SMART ENERGY - AN ENERGY SYSTEM FOR THE 21ST CENTURY

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At the forefront of energy transformation

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Thank you to all Midlands Engine partners, including Siemens, University of Birmingham, Birmingham Energy Institute, City REDI, WM REDI, Energy Research Accelerator and many more, who have all contributed expertise to inform the insights in this report. This report builds on a tremendous range of activities across the Midlands, which places the region in a leading position to embrace the smart energy transition.

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60 SECOND SUMMARY

The UK's energy system is changing at an unprecedented pace to meet its economy-wide net zero target by 2050. Energy systems are based on delivering different types of energy to end-users at a location, time, price and emission level that strikes a balance between the interests of producers, distributors, end-users and the impact of energy systems on the environment. The 2022 energy crisis has shown that a robust policy structure is required to manage the price of energy, a reminder of the importance of energy to people and the economy.

Greater digitalisation is already disrupting and providing benefits such as monitoring and optimisation to other sectors and the goal of a Smart Energy System is based on leveraging increased amounts of data to provide a more resilient, dynamic system at lower cost. A Smart Energy System is an approach in which smart electricity, thermal and gas grids are combined and coordinated to identify synergies between them in order to achieve an optimal solution for each individual user, or sector, as well as for the overall energy system. This drives down costs, enhances efficiency and reduces carbon emissions. This digital approach creates data through the increased monitoring of its electrical, gas, heat and transport systems. This data empowers consumers and businesses to deliver greater efficiency, unlock cost benefits and enhance flexibility. The electrification of major parts of heating and transport demand, and the deployment of greater amounts of low-carbon generation are opportunities to deploy smart solutions. This report sets out where the Midlands Engine is leading in this sector and recommends actions to accelerate delivery of Smart Energy across the region bringing benefits to the citizens of the Midlands.


Current Process
Process time

EXECUTIVE SUMMARY: SMART ENERGY – AN ENERGY SYSTEM FOR THE 21ST CENTURY

Never, it would seem, has there been so much focus on energy. Soaring energy prices and the associated costs for individuals and businesses both directly through energy bills and indirectly through increased national borrowing will have an economic impact on a scale which is not so dissimilar to Covid-19. Coupled with the long-term ambition to reach net zero by 2050 as enshrined in UK legislation, the pressures could not be higher. Energy is, of course, not just electricity; energy is generated from diverse sources. Transport and heat are two sectors which currently exploit liquid or gaseous fuels. In the fullness of time these sectors will transition to being predominantly electric with the consequence that there will be major investments into new electricity generation (e.g., wind, solar and nuclear), new and upgrades to existing electricity grids, as well as energy efficiency programmes (e.g., thermal insulation for homes). This transition will need new ways of managing the energy system beyond the mechanisms we have in place today, particularly as the removal of large coal and gas plants changes the buffers of fuel available to the electricity grid and its inherent stability. The introduction of large amounts of renewable generation increases the variability of available electricity and therefore creates a need for non-fossil fuel balancing and storage at a greater scale.

In parallel with this energy transition there is an ongoing revolution in computing and artificial intelligence. The pervasive development of machine learning algorithms means that modern high performance computing capability can process huge amounts of data to "learn" how to implement solutions. In tandem the move from analogue to digital systems means that there is an extraordinary amount of digitized data for machine learning to process. The opportunities through enhanced access to data are already making their presence felt to the consumer with innovative companies offering tariffs that are sensitive to the variations in market prices for electricity. However, much of the data from the energy system required to provide maximum benefit is not available, such as real-time disaggregated domestic and non-domestic renewable electricity generation. The transition of the energy system in the next two decades is a chance to invest to ensure that the energy system is fit for the 21st century.

The Midlands has a number of exemplar projects and programmes which are paving the way for this transition. These have been often driven by industry in partnership with universities and include: the SEND project at the University of Keele with Siemens and Engie/EQUANS, which is a Smart Energy network; the Trent Basin project in Nottingham, which is a housing development focused on local Smart Energy Systems, and; the Regional Energy Systems Operator project in Coventry which has been a pathfinder for 5G rollout. There is also great ambition, such as the University of Birmingham and Siemens' plans for the creation of the smartest campus worldwide with 38,000 sensors across the buildings linked to a Smart Energy System. Partners across the Midlands Engine who can build on these foundations. Due to its' size the Midlands Engine region accounts for approximately one-sixth of the electrical and gas demand of Great Britain. The scale of energy utilisation and the ambition to reach net zero, as set out in the Midlands Engine's Ten Point Plan for Green Growth, creates a platform for being an exemplar Smart Energy region.

This report sets out the benefits to the Midlands Engine region from an accelerated shift to a Smart Energy System and why, with the right innovation and support mechanisms, this can provide a net-benefit to energy consumers and businesses in the region and beyond. The net zero transition is underpinned by a low-carbon energy system, and smarter energy systems provide the basis of achieving a secure, resilient energy system at a lower cost than would otherwise be the case.

A Smart Energy System is an approach which utilises new and emerging digital technologies, artificial intelligence, and machine learning, to actively monitor and balance energy needs across connected energy networks, of all scales, by making real-time autonomous interventions empowering energy users and companies and ensuring costs are reduced, energy networks are resilient, and the energy system transitions to net zero.

In order for the Midlands to become an exemplar for Smart Energy, the region will need to work with key organisations to build a Smart Energy System based on implementing projects and programmes. This will support the UK's energy systems transition by maximising the benefit that smart systems offer, not only for the Midlands itself, but also for the UK as a whole. This report shows there is a credible basis for the Midlands taking a leading role in this sector.

We have reviewed selected Smart Energy activities in England to understand where the Midlands region stands. The analysis shows that, on average, the Midlands ranks second for selected Smart Energy activities compared to other regions in England. The Midlands performed better in than the other regions in the UK due to having a higher proportion of the population working in the sector (Rank 1) and greater numbers of EV charging devices per population (Rank 2). In this analysis the best performing region was the East of England (Rank 1), with the South West (Rank 8) the worst performing due to a low rank in smart meter rollout, low-carbon energy generation and number of businesses in the sector. The Midlands' performance in this sector would be improved by targeting greater levels of resource toward low-carbon electricity generation such as solar, wind and nuclear and a focussed programme on developing a Smart Energy Systems industry.

Through scale-up activities in different market segments, the region could have the following gains through investment in these Smart Energy interventions by 2050 (next 28 years):

Smart meters: if 45,000 smart meters were installed in the region per month, then the smart meter roll-out could be completed by June 2024. By 2050, through smart metering, a total of £0.25 billion in energy costs can be saved by domestic consumers and an associated carbon emission reduction of up to 260 ktCO_2e during the time which is 0.4% of the total emissions generated in the region.

Energy monitoring and optimisation in SMEs: if at least 12,000 SMEs (just 3% of Midlands businesses) in the region fully monitor and optimise their energy usage, then they can save between £0.19 billion to £0.77 billion in energy costs and reduce carbon emissions by 25 ktCO_2e to 102 ktCO_2e by 2050, depending upon their level of energy consumption.

Smart Grids: with a steady deployment of smart grids by 2050, the region would see significant reduction in emissions levels and £3.84 billion - £9.02 billion in cost savings to the energy system. This would generate between £1 billion and £1.5 billion in GVA and would sustain between 900 and 1,400 jobs throughout the 2020s and 2030s.

Vehicle-2-Grid: with an estimated 156,000 EVs in the region by 2030, fleet aggregators can save between £1.3 billion and £2.4 billion in energy costs and reduce carbon emissions by 9,845 ktCO_2e by 2050. Vehicle-2-Grid would also save £0.26 billion - £1.88 billion to the energy system.

Micro-grid: with at least 70 regional microgrids by 2040, the region can save up to 96,240 ktCO_2e by 2050 at the cost between £0.56 billion and £1.25 billion and sustain an average of 5,740 jobs per year.

Using the gains from these Smart Energy interventions in the region, we present two scenarios which examine the potential future of Smart Energy deployment in the area[1].

1. Do minimum scenario: in this scenario, the Smart Energy System would only comprise of energy monitoring and optimisation through smart meters and other energy management platforms in households, commerce and industry. Such a Smart Energy System would cost the Midlands anywhere –up to £14.63 billion, leading to up to £1.03 billion in savings to the consumer and emissions reduction up to 362 ktCO_2e which would save in addition –up to £0.15 billion due to emission reduction by 2050.

2. Do maximum scenario: in this scenario, the Smart Energy Systems would comprise energy monitoring and optimisation in households, commerce and industry, Vehicle-2-grid deployment to store energy and manage peak demands, and micro and smart grids to manage and distribute energy. Such a Smart Energy System would cost the Midlands anywhere –up to £20.37 billion leading to emissions reductions of around 106,447 ktCO2e by 2050 which is 25% of total emissions generated in the UK in 2022. Such a system would provide a total savings of –up to £14.3 billion, which includes savings for the consumer, the system and the costs avoided due to Smart Energy Systems. Moreover, such a system would generate –up to £68.46 billion in GVA, ~£0.6 billion in exports and sustain up to 7,140 jobs in the Midlands per year.

The total costs in **do minimum** scenario amounted to £7.34 billion - £14.63 billion with total benefits ranging between £0.48 billion - £1.18 billion from 2022 to 2050, thus generating a benefit-cost ratio of 6.5% - 8%. In the **do maximum** scenario, the total costs were £11.15 billion - £20.37 billion with benefits ranging between £24.6 billion - £68.46 billion from 2022 to 2050, thus generating a benefit-cost ratio of between 221% - 336%. This shows that the do maximum scenario in Smart Energy Systems would generate benefits and savings that would cover the costs at least twice over, and thus be of significant benefit to the region.

Beyond the financial benefits, Smart Energy Systems are crucial for energy security. Small-scale and local low-carbon energy generation combined with proper energy management and distribution would allow for the region to become more self-sufficient in managing its energy demand and supply. The region would become less reliant on outside energy sources, thus becoming more resilient against the volatility of global energy prices. The implementation of various Smart Energy interventions for monitoring and optimisation would be able to better address the energy flows, further helping to match energy needs of different areas.

By reviewing current regional Smart Energy activities and influenced by the regional stakeholder interviews, we identified four challenges to Smart Energy and suggest nine actions the Midlands Engine Partnership can enact to support the development.

1: Note that the cumulative impact of the do maximum scenario may result in the double counting of some benefits, including avoided cost, system cost reduction and emissions reduction. It is not possible to separate out this effect.

Challenge A: Lack of long-term planning and coordination from national government through to local governments on the development of regional and local energy systems.

Action 1: Create a regional coordination body for Local Area Energy Planning, to provide a focus for data sharing on Smart Energy Systems and their deployment, including microgrids. This would involve local and combined authorities through to energy companies and consumer organisations.

Action 2: Support the development and rollout of a series of large-scale Smart Energy Pathfinder projects building on the expertise and leadership in the Midlands.

Challenge B: Existing energy market frameworks do not fully incentivise the flexibility that Smart Energy Systems could provide or its innovation potential.

Action 3: Develop initiatives to support the enhanced rollout of smart meters in the Midlands.

Action 4: Work with energy companies to encourage the uptake of smart electricity and gas tariffs to enable targeted reduction and bi-directional distribution of energy.

Action 5: Encourage businesses to engage in energy monitoring, optimisation and uptake of energy efficiency measures in buildings and industry. An appropriate level of data sharing with trusted parties would be encouraged as part of this activity.

Action 6: Create a regional energy data task force to drive Smart Energy system-related cybersecurity and privacy, and increase innovator's and investor's trust in these systems.

Challenge C: Many current energy jobs in the Midlands will no-longer exist by 2050 and the workforce needs to be retrained to adapt to new and emerging technologies.

Action 7: Form a Smart Energy skills programme to (re-)train employees in the energy sector supporting the accelerated delivery of Smart Energy Systems.

Challenge D: Opportunities for large scale low-carbon energy generation in the Midlands are lower compared to other regions in the UK.

Action 8: Support decentralised energy systems through more low-carbon and small-scale local energy generation.

Action 9: Support the development of energy intensive industrial clusters and energy users around energy from waste plants, small scale nuclear or other emerging energy generation technologies which can produce electricity, heat and potentially hydrogen.

1. INTRODUCTION

The shift to low-carbon is a significant and sizable opportunity for business, industry and job creation in the Midlands. In 2021, the Midlands Engine launched the **Ten Point Plan for Green Growth.** The plan recognised that economic recovery and levelling up requires collective action. The Plan prioritised ten key themes for action:

- **Green Buildings.**
- **Net Zero Transport.**
- **Nature's Recovery.**
- **Blue-Green Places.**
- **Low-carbon Hydrogen.**
- **Clean Energy.**
- **Smart Energy.**
- **Green Innovation.**
- **Energy Workforce.**
- **Green Finance.**

Delivery of the pan-regional, collaborative activity identified in the Plan has the potential by 2041 to deliver:

- More than 196,000 jobs.
- A 36% reduction in regional CO_2 (20.8m tonnes).
- Produce more than £24.2b in GVA.

1.1. Aim and Objectives

The Smart Energy focus theme within the **Ten Point Plan for Green Growth** included aims to support the development of digital infrastructure, which delivers decarbonisation, whilst driving coordination, support for SMEs and households for energy monitoring, optimisation and smart technology installation, regional data collection and green skills training. The present report aims to advance the thinking by examining the Smart Energy area in more detail and identify clear actions for the region.

The present review addresses the following objectives:

1: Develop a definition of Smart Energy, or Smart Energy System, which can be applied across the region.

2: Identify what Smart Energy Systems are in place in the Midlands Engine Region.

3: Explore the challenges related to Smart Energy deployment, including any potential barriers.

4: Evaluate the economic impacts of a Smart Energy System.

1.2. Approach

The present work has attempted to develop a deep understanding of Smart Energy approaches, what has been done globally, nationally and regionally and where the potential lies for ambitious new projects for the Midlands. The project group involved participants from the Birmingham Energy Institute, the Energy Research Accelerator, the City/WM REDI teams and Siemens. The team utilised expertise in energy data, energy policy, digital systems, energy generation and regional oversight.

In order to inform the thinking and the conclusions, we completed a series of interviews on Smart Energy deployment in the region to understand the challenges and barriers the system is facing, or will face, in the future. The organisations we interviewed, and the questions covered are shown in Table 1. Though these did not include consumer groups, many of the discussions involved how consumers would benefit from a Smart Energy transition.

Table 1: List of organisations interviewed and questions asked.

Organisation	Interview Questions
Energy Capital	1. What does Smart Energy mean for your company?
Energy System's Catapult	2. What are the barriers to the deployment of Smart Energy in the region?
Smart Energy Research Lab	3. What are the challenges for Smart Energy deployment now and in the future?
Midlands Net Zero hub	4. What issues are faced regarding Smart Energy Systems?
Octopus Energy	5. What are the problems with consumer engagement and uptake?
Kew Technologies	6. What are the lessons learned, either from previous projects or international deployment?
ClearVUE, a Net Zero Consultancy	7. What Smart Energy projects are your organisation involved with?
Western Power Distribution	8. What needs to be done to deliver a Smart Energy transition?
Worcester Bosch	9. What are the key regional policy drivers and who are the key organisations? Shift away from fossil fuel supplies to the electrical system.
Midlands universities	

More details about the interviews is provided in the Appendix A.

The development of the research and the conclusions of the report were shared with a Midlands Engine convened steering group to ensure robustness. Though it should be conceded that any review of this type will have omissions and will reflect the perspectives of those sampled in the interviews and engaged in the programme. The report aims to set out a vision for the region. It then concludes with a set of proposals for next steps on how the region can successfully take this area forward and maximise economic and sustainable outcomes.

2. OVERVIEW OF THE UK ENERGY SYSTEM AND THE POTENTIAL ROLE OF SMART ENERGY

For decades, the generation and transmission of electricity to consumers has been via large "centralised" fossil-fuelled and nuclear power stations. These larger capacity power stations connect directly to the electrical national transmission system, which itself connects to regional distribution networks that deliver electricity to end users. Electricity bill costs are partly based on meter readings on how much electricity is used, with additional costs for standing charges to cover network infrastructure, and further costs for levies and taxes.[2] Natural gas has a conceptually similar framework of larger sources of supply connected to a national transmission system, that connects to gas distribution networks that deliver the gas to end users. For both electrical and gas systems, there are also industrial customers with single site demand that is so large that they connect directly to the transmission system, and therefore do not take their supply through the distribution networks.

Historically, the electrical and gas systems have been mostly demand led, meaning when demand varied the supply would have to adapt to accommodate and keep the system balanced. The electrical system in particular is required to be kept in balance at all times within a tightly controlled range of frequency around 50 Hz.[3] When generation exceeds demand the frequency rises, and when it is lower than demand the frequency falls. The balancing of electrical networks is complex but is based on the simple principles that it requires appropriate data for those in charge (the electrical system operator) to be able to understand the state of the system at any given point in time, and then to incentivise generation or demand to change to match each other. Historically, this used to happen with larger sources of electrical supply and demand (and still does), but increasingly, the function of balancing is being supported by control of smaller and smaller individual sources that are connected to the distribution networks. This is an example of the possibilities of a smart electrical system that not only provides appropriate levels of data for system balancing, but also allows control and action of devices to bring the system back into balance. Many more devices may also choose to vary demand or supply without central control or direction, but the overall electrical system will need to be aware, and take account of the aggregate impact of these devices on the network to manage resilience.

The electrical system operator has a range of different market frameworks, bilateral agreements and grid codes to allow it to balance the system under a range of scenarios including extreme events. The natural gas system also has a range of market frameworks and design codes, but it is managed in a different way to the electrical system due to the inherent buffering of natural gas as line-pack in the higher-pressure tiers of the transmission and distribution systems. A Smart Energy System will help the interchange of data between gas, electrical, heat and transport systems of the wider energy network of Great Britain, with the goal of a more resilient and lower cost energy system than would otherwise be the case.

The transition to a decentralised and increased low-carbon network

In recent decades the UK has begun a significant shift in how and where electricity is generated and distributed. This transition will likely accelerate in the coming years due to pressures to decarbonise electrical generation coming from a combination of National, Combined Authority and Local Authority targets, leading to many fossil-fuelled power stations closing and introducing more localised, renewable generation such as solar photovoltaic (PV) in addition to the deployment of larger offshore wind farms connected to the transmission system.

Moreover, the shift towards decarbonised and decentralised energy systems suggests greater amounts of demand will become electrified. There has already been legislation banning the sale of new petrol and diesel-fuelled cars from 2030.[4] The heat and buildings strategy,[5] combined with previous announcements on the ban of fossil fuel boilers,

2: https://www.ofgem.gov.uk/information-consumers/energy-advice-households/costs-your-energy-bill.

3: 50 Hz is the frequency of the UKs electrical grid - https://www.nationalgrideso.com/electricity-explained/how-do-we-balance-grid/what-frequency.

4: https://www.gov.uk/government/consultations/consulting-on-ending-the-sale-of-new-petrol-diesel-and-hybrid-cars-and-vans/outcome/ending-the-sale-of-new-petrol-diesel-and-hybrid-cars-and-vans-government-response.

5: https://www.gov.uk/government/publications/heat-and-buildings-strategy.

suggests that as part of the Future Homes Standard that no new homes would be able to connect to the natural gas network from 2025.[6] These decisions mean that major parts of both transport and space heating demand in the UK will shift away from fossil fuel supplies, not only at the final use step in vehicles and gas boilers, but also as an input fuel to larger electrical generators too. To reach an economy-wide net zero target, energy systems will have to be de-fossilised, although the aviation sector may have to continue to use fossil fuels longer than most.

Several large nuclear power stations are nearing the end of their design life and are likely to be replaced with more modern equivalents; there is also the expectation that more localised, smaller modular nuclear power plants will be available too. This transition has several impacts:

- There is a greater variety and mix of electrical generation with more dependency on weather dependent generation, e.g., solar and wind. The generation from these sources needs to be managed over different timeframes: from the short-term (hours and days) to the longer-term (days, weeks and seasons). For short-term balancing and grid-services, it is likely that energy storage will be of significant benefit, including lithium-ion battery storage. Many battery storage facilities have been constructed to date, but in the future will include more energy storage technologies such as compressed air energy storage (CAES) and liquid air energy storage (LAES).
- Lower load factors for solar and wind generation (the fraction of time they are generating) means that greater capacity needs to be built to generate the same electrical output over a year as the historical plants they replace. This in turn means that there will be more times when there are greater levels of generation than there is demand, which also drives the need for system balancing through storage and other means.
- The generation landscape is changing in terms of scale. Large wind farms are directly connected to the electrical transmission system, conceptually similar to the large, centralised fossil-fuel plants they replace. But increasingly, there is much more local generation too, e.g., energy-from-waste plants, biomass plants, combined heat and power units and domestic and commercial generation by solar PV is becoming more common.
- The rise of the "prosumer" as the homeowner (and business and industry) changes to being both a consumer and a producer of renewable electricity. Here electricity generated is being used by the business or homeowner and at times there is export to the distribution system for others to use, e.g., by solar PV. This change means that the electrical distribution system needs to operate in a more dynamic way by managing electrical supply coming onto the network at lower voltage levels. It is an opportunity and a challenge for the electrical grid and the markets that underpin its operation.
- The transition in the historically relatively unconnected transport sector from fossil fuel vehicles (mainly powered by diesel or petrol) to electric vehicles (EV) creates increased demand on the electrical system. This means greater low-carbon generation capacity will need to be built and the transmission and distribution systems will have to be adapted to cope with changes in not only the levels but also the patterns of demand. In addition, and most importantly, the vehicles themselves require batteries which can be connected to the electrical distribution system with the appropriate safeguards. EV batteries would provide extra flexibility to the network by acting as energy stores and by generating electricity at peak times to export back onto the network and charging when electrical demand is low, particularly when there is an excess in generation.
- Under the Future Energy Scenarios[7] from National Grid, the electrification of heat demand, and the move away from natural gas for space heating, through heat pumps and transport demand through EVs would contribute to an annual electrical demand in 2050, at least double that of now.
- There has already been a large decrease in electrical grid inertia as fossil-fuel thermal plant with rotating steam turbines has been decommissioned. This requires innovative ways of providing support and stability to the grid.

One way of meeting the increased level of electrical demand could be to build greater amounts of large centralised low-carbon generation and to significantly increase the network capacity to cope with the predicted increase in additional demands from heat and transport. Another is to consider how smart approaches would optimise electrical generation and how appropriate electrical usage data would allow for more dynamic management of networks to limit the amount of capacity that needs to be built.

6: https://www.homebuilding.co.uk/advice/future-homes-standard.
7: https://www.nationalgrideso.com/future-energy/future-energy-scenarios.

3. THE ROLE OF SMART ENERGY SYSTEMS AND APPROACHES

3.1 The Definition of Smart Energy Systems and smart grids

The terms 'Smart Energy' and 'smart grid' are often used interchangeably, particularly in the electrical sector.[8] However, the latter has been in use longer and various institutions have tried to define it.[9] For the purpose of this report, the International Energy Agency's definition of smart grid has been adopted, which is:

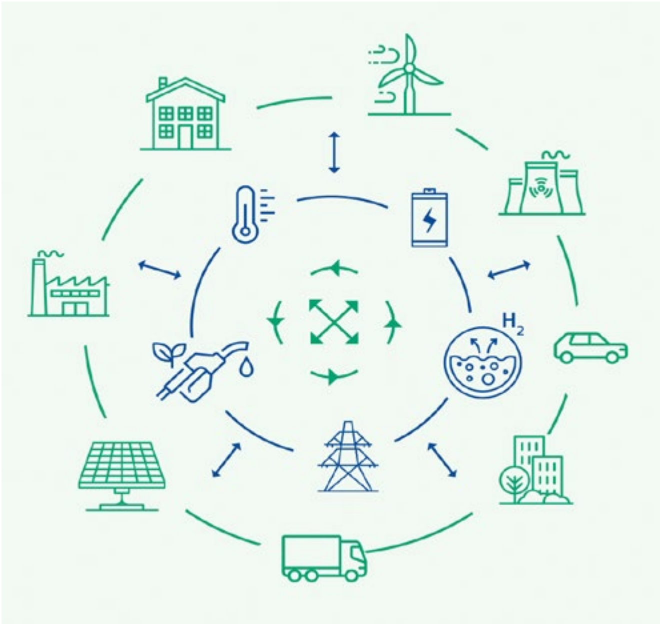
> *"A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users. Smart grids coordinate the needs and capabilities of all generators, grid operators, end users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impacts while maximising system reliability, resilience and stability.[10]"*

Going beyond the electricity only concept, Smart Energy Systems take a holistic, multi-vector, cross-sector approach to reach beyond individual energy carrier limitations and identify overarching solutions. As with 'smart grid', the term 'Smart Energy Systems', or 'Smart Energy Networks' is still in its forming phase, with several definitions being suggested; however, for the purpose of this report, the following definition from Aalborg University has been adopted:

> *"A Smart Energy System is defined as an approach in which smart electricity, thermal and gas grids are combined and coordinated to identify synergies between them in order to achieve an optimal solution for each individual sector as well as for the overall energy system.[11]"*

In summary, Smart Energy Systems provide ways of managing the additional complexity in a multi-grid system at a lower cost than focusing on a particular sector or infrastructure in isolation, e.g. by limiting the costs of building additional network capacity (electricity, hydrogen or heat) to meet peak demand. Pro-active energy system management using granular data offers innovative ways to manage the impacts of the electrification of heating and transport on the electrical grid, whilst anticipating the requirement changes for legacy infrastructure. A Smart Energy System has the capability to manage greater levels of decentralised low-carbon generation. A Smart Energy System should also have considerations of cost versus benefit at its core, which can include different generation and forms of storage. In addition, it could help to build trust back into the energy system through the public disclosure and sharing of open data where feasible. The overarching energy system understanding such a system provides, ensures that the design, implementation and operation of the energy system as a whole is in line with national carbon emission targets.

Figure 1: Smart Energy System concept – European Commission.[12]



8: smart energy | IEC
9: http://dx.doi.org/10.13140/2.1.2826.7525
10: Smart Grids - Analysis - IEA
11: Smart_Energy_Systems_Aalborg_University.pdf (aau.dk)
12: EU strategy on energy system integration (europa.eu)

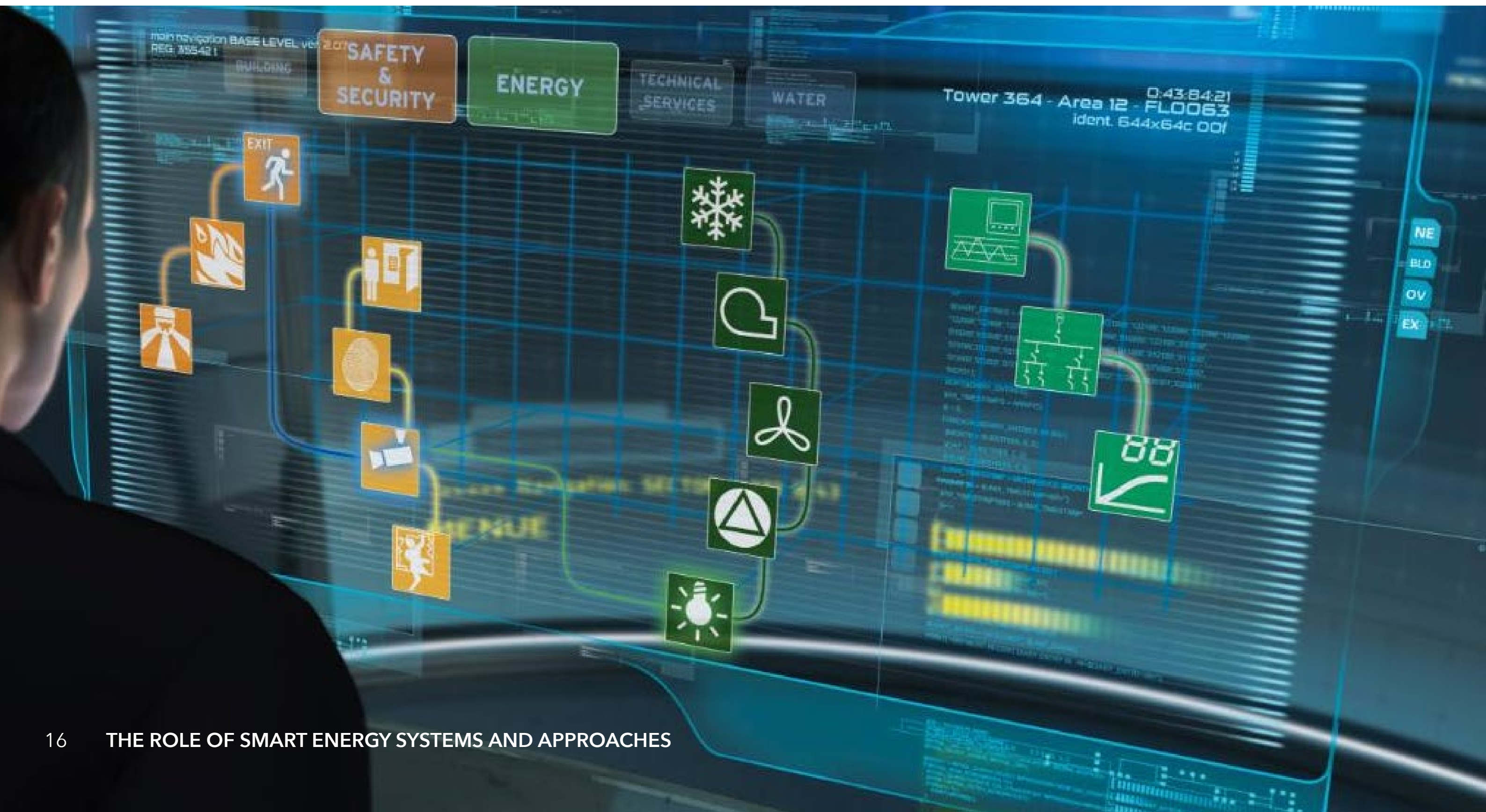
3.2 The potential of smart grids and smart technology

The UK recognises that energy systems must become smarter to manage the increasing complexity on its journey to net zero. Access to appropriate data would allow energy users greater levels of choice in where and when they source their energy and encourage greater levels of energy efficiency. However, creating and managing data has costs; thus, only appropriate data should be collected, allowing a Smart Energy System to operate at a greater net benefit.

Smart grids and smart technology allow for the integration of large, small and distributed generation, and employ metering to allow a more sophisticated understanding of the energy flows around the system. They also provide granular data that can be analysed with state-of-the-art computing and IT systems for optimisation. In recent times, cloud-based computing, high-performance computing, artificial intelligence and machine learning have driven a revolution in what is possible across the digital sector. The connectivity of mobile phones, mobile apps, and mobile networks and enhanced connectivity and bandwidth through 5G and 6G mean that it is now possible to consider what this smartness allows in terms of the energy system and what a smart grid combined with a Smart Energy System allows.

Smart Energy allows the development of energy systems that have different types, and layers, of flexibility than previously possible. Energy system flexibility in the UK (similar to most other countries) has been based on the benefit of fossil-fuels, and their dispatchable nature. A simple example of this is the ability of coal-fired power stations to have months of coal stocks sat next to a power plant, that was able to be converted into electricity when required. However, the transition to a net zero economy means that fossil fuels will eventually be phased out of the energy system, and thus, their ability to underpin wider energy system flexibility will be phased out too. This creates a challenge for energy systems. Smart Energy Systems can help here, as data and control allow more demand (greater numbers and types) to be available to help keep the wider energy system in balance over different timeframes. This should drive down costs for consumers and further enhance innovation in business models within the energy system as more data become available.

The heart of Smart Energy is the availability of data that can be analysed to create information and insights, and a system or devices that are capable of integrating and exploiting it in a smart way. Data can be used for optimisation of energy systems over different geographical scales and timescales, to predict future supply and demand to underpin a resilient energy system. A Smart Energy System will



have greater amounts of data from various points including end-users and at various points in energy networks to provide a more accurate knowledge of the state of the energy system itself. In addition, weather predictions, air quality information, transport activity and volume, carbon intensity, market data, political and social trends, etc… In other words, a Smart Energy System will interlink with other data sources, it is much more than the energy system alone.

The Smart Energy home is already emerging but will continue to evolve. It will have smart devices which will at the most basic level have the ability to operate in a binary on/off mode, but potentially with a level of sophistication beyond that. Homes will have greater amounts of energy generation and storage, e.g., solar PV combined with heat pumps and battery, and an energy management system which adds functionality to a smart meter. Home systems can be responsive to external signals such as market price to optimise against different criteria such as cost, consumption or carbon intensity. These external signals can be responsive to local constraint conditions, or default to helping at a national level when this does not contradict a more local priority.

Like Smart homes, business can also generate, store, and monitor their energy usage. Domestic systems as well as commercial systems could therefore have some sensitivity to grid constraints and work collectively with other homes and businesses to manage local network demand. Aggregated homes and businesses can collectively work as virtual power stations to provide electricity onto or extract electricity from the grid, potentially providing national-level grid balancing frequency management. Increasing numbers of electric vehicles will provide a national energy storage capability if they can be appropriately incentivised to manage their demand and to generate electricity at various times.

While this vision is powerful, it can seem distant. However, there are already cloud computing platforms which take consumer and customer data and integrate it with electrical market data to provide signals to allow consumers to adjust their behaviour. There is already smart charging of electric vehicles and aggregation of consumers to provide virtual power stations, and there are already smart devices and smart meters in increasing numbers of households.

The challenge with this approach is to ensure that progress in parts of the system, such as the generation, market, grid, digital platforms and systems and the devices and homes are able to communicate appropriately to be of benefit to the wider system. **A second challenge is that the data and information that the Smart Energy System creates are secure and do not expose the consumer or business to risks. We need to be careful that the digitalised and Smart Energy System does not become a critical piece of national infrastructure that can be manipulated with malign intent.**

Whether deployed across individual buildings, campuses, city regions or entire countries, Smart Energy Systems can help energy users realise their energy ambitions by using advanced digital driving processes. They offer the following potential benefits:

- They can enable the transition to low-carbon (and more localised) energy sources by exchanging data on energy production and storage and using data to minimise carbon emissions.
- The data can be used to optimise operational expenditure (OPEX) associated with producing, storing, using and selling energy associated with different assets.
- They can support optimal charging and electrification of vehicle fleets.
- They can encourage greater levels of energy efficiency.
- Increased resilience by integrating multiple sources of energy production can increase the network's overall resilience.
- Increased transparency of network health and performance.
- The deployment of smart grids that can integrate new technologies and solutions such as Vehicle-to-Grid (V2G).
- More sustainable living across society through more engagement with our energy use.
- Improving the resilience of the system to the impacts of climate change, such as extreme weather, which can have a major effect on the functioning of the incumbent energy system.

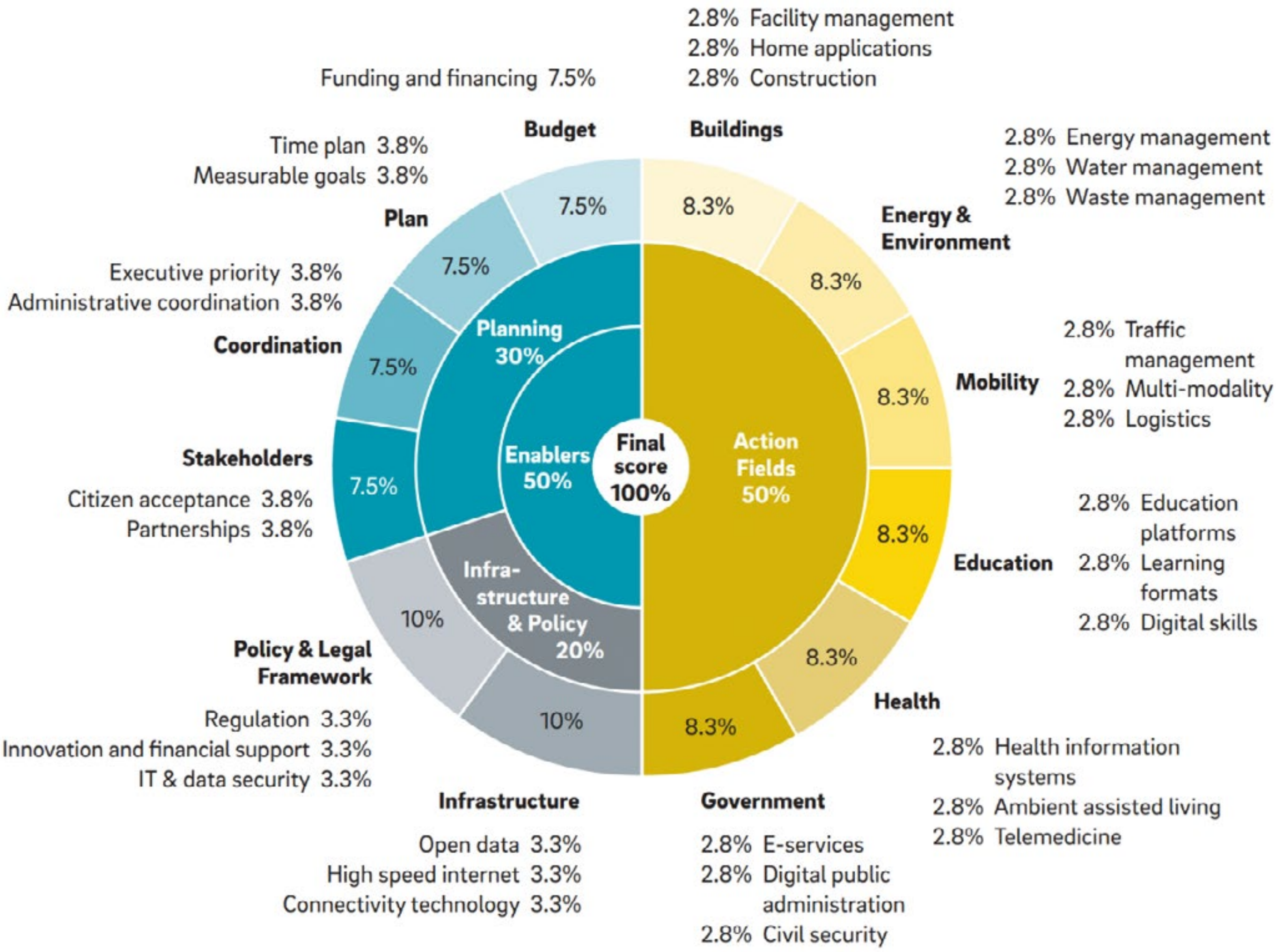
Beyond this, Smart Energy Systems can integrate with other smart digital ecosystems to provide wider benefits, such as the monitoring of air pollution, more energy-efficient and reliable transportation systems or more efficient and greener supply chains.

3.3 Smart Cities in a Global context

In 2019, 153 cities worldwide – large and small – had published an official Smart City strategy, of which 15 had plans that demonstrate a comprehensive strategic approach, and 8 were at an advanced stage of implementation.[13] The Smart City Strategy Index (Figure 2) assigns 2.8% directly to the 'energy management' sub-criteria. However, under the definition of Smart Energy, 9 out of the 12 criteria listed below are directly or indirectly associated to energy, i.e., excluding 'education', 'health' and 'government'. By improving the Smart Energy capabilities across the Midlands, cities within the region could significantly improve their internationally perceived and measured performance, e.g., Birmingham was ranked 50th out of 118 cities in 2021 by the Smart Cities Index.[14]

Ranking 'smart cities' is a relatively recent endeavour with the two main indexes being the Smart City Index[14] by IMD (International Institute for Management Development) and SUTD (Singapore University of Technology and Design) and the Smart City Index Report by Yonsei University and the University of Cambridge, with both being updated every two years. Other ranking mechanisms have also been created by the likes of Roland Berger[13] and EasyPark.[16] The Midlands Engine could lead the way in designing and enacting a 'Smart Region Index' ranking assessment to supplement and track the tangible impact of its Smart Energy progress, and make it comparable to other regions in the UK and worldwide.

Figure 2: Smart City Strategy Index Assessment Framework is based on 3 dimensions, 12 criteria and 31 sub-criteria.[13]



13: Source: The Smart City Breakaway (2019).
14: Source: Smart City Index (2021).
15: Source: Smart cities index report 2022.
16: Source: Easy Park (easyparkgroup.com).

3.4 Global Smart Energy Examples

To inform the discussion of what is possible within the Midlands, this section details a series of examples where Smart Energy principles have been deployed.

3.4.1 Expo/District 2020 - Dubai, United Arab Emirates: Blueprint of a smart, sustainable city

Expo 2020, Dubai, was built on a 4.38 km^2 site and featured more than 24 million visits from 178 countries. After the Expo ended in March 2022, the site was converted to District 2020 which now serves 145,000 people.

The Expo was the largest single installation of smart technologies in the world, which supported 54,000 jobs and added a Gross Value of $16.9 billion. The Expo focused on Smart Mobility, Smart Logistics, Industry 4.0, and Smart Cities. For more information see Appendix B.

3.4.2 Digital Twin City – Barcelona, Spain: Urban planning based on real-data foresight

Barcelona's municipality is pioneering a digital approach to urban planning. The aim is to create a 15-minute city, where people can access their homes, workplaces, and all essential services, including education, healthcare, shops, etc., within a 15-minute walk or bike ride. In addition, to tackling climate change, this approach will account for the impacts of gentrification and highlight areas in need of regeneration.

Using the MareNostrum supercomputer located in a 19th century chapel, the Barcelona Supercomputing Centre is creating a digital twin replica of the city to test and validate potential planning scenarios ahead of the decision-making processes using real-life data. Citizens are also encouraged to contribute and scrutinize the input information, which strengthens community buy-in and trust in the process.

3.4.3 Aspern Seestadt – Vienna, Austria: Smart Energy district as a living laboratory

Vienna's 22nd district is one of Europe's largest urban energy research projects. The 240-hectare living lab is expected to include housing for over 25,000 people, 20,000 workplaces, several educational facilities for all age groups, an industrial park, and a research centre by 2028, which is equivalent to a total investment of €5bn.

To create a thriving and sustainable city, Aspern has focused on energy efficient building standards, effective transport infrastructure, local recycling of building materials and a rainwater management system. In addition, the Aspern Smart City Research team operate five distributed and intertwined testbeds focusing on Smart Buildings, Smart Grids, Smart Users, Smart ICT systems and Smart Charging. A city-wide data centre brings all elements of these systems together to cost-optimise local energy generation, storage and consumption, whilst identifying system efficiencies.

3.5 National Smart Energy Policy and Funding Context

Overall policy context

In 2019, the UK committed to net zero emissions by 2050, and is already working towards achieving this target. By 2020, the UK had already achieved a 50% reduction in territorial emissions compared to 1990 levels; however, this reduction was partially assisted by temporary social and economic inactivity caused by the COVID-19 pandemic and its associated restrictions and some offshoring of carbon intensive manufacturing. Emissions rose 4% between 2020 and 2021 as the economy recovered post-pandemic; however, emissions in 2021 were still 47% below the levels of the 1990s.

In November 2020, the government introduced The Ten Point Plan for a Green Industrial Revolution, which sets out the approach to support green jobs and accelerate the path to net zero. In 2021, new targets were set by the UK government that emissions will be reduced by 68% by 2030 and 78% by 2035 compared to the 1990 levels. In October 2021, Net Zero Strategy: Build Back Greener was introduced, which sets out policies and proposals for decarbonisation of all sectors in the UK to meet the 2050 net zero goals.

Policy changes by market segment

Figure 3 summarises key targets which have been set by market segment.

Figure 3: Relevant Smart Energy targets announced in recent years.

Residential	2022 Fixed minimum annual installation targets for energy suppliers for smart meters 2025 All homes have smart meters 2028 600,000 heat pump installations per year by 2028 2030 As many fuel-poor homes have an EPC Band C 2035 All-new heating appliances installed in homes and workplaces will be low-carbon technologies, like electric heat pumps or hydrogen boilers. 2035 As many homes to reach EPC Band C
SMEs	2023 By 2023, there will be support to begin hydrogen heating trials in a local neighbourhood 2027 Raising total R&D investment to 2.4% of GDP by 2027
Energy-Intensive Users	2021 £120 million in investment to begin the introduction of at least 4,000 more British built zero-emission buses 2022 £582 million to extend the Plug-in Car, Van, Taxi and Motorcycle grants to 2022–23 to reduce their sticker price for the consumer 2030 Deliver four carbon capture usage and storage (CCUS) clusters, capturing 20-30 $MtCO_2$ across the economy, including 6 $MtCO_2$ of industrial emissions, per year by 2030 2035 All vehicles are required to be 100% zero emissions from 2035
Regional-grid infrastructure	2032 Work with industry to complete testing necessary to allow up to 20% hydrogen blending into the gas distribution grid for all homes on the gas grid 2025 Will support the industry to begin a large village hydrogen heating trial and set out plans for a possible pilot hydrogen town before the end of the decade 2026 Launching a Hydrogen Village trial to inform a decision on the role of hydrogen in the heating system 2030 Develop 5GW of low-carbon hydrogen production capacity by 2030 2030 The network of charge points on England's motorways and major A roads to be extensive, with more than 2,500 high-powered charge points that can charge your car so it can drive over 100 miles, all in the time it takes to have a cup of coffee 2035 England's motorways and major A roads will have around 6,000 high-powered charge points
Energy Generation	2025 We hope to see 1 GW of Hydrogen production capacity 2030 We aim to produce 40GW of offshore wind, including 1GW of innovative floating offshore wind in the windiest parts of our seas 2030 The UK is home to the world's first two floating offshore windfarms, and by 2030 we intend to have scaled this twelvefold 2035 Fully decarbonised power system
Other Targets	2021 We will invest £5.2 billion in a six-year capital investment programme for flood and coastal defences 2022 Initiate ten long-term Landscape Recovery projects 2025 Double cycling rates from 2013 levels to 1.6 billion stages per year 2025 £295 million of capital funding which will allow local authorities in England to prepare to implement free separate food waste collections for all households 2030 50,000 new green jobs by 2030. Capture 10Mt of carbon dioxide a year by 2030. Protect and improve 30% of UK land by 2030 2032 The public sector has reduced its direct emissions by 50% compared to a 2017 baseline 2037 Additional funding of £1.425 billion for Public Sector Decarbonisation to reduce emissions from public sector buildings by 75% by 2037 2040 Remove all diesel-only trains 2050 Net zero rail network 2050 Restoring approximately 280,000 hectares of peat in England

Table 2 shows the additional funding made available to support the Smart Energy agenda from a national perspective.

Table 2: Government programmes that are influenced by Smart Energy.

Thematic Area	Programmes and funding
Innovation	Net Zero Innovation Portfolio A £1 billion fund to accelerate the commercialisation of innovative low-carbon technologies, systems and processes in the power, buildings, and industrial sectors Energy Storage and Flexibility innovation challenges A £100 million fund to explore challenges for energy storage as we move towards an increasingly renewables-heavy system to allow us to store energy over hours, days and even months.
Green Recovery	The government has announced £5 billion to support a green recovery. Private investment for green recovery is estimated to be £12 billion
Renewable Energy	Wind Energy Investing £160 million into modern ports and manufacturing infrastructure, providing high-quality employment in coastal regions Offshore Transmission Network Review It will set out the strategy to connect offshore wind in a clean and cost-effective way and will outline plans for smart systems
Training	Lifetime Skills Guarantee will equip people with the training they need to take advantage of these opportunities
Hydrogen	Net Zero Hydrogen Fund £240 million in the fund to support the development of the business model. Smart generation and utilisation of hydrogen needs to be integrated into the future energy system.
Transport	Electrification of UK transport sector £1 billion to support the electrification of UK vehicles, including the establishment of 'giga-factories'. First £500 million of the fund to protect existing jobs in the West Midlands, Wales and the North Charging infrastructure Investment of £1.3 billion to accelerate the roll-out of charging infrastructure, targeting support on rapid charge points on motorways and major roads to reduce customer anxiety around long journeys. Installing more on-street charge points near homes and workplaces to make charging as easy as refuelling a petrol or diesel car. Plug-in grant Investment of £582 million to extend the Plug-in Car, Van, Taxi and Motorcycle grants to 2022 - 23 to reduce the on the road price for the consumer. Freight trials £20 million investment to pioneer hydrogen and other zero-emission lorries to support the industry to develop cost-effective, zero-emission HGVs in the UK. Renewal of public transport Investment of tens of billions of pounds in enhancements and renewals of the rail network, £4.2 billion in city public transport and £5 billion on buses The fully zero-emission city centre Funding at least two all-electric bus towns, beginning this financial year Midlands Rail Hub Progress the existing scheme in Birmingham and improvements in Manchester and Leeds
Buildings	Extension of existing schemes £1 billion of funds provided for the extension of existing retrofitting schemes Green homes grant Extension for another year to improve energy efficiency in homes and replace fossil-fuel heating Public sector decarbonisation scheme Funding to reduce emissions in schools, hospitals and public funding Homes upgrade grant Upgrade of heating systems for rural homes off the gas grid Social housing decarbonisation fund Further funding to continue upgrading social housing stock

3.6 UK Smart Energy projects

There are several UK-based Smart Energy projects that we have reviewed in order to understand the potential for Midlands-based action. Examples of these are summarised in Table 3.

Table 3: A summary of notable Smart Energy projects in the UK.

Smart Energy Projects	Description
Smart Energy Research Lab (SERL)	The Smart Energy Research Lab (SERL) is an EPSRC-funded consortium of 7 UK universities, led by University College London, which provides accredited UK researchers with access to daily and half-hourly gas and electricity smart meter data for 13,000 GB Homes. The pseudo-anonymised data is linked to Energy Performance Certificate (EPC) data, weather data, and to a participant survey giving contextual information on the household and building. SERL developed the technical and governance infrastructure that allows the collection of smart meter data through the national smart meter communication system (DCC). The team also recruited the observatory sample of 13,000 households – obtaining informed consent to access their smart meter data. SERL has its own research programme of eight projects, and a further thirteen approved external projects are using the SERL researcher portal. SERL also works with government departments on several projects evaluating energy-saving interventions. In total, there are fifty researchers across seventeen institutions accessing the data with a steady stream of applications. The SERL Statistical Report: Vol 1 (May 2022) and accompanying datasets made data from the SERL observatory publicly available for the first time and have been downloaded over 550 times across thirty-two countries. Access to fine-grained domestic energy consumption data combined with contextual data allows researchers to build a much more accurate and detailed picture of real-life domestic energy consumption, thus enabling better modelling and evaluation of Smart Energy interventions and policies. For more info, visit: www.serl.ac.uk
Go Neutral Smart Energy - Greater Manchester	Go Neutral is a Smart Energy initiative to decarbonise the Greater Manchester city region. A pipeline of renewable energy generation and battery storage projects are planned under the initiative to deliver between 15 MW - 40 MW of low and/or zero carbon energy infrastructure capacity by 2024. For Greater Manchester, Go Neutral Smart Energy is about: Taking control of how we generate, use, and trade our energy locally to create a resilient and connected energy system. Creating a greener, healthier, and more affordable lifestyle. Creating investment opportunities that will support new jobs and skills on our pathway to carbon neutral by 2038. Phase 1 of the project is currently ongoing under which a pipeline of 20 MW of new renewable energy generation and battery storage across the area would be installed by 2023. This is being supported by 575 jobs through feasibility, design and delivery and estimation of 10,000t CO2 emission reduction annually. For more info, visit: https://carboncopy.eco/initiatives/go-neutral-call-off-framework
Project LEO (Local Energy Oxfordshire)	Project LEO (Local Energy Oxfordshire) is one of the UK's most ambitious, wide-ranging and innovative energy trials, seeking to accelerate the UK's transition to a zero-carbon energy system. Project LEO is running trials in Oxfordshire to understand how new technologies and services, particularly at the 'edge' of the network – closest to the point where people are using energy – can benefit local people, communities, and the energy system. This cross-sector collaborative project is building a broad range of reliable evidence of the technological, market and social conditions needed for a greener, more flexible and fair electricity system. It is also learning what changes need to happen within national and local policy to enable this to happen. Project LEO is: Testing new market and flexibility models – exploring new products and services that create commercial opportunities for everyone to benefit from the way we generate, store, and use energy in our homes, businesses, and communities. Advancing the capabilities of networks to manage smart, renewable, and storage technologies – learning what needs to happen to our electricity networks to make them ready for a change to a smart local energy system. Facilitating local participation in the energy system – ensuring that individuals, households, and organisations are part of the energy transition. Project LEO is partly funded by £15 million from the Industrial Strategy Challenge fund, which set up a fund in 2018 of £102.5 million for UK industry and research to develop systems that can support the global move to renewable energy called: Prospering from the Energy Revolution (PFER). The rest of the funding for the £40 million project comes from the project partners. For more info, visit: https://project-leo.co.uk

Table 3: A summary of notable Smart Energy projects in the UK (continued).

Smart Energy Projects	Description
ReFLEX – Orkney	ReFLEX (Responsive Flexibility) Orkney is a £28.5 million project aiming to create an integrated energy system (IES) in Orkney, Scotland. Funded by UKRI through the Industrial Strategy Challenge Fund, the project is led by the European Marine Energy Centre (EMEC) with cross-sector partners including Aquatera, SMS, Community Energy Scotland, Heriot-Watt University and Orkney Islands Council. The project aims to interlink local electricity, transport and heat networks into one controllable, overarching system, digitally connecting distributed and variable renewable generation to flexible demand. At the heart of the project is the demonstration of flexibility (the ability to modify electricity generation and consumption patterns in response to variability) using technologies like battery storage, electric vehicles, smart chargers and smart meters. Once demonstrated and proven in Orkney, it is expected that the IES model and associated integrated energy service supply framework will be replicated in other areas across the UK and internationally. This would mean long-term export opportunities for the ReFLEX project partners and would help create more flexible and renewable-based energy systems across the globe. For more info, visit: https://www.reflexorkney.co.uk/
Whole Energy System Accelerator (WESA)	The Whole Energy Systems Accelerator (WESA) is a world-first energy innovation test and evaluation facility, enabling interactions between homes, energy networks, and market & policy frameworks to be tested in real-time and across a range of potential future energy system and market scenarios. WESA combines Energy Systems Catapult's real-world test environment of over 1100 digitally connected homes – the Living Lab – with the Power Networks Demonstration Centre's, PNDC's, unique power networks demonstration facility to research, test and accelerate multi-vector energy systems that stimulate the advancement of vital innovations needed to reach net zero. The Scottish Government is investing £2.5 million from the Green Jobs Fund to support and accelerate the development of WESA – including the creation of a 'Living Lab Scotland' of 300 homes linked to PNDC. The Whole Energy Systems Accelerator is a multi-disciplinary partnership between the University of Strathclyde's Power Networks Demonstration Centre and the Energy Systems Catapult's Living Lab, working closely with industrial partners and policy makers. WESA combines the partners' strong reputations in energy systems innovation across electrical power systems, cybersecurity capabilities, whole energy system expertise, and consumer focused capabilities. This makes it possible to test the physics, human behaviour, technology, and market aspects of new energy solutions concurrently and rapidly, thereby supporting the creation of a robust and affordable net zero energy system that considers consumers' needs. WESA will for the first time enable the interactions between activity in homes, energy networks, and market & policy frameworks to be tested concurrently across many different future energy scenarios. UK innovators will be able to test smart products and services with real consumers to ensure they not only drive down carbon emissions but work with human behaviour to give people a great experience and concurrently with the physics of the energy systems to create robust physical and market systems fit for net zero. For more info visit: https://es.catapult.org.uk/tools-and-labs/whole-energy-systems-accelerator/

4. REVIEW OF CURRENT SMART ENERGY ACTIVITY IN THE MIDLANDS

4.1. Smart Energy in the Midlands

The Midlands Engine region covers 10,629 square miles and is home to 11 million people. It comprises 65 local authorities and nine local enterprise partnerships. The Midlands Engine is the largest regional economy in the UK after London, equivalent to £240 billion. Midlands Engine contributes 20% to England's share of exports and £9 billion to the national economy through international activities.

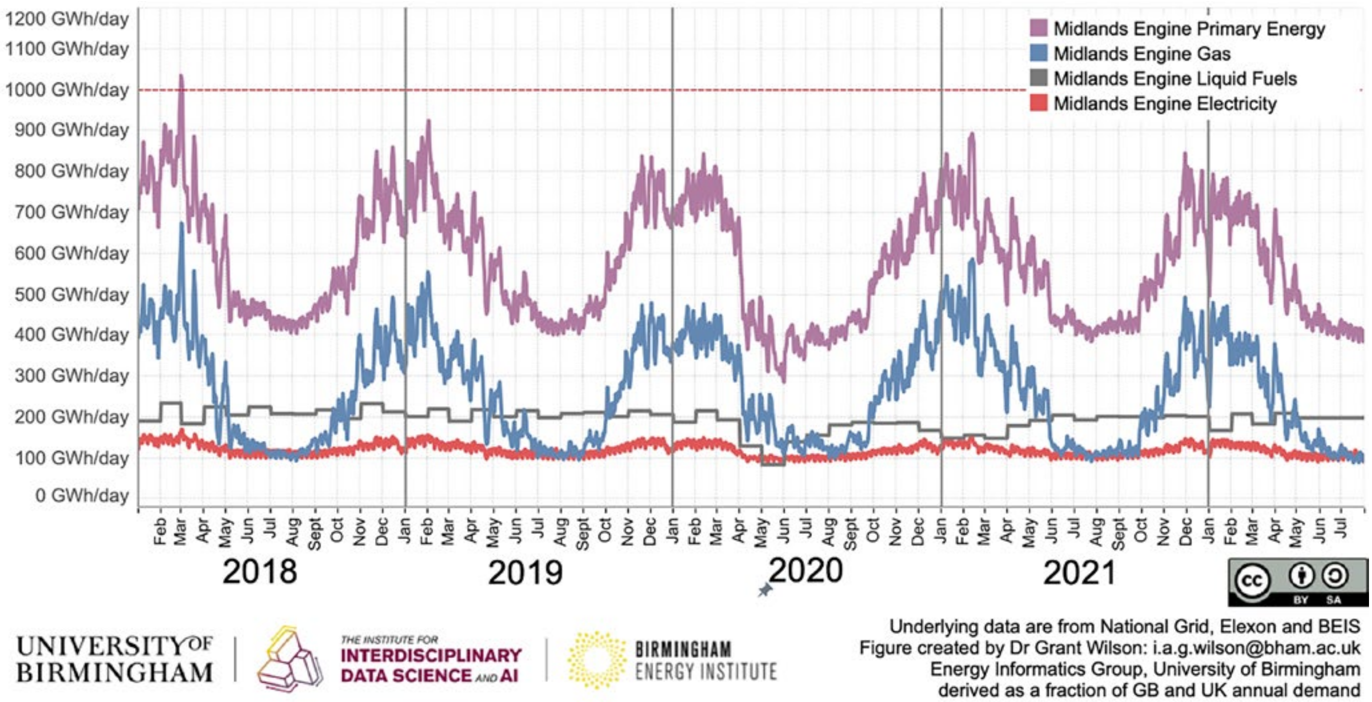
Approximately 15.6% of the UK's private sector R&D occurs in the Midlands Engine, investing £4 billion annually. The Midlands is the leader in the R&D industries, such as automotive, with Europe's largest automotive R&D facility, the National Automotive Innovation Campus, located at the University of Warwick. 25 high-tech business parks, innovation and technology centres and 8 Enterprise Zones are located in the Midlands. Furthermore, the Midlands is centrally located in the UK, so 80% of all UK rail freight passes through the Midlands, and 94% of the UK's population is located less than 4 hours from the Midlands.

This section sets out the present analysis of the size and scale of the Midlands in terms of energy consumption and national standing in the sector.

Energy Consumption

Estimates for the daily Midlands Engine primary energy demand between 2018 and 2022 (based on these being circa one sixth of the national demand) are shown in Figure 4. This estimated primary energy demand varied between 300 (in lockdown) to 1000+ GWh/day (Beast from the East) and was a combination of primary electricity (from nuclear and renewables), coal (for electrical generation), gas (for all types of gas demand) and liquid transport fuels (including aviation). Electricity demand only makes up a proportion of total primary energy in the range between 150 and 180 GWh/day. In contrast, the natural gas demand is highly seasonal with the highest usage in the winter months peaking at around 700 GWh/day. This seasonality is primarily driven by the space heating demand of households, businesses and the public sector. Liquified fuel is utilised significantly in the transport sector and use is consistently around 200 GWh/day, other than the major impacts from Covid lockdowns.

Figure 4: Multi-vector energy consumption for the Midlands Engine region.



Domestic consumption levels of gas and electricity are similar to national averages (Table 4).

Table 4: Domestic gas and electricity consumption in England and Midlands Engine (2021).

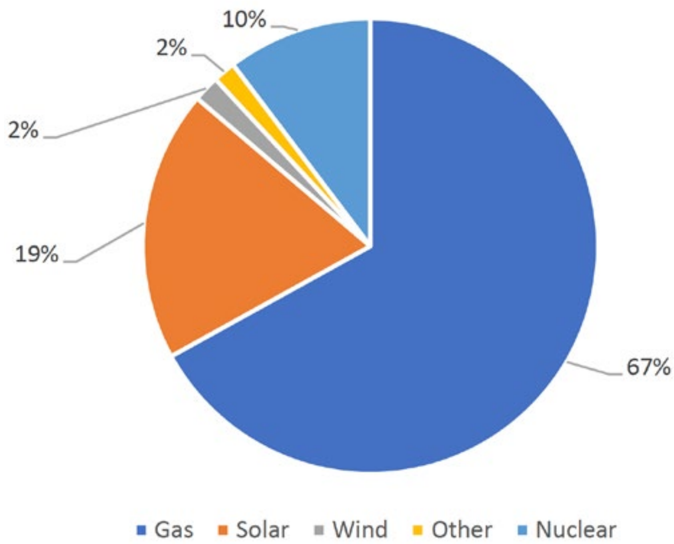
	Gas		Electricity	
	Number of meters	Average annual consumption (kWh)	Number of meters	Average annual consumption (kWh)
England	17,280,730	13,400	21,218,990	3,700
Midlands Engine	3,466,070	13,450	4,077,240	3,600

Source: National Energy Efficiency Data-Framework (NEED) consumption data tables (2021)

Electricity Generation

Whilst electricity generation to the region was previously dominated by coal-fired plants, most of these facilities have either closed or are about to close; hence in 2022, supply to the region was dominated by gas, with renewable energy making up 21% and nuclear an additional 10%. The "dash for gas" was in part driven by the access to UK gas reserves in the North Sea, which for many decades has provided the UK with energy security, and whilst the energy price remained low and decarbonisation was not such a high priority, this was a sound option. However, the world has changed, and the abundance of UK gas reserves has declined; thus, the need for alternative source of electricity generation.

Figure 5: Fuel used in electricity supply to the Midlands (2022).



Source: UK electricity production (2022), primary data thought to be from the carbon intensity automatic programming interface https://api.carbonintensity.org.uk/

Smart Energy in the Economy

We define the future Smart Energy Sector according to the following industry classification to determine how the sector contributes to GVA, business and workforce:

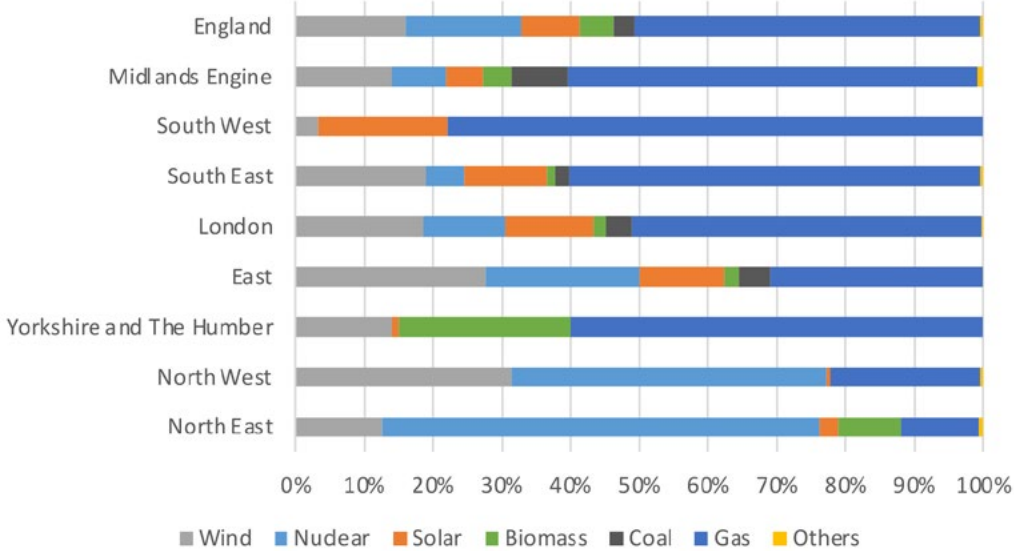
Direct Smart Energy:	Electricity, gas, steam and air conditioning supply.
Indirect Smart Energy:	Manufacture of computer, electronic and optical products. Manufacture of electrical equipment. Manufacture of machinery and equipment. Manufacture of transport equipment. Water supply; sewerage and waste management. Construction. Wholesale and retail trade; repair of motor vehicles.

Next, we examine the Midlands Engine's Smart Energy activities compared to those in other regions in England.

Electricity Production

- Approximately 46% of the total electricity generated in England is from low-carbon sources such as wind, solar, nuclear and biomass.
- Approximately 31% of all electricity generated in the Midlands is from low-carbon sources, and ranks 7th out of the 8 regions in England, only performing better than the South West.

Figure 6 : Electricity Supply by fuel type to regions in England (2022).

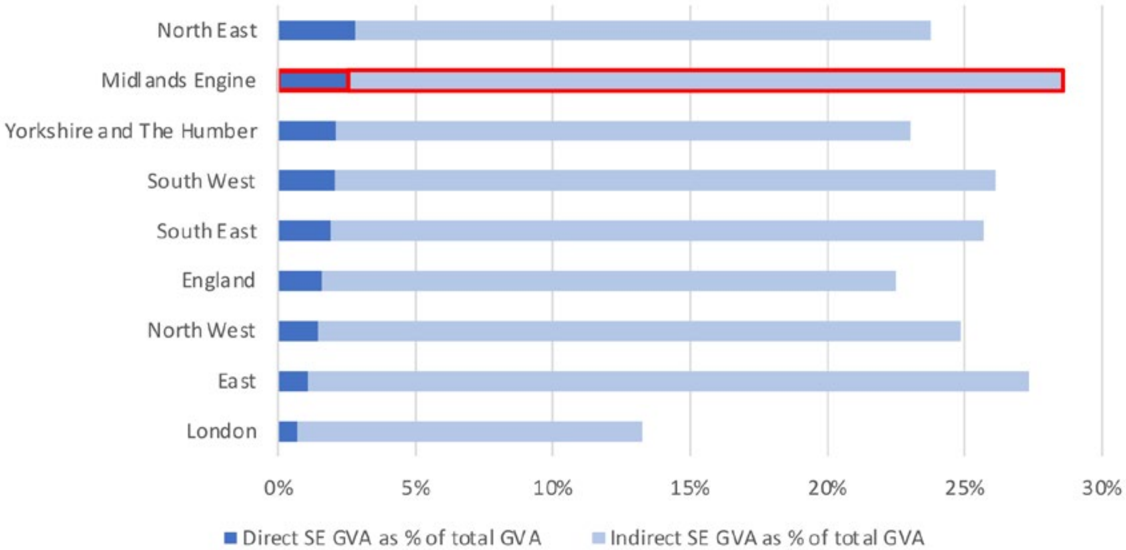


Source: UK electricity production (2022), primary data thought to be from the carbon intensity automatic programming interface https://api.carbonintensity.org.uk/

GVA generated by the Energy System

- The total value of the economy of the Midlands Engine was £240.3 billion in 2020, which is 14% of the total GVA generated in England.
- The direct GVA generated by Smart Energy was £6 billion and indirect GVA was £61 billion in the Midlands in 2022.
- In terms of GVA generated by Smart Energy sector, the Midlands rank second highest in both direct and indirect GVA compared to other regions in England and thus the region performs above England's average.

Figure 7: Direct and indirect Smart Energy GVA as a percentage of regional GVA.



Source: ONS Regional gross value added (balanced) by industry (2022)

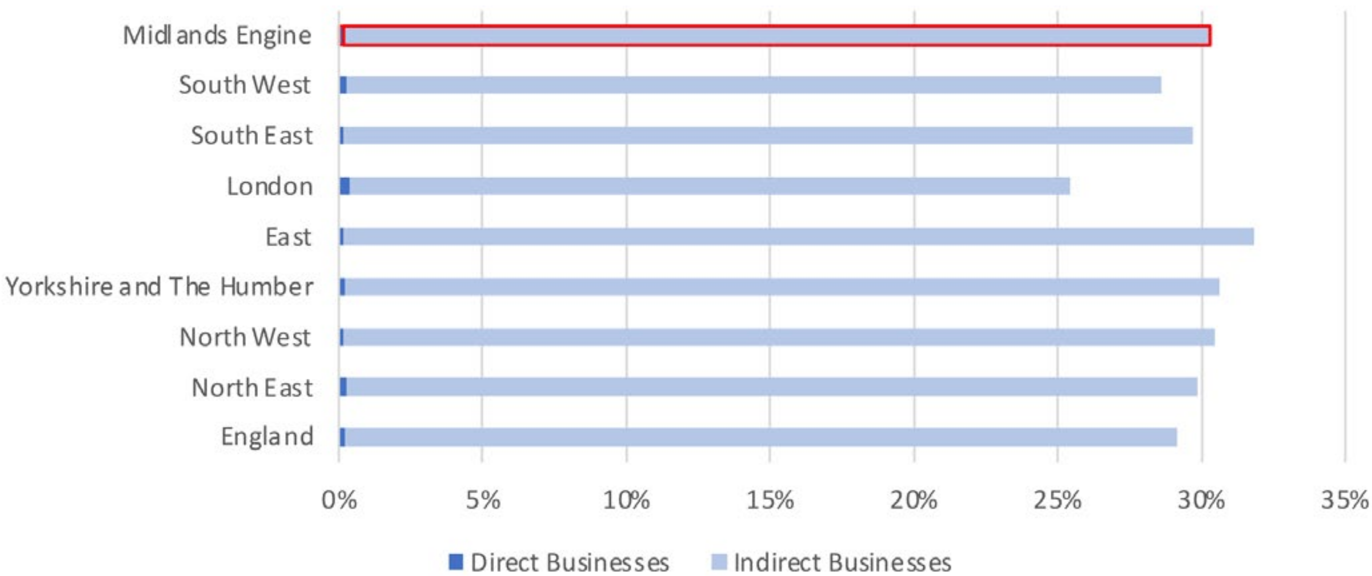
Businesses in the Energy sector

- The total number of businesses in Midlands Engine was 408,320 in 2021, which is 17% of the total number of businesses in England.
- 620 (or 0.15%) of the businesses in the Midlands Engine work directly in the Smart Energy sector while 123,115 (or 30%) businesses are indirectly involved in energy and related activities.

Table 5: Number of businesses in the Energy Sector (direct and indirect) for all regions in England.

Regions	Direct Energy Businesses	Indirect Energy Businesses
England	5255	696160
North East	200	21455
North West	425	82060
Yorkshire and The Humber	385	58230
East	405	85905
London	1920	134100
South East	635	124245
South West	665	67050
Midlands Engine	620	123115

Figure 8: Percentage of businesses who work directly or indirectly in the energy and related sectors for regions in England (2021).

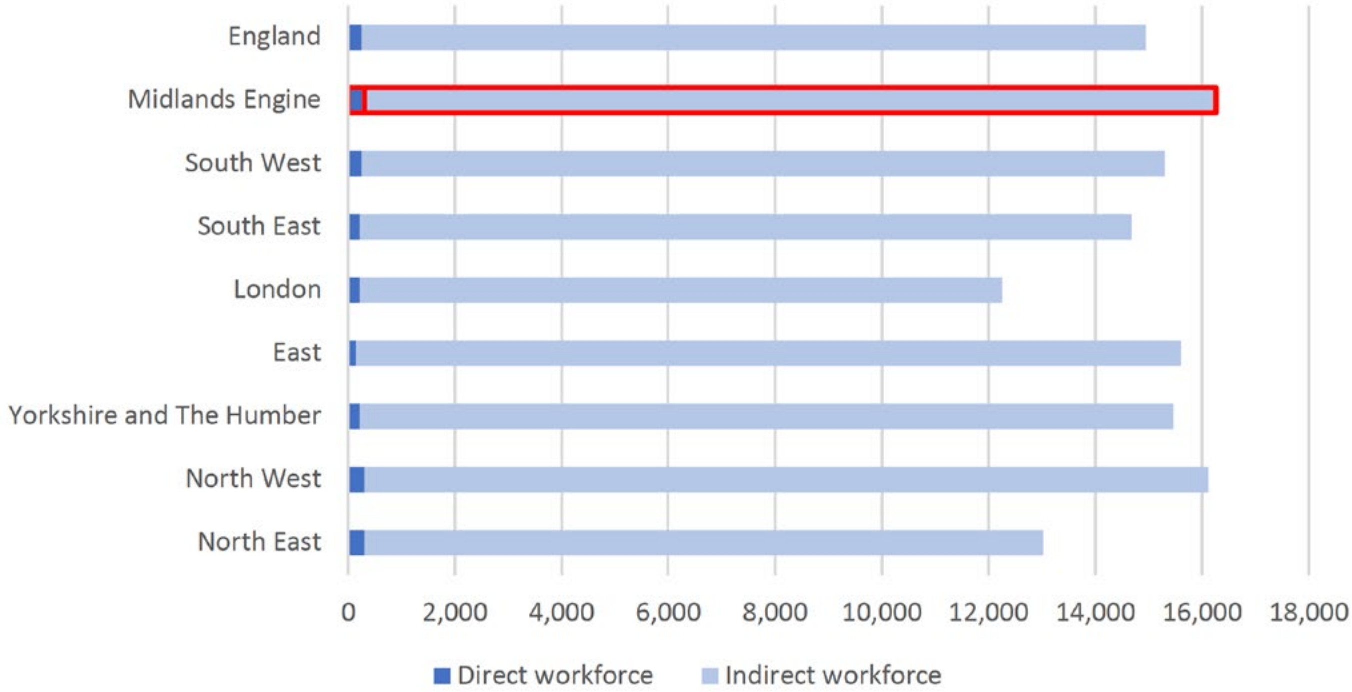


Source: ONS UK business: activity, size and location (2021).

Workforce in the Energy Sector

- Approximately 33% of the 5.3 million workforce in the Midlands works in the energy and its related sectors.
- 306 people per 100,000 population are employed directly and 15,954 people per 100,000 population are employed indirectly by the energy sector in the Midlands which is higher than that of England's average of 246 and 14,700 people per 100,000 population, respectively.

Figure 9: Direct and indirect workforce per 100,000 population working in the energy sector in regions in England (2022).[17]



Source: Nomis. Workforce jobs by industry (2021).

17 The estimate for workforce for indirect energy activities would be high as they show aggregated numbers for manufacturing sector as disaggregated values were not available.

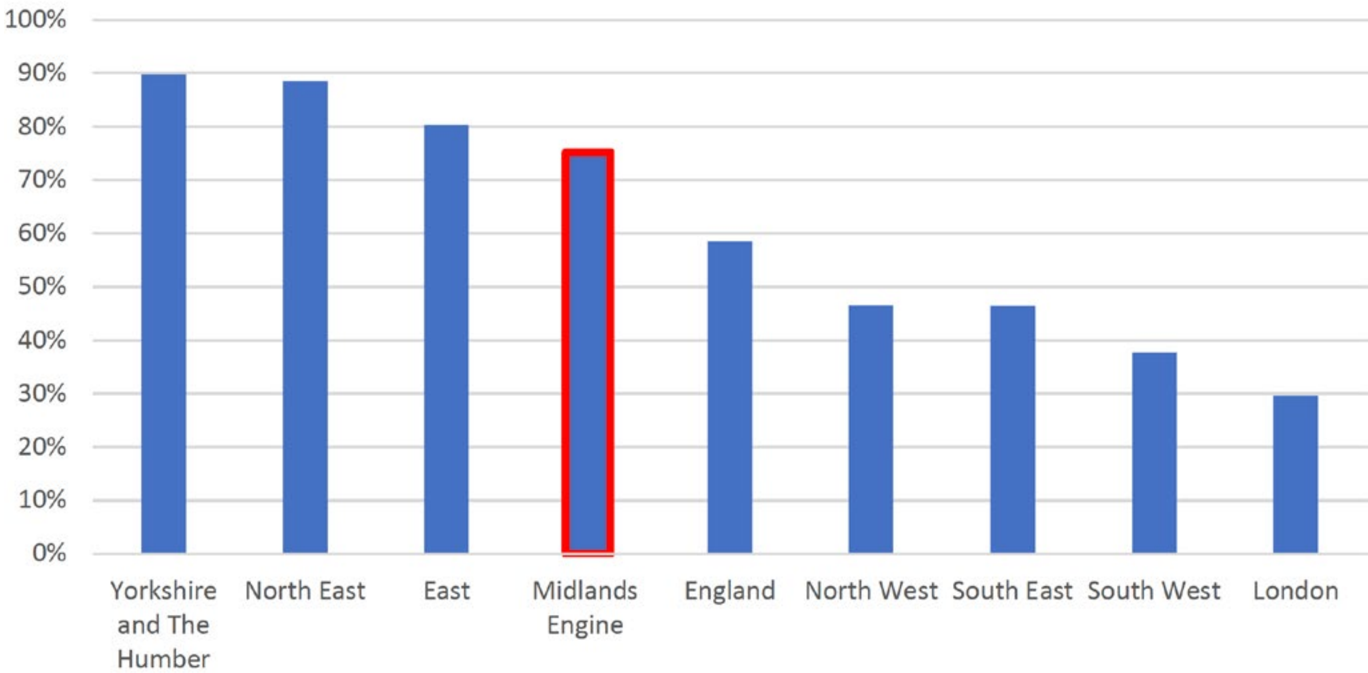
Smart Meters

The total number of meters, smart meters, and monthly installation numbers are presented in Table Figure 10 shows the market share of smart meters compared to traditional meters in different regions in England.

Table 6: The total number of meters, smart metres, and monthly installation numbers for regions in England.

Regions	Total meters[18]	Total smart meter	Monthly installation[19]
North East	1,249,107	1,105,922	11,577
North West	3,315,308	1,543,914	15,736
Yorkshire and The Humber	2,441,974	2,191,819	15,222
East	2,727,004	2,191,819	26,324
London	3,666,594	1,086,547	12,477
Midlands Engine	4,626,319	3,477,991	37,079
South East	3,994,594	1,854,105	23,264
South West	2,610,267	985,177	12,001
England	24,631,167	14,437,294	153,680

Figure 10: Percentage of smart meters in residence in regions in England.



In terms of smart meter installation in domestic properties, the Midlands Engine region performs better than 4 regions in England and falls behind 3 regions. The smart meter installation in the Midlands Engine region is higher than England's average.

18: Source: BEIS. Regional and local authority electricity consumption statistics (2020).
19: Source: Electralink. May smart meter installations (2021).

Electric Vehicles

Figure 11 presents the number of vehicles in regions in England according to fuel type (2022 Q1), other fuels include plug-in and non-plug-in electric vehicles.

Figure 11: Number of Vehicles (VEH0105).

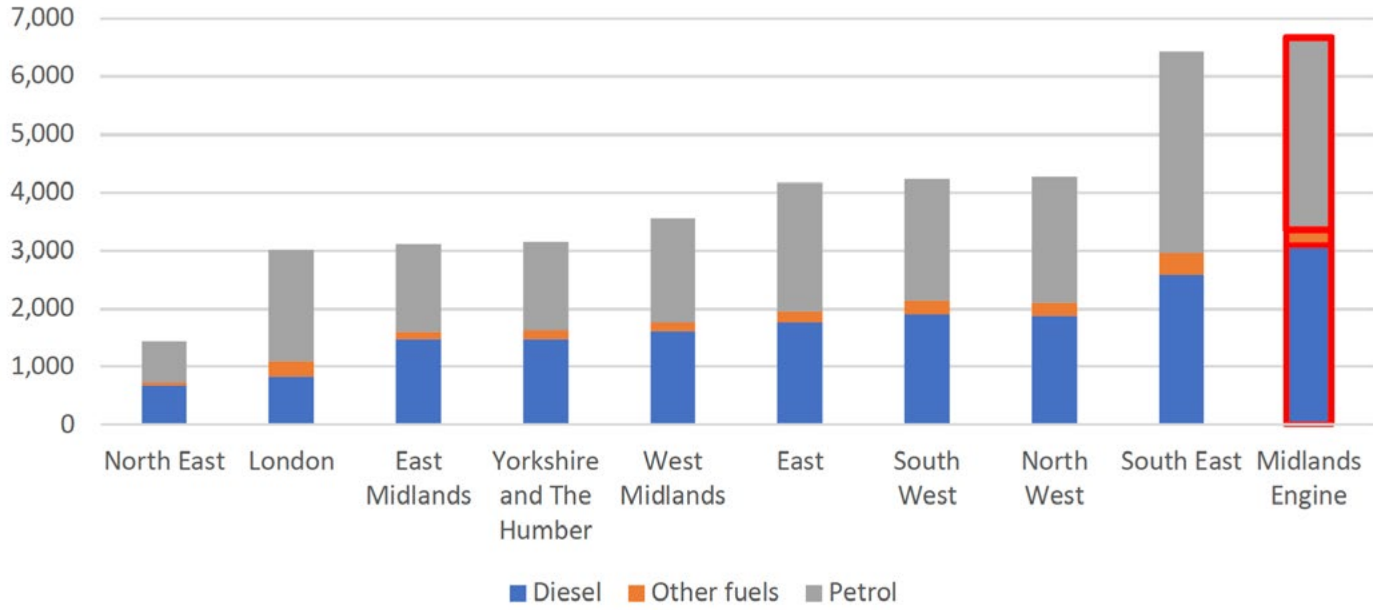
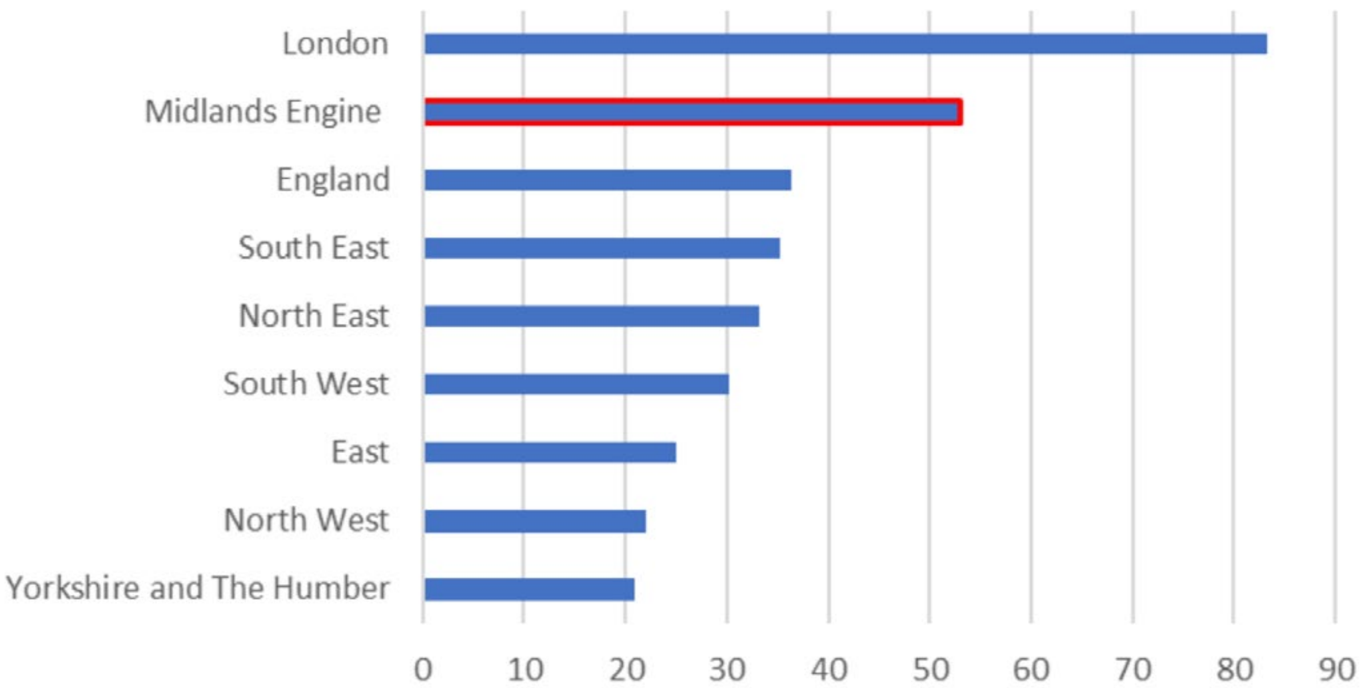


Figure 12: Electric Vehicle Charging public charging devices. Source: Vehicle licensing statistics (2021).

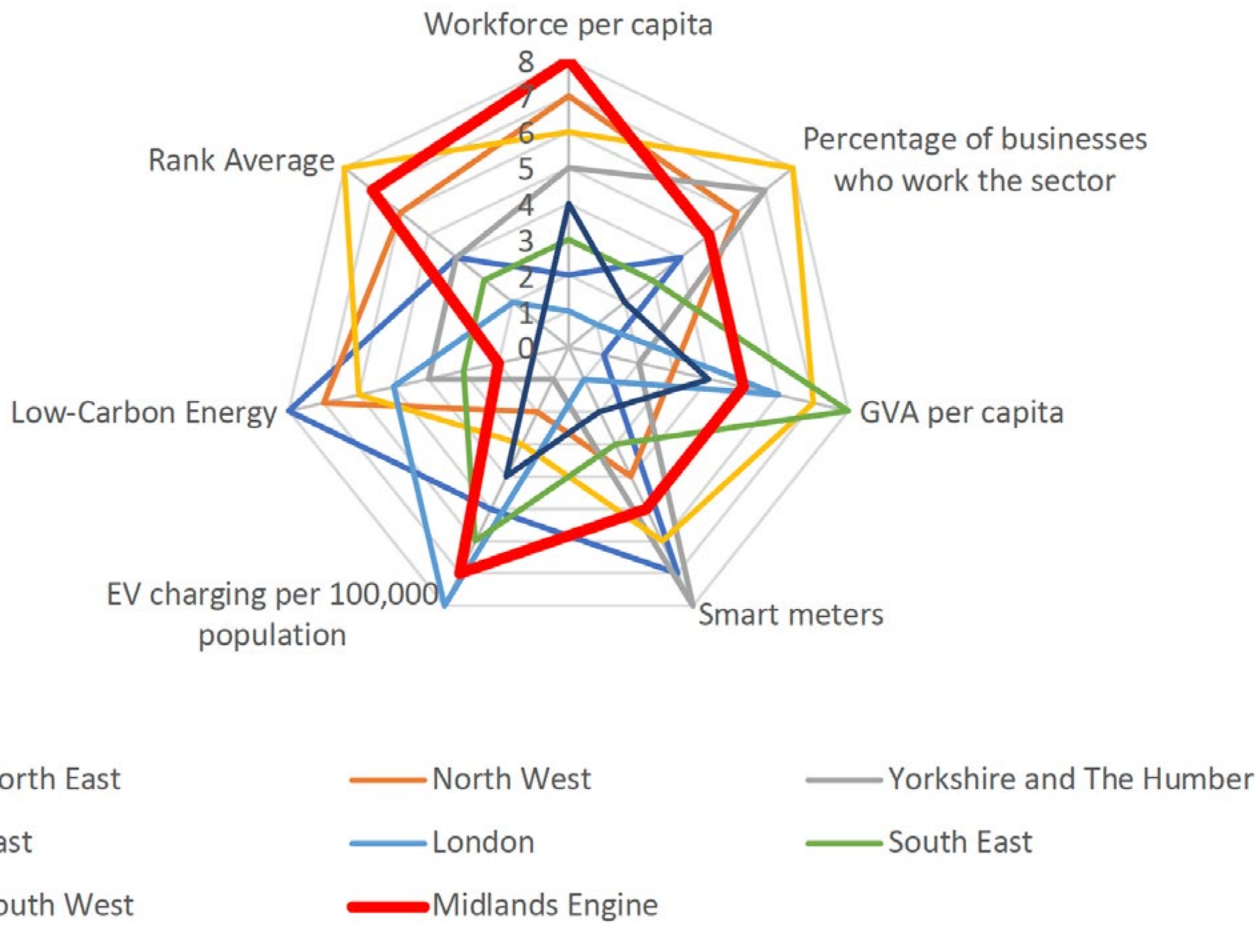


The Midlands performs well in EV charging infrastructure (Figure 12) with around 53 ECV charging devices per 100,000 population. London has the most EV charging devices per 100,000 population, and Yorkshire and The Humber have the least.

Comparison with Other Regions

Figure 13 shows the ranking of different regions in England according to different activities, which would provide an overview of the Smart Energy sector in the region.

Figure 13: Ranking of regions in England according to different Smart Energy activities.[20]



The analysis shows that, on average, the Midlands ranks second for selected Smart Energy activities compared to other regions in England. The Midlands performed better than other regions in the UK due to having a higher workforce per 100,000 population working in the sector and EV charging devices per 100,000 population. The Midlands ranked 7th out of 8 regions in England for low-carbon energy generation. Thus, the Midlands's ranking can be improved if more resources are allocated toward low-carbon energy generation such as solar, wind and nuclear in the region. The best performing region in this regard was the East of England, with the South West being the worst performing region due to low ranking in smart metering, low-carbon energy generation and businesses who work in the sector.

20: Average ranking for regions in England (from best to worse): (8) East; (7) Midlands Engine; (6) North West ; (4) North East ; (4) Yorkshire and The Humber ; (3) South East ; (2) London; (1) South West

4.2 Key Enabling Organisations and Facilities in the Midlands

In addition to the national policy drivers overseen by BEIS, several key organisations are operating in the region that can influence, plan, lead and support the deployment of Smart Energy measures. In addition to the Midlands Engine, these include:

- **Energy Capital:** Energy Capital is embedded within the West Midlands Combined Authority and drives and links a number of programmes, including those associated with the UKRI Prospering from the Energy Revolution programme. These include the RESO (Regional Energy System Operator), Repowering the Black County and Zero Carbon Rugeley (led by EQUANS) projects. Energy Capital has developed the concept of Energy Innovation Zones, which are focussed geographic areas for developing the energy transition with a platform for bringing partners together with shared objectives. There are presently 5 Energy Innovation Zones across the West Midlands. These zones are platforms for aggregating innovation and then defusing into the wider Midlands economy.
- The **Local Authorities, City Councils and the Local Enterprise Partnerships** have resources for energy activity.
- **Midlands Net Zero Hub** is a cross-Midlands body which supports the deployment of low-carbon infrastructure across the region and is funded by BEIS. The Hub has secured over £180m from BEIS to deliver a range of projects and programmes in the region (and nationally) including Community led projects, large scale infrastructure opportunity mapping and at scale retrofit of domestic properties and the public estate.
- The **Energy Research Accelerator and its associated universities** – a long-term collaboration of eight research intensive universities in the region (Aston, Birmingham, Cranfield, Keele, Leicester, Loughborough, Nottingham, Warwick) plus the British Geological Survey which focuses on energy innovation, often working with industry and the civic sector to develop large scale, innovative projects. The universities are also host to a large number of R&D facilities ranging from biomass test rigs (Aston University), V2G test programmes (University of Nottingham), the Keele SEND facility and nuclear test facilities (University of Birmingham).
- In addition the University of Birmingham has played a key role in developing **Tyseley Energy Park,** which was established as an Energy Innovation Zone and has a large number of energy innovations brought together in one industrial setting in East Birmingham.
- **Energy Systems Catapult:** Based in Birmingham, the Energy Systems Catapult has a range of expertise which extends from energy markets, energy data and systems modelling, deployment of large scale energy solutions, a living laboratory through to and SME support programme. They have co-developed tools for local authorities and helped develop the Smart Systems and Heat programme. This is a one-stop-shop to support the national energy transition, with opportunity to maximise the benefits regionally.
- **Horiba-MIRA:** Based in Nuneaton, Horiba-MIRA provides a platform for innovation in the automotive sector which most recently is focusing on low-carbon vehicles, particularly hydrogen. It has a range of facilities including testing and validation and a large test track for vehicle development. The site has become the location for a number of sector leading businesses to base themselves to accelerator technology development, particularly in the hydrogen vehicle sector.

MIRA's proposed Hydrogen Technology Hub based on the A5 in Nuneaton.

- **Energy infrastructure and suppliers:** The Midlands is home to a number of major energy suppliers including National Grid Electricity Transmission, National Grid Energy System Operator, National Grid Gas Transmission, Cadent (who transport 50% of the natural gas consumed at a local level), E.ON (one of the big six energy suppliers), Western Power Distribution and Xoserve.
- **Energy related organisations** that are based or operate in the region, including Adelan; Ansaldo; Arup; Atkins; Baxi; EDF; Engie; EQUANS; Intelligent Energy; ITM Power; Orsted; Philips66; Rolls-Royce; Severn Trent; Siemens; Siemens Energy; Uniper; Worcester Bosch; WSP.
- **Transport related companies** such as Jaguar Land Rover, Alstom; Aston Martin; Birmingham Airport; Caterpillar; Cenex; JCB; Horiba-MIRA; HS2; LEVC; MAG-East Midlands Airport; Porterbrook; Raleigh; Toyota.

As a group these organisations give the region significant strength in terms of being able to influence or benefit from Smart Energy Systems.

4.3 Smart Energy Current Developments in the Region

As well as the large number of relevant organisations in the region there are also a number of Smart Energy-related developments in the region:

Low-carbon hydrogen

- Tyseley Energy Park in Birmingham has installed a 3 MW electrolyser and a 10 MW biomass plant providing green hydrogen for hydrogen-fuelled buses and green electricity. The facility is looking to scale up the hydrogen production with a 35 MW plant.
- The University of Birmingham has collaborated with Porterbrook to develop the first hydrogen-powered train in the UK as part of the HydroFLEX project.
- A number of sites in the region are developing hydrogen refuelling infrastructure including Worcester, Derby and Horiba-MIRA in Nuneaton.
- Cadent is looking at the possibility of injecting hydrogen into the natural gas network.
- The Midlands Engine Hydrogen Technologies Strategy, centred around a Midlands Hydrogen Technologies Valley vision, has the potential, by 2041, to create or safeguard 167,000 jobs; boost the economy by £10 billion; reduce CO2 emissions by 29%.
- Under the Midlands Engine, the HyDEX programme, funded by Research England is developing a hydrogen innovation support programme. This programme is managed by the Energy Research Accelerator.

Energy

- Three of UKRI's 'Prospering from the Energy Revolution' smart local energy systems are in the region, including:
  - GreenSCIES or the Green Smart Community Integrated Energy Systems is devised of a smart grid integrating heat sources such as the underground system, substations, sewers, supermarkets and data centres, with battery storage and electric vehicle-to-grid points.
  - RESO, the Regional Energy Systems Operator, that focussed on governance and investment models for a regional approach to multi-vector systems operation. A smart system is a necessary foundation for a regional systems operator.
  - Repowering the Black Country, is one of seven projects in the government's £170 million Industrial Clusters Mission.
- Projects such as Energy Research Accelerator, Advanced Propulsion system and Tyseley Energy Park provide valuable investment in innovation, incubation, and engagement programmes.
- Plans to establish a National Centre for Decarbonisation of Heat (NCDH): bringing together skills training, manufacturing, testing and SME support to deliver heat decarbonisation at scale.

Transport and mobility

- Leading-edge research in vehicle propulsion: Centre for Hydrogen & Fuel Cell Research; Centre of Excellence in Rail Decarbonisation; Centre for Advanced Low-carbon Propulsion Systems.
- Innovations in modal shift, smart ticketing, integrated systems and data transfer, are being delivered through Transport for West Midlands to reduce dependency on petrol and diesel cars.
- West Midlands is home to a third of the UK's car production, thus having a mature automotive ecosystem of brands such as Jaguar Land Rover, Lotus Cars, and the London Electric Vehicle Company (LEVC). These brands are leading the EV revolution and are supported by research and development by UK Battery Industrialisation Centre (UKBIC).
- London Electric Vehicle Company and Jaguar Land Rover have recently announced fleet conversion to electric by 2025.
- Plans are underway to utilise the existing industry infrastructure to build the UK's largest Gigafactory in the West Midlands, which would help the automotive industry transition to an electrified future. At full capacity, the Gigafactory could produce lithium-ion batteries for 600,000 Evs per year.

4.4 Smart Energy Plans within the Midlands Engine Ten Point Plan for Green Growth in the Midlands Engine

The **Ten Point Plan for Green Growth** highlights the impact potential of delivering the pan-regional, partnership activity it identifies within it.. Much of this potential impact would support the development of a Smart Energy agenda, noting that Smart Energy extends to carbon emissions, sequestration and environmental conditions.

Table 7: Potential impact of delivery of the Ten Point Plan for Green Growth on regional Smart Energy agenda.

Focus Area	Potential impact
Green Buildings	The deployment of 200,000 heat pumps per year by 2040 will require 30,000 trained installers and, along with other retrofitting measures, help reduce energy bills by £290m and emissions by 1.75 MtCO2. Smart technologies like smart meters will support this agenda.
Net Zero Transport	Estimates suggest the UK requires at least four gigafactories, one or more of which could be sited in the Midlands employing up to 8,000 people. This will enable people to switch to EVs in greater numbers, reducing emissions by as much as 7 MtCO2 per year. Smart technologies like Vehicle-2-Grid will optimise and balance energy demand in this EV-dominated transport sector.
Low-Carbon Hydrogen	Scaling up hydrogen solution , supported by Smart Energy Systems, can unlock £3.3 billion in GVA and 14,000 jobs by 2035, 0.75 MtCO_2 reduction in UK emissions per year.
Clean Energy	Smart Energy-supported solar power in homes in the Midlands can reduce GHG emissions by 187 ktCO_2. 3 million regional homes powered by Smart Energy-supported wind power will reduce emissions by 4.2 MtCO_2 by 2030. 3,000 jobs created in renewable generation industries which will require smart technologies to balance the grid.
Smart Energy	The Ten Point Plan for Green Growth's Smart Energy theme demonstrates that the Midlands is an ideal location for new smart energy initiatives, contributing to savings in costs, carbon emissions and energy use.
Green Innovation	£2.3 billion annual increase in R&D investment by 2027 part of which can fund Smart Energy innovations to support Smart Energy activities.
Energy Workforce	Approximately 1 in 7 jobs in the low-carbon sector in the UK will be in the Midlands in 2030 many of which will utilise smart technologies.
Green Finance	To meet the UK R&D investment target, private investment in R&D in the Midlands will need to be increased annually by £1.9 billion by 2027 and some of this should support development of smart technologies.

4.5 Challenges and barriers to Smart Energy in the region

Interviews were undertaken with leading organisations active in the Midlands region regarding Smart Energy. The interviews helped identify challenges and barriers in the region for Smart Energy deployment. These challenges are separated into four categories: consumers, policy, industry and technology

Consumer:

- Consumers do not have easy access to, or knowledge about, smart technologies, such as smart meters.
- The current energy pricing framework does not incentivise the flexibility that Smart Energy Systems provide.
- The cost of related technologies is too high for households. For example, the EV cost can be higher than the cost of petrol and diesel-fuelled vehicles.

Policy:

- Local and central governments have a leading role in setting common standards to ensure the growth and uptake of Smart Energy technologies such as EVs and smart meters. They need to coordinate to develop the supporting infrastructure and to (re-) train workforce to carry this out.
- There is a lack of long-term planning to create an integrated Smart Energy System which is necessary due to interdependence between the sectors.
- Energy systems are constantly and quickly evolving, and the policies made today may not be applicable tomorrow.

Technology:

- Most of the Smart Energy System studies conducted are unable to replicate real-world conditions, which makes it harder to determine if scaling up after a positive result from the trial would yield similar results on a larger scale.
- The technologies in the energy system are just becoming commercially viable. As such business models are required in which all the parties benefit.
- Smart Energy Systems require significant investment to accelerate the commercialisation of smart technologies.
- Battery storage is integral to demand management in the Smart Energy System. Currently, no study shows how constant charging and discharging of the battery would affect battery life. Changing batteries frequently would not be favourable to the customers either economically or environmentally.

Infrastructure:

- Electrification of energy systems forms the basis of the future of energy systems. The current national and local infrastructure might not be sufficient to handle the future increase in electricity demand due to electrification. Capacity needs to be increased to manage the additional inflow of energy.
- Consumers are reluctant to purchase EVs due to a lack of charging infrastructure, especially for those households with on-the-street parking. Studies have shown that households with off-street parking would be more likely to purchase an EV.
- The grid would need updating as the flow of electricity would be bidirectional as consumers are also becoming the producers of energy.

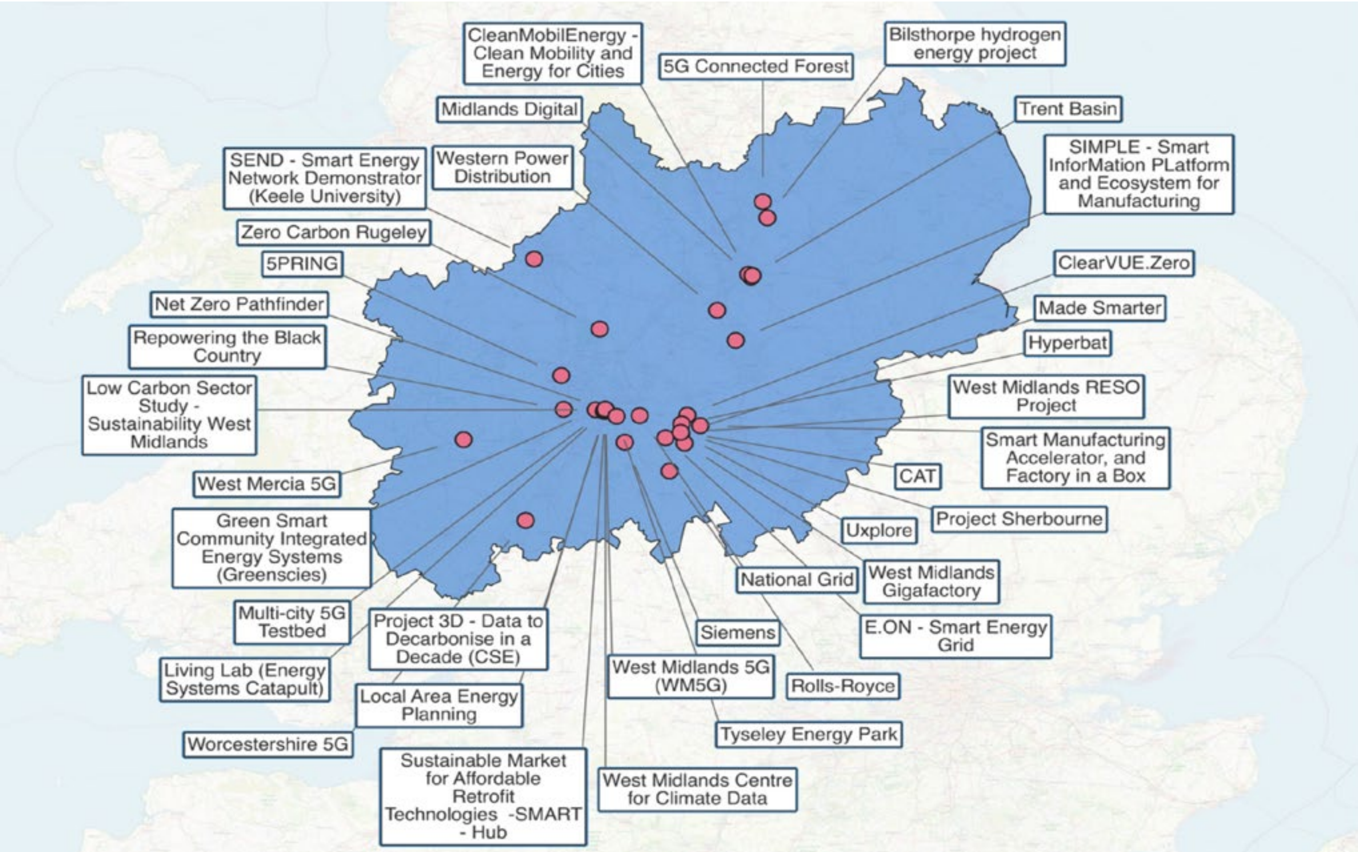
These challenges are barriers aided in creating interventions for different market segments to accelerate the deployment of Smart Energy Systems and its related technologies in the region. It is clear that some businesses are more agile than others and have been able to navigate the market barriers, as illustrated by the case of Octopus Energy.

4.6 Regional Smart Energy projects and programmes and their potential impact

Within the region, a significant number of Smart Energy projects are already taking place. This section examines these projects, categorised by market segment and identifies the potential of these projects if deployed at scale across the region.

Key Smart Energy Projects from across the Midlands Region are shown on the map in Figure 14 and a list with their description is given in Appendix C.

Figure 14: Map of key Smart Energy Projects in the Midlands (background map: https://www.openstreetmap.org/copyright



Three key examples of Midlands-based Smart Energy case studies are provided in Appendix D. These include:

1. **The Trent Basin Community Energy Scheme**
   This is a 500-home development on a 250 acre site based around the River Trent. The development includes energy generation through solar PV, energy storage through a large battery storage facility and an overlying Smart Energy System which allows consumers to have detailed access to their energy data. Through an Ofgem derogation, the project is also exploring innovative energy billing mechanisms using a local Energy Service company (ESCo).
2. **The Smart Energy Network Demonstrators (SEND)**
   The SEND project involves the energy management of the University of Keele campus with a smart grid which integrates energy generation with the ability to optimise the energy utilisation across the campus for cost and carbon intensity. This project is co-delivered through a collaboration with Siemens and EQUANS. The Keele campus was also the location for the HyDeploy project which was the first UK demonstration of hydrogen blended with natural gas into the gas network.
3. **Regional Energy Systems Operator (RESO)**
   The RESO project is based around the City of Coventry and examines the opportunities for the energy transition in the context of the future energy infrastructure that will be required. Through local energy management, via a regional systems operator, it was found that there are energy systems savings which can be monetised either in terms of consumer savings or that can be reinvested into the system.

To examine the potential for Smart Energy solutions to be deployed, we have reviewed potential interventions by market segment, using exemplars of current or recent projects taking place to identify potential interventions that could be made at scale. The section that follows attempts to quantify the potential impact that the intervention could make.

5. POTENTIAL SMART ENERGY INTERVENTIONS FOR THE MIDLANDS

This section outlines potential interventions that could be adopted in the region, drawing on exemplar projects from either within or outside the region as ideas that could be deployed to enable the region to become an "exemplar Smart Energy region".

5.1 Market segment 1: Residential

Decarbonising the residential sector is one of the crucial steps for the Midlands Engine to reach its targets of net zero economy by 2041. The Midlands will need to install 200,000 heat pumps per year by 2040, requiring nearly 30,000 trained heat pump installers. Through retrofitting, it is expected that the residential sector in the region would save £290 million in energy bills, 1.75 MtCO_2e in GHG emissions and generate £3.4 billion in GVA.

The potential of Smart Energy in the residential sector can be realised through data collection and smart tariffs. Within the household, data collection allows users to better monitor energy use, which would aid in improving energy efficiency and reducing emissions. The smart tariffs would allow households to reduce their electricity costs through utilisation of more dynamic tariffs.

Intervention 1.1: Data Collection

The future Smart Energy System will include millions of smart meters, EVs, solar panels, heat pumps, batteries and other assets. These assets need to be better optimised across the network, which would not be possible without appropriate levels of measurement and control across an increasingly digital energy system. Such a digital energy system can only take shape and form by leveraging the benefit of data across the system. The Energy Data Taskforce, in 2019, highlighted some issues, including the lack of common data standards, the culture of data hoarding and no open access to data or shared data repository. The digitalisation of the UKs energy systems has a number of key issues that need addressed in terms of trust, ownership, data pipelines and data sharing agreement to mention a few. As data is the foundation of Smart Energy Systems it is important to consider where standard approaches can be applied, e.g., not all data can be made open or accessible to a wider range of stakeholders. However, there may be a case that at a certain level of aggregation in either geography (such as postcode aggregated data) or in timeframes (over a year) or both, that data would become open. In order to do this, trusted intermediaries would undertake the aggregation. The Midlands have a range of data gathering projects and activities that aim to address some of these issues

Intervention 1.1 exemplar: Living Lab (Energy Systems Catapult)

Energy Systems Catapult created the Living Lab to offer a quick, safe, affordable, real-world test environment to de-risk and scale innovations by running trials directly with consumers in their homes.

With over 1000 digitally connected smart homes, spread across England, Scotland and Wales with a variety of tenures, property types and demographics, the Living Lab is digitally open, interoperable and scalable. With room-by-room sensors and a digital integration platform – innovations can be tested with mainstream smart meters, IoT devices, smart heating controls, battery storage, solar PV and electric vehicle chargers.

Innovative businesses can rapidly design, market-test and launch smart energy products, services and business models. The Living Lab also provides the national capability to test and demonstrate market arrangements, policy and regulations with real consumers – as we move towards a Net Zero carbon future.

Source: https://es.catapult.org.uk/tools-and-labs/living-lab/

Intervention 1.1 exemplar: Project 3D - Data to Decarbonise in a Decade (CSE)

3D is an initiative to help decarbonise Birmingham (the largest metropolitan borough in England) within a decade. CSE is working alongside Birmingham City Council, the Birmingham Route to Zero Taskforce (R20 Taskforce) and local community partners to:

- Establish an energy data hub.
- Engage with a wide range of stakeholders, including through training and demonstrations.
- Support city-wide applications of the data as well as local community projects using data to help reduce carbon emissions.
- Evaluate the project and share our learning.

As a result of the project, a depository of useful datasets for Birmingham will be freely available online. We're calling this the energy data hub. A range of stakeholders will use the data to plan, initiate and improve projects that cut carbon in the city, for example, through the installation of solar PV or increasing provision for low-carbon transport.

The data (which will be held and managed securely and in line with GDPR guidelines) will cover areas such as demographic, socio-economic and health-related data, solar PV potential, housing energy efficiency and retrofit options, district heating system mapping, EV charging points, and transport modes, behaviours and associated emissions. Specific datasets could be added or analysed in more depth in response to needs identified as the project progresses.

Source: https://www.3dhub.org.uk/, https://www.cse.org.uk/projects/view/1374

Intervention 1.1 exemplar: Sustainable Market for Affordable Retrofit Technologies - SMART - Hub (Energy Capital)

WMCA have been awarded £7.5 million to make hundreds of social housing homes more energy efficient. The funding will provide warmer homes for tenants, tackle fuel poverty and reduce the threat from energy price hikes. It will also help boost business confidence among retrofit companies and increase the number of green jobs. This comes from several different partners making a successful bid for a share of the Governments Social Housing decarbonisation fund. Aims to help retrofit around 622 of the worse performing homes across the region. The retrofit campaign is part of the WMCA's SMART Hub Initiative.

The SMART Hub (Sustainable Market for Affordable Retrofit Technologies) has been created by the WMCA as part of its investment to deliver its net zero targets.

SMART Hub represents a wider ambition for WMCA to support the growth of the retrofit market across the region. SMART Hub is leading the delivery of demonstrator programmes. SMART Hub will support partners in building knowledge and capacity, coordinate local retrofit activity, engage the supply train, and work with partners to overcome key market barriers, such as finance, skills and training, and demand. Ultimately, their aim is to be a catalyst behind the decarbonisation of 1.2 million homes in the West Midlands by 2041.

Source: https://www.wmca.org.uk/news/wmca-led-consortium-is-awarded-75m-to-retrofit-social-housing/

Intervention 1.1 exemplar: Smart meters

The UK has set targets to have a smart meter across all residential properties by 2025. These smart meters come with a digital display which shows in real-time how much energy is being used and how much it costs in pounds / pence. Consumers no longer need to provide meter readings to the suppliers as the readings are sent directly to the energy supplier. In the Midlands, as of 2020, there were **4.6 million** meters; by May 2022, **3.5 million** were smart meters. With a monthly installation rate of **37,000** devices per month, the smart meter rollout has a target to finish by January 2025.

Table 8: Smart meter numbers in the Midlands and the UK[21]

	Total smart meter number (May 2022)[22]	Monthly smart meter installation (May 2022)	Total meters (2020 numbers)[23]	% of smart meters (May 2022)
Midlands	3,477,991	37,079	4,626,319	75.18%
UK	18,923,691	207,088	28,923,313	65.43%

21: Smart meters numbers only include electricity. The latest statistics on the total number of meters are available for 2020. The % of smart meters assumes that in 2022 there will be the same number of meters as last reported in 2020.

22: Source: Electralink. May smart meter installations (2021)

23: Source: BEIS. Regional and local authority electricity consumption statistics (2020)

Scale-up: Smart meters

Carrying forward the 3.5 million May 2022 value, the impact by the end of 2025 of a range of scenarios has been calculated based on historic trends (~37,000 meters per month) and high-low estimates. This is summarised in the table below.

Table 9: Smart meter installation

	Completion date	Energy savings by 2025 (MWh)	Energy savings by 2025 (£m)*	Emissions savings by 2025 ($ktCO_2e$)	Emissions savings by 2025 (£m)*
30k installations/ month	Aug-25	259,017	26.5	61.1	14.6
37k installations/ month	Jan-25	297,542	30.4	70.5	16.8
45k installations/ month	Jul-24	326,831	33.5	77.8	18.6

BEIS' Smart Meter Cost-Benefit Analysis (2019) shows that smart meter installations cost £88 for electric only or £143 for dual fuel. The base year of prices is 2011. The cost of installing an additional 1.1 million smart meters in the Midlands is estimated to be £124 million for electric only or £202 million for dual fuel based on prices updated to 2022 using the **electrical equipment price index.**

Intervention 1.2: Demand management through smart tariffs

Developing smart tariffs which recognise the evolution of the energy system and the integration of heat and transport with electricity are vitally important. Allowing the consumer to access energy market data and integrating Smart Energy devices which themselves are capable of responding to energy market signals is vital. Enabling this sector is key to the Smart Energy transition and will drive investment.

Electric Vehicles are part of the future of transport and are a major component in the Smart Energy System. Smart charging is a way of charging EVs when the demand for electricity is low or when there is a potential surplus of renewable electricity that needs balanced. Charging EVs during these times typically means that wholesale electricity rates will be lower, with some of this passing through to customers.

Intervention 1.2 exemplar: Octopus Go and Agile

Octopus Energy offers Octopus Go which is a smart tariff with much lower cost electricity for 7.5p/kWh between 000:30 to 04:30 every night. Octopus Go provides fuel for around 2p per mile compared to 18p for petrol and 17p for diesel per mile.

Octopus Energy also has a service called outgoing octopus which is a smart export service which allows the customer to sell their electricity back into the electrical grid and Octopus energy can sell the electricity to the next octopus energy user which enables mass peer to peer trading. Outgoing Octopus also offers two services that the consumer can choose from, these are fixed or agile. Outgoing fixed guarantee's 7.5p per kWh for every unit exported. Outgoing Agile matches the consumers half hourly prices with day-ahead rates which allows the consumer to make the most of the energy they generate.

Source: https://octopus.energy/go/

5.2 Market Segment 2: SMEs

SMEs account for 99% of the business in the UK and are responsible for 50% of energy use. SMEs are being encouraged by governments, consumers, and other regulatory bodies to reduce their carbon emissions and become a part of the Smart Energy transition. The decision on how and when to become carbon-free is an important one which requires careful planning so that the costs associated with the transition are not greater than the benefits. In 2021, there were 406,675 SMEs[24] in the Midlands Engine. In the West Midlands, 100 SMEs are also being offered sponsored access to Zellar, the UK's first one-stop sustainability online platform. WMCA launched Net Zero Business Pledge in 2021 to provide practical help for businesses and other organisations who want to fight climate change by cutting their carbon emissions and making a faster transition to net zero. Smart Energy Systems will aid SMEs in transitioning to a carbon-free business through energy monitoring and optimisations, business support and supply chain management.

Intervention 2.1: Energy monitoring and optimisation

SMEs need granular-level information on their energy consumption to make important decisions quickly toward decarbonisation and energy cost savings. Any objectives set by the SMEs toward decarbonisation would require ongoing analysis of their energy data so that they know how they are performing against targets. Shared data with trusted aggregators could allow regional values at a sector level to allow SMEs to consider whether they are above or below average in terms of various metrics such as energy per unit of floor space.

24: https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/datasets/ukbusinessactivitysizeandlocation

Intervention 2.1 exemplar: ClearVUE.Zero

The Morgan Motor Company, based in Worcestershire, employs approximately 220 people and produces 850 cars annually. They have been operating since 1910 and produce their vehicles at a site built in 1914, due to which they have faced energy inefficiencies. This is especially true in painting, which relies on power-intensive paint powder-coating ovens and other machinery. ClearVUE.Zero has allowed them to monitor their energy use and pinpoint a machine and the process.

ClearVUE.ZERO is a powerful energy and carbon management and accounting platform that digitises energy data across all utilities and site locations globally, down to an asset level. Enables real-time, streamlined energy and carbon reporting and monitoring of reduction targets through the accurate measuring of a business' energy and carbon intensity.

By using ClearVUE.ZERO, the Morgan Motor Company, identified all the machinery that was powered on early in their daily production processes for years. By making simple adjustments - changing when they switched machinery on or off - the company cut down on energy consumption and saved significant sums.

Source: https://clearvue.business/case-study/the-morgan-motor-company/

Scale-up: Energy monitoring and optimisation

- Assuming 1% installation rate (414 SMEs per year) – by 2050 12,025 SMEs
- Cost of monitoring and optimisation: £1,200 / year / meter
- Energy consumption by SMEs : 15,000 – 50,000kW
- The total cost of monitoring and optimisation by 2050: £0.12 billion
- Cost of monitoring and optimisation if costs fall by 50% by 2050: £0.08 billion
- Average reduction in bills – 25-30%
- Electricity cost savings by 2050 - £0.19 billion - £0.77 billion
- Emission savings by 2050 – 25 ktCO_2e - 102 ktCO_2e

Intervention 2.1 exemplar: SIMPLE - Smart InforMation Platform and Ecosystem for Manufacturing

The SIMPLE platform will allow better monitoring and optimisation of their manufacturing operations by facilitating the collection of this core data set. The SIMPLE solution will also provide an open and scalable platform to stimulate the deployment of data centric application ecosystems, facilitating the development of wider digital capabilities in UK manufacturing organisations. The SIMPLE platform will benefit manufacturing SMEs in particular, as they lack either the skills to effectively take advantage of the currently fragmented technological landscape, or to invest in large integrated engineering solutions.

The SIMPLE platform will focus on providing robust and scalable data models and reinforce the use of those models throughout the production system lifecycle and across all domains of engineering and production management. The platform will materialise as a combination of software components, web services, a design framework (recommendations, rules and guidelines) as well as a technology deployment road map for software and hardware technologies.

Source: https://gtr.ukri.org/projects?ref=105820

Intervention 2.2: Business support for SMEs

BEIS has made available £6 million under Boosting Access for SMEs to Energy Efficiency (BASEE) competition to help accelerate the growth of the energy services market for SMEs by driving down transaction costs and promoting third-party investment in small-scale energy efficiency projects.

Intervention 2.2 exemplar: Made Smarter

Made Smarter is an initiative being pursued between various regional institutions and BEIS. The Government has **provided £8 million** for SMEs in the Midlands to help them 'modernise, go digital and create new jobs. This funding will support up to 1,000 small and medium sized manufacturers across the North West, North East, Yorkshire and the Humber and the West Midlands regions, in adopting digital technology: 'The Made Smarter Adoption programme includes free impartial, advice, funded digital internships, access to specialised leadership and management training, as well as match funding for digital transformation projects. Alongside support for adoption, government is also investing £147 million through a Manufacturing Made Smarter Challenge to drive innovation in new digital solutions for manufacturers.

Made Smarter has also launched a £1.9 million digital adoption fund to drive growth in the West Midlands manufacturing and engineering SMEs to help them boost productivity. Digital experts will provide advice to manufacturing businesses on how to switch to advanced and automated technologies as well as working to improve employees overall digital skills. The Coventry and Warwickshire LEP Growth Hub is leading the one year Made Smarter scheme.

Source: Boosting manufacturing in the West Midlands – Made Smarter

Intervention 2.3: Supply chain management

Every year **£2.5 billion** is invested in energy technologies and infrastructure (excluding building and transport) in the West Midlands. Currently, 10,000 energy-related and 2,240 transport-related companies are located in the West Midlands.

The Midlands is well placed to take advantage of the latest energy innovations. The diversity and flexibility of the supply chain provide support to energy systems and industry across the Midlands.

Intervention 2.3 exemplar: Smart Manufacturing Accelerator

The Smart Manufacturing Accelerator (SMA) is a framework for delivering integrated manufacturing and supply chain solutions enabled by the application of industrial digital technologies. The SMA has been developed by the Manufacturing Technology Centre (MTC) in collaboration with industry and academia through the Energy Research Accelerator programme funded by Innovate UK.

The SMA can assess and evaluate manufacturing and supply chain needs. Utilising the expertise of the MTC and working with leading industrial technology providers, the SMA helps plan, design and implement innovative manufacturing and supply chain solutions. Through remote control monitoring and optimisation, the SMA allows for production optimisation based on manufacturer's objectives.

Source: https://smartmanufacturingaccelerator.co.uk/what-is-factory-in-a-box/

5.3. Market Segment 3: Energy Intensive users

The "green industrial revolution" is underway, and it has become imperative for energy-intensive users to become part of the Smart Energy transition. This is being achieved in the region through developing industrial clusters, help and support from public bodies and establishing a gigafactory.

Intervention 3.1: Industrial Clusters

Industrial clusters, which are co-located, energy-intensive centres of economic activity, are critical to the UK's low-carbon transition. The country's six industrial clusters[25] as set out in the UK government's Industrial Strategy are responsible for half of its industrial greenhouse gas emissions. Thus, prioritising their decarbonisation presents a great opportunity for environmental, economic and societal gains.

Intervention 3.1 exemplar: Repowering the Black Country

Plans are underway to deliver the world's first zero carbon industrial cluster in the Black Country. The industrial cluster will enable clean GVA growth of £16 billion by 2030, creating or safeguarding at least 20,000 skilled jobs. Repowering the Black Country builds on the Black Country's strategic advantages of greater flexibility (stemming from large numbers of smaller businesses); connectivity; strong local partnerships; a regeneration imperative and strong local culture of enterprise and energy-intense manufacturing.

The project will create mini-clusters of zero carbon industry across the region in multiple industrial sectors by proactively using local authority planning powers and inward investment – reshoring activities which have drifted overseas over the past three decades - to create strategically-selected circular economy zero-carbon industrial hubs.

This economic planning approach will be co-ordinated with spatial planning and energy network infrastructure planning (in partnership with WPD and Cadent Gas) using an energy innovation zone model. It will also be supported by targeted specialist energy efficiency and process optimisation support for local businesses and by tailored local investment funds.

Source: Final Repowering the Black Country - Main Body Phase 1 Report.docx.pdf (blackcountrylep.co.uk)

Intervention 3.2: Public sector projects

Public sector projects such as SEND at Keele University collaborate with industry to improve energy management through research, trials, innovation and demonstration. These existing projects can be expanded to develop next generation pathfinder projects which are of a scale which builds the Midlands as the place to invest in Smart Energy projects.

Intervention 3.2 exemplar: SEND - Smart Energy Network Demonstrator (Keele University)

The SEND is a at scale environment providing a platform that allows energy generation, distribution, storage and forecasting and energy balancing to be intelligently carried out across different energy sources using the Keele university as a genuine living campus.

The SEND will deliver better energy management, reduce reliance on fossil fuel derived energy, significantly reducing energy waste and provide the opportunity to trial innovative ways of energy use and management.

The SEND project is part funded through the European Regional Development Fund and is also receiving funding from the Department for Business, Energy and Industrial strategy.

Source: Smart Energy - Keele University

25: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/803086/industrial-clusters-mission-infographic-2019.pdf

Intervention 3.3: Creation of Manufacturing

West Midlands is home to a third of the UK's car production, thus having a mature automotive ecosystem of brands such as Jaguar Land Rover, Lotus Cars, and the London Electric Vehicle Company (LEVC). These brands are leading the EV revolution and are supported by research and development by UK Battery Industrialisation Centre (UKBIC). This is a prime example of the type of development which will bring opportunities to the Midlands which links the deployment of Smart Energy Systems to manufacturing, jobs creation and the associated service industry.

Intervention 3.3 exemplar: West Midlands Gigafactory

Plans are underway to utilise the existing industry infrastructure to build the UK's largest Gigafactory, which would help the automotive industry transition to an electrified future. At full capacity, the Gigafactory could produce lithium-ion batteries that would provide enough power to run 600,000 EVs per year.

Production on the Gigafactory is expected to start in 2025 and will be powered by 100% renewable energy. The project will inject £2.5 billion investment into the region and will create up to 6000 new highly skilled jobs and thousands more in the supply chain.

Source: The UK's largest battery Gigafactory | WM Gigafactory (ukgigafactory.com)

5.4. Market Segment 4: Regional grid infrastructure

Regional electricity and natural gas grid infrastructure connects energy demand with energy supply. Heat networks also do this, but at a local rather than a regional level. Supporting interventions include infrastructure planning, vehicle-2-grid deployment, smart grids and 5G connectivity, without which it is unlikely to harness all the potential gains from a Smart Energy Systems.

Intervention 4.1: Infrastructure Planning

Three of UKRI's 'Prospering from the Energy Revolution' smart local energy systems are in the region, including RESO, the Regional Energy Systems Operator, focusing on governance and investment models.

Intervention 4.1 exemplar: Local Area Energy Planning

Local area energy planning guidance to help local leaders plan for net zero

- Innovate UK-funded guidance from Energy Systems Catapult provides a detail to help local authorities create a plan for achieving Net Zero.
- Sits as part of the Energy Systems Catapult's suite of energy planning guidance for local government which includes digital resources and decarbonisation toolkits.

A companion report, also Innovate UK-funded, finds that coordinated local area energy planning – rather than an organic, uncoordinated approach – could give cost savings in the order of 1% GDP or £252 billion between 2025 and 2050. According to the report, Ofgem should encourage better and more consistent coordination between local authorities and network companies on local energy planning to avoid the risk of misaligned strategies.

Around 300 councils have declared a climate emergency, prompted increased interest and focus on local area energy planning – only 15 local authorities had completed a LAEP in December 2021, which has grown to 18 today with dozens more in progress.

Source: https://es.catapult.org.uk/news/local-area-energy-planning-guidance-to-help-local-leaders-plan-for-net-zero/

Intervention 4.2: Smart grids

A Smart Grid is typically used as a shorthand way to describe a smart electricity network which can cost efficiently integrate the behaviour and actions of all users connected to it in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety. A smart grid employs innovative products and services together with intelligent monitoring, control, communication, and other technologies to maintain and improve energy efficiency, provide more information, reduce emissions and improve resilience. Smart grids can technically cover heat networks and gas networks too, however the common usage of Smart Grids has a focus on electrical networks.

Intervention 4.2 exemplar: E.ON - Smart Electrical Grid

E.ON are working on a smart grid that can balance demand and supply, which will enable the use of more renewables as wind and solar power generation can vary dramatically on the weather and the time of year.

Smart grids use computer technology to monitor and control both electricity generation and demand in real time, as well as minimising disruptions by healing itself when things go wrong.

Source: What is the grid? | E.ON (eonenergy.com)

Scale up: Smart grids

If smart grid technology is deployed between 2022 and 2050 at a steadily increasing rate, the following cost and benefits will impact the region by 2050. Values in 2022 prices and discounted at 3.5% unless otherwise stated.

- Regional smart grid investment of between £3.2 billion - £4.4 billion (non-discounted)
- Avoided capital cost of between £2.6 billion - £3.6 billion compared to investment in conventional grid technology in the region up to 2050. (non-discounted)
- Cumulative distribution system savings of between £1.2 billion - £5.4 billion.
- Regional gross GVA impact (direct, indirect, induced) of £1 billion - £1.5 billion.
- Export potential between £0.4 billion - £0.6 billion.
- Between 900 - 1,400 jobs sustained throughout the 2020s and 2030s.

Intervention 4.3: Vehicle - 2 – Grid

Vehicle-2-Grid enables electricity to be exported to the electrical distribution network from the battery of an electric car. With vehicle-to-grid technology a car battery can be charged and discharged based on different signals such as local or national electricity production and consumption, and transmission constraints of the higher voltage electrical network.

Intervention 4.3 exemplar: CleanMobilEnergy - Clean Mobility and Energy for Cities

The project CleanMobilEnergy integrates various renewable energy sources, storage devices, electric vehicles and optimisation of energy consumption through one unique Smart Energy management system. The development of this intelligent Energy Management System (iEMS) will increase the economic value of renewable energy and significantly reduce CO2 emissions. The iEMS will ensure smart integration through interoperability based on open data flows and analysis tools standards.

Funded by Interreg, under CleanMobilEnergy - Clean Mobility and Energy for Cities Project, Nottingham will procure 40 vehicle-2-grid units and electric vans along with an 88 kW peak solar PV system which will generate an excess of 50,000 kWh per year of renewable electricity. As part of the project, they will also be installing a 378 kW/676 kWh lithium-ion battery controlled by a site energy management centre to store excess energy generated.

Source: CleanMobilEnergy - Clean Mobility and Energy for Cities | Interreg NWE (nweurope.eu)

Scale up: Vehicle-2-Grid

If 156,000 V2G electric vehicles are licensed in the Midlands Engine region by 2030, the following cost and benefits will impact the region by 2050. Values in 2022 prices and discounted at 3.5% unless otherwise stated.

- V2G charging infrastructure investment £0.05 billion - £0.09 billion by 2030 (non-discounted)
- Distribution system savings of £0.24 billion - £1.71 billion by 2050.
- System cost avoidance of £0.02 billion - £0.17 billion by 2050.
- Fleet aggregator benefits of £1.33 billion - £2.38 billion by 2050.

Intervention 4.4: 5G deployment to support the manufacturing industry

Midlands is home to the first multi-city 5G testbed with 20,000 businesses and 127,700 jobs in the digital sector. 5G alone would contribute £5 billion to the region's economy in the next five years

Intervention 4.4 exemplar: West Midlands 5G (WM5G)

The West Midlands is home to the first and largest multi-city 5G testbed. WM5G have also launched 5PRING which is to build 5G accelerators in the three major cities in the West Midlands to bring together supply and demand side businesses to take 5G ideas and work together to turn them into commercially viable products.

One accelerator is the smart cities accelerator which is to provide start-ups and other small businesses with support in developing and scaling 5G innovations targeted at the health, social, public and transport sectors. This includes developing smart city solutions to support health and wellbeing, smart parking, journey planning, waste management and many more.

Source: The Smart Cities Accelerator - West Midlands 5G (wm5g.org.uk)

Intervention 4.4 exemplar: 5prinG

5prinG is an open innovation platform that works with start-ups, enterprise organisations, sector experts and technology providers to transform the way we live and do business leveraging 5G capabilities.

Offers a few different programmes ranging from using 5G to come up with solutions to problems faced by the transport or manufacturing sector but also offers a smart cities program to develop a smart city solution on key issues ranging from health and wellbeing to public safety.

Source: 5PRING - the UK's first 5G commercial application accelerator.

5.5. Market Segment 5: Energy Generation

Energy generation is an integral part of a Smart Energy System. The future of energy generation lies in low-carbon and renewable energy (hydrogen as well as electricity). The reliance on fossil fuels for electricity generation has already declined, and this trend will continue in the future. Interventions for energy generation include renewable and low-carbon electricity, conversion of some of this to hydrogen, and micro-grids.

Intervention 5.1: Renewables and low-carbon energy

The future of electricity generation in the UK will be a mixture of smaller-scale, local, renewable and low-carbon generation with the bulk being provided by large offshore wind arrays. Nuclear generation will continue to play a role in the UK's electrical generation portfolio. Approximately a third of the electricity consumed in the Midlands is low-carbon, from nuclear, solar and wind, (primary data is from the carbon intensity automatic programming interface https://api.carbonintensity.org.uk/). Several projects are going on in the region that support low-carbon energy generation

Intervention 5.1 exemplar: Zero Carbon Rugeley

Is a project to design a town-wide Smart Local Energy system including the former Rugeley Power station site and will demonstrate how carbon emissions and energy costs can be reduced whilst also providing a boost for local regeneration. Project partner will take full advantage of latest renewable energy technologies and smart control system to deliver clean, affordable energy for residents. As such the SLES will create a scalable energy solution that can be replicated in other areas in support of the UK's transition to a zero carbon future.

The project has adopted a User-Centric Design approach which will use innovative community engagement methodologies to ensure the wants and needs of the community are addressed. As such this will create a bespoke SLES system for Rugeley demonstrating how carbon emissions and energy costs can be reduced whilst simultaneously boosting local economy regeneration and social integration.

Source: Zero Carbon Rugeley project – Rugeley Power Ltd

Intervention 5.1 exemplar: Nuclear - Rolls-Royce

Developing power plants that generate electricity using a small modular reactor. Fleets of these small modular reactors have the potential to provide increased stability and security of supply to electricity grids alongside other sources including renewables. SMR's could also power the extraction of carbon dioxide from the air for use in production of synthetic, sustainable aviation fuels. Known as direct air capture the technology is currently in its infancy but could one day help decarbonise long haul flights.

Aims for manufacturing facilities being built by 2025 and the first SMR to be commissioned by the early 2030's. The consortium led by rolls Royce plans to have 16 power stations in the UK fleet generating around 440MWe from each station and also aims to have this account for 20% of UK electricity generation by 2050. The small modular reactor power stations can have a lifespan of over 60 years.

Rolls Royce also received around £195 million from investors to fund the plans for three years and the government will match fund the consortium's investment when the second phase is starting. Rolls Royce will get an additional £50 million top up with £210 million to help roll out the small modular nuclear reactors.

Source: Small nuclear power stations | Rolls-Royce:
Rolls-Royce secures £450m for mini nuclear reactors venture | Energy industry | The Guardian

Intervention 5.2: Clean hydrogen

Tens of thousands of jobs, billions of pounds in investment and new export opportunities will be unlocked through government plans to create a thriving low-carbon hydrogen sector in the UK over the next decade. UK government will work with industry to meet its ambition for 5GW of low-carbon hydrogen production capacity by 2030 – the equivalent of replacing natural gas in powering around 3 million UK homes each year as well as powering transport and businesses, particularly heavy industry.

Intervention 5.2 exemplar: Bilsthorpe hydrogen energy project

Planning has been approved for the hydrogen energy project. Will include the installation of a 1.25-megawatt electrolyser inside a largely unmanned compound near where solar farms and wind turbines are already located.

The electrolyser will use electricity from the solar farm and wind turbine to turn water into green hydrogen which once turned back into electricity through a fuel cell will only emit water vapour and air. Once generated, the fuel from the scheme can be taken for use off-site or used to power farm vehicles that have been adapted.

Source: New 'innovative' hydrogen power plant approved in Nottinghamshire will only emit water vapour and air - Nottinghamshire Live (nottinghampost.com)

Intervention 5.3: Micro-grid

A microgrid is a local energy grid (typically an electrical grid) which has control capabilities; thus it can be disconnected from the traditional grid and operate autonomously. A microgrid can be powered by distributed generators, batteries, and/or renewable resources like solar panels.

Intervention 5.3 exemplar: West Midlands Gigafactory

The 309-acre Coventry site is perfectly located at the heart of the UK's automotive industry in the West Midlands with access to world-class skills, talent and supply chain capabilities in the region. It benefits from a strong transport infrastructure for the future Gigafactory's logistics requirements, supply chain and access for up to 6,000 employees. The future Gigafactory will be powered by 100% green, renewable electricity from sustainable sources as well as an onsite microgrid of photovoltaic panels on the Gigafactory's roof.

Source: West Midlands Gigafactory

Scale up: Micro-grid

If 70 microgrids are delivered across the Midlands Engine region at a steady rate between 2022 and 2040, the following cost and benefits will impact the region by 2050. Values in 2022 prices and discounted at 3.5% unless otherwise stated.

- Microgrid investment £0.56 billion - £1.25 billion by 2040 (non-discounted).
- Cumulative avoided emissions of 96,240 ktCO2e by 2050, equivalent to £17.1 billion today.
- Annual avoided emissions of 4,812 ktCO2e from 2040 onwards, equivalent to approximately £0.8 billion today.
- Sustain an average of 5,740 jobs per year[26]

26: Low confidence in job impact calculation

5.6. Summary of impact by 2050

The following table summarises the potential impact [27] of different Smart Energy interventions in the Midlands by 2050. Impact figures are cumulative to 2050, based on 2022 prices and discounted at 3.5% unless otherwise stated. Capital investment values are stated at 2022 prices and not discounted.

	Smart meters	Energy monitoring and optimisation	Smart grid	V2G	Microgrid
Key assumption	*30,000 - 45,000 installed/month until Aug - 25*	*1% of SMEs/year (414 SMEs / year) (12,025 SMEs by 2050)*	*Steady deployment up to 2050*	*156,000 V2G EVs in Midlands Engine by 2030*	*70 microgrids by 2040*
Capital investment needed	£0.1bn - £0.2bn	£7.2bn - £14.4bn (service charge)	£3.2bn - £4.4bn	£0.05bn - £0.09bn	£0.56bn - £1.25bn
Avoided cost	_	_	£2.6bn - £3.6bn	£0.02 - £0.17bn	_
System cost reduction	_	_	£1.2bn - £5.4bn	£0.24bn - £1.7bn	_
GVA (gross)	_	_	£1bn - £1.5bn	_	_
Exports	_	_	£0.4bn - £0.6bn	_	_
Jobs	_	_	900 - 1,400 jobs sustained throughout the 2020s and 2030s	_	Sustain an average of 5,740 jobs per year
Emissions reduction	243kt - 260kt £0.03bn - £0.11bn	25 - 102kt £0.003bn - £0.04bn	Supports the reduction in CO_2 emissions	9,845kt £1.6bn - £4.8bn	96,240kt £15.7bn - £47bn
Other benefits	£0.25bn to domestic consumers	£0.19bn - £1.03bn to SMEs	_	£1.3bn - £2.4bn to fleet aggregators	

Using the figures generated for the impact of Smart Energy in the region, we present two scenarios which examine the potential future of Smart Energy deployment in the area.

Do minimum scenario: in this scenario, the Smart Energy System would only comprise of energy monitoring and optimisation through smart meters and other energy management platforms in households, commerce and industry. Such a Smart Energy System would cost the Midlands anywhere between £7.34 billion - £14.63 billion, leading to £0.45 billion - £1.03 billion in savings to the consumer and emissions reduction between 269 $ktCO_2e$ - 362 $ktCO_2e$ which would save in addition £0.04 billion - £0.15 billion due to emission reduction by 2050.

Do maximum scenario: in this scenario, the Smart Energy Systems would comprise energy monitoring and optimisation in households, commerce and industry, Vehicle-2-grid deployment to store energy and manage peak demands, and micro and smart grids to manage and distribute energy. Such a Smart Energy System would cost the Midlands anywhere between £11.15 billion - £20.37 billion leading to emissions reductions of around 106,354 $ktCO_2e$ - 106,447 $ktCO_2e$ by 2050 which is 25% of total emissions generated in the UK in 2022. Such a system would provide a total savings of £5.88 billion - £14.3 billion, which includes savings for the consumer, the system and the costs avoided due to Smart Energy Systems. Moreover, such a system would generate £1 billion - £1.5 billion in GVA, £0.4 billion - £0.6 billion in exports and sustain anywhere between 6,640 to 7,140 jobs in the Midlands per year.

27: Note there is potential for double counting benefits across interventions although this effect is not possible to separate out

Table 10 presents the summary of costs, benefits and Benefit-Cost Ratio (BCR) [28] for the scenarios until 2050.

Table 10: Summary of costs, benefits and BCR for the scenarios until 2050

Scenario	Costs	Benefits	Benefit-Cost Ratio (%)
Do Minimum	£7.34 bn - £14.63 bn	*Total benefit of £0.48 billion - £1.18 billion which includes:* £0.45 billion - £1.03 billion in savings to the consumer 269 ktCO_2e - 362 ktCO_2e in emissions £0.04 billion - £0.15 billion due to emission reduction	6.5% - 8%
Do Maximum	£11.15bn - £20.37bn	*Total benefit of £24.6 billion - £68.46 billion which includes:* £1.78 billion - £3.41 billion in savings to the consumer 106,354 ktCO_2e - 106,447 ktCO_2e in emissions £18.95 billion - £18.97 billion due to emission reduction £2.62 billion - £3.77 billion in costs avoided due to the Smart Energy System £1.49 billion - £7.1 billion due to reduction in system costs £1 billion - £1.5 billion in GVA £0.4 billion - £0.6 billion in exports Sustain anywhere between 6,640 to 7,140 jobs	221% - 336%

The total costs in do minimum scenario amounted to £7.34 billion – £14.63 billion with total benefits ranging between £0.48 billion-£1.18 billion from 2022 to 2050, thus generating a benefit-cost ratio of 6.5% - 8%. In the do maximum scenario, the total costs were £11.15 billion – £20.37 billion with benefits ranging between £24.6 billion -£68.46 billion from 2022 to 2050, thus generating a benefit-cost ratio of between 221%-336%. The benefit-cost ratio for the do maximum scenario is likely to be higher than our results as our benefits do not include emissions savings from smart grids. This suggests that doing maximum in the Smart Energy Systems would generate benefits and savings that would cover the costs at least twice over, thus being profitable for the region.

28: Benefit-Cost Ratio (BCR) compares the present value of all benefits with that of the cost and investments of a project or investment. BCR<1 implies that the investments would generate loss. BCR=1 implies that the investments would neither generate profit or loss. BCR>1 implies that the investments would be profitable.

5.7. Enabling activity

There are a number of areas that would help enable the Smart Energy sector to develop in the region.

5.7.1. Skills development

The Midlands Engine has a huge skills-based asset. Currently, 387,000 students are enrolled in 22 universities across the Midlands. Individuals are improving their level of qualifications as approximately 16% of people with no qualification in 2019 qualified in 2020.

It is estimated that out of 700,000 new jobs in the UK low-carbon sector, 100,000 jobs would be located in the Midlands by 2041, nearly 100,000 jobs.

Exemplar: Retrofit training by Midlands Net Zero Hub

Midlands Net Zero Hub was awarded grant funding by Green Homes Grant (GHG) Training Programme to deliver accredited training to the low-carbon installation sector at scale.

A total of 8,959 learners started a funded course, with 6,938 (77%) completing. From an original funding pot of £6.9m, a total of £5,928,530 was paid to providers. Overall learner satisfaction was very high, with 92% satisfied or very satisfied with the Green Homes Grant STC training and support they received, 98% reporting that they would use the training provider again, and 98% saying that they would recommend the course to others.

Source: https://www.midlandsnetzerohub.co.uk/wp-content/uploads/2022/06/GHG-Skills-Competition-Evaluation-report-FINAL-003.pdf

5.7.2. SME support

Funding and support is available for SMEs who want to transition to Smart Energy. However, sources of this support is limited by the funding horizons of the programmes. There is a need for a longer-term strategy to support SMEs to gain access to support programmes that allow them to access this sector.

Exemplar: ATETA

ATETA is an SME engagement programme designed to provide support to help businesses identify opportunities for clean energy innovation.

Funded by the European Regional Development Fund (ERDF) this programme led by the Birmingham Energy Institute has already helped 170 businesses across our region, generate a net income of over 25 million for our local economy.

Source: https://www.birmingham.ac.uk/research/energy/research/ateta.aspx

5.7.3. Energy Innovation Zones

Energy Innovation Zones come together to find a solution to an energy challenge, which may require some regulatory derogations. This allows innovators to deploy clean energy solutions under bespoke rules and conditions agreed between local authorities and national regulators. This facilitates a "place-based" approach towards energy decarbonisation, galvanising local energy innovation towards reducing emissions.

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Exemplar: EIZs

Tyseley and Birmingham EIZ: This EIZ is optimising the city's 350,000 tonnes of waste for energy and heating, and creating a distributed heating grid for homes and businesses. It will establish clean transport infrastructure and create demonstrators for energy storage and waste-to-energy technologies. It will direct city planning powers to improve energy performance of buildings, creating new markets for low-carbon innovations.

Black Country EIZ: This EIZ will secure investment to develop clean energy generation to deliver local power at competitive prices, attracting advanced manufacturing to the region. Investment will be encouraged through policy measures such as simplification of supply exemptions; local incentives; and matchmaking between energy generators, Distribution Network Operators and industrial energy users.

UK Central EIZ: As home to many energy intensive users, this EIZ hopes to use the concentration of electricity and heat demand to create opportunities for clean energy and building efficiency innovation. Specific opportunities have been identified including for a low-carbon heat network and a hydrogen hub.

Coventry and Warwickshire EIZ: This EIZ is focussed on meeting growing electricity demand through cost-effective clean energy solutions and developing infrastructure for connected autonomous vehicles.

Rugeley EIZ: This EIZ will oversee redeveloped the 350-acre site of Rugeley's decommissioned coal power station to include ~2000 homes. It will ensure these are developed with energy efficiency in mind, as well as assessing retrofitting existing homes, and generating power for new residents, including through repurposing subterranean cooling tank and surface water lake

5.7.4. Connectivity

The Midlands is home to the first multi-city 5G testbed with over 20,000 digital businesses in the Midlands. 5G alone would contribute £5 billion to the region's economy in the next five years. Connectivity and data sharing are key components to the Smart Energy System.

Exemplar: Digital Boost

Digital Boost is a free online platform that supports people who work at small businesses and charities to get the essential digital advice skills they need to adopt new digital ways of working and grow their businesses. The programme pairs small businesses with digital experts from the likes of Google and BT – to equip you with the essential skills to bring, or grow, your organisation online

Source: https://www.cwgrowthhub.co.uk/digital-boost-0

5.7.5. Data and Digital Twins

With the increase in number of Smart Energy projects in the West Midlands – there is also a growing interest in how these projects are collecting Smart Energy data as there are a number of different restrictions and limitations when using and collecting Smart Energy data to deliver insights. This is paralleled by projects focusing on the creation of digital twins (for more detail see [29]) which are used to create a digital representation of a real-world system or process. For these to be successful, the digital twin typically needs access to appropriate streams of data in order for it to provide meaningful outputs in a timely fashion.

Example projects involving data collection/data usage are shown as exemplars.

29: https://www.cdbb.cam.ac.uk/what-we-did/national-digital-twin-programme

Exemplar: **Digital twin for East Birmingham**

he purpose of this project is to create a digital twin "to accelerate investment, the net zero transition, citizen wellbeing and creating a global showcase for an innovative, forward-looking Birmingham with the application of a scalable and referenceable digital twin for East Birmingham and TEED." Creation of a digital twin has been given 10 use cases to define the objectives that the digital twin will fulfil for East Birmingham, this ranges from an investor community and opportunity portal, future city investment simulation and carbon intensity analysis etc. Developing this digital twin is important as with more pressure being put on city leaders to find new ways to tackle sustainability a digital twin can be used to create an accessible digital version of regional energy systems, land use and planning and transport. This can be used to drive investment into areas that were not available before a digital twin can help to make these systems more sustainable.

Data collection for a digital twin for East Birmingham echoes some issues that other organisations/projects have when trying to find or access data for their needs. Data is held in multiple different silos both internally and externally to the Local Authority, which can make retrieval time-consuming and challenging due to a number of different barriers. Gaining access to non-open data requires agreements on licensing which typically restricts the collection of data and its further use. There is also an increasing value put on the use of data, and some stakeholders may wish to valorise their data to such an extent that it makes access to data unworkable for various other projects.

This points to the benefit of more open data that depending on the licensing can be used for a wider set of purposes. However, all data has a cost to it somewhere along the data chain, and it may be that paying for data that has had value added to it (such as errors replaced) is the sensible approach. Although data may be open and accessible, it may not be easily utilised, which itself requires data science approaches, which has a cost.

Source: https://www.era.ac.uk/write/MediaUploads/Other%20documents/CSR_General_Version_v8_270921.pdf

Exemplar: Regional Energy Systems Operator Data Catalogue – This data catalogue is made up of 145 datasets that had some connection to understanding the local energy system of Coventry. The data catalogue provides a helpful source of data links, many of which can be publicly accessed. Data cataloguing is an efficient way to compile dataset metadata into one place, and benefits from the inclusion of descriptions of each dataset that is useful for the users trying to track down data to know if particular datasets are relevant to their needs.

Source: https://zenodo.org/record/4776522#.YyL3o3bMKHs

Exemplar: **Enabling Smart Energy Systems**

The value of digitalisation and data best practices – Energy Systems Catapult have published recommendations on data best practices to ensure data can be used to its full value.

Provides a number of recommendations when working with high granularity data. One of which is that Regulators or BEIS should publish anonymised data to Smart Local Energy Systems project developers to enable them to maximise the benefit from an existing resource. Also, the regulators should continue to push for access to high granularity network data that exists, adoption of more modern techniques would lower the cost for networks to provide data to Smart Local Energy System project leads.

The report also gives recommendations on how Smart Local Energy System project leads can access commercially sensitive data whilst maintaining the organisations commercial value and intellectual property rights. One recommendation is that Smart Local Energy System project leads should map stakeholder needs to think of data as a service that can be provided rather than a commodity as this will disclose the true value of open data. Local Authorities and energy network operators should follow recommendations of the energy data task force and run open data triages on their data in order to identify the most appropriate way of sharing each dataset.

It also gives recommendations on privacy and consent when using sensitive data. Smart Local Energy System project developers, local authorities and energy network operators should adopt open source anonymisation tools, this will help them fulfil their GDPR obligation while keeping data secure. Also, Smart Local Energy System project developers should create a full data management plan for the information they collect, building on their existing obligations under GDPR to understand all of their data.

Source: https://es.catapult.org.uk/report/enabling-smart-local-energy-systems-the-value-of-digitalisation-and-data-best-practice/

6. HOW CAN CONSUMERS ENGAGE IN THE OPPORTUNITIES OF SMART ENERGY SYSTEMS?

This section outlines potential interventions that Smart Energy is not necessarily tangible such as smartphones. It combines different interventions, processes, management and digitalisation to ensure efficient energy generation, storage, management and distribution. Thus, Smart Energy Systems encompass all economic sectors, including energy, residential, commercial, industrial, transport etc. There are some basic steps which open an engagement in Smart Energy Systems:

Step 1: Determine what smart means.

- Is becoming smart all about purchasing new smart appliances that can switch on and off when energy costs are low?
- Is becoming smart about monitoring your energy usage and using that data to change your behaviour?
- Is smart all about producing your own low-carbon energy?
- Is smart all about reducing your emissions?
- Is becoming smart all about being digital and having AI in homes, such as Alexa?

Step 2: Determine why there is a need to be smart.

It needs to be clear what the driving force behind being part of a Smart Energy System is.

- Is there a need to become smart to save energy costs?
- Is there a need to become smart to generate electricity to shelter from changing energy prices?
- Is there a need to become smart and proactive in the expectation that future regulations will demand it?
- Is there a need to become smart to increase comfort?
- Is there a need to become smart to reduce an environmental footprint due to energy consumption?

Step 3: Data collection

After the decision and the reason for being smart has been established, the next step is to collect relevant information such as:

- What are the energy costs?
- What is you're the energy consumption?
- What processes/appliances/equipment require energy, and how much energy is required?
- What are the costs and saving for different interventions?
- What is the payback period?
- What sort of life does an intervention have?
- How long does it take to install an intervention?
- What sort of support is available to go smart, either in terms of funding or just business support?

Step 4: Making a decision:

Once all the relevant information has been collected, there is a need to decide which interventions would provide y the most benefit while costing the least. Once the decision has been made, the next step is implementation.

Step 5: Implementation

No matter you're the reason for going smart, the first step would be to minimise energy losses. This can be achieved either through improving the insulation of buildings, reducing the distance between different processes and equipment, replacing inefficient and energy consuming machinery or just switching on equipment and appliances when the energy costs are low such as at night. There are energy companies offering smart tariffs today. These companies will help users understand the options and which one matches their requirements.

7. SUMMARY OF PROPOSED MIDLANDS ENGINE SMART ENERGY DEFINITION, VISION AND ACTION PLAN

In this section, we summarise the proposed definition of Smart Energy Systems, the vision statement for the Midlands and an action plan that could facilitate the acceleration of Smart Energy in the region.

7.1. Smart Energy Definition for the Midlands

We define a Smart Energy System as:

"A Smart Energy System utilises new and emerging digital technologies, artificial intelligence, and machine learning, to actively monitor and balance energy needs across connected energy networks, of all scales, by making real-time autonomous interventions to empower energy users and companies to ensure costs are reduced, that energy networks are resilient, and the energy system transitions to net zero."

7.2. Vision Statement for the Midlands

The conclusion of the present work is that there is an opportunity for the Midlands Engine to play a significant role in steering the development of Smart Energy for the region. In order to steer activity there needs to be a regional vision. It is proposed that the Vision for the Midlands Engine is:

> *"To become an exemplar region both within the UK and internationally in terms of Smart Energy Systems. The Midlands Engine will partner with key regional organisations to support the development of a Smart Energy System building on the distinctive regional projects, expertise and industry base. The aim is to create a state-of-the-art energy system for the citizens of the Midlands, driving down energy costs, increasing energy security and resilience and creating a platform for inward investment into the Midlands energy system."*

7.3. Key recommendations and actions

The following provides a summary of key actions aligned to the challenges in establishing a Smart Energy System.

These actions would be integrated into the delivery of the **Ten Point Plan for Green Growth** in the Midlands Engine.

Challenge A: Lack of long-term planning and coordination from national government through to local governments on the development of regional and local energy systems.

Action 1: Create a regional coordination body for Local Area Energy Planning, to provide a focus for data sharing on Smart Energy Systems and their deployment, including microgrids. This would involve local and combined authorities through to energy companies and consumer organisations.

Action 2: Support the development and rollout of a series of large-scale Smart Energy Pathfinder projects building on the expertise and leadership in the Midlands.

Challenge B: Existing energy market frameworks do not fully incentivise the flexibility that Smart Energy Systems could provide or its innovation potential.

Action 3: Develop initiatives to support the enhanced rollout of smart meters in the Midlands.

Action 4: Work with energy companies to encourage the uptake of smart electricity and gas tariffs to enable targeted reduction and bi-directional distribution of energy.

Action 5: Encourage businesses to engage in energy monitoring, optimisation and uptake of energy efficiency measures in buildings and industry. An appropriate level of data sharing with trusted parties would be encouraged as part of this activity.

Action 6: Create a regional energy data task force to drive Smart Energy system-related cybersecurity and privacy, and increase innovator's and investor's trust in these systems.

Challenge C: Many current energy jobs in the Midlands will no-longer exist by 2050 and the workforce needs to be retrained to adapt to new and emerging technologies.

Action 7: Form a Smart Energy skills programme to (re-)train employees in the energy sector supporting the accelerated delivery of Smart Energy Systems.

Challenge D: Opportunities for large scale low-carbon energy generation in the Midlands are lower compared to other regions in the UK.

Action 8: Support decentralised energy systems through more low-carbon and small-scale local energy generation.

Action 9: Support the development of energy intensive industrial clusters and energy users around energy from waste plants, small scale nuclear or other emerging energy generation technologies which can produce electricity, heat and potentially hydrogen.

GLOSSARY

BCR: Benefit-Cost Ratio

CAES: Compressed-air energy storage

CAPEX: Capital expenditure

CCC: The Committee on Climate Change

CCUS: Carbon Capture, Utilisation and Storage

DCC: Data Communications Company

EMEC: European Marine Energy Centre

EPC: Energy Performance Certificates

EV: Electric Vehicles

GHG: Greenhouse Gas

IES: Integrated Energy System

LAES: Liquid Air Energy Storage

LEO: Local Energy Oxfordshire

ME: Midlands Engine

OPEX: Operating expenditure

PFER: Prospering from the Energy Revolution

ReFLEX: Responsive Flexibility

RESO: Regional energy

SLES: Smart Energy Secure Lab

UKRI: UK Research and Innovation

V-2-G: Vehicle -2- Grid

WESA: Whole Energy Systems Accelerator

DATASETS

- UK business: activity, size and location

https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/datasets/ukbusinessactivitysizeandlocation

- GVA

https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalandrealregionalgrossvalueaddedbalancedbyindustry

- Renewable Energy Generation

https://www.gov.uk/government/statistics/regional-renewable-statistics

- Final Energy Consumption

https://www.gov.uk/government/statistics/total-final-energy-consumption-at-regional-and-local-authority-level-2005-to-2019

- Domestic energy consumption -2019

https://www.gov.uk/government/statistics/national-energy-efficiency-data-framework-need-consumption-data-tables-2021

- Non-domestic electricity consumption (MSOA level)

https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-electricity-consumption

- Energy consumption industry (UK whole) - Aggregate energy balances

https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes

APPENDICES

Appendix A: Interview notes

Interview and discussion were conducted with 10 organisations in the Midlands to understand the barriers and challenges to Smart Energy in the region. These organisations also aided us in developing a list of Smart Energy projects going on in the region as well as other activities which would support Smart Energy deployment. The interview/discussion varied in length from 30 minutes to 60 minutes. The interviews/discussions were recorded and transcribed. The table below presents the organisations, role of the members interviews, length of the interviews and conclusions drawn from the interviews.

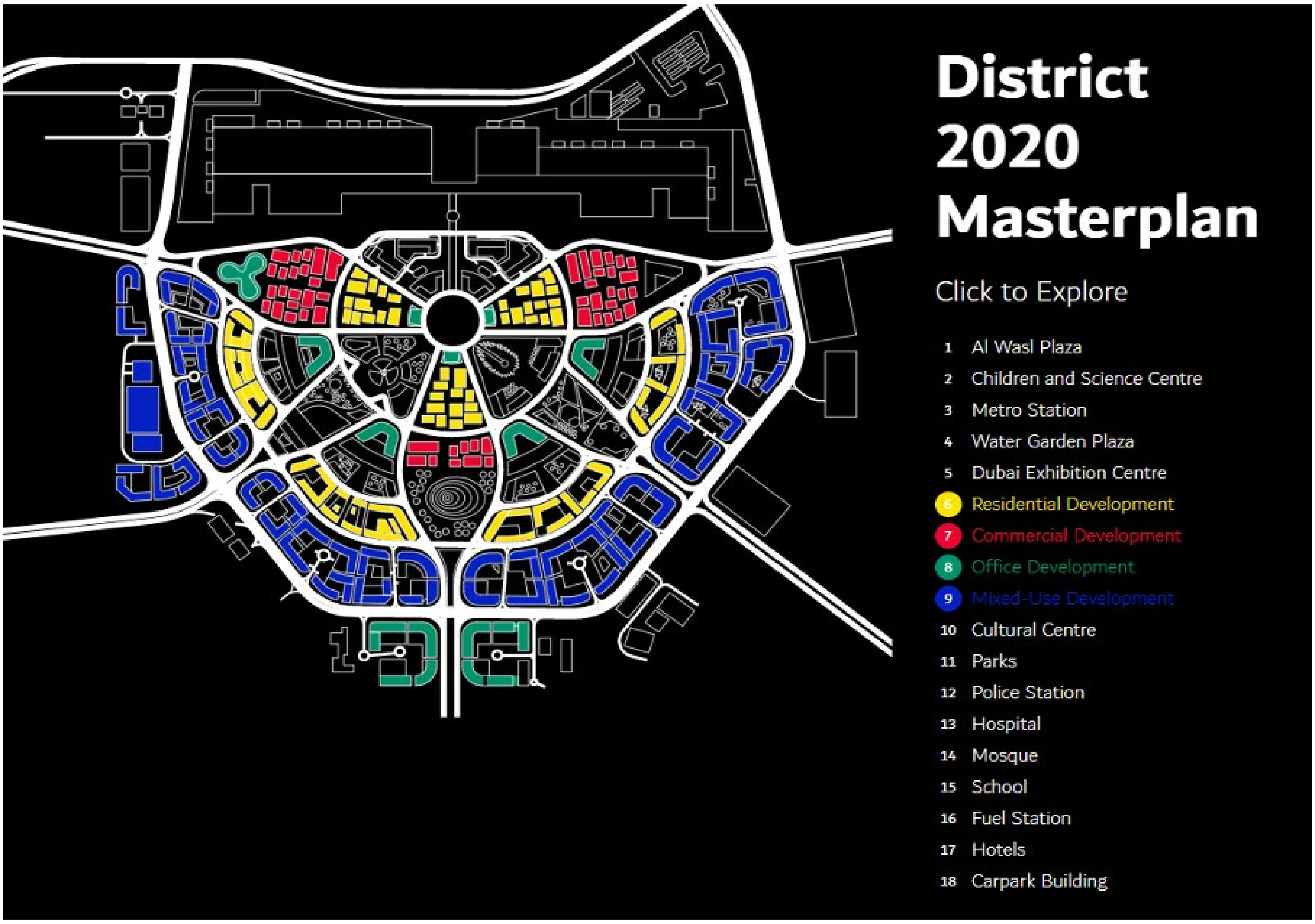
	Organisation	Role	Length of the interview	Conclusions
1.	Energy Capital	Director	45 minutes	1. Opportunities such as large energy generation not available in the Midlands 2. Cost of decarbonising is high and the opportunity is pretty low 3. Not too much incentive available for the customers e.g. Octopus smart energy tariffs 4. Requires flexibility though battery storage and enabling markets to reduce the peak demand 5. Planning is key – need to see how the infrastructure and system would evolve over time 6. Value to smart approach but works need to be done to quantify it 7. Demand side repose is important. – focus on what the customer wants 8. A future with a service model for energy which engages the consumer e.g. heat as service by Energy Systems Catapult. 9. Need for more market-oriented demo sites 10. Need for more living lab type projects to see if scaling up would have benefits 11. Devolution of power so that local governments have more control 12. More funding to build infrastructure and to scale up
2.	Energy System's Catapult	Business Lead	30 minutes	
3.	Smart Energy Research Lab	Manger	60 minutes	
4.	Midlands Net Zero hub	Head MNZH	30 minutes	
5.	Octopus Energy	Director of Regulation and Economics	60 minutes	
6.	Kew Technologies	Operations Director	30 minutes	
7.	ClearVUE, a Net Zero Consultancy	Business Development Manager	45 minutes	
8.	Western Power Distribution	Project Manager	60 minutes	
9.	Worcester Bosch	Director	30 minutes	
10.	Midlands universities	Project Members	30 minutes	

Appendix B: Blueprint of a smart, sustainable city: Expo/District 2020 - Dubai, United Arab Emirates

The Brief

Expo 2020, Dubai, was built on a 4.38 km_2 site and featured more than 24M visits from 178 countries. After the Expo ended in March 2022, the site is being converted to District 2020 - a smart innovation driven ecosystem and mixed-use development with sustainability at its core. It now serves 145,000 people, includes 10 km of bike tracks and 5 km of jogging tracks.

Expo/District 2020 is largest single installation of smart technologies in the world, which supported 54,000 jobs and added a Gross Value of $16.9 billion. The project has a key focus on growth sectors, such as Smart Mobility, Smart Logistics, Industry 4.0, and Smart Cities.



Smart Energy enablers

An adaptable and scalable Industrial Internet-of-Things (IIoT) solution was deployed, with the capacity to grow as use cases emerge and change. Its platform agnostic, cloud-based architecture allowed the integration of native and 3rd party solutions, thus enabling intelligent energy infrastructure and operations management, whilst ensuring a high level of customer satisfaction.

The IIoT was linked to a Smart City App, which gave Expo operations and decision-makers a single point of access for the entire infrastructure, including subsystems. Building system performance, energy consumption and energy supply could be monitored. Artificial intelligence provided predictions and forecasts for some parameters, such as maintenance requirements, whilst other systems, such as large-scale facilities could be directly controlled. Additional connected Smart Energy enablers included:

Lessons learnt

- Planning and development must consider **long-term usage change –** the site was primarily built as an exhibition centre with the ambition of becoming a district
- Primarily **service-based industries**, such as logistics, R&D, digital, management, etc, thrive with access to an integrated platform
    - Ensure **smart applications are realistic** - autonomous vehicles were proposed but then value engineered out
    - Health and well-being - **WELL-certification** available for communities [30], which may be extendable to regions
    - The support of a **strong governance and access authorisation process** is required
- Costs for managing critical infrastructure can be reduced by **optimising resource usage** and dispatch
- High level of satisfaction can be achieved for all types of stakeholders by **increasing transparency and usability**

30: WELL | IWBI (wellcertified.com)

Appendix C: List of key Smart Energy Projects

	Smart Energy Project	Description	Market Segment	Address
1.	Midlands Digital	Through the work of the Midlands Engine Digital Steering Group and Midlands Digital Strategy Board, partners from every part of the Midlands and across sectors are working to accelerate infrastructure roll out, remove barriers to digitisation, and ensure that digital connectivity continues to underpin regional competitiveness and community prosperity for every part of our region	SMEs	NG2 6BJ, Nottingham, East Midlands
2.	Uxplore	Funded support for SMEs in Coventry & Warwickshire to pilot new products, services, and business models by harnessing broadband, WiFi, 4G and 5G connectivity.	SMEs	CV1 2TT, Coventry, West Midlands
3.	Made Smarter	Made Smarter is a national movement to drive growth amongst UK makers and advance the UK economy. Backed by world renowned businesses and the UK government, it will improve the development and adoption of emerging technologies. Making a real, everyday difference to people from the boardroom to the factory floor.	SMEs	CV1 2TT, Coventry, West Midlands
4.	Smart Manufacturing Accelerator, and Factory in a Box	A Factory in a Box (FIAB) is a rapidly deployable, remotely managed, modular manufacturing supply chain network enabled by industrial digital technologies. FIAB manufacture is a rapid route to market for products with a faster ROI on its manufacturing innovation and new disruptive business models for the supply chain. The MTC, in collaboration with partners in industry and academia, have built FIAB demonstrators to showcase how FIAB manufacture and industrial digital technologies will transform your manufacturing and supply chain in the future	SMEs	CV7 9JU, Coventry, West Midlands
5.	ClearVUE.Zero	ClearVUE.ZERO is a powerful energy and carbon management and accounting platform that digitises energy data across all utilities and site locations globally, down to an asset level. Enables real-time, streamlined energy and carbon reporting and monitoring of reduction targets through the accurate measuring of a business' energy and carbon intensity.	SMEs	CV7 9QN, Coventry, West Midlands

	Smart Energy Project	Description	Market Segment	Address
6.	SIMPLE - Smart InforMation Platform and Ecosystem for Manufacturing	The SIMPLE platform will allow better monitoring and optimisation of their manufacturing operations by facilitating the collection of this core data set. The SIMPLE solution will also provide an open and scalable platform to stimulate the deployment of data centric application ecosystems, facilitating the development of wider digital capabilities in UK manufacturing organisations. The SIMPLE platform will benefit manufacturing SMEs in particular, as they lack either the skills to effectively take advantage of the currently fragmented technological landscape, or to invest in large integrated engineering solutions	SMEs	LE12 8RE, Loughborough, East Midlands
7.	Living Lab (Energy Systems Catapult)	Energy Systems Catapult created the Living Lab to offer a quick, safe and affordable, real-world test environment to de-risk and scale innovations by running trials directly with consumers in their homes.	Residential	B4 6BS, Birmingham, West Midlands
8.	Project 3D - Data to Decarbonise in a Decade (CSE)	3D is an initiative to help decarbonise Birmingham (the largest metropolitan borough in England) within a decade through hosting a Data-hub which makes available a range of data sets including open data on housing, travel, waste, energy, and emissions	Residential	B2 4AJ, Birmingham, West Midlands
9.	Sustainable Market for Affordable Retrofit Technologies -SMART - Hub	SMART Hub represents a wider ambition for WMCA to support the growth of the retrofit market across the region. SMART Hub is leading the delivery of demonstrator programmes. SMART Hub will support partners in building knowledge and capacity, coordinate local retrofit activity, engage the supply train, and work with partners to overcome key market barriers, such as finance, skills and training, and demand. Ultimately, their aim is to be a catalyst behind the decarbonisation of 1.2m homes in the West Midlands by 2041	Residential	B19 3SD, Birmingham, West Midlands
10.	Worcestershire 5G	To allow manufacturers to test the potential of 5G investments from factory floor • Published 5G Skills Report, providing key insights into the 5G skills shortages in the UK and outlining potential steps to tackle this gap • A potential of 2% productivity gains just through the improved operations and plant efficiency.	Regional Grid Infrastructure	
11.	West Mercia 5G	The project explores infrastructure challenges when planning, building and operating a rural 5G network and look at how 5G can enhance services for the benefit of residents, particularly researching 5G enabled health and social care applications	Regional Grid Infrastructure	Shropshire and Worcestershire, West Midlands

	Smart Energy Project	Description	Market Segment	Address
12	West Midlands RESO Project	The project looks to explore the advantages of a new kind of energy system operating at a city scale. The new system will include local low-carbon energy generation, storage and management and will integrate future mobility assets such as electric vehicles into its overall envelope.	Regional grid infrastructure	
13	E.ON - Smart Energy Grid	E.ON is the energy consultant for GreenSCIES, providing advisory and technical oversight for a revolutionary low-carbon Smart Energy grid in the West Midlands.	Regional grid infrastructure	
14	5G Connected Forest	Project designed to assess the potential for 5G applications. • Provide base for innovation accelerator programme to allow for 5G applications to be tested and commercialised • Key element of the project's ambition to help enable the successful adoption of 5G technologies and the economic growth of Nottinghamshire	Regional Grid Infrastructure	NG21 9QB, Sherwood Forest, Nottinghamshire, East Midlands
15	West Midlands 5G (WM5G)	Its mission is to accelerate the deployment of 5G networks and to test, prove and scale new 5G services across the West Midlands. • Has helped towns and cities in all of the seven local authorities in the West Midlands to accelerate the access to 5G. • Has accelerated the deployments of 5G across West Midlands by 6 to 12 months	Regional Grid Infrastructure	B19 3SD, Birmingham, West Midlands
16	Green Smart Community Integrated Energy Systems (Greenscies)	The project aims to deliver low-carbon, affordable energy to the local community through a Smart Energy System connecting intermittent electricity demands, such as heat pumps and electric vehicles, to intermittent renewable energy sources such as solar power. • When constructed, GreenSCIES systems will deliver low-carbon heat, mobility and power to an estimated 33,000 residents and nearly 70 local businesses in Islington. • The new Smart Energy grid will help to reduce carbon emissions by an estimated 80% (against conventional systems) while addressing fuel poverty by providing a significant reduction on consumer bills. • The system will also deliver air quality improvements by reducing pollutants while improving provision of local skills training and job prospects, helping to invigorate local economies.	Regional Grid Infrastructure	Sandwell, West Midlands

	Smart Energy Project	Description	Market Segment	Address
17	Multi-city 5G Testbed	The Urban Connected Communities Project, the next step in the Government's 5G Testbed and Trials Programme, will develop a large-scale, 5G pilot across the region, with hubs in Birmingham, Coventry and Wolverhampton.	Regional grid infrastructure	B1 2ND, Birmingham, West Midlands
18	Local Area Energy Planning	Local Area Energy Planning (LAEP) is a data driven and whole energy system, evidence-based approach that sets out to identify the most effective route for the local area to contribute towards meeting the national net zero target, as well as meeting its local net zero target.	Regional grid infrastructure	B4 6BS, Birmingham, West Midlands
19	Western Power Distribution	Western Power Distribution are the electricity distribution network operator for the Midlands, South West and Wales. The company is investing an extra £60 million into the development of their electricity network that will help to support the connection of new customers, including green projects over the next two years (2021-2023)	Regional grid infrastructure	DE74 2TU, Derby, East Midlands
20	West Midlands Centre for Climate Data	Energy Capital are leading plans for a Centre for Climate Data in the West Midlands. This is still in early stages of development.	Regional grid infrastructure	B19 3SD, Birmingham, West Midlands, B3 1RL
21	Low-carbon Sector Study - Sustainability West Midlands	Sustainability West Midlands and kMatrix Data Services were commissioned by the Midlands Energy Hub to provide an evidence-based study to understand: the current state of the Low-carbon Environmental Goods & Services (LCEGS) Sector in the Midlands; where support is needed to help grow this sector; and the role the sector can play in driving a low-carbon recovery from Covid-19. The study was delivered between November 2020 and March 2021 and the evidence-base will be kept up to date, aligning with delivery of the Midlands Engine Ten Point Plan for Green Growth.	Regional grid infrastructure	B3 1RL, Birmingham, West Midlands
22	Project Sherbourne	Project Sherbourne, named after Coventry's partially underground river, will see the City Council join forces with a host of commercial and public sector partners, including Coventry's universities, to create an unrivalled digital infrastructure at the cutting edge of the global use of digital connectivity such as full fibre and 5G. It will look at how the next generation of digital technology, infrastructure and services is set to radically transform the retail, leisure, transport, education, health and public service areas, underpinning today's and tomorrow's next generation experience for Coventry's citizens, visitors, businesses and learners.	Regional grid infrastructure	CV1 5RR, Coventry, West Midlands

	Smart Energy Project	Description	Market Segment	Address
23	Net Zero Pathfinder	Building on the work of the West Midlands Energy Capital initiative, the West Midlands Combined Authority is creating a Net Zero Pathfinder which will deliver a step change in net zero ambitions and boost the green industrial revolution in the region.	Regional grid infrastructure	B19 3SD, Birmingham, West Midlands
24	National Grid	National Grid are heavily involved in research and engaged with both ERA and Energy Systems Catapult. National Grid use such platforms and initiatives ongoing in the Midlands to listen, learn, observe, engage with the start-up companies and potentially look to springboard tech into the wider company.	Regional grid infrastructure	CV34 6DA, Coventry, West Midlands
25	Hyperbat	Hyperbat, one of the UK's largest independent vehicle battery manufacturers based at Unipart Manufacturing in Coventry, is using the latest 5G enabled technology to significantly speed up the manufacturing process for hybrid and electric vehicle production in the UK. A joint venture between Williams Advanced Engineering and Unipart Manufacturing Group, it aims to become the UK leader in high voltage battery systems, growing the UK battery technology supply chain. Hyperbat's UK battery manufacturing plans to bridge the gap between low volume prototype build and high volume hybrid and electric vehicle production.	Regional grid infrastructure	CV6 5LZ, Coventry, West Midlands
26	CleanMobilEnergy - Clean Mobility and Energy for Cities	CleanMobilEnergy is a three year, European funded project which involves many partners across North West Europe working together to develop a Smart Energy Management System, integrating Renewable Energy and Electric Vehicles.	Regional grid infrastructure	NG2 3NG, Nottingham, East Midlands
27	5PRING	5PRING is UK's first 5G commercial innovation centre whose aim is to help organisations of all sizes harness the power of 5G to deliver growth and innovation throughout the West Midlands and beyond	Regional Grid Infrastructure	WV10 9RU, Wolverhampton, West Midlands
28	SEND - Smart Energy Network Demonstrator (Keele University)	SEND is Europe's first at scale environment providing a platform that allows energy generation, distribution, storage, forecasting and energy balancing to be intelligently carried out across different energy sources using the Keele University campus as a genuine 'living laboratory.'	Energy-Intensive Users / Regional Grid Infrastructure	ST5 5BG, Keele, West Midlands

	Smart Energy Project	Description	Market Segment	Address
29	West Midlands Gigafactory	West Midlands Gigafactory's mission is to create the UK's largest battery Gigafactory in the heart of the UK automotive industry. A battery gigafactory is a strategically crucial investment for the region and the UK. It will play a major role in securing the future of the automotive industry as it transitions to an electrified future.	Energy-Intensive Users / Energy Generation	CV8 3AZ, Coventry, West Midlands
30	Repowering the Black Country	Repowering the Black Country is one of seven industrial cluster decarbonisation projects funded by BEIS and UKRI. The Black Country Industrial Cluster consists of more than 3000 energy-intense manufacturing businesses. The project is supporting the national industrial decarbonisation strategy by developing approaches which work in the Black Country and can then be applied more widely. - The project will initially develop four zero carbon industrial hubs in the Black Country. - Within the next 10 years, they aim to reduce industrial carbon emissions by around 1.3M tCO_2	Energy-Intensive Users	DY5 1LW, Dudley, West Midlands
31	Siemens	Siemens have demonstrated potential cost-effective decarbonisation through more effective utilisation and coordination of current and planned generation assets. Siemens energy experts worked with a wide range of local stakeholders using bespoke digital modelling tools, based on real-time data, and have shown how a more coordinated net zero system could supply up to 50,000 users with CO2-neutral electricity or supply Birmingham airport with green electricity, heating and cooling.	Energy-Intensive Users	B90 8AF, Birmingham, West Midlands
32	CAT	The CAT VLR project is exploring how 5G can improve the safety of such autonomous vehicles through its real time applications. The project will trial a 5G connected control system which operators will be able to interact with and respond to in real-time.	Energy-Intensive Users	CV1 5RR, Coventry, West Midlands
33	Trent Basin	Trent Basin is a new neighbourhood delivering 350 homes to the Nottingham Waterside area, a 250-acre regeneration zone just over a mile from Nottingham's city centre, bringing jobs, inward investment, and an enhanced public experience through a new riverside walk by the River Trent. Trent Basin is also home to a ground-breaking energy installation which has attracted international attention, providing the template for future models of community generation.	Energy generation / Residential	NG2 4DN, Nottingham, East Midlands

	Smart Energy Project	Description	Market Segment	Address
34	Zero Carbon Rugeley	The project aims to produce an innovative design for a town-wide Smart Local Energy System (SLES) including the former Rugeley Power Station site. This is one of just a dozen such pioneering programmes in the UK and will demonstrate how carbon emissions and energy costs can be reduced whilst also providing a boost for local regeneration.	Energy generation	WS15 2WA, Rugeley, West Midlands
35	Tyseley Energy Park	Located in East Birmingham, Tyseley Energy Park (TEP) is on a mission to transform clean energy innovation in Birmingham and the West Midlands by stimulating and demonstrating new technologies and turning them in to fully commercially viable energy systems that will contribute to Birmingham's commitments to reduce CO_2 emissions by 2030.	Energy generation	B25 8DW, Birmingham, West Midlands
36	Rolls-Royce	Aims for manufacturing facilities being built by 2025 and the first SMR to be commissioned by the early 2030's. The consortium led by rolls Royce plans to have 16 power stations in the UK fleet generating around 440MWe from each station and also aims to have this account for 20% of UK electricity generation by 2050. The small modular reactor power stations can have a lifespan of over 60 years.	Energy generation	B37 7YP, Birmingham, West Midlands
37	Bilsthorpe hydrogen energy project	Planning has been approved for the hydrogen energy project. Will include the installation of a 1.25-megawatt electrolyser inside a largely unmanned compound near where solar farms and wind turbines are already located.	Energy generation	NG22 8RD, Bilsthorpe, East Midlands

Appendix D: Case Studies of Smart Energy Schemes

1. The Trent Basin Community Energy Scheme in Nottingham

Overview

The Trent Basin housing development and community energy scheme in Nottingham, is a result of several collaborative projects that shaped it from inception to delivery.

The infrastructure at Trent Basin was funded primarily through the Energy Research Accelerator and Innovate UK, and includes an urban solar farm (272 kWpeak); one of Europe's largest community energy batteries (2.1 MWh); and a hub with a digital twin of the development where residents and visitors can visualise energy flows. The community energy scheme is operated by the Trent Basin energy supply company (ESCo) which generates income by selling electricity to electricity suppliers. The ESCo is co-owned by Trent Basin residents who are involved with decision making and receive a share of surplus income.

The vision of the Trent Basin community energy scheme is to provide a model for future housing developments to embrace renewables to lower the energy costs for residents and the carbon footprint.

An active energy community

Trent Basin is a housing development with 76 energy-efficient dwellings that form an active energy community, soon to be joined by a further 100 homes and a school. The Nottingham Waterside regeneration area where it is situated, covers 250 acres along the banks of the River Trent, and includes several thousand homes, amenities and businesses, which may also join the community energy scheme as they are built.

The houses themselves were built by the developers Blueprint, who partnered early on with the University of Nottingham to develop the Trent Basin vision and push the boundaries in terms of energy efficiency targets in a commercially viable development in Nottingham. The University team had the opportunity to bring lessons from various projects to the Trent Basin before starting 'Project SCENe', which funded the key part of implementing the community energy scheme whilst engaging with the community. The University facilitated the design, installation and monitoring of the community energy scheme assets and the formation of the Trent Basin ESCo, managed by partners

Funding from the Energy Research Accelerator enabled significant energy assets to be purchased. These included a 2.10 MWh battery supplied by Tesla, 272 kWpeak photovoltaics panels, and a community hub with a digital twin of the development where residents and visitors can visualise energy flows and better understand their role in saving energy and helping mitigate climate change. Each participating home is equipped state of art wireless Smart Energy monitoring and control equipment, including voice activated interfaces. This allows residents to visualise their energy use with a high level of granularity, and also produces datasets that are hosted within the digital twin. These are used by the partners to advance research knowledge and shape the innovative business model used by the Trent Basin ESCo.

Follow up project 'Active Building Centre Behind-the-Meter' allowed the more direct involvement of the residents in the energy trading decisions between the community and the grid. The Trent Basin ESCo is able to supply Trent Basin participants directly with locally generated energy. Different energy supply scenarios optimising the renewables and storage assets are being tested, with a view of providing residents with solar electricity directly, bypassing the grid meter. Revenues from the sale of energy flow back into the community, making the scheme appealing to customers.

Smart Energy Systems

The University of Nottingham team built a digital model replicating Trent Basin's physical environment and populated it with both real and simulated data. This digital twin platform can be accessed online but it is also pre-loaded in 147-inch screen at the development's community hub.

The platform was launched in 2018 and updated in 2020 to display real-time data collected from the community energy scheme. The platform is a public user-friendly visually interactive tool, available to all residents and visitors. Through this platform users can learn and interact with community energy data; multiple-users can interact at the same time on the screen and children are also welcomed to engage. It is important to note that personal home data is secure and not open to public access.

The objectives are to engage and inform the residents and a wider audience about energy issues and the benefits of energy efficiency and community energy approaches. The residents are able to review information about community energy data and this helps them to make more informed decisions in order to optimise the operation of the scheme and the operation of their own homes. This in turn could help drive behavioural change and help reduce carbon footprint.

> *"A Smart Energy System is a data-driven system and that data relies on smart meters," says Professor Mark Gillott of the University of Nottingham. "They are the key that enables efficient use of both renewables and a flexible, optimised infrastructure, and the establishment of smart, local energy systems."*

> *"We're now seeing a lot of smart appliances able to switch on and off remotely, which will make it possible to turn dishwashers and washing machines on in the middle of the night, when the energy's cheapest,"*

says Gillott.

Innovation

There were many innovative developments which enabled the Trent Basin community energy project to be delivered, such as:

1. The holistic approach to energy efficient building and community design is in itself unique in a commercial environment, and has the potential to revolutionise energy systems;
2. The various and innovative means of engaging the community, including voice activated commands and a digital twin, which ensured residents were on board;
3. The ESCo business model, which is focused not only on carbon management but also on financial gains in order to remain sustainable;
4. The 'behind-the-meter' approach for energy and carbon management;
5. The delivery of increased grid flexibility through the community energy assets, opening further opportunities for the better integration of electric mobility and electric heating.

Outputs and Impact

Data from 2019 showed that Trent Basin generated 152.5 MWh of electricity through its PV panels. The 2.10 MWh battery was used to trade 273.9 MWh of electricity with the grid. The electricity generated onsite alone could supply 75% of current community needs, and it is estimated that at least 34 tonnes of CO_2 is being saved per year.

Trent Basin has appeared in numerous media publications and has received several important visits such as Sir David King, Foreign Secretary's Special Representative for Climate Change, Foreign & Commonwealth Office. Trent Basin has won numerous awards and has also appeared in 18 peer reviewed academic publications. It was also featured in the UK100 report "Financing the Transition: Harnessing UK Cities' Ambition for Clean Energy (2017).

The UK Smart Cities Index recognised Trent Basin as one of the key projects contributing to Nottingham being ranked the top smart city for energy. It was also a featured project by UK Government's 'Climate Leaders' for COP26 in Glasgow in 2021.

Looking to the future

The next stage for Trent Basin is to further integrate electric mobility into the local system, in order to make use of vehicle batteries as energy assets for the community and the ESCo grid services.

Contact

For more information about Trent Basin, contact either Professor Mark Gillott at the University of Nottingham

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Or

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2. The Smart Energy Network Demonstrator at Keele University

Leading the way

The Trent Basin housing development and community energy scheme in Nottingham, is a result of several collaborative projects that shaped it from inception to delivery.

Keele University is driving forward world-leading research into environmental sustainability, enabling local solutions to the global challenge of climate change – the effects of which are becoming increasingly wide-spread.

Keele has recently been recognised as the top university in the world for sustainability, having been named Global Sustainability Institution of the Year at the International Green Gown Awards 2021. The award celebrates and reflects Keele's commitment to embedding sustainability across all its campus operations, including in its research, education, operations and community engagement.

At the heart of Keele's actions is the Smart Energy Network Demonstrator* – a European first at-scale environment that allows for new energy generation, distribution, monitoring and modelling technologies to be developed, utilised and evaluated in a unique living laboratory.

The programme, which has been delivered in partnership with Siemens, will result in better energy management, reduce reliance on fossil-fuel derived energy, significantly reduce energy waste and provide the opportunity to trial innovative new systems for energy use and management.

The data and knowledge generated through the programme will underpin new research and innovation partnerships with local, regional and international business, leading to the creation of new products, services and attitudes that will drive sustainable high value economic growth and jobs locally as part of a UK-wide commitment to become the home of 'clean growth'.

Keele – the perfect environment

The Keele University campus is like a small town, with 350 buildings ranging from family homes, flats and student accommodation, to teaching spaces, laboratories, sports facilities and business premises. It's the perfect living laboratory environment to host the Smart Energy Network Demonstrator.

The energy produced by the University's new Low-carbon Energy Generation Park, which officially opened in 2022, is also managed by the Demonstrator. Built in partnership with energy technology specialists EQUANS, the Park features an array of 12,500 solar panels and two wind turbines, which generate clean, renewable energy for the Keele campus and neighbouring communities. The facility, which also includes an industrial-sized battery, is generating up to 50% of the University's campus electricity requirements from renewable sources.

The Smart Energy Network Demonstrator is a multi-vector system, integrating combined heat and power, solar, wind and hydrogen – the latter thanks to Keele's crucial role in testing, demonstrating and embracing the potential of this alternative fuel source.

Hydrogen is a zero-carbon gas that, when burned, produces just heat, water and NOx if not managed. The Committee on Climate Change has determined that the use of hydrogen in the UK's energy system is necessary in order to reach net zero.

The landmark HyDeploy project, which took place at Keele between 2019 and 2021, saw the University partner with Cadent and other leading organisations to successfully blend hydrogen into Keele's campus gas network to show the potential for hydrogen to significantly reduce the carbon emissions associated with domestic and business heating and cooking.

The 20% hydrogen blend which was trialled at Keele was the joint-highest in Europe. If this blend was rolled out across the UK, it could save around six million tonnes of carbon dioxide emissions every year, the equivalent of taking 2.5 million cars off the road.

In January 2022, the University was announced as the lead for a new hydrogen-focused programme, HyDEX[31], designed to support and foster the creation of a new hydrogen economy in the Midlands.

HyDEX brings together universities from the Energy Research Accelerator partnership with multinational businesses, SMEs and other partners, to accelerate innovation in hydrogen, build markets and the supply chain, and support the skills needed for the new hydrogen economy and ecosystem.

The aim of HyDEX is to address the challenge of building a thriving new business, industrial and manufacturing sector in hydrogen, where very little currently exists. The programme will allow businesses to accelerate the development and viability of new hydrogen products and associated intellectual property, while supporting the transition from declining industrial sectors and enabling the training and re-skilling required.

31: https://hydex.ac.uk/

Collaborate with Keele and be part of the Green Industrial Revolution

Sustainability, low-carbon, energy-efficient, Smart Energy… if your business wants to become greener in what it makes, how it runs or the technology it uses, Keele University can help.

Low-carbon technologies, innovative data management systems and new energy products and services will be essential as the world acts to tackle climate change. With a wealth of rich data being generated through projects such as the Smart Energy Network Demonstrator, coupled with Keele's world-leading expertise in sustainability, the opportunities for collaborations that can add genuine value.

Hundreds of businesses across Stoke-on-Trent and Staffordshire have already benefitted from energy-focused research and consultation projects with Keele University, with specialist researchers matched to business needs to help develop innovative technologies, systems and improved energy management.

Businesses that are already working with the University as part of the programme are benefiting from:

- the ability to plug into the European leader in at-scale Smart Energy network demonstration;
- getting research support from Keele University (or another top university partner) to harness the skills and expertise of academic experts;
- placement of a specialist researcher for three months at no salary cost to the company;
- exclusive access to networking events with industry leaders on Smart Energy, generation, networks and systems.

Testimonials

"Our experience with Keele has been fantastic. We have been really impressed with our researcher and their enthusiasm, passion and attention to detail. We are so fortunate that Keele has the largest Smart Energy demonstrator of its kind in Europe, so we really feel that it is the best university that we could hope to collaborate with. Thanks to our collaborations with Keele, we are able to continue to push the boundaries of innovation in sustainable clean energy solutions."

Matthew Bell, Founder and Director, Grid Edge Estates

"It has been great to partner with Keele University and to collaborate with the academics and experts within the Smart Energy Network Demonstrator programme. It has enabled us to blend our existing work with new research that will not only improve our portfolio, but also has the potential to contribute to the UK's climate change agenda."

Trevor Hirst, Operations Director, Quorum

Get involved

Want to find out more about how you or your business could be part of Keele's ground-breaking projects?

keele.ac.uk/send | gateway@keele.ac.uk |

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3. Regional Energy System Operator, RESO

The RESO[32] project, led by Energy Capital and the West Midlands Combined Authority, focused on the energy system of the city of Coventry and the net zero transition. It included organisations such as Coventry City Council, the University of Birmingham, University of Warwick, ENZEN Global Ltd, Electron Ltd, Camirus Ltd, Western Power Distribution (WPD), Cadent Gas, and Places in Common. The project was funded through Innovate UK as part of the second wave of Smart Local Energy Systems projects under the Prospering from the Energy Revolution programme. It ran over the two calendar years 2020 and 2021.

The starting point for the concept of a Regional Energy Systems Operator is that the energy system is fundamentally changing not only at the national level, but also at the local level. This is driven by the need to reach net zero, which will require electrification of major parts of heating and transport demand that are currently provided by natural gas and liquid fuels respectively. These very substantial changes to local demand require changes to homes and networks and requires a level of coordinated development of energy networks at a local level. Local Area Energy Planning[33] is inherently a data driven and place-based approach to the development of local energy systems, that accepts that different local areas are likely to benefit from different approaches, i.e., there is no one size fits all approach that will work. Nonetheless, Local Area Energy Planning has to take account of national level approaches, and ideally would support and accelerate national decarbonisation efforts at lower cost than might otherwise be the case.

32: https://energy-capital-tfwm.hub.arcgis.com/pages/coventry-eiz
33: https://es.catapult.org.uk/tools-and-labs/our-place-based-net-zero-toolkit/local-area-energy-planning/

The transition to an energy system that is the foundation for the UK's net zero ambition, has to be a Smart Energy System with use of data to offer innovative ways of optimisation of the energy system (electricity, hydrogen and heat) in terms of cost and performance. For example, homes will increasingly have their own electrical generation from solar PV panels and storage in the form of static or Electric Vehicle batteries. This offers opportunities for their electrical connections to operate in a bidirectional mode in which they can demand electricity from but also supply electricity onto the local electrical grid. Homes will be able to exchange information with the wider energy system across different energy vectors, which offers the hope that the energy system can be optimised locally to return a net-benefit to the consumer. The project considered that in order to deliver benefits at a more localised level, that a greater level of coordination is required than is currently able to be achieved through the current disparate regulatory environment for different energy networks. This increased level of coordination was proposed via a Regional Energy Systems Operator that would be able to take whole systems view across different energy vectors, with a stronger input from local authorities in terms of the ambition and timeframes for energy system decarbonisation. A major foundational element of the Regional Energy Systems Operator would be to manage a Local Area Energy Planning process that was regularly updated (annually or every two years) and brought together multiple stakeholders.

The key findings of the project were:

- A defined role for regions, cities and localities in the UK energy system will support faster, more cost-effective national pathways to net zero.
- Technical design simulations for Coventry suggested future customer bill reductions of up to 35% would be deliverable under the right national and local scenarios, in comparison to the increases that would otherwise be expected to happen.
- The key elements of a Regional Energy System Operator (RESO) for Coventry included a local data governance capability ('data authority'); whole systems planning and potentially delivery capabilities; consumer and vulnerable citizen protection; and 'security of supply' functionality.
- Local electrical system balancing markets supported, targeted and encouraged by a RESO were calculated to offer potential benefits of up to £3.4m per year to Coventry, but this annual value was expected to increase post 2032 (the target year of analysis for the RESO project)
- 'Security of supply' functionality essentially means ensuring city energy system governance does not create additional or adverse risks to either national or local security of supply.
- The RESO proposals are entirely consistent with current Ofgem/BEIS proposals for a national Future System Operator (FSO).
- A RESO model could be replicated nationally within (and potentially reducing) the current projected cost envelope for FSO implementation.
- A preliminary cost benefit analysis suggested implementing RESO in the West Midlands would deliver a significant savings over 30 years by accelerating the changing away from fossil fuels to electricity for heat and transport. This led to a combination of savings from a reduction in primary energy demand itself and also by savings from cheaper energy particularly by the shift from transport fuels (with high taxation) to electricity (with low taxation).
- A progressive, least-regrets pathway to RESO implementation is possible starting with data governance and whole systems local area energy planning functions, and supported by rapid implementation of neighbourhood-level citizen engagement and consumer protection functions.
- Regional and sub-regional consolidation of functions and development of shared services between adjacent Local Authority focused RESOs is possible but not necessary for the model to be viable.
- Alignment between administrative and physical boundaries of infrastructure networks, local authorities and RESOs would be helpful to reduce data and engagement costs but will not occur without major restructuring in England.

In order to deliver such a model there is need for local data, collaboration, regulatory change and governance. The thinking of the project has been shared with BEIS and Ofgem.

This is a powerful and potentially disruptive vision, which needs to be integrated with market led approaches . The optimisation of the energy use of the consumer needs to connect with the operation and development of the system in order to maximise the benefits of a Smart Energy approach.

Contact

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TECHNICAL APPENDICES

Technical Appendix A: Assumption for smart meters

In 2020 there were 4.6m electricity meters installed in the Midlands area. As of May-2022 almost 3.5m of these (75.2%) were smart meters. The impact by the end of 2025 of a range of scenarios has been calculated based on historic trends (~37,000 meters per month) and high-low estimates. The impact is summarised in the table below.

	Additional Installations	Completion date	Energy savings (MWh)	Energy savings (£m)*	Emissions savings (kt CO_2e)	Emissions savings (£m)*
30k installations/month	1,148,328	Aug-25	259,017	26.5	61.1	14.6
37k installations/month	1,148,328	Jan-25	297,542	30.4	70.5	16.8
45k installations/month	1,148,328	Jul-24	326,831	33.5	77.8	18.6

** figures are discounted at 3.5% p.a.*

BEIS' Smart Meter Cost-Benefit Analysis (2019) shows that smart meter installations cost £88 for electric only or £143 for dual fuel. The base year of prices is 2011. The cost of installing an additional 1.1m smart meters in the Midlands is estimated to be £124M for electric only or £202M for dual fuel based on prices updated to 2022 using the electrical equipment price index.

Smart meters costs & benefits to 2050

If 1.1 million domestic smart meters are installed in the Midlands Engine region by August 2025 at the latest, the following cost and benefits will impact the region by 2050. Values in 2022 prices and discounted at 3.5% unless otherwise stated.

- Smart meter investment £0.12 billion - £0.2 billion by August 2025 (non-discounted).
- Energy savings of £0.25 billion by 2050.
- Cumulative avoided emissions of 243 kt CO_2e - 260 kt CO_2e by 2050, equivalent to £0.05 billion today.

Technical Appendix B: Assumption for Energy Monitoring & Optimisation

There are 41,465 SMEs in the region (provided by AR). If 1% of SMEs have energy monitoring and optimisation solutions installed per year form 2022 then 29% (12,025) will have the capability installed by 2050. The cost of a meter is charged at £1,200 per unit per year, although may fall over time.

Small to medium sized business use between 15,000 and 50,000 kWh of electricity per year on average. It is anticipated that energy savings from energy monitoring and optimisation could be anywhere between 25-30%. The **variable cost of electricity** between 25th July and 1st August for small businesses was 52.0p/kWh for small businesses and 52.7p/kWh for medium sized businesses.

The following table summarises the potential costs and savings from energy monitoring and optimisation up to 2050 based on the above. Values are discounted at 3.5% to 2022.

Cost	Energy savings	Emissions savings
£0.12bn in metering costs. (£0.08bn if costs fall by 50% by 2050.)	Electricity savings £0.19bn-£0.77bn.	Cumulative emissions savings of 25-102 ktCO_2e by 2050, valued at £0.005bn-£0.02bn.

If electricity costs continue to rise, then the value of electricity savings will be higher.

Technical Appendix C: Assumptions for Smart grids

The following table summarises the potential costs and benefits by 2050 based on the three approaches described on page 77.

		Midlands Engine impact based on...	
	UK wide	**Population (15.4%)**	**Land area (11.2%)**
Capital cost	£28.3bn	£4.4bn	£3.2bn
Capital cost avoidance	£23.3bn	£3.6bn	£2.6bn
System savings	£0.4-£1.2bn/year (by 2030) £1.5-£4.8bn/year (by 2050)	£0.06bn-£0.18bn (by 2030) £0.23bn-£0.74bn (by 2050)	£0.04bn-£0.13bn (by 2030) £0.17bn-£0.54bn (by 2050)
GVA (gross)	£15.5bn	£2.4bn	£1.7bn
Export potential	£6bn	£0.9bn	£0.7bn
Job creation	8,000-9,000 jobs sustained throughout 2020s & 2030s	1,200-1,400 jobs	900-1,000 jobs

Note: these figures have not been discounted.

An estimate of the economic impact by 2050 of a smart grid on the Midlands Engine has been calculated using the range of estimates in the table above. The following assumptions have been made:

- Smart grid technology, associated capital investment, is deployed at a steadily increasing rate between 2022 and 2050.
- There has been little investment in smart grid technology to date. All cost and benefit estimates are assumed to be additional to the 2022 baseline.
- Cumulative costs and benefits are discounted back to 2022 at 3.5%.

Smart grid calculated costs & benefits to 2050

If smart grid technology is deployed between 2022 and 2050 at a steadily increasing rate, the following cost and benefits will impact the region by 2050. Values in 2022 prices and discounted at 3.5% unless otherwise stated.

- Regional smart grid investment of between £3.2bn - £4.4bn. (non-discounted)
- Avoided capital cost of between £2.6bn - £3.6bn compared to investment in conventional grid technology in the region up to 2050. (non-discounted)
- Cumulative distribution system savings of between £1.2bn - £5.4bn.
- Regional gross GVA impact (direct, indirect, induced) of £1bn - £1.5bn.
- Export potential between £0.4bn - £0.6bn.
- Between 900 – 1,400 jobs sustained throughout the 2020s and 2030s.

Technical Appendix D: Assumptions for Vehicle-2-Grid

Estimates of annual systems savings range from £0.02bn - £0.14bn per year by 2030.

Avoided systems cost estimates range from £0.02by by 2030 to £0.12bn per year by 2030. It is not clear how long the avoided systems costs would persist beyond 2030.

Fleet aggregator benefits range from £700 to £1,250 per V2G EV. It is assumed this is on an annual basis.

Charging infrastructure cost estimates (for 2030) range from £650 to £1,150 per 7kW charger.

Conservative assumptions have been used to calculate the cumulative economic impact of V2G technology, as follows:

- 1 million V2G electric vehicles in operation nationally by 2030 with 15.6% of these in the Midlands Engine area.
- There are only **320 V2G units** in use nationally as of 2020.
- Installation growth is expected to compound between 2020 and 2030.
- No additional V2G vehicles are added beyond 2030, or at least if they are there are no marginal benefits to the grid.
- A 2:1 ratio of V2G vehicles to chargers is assumed in all years.
- Avoid systems cost are included up to 2030 but no estimate is made beyond this year.
- Cumulative costs and benefits are discounted back to 2022 at 3.5%.

SV2G calculated costs & benefits to 2050

If 156,000 V2G electric vehicles are licensed in the Midlands Engine region by 2030, the following cost and benefits will impact the region by 2050. Values in 2022 prices and discounted at 3.5% unless otherwise stated.

- V2G charging infrastructure investment £0.05-£0.09bn by 2030 (non-discounted).
- Distribution system savings of £0.24-£1.71bn by 2050.
- System cost avoidance of £0.02-£0.17bn by 2050.
- Fleet aggregator benefits of £1.33-£2.38bn by 2050.

Technical Appendix E: Assumptions for Micro-grid

Assumptions have been made as follows:

- The Midlands Engine has potential for at least 70 microgrids.
- A microgrid costs between £8M - £17.9M.
- Microgrids are delivered at a steady rate between 2022 and 2040.
- Carbon emissions savings are proportional to the rate of microgrid delivery.
- Carbon emissions valued using BEIS guidance.
- Cumulative costs and benefits are discounted back to 2022 at 3.5%.
- Low confidence in job impact calculation.

Smart grid economic impact estimate

The following table summarises the potential costs and benefits by 2050 based on the three approaches described below.

		Midlands Engine impact based on...	
	UK wide	Population (15.4%)	Land area (11.2%)
Capital cost	£28.3bn	£4.4bn	£3.2bn
Capital cost avoidance	£23.3bn	£3.6bn	£2.6bn
System savings	£0.4-£1.2bn/year (by 2030) £1.5-£4.8bn/year (by 2050)	£0.06bn-£0.18bn (by 2030) £0.23bn-£0.74bn (by 2050)	£0.04bn-£0.13bn (by 2030) £0.17bn-£0.54bn (by 2050)
GVA (gross)	£15.5bn	£2.4bn	£1.7bn
Export potential	£6bn	£0.9bn	£0.7bn
Job creation	8,000-9,000 jobs sustained throughout 2020s & 2030s	1,200-1,400 jobs	900-1,000 jobs

Note: these figures have not been discounted.

An estimate of the economic impact by 2050 of a smart grid on the Midlands Engine has been calculated using the range of estimates in the table above. The following assumptions have been made:

- Smart grid technology, associated capital investment, is deployed at a steadily increasing rate between 2022 and 2050.
- There has been little investment in smart grid technology to date. All cost and benefit estimates are assumed to be additional to the 2022 baseline.
- Cumulative costs and benefits are discounted back to 2022 at 3.5%.

MIDLANDS ENGINE

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