it undermines the business case. The exact needs and timing of the UK Central Hub development are not yet fixed, but its planning consultants, Peter Brett Associates, believe it would be an advantage to define and reserve corridors for important elements of its infrastructure in advance, and that this could be a feature of any potential EIZ.

The traditional approach is to route utilities alongside roads – either existing or proposed. But this often results in inefficient routes that need more labour and materials, and agreement from a greater number of stakeholders. It would therefore make sense to develop a map of strategic corridors and locations in where utilities could be developed across the EIZ. This would allow utilities to be provided more efficiently, and costs and benefits distributed equitably between stakeholders, while protecting the interests of landowners. This approach could only proceed with the support of a strategic authority such as the EIZ.

Governance and political leadership

One of the defining characteristics of the EIZ is that it is local. This is important not only because consumption, heat and system integration are inherently local issues, but because it would allow the EIZ to tap regional identity to build support for energy innovation.

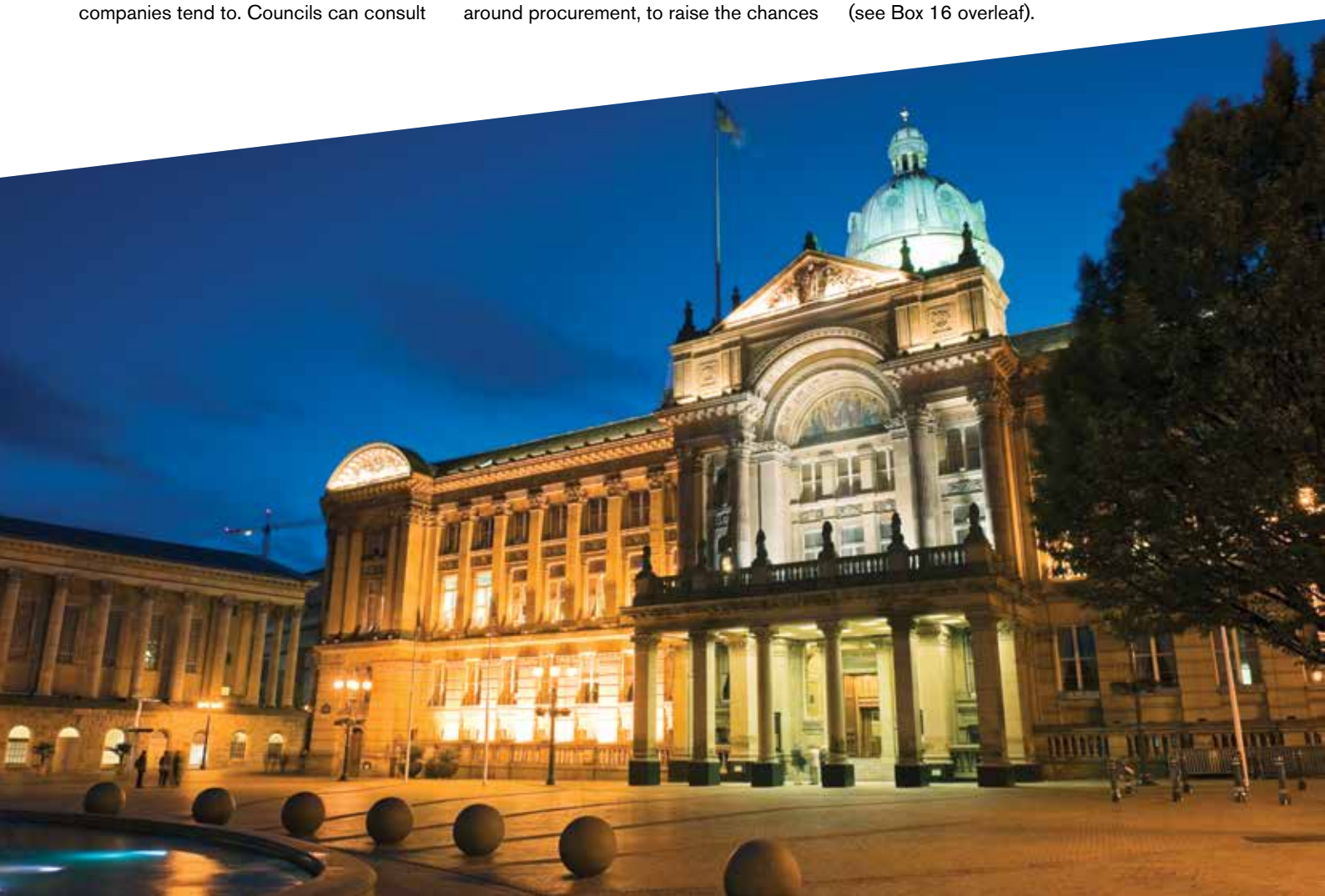
Public support is not just a political 'nice to have', but a critical condition for successful clean energy innovation. Many a wind farm or energy-from-waste plant has been stymied by a failure to demonstrate real benefits for the local community, and investments in home energy efficiency have often failed because the occupants' behaviour was not taken into account. These issues are starkest when the project developer is a distant entity, such as a national or global company.

But local political leaders have the potential to engage public enthusiasm for clean energy without provoking the indifference or mistrust that big energy companies tend to. Councils can consult voters to set priorities for energy innovation. And resistance to local development can be tempered by involving communities in planning and making sure projects provide direct benefits to them, as shown in Denmark and elsewhere (section 3). In practical terms, councils control large building estates, vehicle fleets and local waste streams that are vital for system integration and clean energy innovation.

As we showed in section 3, however, local authority capacity to lead clean energy innovation is hampered by their lack of statutory authority and core funding for this policy area, austerity, and a historically bureaucratic approach to procurement. Because of these factors, successful local authorities have often been those that worked with trusted arms-length organisations such as the Birmingham District Energy Company, and Thameswey Energy in Woking. The EIZ could perform a similar role but on a broader canvas: helping the local authority identify and frame the problem; clearing the regulatory and other barriers; flexing energy market regulations, and those around procurement, to raise the chances of success. Local authorities are essential members of an EIZ, but not the only channel for democratic accountability.

Regional and city mayors are also central to the EIZ. They have responsibilities and budget for areas such as transport, housing and land, the integration of which is central to energy innovation, and for related areas such as productivity and skills. They are therefore ideally placed to coordinate resources across sectors at a regional and strategic level – although day-to-day running of the EIZ would fall to consortium members. More broadly, regional mayors would have a galvanising role as clean energy champions.

This Commission is supported by the West Midlands Mayor, Andy Street, and has been recognised by the government under the region's second devolution deal, published alongside the budget in November 2017. EIZs would work closely with BEIS and its new regional offices, and with Ofgem. The precise governance arrangements are yet to be agreed, but the experience of Solihull and the Urban Growth Company could be relevant (see Box 16 overleaf).



BOX 16: The Urban Growth Company model

Solihull Metropolitan Borough Council (SMBC) created the Urban Growth Company (UGC) in 2016 to coordinate the development of the UK Central Hub area (see Appendix 1). Its structure and governance may be relevant to the design of EIZs.

SMBC created UGC as a wholly owned but arms-length private company because:

- Such an organisation can focus solely on the complex problems to be solved without distraction by other council activities and priorities
- It demonstrates to both private and public sector organisations that SMBC strongly supports the delivery of the UK Central Hub and is allocating sufficient resources
- A private company can recruit staff and consultants on more flexible terms – which is important for the delivery of dynamic projects where resources need to be re-allocated from time to time

The UGC does not own land, nor is it intended to carry out direct development. Instead, it exerts influence through its links with other powerful organisations, and acting as an 'informed conduit' to filter significant levels of public funding. It achieves this by:

- Liaising with stakeholders to persuade them of the sound commercial reasons to invest in UK Central Hub
- Acting as gatekeeper for the more than £500 million of public funding available from WMCA for transport and infrastructure improvements in the Hub area. UGC leads many funding applications, and SMBC and WMCA will consider others only if they have the support of UGC
- Being recognised as a key stakeholder by important public sector groups such as HS2, Highways England and Transport for West Midlands, which support our aims and expect all others working with them to do the same

UGC is a private company wholly owned by SMBC, and controlled by an independent board comprising one-third SMBC representatives and two-thirds external industry experts, which meets monthly. The UGC is entirely funded by the West Midlands Combined Authority as part of the devolution deal. Day-to-day funding is provided by WMCA via SMBC. Specific projects require UGC to put forward an additional business case to WMCA, which must pass through its governance process. This structure ensures that the public money is spent properly and under the control and guidance of local and regional government. It is also the policy of the UGC that all funding applications to the WMCA are also endorsed by the Greater Birmingham and Solihull LEP in advance to show the widest possible public support.

The UGC organisation is lean, consisting of an MD, Development Director, Finance Director, Head of Communications, two project managers and a PA. The headcount may rise if the number of projects increases, but the additional resource may be found through secondments and consultants. Even so, the UGC needs a five-year budget of around £10 million to cover running costs, salaries and project costs including consultants and lawyers.

The UGC may be relevant to the EIZs because:

- EIZs would be independent organisations with strong backing from public-sector bodies that set its goals
- Control of the purse strings would remain with existing public sector bodies (eg, the WMCA), so the EIZ acts as a gatekeeper without having to set up the necessary structures and governance to hold public funds
- The EIZ is focused solely on its aims, so can build the necessary relationships with regulators and utilities without distraction
- Depending on workload, there might only be need for a single regional EIZ executive body, which employs individuals to lead on specific EIZ areas, minimising costs initially

Funding

The EIZ is not primarily a funding mechanism, but a means of clearing regulatory and other barriers. Whereas Enterprise Zones encourage business activity in a particular area by offering tax breaks, the EIZ would stimulate innovation mainly by helping to integrate across different parts of the energy system and, where particular barriers can be identified, flexing regulations. It should therefore require less public expenditure.

The EIZ will require substantial funding, however, to build clean energy infrastructure and markets, and far smaller sums to support a lean administrative body. This could be provided either through the conventional approach of government grants matched or multiplied by private investment, or by developing innovative 'value capture mechanisms' that ensure risks and returns are borne locally.

Government funding is justified because the policy would deliver public goods – demonstrating innovative low-carbon technologies with higher levels of risk than can be borne by the private sector alone – and to counter-balance commercial interests, so the results of EIZ work can be more widely disseminated than if wholly owned by a single company. As a practical matter, government funding will also be needed to replace substantial amounts of EU money for energy innovation in the UK – projects such as the Cornwall Local Energy Market – which we must assume will no longer be available post-Brexit.

EIZs could be funded from existing budgets. In the budget in November 2017, the government announced a new body, UK Research and Innovation, which will invest £8 billion per year by 2020 to 'help translate excellent research into better business outcomes'.[143] The EIZ is intended to achieve exactly that aim. As with university research funding, the government might secure the best value by establishing a limited pot of funding and opening it to competition. This would stimulate the formation of consortia involving universities, local authorities and business, and competition between them.

Another approach would be to fund EIZs through value capture mechanisms that divert a fraction of some local revenue stream, which would bind the EIZ even more tightly to local interests: local funding would ensure the locality bears both the risk and reward of the investment. One example is the Energy Company Obligation (ECO), which funds measures such as home insulation for those in fuel poverty.[144] ECO raises domestic customers' bills by 2%, but has been criticised for creating a monopoly in what ought to be a competitive market. The West Midlands' share of the ECO investment pot equates to between £175 million and £250 million depending on the carbon price.[145] If the ECO funding derived from the West Midlands were diverted to the administrator for the EIZs, it could both stimulate clean energy innovation and improve the outcomes of the ECO scheme.

Conclusion

The EIZ is a novel idea developed within the West Midlands but it aligns closely with the direction of policy and advances the government's aims in both innovation and devolution. It also improves upon the alternative models for local energy provision and clean energy innovation.

The UK devolution agenda has already produced some outstanding results, such as the transformation of public transport in London. The government has extended devolution to other regions and cities, and has begun to include energy in the process.

Cornwall's devolution deal in 2015 included measures to help the county develop its geothermal resource, for example, and the second West Midlands' devolution deal, announced with the budget in 2017, provided financial support for the work of the Policy Commission that produced this report.

BEIS has recognised the need to do more to foster local energy innovation with its plans for five regional offices. The government has also set up UK Research and Innovation to improve Britain's ability to turn its inventions into commercial propositions, and Ofgem's Innovation Link and Sandbox arrangements are intended to clear specific regulatory barriers on a case-by-case basis.

The EIZ complements, extends and integrates all of these initiatives, and we believe there is a strong case for pursuing it further. The next question is where.

5. **WHY** WEST MIDLANDS?

Energy Innovation Zones could be set up anywhere in the UK, but there is a strong case for starting in the West Midlands – where the idea was born. The region faces some acute energy, business and social challenges, but also enjoys distinct advantages that would support the introduction of this approach. The West Midlands suffers some of the worst energy poverty in the country, a high concentration of energy-intensive manufacturing, and areas of grid constraint and poor air quality. But it also hosts world-class universities, manufacturers and innovation agencies, and will need to build huge amounts of energy infrastructure over the coming decades. The West Midlands is the biggest regional economy outside London, and its annual energy bill of £10 billion could provide a platform for local clean energy innovators to grow into major export businesses. This combination of need, capacity and scale makes the West Midlands an ideal place to trial EIZs.

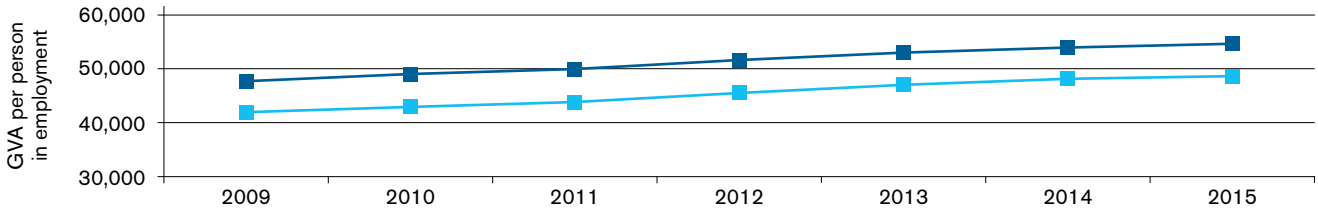
Challenges

The challenges and opportunities for the West Midlands are much like those of the country as a whole – only more so. A report[146] by Sustainability West Midlands published in 2010 found the region suffers a number deficits or 'gaps' compared to the rest of the UK, including:

- **Productivity gap** of £15 billion per year compared to the UK average due to poor productivity, skills and long-term unemployment.
- **Carbon gap** of around 2mtCO_2e per year on top of national targets due to the high concentration of manufacturing and motorways in the region, and limited access to renewable generation such as offshore wind. Renewable generating capacity in the West Midlands would need to rise 15-fold to hit the national target for 2020.
- **Health gap**, as shown by the ten-year difference in average life expectancy between the best and worst areas in the region, due to social, economic and environmental factors.

The report set targets for 2020 to raise productivity by 30%, reduce the region's direct CO_2 emissions by 30%, and shrink the life expectancy gap to six years. Sustainability West Midlands' 2016 annual progress report found productivity was on track, greenhouse gas emissions would need renewed effort, and the health gap target was highly unlikely to be met and required immediate action.[147] Although improving, productivity in the West Midlands continues to lag the national average, as shown in Figure 22.

FIGURE 22: PRODUCTIVITY 2009–2015, WEST MIDLANDS (3-LEP) VS GB



The Local Enterprise Partnerships included in this analysis are Black Country LEP, Coventry & Warwickshire LEP and Greater Birmingham and Solihull LEP.

Source: WMCA[148]

More broadly, the West Midlands' challenges include:

- **Energy poverty**. The West Midlands has the highest level of fuel poverty of the nine English regions, at 13.5%. Among English cities, Birmingham has 15.6% fuel poverty – second only to Nottingham at 15.8%. Within the city there are plenty of pockets with 25% or higher, several at around 33% and one at almost 42%.[149]
- **Poor housing stock**. The West Midlands has the highest proportion of homes (74.5%) in the lowest energy efficiency categories (D–G) of any region in England.[150] This is of course one of the main causes of the region's high levels of fuel poverty.
- **Poor air quality**. Criss-crossed with motorways, the West Midlands has some of the country's worst air pollution, which causes 2,830 premature deaths (or almost 30,000 life-years lost) in the region each year, and more than 500 premature deaths in Birmingham alone.[151] In 2015, the government ordered Birmingham and four other cities to introduce Clean Air Zones by 2020.[152]
- **Grid constraints**. Some areas in central Birmingham, Solihull, South Coventry and the Black Country suffer grid constraints, and/or will soon need to expand or evolve to accommodate huge new development projects and the growth of decentralised generation, EV charging and heat pumps.
- **High concentration of energy-intensive manufacturing**. The West Midlands accounts for 9% of Britain's manufacturing[153], and the Black Country in particular has a high concentration of energy-intensive metal processing companies, which are affected by British industrial electricity prices being among the highest in western Europe (section 1).
- **Skills**. Although many companies in the West Midlands employ highly skilled workforces, across the region as a whole there is a higher than average proportion of people with no skills, a lower than average proportion with degree-level skills, and patches of high unemployment. The skills challenge is also an opportunity, however: if the skills profile of the area matched the England average, annual GVA in the area would increase by around £22 billion.[154]

Opportunities

At the same time, the West Midlands has huge opportunities to exploit where the EIZ greatly improves the economic and environmental outcomes. These include:

- **UK Central Hub** – a series of large developments around the planned HS2 interchange in Solihull. Over the next 20–30 years, the Hub could deliver 35,000–77,500 new jobs, 3,000–4,000 new homes, 775,000m^2 of commercial space and generate £2 billion–4 billion GVA per year.[155] Consultants for UK Central estimate these developments could require local grid capacity to expand by 80MW, and far more may be needed for EV charging (see Appendix 1).
- **Birmingham city centre development** over the next 15 years – including £900 million of development around the HS2 Curzon Street station, and £600 million around Smithfield. The energy infrastructure required to service such developments presents a major opportunity for innovation.
- **Energy investment**. The West Midlands routinely invests £2.5 billion per year in energy infrastructure and technology, most of which is spent on upgrading the electricity grid and replacing gas boilers (the figure excludes buildings and transport).[156] Additional investment will be required to develop dynamic grids capable of absorbing ever more intermittent renewable generation; raise building energy efficiency; and decarbonise heat and transport. This investment is not simply a cost to be borne, but also a major opportunity for local innovators and manufacturers. The West Midlands innovation audit found that 75% of the region's future market opportunities are in low-carbon energy, transport and buildings.[157]
- **The West Midlands' £10 billion annual energy bill** equates to around 10% of its Gross Value Added (GVA), money that largely leaves the region. If even a fraction could be diverted into distributed clean energy, the impact on local growth could be significant. The Mini-Stern Review for Birmingham and the Wider Urban Area found that if the area invested £3.6 billion in cost-effective clean energy and efficiency measures, by 2022 it could reduce its greenhouse gas emissions by 46% and cut its annual energy bill by almost £1 billion per year.[158]
- **Global clean energy market**. The IEA estimates that to fulfil the Paris Agreement, the energy sector needs to invest $13.5 trillion 2015–30 in low-carbon technologies and energy efficiency.[159] As a major manufacturer and exporter, the West Midlands is already well placed to exploit this opportunity. But EIZs would accelerate clean energy innovation to develop new products and services for the local market, which could then be exported into a global market worth $840 billion per year. This represents a significant increase from current global investment in clean energy, which has averaged $300 billion per year since 2010.[160]

Competitive advantages

In tackling its challenges and opportunities, the West Midlands enjoys some formidable competitive advantages. The first is simply its economic strength:

- **Size and growth**. The West Midlands is the largest regional economy outside London. The areas covered by Black Country, Coventry and Warwickshire, and Greater Birmingham and Solihull have a combined GVA of around £90 billion per year. That makes the West Midlands' LEPs larger than those of Greater Manchester, the Leeds City Region and the South East. The West Midlands LEPs have also grown their GVA faster than those regions from 2010 to 2015 (see Figure 23).
- **Manufacturing heartland**. The West Midlands has the highest concentration of manufacturers of any region[161], and accounts for 9% of all manufacturing employment in Britain.[162] It is home to world-class companies including Jaguar Land Rover, Aston Martin and Worcester Bosch and many of their supply chains.
- **Major exporter**. The West Midlands is Britain's largest exporter after the South East and London.[163] In 2016, the West Midlands exported goods worth £3.3 billion to China, more than three-quarters of which were road vehicles. This represented 26% of all UK exports to that country, twice as much as the next largest region. With imports from China of £3.5 billion, the West Midlands is the only region to achieve anything close to trade balance with what is predicted to become the world's largest economy by 2030.[164]
- **Inward investment**. The West Midlands has also secured more inward investment from China than any other region bar London – 52 projects in the past 20 years, and 30 in the past six – creating 2,500 jobs and safeguarding a further 1,500.[165]
- **Entrepreneurial culture**. In 2014, Birmingham registered more new businesses than any other British city bar London[166], and had the highest business birth-to-death ratio in the UK.[167]
- **Location**. Birmingham is Britain's second largest city, whose central location means 90% of country's population is within four hours' drive.[168]

FIGURE 23: GVA IN 2015 AND GROWTH 2010–2015 FOR WEST MIDLANDS LEPS AND THOSE OF OTHER REGIONS

Area	GVA in 2015 (£bn)	GVA growth 2010–15
London	378.4	27%
3-LEP WM SIA geography	87.5	20%
South East	85.8	18%
Leeds City Region	64.6	14%
Greater Manchester	59.6	16%

Source: WMCA[169]

Enabling competencies and market strengths

As well as its overall size and strength, the West Midlands economy also has many specific advantages relevant to clean energy innovation. The West Midlands innovation audit identified a series of *enabling competencies* and *market strengths*, which we believe would underpin the work of Energy Innovation Zones.

Enabling competencies

The enabling competencies include Advanced Manufacturing and Engineering, Digital Technologies and Data, and Systems Integration. All three enabling competencies will be vital to developing clean energy products and services that are both innovative and cost-effective. These competencies are not sector specific but widely shared across companies, universities and innovation institutions through people and partnerships.

In Advanced Manufacturing and Engineering, the enabling competency is shared by a swathe of world-class companies based in the West Midlands, and by regional institutions that support manufacturing innovation, including:

- Manufacturing Technology Centre, based in Coventry and part of the High Value Manufacturing Catapult (HVM)
- Warwick Manufacturing Group at University of Warwick, also part of HVM Catapult
- Institute for Advanced Manufacturing and Engineering, a collaboration between Coventry University and Unipart
- High Temperature Research Centre, a collaboration between the University of Birmingham and Rolls-Royce at Ansty Park in Coventry
- Midland Simulation Group at the University of Wolverhampton
- Elite Centre for Manufacturing Skills at the University of Wolverhampton

Systems Integration is particularly important in transport and energy, and the West Midlands' competency is shared across 'private-sector firms with internationally significant systems integration offers', universities and innovation institutions. These include: Transport for West Midlands, the combined transport authority; the Centre for Mobility & Transport at Coventry University; the Energy Systems Integration Laboratory at the University of Birmingham; and HORIBA MIRA in Warwickshire, one of Britain's largest transport R&D companies, with 500 technical staff.

Market strengths

The innovation audit also identified several market strengths, which are more sector-specific than the enabling competencies, including Next Generation Transport, Sustainable Construction, and Energy Storage and Systems. These too are directly relevant to the challenges that EIZs are intended to tackle: decarbonising transport and heat; reducing air pollution; grid balancing, and energy systems integration. These market strengths are the result of both industrial and publicly supported innovation capacity.

The West Midlands' market strength in Next Generation Transport is unrivalled in Britain. The region hosts vehicle production by BMW, Jaguar Land Rover, MG, Aston Martin, London Taxi Company and Dennis Eagle, along with 17% of the country's vehicle parts manufacturers. London Taxi recently opened a £300 million plant in Coventry to produce range-extended electric vehicles and conduct light-weighting R&D. The automotive sector employs 45,000 across the region.

Market strength in Next Generation Transport is also supported by a swathe of innovation bodies in the region:

- Manufacturing Technology Centre
- Warwick Manufacturing Group at the University of Warwick
- Institute for Advanced Manufacturing and Engineering
- The Advanced Propulsion Centre (APC) Hub, based at the University of Warwick
- The Birmingham Centre for Rail Research and Education at the University of Birmingham
- Rolls-Royce University Technology Centre in Materials in Birmingham
- The National Automotive Innovation Centre (NAIC) at the University of Warwick, in partnership with Jaguar Land Rover and Tata Motors European Technical Centre
- The National Transport Design Centre at Coventry University
- National College for High Speed Rail

The West Midlands has a similarly broad-based market strength in Sustainable Construction, based on expertise in building information modelling technologies, off-site manufacture, modular construction, building materials and technologies, and zero-carbon building and efficiency measures. The region is home to many significant construction companies and a range of innovation bodies including: the Built Environment, Information Systems and Learning Technology Research Centre at the University of Wolverhampton; the Centre for Low Impact Buildings at Coventry University, and the National Low Carbon Centre at Stoneleigh Park, backed by HEI partners Aston, Birmingham City, Coventry and Warwick.

Energy sector

In Energy Storage and Systems, the West Midlands' market strength is built on more than 10,000 companies in the energy supply chain that employ over 56,000 people. In Greater Birmingham & Solihull alone the low-carbon sector supports 33,000 jobs.[170] Some of the country's largest and most important energy businesses are based in the region, including National Grid, E.ON UK, nPower and Worcester Bosch, as well as some of the newest, such as First Utility and Co-operative Energy.[171] The regional grid operator Western Power Distribution is investing £125 million to transform its passive distribution network into an actively managed system capable of absorbing far more variable generation and supplying new 'peaky' forms of clean energy demand such as EV charging and heat pumps.[172]

The West Midlands market strength in energy is also supported by two key innovation bodies:

CATAPULT Energy Systems

- Energy Systems Catapult (ESC), which is based in Birmingham, helps unleash innovation and open new markets in the energy system to capture the growth opportunity recognised in the UK Industrial Strategy. Its vision for the UK energy sector will see it overcoming systemic barriers and delivering the innovation, products, services and value chains required to deliver the UK's economic ambitions. The ESC has developed unique capabilities and assets, including:
  - Transformation Insight – 'whole-system' modelling and analysis at national, regional, town and building level, revealing cost-optimised low-carbon pathways for any energy system to support policy-makers, businesses and investors to better understand the risks and opportunities in decision-making.
  - Future System Design and Integration – supporting the design of new energy market models and architectures, define change management processes, system and technology integration requirements; build market simulation environments to enable innovators, regulators and other stakeholders to work with emerging business models whilst assuring system integrity and coherence.
  - Design and Governance of Innovation Environments – supporting the creation and operation of demonstration environments for real-world testing of innovative technologies and business models for future energy systems.
  - Consumer Insight and Data Analytics – using a unique set of relationships with energy consumers and the capture of 'big data' – particularly on system operation and consumer energy use – and applying Artificial Intelligence and other techniques to deepen insight, enable innovation, and identify commercial value.
  - Consumer Insights – capabilities to identify, recruit and manage a cohort of relevant consumers who could support the EIZ's objectives and participate in its demonstration activities.
  - Support to Innovators – in developing novel propositions, formulating test and demonstration activities that test the efficacy of the proposition and planning for integrating the proposition with the wider energy system which is developing within the EIZ.
  - Energy System Modelling – operation of local area energy models in support of strategic regional decision-making around the planning and development of new energy system assets.
  - EIZ Governance and market arrangements – capabilities to synthesise EIZ design and operation lessons and share sector-wide and nationally.

ERA ENERGY RESEARCH ACCELERATOR

- Energy Research Accelerator, a cross-disciplinary energy innovation hub, which brings together assets, data and intellectual leadership to foster collaboration between academia and business to accelerate the development of clean energy solutions. It is made up of six Midlands universities – Aston, Birmingham, Leicester, Loughborough, Nottingham and Warwick – and the British Geological Survey.
  - The ERA partners have long worked closely with each other and industry to produce essential research and postgraduate skills. ERA is the next step, bringing together their expertise across the three themes: Geo-Energy Systems, Integrated Energy Systems and Thermal Energy.
  - ERA develops new technologies and works to reduce their cost, feeding into existing Catapult programmes including Energy Systems, Future Cities, Transport Systems and High Value Manufacturing.
  - ERA was supported in its first phase of development by £60 million government capital funding, supported by an additional £120 million of co-investment secured from industry and academic partners. The government's initial investment is expected to generate a return of £323 million.

More generally, the innovation audit describes a huge spread of industrial companies and publicly funded organisations that support innovation, but identifies four as 'anchors': the University of Birmingham with the Birmingham Energy Institute, the University of Warwick, Jaguar Land Rover and the Manufacturing Technology Centre. Other important research and innovation groups include: European Bioenergy Research Institute at Aston University; Willenhall Battery Storage Test Facility; Energy Innovation Centre

at WMG; Birmingham Centre for Cryogenic Energy Storage, and Birmingham Centre for Fuel Cell Research and the Birmingham Centre for Strategic Elements & Critical Materials. Additionally, the Climate-KIC Accelerator programme is based in Birmingham.

While the West Midlands has a world-class innovation ecosystem, public funding of R&D in the region has in the past been dwarfed by that in London and the South East.[173] The EIZ may be an opportunity to reduce the regional imbalance and achieve greater returns from the West Midlands' powerful research base.

Political and business leadership

Another reason EIZs should be trialled in the West Midlands is that they align closely with the aims of the region's political and economic leadership. The West Midlands elected its first regional mayor in 2017, with new powers, an £8 billion investment budget and ambitious vision for 2030. Andy Street, through the West Midlands Combined Authority he chairs, has strategic responsibility for growth, transport, housing, skills and jobs, and will also play a role in other issues including air quality. The second devolution deal raises the possibility of greater local powers over aspects of energy innovation.

The mayor's West Midlands Strategic Economic Plan (SEP) builds on previous plans of the region's three LEPs and sets more ambitious targets for 2030, including: create 504,000 new jobs; raise GVA by £7 billion and output per head to 5% above the national average; cut greenhouse gas emissions of transport, business and housing to 40% below 2010 levels; and eliminate the tax-public spending deficit of £3.9 billion.[174] The SEP creates eight action plans and identifies three themes that unify them: *productivity*, *transforming lives* and *innovation*. EIZs would have a fundamental impact on all three.

If an EIZ were to facilitate a commercial demonstration of an innovative house retrofit programme, for example, it could create new manufacturing capacity, business models, IP and skills – so raising productivity – and could also transform the lives of the energy poor. Similarly, if the EIZ were to facilitate new approaches to improve industrial energy efficiency, it could divert part of the region's £10 billion annual fuel bill into local manufacturing, which would also boost growth and productivity. This, in turn, could create skilled jobs and potentially transform lives. Since EIZs are intended to facilitate *commercial* activity, it follows that their large-scale demonstrations would need to offer energy at a lower cost than business as usual, or offer an improved or novel service – either of which would tend to raise productivity.

The EIZs will also improve productivity in a more general sense by improving the links between companies on the one hand and universities and innovation bodies on the other – which the SEP identifies as a priority.

Energy Capital

The final reason Energy Innovation Zones should be trialled in the West Midlands is that the concept was developed in the region, and has widespread support here among all the relevant stakeholders: regional and local authorities, companies, innovators and academics.

Energy Capital was launched in early 2017 as a clean energy innovation partnership for the West Midlands, whose main purpose is to advance the Energy Innovation Zone concept. Members include the West Midlands Combined Authority, Greater Birmingham and Solihull LEP, Black Country LEP, Coventry & Warwickshire LEP, local research-intensive academic institutions (represented by the Universities of Aston, Birmingham and Warwick), the Department for Business, Energy & Industrial Strategy, the Energy Systems Catapult and local authorities. It is backed by an industrial advisory group including representatives of Jaguar Land Rover, Liberty Group, Western Power Distribution and the National Grid.

Energy Capital has two objectives: to ensure the West Midlands economy is supported by a competitive, flexible and secure modern energy system providing low-cost, clean and efficient power to its industries and people; and to make the West Midlands the most attractive location to develop and build an innovative, smart energy technology company in the world. The initiative therefore aligns perfectly with the WMCA's Strategic Economic Plan: the SEP aims to make the West Midlands the best place to do business; Energy Capital seeks to make it the best place to do clean energy innovation.

Energy Capital's mission is to establish the conditions that allow businesses and research institutes in the region to collaborate and grow local share of the national and international market in clean energy. It will do so by building on the existing enabling competencies (Advanced Engineering and Energy Systems Integration) and market strengths (Energy Storage and Systems) identified in the innovation audit. It believes the best way to achieve this is through a series of Energy Innovation Zones, as we have argued throughout this report. In the next section (Appendix 1), we propose four candidate EIZs.

Conclusion

In summary, the Energy Innovation Zones should be trialled in the West Midlands because the region faces some of the greatest challenges in clean energy innovation, but also some of the greatest opportunities. Its natural strengths raise the chances that EIZs will be successful, while its faster economic growth and export profile should lever that success into broader economic benefits – for the region and the country as a whole.

APPENDIX 1. POTENTIAL ENERGY INNOVATION ZONES

The four potential EIZs described in this section have been proposed by local communities across the West Midlands and reflect local needs and perceptions of energy system opportunities and challenges. This is in itself a critically important feature and point of departure for EIZs: that they are driven not only by climate imperatives and technical opportunities, but also by local market and customer needs. It immediately makes them distinct to many demonstration and innovation projects in the energy sector and aligned with the general shift towards more customer-centric approaches.

Each proposed EIZ presents distinctive opportunities for energy-system innovation, and each is at a different stage of development (Figure 24). This should help the process of generalising from the West Midlands experience to develop a generic EIZ 'template' – meaning an institutional and process model – that could be rolled out nationally. The philosophy is to be inclusive and offer any community the opportunity to nominate an area as an EIZ, provided it meets defined criteria such as willingness to accept innovative low-carbon solutions and special regulatory oversight. In this way, EIZs should be seen and designed as a privilege for which areas compete, and a mechanism with potential significantly to accelerate energy systems transition nationally.

On the other side of the equation, innovators and government will in turn need to accept the validity, diversity and importance of particular local needs in defining the goals of a given EIZ, even where these needs may not align exactly with national priorities. In some cases, it may be possible to meet these needs purely through integrating existing technologies in new ways, and require no fundamental technical or product innovation. Such EIZs may still create new markets and industries simply by providing scale; in other cases, pure process or business model innovation may be sufficient. All EIZs will accelerate the transition to a low carbon, more competitive energy system in the UK.

FIGURE 24: PROGRESS OF POTENTIAL WEST MIDLANDS EIZS

EIZ Criteria	UK Central	Birmingham (Tyseley)	Black Country	South Coventry
Local leadership	Yes	Yes	Yes	Yes
Democratic support (incl for innovation)	Yes	Yes	Yes	Yes
Market-making scale	Yes	Yes	TBC	TBC
Identified-strategic energy need	Yes	Yes	Yes	Yes
Necessary infrastructure and regulatory flexes identified	WIP	WIP	WIP	Yes
Competitive project pipeline (incl partners identified)	WIP	Yes	WIP	Yes
Business and financial case prepared	WIP	WIP	WIP	Yes
Governance structures and finance in place	Yes	WIP	No	WIP
Ofgem and BEIS approval	No	No	No	No

TBC = to be confirmed WIP = work in progress

UK Central Hub

UK Central is a well-defined and developed potential EIZ. Local institutional structures to support major investment and regeneration projects already exist; the location is one of the best current opportunities in the world to set the benchmark for the type of mixed-use development that can be delivered around a multi-modal transport interchange, and there is strong stakeholder support for innovation. Significant work has already been undertaken to define future energy and utility scenarios and potential local investment incentives and value capture mechanisms.

The UK Central Hub is an economic area that includes the significant infrastructure of Birmingham Airport, the National Exhibition Centre, Jaguar Land Rover, Birmingham International Station and Birmingham Business Park. From 2026 it will also include the High Speed 2 rail station and the enormous mixed-use Arden Cross development. Each of the stakeholders has ambitious growth plans that will dramatically increase the level of employment and housing in the Hub area, and support the wider West Midlands economy. In order to support this opportunity, Solihull Borough Council formed the Urban Growth Company (UGC) to concentrate public sector investment on removing infrastructure constraints.

UGC has already done considerable work to develop infrastructure plans for the area[175], and a 'value capture' framework of potential funding mechanisms.[176] It is now investigating potential constraints in the capacity of utilities to supply the planned developments, and has commissioned Peter Brett Associates (PBA) to analyse current capacity and potential demand over the next 30 years. Initial discussions with Western Power Distribution and National Grid suggest current spare electricity grid capacity amounts to 20–25MW at the Elmdon Primary Substation, but that planned developments may need a further 80MW. This could require an additional primary substation and reinforcement of the local substations. Without this investment, the growth will either stall due to power shortages, or be delivered at a much slower rate, as the developments need to bear the additional costs of upgrading the electricity network.

Electric vehicles could present an even greater challenge to grid capacity. The Hub currently has around 40,000 car parking spaces, which could rise to over 60,000 in the next 20 years. High-level estimates procured by UGC suggest that if the Hub installs lots of EV charging points it could require significant additional grid capacity. This estimate is based on private cars only, and does not include any allowance for future electric heavy goods vehicles or aircraft.

No one yet knows exactly how much impact the planned development and electric vehicles will have on electricity demand at the Hub, but it is clear that innovation in supply, control and use must be encouraged if we are to design a system in the most economical way.

One potential solution might be to find alternative funding mechanisms to build additional substation capacity ahead of demand and reserve the capacity for Hub members – similar to the approach of the

FIGURE 25: UK CENTRAL HUB

Ebbsfleet Development Corporation, which is investing £30 million for new substations to supply the new garden city in Kent.[177] Another would be to create an Energy Innovation Zone to encourage cheaper and more innovative solutions. The Hub has many energy-intensive users with large peaks and troughs in demand, and it may be possible to avoid or at least minimise capacity upgrades through innovative approaches.

The Hub also has large heating and cooling loads that could also be integrated with the electricity grid and wider systems such as waste. The scale and concentration of its electricity and thermal demand creates a huge opportunity for clean energy innovation and building efficiency that is probably unmatched in Britain over the next two decades. The Hub has just started a Heat Network Techno-Economic Feasibility Study, which is due to report later this year.

The Hub is only one of UK Central's four development zones. The others are North Solihull (Zone 2, a £1.8 billion regeneration programme), Solihull Town Centre (Zone 3, a major retail, office and leisure destination), and Blythe Valley Park (Zone 4, a business park). Each has its own energy challenges and priorities. North Solihull, for example, must regenerate large amounts of 1950s/60s housing stock in Chelmsley Wood, where there are high levels of fuel poverty. Solihull Town Centre has recently completed a feasibility study that identified a low-carbon heat network opportunity that would be both technically and economically viable. Blythe Valley has the potential to develop a hydrogen hub. Each could therefore form its own EIZ, but there may also be a case for creating a single overarching EIZ to cover all four UK Central development zones.

Tyseley and Central Birmingham

Central Birmingham is also a well-developed potential EIZ, and the context is much more an established and dense urban environment, so the needs and opportunities are clearly distinct from those at UK Central Hub, which is essentially greenfield. There is not yet a dedicated institutional structure congruent with the potential zone. There is, however, strong stakeholder and community engagement; a well-defined and large local market; a portfolio of energy innovation and investment projects at the Tyseley Energy Park; and 35MW of existing waste-to-energy power plants.

Birmingham city centre will undergo massive redevelopment over the next 15 years[178], particularly around the HS2 Curzon Street station (£900 million), Smithfield (£600 million), Snow Hill, Typhoo Wharf and Arena Central.[179] The area also suffers serious air pollution and the City Council is developing plans for a Clean Air Zone to start by 2020. This will require the construction of a substantial clean energy transport refuelling infrastructure including hydrogen and electric vehicle charging at scale.

There is little space available for vehicle recharging in the city centre. Part of the solution may be to use the industrial land available at Tyseley, 5km east of the city centre, to produce clean energy for the city centre and local communities, and power a new clean transport refueling infrastructure. Tyseley is already the site of the city's energy-from-waste (EfW) plant, which burns 350,000 tonnes of waste per year to generate 25MWe. The 16-acre industrial site next door is being developed as Tyseley Energy Park by its owners, Webster and Horsfall, and partners including the University of Birmingham, the City Council and the Local Enterprise Partnership.

Tyseley Energy Park already hosts a 10MWe biomass generating plant and private wire electricity supply, and is also the depot for a growing fleet of rent-by-the-hour electric taxis – most of the city's taxi drivers live nearby. A clean energy refueling station is being built to provide EV charging, hydrogen and CNG for the city's bus fleet, and for the refuse vehicles that supply the EfW plant.

Future plans include recycling waste heat from the EfW plant through a heat pipe to the Birmingham District Energy Scheme in the city centre, which is owned and operated by ENGIE. This route would run through areas of dense housing including many energy-poor households. There may also be synergies with new transport initiatives such as the proposed tram route to the airport, and refuelling and recharging infrastructure for the city.

Key energy challenges and opportunities for an EIZ based around Tyseley and the city centre include:

- Integrating energy and transport infrastructure developments at a time of rapid change in both sectors
- Optimising use of the city's 350,000 tonnes of waste which currently pass through Tyseley annually, ensuring neither waste nor energy market regulation inhibits delivery of sensible outcomes
- Making use of the latest clean technologies already being developed and deployed by the universities of Birmingham and Aston at Tyseley and elsewhere
- Making best use of the city's planning powers to optimise the energy performance of new and existing buildings as more than £2 billion of construction investment flows into the city
- Ensuring the local community is fully engaged in the major changes proposed, and actively contribute to the success of the zone

The key stakeholder group for this EIZ includes the Birmingham City Council Planning and Regeneration Team, along with key city centre development stakeholders; ENGIE; the University of Birmingham; and Webster and Horsfall. The Tyseley Energy Park already falls within the Tyseley Energy and Environmental Enterprise District, and the Council has decided it will become Birmingham's Energy and Waste nexus.

Tyseley Energy Park has the potential to become an innovative demonstrator that integrates energy vectors including electricity, heat, liquid air, hydrogen. The site will also be home to a University of Birmingham/Fraunhofer Institute shared research platform and Energy Skills Academy.

Work already completed or ongoing includes:

- Birmingham District Energy Scheme (owned by ENGIE)
- Clean Air Zone/vehicle refueling recharging studies
- Masterplans for the Tyseley site by owners Webster and Horsfall/Energy Capital
- Heat network project at feasibility part 1 stage
- City solar feasibility study completed

Black Country

As the seat of the industrial revolution in the late eighth century, the Black Country can claim to be the world's first 'energy innovation zone', and this heritage perhaps explains the enthusiastic local support for the proposed EIZ. But of the four potential EIZs, the Black Country is the least developed, and so provides the greatest opportunity to demonstrate a complete model of how an EIZ can be defined, developed and implemented. There is a strong desire in the area to lead the energy transition by securing investment in modern, clean energy systems which deliver power at globally competitive costs and thus support delivery of the national industrial strategy. The EIZ is intended to provide a focus for this, specifically within the geography of the existing Enterprise Zones.

The Black Country Enterprise Zones comprise a portfolio of sites in Dudley, Wolverhampton, Darlaston and i54 – Wolverhampton North, spread over 120 hectares.[180] [181] [182] The focus of these zones is to promote and attract advanced manufacturing in the Black Country – by offering competitive advantage to manufacturers who locate there – especially targeting aerospace, automotive and high added value engineering.

There are already major manufacturing companies located on the i54 site, including Jaguar Land Rover, Moog, Eurofins and ISP. This enterprise zone is known as one of the most successful in the country, and total investment of more than £1.5 billion is expected across the Black Country over next 15 years.

A key competitiveness issue for the Black Country is the cost of energy, and in particular the energy used in metal processing. Manufacturers using electricity to drive their processes are keen to secure reliable and high-quality energy supplies with predictable and highly competitive pricing.

FIGURE 26: BREAKDOWN OF ELECTRICITY CHARGES FOR SINGLE, LARGE BLACK COUNTRY MANUFACTURING BUSINESS, 2017

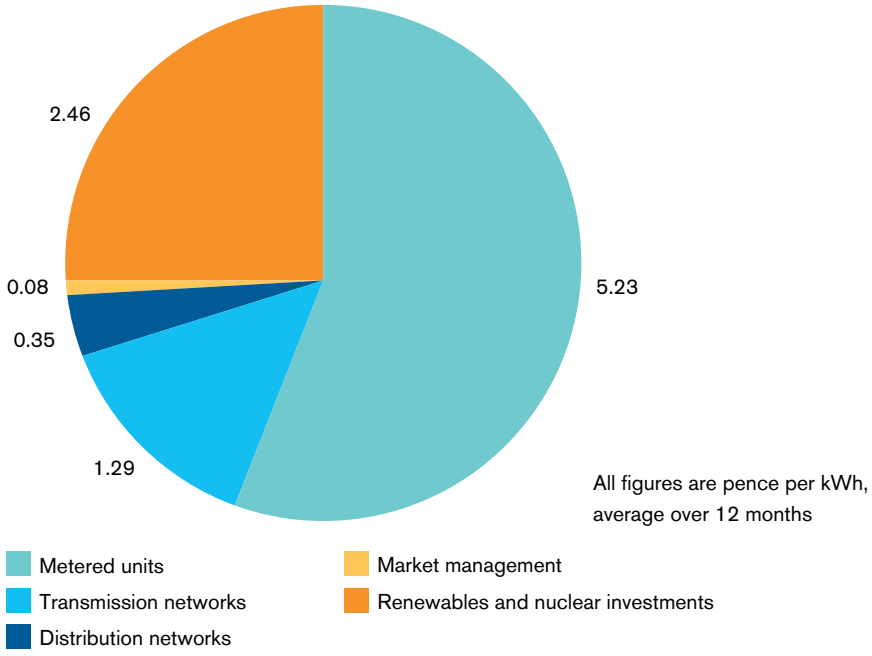
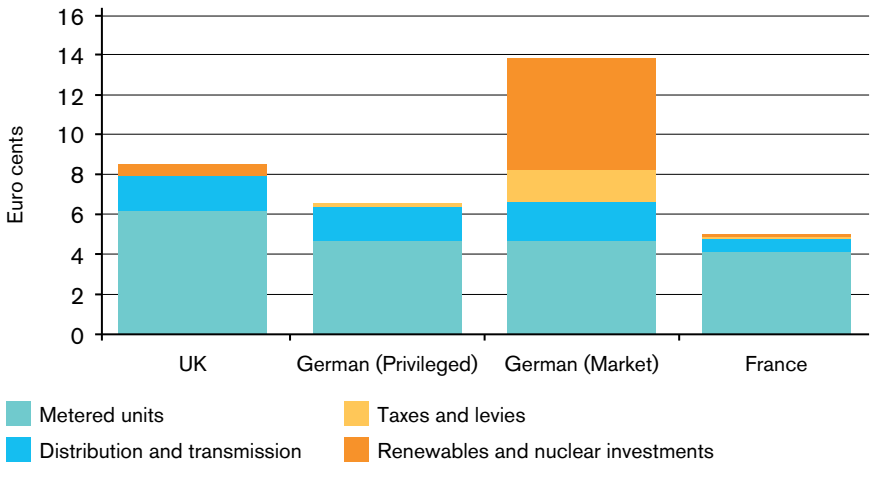


Figure 26 shows a breakdown of the electricity charges paid by one large Black Country manufacturer in 2017.[183] Only 56% of the cost of energy for this manufacturer is made up of the payment to the energy supplier. The remaining 44% is the cost of infrastructure (distribution and transmission use of system and capacity charges) and a share of the costs of the clean energy transition in the form of renewables and nuclear investment levies (ROCs, FITs and Contracts for Difference).

This breakdown of charges compares unfavourably with the prices paid by similar industries in competitor economies, where differential energy pricing is an instrument of industrial strategy. In countries such as Germany, the Netherlands, France, Italy and Denmark[184], some industries pay less towards infrastructure and energy transitions and domestic consumers pay more. The resulting contrast in electricity costs for energy-intensive industries in the UK, Germany and France is shown in Figure 27.

FIGURE 27: INTERNATIONAL COMPARISON OF ELECTRICITY PRICES OF ENERGY-INTENSIVE INDUSTRIES, 2015

Source: Frauenhofer ISI



If a Black Country EIZ were to propose lowering industrial electricity costs through differential pricing as in Germany, it would in effect mean loading that cost onto domestic consumers, which would be politically unacceptable in a region with such high levels of fuel poverty. The prospective role of the Black Country EIZ would therefore be to reconcile these competing and legitimate concerns through clean energy innovation.

There are specific opportunities for local generation and supply in the Black Country, and in particular a cluster of waste-to-energy firms is developing close to the Darlaston sites that need to be integrated with the LEP's plan for the region. Private-sector investment in this type of activity could be encouraged through simplification of supply exemptions; support for manufacturers in managing relationships with the DNO; local incentives for energy from waste technologies, and the public sector taking an active role in matchmaking between potential generators and industrial energy users. In addition, given the high density of similar small- and medium-sized metal processing businesses (more than 250 across the region) there is scope for the Black Country to pioneer the collective use of smart energy data in optimising energy efficiency, for example, by subsidising or mandating installation of smart sub-metering in industry connected to a common software platform; supporting collective purchasing and investments in storage and generation, and recouping this investment by a long-term levy on businesses within the region.

Since the region's energy-intensive industries use electricity to power furnaces, there may also be opportunities to integrate industrial waste heat through heat networks to alleviate fuel poverty.

Coventry South

Coventry South is an example of a potential EIZ driven by a small number of stakeholders – essentially Jaguar Land Rover and Coventry City Council – with a tightly defined agenda: to satisfy strong electricity demand growth and develop infrastructure to support connected autonomous vehicles (CAVs). An EIZ could therefore be used as an effective mechanism to ensure innovation and carbon reduction are effectively built into development plans, and these are properly scrutinised and integrated into local infrastructure.

Coventry South covers Whitley, Bagington and a wide area around Coventry Airport, incorporating land in both Coventry and Warwickshire. This area is well served by transport networks, and significant growth is planned through developments such the £250 million Coventry and Warwickshire Gateway scheme, and the £500 million development of Whitley South – a 60-acre engineering technology hub next to Jaguar Land Rover's global headquarters.

There is little spare capacity in the local electricity network, yet demand is forecast to rise significantly over the next decade. Coventry Central and Coventry South are reaching the limits their circuits can supply, requiring major reinforcement works to raise capacity. The city council has investigated options including a new 132kV bulk supply point to the south of Coventry and a new super-grid transformer, which would involve significant capital expenditure. Current regulations do allow capacity to be built ahead of demand, but this requires someone to bear the risk, and if no entity is willing to, then it could hold up development.

Other areas of planned expansion in Coventry and Warwickshire are Gaydon and Ansty. Jaguar Land Rover and Aston Martin have plants at Gaydon, which suffers grid constraints that would limit the growth plans of these and other companies. Ansty has shown considerable growth in recent years and has potential for large development in the future. Both sites need to ensure adequate power supply to enable future development.

Like UK Central Hub, these areas of economic growth and grid constraints need to develop timely and cost-effective clean energy solutions, which an EIZ could facilitate.

APPENDIX 2. COMMISSIONERS' BIOGRAPHIES

CHAIR

1. David King

Sir David King was the UK Government Chief Scientific Adviser from 2000 to 2007 during which time he raised the need for governments to act on climate change. He created an in-depth futures process, which advised government on a wide range of long-term issues, from flooding to obesity. From 2013 to 2017, he served in the British Foreign Office as the Foreign Secretary's Special Representative on Climate Change, making 96 official country visits over this period. He initiated the Climate Change – A Risk Analysis project with China and India over this period and was the thought leader behind Mission Innovation, the $30 billion p.a. international thrust in research funding for missing technologies needed to defossilise the global economy.

David was Science Advisor to UBS from 2008–12. He served as Founding Director of the Smith School of Enterprise and the Environment at Oxford University, 2008–2012, Head of the Department of Chemistry at Cambridge University, 1993–2000, and Master of Downing College Cambridge 1995–2000.

He has published over 500 papers on surface science and catalysis and on science and policy, for which he has received many awards and medals. Elected Fellow of the Royal Society in 1991; Foreign Fellow of the American Academy of Arts and Sciences in 2002; knighted in 2003; made Officier de l'ordre national de la Légion d'Honeur in 2009 for his work on climate change and on the political process to establish the international fusion energy project, ITER.

COMMISSIONERS

2. Patrick Allcorn

Patrick has led the local energy team in BEIS since October 2015. Before joining local energy he worked in the Heat Strategy team where he developed a range of community energy initiatives and led the team that developed and launched the domestic Renewable Heat Incentive. Previous to joining DECC in 2009, Patrick spent 10 years as a sustainable transport officer where he set up the Smarter Travel team for Transport for London. The team developed school and workplace travel plans as well as some of the initial programmes around community travel plans and destination travel plans including ideas for the 2012 Olympic bid.

3. Jon Berry

Jon has worked in the electricity distribution industry since 2006, where he has focused on a number of technical areas including re-generation planning and renewable generation integration.

He now leads the development of smart grid technologies, methodologies and applications through demonstration projects, principally funded through Ofgem's Network Innovation Allowance and Competition mechanisms, and the implementation of new solutions into core business activities.

Jon has a particular interest in the advancement of new technologies and demonstrating their application, operation and benefit on the distribution network and sharing this learning throughout the industry. He is a member of CIRED's Session 4 Advisory Group; Distributed Energy Resources and Active Demand Integration.

4. Martin Crouch

Martin Crouch is Senior Partner, Improving Regulation at Ofgem. His current responsibilities include overseeing Ofgem's horizon scanning and sustainability work, its Chief Economist's office, Innovation Link and Enforcement function.

Martin joined Ofgem in 2003 and has led teams responsible for electricity distribution, European markets, renewable and energy efficiency support schemes and electricity transmission, including interconnector development and offshore tenders. From 2012 until early 2015, he chaired the Electricity Working Groups of the European regulatory bodies CEER and ACER. Prior to Ofgem, he worked in the electricity industry and as an economic consultant, and has MSc and BSc degrees in Economics.

5. Phil Farrell

Phil is a Chartered Surveyor who specialises in advising Public Sector organisations on complex development and regeneration projects. After nearly a decade at Jones Lang LaSalle, where he rose to Director level, Phil joined the Solihull Urban Growth Company (UGC) in June 2017 as Development Director. At UGC Phil is working on a number of work streams including leading negotiations with HS2 on behalf of local stakeholders to amend the station design to facilitate the delivery of a major mixed-use development. Phil is also leading on the research into the capacity of utilities in the area and opportunities to enhance them to allow the growth agenda to proceed without constraint.

COMMISSIONERS

6. Martin Freer

Professor Freer is Director of the Birmingham Energy Institute and Head of Physics and Astronomy at the University of Birmingham, BEI. He is former Director of the Birmingham Centre for Nuclear Education and Research, which he established in 2010. His background is in Nuclear Physics for which he was awarded the Rutherford Medal for his contributions to the subject.

He has overseen the development of the BEI, helped establish Energy Capital and has co-led the establishment of the joint University of Birmingham–Fraunhofer Germany research platform. He has led two previous policy commissions for the University of Birmingham, the first on the 'Future of Nuclear Energy in the UK' and the second on 'Doing Cold Smarter', an examination of the global demand for clean cooling technologies and the potential for UK leadership.

7. Richard Friend

Sir Richard Friend holds the Cavendish Professorship of Physics at the University of Cambridge. His research encompasses the physics, materials science and engineering of semiconductor devices made with carbon-based semiconductors, particularly polymers. His research advances have shown that carbon-based semiconductors have significant applications in LEDs, solar cells, lasers, and electronics. These have been developed and exploited through a number of spin-off companies. His current research interests are directed to novel schemes – including ideas inspired by recent insights into Nature's light harvesting – that seek to improve the performance and cost of solar cells. Professor Friend is a Fellow of the Royal Society and of the Royal Academy of Engineering, and a Foreign Member of the US National Academy of Engineering. He has received many international awards for his research, including Laureate of the Millennium Prize for Technology (2010) the Harvey Prize (2011) of the Israel Institute of Technology and the von Hippel Award of the Materials Research Society (2015). He was knighted for "Services to Physics" in the Queen's Birthday Honours List, 2003.

8. Paul Jordan

Business Development Director
Paul Jordan joined the Energy Systems Catapult in December 2015 with 20 years' experience of working in the energy sector, most recently at Ricardo where he led the strategic direction of the clean energy and power generation area.

In that role, he was principally focused on areas such as conventional power (large engines, waste heat recovery, alternative fuels), renewable energy (wind, marine, solar) and enabling technologies (energy storage, hydrogen/fuel cells, EVs).

Previously, Paul was Business Development Director at Ocean Power Technologies (OPT), a wave energy technology developer. Prior to OPT, Paul worked in the Innovation Programme at the Carbon Trust, developing new low-carbon technologies and setting up the Marine Energy Challenge programme.

Paul has a Masters in Mechanical Engineering from Newcastle University and an MBA from INSEAD. Paul also Chaired RenewableUK's Marine Strategy Group from 2010 to 2012.

9. Caroline Kuzemko

Caroline is an Assistant Professor in International Political Economy in the University of Warwick's Politics and International Studies department. She currently holds an ESRC Future Research Leader grant for her project on 'Power Distributions: Local Authorities, Sustainable Energy and Devolution'. From 2012 to 2016, she worked as a Senior Research Fellow in the University of Exeter's Energy Policy Group on an EPSRC-funded project 'Innovation and Governance' (IGov). Caroline has (co-)authored The Energy Security-Climate Nexus: Institutional Change in the UK and Beyond (2013) and co-authored The Global Energy Challenge: Environment, Development and Security (2016) (with Michael Keating and Andreas Goldthau). She is a Commissioner of the West Midlands Combined Authority's Regional Energy Policy Commission and is an Associate Editor of Energy Research & Social Science. She previously worked for UBS in emerging market equities.

10. Philip New

Philip joined the Energy Systems Catapult as CEO in November 2015.

Before joining the Catapult, Philip worked for BP for over 30 years in a range of commercial and general management positions, mostly in customer-facing businesses, operating in Asia, North and South America, and Europe. He started working in the cleantech sector in 2002, initially building BP's portfolio of Biofuels businesses and technologies, latterly becoming CEO of BP Alternative Energy, during which time he wrestled with, and became fascinated by, the dynamics of the interplay of markets, technology and policy created by the emergence of new energy sources and uses, and the opportunities to create new businesses.

Philip is a Commissioner at the global Energy Transitions Commission, a member of the Global Futures Council on Energy at the World Economic Forum, and a non-executive director of FRV. He has an MA in Philosophy, Politics and Economics from Oxford University.

11. Stephen Marland

Stephen has had experience in project management, strategy, finance, regulation and commercial roles. Stephen has specialised in energy-system scenario planning, technology scouting, and innovation strategy and delivery. He has worked within Gas Distribution, GB System Operator (power and gas) and Corporate Development teams since 2001. Stephen has a PhD and Bachelors degree in Chemical Engineering from the University of Birmingham (UK), is an Associate Member of the IChemE and has an MBA from Warwick Business School (UK).

12. Matthew Rhodes

Matthew Rhodes is a Board member of the Greater Birmingham and Solihull Local Enterprise Partnership and Chair of Energy Capital in the West Midlands. He's worked in the energy industry for over 20 years, initially with international companies including RWE and BP. Prior to this he worked in manufacturing and management consultancy. From 2003 to 2017 he founded and ran an independent engineering and building physics consultancy specialising in low-carbon innovation, developing and delivering collaborative projects at the leading edge of the energy system transition.

Matthew has an MA in Engineering, Economics and Management from the University of Oxford. He's a Fellow of the Institution of Engineering and Technology, Trustee of the National Energy Foundation and an Honorary Research Fellow in Energy Policy at Exeter University. Matthew received the Sir Thomas Atwood Award from the City of Birmingham in 2011 for his collaborative work to address fuel poverty in the city.

13. Ilias Vazaios

As an Ecuity partner, Ilias provides policy and strategic advice to energy suppliers, manufacturers, industry consortia and start-ups. At Ecuity, Ilias has led several successful initiatives on behalf of Ecuity clients to achieve tangible policy change in the UK and EU thus unlocking low carbon investment in areas ranging from building energy efficiency to large-scale energy infrastructure.

Prior to Ecuity, Ilias worked on energy policy at the European Commission Delegation in Washington DC and then at the Bellona Foundation, COGEN Europe and Edelman in Brussels. He holds postgraduate degrees in Management from Cass Business School and EU Policy from Essex University. Native Greek, he also speaks English, Spanish and German.

POLICY COMMISSION MANAGER

14. Gavin Harper

Gavin Harper is Energy Development Manager at the University of Birmingham. He was seconded to support the development of the Energy Research Accelerator and Energy Capital. He sits on the International Energy Agency's Experts' Group on Research and Development Priority setting and the Advisory Council of the National Energy Foundation.

He is a Chartered Manager, Member of the CMI and Member of the IET, and is a Fellow of the RSA and HEA.

His PhD examined Business Models for Sustainable Mobility. He holds Masters in Business Research (Cardiff), Renewable Energy (Loughborough) and Sustainable Architecture (East London), and an MBA (Keele). He has Honours degrees in Engineering and Technology (Open) and a Professional Certificate in Energy Innovation & Emerging Technology (Stanford).

EDITOR

15. David Strahan

David Strahan has been a professional writer for over 30 years. He learned his trade through the exacting discipline of writing for television, first as a reporter for Thames TV, and then as a business correspondent and producer-director at the BBC. For ten years he made investigative documentaries for *The Money Programme* and *Horizon*, until leaving to write *The Last Oil Shock* (John Murray Ltd, 2007). Since then he has worked as a writer and editor specialising in clean energy, including journalism for *Bloomberg New Energy Finance* and *New Scientist*, and commercial reports for clients including Dearman and the University of Birmingham Energy Institute. He now also teaches clear writing: **www.writefirstdraft.co.uk**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APPENDIX 3. LIST OF WITNESSES AND PEOPLE PROVIDING EVIDENCE TO THE COMMISSION

Patrick Allcorn
Department for Business, Innovation & Industrial Strategy

Tom Andrews
Cornwall Insight

Jon Berry
Western Power

Wayne Bexton
Nottingham City Council

Dave Biss
Solihull Metropolitan Borough Council

Ric Bravery
City of Wolverhampton

Sylvia Broadley
Birmingham City Council

Colin Calder
PassivSystems

Caroline Carroll
Cornwall County Council

Rosemary Coyne
Energiesprong UK

Mike Crone
Jaguar Land Rover

Martin Crouch
Ofgem

Rune Drægni
Mobman, Norway

Stuart Easterbrook
Cadent

Bill Edrich
Bristol City Council

Paul Edwards
GBS LEP

Steven Ford
Cornwall County Council

Alex Heath
Urban Growth Company

Jackie Homan
Climate KIC

David Horsfall
Webster & Horsfall

Christopher Jenkins
Dudley MBC

Margarett Jolly
ConEd

Matthew Kennedy
International Energy Research Centre, Ireland

Samantha Kennedy
BEIS

Wayne Langford
Black Country LEP

Birger Lauersen
Danish District Heating Association

Jacky Lawrence
Warwickshire County Council

Anna Livesey
Sustainable Energy Association

Stephen Marland
National Grid

Shivali Mathur
Daikin

Tim Miller
Aston University

Catherine Mitchell
University of Exeter

Russell Park
Centrica

Walt Patterson
Chatham House, SPRU, University of Sussex

David Pickering
Cadent

Alex Rathmell
Energiesprong UK

Richard Rees
Birmingham City Council

Matthew Rhodes
Energy Capital

Simon Slater
Sustainability West Midlands

Mike Smith
ENGIE

Tim Stiven
Energy Systems Catapult

Mark Taylor
Sandwell MBC

Alan Thompson
Arup

Cllr Lisa Trickett
Birmingham City Council

Sarah Watson
Coventry City Council

Janette Webb
University of Edinburgh

Tom Westley
Westley Group, Black Country LEP

Bridget Woodman
University of Exeter

APPENDIX 4. POLICY COMMISSION PROCESS

The Policy Commission heard and deliberated on evidence from a range of sources, agreed conclusions and recommendations, and explored these through a variety of tools, including consultation group discussions.

Scoping Phase Activities included:

- Appointing the commissioners
- Developing the idea for the Policy Commission with the Energy Capital Partnership, the Energy Systems Catapult, Birmingham Energy Institute academics and commissioners
- A commissioners' meeting to agree the content and process of the Policy Commission held at the Energy Systems Catapult

Expert witness session

- To catalyse the discussion around West Midlands Growth, Energy Innovation and Regional Policy, a panel of expert witnesses was assembled to present to commissioners at the Energy Systems Catapult

Evidence gathering

- Researching literature and data in the public domain
- Global consultation exercise, inviting written evidence from interested parties

Evidence gathering workshops

- Evidence workshops were organised across the West Midlands geography, and also in London
- The first session was held in Birmingham at the Energy Systems Catapult
- The second session was held in Wolverhampton, at Grand Station
- The third session was held in London at The Institution of Engineering and Technology
- The fourth session was held at the Manufacturing Technology Centre at Ansty Park, Coventry

Review and writing phase

- Reviewing written evidence submitted to the commission
- Two commissioners' meeting, at the Manufacturing Technology to reflect on the issues raised in the workshops and consultations, and to deliberate on policy options
- Commission findings and recommendations finalised at commissioners' meeting at the Manufacturing Technology Centre

Launch and dissemination

- Westminster Preview of the commission findings at Parliamentary Reception hosted by Preet Gill MP for Edgbaston, attended by Andy Street, Mayor of the West Midlands
- Policy Commission Launch at the University of Birmingham, 28 March 2018

REFERENCES

1 Delivering a Smart Energy System, University of Bath/ Regen, https://www.regensw.co.uk/delivering-a-smart-energy-system-publication

2 *Energy and Climate Change: World Energy Outlook Special Briefing for COP21*, IEA, http://www.iea.org/media/news/WEO_INDC_Paper_Final_WEB.PDF

3 *Combined Authority Sustainability Benchmarking*, Sustainability West Midlands, October 2017, http://www.sustainabilitywestmidlands.org.uk/wp-content/uploads/WMCA-Bench-Report-Oct-2017-Final.pdf

4 http://www.bbc.com/news/uk-42495883

5 *Meeting Carbon Budgets: Closing the policy gap, 2017 Report to Parliament*, Committee on Climate Change, https://www.theccc.org.uk/wp-content/uploads/2017/06/2017-Report-to-Parliament-Meeting-Carbon-Budgets-Closing-the-policy-gap.pdf

6 *Industrial Strategy: Building a Britain fit for the future*, HM Government, November 2017, https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

7 *UK business opportunities of moving to a low carbon economy*, Ricardo Energy and Environment for the Committee on Climate Change, 2017, https://www.theccc.org.uk/publication/uk-energy-prices-and-bills-2017-report-supporting-research/

8 *The utility of the future*, MIT, http://energy.mit.edu/research/utility-future-study/

9 *Energy Governance, Suppliers and Demand Side Management*, Caroline Kuzemko, 2015, http://projects.exeter.ac.uk/igov/wp-content/uploads/2015/05/CK-SuppliersGovernanceDemand-Final.pdf

10 *Reshaping Regulation: Powering from the Future*, October 2017, Energy Systems Catapult, https://es.catapult.org.uk/news/reshaping-regulation-report-suggests-new-winners-and-losers-in-a-future-energy-market-driven-by-data-and-consumer-focus/

11 http://geography.exeter.ac.uk/staff/index.php?web_id=Bridget_Woodman

12 *Local Engagement in UK Energy Systems, A pilot Study of Current Activities and Future Impact*, University of Edinburgh and Energy Technologies Institute, https://s3-eu-west-1.amazonaws.com/assets.eti.co.uk/legacyUploads/2014/07/Edinburgh-Report-Version11.pdf

13 *UK Industrial Strategy: building a Britain fit for the future*, BEIS, 2017, https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

14 ECO pot given as £3.6 billion in the Clean Growth Strategy, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/651916/BEIS_The_Clean_Growth_online_12.10.17.pdf

15 http://www.energycapital.org.uk/wm-energy-facts/

16 http://www.ugcsolihull.uk/publications/

17 http://www.ugcsolihull.uk/wp-content/uploads/2017/09/170919-Value-Capture-Framework.pdf

18 https://bigcityplan.birmingham.gov.uk/

19 https://www.birmingham.gov.uk/downloads/download/155/birmingham_curzon_hs2_masterplan_for_growth

20 http://www.bbc.com/news/uk-42495883

21 https://www.ft.com/content/437c4e8a-efc0-11e7-ac08-07c3086a2625?desktop=true&conceptId=eae81e92-5092-350c-8dbf-741d54be79a5&segmentId=7c8f09b9-9b61-4fbb-9430-9208a9e233c8#myft:notification:daily-email:content:headline:html

22 http://www.cetusnews.com/life/Britain-had-the-greenest-year-ever-in-2017.rJf4xT-QM.html

23 DUKES, chapter 6, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/633782/Chapter_6.pdf

24 *Energy and Climate Change: World Energy Outlook Special Briefing for COP21*, IEA, http://www.iea.org/media/news/WEO_INDC_Paper_Final_WEB.PDF

25 https://news.sky.com/story/carbon-dioxide-levels-rise-at-record-pace-to-worst-in-three-million-years-11105744

26 https://www.theccc.org.uk/wp-content/uploads/2017/06/2017-Report-to-Parliament-Meeting-Carbon-Budgets-Closing-the-policy-gap.pdf

27 *Energy Technology Perspectives 2017*, IEA, http://www.iea.org/Textbase/nppdf/stud/17/ETP2017.pdf (full report); https://www.iea.org/publications/freepublications/publication/EnergyTechnologyPerspectives2017ExecutiveSummaryEnglishversion.pdf (free summary)

28 *Energy Technology Perspectives 2017*, IEA, http://www.iea.org/Textbase/nppdf/stud/17/ETP2017.pdf (full report); https://www.iea.org/publications/freepublications/publication/EnergyTechnologyPerspectives2017ExecutiveSummaryEnglishversion.pdf (free summary)

29 *Climate policy risk and the Paris Agreement*, Bloomberg New Energy Finance, 8 August 2017, https://www.bnef.com/core/insights/16771/view

30 https://www.ft.com/content/437c4e8a-efc0-11e7-ac08-07c3086a2625?desktop=true&conceptId=eae81e92-5092-350c-8dbf-741d54be79a5&segmentId=7c8f09b9-9b61-4fbb-9430-9208a9e233c8#myft:notification:daily-email:content:headline:html

31 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/679334/2016_Final_Emissions_Statistics_one_page_summary.pdf

32 https://www.theccc.org.uk/2018/01/17/uks-ambitious-clean-growth-strategy-must-translated-urgently-action/

33 http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/

34 *Air Quality in Europe – 2016 Report*, European Environment Agency, https://www.eea.europa.eu/publications/air-quality-in-europe-2017

35 *Valuing impacts on air quality: Updates in valuing changes in emissions of Oxides of Nitrogen (NOX) and concentrations of Nitrogen Dioxide (NO2)*, Defra, September 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/460401/air-quality-econanalysis-nitrogen-interim-guidance.pdf

36 Because PM and NOx emissions usually occur together it is difficult to disentangle their impact. Mortality is typically calculated against PM, for which the effects are better understood, but while PM emissions have fallen in the last few years, recent work suggests NOx causes significant additional harm [*Statement on the evidence for the effects of nitrogen dioxide on health*, COMEAP, 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/411756/COMEAP_The_evidence_for_the_effects_of_nitrogen_dioxide.pdf]. One study concluded there is evidence that the impact of nitrogen dioxide (NO_2) on long term mortality is 'as great as that of PM2.5[2.5]' [*Nitrogen dioxide and mortality: review and meta-analysis of long-term studies*, Annunziata Faustini et al, European Respiratory Journal, 19 December 2013, http://erj.ersjournals.com/content/early/2014/02/20/09031936.00114713.abstract][36], and another recent paper suggests the number of premature deaths caused by NOx by traffic in Britain was ten times greater than that of PM in 2010, and more than 20 times greater in 2015 [*Efficacy of Recent Emissions Controls on Road Vehicles in Europe and Implications for Public Health*, Roy M. Harrison and David C. Beddows, Scientific Reports, https://www.nature.com/articles/s41598-017-01135-2]. Transport caused 46% of EU NOx emissions in 2014 [*Air Quality in Europe – 2016 Report*, European Environment Agency, https://www.eea.europa.eu/publications/air-quality-in-europe-2017].

37 https://www.gov.uk/government/news/improving-air-quality-in-cities

38 *Air pollution a concern at levels currently accepted as 'safe'*, American Thoracic Society, https://www.sciencedaily.com/releases/2017/06/170630124346.htm

39 http://news.sky.com/story/theresa-mays-promised-energy-price-cap-will-expire-in-2020-11076798

40 http://www.mirror.co.uk/money/theresa-vows-end-rip-energy-11286064

41 http://www.independent.co.uk/news/business/news/theresa-may-energy-price-cap-gas-and-electric-company-shares-fall-a7983041.html

42 https://www.ofgem.gov.uk/system/files/docs/2017/10/state_of_the_market_report_2017_web_1

43 https://www.theccc.org.uk/2017/10/31/five-reflections-dieter-helms-cost-energy-review/

[44] *Annual Fuel Poverty Statistics Report, 2017 (2015 Data)*, Department for Business, Energy & Industrial Strategy, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/639118/Fuel_Poverty_Statistics_Report_2017_revised_August.pdf

[45] *Annual Report 2017*, Committee on Fuel Poverty, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/652701/CFP_report_formatted_-_final.pdf

[46] *Minimum home temperature thresholds for health in winder – A systematic literature review*, Public Health England, 2014, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468196/Min_temp_threshold_for_homes_in_winter.pdf

[47] *Cost of Energy Review*, Dieter Helm, October 2017, https://www.gov.uk/government/publications/cost-of-energy-independent-review

[48] *Cost of Energy Review*, Dieter Helm, October 2017, https://www.gov.uk/government/publications/cost-of-energy-independent-review

[49] https://gaswinner.de/en/gaswinner-032016/sector-coupling-everything-linked-together.html

[50] *Energy and Climate Change: World Energy Outlook Special Briefing for COP21*, IEA, http://www.iea.org/media/news/WEO_INDC_Paper_Final_WEB.PDF

[51] *Industrial Strategy: Building a Britain fit for the future*, HM Government, November 2017, https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

[52] *UK business opportunities of moving to a low carbon economy*, Ricardo Energy and Environment for the Committee on Climate Change, 2017, https://www.theccc.org.uk/publication/uk-energy-prices-and-bills-2017-report-supporting-research/

[53] Presentation to the policy commission, Dr Simon Slater, Sustainability West Midlands, 6 October 2017, http://www.sustainabilitywestmidlands.org.uk/wp-content/uploads/SWM-Energy-Commission-6-10-17.pdf

[54] BNEF, https://data.bloomberglp.com/bnef/sites/14/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf

[55] https://data.bloomberglp.com/bnef/sites/14/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf

[56] https://ore.catapult.org.uk/our-knowledge-areas/knowledge-standards/knowledge-standards-projects/cost-reduction-monitoring-framework/

[57] https://data.bloomberglp.com/bnef/sites/14/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf

[58] Slide 76, https://data.bloomberglp.com/bnef/sites/14/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf

[59] Slide 163, https://data.bloomberglp.com/bnef/sites/14/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf

[60] https://www.ft.com/content/db504ee4-caf1-11e7-ab18-7a9fb7d6163e?desktop=true&conceptId=7aad419b-765e-34bd-bb8d-5d84cd6b596d&segmentId=7c8f09b9-9b61-4fbb-9430-9208a9e233c8#myft:notification:daily-email:content:headline:html

[61] https://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch1s1-3-3.html

[62] *Tracking Clean Energy Innovation Progress 2017*, IEA, http://www.iea.org/media/etp/tracking2017/TrackingCleanEnergyInnovationProgress.pdf?utm_content=buffer87b1c&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

[63] https://greatb2bmarketingcom.r.worldssl.net/wp-content/uploads/2016/04/Valley-of-Death.jpg

[64] https://data.bloomberglp.com/bnef/sites/14/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf

[65] *Energy Technology Perspectives 2017*, IEA, https://www.iea.org/etp2017/

[66] *Global Trends in Renewable Energy Investment 2017*, UNEP, BNEF, http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf

[67] *Tracking Clean Energy Innovation Progress 2017*, IEA, http://www.iea.org/media/etp/tracking2017/TrackingCleanEnergyInnovationProgress.pdf?utm_content=buffer87b1c&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

[68] *The 2017 Global Innovation 1000 Study*, PWC, https://www.strategyand.pwc.com/innovation1000#GlobalKeyFindingsTabs4

[69] *Tracking Clean Energy Innovation Progress 2017*, IEA, http://www.iea.org/media/etp/tracking2017/TrackingCleanEnergyInnovationProgress.pdf?utm_content=buffer87b1c&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

[70] *Tracking Clean Energy Innovation Progress 2017*, IEA, http://www.iea.org/media/etp/tracking2017/TrackingCleanEnergyInnovationProgress.pdf?utm_content=buffer87b1c&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

[71] *Tracking Clean Energy Innovation Progress 2017*, IEA, http://www.iea.org/media/etp/tracking2017/TrackingCleanEnergyInnovationProgress.pdf?utm_content=buffer87b1c&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

[72] *Tracking Clean Energy Innovation Progress 2017*, IEA, http://www.iea.org/media/etp/tracking2017/TrackingCleanEnergyInnovationProgress.pdf?utm_content=buffer87b1c&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

[73] *Energy Technology Perspectives 2017*, IEA, https://www.iea.org/etp2017/

[74] *The 2017 Global Innovation 1000 Study*, PWC, https://www.strategyand.pwc.com/innovation1000#GlobalKeyFindingsTabs4

[75] https://www.theguardian.com/politics/2016/jul/18/tech-giant-arm-holdings-sold-to-japanese-firm-for-24bn

[76] https://www.globalinnovationindex.org/gii-2017-report

[77] https://www.globalinnovationindex.org/gii-2017-report

[78] *International Comparative Performance of the UK Research Base 2016*, Elsevier/BEIS, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/660855/uk-research-base-international-comparison-2016.pdf

[79] https://www.ft.com/content/e09d1f88-c9fe-11e7-ab18-7a9fb7d6163e?emailId=5a0e3d9f7c0edd000462e0bc&segmentId=2f40f9e8-c8d5-af4c-ecdd-78ad0b93926b

[80] DUKES, chapter 6, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/633782/Chapter_6.pdf

[81] *UK Industrial Strategy: building a Britain fit for the future*, BEIS, 2017, https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

[82] *Local engagement in UK energy systems*, Energy Technologies Institute, University of Edinburgh, http://www.ukerc.ac.uk/publications/local-engagement-in-uk-energy-systems.html

[83] https://blogs.exeter.ac.uk/energy/2014/11/12/mapping-the-power-in-the-electricity-system/

[84] *Energy Market Investigation: Case studies on barriers to entry and expansion in the retail supply of energy in Great Britain*, Competition and Markets Authority, 2015, https://assets.digital.cabinet-office.gov.uk/media/54e378c7e5274a4511000012/Retail_Barriers_to_Entry_and_Expansion.pdf

[85] *Our resilient future: a framework for climate and energy security*, Bristol City Council, 2015, https://www.bristol.gov.uk/documents/20182/33423/Our+Resilient+Future+A+Framework+for+Climate+and+Energy+Security/2ee3fe3d-efa5-425a-b271-14dca33517e6

[86] *Reshaping Regulation: Powering from the Future*, October 2017, Laura Sandys, Dr Jeff Hardy and Professor Richard Green, Energy Systems Catapult, https://es.catapult.org.uk/news/reshaping-regulation-report-suggests-new-winners-and-losers-in-a-future-energy-market-driven-by-data-and-consumer-focus/

[87] *Shared Warmth*, Association for Decentralised Energy (ADE), 31 January 2018, https://www.theade.co.uk/resources/publications/shared-warmth-a-heat-network-market-that-benefits-customers-investors-and-t

[88] http://geography.exeter.ac.uk/staff/index.php?web_id=Bridget_Woodman

[89] http://www.covenantofmayors.eu/media/case-studies_en.html

[90] https://www.itdp.org/brt-transcaribe-improved-transport-cartagena/

[91] http://www.c40.org/awards/2017-awards/profiles/118

[92] http://www.iclei.org/activities/agendas/low-carbon-city/iclei-100re-cities-regions-network.html

[93] http://www.iclei.org/details/article/global-covenant-of-mayors-for-climate-energy-launches-with-7400-committed-cities.html

[94] https://about.bnef.com/blog/high-renewable-future-uk-germany-create-new-power-systems-flexibility-challenge/

[95] *City Energy: a new powerhouse for Britain*, IPPR, https://www.ippr.org/files/publications/pdf/city-energy_Jul2014.pdf

[96] https://www.ofgem.gov.uk/system/files/docs/2017/01/ofgem_future_insights_series_3_local_energy_final_300117.pdf

[97] *Digitalization and Energy*, IEA, 2017, https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf

[98] http://www.eurelectric.org/media/309103/dynamic_pricing_in_electricity_supply-2017-2520-0003-01-e.pdf

[99] http://www.c40.org/why_cities

[100] https://c40-production-images.s3.amazonaws.com/fact_sheets/images/5_Why_Cities_Dec_2015.original.pdf?1448476459

[101] *Local Engagement in UK Energy Systems, A pilot Study of Current Activities and Future Impact*, University of Edinburgh and Energy Technologies Institute, https://s3-eu-west-1.amazonaws.com/assets.eti.co.uk/legacyUploads/2014/07/Edinburgh-Report-Version11.pdf

[102] http://eemonitor.co.uk/about-us/

[103] https://www.bristol-energy.co.uk/media-center/our-quarterly-updates

[104] https://www.bristolpost.co.uk/news/bristol-news/bristol-energy-running-84million-loss-1132124

[105] Compared to the average standard variable tariff of the big six, 9th January 2018. Bristol Energy Company, personal communication.

[106] *Local Engagement in UK Energy Systems, A pilot Study of Current Activities and Future Impact*, University of Edinburgh and Energy Technologies Institute, https://s3-eu-west-1.amazonaws.com/assets.eti.co.uk/legacyUploads/2014/07/Edinburgh-Report-Version11.pdf

[107] *Financing the Transition: Harnessing UK cities' ambition for clean energy*, UK100, http://www.uk100.org/wp-content/uploads/2017/09/UK100_Report_SEP04_Final.pdf

[108] *Local Engagement in UK Energy Systems, A pilot Study of Current Activities and Future Impact*, University of Edinburgh and Energy Technologies Institute, https://s3-eu-west-1.amazonaws.com/assets.eti.co.uk/legacyUploads/2014/07/Edinburgh-Report-Version11.pdf

[109] *Local authority engagement in UK energy systems: highlights from early findings*, UKERC, https://heatandthecity.org.uk/wp-content/uploads/2017/11/LA-Engagement-in-UK-Energy-Systems-Report-1.pdf

[110] https://www.worldfuturecouncil.org/energy-remunicipalisation-hamburg-buys-back-energy-grids/

[111] https://www.theguardian.com/cities/2014/nov/12/hamburg-global-reverse-privatisation-city-services

[112] https://www.sierraclub.org/ready-for-100/commitments

[113] http://tcdc2.undp.org/GSSDAcademy/SIE/Docs/Vol15/10Colombia.pdf

[114] http://citiscope.org/story/2017/lessons-mexico-citys-green-bond-first-municipal-issuance-latin-america

[115] https://www.ukmba.org/about-the-agency/

[116] *City Century: Why Municipalities Are the Key to Fighting Climate Change*, Michael Bloomberg, https://www.foreignaffairs.com/articles/2015-08-18/city-century

[117] https://www.theguardian.com/public-leaders-network/2015/jul/06/european-cities-clean-energy-governments-eu-climate-targets

[118] *Copenhagen climate plan 2017-2020*, kk.sites.itera.dk/apps/kk_pub2/pdf/1586_0kE7bzR28V.pdf

[119] https://www.kommunekredit.dk/wp-content/uploads/filebase/en/press/GreenBondPressRelease24May2017.pdf

[120] https://scanclimber.com/references/construction/item/2213-skiing-on-waste-to-energy-plant-at-amager-bakke

[121] https://www.swm.de/dam/swm/dokumente/english/swm-annual-report-2016.pdf

[122] https://www.swm.de/english/company/energy-transition-munich.html

[123] https://www.swm.de/english/company/energy-generation/renewable-energies.html

[124] http://www.4coffshore.com/windfarms/gwynt-y-m%C3%B4r-united-kingdom-uk09.html

[125] https://www.bnef.com/core/news/101527

[126] http://munichnow.com/munich-aims-for-100-green-energy-by-2025/

[127] https://asia.nikkei.com/Business/Companies/Munich-aims-to-meet-all-power-demand-with-renewables-by-2025?page=1

[128] https://pv-magazine-usa.com/2016/09/28/new-yorks-rev-process-more-questions-than-answers/ https://www.greentechmedia.com/articles/read/the-shine-wears-off-new-yorks-rev-as-hard-work-sets-in#gs.FCkPuXI

[129] https://www.cornwall.gov.uk/media/13409340/20150715-cornwall-devolution-deal-final-reformatted-pdf.pdf

[130] https://www.gov.uk/government/publications/a-second-devolution-deal-for-the-west-midlands

[131] https://www.cornwall.gov.uk/business/economic-development/geothermal/

[132] http://www.cornwallislesofscillygrowthprogramme.org.uk/hot-opportunity-european-investment/?platform=hootsuite%20

[133] https://www.cornwall.gov.uk/media/21261725/160815-cc-draft-cornwall-council-response-to-eco-help-to-heat-obligation-v06.pdf

[134] https://www.cornwall.gov.uk/media/28862363/170901-cornwall-council-eco-flexible-eligibility-statement-of-intent-version-11-final.pdf

[135] https://www.wavehub.co.uk/wave-hub-site

[136] https://www.ofgem.gov.uk/system/files/docs/2017/07/update_on_regulatory_sandbox.pdf

[137] DUKES, chapter 6, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/633782/Chapter_6.pdf

[138] https://www.passivsystems.com/press-releases/passivsystems-completes-first-installation-phase-for-freedom-future-of-energy-hybrid-heating-project-targeting-1-3bn-annual-savings-by-2030/ http://events.utilityweek.co.uk/wales/wp-content/uploads/sites/163/2016/10/Faithful-Chanda.pdf

[139] Freedom Project Interim Report, January 2018, http://wwutilities.co.uk/about-us/our-company/publications/the-future-of-energy-research/.

[140] http://www.energiesprong.uk/

[141] Energiesprong video, https://www.youtube.com/watch?v=I3WBT2eAArI

[142] The carbon savings would shrink over time as the grid decarbonises, but the energy savings would remain. Calculation by Energiesprong UK. Data and assumptions: 5 million homes in social tenure (from DCLG, table 101: https://www.gov.uk/government/statistical-data-sets/live-tables-on-dwelling-stock-including-vacants); retrofit cost of £45,000 per home; total energy consumption per home before retrofit of 21,000kWh falls to 5,000kWh afterwards; as a result, CO2 emissions of 4.3tCO2e/year before retrofit fall to 1.15tCO2e/year.

[143] *UK Industrial Strategy: building a Britain fit for the future*, BEIS, 2017, https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future

[144] https://www.ofgem.gov.uk/environmental-programmes/eco/about-eco-scheme

[145] ECO pot given as £3.6 billion in the Clean Growth Strategy, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/651916/BEIS_The_Clean_Growth_online_12.10.17.pdf

[146] *Sustainability Challenges in the West Midlands*, Sustainability West Midlands, December 2010, http://www.sustainabilitywestmidlands.org.uk/wp-content/uploads/Sustainability-Challenges-in-the-West-Midlands.pdf

[147] *West Midlands Roadmap to a Sustainable Future in 2020: Annual Monitoring Report 2016*, Sustainability West Midlands, http://www.sustainabilitywestmidlands.org.uk/wp-content/uploads/SWM-2020-Roadmap-Monitoring-Report-2016-Final.pdf

[148] *A Science & Innovation Audit for the West Midlands*, June 2017, WMCA, https://www.wmca.org.uk/media/1682/west-midlands-sia-final-for-publication-21617.pdf

[149] *Sub-regional fuel poverty data 2017*, BEIS, https://www.gov.uk/government/statistics/sub-regional-fuel-poverty-data-2017

[150] *Mapping Energy Performance Certificate data by parliamentary constituency, feasibility report to Citizens Advice*, Dr Toby Bridgeman, Centre for Sustainable Energy, derived from table 4.24. https://www.cse.org.uk/downloads/reports-and-publications/policy/insulation-and-heating/planning/building-performance/mapping-EPC-data-full-feasibility-report.pdf

[151] *Estimating Local Mortality Burdens associated with Particulate Air Pollution*, A M Gowers, B G Miller and J R Stedman, PHE-CRCE, 2014, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/332854/PHE_CRCE_010.pdf

[152] https://www.theguardian.com/environment/2017/apr/04/the-car-is-ingrained-into-people-here-west-midlands-faces-air-pollution-crisis

[153] *A Science & Innovation Audit for the West Midlands*, June 2017, WMCA, https://www.wmca.org.uk/media/1682/west-midlands-sia-final-for-publication-21617.pdf

[154] *West Midlands Combined Authority Strategic Economic Plan*, WMCA, https://www.wmca.org.uk/what-we-do/strategy

[155] https://www.ugcsolihull.uk/hub/

[156] http://www.energycapital.org.uk/wm-energy-facts/

[157] Presentation to the policy commission, Dr Simon Slater, Sustainability West Midlands, 6 October 2017, http://www.sustainabilitywestmidlands.org.uk/wp-content/uploads/SWM-Energy-Commission-6-10-17.pdf

[158] *The Economics of Low Carbon Cities: A Mini-Stern Review for Birmingham and the Wider Urban Area*, CLCF, 2013, https://www.sustainabilitywestmidlands.org.uk/resources/the-economics-of-low-carbon-cities-a-mini-stern-review-for-birmingham-and-the-wider-urban-region/

[159] *Energy and Climate Change: World Energy Outlook Special Briefing for COP21*, IEA, http://www.iea.org/media/news/WEO_INDC_Paper_Final_WEB.PDF

[160] https://data.bloomberglp.com/bnef/sites/14/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf

[161] http://www.sustainabilitywestmidlands.org.uk/wp-content/uploads/SWM-Energy-Commission-6-10-17.pdf

[162] *A Science & Innovation Audit for the West Midlands*, June 2017, WMCA, https://www.wmca.org.uk/media/1682/west-midlands-sia-final-for-publication-21617.pdf

[163] https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKEwjihoOu7KzYAhWJLFAKHf9QCBwQFgguMAE&url=https%3A%2F%2Fwww.uktradeinfo.com%2FStatistics%2FRTS%2FRTS%2520Releases%2FRTS_Q2_2017.pdf&usg=AOvVaw25Z1KNSr6vOhll_4SoCuYL

[164] http://fortune.com/2017/02/09/study-china-will-overtake-the-u-s-as-worlds-largest-economy-before-2030/

[165] https://www.ft.com/content/908ba3d0-75da-11e6-b60a-de4532d5ea35

[166] https://www.wmca.org.uk/what-we-do/strategy; http://startupbritain.org/

[167] https://wealth.barclays.com/en_gb/home/research/research-centre/uk-prosperity-map/west-midlands.html

[168] *West Midlands Combined Authority Strategic Economic Plan*, WMCA, https://www.wmca.org.uk/what-we-do/strategy

[169] *A Science & Innovation Audit for the West Midlands*, June 2017, WMCA, https://www.wmca.org.uk/media/1682/west-midlands-sia-final-for-publication-21617.pdf

[170] https://www.sustainabilitywestmidlands.org.uk/resources/gbs-lep-low-carbon-energy-plan/

[171] http://www.energycapital.org.uk/wm-energy-facts

[172] https://www.westernpower.co.uk/About-us/Our-Business/Our-network/Strategic-network-investment/DSO-Strategy.aspx

[173] https://www.ft.com/content/76860102-c3d5-11e7-b2bb-322b2cb39656

[174] West Midlands Combined Authority Strategic Economic Plan, WMCA, https://www.wmca.org.uk/what-we-do/strategy

[175] http://www.ugcsolihull.uk/publications/

[176] http://www.ugcsolihull.uk/wp-content/uploads/2017/09/170919-Value-Capture-Framework.pdf

[177] http://ebbsfleetdc.org.uk/2017/07/27/future-of-electricity-supplied-to-ebbsfleet-garden-city-has-been-secured-in-a-ground-breaking-30million-deal/

[178] https://bigcityplan.birmingham.gov.uk/

[179] https://www.birmingham.gov.uk/downloads/download/155/birmingham_curzon_hs2_masterplan_for_growth

[180] http://www.investblackcountry.com/investment-opportunities/industrial/gasholders/

[181] http://www.investblackcountry.com/investment-opportunities/industrial/i54/

[182] http://www.investblackcountry.com/investment-opportunities/industrial/phoenix-10/

[183] Actual figures, calendar year 2017, for a large metalworking business.

[184] Electricity Costs of Energy Intensive Industries, An international comparison, Ecofys and Frauenhofer ISI, 2015.

ENERGYCAPITAL

Energy Capital is the smart energy innovation partnership for the West Midlands. By responding to the needs of our vibrant manufacturing economy and diverse local markets, we aim to make the West Midlands one of the most attractive locations to build innovative clean energy technology companies in the world. Our partnership combines world-leading academic expertise with ambitious local authorities, diverse businesses, innovators and entrepreneurs.

Energy Capital provides a single point of contact for investors, project funders and potential partners across the West Midlands geography. We are facilitating and co-ordinating collaborative public-private investment projects across the region, and working with the local communities and public bodies and national government to create an attractive and creative environment for companies that want to become part of the global low-carbon and smart energy transition.

CATAPULT Energy Systems

The Energy Systems Catapult's mission is to help unleash innovation and open new markets to capture the growth opportunity recognised in the UK Industrial Strategy. Our vision for the UK energy sector sees it overcoming systemic barriers and delivering the innovative products, services and value chains required to deliver the UK's economic ambitions.

We are part of a network of world-leading centres set up by the government to transform the UK's capability for innovation, however we are independent. We take a whole-system view of energy with expertise across electricity, heating and transport through to infrastructure, industry and consumers. By working with stakeholders across the energy sector including industry, academia and government we can identify innovation priorities, gaps in the market and help innovators overcome barriers to accelerating the transformation of the energy system at least cost.

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The Birmingham Energy Institute is the focal point for the University of Birmingham and its national partners, to create change in the way we deliver, consume and think about energy. We have over 140 academics engaged in energy and energy-related research and development. The Institute harnesses expertise from the fundamental sciences and engineering through to business and economics to deliver co-ordinated research, education and the development of global partnerships. By creating technology and guiding policy today, we aim to help shape energy solutions tomorrow.

The Institute is driving technology innovation and developing the thinking required to solve the challenges facing the UK, as it seeks to develop sustainable energy solutions in transport, electricity and heat supply. Co-ordinated research, education and global partnerships are at the heart of our vision.

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