EXPLORING THE EVOLUTION OF LOW-CARBON LOCAL ENERGY.

Institution of MECHANICAL ENGINEERS

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The nature of local energy is changing fast. Instead of single technology projects that generate heat and/or electricity, we are now seeing more joined-up schemes that might involve energy storage, smart demand management, and more consumer engagement. The UK is well-placed to take advantage of the new opportunities this will present and the IMechE can assist by bringing people across the industry together for knowledge sharing events, like our Community Renewable Energy Workshop that was used to inform this report.

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Cover image: Project SCENe (Sustainable Community Energy Networks)

This report has been produced in the context of the Institution's strategic themes of Education, Energy, Environment, Healthcare, Manufacturing and Transport and its vision of 'Improving the world through engineering'.

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EXECUTIVE SUMMARY

The Climate Change Act was passed in 2008, and since then renewable energy has expanded rapidly in the UK. Government schemes in the form of mandates and subsidies have meant that wind and solar power have proliferated, as well as biomass for heat and power.

Small-scale local energy projects, often with some degree of community involvement, have taken off all around the country. The major expansion in the UK occurred between 2010 and 2015, but this has slowed with the recent withdrawal of one of the Government's main incentivising policy instruments, the Feed-in Tariff (FIT).

However, there is potential for a revival. Policy incentives were initially required to create a market for new technologies, but costs in some cases have declined to the extent that subsidy-free deployment is now within reach.

Most of the original local energy projects were made up of a single technology that simply provided power and/or heat. As more of these small-scale, distributed and variable technologies are deployed, complexity increases and managing the system becomes more challenging, especially in the case of distributed electricity generation. In order to expand, future local energy projects may increasingly need to offer a net system benefit.

The rapidly evolving nature of our energy system means there are opportunities for more joined-up schemes, which for electricity might include smart metering, time-of-use tariffs, energy storage and demand management. In the broader energy system, this could include the integration of heat and transport through alternative fuel production, storage and distribution.

As the distribution network operating companies are being encouraged to be more involved in actively managing electricity supply and demand, this should be complementary to the roll-out of such integrated local energy projects.

The UK has made good progress in decarbonising its power sector, but much more needs to be done in heating, transport and industry. Local energy projects can contribute to these sectors by, for example, providing technologies to enable the electrification of road transport, or by organising and promoting the deployment of innovative, low-carbon district heating schemes.

To enable the expansion of local energy schemes that help the UK to meet its decarbonisation targets, while also providing wider system benefits and encouraging innovation, this report from the Institution of Mechanical Engineers (IMechE) explores this exciting sector and makes the following recommendations:

- The implementation of the proposed Smart Export Guarantee (SEG)[1], in which small generators are paid for the value of the electricity they produce at a given time rather than a fixed price, should be a priority. The policy outcomes should be monitored to ensure developers are fairly rewarded and barriers to entry are not burdensome.
- The UK Government and devolved administrations should conduct reviews into the planning system, against the suspicion that low-carbon local energy projects are being held back by unnecessarily strict regulations.
- IMechE and other similar institutions should do more to create an evidence base for determining how successful previous local energy projects have been. Government should provide extra funding for local councils to allow them to participate in the evaluations.
- The disconnect between energy system modelling at different scales needs to end. BEIS should create a working group in collaboration with National Grid, distribution network operators (DNOs), academia and other relevant stakeholders, to develop and promote new approaches to modelling work that link international, national and local scales.
- The UK's universities should increasingly become test-beds for new energy technologies. Government should incentivise further trials to take place on campuses, which could be partnerships between the universities, students, academics, local energy companies/co-operatives and DNOs.

WHY WE PRODUCED THIS REPORT

In an article published in January 2019, the former Minister for Energy and Clean Growth, Claire Perry, declared that 'the future is local'[2]. She said that, 'Community energy is a key cornerstone of the government's ambition for transition to a low-carbon, smart energy system.' It is clear that the UK Government wishes to encourage more heat and electricity to be generated, stored and even traded locally. This will provide both challenges and opportunities for everyone involved in the transition, including individual citizens, utilities, the system operator, DNOs and local councils.

HOW WE PRODUCED THIS REPORT

In February 2019, the Institution of Mechanical Engineers convened a group of about 40 experts for a full-day Community Renewable Energy Workshop, to discuss the future of the sector and what can be learned from past experience. Participants consisted of representatives from central and local government, DNOs, project developers and energy policy professionals. Seven formal presentations were given and two breakout sessions were held, during which nine policy questions relating to community energy were put to attendees. The output from these presentations and breakout sessions has been used to inform the output of this report.

Case studies have been used to highlight how local energy is evolving. Projects selected for inclusion were primarily derived from those presented at the IMechE workshop and the UKERC Local Energy Systems Conference 2019. More details about the workshop and the exact questions that were posed can found on the IMechE website, as supplementary material to this report.

INTRODUCTION

DEFINING LOCAL/ COMMUNITY ENERGY

There are many different forms of local and community energy, and various definitions exist. In broad terms, local energy should involve generation, storage and/or demand management that is embedded within or near to a town, city or community where people live. Community energy will involve local people in the project in some way, from very simple engagement programmes, all the way to direct ownership and management. The definitions of community energy include[3]:

1. **Partnerships:** The exact nature that these partnerships can take will vary from country to country, depending on local laws and regulations. This can often take the form of a limited partnership in which a new corporate entity is created.
2. **Co-operatives:** The term co-operative is not legally defined in the UK, but it will usually take one of two broad forms. It can mean a 'community benefit society', which will be set up to benefit the community as a whole, or a 'co-operative society', which will be set up only for the intention of benefiting members.
3. **Community trusts and foundations:** In this model all proceeds from the project will be reinvested in the local area for the benefit of the whole community.
4. **Non-profit customer-owned enterprises:** This might be where a group of citizens come together for a specific project, for example a new district heating system for a housing estate.
5. **Housing associations:** Typically bodies in charge of running social accommodation for people on low incomes, their centralised control of whole apartment blocks or housing estates mean that they can be powerful vehicles for change. Tenants will have a say in any changes through membership of the association board.
6. **Individuals:** Householders may choose to generate and/or store heat or electricity onsite. New technologies may even allow people to buy and sell electricity from their neighbours. Trials of peer-to-peer electricity trading have begun in the UK earlier this year[4].

Local energy may also take the form of municipal ownership, for example:

1. Energy Service Companies (ESCos), which can be wholly owned by local councils
2. Co-operation between municipalities: public-public partnerships
3. Public-private partnerships

In addition to this, in order to receive buy-in from local communities, private sector ventures will sometimes be labelled 'community benefit' projects. This might mean that local people will receive a share of the profits or discounted energy, if they accept a new facility in their locality.

Another subset of local energy projects will be those that have the purpose of demonstrating immature technologies that are thought to be able to contribute to future low-carbon and secure energy systems. As these are typically first-of-a-kind projects, they will often be funded by a Government grant. The UK Energy Research Centre has collated and reviewed all such projects in its Energy Demonstrators database[5]. It estimated that there are 119 in total. The demonstrator projects comprise a broad range of technologies, including low-carbon transport demonstrators, smart energy management systems and energy storage.

In this report, we have kept the definition of local energy deliberately broad and do not advocate for any particular form of ownership or model. The case studies presented take different forms and all have their advantages and challenges. As Prof Jim Watson, Director of the UK Energy Research Centre, recently wrote, 'Local energy is not one thing; it means different things to different people, and will involve new technologies and new ways of working.'[6]

This report mostly focuses on technologies for the generation and storage of electricity and heat. A stronger emphasis is placed on electricity, which only represents 17% of the UK's final energy consumption[7]. However, due to the increasing electrification of transport and, potentially, the rollout of heat-pumps and smart storage heaters, this percentage is set to rise significantly.[8]

It is also important to note that, although not discussed in detail here, energy conservation and efficiency measures should be a priority, as IMechE explained in our 2009 report, *The Energy Hierarchy*.[9]

Figure 1: The IMechE Energy Hierarchy

SUSTAINABLE

Priority 1: Energy conservation. Changing wasteful behaviour to reduce demand

Priority 2: Energy efficiency. Using technology to reduce demand and eliminate waste.

Priority 3: Utilisation of renewable, sustainable resources.

Priority 4: Utilisation of non-sustainable resources using low-carbon technologies.

Priority 5: Utilisation of conventional resources as we do now.

UNSUSTAINABLE

THE STATE OF LOCAL/ COMMUNITY ENERGY IN THE UK

Local and community energy makes up only a small part of the UK's energy system, especially in the heat sector, but the exact number and scale of such projects is difficult to estimate. This is partly due to the ambiguous nature of what exactly is meant by 'community' or 'local', but also because there is no central register of all small-scale energy projects.

In an attempt to estimate the scale, in recent years Community Energy England has begun to produce yearly State of the Sector reports, with the latest covering the period to the end of 2018.[10] These also include details of projects in Wales and Northern Ireland. Their survey found 275 organisations actively involved in community energy projects overseeing a total electrical capacity of 168 megawatts (MW) in England, Wales and Northern Ireland, while a figure of 80MW was given for Scotland. A total of 14MW of community heat generation capacity across the UK was reported.

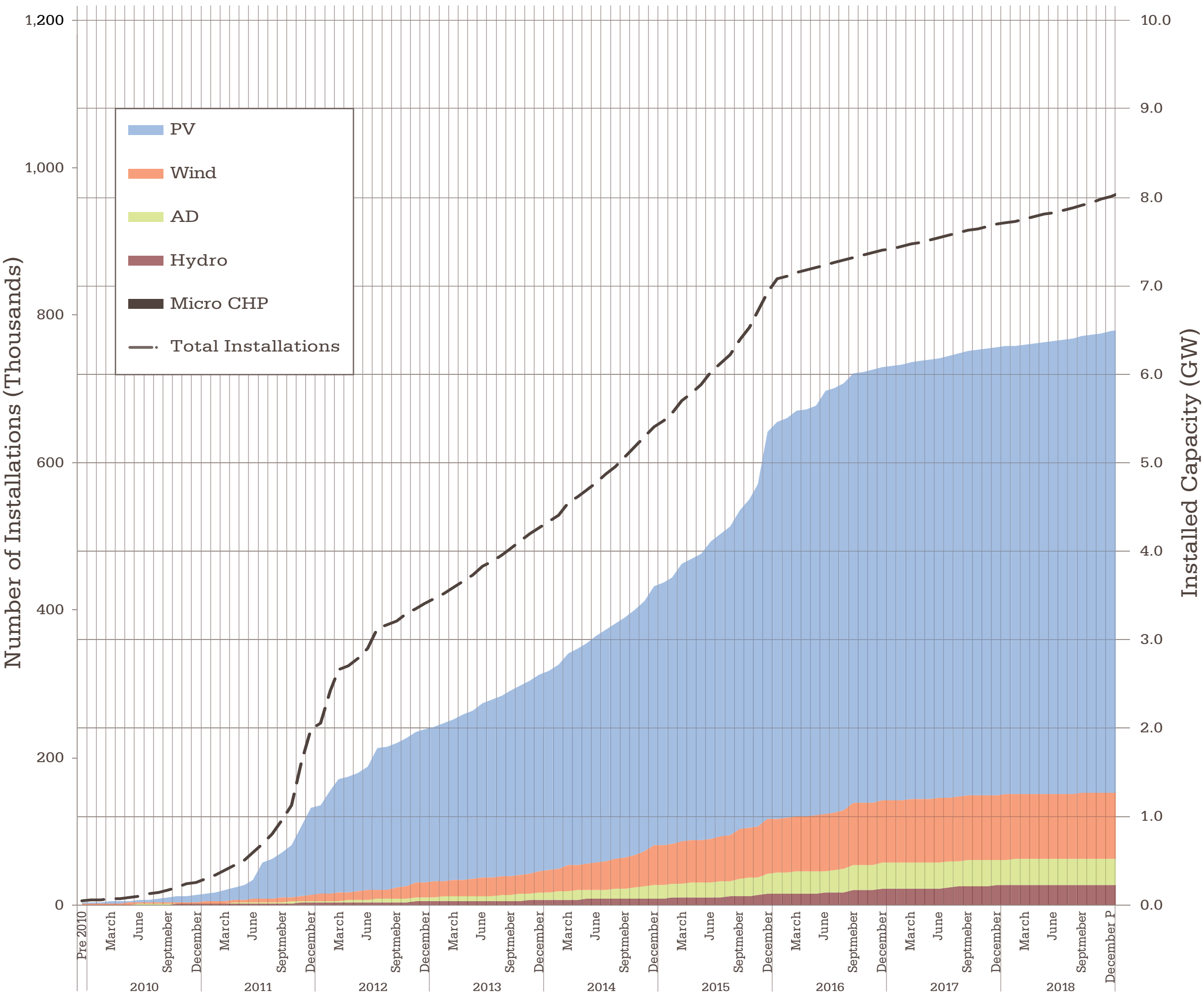
However, this is a self-identifying survey of community groups, so the number of locally owned energy projects in a broad sense is much larger. The Department for Business, Energy and Industrial Strategy (BEIS) estimates that over 5,000 community groups were involved in energy initiatives from 2010 to 2015.[11] While the Energy Savings Trust reported that as of 2018, there were over 18,830 individual local or community owned schemes in Scotland alone, with a capacity of 697MW.[12] Some schemes classified as 'community energy' by the Government will also include non-generation projects, such as collective building insulation programmes and even collective power/ heat purchasing agreements.

Growth of the sector has slowed since 2016, when amendments were made to the Feed-in Tariff (FIT), a Government policy that subsidised small-scale renewable electricity projects. From April 2019, the FIT scheme was closed to new entrants, but the BEIS has recently announced a replacement, the Smart Export Guarantee (SEG), which will be available from 2020[13,14]. Key features could include guaranteeing above zero price remuneration for small-scale producers exporting to the grid, and making all installations currently eligible for the FIT, eligible for the SEG. Electricity suppliers with more than 150,000 customers will then have a legal obligation to remunerate small-scale generators who export power to the grid.

The technology that has been the largest recipient of FIT payments has been solar photovoltaics (PV), as shown in **Figure 2**. One of the reasons cited for the cut in the FIT rate was that uptake of domestic solar PV systems was higher than anticipated in the original Government impact assessment, meaning the subsequent customer levy applied to consumer bills was also higher than expected.[15]

While most of these installations are small-scale domestic solar PV systems, there has been a number of large PV arrays installed with rated capacities in megawatts (MW), or even tens of megawatts more recently. One such project is the Westmill Solar Co-operative.

Figure 2: Installed capacity of different technologies in receipt of a Feed-in Tariff[16]



CASE STUDY: SINGLE TECHNOLOGY (SOLAR PV)

Westmill Solar Co-operative[17]

Created by Adam Twine on the site of his organic farm, Westmill was the UK's first large-scale community energy project, and the world's largest until 2015. Originally developed as a private enterprise by Blue Energy, it was purchased by Westmill Solar Co-operative in April 2012. Revenue is made through a combination of power sales and Feed-in Tariff revenue, and a community benefit fund returns a share of revenue and any surplus. Members have the option to waive the dividend and return it to the fund. The area is now also host to the Westmill Wind Farm Co-Operative.[18]

About Westmill Solar Park:

- Total capacity: 5MW
- Annual output (2018): 4,800 megawatt-hours (MWh)

Although crucial to scaling up the development of solar power, projects such as Westmill Solar Co-operative were wholly reliant on the FIT to be viable in the beginning. As we move to a post-FIT policy world, local energy project developers will need to develop new business models and adapt to a smarter energy system. This could mean exporting electricity to the grid under time-of-use tariffs, where electricity prices are determined by the value of the electricity at the time of sale, rather than given a fixed price. Or it could mean households or businesses using the electricity directly off-grid and storing it at times when supply exceeds demand. Another alternative model is selling electricity directly to industrial users, or for companies to self-generate onsite.

JUSTIFYING LOCAL ENERGY

One challenge for local energy is often the lack of economies of scale compared with some fully commercial ventures. Over many decades, the trend in the developed world was for electricity generation units to become larger with each generation of plant, whether powered by coal, gas, hydro or nuclear.

To some degree this has continued in the 21st century with renewable energy. One of the contributing factors to cost declines in wind power has been the construction of larger turbines and wind farms.[19] In the UK, the two projects that produced the lowest auction clearing price through the Government's Contracts for Difference scheme in 2017 (£57.50/MWh for Hornsea II and Moray East) have capacities of 0.95 and 1.4 gigawatts (GW). Hornsea II will consist of 165 wind turbines with individual outputs rated at over 10MW each. The trend is similar for solar PV with large utility-scale projects coming online, with some claiming to be subsidy-free. Notably the deal between Lightsource BP and AB InBev (Budweiser). The 15-year Power Purchase Agreement will see Budweiser buy electricity from 100MW of solar capacity that BP Lightsource plans to build on different sites across the country.[20]

In order to compensate for the smaller size of many local energy projects, to compete they will have to either scale up or provide different benefits. In our IMechE workshop on community energy, we asked our assembled experts what they considered to be the main benefits of local or community energy schemes, and the following answers were put forward:

- Generating and using electricity locally can reduce transmission and distribution system losses.
- Remote communities, especially those not connected to national gas and electricity grids, can often reduce costs by generating power and heat locally.
- Dividends from the projects can be reinvested in the local community.
- Having local people directly involved can increase trust in an energy provider.
- Citizens become more engaged with technology that provides their electricity and heats their homes.
- Schemes can be used to educate young people in engineering and technology.
- Such projects can create jobs and develop the technical skills of the local people.

The added benefits of local energy are often brought together and analysed in the form of a Social Impact Framework. Community Energy England has developed a tool to help community groups measure their social impact.[21]

Regarding the first and second bullet points above, this is one area where local energy projects can have an obvious benefit. Island or remote communities will often face higher energy costs, and therefore local energy can be more economically viable in such places. These communities have higher rates of fuel poverty than the national average[22], adding a social and political incentive to find new and better ways of providing energy. Such schemes have already taken off, for example, in remote islands of Scotland, and these areas can act as test-beds for new technologies and business models.

CASE STUDIES: REMOTE ISLAND ENERGY SYSTEMS

1. Orkney 'Surf and Turf'

The Orkney Islands until recently received electricity from the Scottish mainland through an undersea cable. However, being sparsely populated with large potential resources of wind and wave energy has made Orkney a test-bed for local energy schemes. Deployment of wind power in particular has meant that, on average, it produces more electricity than it requires. The question for Orkney became: what should it do with this excess electricity?

Upgrading grid connections to the Scottish mainland was one option, but it has decided to use the electricity locally instead. The Orkney Surf and Turf project uses a 500 kilowatt (kW) polymer electrolyte membrane electrolyser to produce hydrogen from wind and tidal power on the island of Eday, which is then compressed and transported to Kirkwall Pier on the Scottish mainland. The hydrogen is currently used by a fuel cell to power auxiliary systems on ferries that are parked at the pier overnight.[23] The project is also helping to develop skills in hydrogen handling at Orkney College, as its use in the region could be expanded in the future for other applications, including as a transport fuel. The Surf and Turf project is part of a wider project called ReFLEX, through which Orkney is attempting to create an entire 'smart energy island'.[24]

2. Mull Assisting Communities to Connect to Electric Sustainable Sources (ACCESS)

Electric storage heaters are common in the UK. Originally deployed to take advantage of low demand overnight, they would use inexpensive night-time electricity to store as heat energy, typically in a bank of clay bricks, which could then be slowly released the following day to warm the home. This fell out of fashion following the proliferation of natural gas for home heating, but there are still about 1.6 million installed today.[25] One area where storage heaters have persisted is on the Isle of Mull. Remote areas of the UK that are not connected to the gas grid suffer from higher levels of fuel poverty, and Mull is no exception.

The ACCESS project recruited 100 homes to take part in a trial that would use smart electricity storage heaters to reduce heating costs.[26] Storage heaters could be on the brink of a renewal as – with upgraded smart technology – they would be a valuable way to make use of excess electricity from intermittent renewable technologies.

3. Isle of Eigg[27]

The Isle of Eigg was a pioneer in developing an off-grid electricity system consisting primarily of renewable energy sources. A small and scattered community, the residents of Eigg used to be responsible for generating their own power using diesel generators. However, in 2008 their whole island electrification project was completed, and all residents and businesses were connected to the grid for the first time. Since then, renewable electricity has been expanded progressively and now consists of:

- A 50kW static photovoltaic array
- 110kW hydroelectric capacity, primarily consisting of a 100kW generator located on the River Burn
- Four 6kW wind turbines

A control building containing 96 4-volt batteries and 12 inverters balances supply and demand, and ensures smooth functioning of the island-wide high-voltage transmission system. 95% of Eigg's electricity is now supplied by water, wind and solar, with the remaining delivered by two 80kW diesel generators, which operate during periods of low solar and wind output, or at times of maintenance.

MOVING TO MORE INTEGRATED, WHOLE SYSTEM, MULTI-TECHNOLOGY LOCAL ENERGY PROJECTS

For remote and island communities that already suffer from a lack of energy infrastructure and high costs, there is already an incentive to find cheaper, smarter ways of providing energy for inhabitants. For homes, businesses and communities in more populous areas, which are connected to the national gas and electricity grids and receive convenient, cheap and increasingly clean energy, the incentives are not as strong. There is also the issue of the increased complexity of managing an electricity system that has transformed from comprising a small number of large power stations, to now also incorporating thousands of small and distributed sources. The codes and standards that govern the power system will need to be updated and refined, if this move away from conventional thermal power stations continues. The Institution of Engineering and Technology has even gone as far as suggesting that a new 'System Architect' is required to oversee the decarbonisation of Britain's electricity.[28]

However, there is a growing realisation that opportunities are increasing for fully integrated whole system local energy schemes, even in populous town and cities. Through incorporating smart metering, micro-grids, storage and demand response, such projects can become an asset in terms of grid management. As our local electricity networks attempt to move away from distribution network operators (DNOs) to distribution system operators (DSOs),[29] projects like this will be increasingly valuable in managing electricity supply and demand at local levels.

There are 14 DNO regions in Britain that are operated by six different companies (Northern Ireland is separate). The responsibility of the DNO in the past has been simply to ensure a reliable distribution of electricity from the national high-voltage transmission system to its final use in homes and businesses. The DSO transition is the process by which DNOs are evolving to incorporate more distributed generation, demand management, local storage and consumer engagement.

CASE STUDIES: WHOLE SYSTEM, MULTI-TECHNOLOGY

1. Sustainable Community Energy Networks (SCENe)[30]

SCENe is an innovative energy project based at the new housing development, Trent Basin, in Nottingham.The project developers are aiming to demonstrate new community scale energy systems that they hope will be deployed subsidy-free in the future. Integrated within this new community are:

- Solar PV in every viable position (panels are moved from the ground to new roofs as each additional building is erected)
- A 2.1 MWh community energy battery
- A community hub
- A cloud-based demand management system

Included within the project consortia are researchers at the University of Nottingham, who have access to data relating to energy use, cost and carbon intensity. Indoor humidity and temperature are also logged, and the site has a weather station to measure solar irradiance. Household information is anonymised to protect people's privacy, and then researchers will be able to search for trends over time in order to optimise for cost, energy and carbon emissions. As well as being able to find out more about the project in the community energy hub, residents have in-house displays, giving them real-time information about the energy usage of their home.

2. Project LEO[31]

Whereas SCENe is attempting to create an integrated energy system across one housing estate, Oxfordshire is looking into how it can do more across the whole of the county. Project LEO is a £40 million county-wide trial to study, 'How the growth in local renewables, electric vehicles, battery storage and demand-side response can be supported by a local, flexible and responsive electricity grid and help reduce costs for consumers.'[32] It is one of four projects funded through the Government's Prospering from the Energy Revolution Challenge.[33]

The consortium involved in Project LEO comprises the city's two universities, both the city and county councils, three technology companies, EDF, while being overseen by the region's distribution network operator (SSEN).

Most innovatively, the project will seek to demonstrate the technical feasibility of using aggregated electric vehicle batteries to provide flexibility and balancing services to the local network.

3. Media City UK

Salford Quays was chosen as the location when the BBC decided to move jobs from London to Manchester in 2004. Media City UK is now also home to Salford University, ITV, and more than 200 small and medium enterprises (SMEs). At the heart of the regeneration was a 'tri-generation' scheme that serves the site with combined cooling, heat and power (CCHP). Although there is no direct community involvement, this is a good example of an innovative and efficient system that could be rolled out in new-build developments across the country.

Sites that have high levels of low-grade waste heat, can use this energy to provide cooling through the use of adsorption chillers. Such systems not only increase the energy efficiency of a given site, but through using waste heat to power air-conditioning units, they can reduce the burden on local electricity networks.[34]

The system is made up of a 2MW gas-fired combined heat and power unit, which provides electricity for the site's medium-voltage network and gives 2MW heat energy. This is supported by two 9MW thermal boilers for extra resilience. A 1.5MW absorption chiller uses waste heat as an energy source to provide cooling onsite. Although highly efficient, the system is powered by natural gas, so there are associated carbon emissions. However, if this primarily fossil-derived methane were to be replaced with methane derived from a sustainable biological source (food waste, for example), or low-carbon hydrogen, the whole system would effectively become carbon-neutral.

LESSONS FOR POLICY TODAY

At the IMechE Community Renewable Energy Workshop, a common complaint from participants was a regulatory environment that changes so fast, that businesses and community groups cannot keep up. Indeed, across all industries, policy uncertainty is cited as an impediment to business investment and employment growth.[35] It is especially difficult for smaller enterprises to keep pace, as it is unlikely that they will employ dedicated policy professionals. Developing relevant technical expertise and maintaining trained staff will also be more difficult.

For local energy, the obvious example of this was the closure of the Feed-in Tariff, with evidence suggesting that this was severely damaging to small-scale energy suppliers.[36] The complete removal of the Feed-In Tariff without at least an interim replacement has set back the industry.

- **Policy recommendation:** The implementation of the proposed Smart Export Guarantee (SEG),[37] in which small generators are paid for the value of the electricity they produce at a given time rather than a fixed price, should be a priority. The policy outcomes should be monitored to ensure developers are fairly rewarded and barriers to entry are not burdensome.

By obligating large suppliers to offer smart tariffs to small generators, the SEG will mean that they are offered a fair price for the electricity they generate, while also encouraging innovation in terms of the roll-out of smart appliances, electricity storage and demand response.

There is evidence that local energy projects are finding it difficult to meet regulatory requirements, due to the high costs imposed and policy barriers. New renewable energy projects have experienced high planning permission rejection rates in recent years, and the reasons need to be investigated and better understood.[38] A specific and stark example was the experience of the Ambergate hydroelectricity project, which highlighted how regulatory barriers can hold back local energy.[39]

- **Policy recommendation:** The UK Government and devolved administrations should conduct reviews into the planning system, against the suspicion that low-carbon local energy projects are being held back by unnecessarily strict regulations.

There should also be consideration of the differences between regions, and whether a localised approach to energy strategy might be the best way forward. Analysis of pilot programmes by the Energy Systems Catapult has suggested that the cost of decarbonisation can be reduced by taking a whole systems approach, but tailoring each strategy to the specifics of the area in question.[40]

A consideration of local issues is also important in energy modelling. This report has detailed how local energy is transitioning from subsidised, single-technology heat and/or power projects, to those that are more joined up and serve the needs of an evolving energy system. The numerous trials and demonstration projects, led by the likes of the Energy Systems Catapult, are good first steps towards managing this transition. However, a blind spot that was highlighted at the UKERC Local Energy Systems conference, was the lack of energy modelling tools that connect local to national. Researchers studied a large selection of energy models and categorised them into global, national, regional, local (town or city level). Very few models were found to adequately connect local to national. This means that policy at local and national levels may not be complementary, or may even come into conflict. According to previously published research in this field, 'The optimal choice of technology is found to differ according to the spatial characteristics of the location.'[41] This is an area of research for UKERC[42] and other organisations, such as Newcastle University's National Centre for Energy Systems Integration.[43] Policymakers in Government need to be aware of the issue and work with the relevant bodies to address it.

- **Policy recommendation:** BEIS should create a working group in collaboration with National Grid, distribution network operators (DNOs), academia and other relevant stakeholders, to develop and promote new approaches to modelling work that link international, national and local scales.

Another issue highlighted at the IMechE workshop, was a lack of evidence and data that could be used to assess the successes and failures of previous projects, particularly those implemented by local authorities. This was put down to the absence of any requirement to evaluate finished projects and make an assessment of whether they fulfilled their specified aims, in terms of emissions savings and other relevant metrics.

- **Policy recommendation:** IMechE and other similar institutions should do more to create an evidence base for determining how successful previous local energy projects have been. Government should provide extra funding for local councils, to allow them to participate in the evaluations.

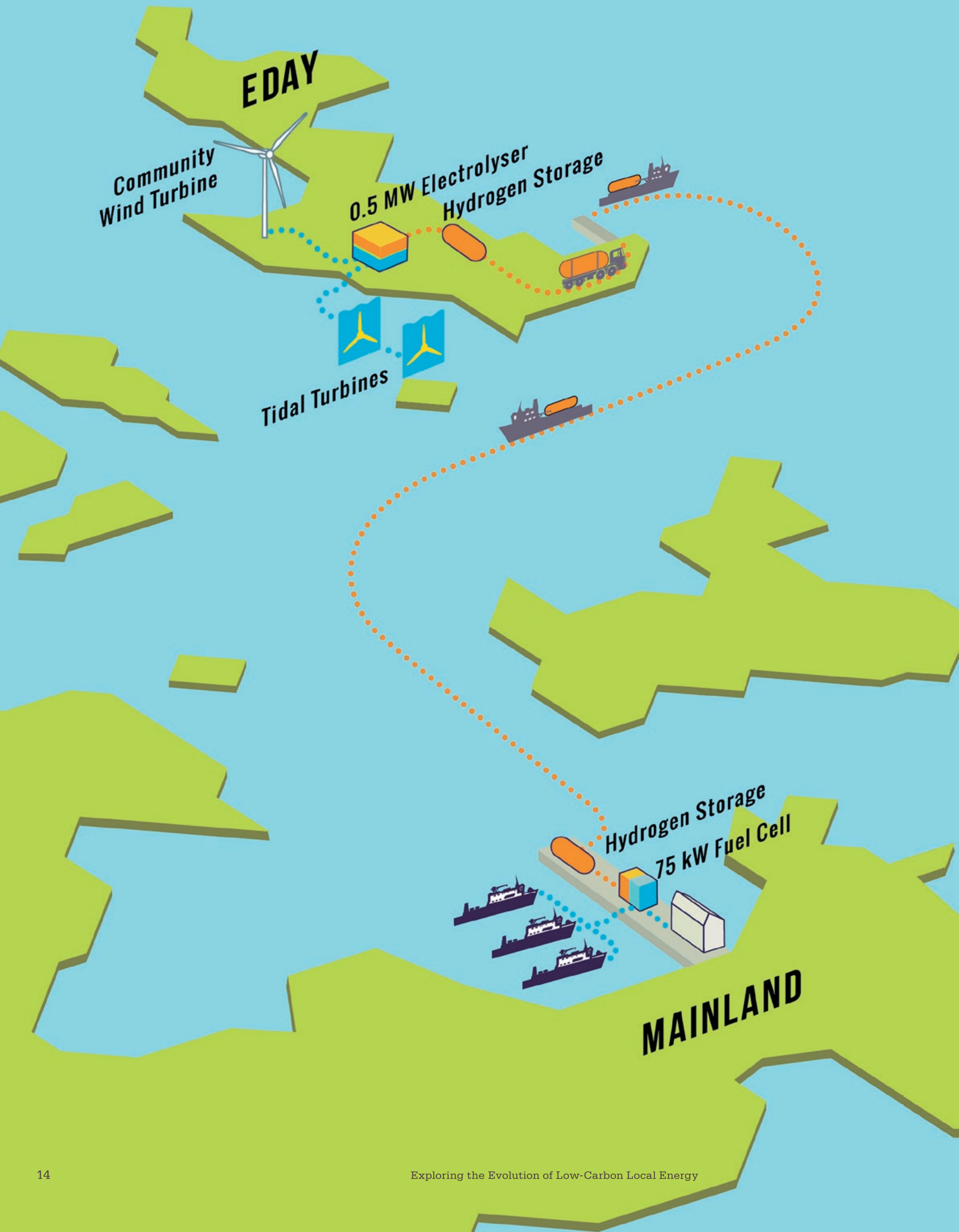
Peer mentoring and e-learning should also be encouraged to share experience.

Demonstration projects are necessary for determining which technologies will work technically, which are economically viable, and crucially which will be acceptable to the public. There is one sector that is highly suitable to act as a test-bed for local energy demonstrators and should be expanded: our universities. It has been estimated that the UK's universities were responsible for 1.83 $MtCO_2e$ (~0.4% of UK total) of greenhouse gas emissions in 2015[44] and it has been more recently reported that most universities are failing to meet their own targets for emissions reduction.[45,46] With high levels of technical expertise, ownership of large buildings and areas of land, and environmentally conscious student bodies,[47] universities should be ideal organisations for hosting new energy demonstration projects.

- **Policy recommendation:** Government should incentivise further trials to take place on campuses, which could be partnerships between the universities, students, academics, local energy companies/co-operatives and DNOs.

By doing this, the Government will help to promote energy innovation on campuses, while also assisting universities in meeting their own ambitious decarbonisation targets from existing building stock. As the university sector expands, this also presents opportunities for innovation in new-build facilities.

The Orkney Surf and Turf Project generates hydrogen from wind and tidal turbines. The hyrdogen is then used in a fuel cell to make electricity and heat.



POTENTIAL FUTURE DEVELOPMENTS IN LOCAL ENERGY

So what will the future of local energy look like? We can speculate as to possible outcomes from some of the technologies and business models being tested in the UK and around the world. Some examples of the types of innovation we can expect to see include:

- New business models and financing schemes: CitizEnergy, for example, is an initiative funded through the EU that aims to kick-start 'crowdfunding platforms and cooperatives with a focus on getting the public involved in sustainable energy projects'.[48] This expands on the idea of community energy to allow anybody in the world to support clean energy projects. As smaller-scale projects often have difficulty in raising finance, it is one alternative model that could help to remedy this.
- Peer-to-peer energy trading: Another example of a potential new business model could be consumers directly buying and selling energy from one another. Tests have already begun and one example is EDF's 'peer-to-peer' trial in a block of flats in Brixton.[49] Residents can choose to sign up to a special tariff that will give them a discount if they use (or do not use) electricity when there is local generation available (such as rooftop solar PV). They also have the option to sell their allocation to fellow residents. Although at this stage it is virtual trading, in that electricity does not physically flow from one property to another, with the right technologies, regulation and market in place, physical trading could happen in the future. This model of local electricity trading has the potential to increase efficiency and reduce costs to consumers and businesses who generate and store electricity onsite.
- District heating: Going beyond electricity, district heating is one area in which communities have been involved in the past, and could be very important in the future to decarbonise domestic heating, a challenge the Chief Executive of the Committee on Climate Change recently referred as the 'biggest single challenge' in decarbonisation.[50] Sources of energy for such heat networks vary and innovative new methods are being developed all the time, including using mine water, as is the case in a new trial in South Wales.[51] Industrial waste heat is also a huge untapped resource that could be capitalised on more, while even the heat from future nuclear reactors could be put to productive use in housing or businesses. This may seem far-fetched, but it has already happened. In the 1960s and 70s, the Ågesta nuclear power plant provided heating for a suburb of Stockholm. So popular was this cheap and smokeless heat network, that there were said to be protests when it was ended in 1974.[52] The use of nuclear reactors for district heating (in addition to power) in the UK had been advocated by the Energy Technologies Institute as a way of improving the economics of small modular reactors.[53] Internationally, China has designed a pool-type light water reactor, that would purely be used for producing hot water for homes.[54]

As our energy system evolves, there will be increasing opportunities for innovation, and the UK should ensure that it is at the forefront of new technological developments. By expanding the roll-out of local energy demonstration projects,[55] we can quickly find out what technologies offer the best potential for decarbonising our wider energy system, and those that help to manage this transition to a low-carbon economy.

CONTRIBUTORS

IMechE would like to thank the following members for helping to organise the workshop and contributing to the report:

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- Emma Bridge, Community Energy England
- Patrick Allcorn, BEIS
- Ian Jackson, Ambergate Hydro
- Prof Mark Gillott, University of Nottingham and Project SCENe
- Philip Wolfe, Westmill Solar Co-operative
- Stirling Habbitts, Triodos
- Tim Wynn-Jones, Good Energy

Presentation slides from the day are available on the IMechE website alongside this report.

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