A GREEN ENERGY FUTURE FOR THE EAST OF ENGLAND

A TECHNICAL REPORT

THE GREENS/EFA
in the European Parliament

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A Green Energy Future for the East of England
A Technical Report

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FOREWORD

With the rise of climate activism, an increasing number of people are asking – urgently – for an answer on how we can transform our society to one that is truly sustainable. An economy based on ever-increasing consumption and exploitation of finite resources must be recalibrated and replaced with a new, sustainable macro socio-economic model. Regions like the East of England have to play their part in this transformation.

This report presents the technical side of how to build an energy system that is adequate to the challenge of reaching net zero carbon by 2030. It outlines how a distributed energy system, based on generation from renewable sources, can empower communities to take a lead and provide the basis for decarbonisation of energy – far faster than nuclear or centralised production. This report provides specific technical recommendations as to how the East of England can end carbon lock-in as well ensure that energy savings and financial benefits are fairly shared. However, currently there remains too much incoherence or paralysis when it comes to the politics and regulation in this sector.

The accompanying *Energising the East* report outlines the political solutions to these problems. The climate emergency is clear, but so too is the solution. The changes needed to avert it are deliverable. We can and must have *A Green Energy Future for the East of England*.

Catherine Rowett
Green Party MEP
for the East of England

MAP 1 – Land in the Eastern region at risk due to flooding in 2050 (Developed from Climate Central, 2019)

INTRODUCTION

2019 will go down as a watershed year when the threat of climate catastrophe started to become accepted as a mainstream concern, and 2020 will reveal whether leaders are prepared to respond with sufficient measures, some of which are outlined in this document, to avoid the worst impacts.

In June 2019, the UK became the first major economy in the world to mandate reducing carbon emissions to zero by 2050. However, this is far too late; emissions must peak and start stabilising in 2020, with "net zero" achieved by 2030, or before.

Achieving even the government's inadequate 2050 target is in doubt, with policies to deliver emission reductions lacking.[1] The Committee on Climate Change (CCC) has warned that the UK is currently not on course to meet its existing legally binding targets for the period from 2023 to 2027.[2]

Climate change is a global issue that cuts across all sectors of the economy and society, but at the heart of it all is energy consumption – and therefore energy systems are the focal point of this report.[3]

The growing world economy is currently driving energy consumption higher at a rate of 2.3% per annum and carbon emissions are rising beyond policy targets, predicted to cause global heating of around 3°C by the end of this century.[4]

Despite this, investment in and subsidies for fossil fuels continue – with the UK government subsidising fossil fuels more than any other country in Europe.[5] This is hampering efforts by renewable energy systems to reduce overall emissions, even though they are the fastest growing and cleanest energy source.

Here in the East of England (Eastern region), we had the highest mean domestic electricity usage in the UK in 2017 and it is clear that there is potential to do things better and differently in the region to reduce this and its related climate impact.

This report considers the potential for new systems of renewable electricity, particularly distributed and digitalised energy, to drive decarbonisation by displacing fossil fuel use. Reducing demand for fossil fuels while increasing renewable energy resources is required as rapidly as possible, to enable novel electricity systems to deliver the necessary change by 2030. This report has been used to inform the energy transformation plan outlined in the *Energising the East* report.[6]

NET ZERO CARBON

Net zero refers to balancing the amount of emitted greenhouse gases (GHGs) with the equivalent emissions that are either offset or sequestered. This should primarily be achieved through a rapid reduction in carbon emissions.

THE GROWTH IN RENEWABLES

Despite continued support for the fossil fuel industry, the cost of renewable energy has declined to the point where – without subsidisation – some renewables are now the lowest cost energy available on the planet (chapter 1), significantly below that of nuclear power.

Indeed, as early as 2020 (chapter 3), we may see renewables in the UK begin to dominate electricity generation, producing more energy than fossil fuel generators. The potential for a rapid, affordable rollout of renewable electricity in the UK using solar photovoltaics (PV) and offshore wind means much of this report is focused on electricity and heat. However, instead of advocating that our current level of energy production for domestic consumption, transport, space heating and industry are switched to 100% renewables, this report highlights why we need to transform the way we live – across all parts of our society.

TOWARDS A DISTRIBUTED ENERGY SYSTEM

Part of this transformation will require a new way of thinking about our electricity system. This requires a rapid and proactive power down of fossil fuel, nuclear, and large scale, centralised electricity generation. Localised distributed generation, demand and storage assets are ready to displace these 20th-century energy systems and promise a shift to production that balances the demands of local energy users and producers, who may often be the same people or organisations (chapter 2).

However, the UK is currently ranked second to last in a basket of European countries when considering readiness for 'the energy transition'[7] (chapter 3), despite estimates suggesting that between £17 and £40 billion could be saved through introducing these 'flexible' technologies by 2050[8] (chapter 4).

Flexible technology in a distributed architecture also opens up the possibility of new, exciting forms of peer-to-peer (P2P) circular energy trading (chapter 2), where people can trade their own energy production and demand reduction. This will underpin an energy system where large scale, pollution-generating capacity is being rapidly powered down.

TIME FOR ACTION

We cannot continue to pollute the atmosphere by burning fossil fuels to support outmoded models of economic growth if we are to avoid catastrophic global heating.

As melting polar ice caps and glaciers pour water into our oceans, we are already seeing coastal erosion and huge areas are at high risk of flooding across large parts of the region Current plans to reduce GHGs will still result in dramatic impacts on the region[9] (Map 1). The 2050 net zero target date is simply an inadequate response. We need radical change to enable a 2030 target and a transition to a sustainable future instead, and we need it quickly.

Rapid change is needed and the Eastern region is well placed to be the catalyst in this process, as our regional electricity distributor (UK Power Networks) is taking a leading role in exploring the potential gains available from a distributed approach (chapter 2).

However, the large task of integrating the energy system into an economy which is not predicated on growth and the continuous expansion of energy and resource use, has yet to start.

ENDING REGULATORY PARALYSIS

Key players in the UK energy industry have not yet grasped the pace or nature of the change needed to get there. There is too much emphasis on technological fixes and not enough questioning of the very concept of economic growth and personal attitudes towards consumption.

The many policy and regulatory blockages discussed in chapter 3 inhibit key aspects of decentralisation and contribute to delayed emission reductions even within targets that are too low to avoid climate catastrophe. There appears to be no consistent recognition within government that reduction of wasted energy (which could be addressed through demand reduction and energy efficiency measures) is as important as reducing carbon emissions from energy production if we are to deliver a rapid clean energy transition.

We have the answers, but they must be implemented and scaled up as a package:

- Public awareness and acceptance of radical solutions.
- Energy reduction in high consumption areas such as home heating.
- Circular economy thinking to drive waste out of our systems.
- Economically viable renewable energy and storage.
- Flexible technologies to encourage local production, energy trading between people and demand reduction.

These solutions may exist, but they need government support. If we have this, there is nothing to stop us realising the goal.

1 House of Commons' Science and Technology Committee, *Government's target for 'net-zero' by 2050 undeliverable unless clean growth policies introduced,* 22nd August 2019 www.parliament.uk/business/committees/committees-a-z/commons-select/science-and-technology-committee/news-parliament-2017/clean-growth-report-published-17-19/

2 CCC, *How the UK is progressing,* https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/how-the-uk-is-progressing/

3 Analysis in this report is aligned with the regional carbon budget developed for the Eastern region in the *SCATTER* project - Anthesis Group, Nottingham City Council, UK Government Department for Business, Energy and Industrial Strategy (BEIS), Greater Manchester Combined Authority and the Tyndall Centre for Climate Research (Manchester) and a decarbonisation trajectory in line with the International Panel on Climate Change's (IPCC) Special Report on Global Warming of 1.5°C (SR15) following the Paris Climate Agreement. The SCATTER budget recommends the Eastern region remains within a 200.5 megatonnes (Mt) of carbon dioxide (CO_2) carbon budget as its portion of the UK's nationally determined contribution (NDC), which means we must reduce our energy carbon emissions by 13.5% year-on-year from 2020 (https://carbonbudget.manchester.ac.uk/reports/EE/). Aviation and shipping emissions are calculated nationally and so are not included in our analysis, but place an additional burden upon us all to reduce demand from these sectors. Land use, land use change and forestry (LULUCF) will also impact upon the carbon budget and should be developed to sequester carbon.

4 United Nations Environment Programme (UNEP), Emissions Gap Report 2019, 26th November 2019, https://www.unenvironment.org/resources/emissions-gap-report-2019

5 European Commission, *Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Energy Prices and Costs in Europe,* Brussels, 9.1.2019 COM (2019) 1 final, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=COM:2019:1:FIN&from=EN

6 Barrass, K., Boswell, A. and Essex, J. (2020) *Energising the East: An energy transformation plan for the climate emergency,* Produced for Catherine Rowett, Green MEP for the East of England

7 The Association for Renewable Energy and Clean Technology (REA) (2019), *Energy Transition Readiness Index* www.r-e-a.net/resources/energy-transition-readiness-index/

8 Carbon Trust, Imperial College (2016), *An analysis of electricity system flexibility for Great Britain* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/568982/An_analysis_of_electricity_flexibility_for_Great_Britain.pdf

9 Climate Central (2019), Coastal Risk Screening Tool: Land Projected to be Below Annual Flood Level in 2050 https://coastal.climatecentral.org/map/11/1.7131/52.2/?theme=sea_level_rise&map_type=coastal_dem_comparison&amp=&elevation_model=coastal_dem&forecast_year=2050&pathway=rcp45&percentile=p50&return_level=return_level_1&slr_model=kopp_2014

ENERGY AND DECARBONISATION

What does decarbonisation actually mean for the Eastern region and what are the energy options available to reach net zero carbon as quickly as possible? Energy decarbonisation broadly refers to power in the form of electricity, including the fuel required to power transport across the region.

Heat demand is usually the biggest energy requirement in our homes and offices, and we convert natural gas, coal and oil to heat for this. Instead of using fossil fuels (mainly natural gas and oil) for space heating we should use electricity directly to make heat, or collect and concentrate heat from the environment and move it to where we want it by using heat pumps. Concentrated centres of demand such as town centres, businesses and industries also need large amounts of heat to support their processes. In some cases they already use heat generated by combined heat and power (CHP) plants but these systems are almost always based on burning gas.

The Green Party advocates the proactive reduction of energy use alongside the replacement of all fossil fuels with renewable energy by 2030.[1] The imperative to deal with energy reduction across other sectors must be acknowledged. The House of Commons' Science and Technology Committee observed "…emissions reductions cannot continue only in sectors that have decarbonised successfully so far, and must be significantly accelerated in sectors such as transport, heating and agriculture that have made little progress."[2]

However, the government does not appear to have grasped the importance of these measures fully – indeed, public investment in energy efficiency has been cut by 58% since 2012.[3]

DECARBONISATION IN EASTERN REGION

In 2017, the Eastern region registered a combined total of 32.7MtCO_2 emissions from energy, land use and surface transport combined. This translates to over 5 tonnes CO_2 (tCO_2) per person for the estimated 6.2 million people living in the region in 2017.[4] To put this into context, people in London had the lowest direct carbon footprint of 3.4tCO_2 per capita and people in Wales, the highest at 7.9tCO_2 per capita.[5] It is important to note that all of these figures exclude emissions from aviation, shipping and consumption, as data for these sectors is not gathered at a regional level. So while they are illustrative of regional variations, they only reflect a proportion of overall per capita emissions.

Even though people in the region have a per capita carbon footprint that is about average for the UK, this is still not low enough to meet our regional carbon reduction commitment (RCRC) and reflects an overshoot of the fourth national carbon budget, set for 2023-2027. The carbon budgets are set by the CCC to outline what reductions are necessary to deliver the commitments made in the UK Climate Change Act 2008 (CCA). If we plan to reduce GHG emissions to net zero by 2030, we must accelerate emission reductions in the Eastern region by at least 13.5%, year-on-year, from the total in 2020. In addition, we will need to change our behaviour with respect to diet, aviation and shipping, as well as land use changes that increase the sequestration of carbon (Figure 1).

We must therefore reduce energy demand, use energy more efficiently and increase our efforts to remove the carbon from each unit (kilowatt hour, kWh) of electricity we use. Although renewable electricity generation grew by 14% and generation capacity grew by 9.7% in England from 2017-18,[6] this is far too slow to address the scale of the challenge.

Yet the economic argument in favour of renewables is now unassailable. In 2016, Ofgem reported that the target price for offshore wind by 2020 was £100 per megawatt hour (MWh).[7] And the UK government's most recent offshore wind contracts (agreed in September 2019) were priced at just £39.65/MWh – a drop of 60% in just three years.[8]

In the UK, the advance of solar PV energy has been severely hampered by the withdrawal of the Feed-in Tariff (FIT). However, globally the cost of PV energy fell by 77% between 2010 and 2018, making the technology increasingly affordable and significantly, on a par with the lower end of fossil fuel (mainly coal and gas) energy.[9] Earlier this summer, Brazil's renewables auction saw 211 megawatts (MW) of solar PV capacity signed at just £13.3/MWh[10] – not just the cheapest price for solar ever assigned, but the cheapest unsubsidised contract for electricity of any sort.[11]

INTEGRATING RENEWABLE ENERGY INTO ENERGY SYSTEMS

There are still hurdles to overcome before we can achieve a 100% renewable energy system. This requires re-engineering the distribution network to be more suitable for smaller-scale, localised or embedded, sources of renewable generation (chapter 2). We need smarter systems that draw on renewable resources when they are available, store energy and control demand by encouraging people and businesses to use energy very differently and more efficiently.

CONCLUSIONS

- The astonishing and continuing decline in the prices of renewable electricity and large scale storage make renewables by far the most logical option for electricity generation. This is already driving the UK energy system, including in Eastern region, to become digitalised, distributed, decarbonised and democratised;
- These developments also undermine the economic case for nuclear power. But we risk being burdened with the cost and dangers of white-elephant nuclear projects in the region at Sizewell C and Bradwell, which do not reflect our future energy needs.

However, switching to a 100% renewable energy generation system is not enough. We need a new economic framework to accommodate the changes required for decarbonisation – reducing energy demand and consumption practices.

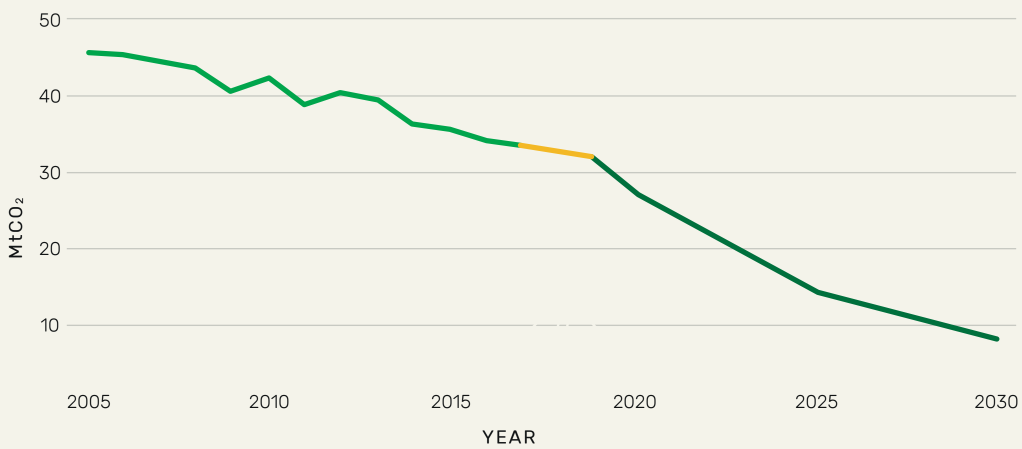

FIGURE 1 – Historic and future emissions in the Eastern region ($MtCO_2$)
(Data derived from BEIS (2019) and SCATTER project (2020))

EXPLORING THE ENERGY SYSTEM OF THE EASTERN REGION

1

The region's electricity distribution network owner is UK Power Networks and its gas distribution network counterpart is Cadent. National Grid owns and operates the onshore electricity and gas transmission infrastructure in the region. We also have electricity and gas interconnectors joining our energy system from the Eastern region to the European continental systems and the national gas and electricity transmission systems. These privately owned energy links, while helping to balance UK energy demand, are most often employed to import rather than export surplus energy.

The continued use of natural gas for power generation, space heating and cooking is an obstacle to net zero.[12] Hydrogen and biomethane are now being considered for injection into gas infrastructure, which could extend its usage by supporting the flexible transition to electrification, but this will not help decarbonise the Eastern region quickly enough.

Processing hydrogen is itself energy intensive and should only be considered where there is a surplus of clean electricity or heat available. Further consideration should be given to hydrogen production using electrolysis from surplus wind generation, for example, and used for freight transport and other fossil fuel substitution.

Biomethane production is problematic, in so far as growing crops for biogas requires the use of arable land that may be better assigned to food production or forestry as a means of providing a carbon sink.[13] Full lifecycle carbon analysis shows that it doesn't save as much carbon as initially claimed. As a carbon-based fuel, it will release GHG into the atmosphere.

For those not connected to the gas grid, there will need to be a move away from heating oil. Instead, heat and power options will be determined by connection to the electricity grid (which is more likely), where there are options to displace fossil fuel heat with direct use of electricity or heat pumps.

1 Green Party of England and Wales (2019) *Green Party Manifesto 2019* www.greenparty.org.uk/assets/files/Elections/Green%20Party%20Manifesto%202019.pdf
2 House of Commons' Science and Technology Committee (2019), *Clean Growth Technologies for meeting the UK's emission reduction targets: Government and Ofgem Responses to the Committee's Twentieth Report of Session 2017-19* https://publications.parliament.uk/pa/cm201919/cmselect/cmsctech/287/287.pdf
3 E3G (2018) *Home insulation crash in England*, www.e3g.org/news/media-room/home-insulation-crash-in-england
4 BEIS (2019a), *UK local authority and regional carbon dioxide emissions national statistics: 2005-2017* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/812142/2005-17_UK_local_and_regional_CO2_emissions_tables.xlsx
5 BEIS (2019b) *2017 Local Authority Carbon Dioxide Emissions* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/812134/2017_LA_CO2_emissions_stats_one_page_summary.pdf
6 BEIS (2019c), *Energy Trends September 2019*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835116/Energy_Trends_September_2019.pdf
7 Ofgem (2016) *Ofgem's Future Insights Series: Overview Paper* www.ofgem.gov.uk/system/files/docs/2016/10/future_insights_overview_paper.pdf
8 Stoker, L. (2019), *Offshore wind smashes price records in third CfD auction round*, Current News – 20 September 2019 www.current-news.co.uk/news/offshore-wind-smashes-price-records-in-third-cfd-auction-round
9 International Renewable Energy Agency (IRENA) (2019), *Transforming the energy system – and holding the line on rising global temperatures* www.irena.org/publications/2019/Sep/Transforming-the-energy-system
10 US$17.5/MWh converted at 1USD=0.7599GBP
11 Willuhn, M. (2019), *BRAZIL A-4 auction signs 211MW of solar for record-low price of $0.0175 kWh*, PV magazine – 1 July 2019 www.pv-magazine.com/2019/07/01/brazil-a-4-auction-signs-211-mw-of-solar-for-record-low-price-of-0-0175-kwh/
12 UK Energy Research Council (2016), *The future role of natural gas in the UK* www.ukerc.ac.uk/publications/the-future-role-of-natural-gas-in-the-uk.html
13 Monbiot, G. (2014), *The biogas disaster* www.monbiot.com/2014/03/14/the-biogas-disaster/

ENERGY IN A CIRCULAR ECONOMY

Energy underpins most aspects of the economy and, to have any realistic chance of decarbonisation, we have to devise a new, 'circular' model of energy conservation, use and reuse.

The climate emergency necessitates that we radically reduce the energy demand underpinning the old carbon-based economy and create a new circular economy driven by renewable energy. This chapter explores how, under the conventional global economic system, any reduction in GHG emissions correlates – with frightening precision – to a reduction in Gross Domestic Product (GDP), what we call 'recession'. Conventional thinking will not work. We must start to judge prosperity on more meaningful and sustainable measures other than GDP or similar measures that have been introduced recently, such as gross value added (GVA).[1] We need to change track towards a circular economy, where any wasted resource and energy is avoided and efficiency and reuse are optimised.

DECOUPLING GDP AND GHG

Energy systems do not exist in isolation (Figure 2). Instead they are embedded within wider socio-economic systems which themselves are embedded in the Earth's natural systems.

Failure to see this wider context and develop new benchmarks for the economy – like social and environmental benefit metrics – will mean efforts to avoid climate catastrophe are likely to fail, because current conventional economic benchmarks encourage consumption beyond that which can be supplied with renewable energy. Global GHG emissions will continue to rise along with average global GDP.[2]

We must decrease global average GHG emissions by 7.6% per year, every year until 2030,[3] to have a chance of staying within the 1.5°C temperature rise above pre-industrial levels, aspired to under the Paris Agreement in 2015.[4]

Eastern region emissions need to be reduced by 13.5% (not including aviation, shipping and consumption) annually within the same period.[5] The difference is due to rich, developed nations needing to make emissions cuts faster under the principles of climate equity and justice embedded in the Paris Agreement. And it gets harder and more expensive for all the longer we leave it, as we are already experiencing the dramatic effects from 1.1°C of global heating.[6]

Given the correlation between GDP growth and GHG emissions, the challenge for our politicians is that continuing with our current carbon-based GDP growth model will risk sending the world into a deep recession if we make the cuts required without changing the nature of our energy economy.

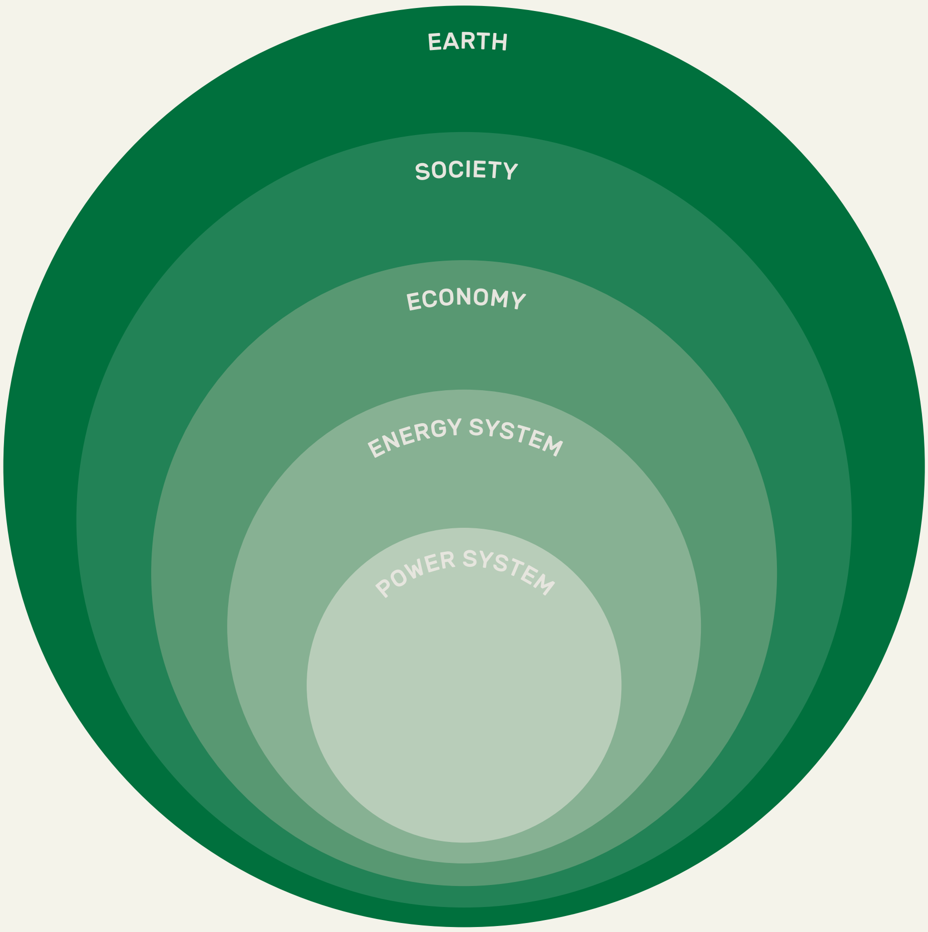

FIGURE 2 – The embedded nature of the energy system
(International Renewable Energy Agency, 2019)

NEW MODELS FOR GROWTH

2

Doughnut economics[7] Kate Raworth proposes a 21st-century framework for defining economic performance. Shaped like a doughnut, a circle with a hole in the middle, her model literally puts people's needs at the centre: the hole depicts where an economy fails to meet basic human needs, from food and health to income, peace and justice. The larger the hole, the greater the economic failure. The outer circle represents planetary boundaries, whether these relate to climate change, biodiversity loss, etc. Any economic activity beyond these ecological ceilings that life depends on likewise represents failure. The space between these two concentric circles thus represents the only safe and just space for human economic activity.

Prosperity without growth[8] Tim Jackson advocates that we redefine prosperity; otherwise we will "trash the system and crash the planet". The change required to the carbon intensity of UK economic growth is to move it from around 264gCO_2/£ where it is now, to 4.6gCO_2/£ in order to meet a 2% increase in GDP.[9] That's a 58 times improvement on the current system and more than 10 times faster and further than anything we have previously achieved in industrial history. His solution is to invest in a new economy based on protecting our ecological assets and transitioning to very low carbon technologies and infrastructures, guided by the idea of a "meaningful, less materialistic prosperity" providing capabilities for people to flourish.

This change requires us to take a new attitude to the environment and possessions. We need to disrupt our 'take-make-use-throwaway' culture and fundamentally question whether we need so much 'stuff', which requires extracting primary resources from the environment.

FROM A LINEAR TO A CIRCULAR ECONOMY

How do these changes fit within the context of the UK's energy system? We need to redesign the energy supply chain to move us away from a fossil fuel-based linear energy supply chain that uses natural resources and deposits its waste, notably GHGs, back into the environment. Instead, we advocate a shift to an energy system that supports a circular economy. The *Energising the East* report outlines in detail the nature of a circular system and the policies needed to reshape the economy.[10] The question now is how can our regional energy system help deliver a circular economy?

DISTRIBUTED ENERGY SYSTEMS (DES)

One argument made against a 100% renewable energy supply is that renewables are 'intermittent': the wind does not always blow; the sun does not shine at night. Proponents of renewable energy, on the other hand, have been focusing on how renewable energy can be stored economically, smoothing out any peaks and troughs in energy generation.

A distributed array system (DES) is an array of meshed (two-way, interconnected), distributed energy resources (DERs) that are connected in an electrical network with voltage flowing between individual resources or assets. Assets include generators, storage capacity and other technologies that assist in managing network stability. These can be both metering and monitoring systems, and smart appliances, which switch themselves on and off, depending on things like energy price, network voltage or frequency.

While electricity is most commonly referred to in a DES, thermal energy resources (hot and cold) from non-electrical assets can also play an important role. These resources can be sourced from the ground, water or air, as well as recovered from commercial and industrial processes. Thermal energy and electricity can work together to heat buildings and support commercial and industrial processes such as food or chemicals production.

Energy storage assets are also an important part of a DES, especially as the price of these technologies falls. Storage helps facilitate a stable system, including in the transition to utilising more renewable energy (Box 3).

In addition to static storage assets such as thermal stores, batteries and kinetic devices, opportunities exist for some mobile battery storage in the form of electric vehicles (EVs). However, replacing the existing vehicle fleet with EVs to simply replace our current transport consumption patterns is not a sustainable option[11] – among many concerns is the environmental impact of the current methods of mining, producing and disposing of lithium-ion (Li-ion) batteries.[12] There are also significant doubts about whether there is enough lithium available on the Earth to meet the likely demand, if this technology became standard in fast-response DES balancing. Greater use of active travel and better provision of public transport are required first.

The dispersed network of batteries thus created can form an essential component of a DES, as it can interact in a bi-directional way with electricity networks to increase stability. For example, charging an EV or a static energy storage system draws energy from the grid but it is also possible to discharge it back onto the network at other times.

As injection of renewable energy into distribution networks increases, via a greater number and size of connected assets, it is also possible to 'virtualise' systems that extend out across regional network boundaries. Such 'systems-within-the-greater-energy-system' are called 'virtual power plants' (VPPs) and they aggregate together different assets depending on their function and market signals.

STORAGE OPTIONS AND DECLINING COSTS

3

Storage is a crucial feature in DES architecture, where the ability to hold surplus energy locally, to be released when required, offers significant flexibility, cost and efficiency benefits. Yet even while this storage is crucial, it is also the case that a diverse energy mix is likely to reduce the need for storage and increase resilience.[13]

Grid-scale storage can take many forms. Examples include:

- **Tidal power** is a form of stored energy. A barrage to hold water levels at high tide can then be gradually opened to release the water, turning a turbine to generate power over the hours until the next high tide. Small scale barrages in estuaries offer considerable scope, with opportunities in the Eastern region at Great Yarmouth, for example.[14]

- **Pumped hydroelectric energy storage (PHES)** uses the gravitational potential energy of water, pumped using low cost surplus off-peak electric power from a lower elevation reservoir to a higher elevation. Dinorwig in Wales is a relevant example, although there may be limited scope in the Eastern region due to lack of significant elevation gain.

- **Underground thermal energy storage (UTES), boreholes (BTES) and aquifers (ATES)** are the most developed storage concepts and are mostly used for seasonal storage.

- **Compressed air energy storage (CAES)** uses surplus energy to compress air to be released when demand returns. Another example is cryogenic **Liquid Air Energy Storage (LAES).** Highview Power operates a heat recovery and energy storage system to offer the advantages of pumped hydro storage without geographical limitations.[15] Highview claims it could increase round-trip efficiency to 70% if it were located next to a conventional power station where excess heat could be recycled.[16]

- One important system characteristic of storage for balancing supply from renewables is that it needs to be fast reacting. This suits **flywheel energy storage (FES)**, which accelerates a rotor (flywheel) to a very high speed and maintains the energy in the system as rotational energy. It also suits large-scale batteries, conventionally considered expensive. Costs are now falling rapidly. Against an expectation by Ofgem in 2016 that Li-ion battery costs would fall to £152/kWh by 2019,[17] the actual market price of battery storage fell to £119,[18] with a predicted price of £71/kWh by 2024 and £47/kWh by 2030.[19] [20]

THE NEED FOR FLEXIBLE DES

As the mix of energy sources connected to an energy network increases, balancing supply and demand becomes more critical and complex, and calls for greater market flexibility compared with conventional systems. Flexibility services (see below) that can give to or take energy away from the system are another significant step in DES evolution. They allow distribution network operators (DNOs) to become distribution system operators (DSOs) and manage their networks more carefully to keep them in balance.

DSOs issue tenders that encourage energy asset owners to ramp up generation or release stored energy when contracted to do so. There are also tenders for demand side response, which removes energy from their network by turning demand up and down, according to price signals about energy availability. Piclo is a trading platform for DSOs to offer competitive tenders to flexibility providers. Figure 3 highlights areas in the Eastern region currently open to bids from flexibility providers.[21]

There are other layers of control within a DES that could be enabled through appropriate regulation by our energy regulator, Ofgem (Chapter 3). A truly democratised DES should permit more types of energy trading, including local energy markets that engage in P2P trading of energy as the population of citizens connecting to DERs increases.

P2P energy trading can be overlaid on existing energy system infrastructure as it largely depends upon data sharing between peers.[22] This system architecture can support several positive attributes of a circular economy, including greater efficiency, less waste, being fairer and open to all stakeholders, and retaining value in the local economy. Box 4 highlights some examples of DES in practice.

Flexibility Services Trading is illustrated in Figure 3, which is taken from a trading platform, Piclo, used by DSOs to tender for flexibility services from DER asset owners or aggregators. The shaded areas on the light brown part of the map are the parts of UK Power Networks' electricity network (the DSO operating in the Eastern Region) that require flexibility.

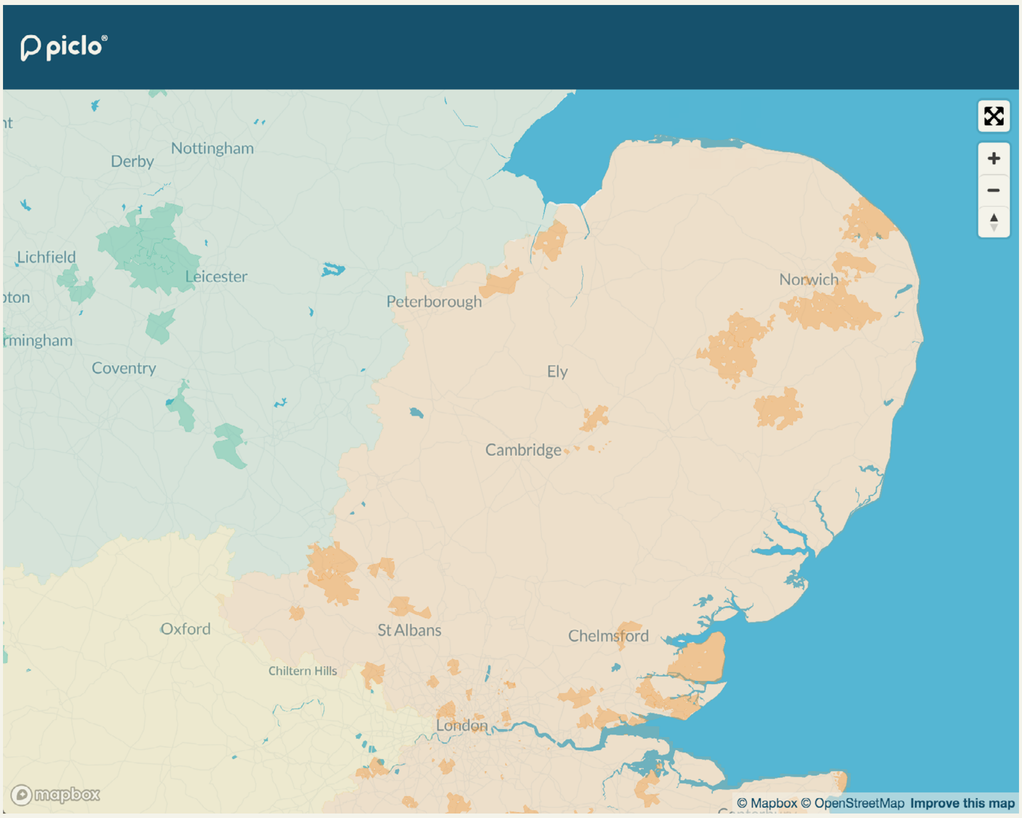

FIGURE 3 – Screen shot of Piclo flexibility tendering platform

CASE STUDIES OF DES SUPPORTING A 100% RENEWABLE ENERGY ECONOMY

4

Cornwall Local Energy Market[23] is a trial funded by the European Regional Development Fund and conducted by Centrica to explore flexible, smart local energy market solutions that could be applied across other regions of the UK with a sufficient concentration of DERs. This 'living lab' is demonstrating the feasibility of P2P energy trading in a local econometric zone.

Power Ledger[24] is an Australian company that has designed P2P software enabling trading of renewable energy and environmental commodities over existing network infrastructure using blockchain and crypto currencies. This facilitates market access for DERs from household to commercial scale and is being trialled in communities and municipalities across the world.

LO3 Energy[25] began demonstrating a P2P energy market in Brooklyn, New York, and is now engaged in a number of P2P energy trading projects across the world, including the Cornwall Local Energy Market, through its blockchain-backed trading system. They work with DER owners, microgrids, DSOs and EV chargers to create markets at a local level.

Open LV[26] is an information initiative by Western Power Distribution (the neighbouring DNO to UK Power Networks, covering the south-west and central England) to provide open data from their substations to enable an understanding of the dynamics of the local energy system. This could support the network through flexibility and DSR projects, and make the system more efficient, more resilient and less in need of reinforcement.

Norwich Community Solar[27] is a Norwich-based community energy start-up that aims to build renewable energy assets under the ownership of community shareholders to deliver clean energy to commercial scale clients. In the first instance it is proposing to implement rooftop solar arrays, but it hopes to become an integral part of local energy systems in the future. A key feature will be the project ownership structure that returns benefits to the community, even if they own a fraction of a renewable energy asset. This is a proven model already operating in dozens of communities around the country.

This report argues that transition to a zero carbon economy requires the reassessment and improvement of the energy supply chain design. This extends from energy assets and services, through their provision and end use, to their decommissioning or extending the assets' life. This needs to be viewed as a whole system requiring optimisation in favour of clean and sustainable energy that is fairly distributed and accessible to all. This will increase local resilience to climate change for both our technical and our social infrastructure.

The Eastern region has the potential to lead other parts of England in the development of renewable energy generation. There are around 2.5 million households in the region,[28] thousands of registered onshore renewable energy sites with several larger registered generation sites (Table 1).

	PV	ONSHORE WIND	OFFSHORE WIND	ANAEROBIC DIGESTION	LANDFILL GAS	PLANT BIOMASS
NUMBER OF INSTALLATIONS	102,204	879	9	62	72	25
INSTALLED CAPACITY (MW)	1,941	473	2,393	78	186	153
GENERATED ENERGY (MWh)	1,939,288	1,078,588	6,817,505	430,300	677,214	758,445

TABLE 1 – Principal Eastern Region Renewable Energy Sites (combined local authorities, 2018)[1]

These represent a diverse range of opportunities for distributed energy production and demand-side response. This could form the basis of a democratised, decentralised and decarbonised energy system across the region.

For the Eastern region, the greater resilience (and therefore capital investment savings) offered by a distributed architecture and flexible technologies could be especially important; they enable grid reinforcement to be deferred, and ensure that future demand can be met while displacing fossil-fuel use.

CONCLUSIONS

- The combination of a distributed network and flexible technologies has the capacity to transform the traditional energy system from large, centrally-located and corporate-owned fossil fuel power stations to a more democratised and decentralised, or distributed, energy system. This transformation is vital to reducing carbon emissions to net zero by 2030.
- This new 100% renewable energy paradigm is eminently suited to a circular economy due to its self-supporting, smart cellular local architecture, as well as introducing new opportunities such as utilising electrical and thermal energy that otherwise would have been wasted.
- There are already significant signs of change within the existing energy system. In the Eastern region we still need an extraordinary growth in renewable generation capacity, and a focus on flexible technologies to allow a more (and more localised) energy system to evolve. We also need a far stronger demand side response.
- However, several regulatory and policy challenges need to be overcome to deliver the circular economy energy paradigm, which will be discussed in the next chapter.

1 New Zealand Treasury (2019), *The Wellbeing Budget 2019* https://treasury.govt.nz/publications/wellbeing-budget/wellbeing-budget-2019-html
2 The ratio of GHG emissions to global average GDP has been about 0.7 (2009-18), meaning for every 1% increase in average global GDP, there is still a 0.74% increase in GHGs. In the UK the current ratio stands at 0.34%, but this is in part due to the transfer of domestic emissions to the countries that manufacture the goods we buy https://www.theccc.org.uk/publication/reducing-uk-emissions-2019-progress-report-to-parliament/
3 UNEP, 2019
4 United National (UN), *The Paris Agreement*, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
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8 Tim Jackson, *Prosperity without Growth* https://timjackson.org.uk/ecological-economics/pwg/
9 At 1USD=0.7599GBP
10 Barrass, Boswell and Essex, 2020.
11 Issues with EVs include: significant embodied carbon emissions in their production, which front-loads emissions costs just when we need to radically reduce them; particulate air pollution from brakes and tyres; 1:1 replacement of vehicles does not reduce congestion; fleet turnover is slower than government policy - current UK EV market share was 2.5% in 2018 against a target of 3.4%; end-of-life obsolescence of batteries.
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20 At 1USD=0.7599GBP
21 Piclo (2020), https://picloflex.com/dashboard
22 This is called a Distributed Energy Resource Management System (DERMS), operated by a third-party company or the DSO, and the energy market they are engaged in
23 Centrica (2018), *Cornwall Local Energy Market* https://www.centrica.com/innovation/cornwall-local-energy-market
24 Power Ledger, https://www.powerledger.io/
25 LO3 Energy, https://lo3energy.com/
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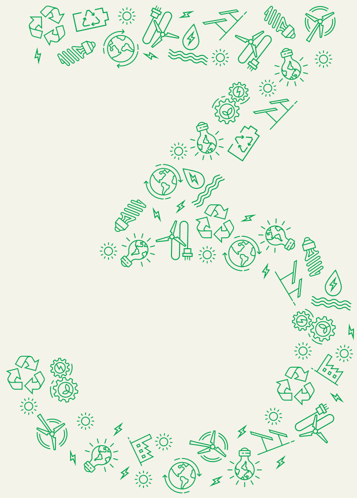
28 Office of National Statistics (ONS) (2016), *Total number of households by region and country of the UK, 1996 to 2017* https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/adhocs/005374totalnumberofhouseholdsbyregionandcountryoftheuk1996to2015



POLICY INCOHERENCE AND REGULATORY PARALYSIS

Flexible technologies are clearly a crucial piece of the jigsaw that will be needed to achieve net-zero carbon emissions. However the UK is lagging behind other European countries when it comes to their adoption.

This is not necessarily due to inertia on the side of the DNOs. The real sticking points are lack of government investment on the scale needed, policy inconsistency, lack of regulation in favour of zero or very low carbon technologies and the time needed to take decisions. These are collectively holding back the rapid pace needed for a clean energy transition.

THE IMPORTANCE OF FLEXIBILITY IN REACHING NET ZERO

Chapter 2 set out that to achieve net zero emissions we need to rapidly increase renewable energy generation alongside storage and demand side response technologies, to create electricity system stability through flexibility.

Broadly speaking, there are five priorities for providing the needed flexibility:

- **Lowering the price of storage.** Battery storage co-located with PV generators is increasingly common, but markets are immature and single-stream revenues may not make a viable business case. We need more markets that these flexibility providers can access.

- **Closer working with commercial and industrial sectors** not only to promote decarbonised energy tariffs but also to show how their assets can integrate and increase flexibility of the wider energy system. Examples of commercial and industrial DSR models are starting to emerge, including the temporary switching off of large electrical loads such as freezer cabinets or furnaces, to supply other sectors.

- **Understanding energy end user profiles.** Information is currently limited or out of date, due to new technologies being introduced. These profiles are essential intelligence to identify opportunities and efficiencies for interventions by renewable and smart assets to engage a wider number of energy users. They will also contribute to setting fair tariffs across different profiles.

- **Raising incentives** for small scale community and household generation and asset owners to engage in flexibility markets following the withdrawal of the FIT. All new houses should be required to embed these measures and retrofits of all existing buildings would stimulate the flexibility market and further displace fossil fuels.

- **Data availability and reporting** are increasingly important for both the provider and recipient sides of flexibility services. Digitalisation is crucial to enact timely and targeted flexibility interventions.

BARRIERS TO FLEXIBLE ENERGY TRANSITION

A recent study[1] ranked the UK second to last in a basket of European countries when considering readiness for 'the energy transition'. The study reinforces the view that the development of flexibility markets is still immature, complex and fragmented. It is essential to turn this around to put us on course to meet zero carbon in 2030. Table 2 highlights examples of challenges that require government intervention and the solutions that would facilitate a rapid clean energy transition.

CHALLENGE	SOLUTIONS
Significant pipeline of storage assets 'awaiting construction' with planning consent but developers holding off[2] formal construction due to uncertainties about a future grid charging regime (see below) and market incentives.	Government and Ofgem must review and change its targeted charging review (TCR) proposals (see below) to avoid further inconsistent and incoherent signals. Greater P2P trading instead of penalising deployment of DERs Bring together stakeholders to overcome uncertainties for storage in future grid-charging regime. Provide regional guarantees to business to enable rapid deployment.
Increased energy exported to distribution networks, not all of which is renewable. Significantly, fossil fuel sources (e.g. gas-fired CHP and power stations, and diesel generator farms[3]) are increasing their share of subsidies in the capacity market.[4]	Address this policy failure and limit emissions from fossil fuel sources at a policy level. Ofgem to cease being 'technology agnostic' and accelerate planned power-down of fossil fuel energy generation.
Lack of simplified planning regimes for energy storage, EV charging and other flexibility assets.	Prioritise assets that are essential to delivering flexibility. This should be designed into local plan energy policies across the region.
Lack of financial incentives or priority to support small scale domestic or community energy initiatives to invest in renewable energy and storage DERs.	Urgent change of policy direction by Ofgem to shift investment in clean energy at the distribution level and energy conservation and storage.
Environmental and social obligation costs. Ofgem describe these as "costs related to government programmes to save energy, reduce emissions and encourage take-up of renewable energy."	Level the playing field around the associated costs related to different fuels. Natural gas is currently penalised less by these charges than electricity (just 1.6% of bills, against 20.44% for electricity). Removing this distortion would discourage fossil fuel usage over cleaner energy from electricity.

TABLE 2 – Solutions to rapid development of a flexible energy transition

THE TARGETED CHARGING REVIEW

Regulatory paralysis is preventing a rapid switch to DES in two ways: Ofgem's lack of regulation in favour of low carbon technologies and the length of time needed to implement decisions which inhibit the necessarily rapid pace of a clean energy transition. However, there is no need for this situation to continue, as solutions are readily available.

After a lengthy consultation exercise called the TCR: Significant Code Review (SCR),[5] Ofgem is about to introduce a charging regime that actually discourages people from installing renewable generation and storage capacity. Put simply, the TCR looked at how residual network charges should be covered (see below), as more and more domestic and industrial energy users choose to generate, store and use their own PV and wind power.

RESIDUAL CHARGES

The dilemma for the Transmission Operator (TO) and the DNOs is that this so-called 'grid defection' results in network charges falling on fewer and fewer customers, so charges have to rise for the remaining customers who do not generate or store their own energy.[6] Extrapolate, and you quickly reach a point where this leaves the suppliers and DNOs with an unsustainable business model.

The TCR tries to rebalance charges, so that all network-connected energy users, including the new, distributed local generators, receive a single charge to keep the core network running, much as telephone network operators pay access fees to use competitors' networks. However, such a flat fee for domestic users (and banding for non-domestic users) distorts the market and deters investment in clean energy at the distribution level. Yet this is exactly where we need it to be, to support zero carbon communities and regional circular economies.

EMBEDDED BENEFITS

'Embedded benefits payments' previously favoured DERs (many of which are small-scale renewable energy generators), as they helped suppliers (whom they have contracted with to buy their energy) avoid the costs incurred at transmission system level for balancing the overall energy demand in the electricity system. Traditionally, the smallest generators, such as at the domestic scale, did not pay balancing charges. However, the burgeoning flow of distributed energy has resulted in Ofgem deciding that small distributed generators must now pay for balancing by the removal of their rights to 'embedded benefits' from which they were previously exempted. In short, it means that smaller generators (many of whom will be renewable energy generators and storage owners) will be charged in the same way as larger generators, which will erode incentives for small investors.

If the market for supplying energy were opened to P2P trading and not monopolised by big energy suppliers, the use of the distribution network by small generators and their customers would increase. In doing so, a regime based on proportional use of the network should obviate the need for a fixed residual charge.

The results from the Cornwall Local Energy Market (Box 4) may help to restore a more democratic and pro-decarbonisation set of regulations, but only if Ofgem adopts a more proactive stance on P2P energy trading and reverses its discrimination against small clean energy generators under the TCR.

THE NEED TO REPLACE THE FIT

Phasing out the FIT, which closed to new applicants on March 31, 2019, has had adverse effects on the adoption of renewable electricity generation[7] and its successor, the Smart Export Guarantee (SEG)[8] has significant limitations.

Offering the SEG is only obligatory for large electricity suppliers (those with more than 150,000 customers). Suppliers (if obligated) can offer any price to micro-generators with surplus energy to sell. The price offered will probably hover between the wholesale price (currently about 6p/kWh) and the system sell price (currently around 5.2p/kWh).[9] As these are far below what domestic customers actually pay to import electricity, it is not a great incentive.

In the current regime, a better use of PV is on site, 'behind the meter', to offset import costs, although the TCR, described above, limits the benefit from that as well. A better way forward would be to either remove the disincentives to small renewable generators under the TCR, or set retail rate remuneration for exported energy to positively encourage adoption of DERs.

ENCOURAGING COMMUNITY ENERGY

Another area where UK policy formulation falls short is in encouraging community-led or community-owned energy projects. The loss of the FIT[10], as well as the loss of tax relief to investors in community energy (CE) through the Enterprise Investment Scheme[11] and the closure of the Urban Community Energy Fund (UCEF - a successful scheme helping to tackle dirty air in our cities), [12]has hit CE practitioners hard, as highlighted in the experiences of Norwich Community Solar.[13] CE is now placed in direct competition with far larger and more established energy corporates. Community and other renewable energy schemes are not fully understood and valued for the work they do because central government policy and associated regulations are only concerned with the cost of energy to the user.

In contrast, other countries have found successful ways to encourage communities to embrace decentralised energy production. Denmark and Germany both incentivise growth in community-led renewable energy generation and the results have been very positive. In Germany, 50% of all renewable power capacity was citizen-owned in 2014 and in Denmark, 70-80% of existing wind turbines were owned by communities in 2013.[14] Getting to these figures requires proactive arrangements and policies. In Denmark, project developers are required to give local people priority in financing CE under its 'right to invest' principle.[15]

In the UK local administrations and funding bodies need to collaborate and open further consultations on the crafting of local and regional strategy and development plans. If we are to develop a clean, smart energy system that works, it must also be socially smart and embody the characteristics of fairness and inclusion for an effective and prosperous circular economy.

CONCLUSIONS

- There are many causes for concern in the policy and regulatory landscape because it seems increasingly hostile to local, decarbonised, distributed and democratised clean energy.

- The government and Ofgem are not paying sufficient regard to the need to rapidly decarbonise the energy system and the economy that rests upon it. Rather, their primary concern is to keep energy bills down, including through the TCR, and in doing so send inconsistent and incoherent signals to sectors of society who support a rapid transition to clean energy.

- The regulatory pitfalls of the FIT abolition, the TCR and the SEG have given us the worst of all possible worlds and we are calling on the government and Ofgem to improve the situation through the solutions identified in Table 2.

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14 Climate Policy Info Hub, https://climatepolicyinfohub.eu/
15 Ofgem, 2017

HOW THE EASTERN REGION CAN LEAD TOWARDS NET ZERO CARBON

As highlighted in Chapters 2 and 3, the electricity industry is already looking at a distributed model, with what it calls ‘flexible technologies’ as an important part of establishing the system. Yet the industry must factor in more profound adaptations that a circular economy requires – notably to reduce the overall energy demand across all sectors and eliminate all fossil fuel assets.

In this chapter the measures that could be implemented to break this carbon lock-in are explored alongside calculations of the potential gains in terms of energy savings and carbon emissions reductions.

CARBON LOCK-IN

Many of the major infrastructure projects that national and local government are currently supporting in the Eastern region will lock in future carbon emissions. Notably:

- Massive subsidies to the declining oil and gas sector;[1]
- Continued government investment in expanding road capacity, including public funding of the Norwich Western Link, the Ipswich Bypass, the Oxford-Cambridge Expressway and the Bedfordshire A6-M1 link.
- Structural contribution to UK consumption emissions. This is the largest UK emissions sector and emissions are exported to producer countries like China for goods imported into the UK. Hosting facilities that underwrite this massive import of goods, and export of emissions, locks in emissions for decades. For example the country’s busiest container port at Felixstowe, air cargo facilities at Stansted and Luton, and significant logistics, warehousing and distribution infrastructure in Bedfordshire.
- Plans for airport expansion by increasing business across the regional airports at Cambridge, Stansted, Luton and Norwich.[2] This is totally inconsistent with the government’s current aviation strategy, which says that expansion of Heathrow must result in a reduction of flights from regional airports across the UK.

- Housing developments failing to implement the highest level of energy conservation measures and DERs, for example the Greater Norwich Local Plan.[3]

- Land use, food production and farming heading in the wrong direction – towards further centralisation and industrialisation.

- Inadequate regulation about waste and resource use beyond municipal waste. Incinerators are still being built (including at Thetford and Peterborough), which increase the carbon intensity of the electricity grid when we need to cut it to zero.

- Plans for a new nuclear reactor at Sizewell and to reopen Bradwell – detracting attention and investment away from renewables.

The implication is that unless there is pressure from government to transform energy and resource use across all sectors of the economy, both in terms of reducing energy and resource use, and on the scale of ambition to shift our economy, neither the Eastern region nor the rest of the UK will make the necessary changes to avoid runaway climate change.

THE SCOPE FOR SAVINGS IN THE EASTERN REGION

Before discussing carbon emissions reductions that can contribute to net zero by 2030, considering the savings from a purely financial perspective could provide strong motivation for those stakeholders not yet inclined to embrace the radical changes needed to achieve net zero carbon by 2030.

According to a report prepared by Imperial College London for the Carbon Trust: "The UK could save £17-40 billion across the electricity system from now to 2050 by deploying flexibility technologies."[4] This is not isolated optimism; other researchers agree.[5] [6]

Exactly how these savings translate on a regional basis has not been calculated until now. We estimate that the savings for the Eastern region could be between £234 million and £654 million annually, or between £109 and £304 per capita (Box 5).

SMART POWER FLEXIBILITY SAVINGS ESTIMATE

5

The figures are derived by allocating the proportion of the national savings figures[7] that could be available to Eastern Power Networks (the division of UK Power Networks that operates the electricity distribution network in our region) by the Eastern region domestic and industrial, commercial and agricultural (ICA) customers:[8]

Lower end saving = (number of Eastern region domestic & ICA customers) / (number of UK domestic & ICA customers)[9] X £2.9 billion

Gross lower end saving = 2,147/26,612 (thousands of MPANs[10]) X £2.9 billion = £234 million

Per customer (annually): Lower end saving = £109

Higher end saving = (number of Eastern region domestic & ICA customers) / (number of UK domestic & ICA customers) X £8.1 billion.

Gross upper end saving = 2,147/26,612 (thousands of MPANs) X £8.1 billion = £654 million

Per customer (annually): Upper end saving = £304 annual

CHANGE THAT CAN BE LED BY THE EASTERN REGION

The Eastern region can take a lead and accelerate action to reach net zero carbon by 2030. To highlight the potential gains from taking a few high priority measures, below are calculations of some possible outcomes of a circular economy approach to energy in the Eastern region.

The Eastern region's direct carbon emissions (occurring within the region itself) are shown in Figure 4.[11] This is around 9% of the national CO_2 budget.

Transport, which makes up 44% of the region's direct CO_2 emissions, is the fastest growing national source of carbon emissions. Therefore transport is an obvious target for electrification and integration into flexibility strategies linked to greater renewable energy deployment. However, EVs can only play a small part in reducing transport emissions; significant reductions in transport emissions must be achieved through modal shift and active travel.

While Figure 4 shows that transport is the largest source of *direct* emissions in the region, Figure 5 shows that the region's consumption-based carbon footprint[12] is much larger when aviation, shipping and consumption (related to the net import of goods) are included. This results in the total per capita Eastern region footprint being 9.9tCO_2[13] as opposed to 5.3tCO_2 for the production-based carbon footprint.[14] This highlights that working to focus the impact of the energy system in the Eastern region is not enough: the impact of transforming overall consumption patterns is equally important and must be prioritised in policy responses.

REACHING NET ZERO CARBON

The data derived in the rest of the report was underpinned by the SCATTER model, which calculates a carbon reduction trajectory for the Eastern region based on a Paris-aligned carbon budget of 200.5MtCO_2 from 2020 to 2100.

This requires, from 2020, a year-on-year carbon emission reduction across all sectors of 13.5%.

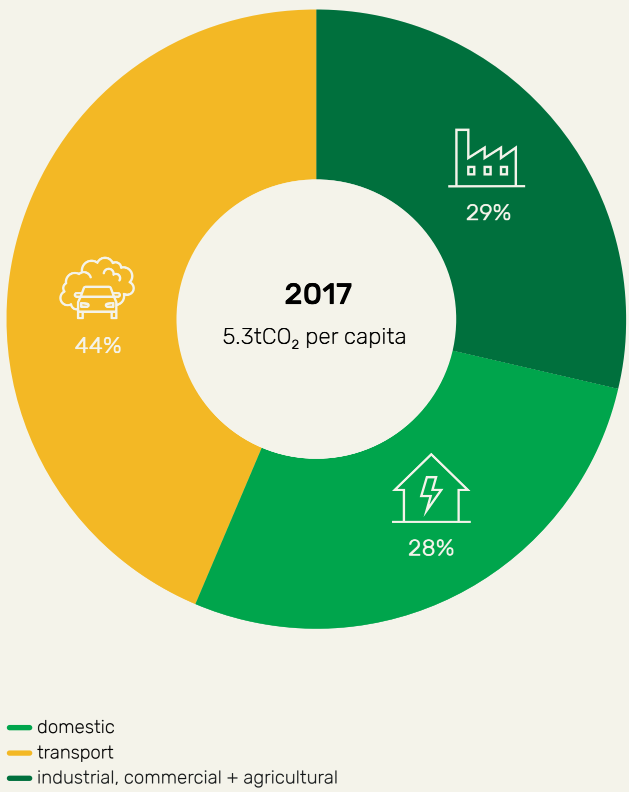

FIGURE 4 – Eastern region direct energy emissions by sector (2017)
(Source: BEIS, 2019)

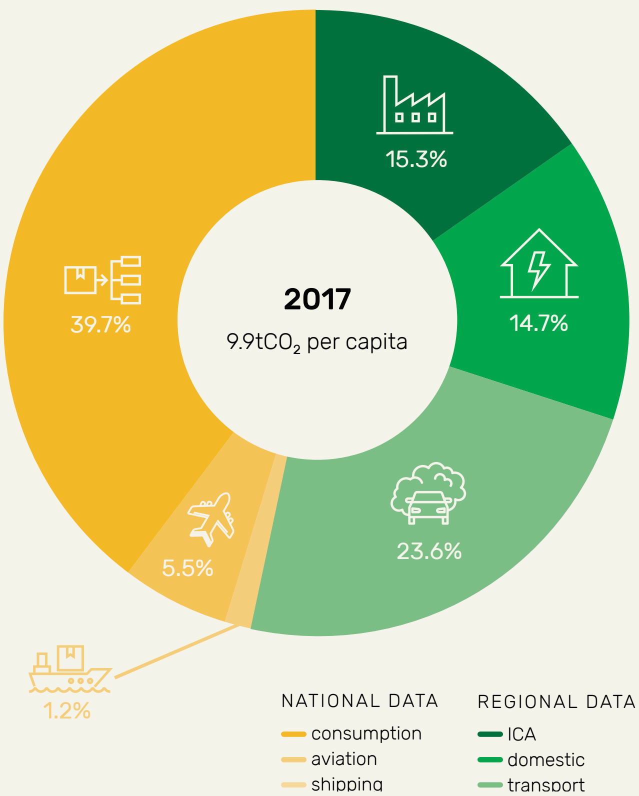

FIGURE 5 – Eastern region emissions, including consumption, aviation and shipping (2017)
(Source: BEIS, 2019)

Following this 2030 trajectory to net zero means we must reduce the Eastern region's carbon emissions by 163MtCO_2 in the years 2020 to 2030, compared with a reduction of 154MtCO_2 from 2020 to 2050 for the government's current less demanding trajectory. It is estimated that the portion due to housing of the gross 163MtCO_2 reduction (based on 2020 energy emissions figures) is 28% (45MtCO_2). For ICA energy emissions, the portion is 29% (47MtCO_2).

Notwithstanding the importance of net zero carbon construction, this section focuses on the retrofit of existing buildings. To establish the steps necessary in the region to meet these targets in line with the net zero 2030 scenario, we calculated the energy savings that could be achieved from the following measures on domestic buildings (as for industrial, commercial and public sector buildings):

- Retrofitting PV to existing houses / recommending it for all new builds.
- Retrofitting energy conservation technologies to a significant number of existing homes.

The UK has the least energy efficient housing stock in Europe.[15] Many homes will require a deep retrofit, so this should be planned on a street-by-street basis as opposed to just incentivising household-by-household.

A new 'whole house' retrofit approach pioneered by Energiesprong (energy leap)[16] is already proving successful in the Netherlands (and in a pilot scheme in Nottingham[17]) and could provide the transformation we require here. Energiesprong homes have around 90% lower heat demand and retain heat for up to 48 hours, making them ideal for electric heat pumps that are four times as efficient as gas boilers. Improvements of this kind would therefore significantly reduce the cost of decarbonising heat.

Switching to electric heating systems should go hand-in-hand with dramatic improvements to a home's insulation in order to reduce energy demand and reduce the need for grid reinforcement and new generation capacity.

Below are details of three changes that we propose to all buildings and the carbon-reduction benefits these changes would yield.

CHANGE 1 / PV RETROFITS TO HOMES

These calculations for homes are based on the number of electricity connections through a designated MPAN.

Baseline recommendation

Retrofit a modest 2 kilowatt peak (kWp) solar PV array to every home in the region. New builds should accommodate at least this capacity in addition to other technologies such as solar thermal panels.

Government figures put the average Eastern region load factor for PV at 10.2% in 2017/18.[18] Using 12 hours per day for generation (average daylight length over the year) the annual generation from the array could be calculate as follows:

Total domestic generation =
number of homes X size of array X
load factor X 12 hrs X 365

Calculation: 1,915,000 X 2 X 0.102 X 12 X 365 = 1,711 gigawatt hour (GWh)/year

Per house/year = 894kWh

Domestic emissions avoided by solar =
number of domestic users X solar energy generated X conversion factor kWh to CO_2[19]

Calculation: 1,915,000 X 900 X 0.2556 = 437.354 kilotonnes (kt)CO_2/year;
Or
4.4MtCO_2 from beginning of 2020 to beginning of 2030

Calculations are based on on the following baselines:

- Whole house retrofit system developed by Energiesprong,[20] who claim an average Energiesprong retrofit reduces a home's total energy demand by 80%;[21]
- Green Party policy to apply 'deep retrofit' to 10 million homes nationally, by 2030;[22]
- Latest data on numbers of households;[23]
- Carbon reduction budget allocated to housing (42MtCO_2).

Number of homes being retrofitted by 2030 in the Eastern region, proportional to Green Party manifesto:

Number of homes = (Eastern region total households/national total households) X 10 million

Calculation: (2,573,000/27,227,700) X 10,000,000 = 944,994 homes;
Or
94,499 households per year from beginning of 2020.

Carbon saving to beginning of 2030 from the above measure:

Carbon saving = portion of carbon budget affected by retrofits X Energiesprong reduction

Calculation: (944,994/2,573,000) X 42 X 0.8 = 12.3MtCO2.

Conclusions – Housing sector
These initial figures of housing carbon reduction gives rise to a combined Eastern region carbon saving of 16.7MtCO_2. This is 39.5% of what is required to meet the carbon reduction budget for this sector. It is acknowledged that over this 10-year period, more new housing will be added to the stock, and that this must be built to a carbon neutral – or negative – standard in order to not increase the carbon reduction burden. Other mitigating factors could include lower average space heating energy demand due to global heating, more home energy storage to leverage duty cycles and more benefits from rooftop solar PV arrays, and more energy conscious behavioural changes in household occupants.

In order to meet the 42MtCO_2 reduction budget therefore, the following measures are recommended:

- Increase the size of retrofit and new build housing PV arrays to 4kW average array size;
- Increase the annual number of Energiesprong whole house retrofits to 250,000 per year.

If measures of this order were implemented to the housing sector, it is estimated that 98% of the net zero housing budget would be met based on the assumptions made about the size of that sector.

CHANGE 2 / RETROFITTING PV TO EXISTING COMMERCIAL AND INDUSTRIAL BUILDINGS AND RECOMMENDING ALL NEW BUILDS FOLLOW SUIT

These calculations for commercial and industrial buildings are based on the number of electricity connections through a designated MPAN. Emission figures relate to energy emissions from electricity, gas and other fuel usage in the ICA sectors.[24],[25]

Baseline recommendation
Retrofit a nominal 20 kilowatt (kW) roof top PV array to all the 232,000 non-domestic Eastern region electricity users. Clearly many will be unable to accommodate this due to limited roof space; shading and roof furniture, but many others could accommodate much larger arrays, especially warehouses. So, the aim here is to realise a balance where some premises take larger arrays than others.

Following the same calculation process as illustrated in (Change 1) above, the annual generation output would be 2TWh/year, saving 530ktCO_2 each year in energy related emissions. This is equivalent to 13.5% of this sector's estimated CO_2 emissions from electricity use and 5.6% of total emissions when emissions from gas and other fuel usage are included.

The total contribution to the 10-year carbon budget from 2020 to 2030 would therefore be 20TWh or 5.3MtCO_2 at today's electricity carbon content.[26]

CHANGE 3 / HEAT REUSE AND RECOVERY IN ICA BUILDINGS

Industrial heat recovery is a means through which excess heat can be put to good use to save energy elsewhere, however it is very complex to assess whether this would in fact contribute to carbon lock-in, if current fossil fuel powered industrial activities were used as a source of recovered or reusable heat.

In order to make an assessment of the potential for industrial waste heat recovery, it would be necessary to make an inventory of its main sources, such as refineries, iron and steel, ceramics, glass, cement, chemicals, food and drink, paper and pulp and large electrical substations. Subsets of these would be energy demand for space heating and energy demand for processes. Then an approach to see how many of these could be treated with demand reduction, heat conservation (insulation etc.) and electrical replacement would be required before estimates could be made of the resource available to the region.

However, the potential for economic heat recovery in the UK has been estimated in the range of 5TWh/year to 28TWh/year,[27] consisting of hundreds of source-sink technology combinations. Although most of the biggest sources of heat will be located in industrialised regions outside of the Eastern region, a simple rationalisation of the region's resource (based on our contribution of 9.3% to national carbon emissions) would yield the potential for waste heat recovery somewhere in the region of 466 gigawatt hours (GWh) per year to 2.6TWh/year. Converting these estimates to CO_2e values would require knowledge of the fuel type used to produce the heat. But an estimate based on heat from natural gas[28] would yield values between 86ktCO_2e/year and 480ktCO_2e/year.

Based on this range of emissions, over a 10-year period from 2020-30, the total contribution made could amount to 860ktCO_2e to 4.8MtCO_2e.

Conclusions – ICA energy use sector

Looking into ICA carbon reduction from energy usage gives rise to a combined Eastern region saving of 6.2MtCO_2e to 10.1MTCO_2e (in the range of 14% to 23% of what is required to meet the carbon reduction budget for this sector). Other mitigating factors could include lower average space heating energy demand due to global heating, more ICA energy storage to leverage a better PV duty cycle and wider benefits from rooftop solar arrays, and more energy conscious behavioural changes in ICA practices, etc.[29]

Savings from better building insulation to improve both hot and cold thermal retention were not calculated because of the vast range of building types and factors concerning their design around processes. But this is an essential component required to narrow the gap between existing heat measures and what will be required to reach net zero by 2030.

In order to meet the 44MtCO_2 reduction budget therefore, the following measures are recommended:

- Increase the size of PV arrays on retrofitted and on new build ICA premises to allow for maximum use of suitable roof spaces.
- Implement an annual programme of Energiesprong-method whole building retrofits to improve thermal insulation in ICA premises. Offices and other 'uniform profile' buildings should be prioritised.
- Transition the ICA sector to electrical energy and displace fossil fuels as soon as possible.
- Increase process efficiency by investment in the latest technologies.
- Implement energy saving behaviour change into standard practices.
- Government to develop coherent industrial energy efficiency policy.[30]

If measures of this order were implemented in the ICA sector (recalculated using a 40kW average PV array size), and even a 45% improvement in ICA space heating energy demand was achieved through retrofit measures, it is estimated that between 94% and 103% of the net zero ICA budget would be met based on the assumptions for the size of that sector.[31]

MAXIMISING THE BENEFITS OF FLEXIBLE TECHNOLOGY

In addition to the four changes outlined above, there are many ways flexible technology (chapters 2 and 3) could further increase efficiency and reduce waste across the regional network:

- Modal shift in transport towards public systems and active travel, with the remaining car usage to EVs. The potential for transition to EVs in the Eastern region has yet to be realised but would be an efficient way to increase flexibility. Investment in smart EV charging infrastructure that is capable of supporting network balancing by choosing the optimal time to charge vehicles depending on pricing signals is recommended. Distributed smart EV charging infrastructure is a priority for accelerating the growth in flexibility capabilities, which in turn could support faster implementation of renewable energy generation capacity around the region.

- Another form of flexibility is enabled from the deployment of heat pumps and static batteries (in both homes, business and elsewhere at different scales). Heat pumps can be switched on and off according to pricing signals to save their owner's money, but necessarily depend on good building insulation to reduce heat loss during these times. Similarly, industrial and commercial flexibility schemes operating with cold storage, lighting and heating as well as fleet EV charging should be encouraged to promote flexibility opportunities.

- All new homes should be built with micro generation and domestic electrical and heat storage as standard – and the waste elimination/insulation necessary to fully take advantage of this. At scale these would not only cost less per home and reduce domestic energy import requirements but, through aggregation, domestic batteries could help satisfy DNO flexibility requirements and reap payments through a number of schemes already on offer.[32] Given that the scale of existing housing dwarfs that of new build, the same principles must also be applied to retrofitting.

- Most of the Eastern region's offshore wind farms are at a scale big enough to connect directly into the 400 kilovolt (kV) national transmission system and so would encounter the need for flexibility at a higher capacity which is often provided by commercial operators. However, as several large offshore wind farms are connecting, or planned to connect, to National Grid substations within the region, there are opportunities for co-locating large scale energy storage and even utilising the waste heat from them (from cooling the transformers and other gear in the substation, as well as cooling batteries if storage is co-located) to support new local circular economies (including fast EV charging hubs) around them.

The power of energy flexibility to drive the transition to a zero carbon circular economy is that it creates the connective tissue between different systems that depend on energy usage. Of course, looking at the benefits of a distributed energy architecture in purely monetary terms is missing the point. Saving money – while an important incentive to make changes – is not the end goal here. The ultimate aim is to achieve zero carbon by 2030 at the same time as delivering wider social benefits. Investment in flexibility also provides the ability to link different systems (energy, waste – which includes carbon emissions – and economic) and helps to build a more resilient, socially smart society.

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4 Carbon Trust/Imperial College, 2016
5 A CCC study put the gross savings (i.e. not including the cost of the additional flexibility technologies deployed) at £3-£3.8 billion annually in 2030: https://d2kjx2p8nxa8ft.cloudfront.net/wp-content/uploads/2015/10/CCC_Externalities_report_Imperial_Final_21Oct20151.pdf
6 The National Infrastructure Commission (NIC) put the gross benefits between £2.9 and £8.1 billion per year in 2030: NIC (2016), *Smart power: A National Commission Report* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/505218/IC_Energy_Report_web.pdf
7 NIC, 2016
8 As measured by MPANs (excludes Economy 7 meters as it is assumed that an Economy 7 meter customer will also have a standard meter connection
9 BEIS (2019f), *Sub-national electricity consumption* data https://www.gov.uk/government/collections/sub-national-electricity-consumption-data
10 MPAN – Meter Point Administration Number – is a 21-digit reference used in Great Britain to uniquely identify electricity supply points such as individual domestic residences
11 BEIS, 2019a
12 Barrass, Boswell and Essex, 2020
13 Based on a pro-rata share in the Eastern region of the national data for aviation, shipping and consumption emissions
14 BEIS, 2019b
15 Association for the Conservation of Energy (2015), *The Cold Man of Europe* http://www.ukace.org/wp-content/uploads/2015/10/ACE-and-EBR-briefing-2015-10-Cold-man-of-Europe-update.pdf
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30 UK Green Business Council (2017) Reforming the Business Energy Efficiency Landscape https://www.ukgbc.org/ukgbc-work/reforming-business-energy-efficiency-landscape/
31 See accompanying calculations spreadsheet – Tab2
32 For example, Moixa – www.moixa.com; sonnenCommunity – www.sonnenenergie.co.uk; Tesla – www.tesla.com; and other commercial arrangements through Limejump – www.limejump.com and others

RECOMMENDATIONS AND CONCLUSIONS

This includes the following recommendations:

- Raise ambition with targets aligned to climate emergency.
- Implement a 100% renewable distributed energy system to underpin a circular economy.
- Link the energy measures outlined here with complete decarbonisation across all sectors.
- Strengthen public sector leadership.

RECOMMENDATION 1 – RAISE AMBITION WITH TARGETS ALIGNED TO CLIMATE EMERGENCY

A target of zero carbon by 2030 is required to meet the global climate emergency. This requires far more rapid decarbonisation than the UK's current zero carbon target. A zero carbon circular economy is proposed based around a renewable electricity system.

RECOMMENDATION 2 – IMPLEMENT A 100% RENEWABLE DISTRIBUTED ENERGY SYSTEM TO UNDERPIN A CIRCULAR ECONOMY

This will combine offshore wind and a range of onshore renewables and storage solutions including community generation. Such a shift to renewables is more cost effective than, and incompatible with, one or more new nuclear reactors in the Eastern region, which is at risk from future rising sea levels.

- An increasingly local, circular and collaborative economic model facilitated by distributed energy architecture and underpinned by new, flexible technologies, such as demand side response, P2P trading platforms backed by local trading markets, and VPPs.
- Storage and flexibility, taking the opportunity of new large offshore wind farms connecting to National Grid substations to co-locate large scale energy storage (e.g. turning surplus wind power into hydrogen). Flexibility will be aided by the use of heat pumps and static batteries (in both homes, business and elsewhere at different scales) as well as industrial and commercial flexible operation of cold storage, heating and fleet EV charging.

RECOMMENDATION 3 – LINK THE ENERGY MEASURES OUTLINED HERE WITH COMPLETE DECARBONISATION ACROSS ALL SECTORS

Complete decarbonisation of energy generation is not enough. Reducing carbon emissions by 163MtCO_2 and meeting the net zero target by 2030 requires clear plans with deep demand reduction and energy efficiency across all sectors, including domestic, transport, ICA and consumption-based emissions. This will create jobs and strengthen local economies across the region.

- Whole-house retrofits following the Energiesprong-method to deliver an average 80% reduction in overall heat demand across all housing stock by 2030. Remaining heating load to be met by non-fossil fuel sources, as part of the retrofit programme (e.g. ground/air/water source heat pumps). Retrofit to include PV arrays and solar thermal to cover viable roof generation area (average of 2kW per dwelling).

- Other buildings. A similar approach is proposed across buildings in the ICA and public sectors.

- New homes (and other buildings) built with a Passivhaus fabric standard, renewable micro-generation and domestic electrical and heat storage as standard. At scale the unit cost of this will be reduced and limit overall domestic energy needs. Through aggregation, domestic batteries could help satisfy DNO flexibility requirements and reap payments through schemes already under offer.

- Transport. The transport sector needs to shift from stalling to leading emission reductions. This requires a system model that prioritises demand reduction (including shift to active travel, rethinking housing planning to reduce journey distances) and modal shift (from private to public modes) before electrification. Roll-out of smart EV charging infrastructure should be integrated into flexibility strategies and will support faster implementation of renewable energy generation capacity.

- Investigate the use of digital or local currencies to service the energy markets and retain additional value in local economies, enhancing local prosperity.

- Other sectors. Action should extend to and include industrial and commercial processes, agriculture and land use and waste management in the Eastern region, as well as imported ‘consumption-related’ emissions.

RECOMMENDATION 4 – PUBLIC SECTOR LEADERSHIP

The UK energy industry and regulators have yet to grasp the scope and pace of changes needed. This reaches far beyond technological solutions, to systemic changes and wider shifts in personal and corporate consumption patterns as part of the transition to a circular economy. A government ‘Energy Deal’ of new policies and funding is needed to mature the distributed energy model, to underpin a new, circular energy economy.

- Government/Ofgem: urgently review the TCR, which is a barrier to achieving zero carbon, as well as SEG and other green energy proposals. Replace TCR’s disincentives to small renewable generators, or set retail remuneration rates for energy exports to support adoption of DERs. Switch strategic priority to rapidly decarbonising the energy system and wider economy. Mainstream decentralised, flexible, renewables based energy system and drop less cost-effective projects including Sizewell C and Bradwell.

- Ofgem: reverse the effective fossil fuel subsidy in the environmental and social obligation costs and instead become pro-renewable energy at all scales, advancing P2P trading, and stop the monopolisation of the network by big energy suppliers. Ofgem should avoid the need for a fixed residual charge by requiring charges based on proportional use of the network.

- Local administrations/funding bodies: collaborate and reconsult on their local and regional strategies and development plans.

CONCLUSION

These recommendations are deliverable. But given the tight timetable (reflecting the climate emergency) change must be coordinated at scale. The public as well as the private sectors across the Eastern region must now take a lead to accelerate carbon reduction, with the government giving clear and consistent signals. Action by individual stakeholders must be embedded in a plan to create a circular renewable energy economy that transforms the whole nature of the Eastern region’s energy supply, in terms of sources, storage and demand.

BIOGRAPHIES

NIGEL HARGREAVES is a Chartered Engineer with expertise in distributed energy system architecture and whole system approaches to sustainability. His career spans 30 years in energy and environmental sectors with practice in renewable energy research and development, whole systems engineering and sustainability. He has worked on solar energy, smart systems and heat infrastructure, smart city infrastructure and local energy markets. His consultancy specialises in systems integration, circular economies and visions for sustainable futures.

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ACRONYMS AND ABBREVIATIONS

ATES	aquifer thermal energy storage
BEIS	UK Government Department for Business, Energy and Industrial Strategy
BTES	borehole thermal energy storage
CAES	compressed air energy storage
CAT	Centre for Alternative Technology
CCA	UK (2008) Climate Change Act
CCC	Committee on Climate Change
CE	community energy
CHP	combined heat and power
CO_2	carbon dioxide
DER	distributed energy resources
DERMS	distributed energy resource management system
DES	distributed energy systems
DNO	distribution network operator
DSO	distribution system operator
EV	electric vehicle
FES	flywheel energy storage
FIT	feed-in tariff
GDP	gross domestic product
GVA	gross value added
GHG	greenhouse gas
ICA	industrial, commercial and agriculture
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
LAES	liquid air energy storage
Li-ion	lithium-ion
LULUCF	land use, land use change and forestry
MPAN	meter point administration number
NDC	nationally determined contribution
NIC	National Infrastructure Commission
ONS	Office of National Statistics
P2P	peer-to-peer
PHES	pumped hydroelectric energy storage
PV	photovoltaic
RCRC	regional carbon reduction commitment
REA	Association for Renewable Energy and Clean Technology
SCR	Significant Code Review
SEG	smart export guarantee
SR15	IPCC *Special Report on Global Warming of 1.5°C*
TO	transmission operator
TCR	targeted charging review
UCEF	Urban Community Energy Fund
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UTES	underground thermal energy storage
VPP	virtual power plant

UNITS

t	tonne
kt	kilotonne
Mt	megatonne
kW	kilowatt
MW	megawatt
kWh	kilowatt-hour
MWh	megawatt hour
GWh	gigawatt hour
TWh	terawatt-hour
kV	kilovolt
kWp	kilowatt peak

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