Cleantech for UK

Innovation in the UK power sector

How to fast track deployment to meet the UK's 2035 goals

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Executive summary

In October 2023, the largest piece of energy legislation in UK history gained Royal Assent. The Act is designed to leverage investment in clean technologies, reform the UK's energy system, protect consumers and maintain the safety, security and resilience of the energy systems across the UK.

Additionally, the energy sector was further supported by policies set out in the government's Autumn Statement to reform both the planning system and the rules around connecting to the national grid designed to reduce wait times for decisions and connections. These measures were supplemented by business-wide policies to incentivise investment such as more generous R&D tax credits, permanent full expensing which provides tax deductions to qualifying expenditure and a new growth fund to give pension funds access to investment opportunities.

While these combined measures undoubtedly provide a positive signal from legislators, there is much more that the UK must do to ensure a stable and reliable clean energy sector that can power the UK's other decarbonisation efforts along the path to net zero.

Based on the current level of renewable energy deployment, the UK's commitment to reach net zero in the power sector by 2035 is increasingly unlikely.[1] This is a threat not only to electricity decarbonisation but also to the UK's overarching net zero commitments that hinge on the availability of cheap, reliable and plentiful clean energy to decarbonise other sectors such as road transport, buildings, industry, and the creation of low carbon fuels.

Encouragingly, the UK is home to a robust and innovative ecosystem of cleantech companies and investors that, with stronger government support, can play a critical role in accelerating the UK power sector transition. Investment in the power sector in the UK is crucial for the country's sustainable economic growth and to meet its targets. However, while the sector has seen more than £2.9 billion of venture capital invested between 2018 and 2022, there is still a need for further investment and joined-up policy and regulation.

The UK's power sector faces significant challenges, including an aging infrastructure, increasing demand for energy, and increased intermittence in generation. To address these challenges, continued investment, as well as

1 https://www.theccc.org.uk/2023/03/09/a-reliable-secure-and-decarbonised-power-system-by-2035-is-possible-but-not-at-this-pace-of-delivery/

innovation is required in the sector to modernise infrastructure, increase energy efficiency, and increase renewable sources.

Moreover, to maximise the impact of investment, policymakers and regulators need to work together to create a cohesive environment for the sector. This includes a clear and consistent regulatory framework, supportive policies for renewable energy, and incentives for innovation and investment. Efforts in this area need to be accelerated to provide a realistic chance of meeting targets. To this end, the headline recommendations presented below offer a concise path forward for decision makers. More detailed recommendations can be found at the end of this report.

1. **Implement long term policy predictability which aligns with principles of energy justice to provide strong market signals and investor confidence.** This includes committing to long-term infrastructure projects, investing in the national grid, incentivising more renewables and energy storage through Contracts for Difference (CfD's), refraining from sudden reversals, and maintaining consistency in energy policies.
2. **Accelerate market reforms to reduce grid connection wait times, and enable flexible trading, and decentralisation.** This includes enabling flexible energy trading, adapting the national grid design to accommodate diverse assets like solar PV, long duration energy storage (LDES), and onshore wind, and reducing the regulatory and licencing regime burden to promote the vital decentralisation of energy sources. This approach reduces overall system costs while enhancing adaptability and resilience in the energy grid.
3. **Incentivise skills development and address urgent skills gaps in energy transition.** Incentivisation, such as starting bonuses, career growth opportunities, and improved access to training, is vital to close the urgent skills gaps required for the energy sector. Encouraging and incentivising skill development is crucial to meet the growing demand and facilitate a well-trained workforce for the sector's transition.

Chapter 1 of this report analyses the status of the UK electricity sector. Chapter 2 provides an overview of breakthrough cleantech solutions emerging in different parts of the value chain and their potential to facilitate and accelerate the transition of the UK power sector. Following these two chapters, Chapter 3 presents the status of the UK cleantech market and investment. Finally, Chapter 4 identifies the barriers and makes detailed recommendations to accelerate cleantech investment.

UK Power sector context

1

It has been a tumultuous few years in the energy market. COVID and global high gas prices which were further distorted after the Russian invasion of Ukraine has resulted in a global energy crisis on the scale not seen since the 1970's. UK consumer prices for gas and electricity increased at a much faster rate than the EU average in both the first and second half of 2022. This can be attributed to the UK's over reliance on gas and its possession of the least energy-efficient building stock in Europe. When it comes to electricity production, the UK is second only to Italy for its reliance on gas among European countries, with 38% (125TWh) of the total generation mix coming from gas.

In October 2023, the largest piece of energy legislation in UK history gained Royal Assent. The Act is designed to leverage investment in clean technologies, reform the UK's energy system and protect consumers and maintain the safety, security and resilience of the energy systems across the UK. It was first introduced over a year ago, but its parliamentary passage was paused and the Bill was reviewed following the resignation of two Prime Ministers. The Bill was subject to significant criticism and amendment during its parliamentary passage.

One key feature of the Act gives the power sector regulator, the Office of Gas and Electricity Markets (Ofgem) a legal duty to consider the UK's net-zero carbon emissions target in all decision making. This is an important step to rebalance the focus of Ofgem, which has tended to prioritise cutting consumers' bills rather than delivering on net zero, but will now proceed to protect its customers from high electricity prices while maintaining a focus on the implementation of net zero.

Energy demand

Electrification is vital to decarbonise almost all sectors: transport, buildings, and industrial decarbonisation including hydrogen production and alternative fuels.

In 2021, the government set an ambition that by 2035 all electricity should be generated using clean sources, subject to security of supply, while meeting an expected increase in electricity demand of up to 60%, or a demand requirement more than 500TWh.

Taking a deeper look into the different sector electrification trends: in the **transport sector,** the adoption and scale up of electric vehicles (EVs) is set to increase demand on electricity. All new cars sold from 2035 onwards will have to be electric, and it is expected that approximately 80% of all cars on UK roads will be electric by then. In the **buildings and residential sector**, heat pumps in combination with distributed solar PV panels are expected to drive change; the UK government has set targets to reach 70 GW of solar capacity by 2035 and to install 600,000 heat pumps a year by 2028. The **industrial sector**, which currently accounts for 19% CO_2 emissions and consumes 13% of UK gas demand, is set to decarbonise by using green hydrogen and other electro-catalytic processes, which will drive the electricity demand. Furthermore, industrial heat pumps and disruptive electric thermal energy storage assets are becoming a gamechanger to electrify thermal processes and may be a more efficient and economical alternative compared to shifting to green hydrogen in many cases.

Power generation

The UK has only 1 remaining coal-fired powerplant online, after Drax shut its two coal-fired units earlier this year. Regarding clean power generation assets, the UK has 5.9 GW of nuclear assets and 53.5 GW of renewables (14.6 GW solar PV, 14.8 GW onshore wind, 14 GW offshore wind, and 4.7 GW Storage assets) (see figure 1).[2] The UK has the second largest installed offshore capacity (China has the largest capacity).

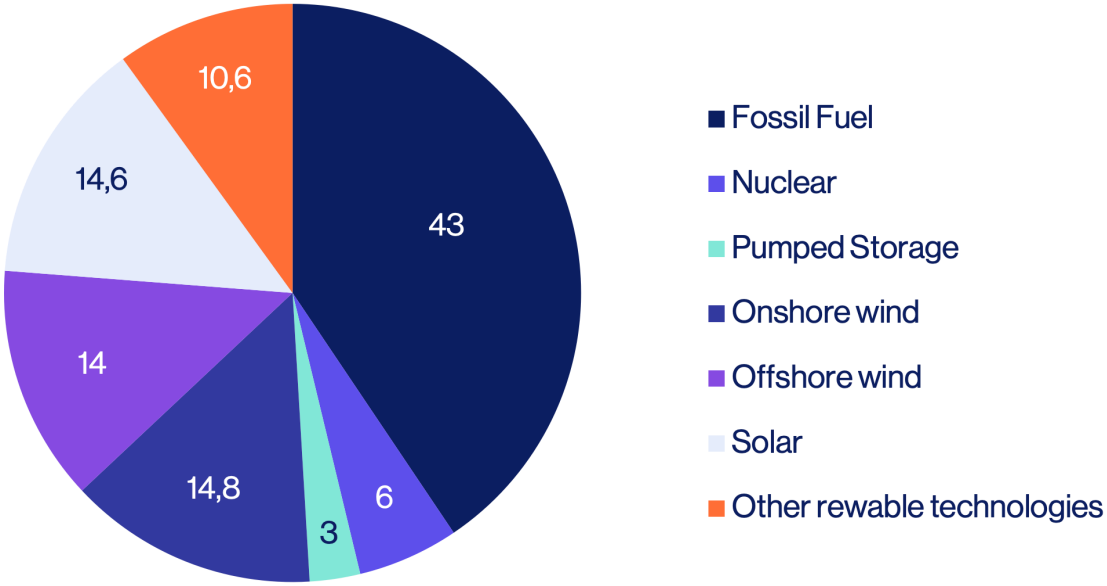

FIGURE 1: INSTALLED CAPACITY FOR ELECTRICITY GENERATION IN THE UK IN GW

2 https://www.gov.uk/government/statistics/energy-trends-section-6-renewables

In terms of power generation, 2022 saw record levels of electricity produced from renewables (41%) but they still contribute less than half of the total UK energy demand (figure 2).[3] The energy crisis demonstrates the impact of continued overreliance on natural gas and brings home the imperative to convert to energy sources which are not only cleaner, but also allows the UK to reduce exposure to factors beyond its control.

Energy UK estimates that £500 billion of investment is needed in the power sector by 2050 to reach UK net zero targets.

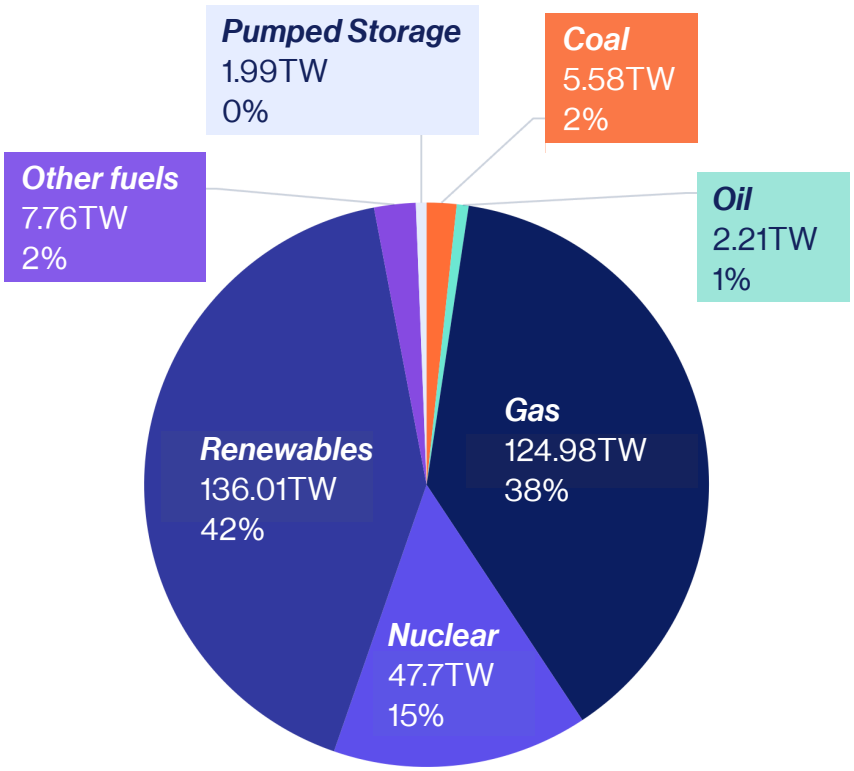

FIGURE 2: FUEL MIX USED IN ELECTRICITY GENERATION (TWH) IN THE UK IN 2022

3 41.5% of the UK's total electricity generation was supplied by renewables in 2022 https://www.data.gov.uk/dataset/894d91a9-5d13-4220-b9a2-e124e6436304/digest-of-united-kingdom-energy-statistics-dukes

Transmission and distribution networks

The UK's national grid is among the oldest in Europe and one of the earliest centralised distribution systems in the world. The onshore electricity network consists of approx. 20,000 km of high voltage transmission cables, and approx. 800,000 km of lower voltage distribution lines.

High voltage electricity is transmitted via National Grid Electricity Transmission, Scottish Hydro Electric Transmission Ltd. and SP Energy Networks to 14 distribution network operators across the country (figure 3).

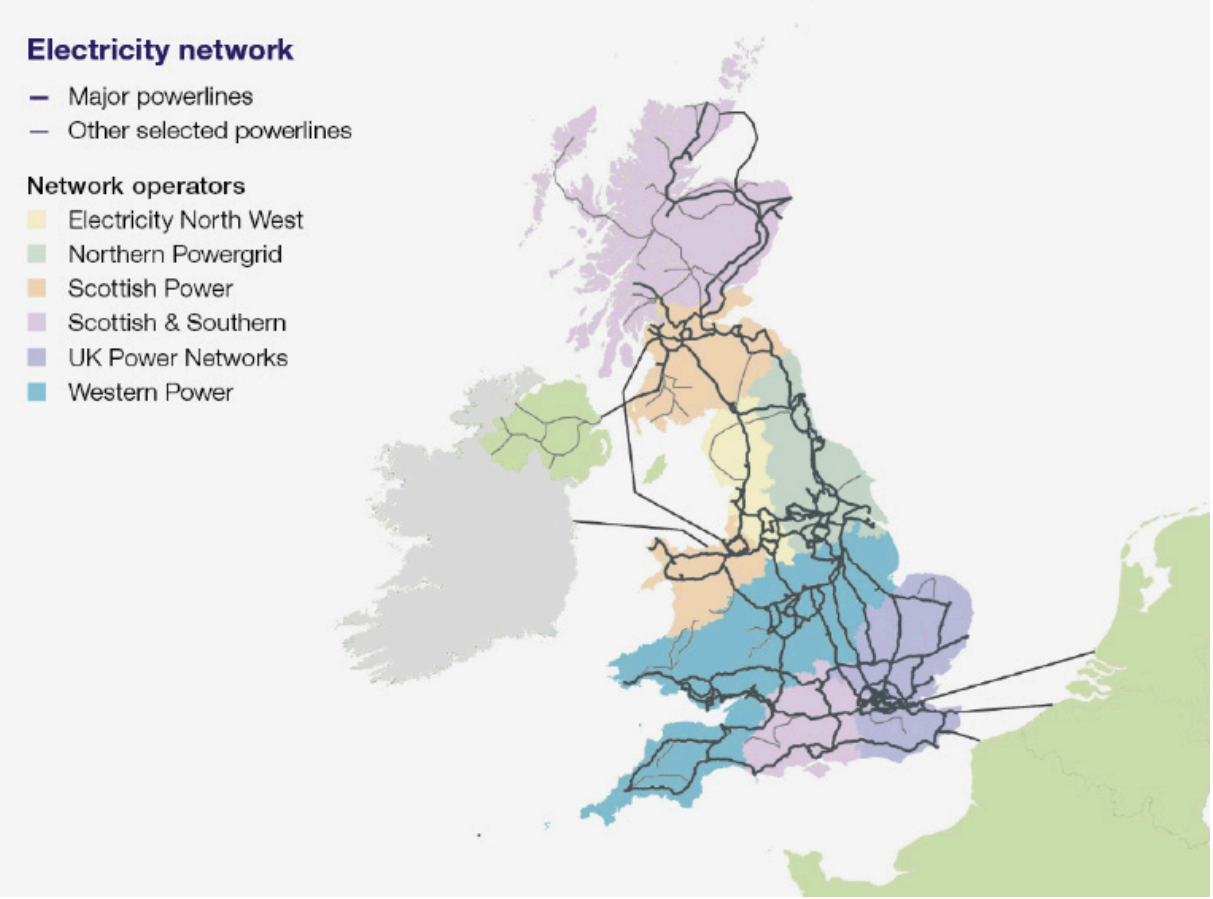

FIGURE 3: UK ELECTRICITY NETWORKS AND DISTRIBUTION AREAS[4]

4 https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future/energy-white-paper-powering-our-net-zero-future-accessible-html-version#chapter-3-energy-system

The national grid serves an island nation with 6 international interconnections and one domestic interconnector (figure 4). This presents unique challenges for grid stability and interconnection with neighbouring grids, such as the one in mainland Europe. However, it does mean that it is easily used as a testbed for grid flexibility compared to continental Europe which has over 400 interconnectors to support.[5]

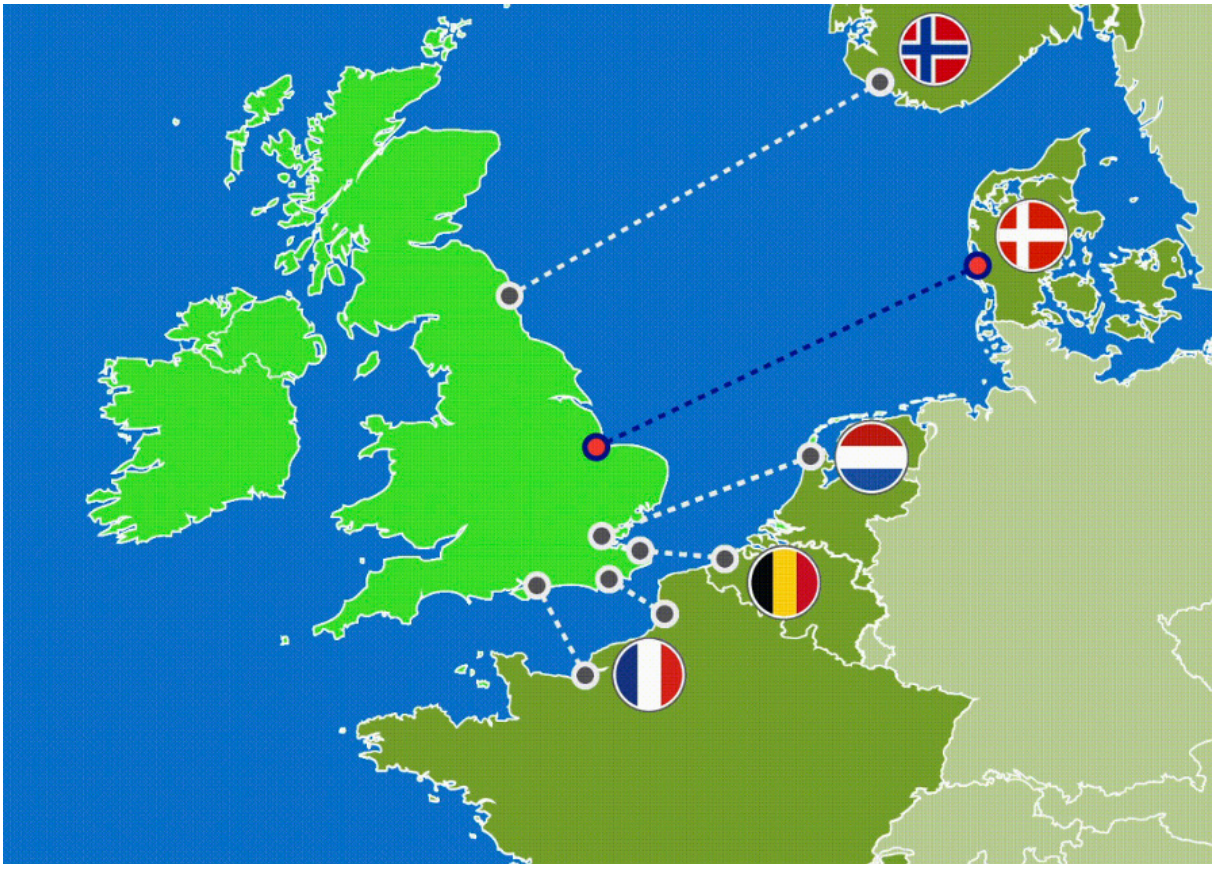

FIGURE 4: MAP OF INTERCONNECTORS IN THE UK[6]

5 https://www.nationalgrid.com/stories/energy-explained/what-are-electricity-interconnectors#:~:text=How%20many%20interconnectors%20does%20National,join%20the%20UK%20with%20Denmark
and
https://ember-climate.org/insights/research/breaking-borders-europe-electricity-interconnectors/

6 https://www.nationalgrid.com/national-grid-ventures/interconnectors-connecting-cleaner-future

Looking at the future power grid needs, the increased need for grid connections for renewable energy has put a significant amount of pressure on both the infrastructure and the operator. Historically, the operator had 40 – 50 grid connection applications per year but the demand for connections has increased exponentially to around 600 per year and there is now a lengthy queue to get renewable projects connected to the national grid (it can take up to 15 years).[7]

For that reason, there are currently over 300 GW of projects (95 GW of which are storage projects), in the queue for grid connections in England and Wales.[8] Earlier this year, National Grid initiated a short term, five-point plan to address the long connection times which includes a Transmission Entry Capacity amnesty and changes to contractual terms to enable more efficient management of the queue, which should free up around 10 GW of connection immediately. In the 2023 Autumn Statement, the government announced permanent reform of the grid connection process to cut waiting times, including freeing up over 100GW of capacity so that projects can connect sooner. Further detail on this was set out in the 'Connection Action Plan' which states that the reforms should start to have an immediate impact and has a deadline of 2025 to reach the connection within six months target.

The situation with grid connections has been compounded by difficulties in getting planning permission for infrastructure. The government announced in its Autumn Statement that it would reform and strengthen the capacity of the planning system to accelerate planning consents along with an extension of the critical national priority designation for nationally significant low-carbon energy projects.

However, the issue with connections to the UK's aging national grid has been magnified by a lack of willingness in some communities to support planning applications to upgrade and increase the pylons and cables needed for new connections.[9] Whilst the changes to planning are welcomed, they will not address the community opposition to big infrastructure, which underlines the potential opportunities and benefits from innovative power grid technologies that could increase their existing capacity, efficiency and help to overcome many of the social push-backs that new line construction brings.

7 https://www.nationalgrid.com/electricity-transmission/queue-management-next-step-accelerating-grid-connections

8 https://www.nationalgrid.com/electricity-transmission/industry-reform-transmission-connections

9 https://www.rechargenews.com/energy-transition/blighted-how-britains-wind-power-highway-plans-sparked-revolt-from-village-greens-to-hollywood/2-1-1499565

Energy Storage

The intermittency of renewables will dictate an increasingly important role for energy storage in providing a reliable supply of electricity. Currently, the UK has 4.7 GW of storage capacity, 3 GW of that storage is from pumped hydro storage, but that volume will need to rapidly expand to support decarbonisation of the grid.[10] Government plans include the deployment of 30 GW of energy storage by 2030, which will be essential to hedge electricity power prices, balance the power system and ensure renewable energy curtailment rates are diminished. As part of the plan, the UK government is also supporting the role of long-duration-energy-storage through the net zero innovation portfolio program. In total, over £69 million of capital funding has been made available across 2 competition streams.

10 https://www.nationalgrideso.com/document/263951/download

The role of cleantech in the Power sector

2

Whilst an aging power grid causes problems for new renewable energy projects trying to connect, in turn, the intermittency of renewable generation brings up additional challenges linked to that supply variability, pushing grid operators to find new ways to balance supply and demand. Innovation is vital in grid management and more broadly in the sector to support the decarbonisation of the grid. Figure 5 shows some of the innovators working in the power sector.

	Description	Active Companies
Energy Networks	• Includes transmission, distribution, DER, VPP management • VC Deals in the past 5 years: UK $133M, Germany $169M, Netherlands $77M	Origami Power over Energy, Cambridge, $74M reactive technologies, London, $31M GridBeyond, Watford, $23M piclo, London, $20.6M
Energy Storage	• Includes batteries, mechanical storage, thermal storage, battery management software • VC Deals in the past 5 years: Germany $700M, France $1.1B, UK $900M	Highview Power, London, $97M FIELD, London, $50M Brill Power, Oxford, $12M gravitricity, Edinburgh, $3M
Hydrogen	• Includes hydrogen production, electrolyzers, fuel cells, storage and transport • VC Deals in the past 5 years: UK $242M, Germany $600M, France $192M	Storegga Geotechnologies, London, $62M PROTIUM, London, $48M HiiROC, London, $34M GeoPura, Nottinghamshire, $6M Ecort energy, Bristol, $6M
Nuclear Fission & Fusion	• Nuclear Fission and Fusion companies including, advanced nuclear, small medium reactors, inertial confinement fusion and tokamaks	newcleo, West End, $307M CORE-POWER, London, $189M first light, London, $105M Tokamak Energy, Abingdon, $100M
Solar	• Includes innovators developing optimized solar PVs, cells and new business models (project developers not included) • VC Deals in the past 5 years: UK $106M, Germany $683M, France $132M	OXFORD PV, Oxford, $136M Naked Energy., Crawley, $14M
Wind	• Includes software and mechanical innovation for wind turbines (project developers not included) • VC Deals from the past 5 years: UK $83M, Netherlands $15M, France $4M	KPS, Glasgow, $10M Perceptual Robotics, Bristol, $3.3M

FIGURE 5: ACTIVE COMPANIES IN THE POWER SECTOR WHO HAVE RECENTLY RAISED VENTURE CAPITAL

Energy Demand

Flexibility can take the form of domestic assets and mechanisms including rooftop solar PV, domestic EV charging and other forms of storage and smart controls which enable load shifting and peak demand reduction. Furthermore, forecasts by National Grid ESO estimate that one third of the UK's 2050 flexibility needs to come from residential flexibility. Some energy suppliers incentivise consumers to shift their energy demand to off-peak demand through tariffs such as "economy 7" or "economy 10" or "Agile Octopus"[11].

At present, domestically produced electricity from intermittent sources can participate in markets through aggregation services, this adds cost and complexity for the household and reduces visibility for network planning.

Wholesale market reform

The current system of a single, national price for electricity is driving huge inefficiencies in the electricity system, pushing up prices for domestic consumers and industry. Moving to a system where prices reflect the local cost would deliver savings of at least £28 to 51 billion across the period from 2025 to 2040. Additionally, it would unleash much greater innovation in the UK energy sector, allowing providers of storage and flex services to make the most of electricity when it is green and cheap whilst helping to manage demand in areas and at times where supply is tight.

11 Economy 7 tariffs offer cheaper electricity for 7 hours overnight and higher prices during the day. Economy 10 offers cheaper electricity overnight and for 3 hours in the afternoon. Agile Octopus provides access to half-hourly energy prices, tied to wholesale prices and updated daily

The role of the UK smart meter programme in managing flexibility

Smart meters have an important role to play in reducing bills for consumers and helping the network operators to predict supply and demand more accurately, making grid balancing easier and more efficient and being the first stone in the pathway towards grid digitisation to become a flexibility enabler.

Whilst the benefits of smart meters are clear, the government programme to roll them out has not been smooth.

The rollout began in 2011 but only 57% (33 million) of all meters in Great Britain are now smart, although around 9% of smart meters – around 3 million – were not working as intended in March 2023.[12] The original meters installed faced interoperability issues and many were rendered dumb when a consumer switched supplier.

The deadline for complete rollout has been moved several times and energy suppliers now have an obligation to install 80% by 2025, but with limited public buy-in it remains to be seen if this obligation will be met[13].

12 https://www.nao.org.uk/press-releases/update-on-the-rollout-of-smart-meters/

13 https://www.telegraph.co.uk/money/consumer-affairs/smart-meter-why-say-no-get-one/#:~:text=The%20chief%20concern%20of%20smart,name%2C%20address%20or%20bank%20details

Power Generation

Renewables

The Climate Change Committee's most cost-effective pathway suggested that 70% of electricity should come from renewables by 2035, rising to 80% by 2050.[14] Most models predict that 150 GW of renewables will be needed in 2035, with the vast bulk of that capacity expected to be provided by offshore and onshore wind and solar PV. To meet the target, renewables development must be accelerated and the delays to connecting to the grid must be removed.

Whilst renewables can provide a significant portion of our electricity needs but may require a diverse energy mix and grid enhancements to meet all demands.

Nuclear can play an increasing role in providing the baseload electricity as the UK moves away from fossil fuels. Hydrogen may also have a role to play, but it is likely that most of the hydrogen produced will be needed for low-carbon fuels for shipping and aviation and heavy industry like steel.

Nuclear

Nuclear fission already plays an important role in the energy system (15%, 6.5 GW) and that role is set to increase to get the UK to a decarbonised power system. The UK has an ambition of 24 GW of nuclear capacity by 2050, and is building its first nuclear power station in more than 20 years, at Hinkley Point C. The government is also investing in small modular reactors and advanced modular reactors, which have the benefit of smaller capital costs and require less investment in the transmission network than large nuclear plants, however they are yet unproven. EDF, GE-Hitachi Nuclear Energy International LLC, Holtec Britain Limited, NuScale Power, Rolls Royce SMR and Westinghouse Electric Company UK Limited have been chosen for the next stage of the SMR competition run by the government. Innovators in the sector include Newcleo and U-battery.

14 https://www.theccc.org.uk/publication/sixth-carbon-budget/

The future is fusion?

The UK, along with the USA is leading the world in developing this technology. The Culham Centre for Fusion Energy is running the STEP programme, which will demonstrate the ability to generate net electricity from fusion. It also aims to demonstrate how the powerplant can be maintained through its operational life and produce its own fuel. Tokamak Energy and First Light Fusion are two key innovators based in the UK.

Geothermal

Although there is currently there is no defined role for geothermal in current UK decarbonisation and net zero plans, a recent report from the British Geological Survey and Arup, estimated that individual projects in the UK could deliver savings of between 2,400 tonnes and 14,0001 tonnes of CO_2 equivalent per year (compared with natural gas) for geothermal heating and power operations respectively.[15] CeraPhi energy is an active innovator in the UK.

15 https://www.bgs.ac.uk/news/new-report-assesses-deep-geothermal-energy-in-the-uk/#:~:text=there%20is%20no%20defined%20role,less%20aware%20of%20geothermal%20options

Transmission and Distribution Networks

Cleantech innovation is playing an increasing important role in helping the operator to manage the grid. Energy supply flexibility, in the form of demand reduction, storage, or exploitation of assets such as EVs or rooftop solar, is forming an alternative to grid system expansion. It can also be used to smooth demand, reducing the need for gas-fired peak generation, and storing excess renewable generation instead of paying for curtailment. There is a real cost to failure to integrate system flexibility: Ofgem calculates cost of system balancing interventions, such as curtailment, as £1.3bn in 2022, (up from £170m in 2010) – and this figure is forecast to keep rising through this decade[16].

Decentralisation of the grid will play an important role longer-term in overcoming the issues. A decentralised energy system allows for more optimal use of renewable energy as well as combined heat and power plants.

> We need a grid operator in a decent sized power system that is willing to go first, and showcase to the rest of the world how to maximise the use of renewables while maintaining system security.

Marc Borrett
Reactive Technologies

16 https://www.ofgem.gov.uk/publications/net-zero-britain-developing-energy-system-fit-future

Mass rollout of flexibility significantly alters the function of network operation at distribution level. Network operators need the resources to be able to evolve to fulfil this new function, to ensure interconnectivity as well as resilience. At the same time activities need to be coordinated at national level, with long term stable policy to support the grid, innovators and consumers.

Innovator insight — Reactive Technologies

London-based innovator Reactive Technologies provides deep grid insights to network operators, businesses and energy traders. Their technology allows first-of-a-kind real-time measurement of grid stability. CEO Marc Borrett notes that the UK grid is more volatile than it was ten years ago, with smaller changes having a bigger impact on stability. Without being able to measure stability, system scenario analysis demonstrates that paradoxically, adding too much storage has the potential to make the grid less stable.

Innovator insight — Piclo

Piclo Flex, a flagship product from Piclo enables system operators to source energy flexibility from flexible service providers (e.g. electric vehicles) during times of high demand or low supply. Piclo has been named on Cleantech Group's 2023 Global Cleantech 100.

Grid flexibility is the linchpin of a successful energy transition. With less than 30 years to achieve our net zero ambitions, Investing in grid innovation such as flexibility services is essential to keep up with the rapid proliferation of distributed renewable energy sources, an increasingly electrified and energy-savvy society and a constantly changing policy landscape. Start-ups require investment from like-minded investors who buy into our vision and want to be a part of the journey. Piclo's mission to decarbonise the global grid has been supported by our successful series A and series B investment rounds and has enabled us to be the market leader for flexibility services in the UK, employing over 70 staff, and with a global client list in 6 countries including the UK, Ireland, Italy, Portugal, Lithuania and North America.

James Johnston
Piclo

Energy Storage

In addition to more renewables and flexibility management, long term energy storage including mechanical, electrochemical, thermal and chemical will be needed to keep the UK powered. A report from Aurora Energy Research shows that up to up to 46 GW of electricity storage is needed by 2035 and 24 GW of that storage would need to come from long duration electricity storage (LDES) – equivalent to eight times the current installed capacity. (The government is currently targeting 30 GW by 2030).

Thermal LDES stores energy as heat or cold in various materials. Energy is then discharged directly into heat networks or reconverted into electricity. Sunamp is a key innovator in the sector and one of the winners of the government's LDES competition.

Electrochemical LDES stores energy in batteries of different chemistries. Stortera and RFC Power are example innovators.

Mechanical LDES stores potential or kinetic energy with the released energy is used to drive turbines or generators, producing electricity. These include flywheel storage, compressed air or liquid air storage, gravitational storage and pumped hydro. Oxto energy and Gravitricity are example innovators.

Chemical LDES stores electricity through the creation of chemical bonds, usually with hydrogen or syngas. Lion Alternative Energy is an example innovator using hydrogen to store energy.

Low carbon hydrogen, part of the chemical long duration energy storage solutions, has been identified as a critical component to decarbonising the power sector by the UK government. Investment into hydrogen is critical to bring its production down the cost curve. Although the initial uses in the UK will be for industry and aviation fuels, hydrogen as a medium for long duration energy storage will be increasingly critical as renewables penetration increases. Between 2018 and 2022 over £74 million of venture capital was invested into the hydrogen sector and over 90% of that funding went to hydrogen production.

Cleantech Venture Capital Investment Landscape

3

The energy sector plays an important role in the UK economy, in 2022 it provided 3.5% gross value added and received 26.4% (£16.7 billion) of total industrial investment. £10.5 billion of that investment went directly into electricity.

The UK energy and power sector is one of the biggest sectors for cleantech venture capital investment and accounted for 2 out of the top 5 cleantech deals of 2022. **Figure 6** shows that the total venture capital investment into the energy and power sector between 2018 and 2022 was over £2.9 billion, which whilst only a small percentage of the total investment into the sector, it plays an important role in supporting innovation. **Figure 6** also shows that investment dropped by more than 40% after a record-breaking year in 2021, likely due to rising interest rates and inflation. (See our cleantech overview report for more detail on overall investment).

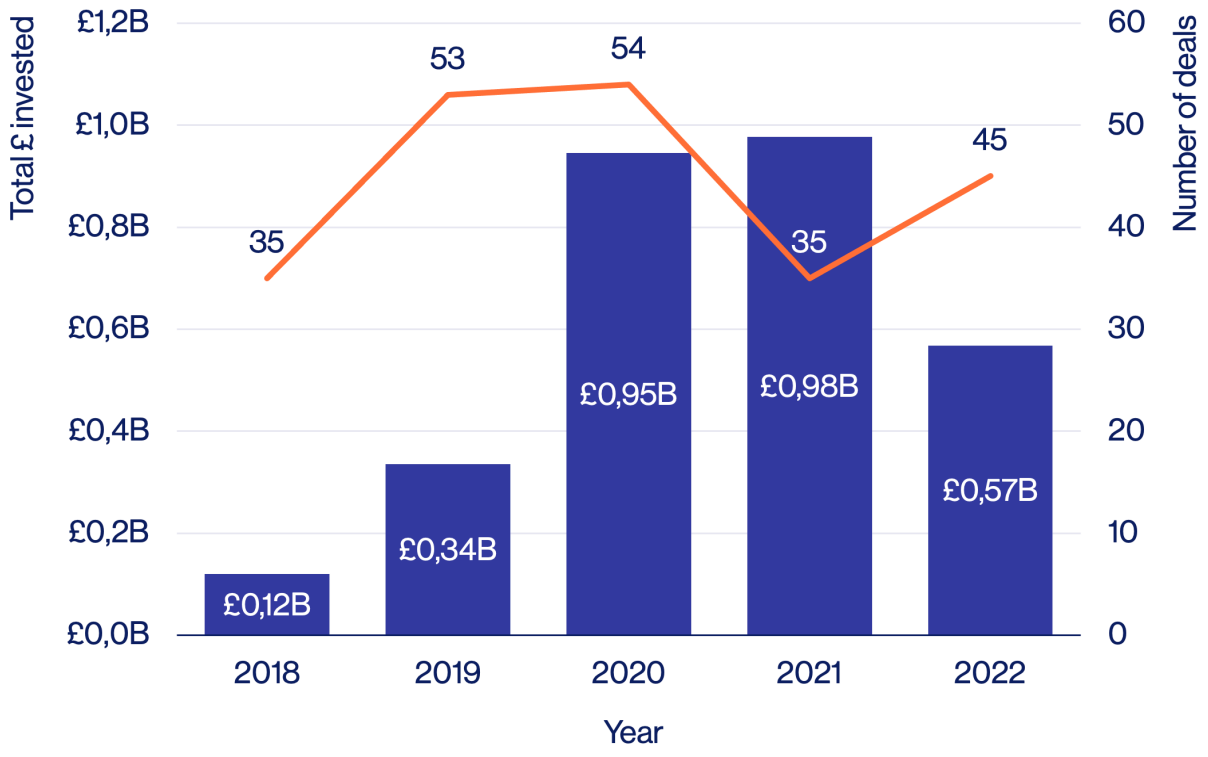

FIGURE 6: TOTAL VENTURE CAPITAL INVESTMENT BY YEAR IN THE ENERGY AND POWER SECTOR

Figure 7 indicates that most of the investment went towards energy services, which includes technologies to manage the grid and retail innovation. Only one small VC investment was made into wind technology, which isn't surprising given wind is a relatively mature technology and therefore is largely financed through project finance/debt. Hydro and marine also received very little venture investment, (£1.2 million over the 5 year period) despite being identified as a high growth and high economic returns opportunity in the Economy 2030 Inquiry.

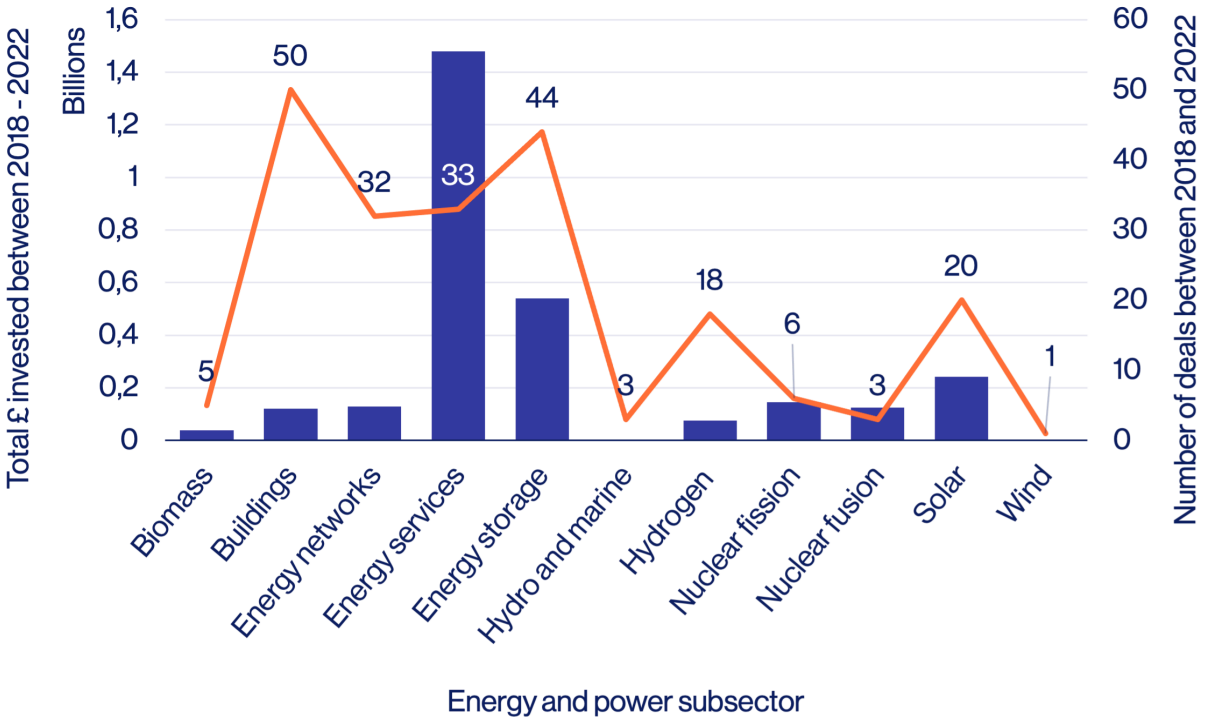

FIGURE 7: TOTAL INVESTMENT AND NUMBER OF DEALS PER SECTOR FROM 2018 TO 2022. ENERGY SERVICES WHICH INCLUDES RETAIL INNOVATION, GRID MANAGEMENT AND DISTRIBUTED ENERGY RESOURCE (DER) MANAGEMENT HAS THE HIGHEST LEVEL OF INVESTMENT

Standout innovators in the sector include virtual utility Octopus Energy, and electric vehicle charging network company, Gridserve. Founded in 2017, Gridserve raised the top funding amount ((£200 million) overall in the UK in 2022.

The UK is losing its leadership in the transition

In the last Cleantech for UK report, we highlighted that the UK is a relatively small investment market for cleantech compared to investment giants USA, China and EU. However, when looking at the energy transition, the UK performs relatively well, ranked 7th in World Economic Forum (WEF)'s Energy Transition Index (ETI)[17], in 2021[18], dropping to 13th in 2023[19]. In comparison, the high levels of investment in the USA and China have clearly paid off as they rose up the ranks from 24 to 12 and 68 to 17 respectively.

Figure 8 compares the level of investment in the top 10 rated countries in the Energy Transition Index (2021). Number 1 ranked Sweden performs similarly to the UK in the level of VC investment, but 2nd and 3rd ranked Norway and Denmark haven't attracted huge amounts of VC into the energy sector and have instead used their Sovereign Wealth Funds to spearhead their transition. Among the list of the top 10 countries, only the United Kingdom does not have a publicly or part publicly owned renewable energy generation company[20]. Despite the UK performing relatively well in attracting VC investment, it hasn't yet propelled the UK into a world leader in the energy transition.

14 The Energy Transition Index rates countries' energy transition based on three aspects: economic development and growth, energy security and access, and environmental sustainability

15 https://www3.weforum.org/docs/WEF_Fostering_Effective_Energy_Transition_2021.pdf

16 https://www3.weforum.org/docs/WEF_Fostering_Effective_Energy_Transition_2023.pdf

17 https://hansard.parliament.uk/commons/2022-10-31/debates/D2E93BD7-1A0E-40FA-8829-0B3D9412F589/PublicOwnershipOfEnergyCompanies#:~:text=As%20the%20independent%20campaign%20group,owned%20renewable%20energy%20generation%20company

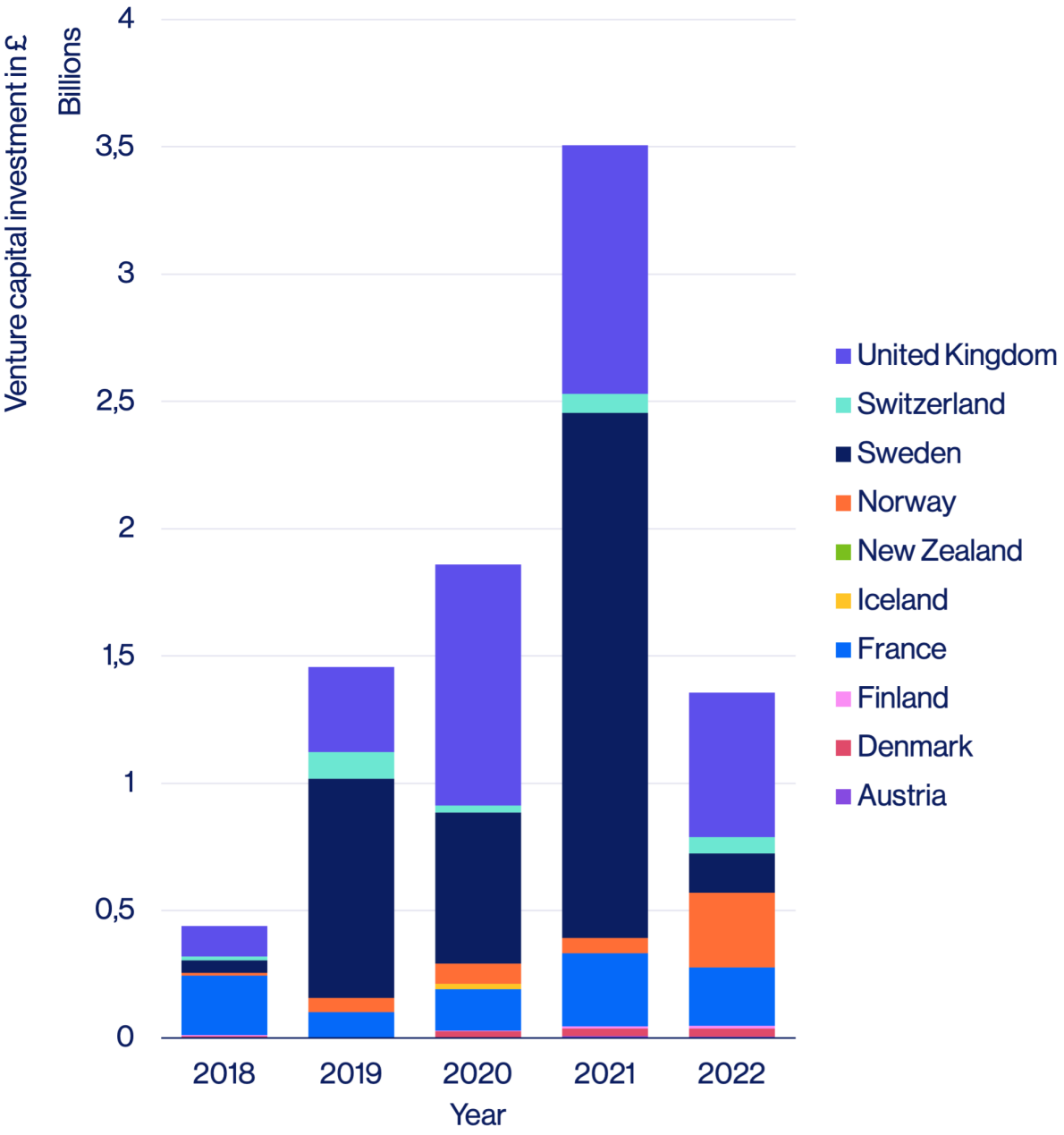

FIGURE 8: COMPARISON OF VC INVESTMENT IN THE TOP 10 RANKED COUNTRIES IN THE ENERGY TRANSITION INDEX (BASED ON THE 2021 INDEX)

Despite the UK's relative success in the energy transition and its ability to attract investment, innovators have reported a variety of obstacles in scaling their business and rolling out their solutions. These range from lack of investment and tactical barriers to system level inefficiencies, which are discussed later in the report.

Figure 9 and **Figure 10** indicate that the power sector is facing a similar series B funding gap as faced by other cleantech sectors as detailed in the first cleantech for UK report, but the unique challenge of the lengthy wait for grid connection may be contributing to investor reluctance to invest at this stage.

Furthermore, the power sector is arguably the most heavily regulated, complex sector and requires huge amounts of capital investment with a long period for return on investment. This has been further compounded by the current high cost of capital and huge increases in project costs relating to inflation and supply chain issues.

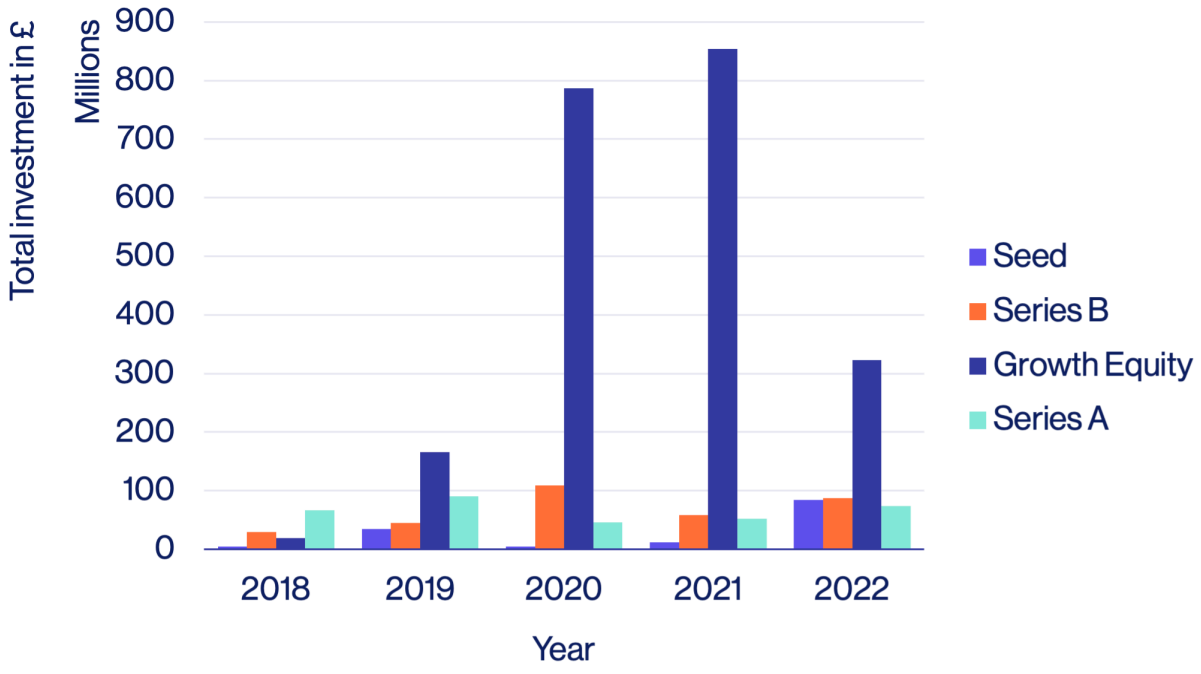

FIGURE 9: TOTAL AMOUNT OF INVESTMENT AT EACH STAGE IN THE UK POWER SECTOR BETWEEN 2018 AND 2022

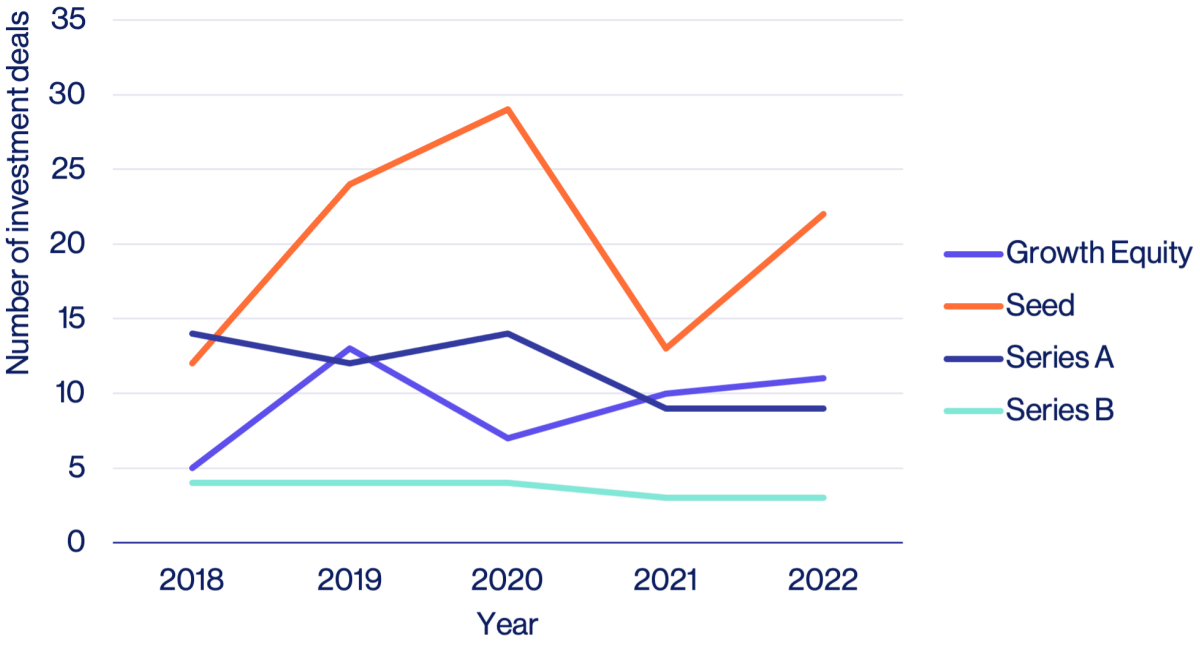

FIGURE 10: NUMBER OF DEALS COMPLETED AT EACH INVESTMENT STAGE BETWEEN 2018 AND 2022

A high level of private investment is needed to reach projected goals

Energy UK has estimated an additional £500 billion of investment into the power sector will be needed between now and 2050 to meet the UK's Net Zero goals.[18] That would require annual investment to double into the sector, based on the total investment in 2022. As well as giving innovators the visibility needed to develop a business model, long term policy signals are essential for investor confidence to attract this level of investment. There is a risk premium associated with short term planning cycles, which translates into lower private investment leverage per unit of public investment.

Ofgem notes that "High levels of uncertainty, combined with long lead times, natural monopolies, new/emerging technologies, and dependencies between different energy assets" mean that "The scale and pace of investment required will not be delivered by free markets alone."[19]

18 https://www.energy-uk.org.uk/news/uk-falling-behind-in-race-for-clean-energy-investment/

19 https://www.ofgem.gov.uk/publications/net-zero-britain-developing-energy-system-fit-future

In the Autumn Statement 2023, the government unveiled several initiatives not specifically tailored to the sector but poised to bolster the advancement of energy infrastructure and innovation. Announcements include a £4.5 billion allocation to fortify the UK's manufacturing capabilities, a new Growth Fund, backed by a permanent capital base exceeding £7 billion sourced from pension funds, and the establishment of a £20 million fund dedicated to cross-disciplinary proof-of-concept research funding.

In tandem with these funding initiatives, the government announced that tax deductions for qualifying expenses, known as full expensing, will be made permanent, the R&D tax credit system would be simplified and made more generous, and an extension of the Enterprise Investment Scheme (EIS) and Venture Capital Trusts (VCT) until 2035.

Barriers to Cleantech Investment and Recommendations

4

Policy consistency is vital to driving the transition. Whilst the policy ambition has been clearly set by the UK government, it has been slow to follow it with concrete delivery plans to get the UK to that target and at the current pace of change it is in danger of missing its target.[20] In addition to the lack of clarity, the government has also rolled back on the deadlines for selling new petrol and diesel cars and the phasing out of gas boilers, which has caused confusion and disappointment in the sectors.

A large increase in deployment of renewable energy technologies is needed urgently to keep the UK on track to meet its 2035 target. To support this deployment, earlier this year, the government lifted restrictions that constituted an effective ban on onshore wind development through changes to the National Planning Policy Framework. However, in September 2023, the UK renewable energy auction secured just 3.7 GW of new renewable capacity – a third of the total from last year's auction – and failed to attract any new offshore wind contracts, seriously undermining the government's commitment to full decarbonize the power sector by 2035. Industry had warned the government ahead of the seminal renewables auction that supply chain constraints, inflation, cost overruns and delays would require a higher floor price in the auction. Instead, the auction returned the lowest renewable generation since the first auction in 2015 and seriously damaged the UK's reputation as a world-leading market for offshore wind energy.

The government acknowledges that the current electricity market arrangements need to reform to deliver the pace and scale of change to meet the changing power demands, but the government has been slow to deliver on a concrete plan for reform. Consultation on the reforms was first launched in 2022, and a second round of consultation is expected in Autumn 2023.

The government has also committed to outlining a clear approach to gas vs. electricity rebalancing by the end of 2023, which will play an important role in consumer behaviour change by sending clear short-term price signals to shift both households and businesses to lower-carbon technologies. Companies should also be obliged to pass on cost savings to consumers to support the price signalling to speed up adoption.

20 https://publications.parliament.uk/pa/cm5803/cmselect/cmbeis/283/report.html

In addition to these policy issues which are creating barriers to investment and scale up, UK innovators point to the following barriers and required actions which would allow them to scale faster, accelerating the adoption of flexibility:

Supply side activity needed

Decentralised energy projects: the regulatory and licensing regime needs to be reformed to reduce the burden on decentralised energy projects.

Small scale market participation: Through the electricity market reform, mechanisms need to be introduced to support small scale market participation, such as marginal locational pricing, which are essential to allow small-scale flexibility assets to trade directly, instead of going through aggregators.

Infrastructure activity

Grid connection delays: The grid connection queue includes gas peak capacity plants which are economically unviable and will not get built, as well as batteries and renewable power generation projects. Whilst National Grid's five-point plan is welcomed to begin to address this issue, long term reforms are urgently needed. UK start-ups also report high grid connection costs, which again disadvantages smaller innovators with limited resources.

Excess curtailment: lack of real time visibility leads to more curtailment than needed. Better modelling of the impact of flexibility additions is needed, to better understand both build out, system planning needs and to quantify the amount of electricity storage is needed.

Visibility of small-scale generation and storage assets: at present there is no register of small-scale assets. This hinders network operation, as well as supply forecasting, and planning. Additionally, utilities are not required to share generation data, which also prevents network operators and innovators from developing a system-wide view of network operations.

Data and Digitalisation: Planning is underpinned by data, and making data accessible to innovators is key to enabling innovations in grid planning as well as optimising ongoing operations.

Difficulty accessing smart meter data: at present data can only be accessed through an energy company, or using a license: this disadvantages smaller innovators, who do not have the resources needed to follow burdensome administrative procedures. More open data access would boost innovation.

Skills gap: as well as supply chain issues, heat pump rollout is constrained by availability of trained installers. Likewise, domestic EV charging infrastructure rollout will require large numbers of electricians with the requisite skillset. Latest data shows there are 259,000 electricians and electrical fitters in the UK, and myenergi projects an installation need of 8 million home charging points by 2030. Similarly, there is currently a 12 week wait for rooftop PV installations, due to a lack of installation capacity. More broadly, several studies highlight the shortage of green skills across all sectors, and whilst this is an issue worldwide, the UK is trailing several major economies when it comes to green skills.[21, 22, 23]

Demand side / consumer activity

Smart meter rollout: bidirectional residential metering is essential, both to allow residential assets to participate in flexibility markets (by sending and receiving capacity signals to distribution networks) and to provide data needed for planning and system modelling. Greater encouragement for smart meter buy-in from consumers is needed to complete the roll out.

Restrictions on maximum connected capacity: distribution network operators are concerned that households which install on-site PV generation, storage and heat pumps may exceed demand thresholds, which is leading some operators[24] to request upgrades to three phase power. This risks adding unnecessary effort and expense.

21 https://economicgraph.linkedin.com/research/global-green-skills-report

22 https://www.pwc.co.uk/press-room/press-releases/Energy-transition-constrained-by-c200000-jobs-PwC-GJB.html

23 https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2023/01/Skills-and-wage-gaps-in-the-low-carbon-transition-Comparing-job-vacancy-data-from-the-US-and-UK-1.pdf

> The supply chain has competing objectives. Our technology simplifies the complex for building operations. Taking into consideration network and supply variables alongside the needs of the building users to predict energy demand and carbon whilst providing simple recommendations that optimise energy usage. Most building operators today cannot get access to appropriate information to make informed decisions. Regulation needs to drive change.

Paul McCorquodale
Grid Edge

Avoid a two-tier system: Minimum energy efficiency standards have driven improvements in residential energy efficiency, especially in rental properties, although these were recently weakened by the government. However, there is still a green premium[25] associated with residential flexibility – a heat pump costs many times more than a new gas boiler. This means that households most in need of energy savings cannot afford the cost of investing in assets which will reduce their bills over the long term. Better availability of financing options, zero VAT on energy efficiency, PV and storage or other consumer incentives, combined with education campaigns, can help to increase uptake across all layers of society.

24 https://www.statista.com/statistics/318824/numbers-of-electrical-and-electronic-trades-professionals-in-the-uk/
25 https://www.gatesnotes.com/Introducing-the-Green-Premiums

Case Study – Companies addressing the skills gap head on

Myenergi Academi

Myenegi offers apprenticeships, internships, and post-graduate schemes throughout all areas of their business. It is open to school, college or university leavers and mid-careers looking to move into climate tech.

Octopus Energy

Octopus Energy offers free training to plumbers and heat engineers to learn how to install heat pumps.

French Battery Manufacturer - Verkor

Verkor formed a consortium of 11 partners to develop new training programmes in battery manufacturing for all qualification levels, from technical training certificates to PhDs.

Detailed Recommendations:

1. **Implement long term policy predictability which aligns with principles of energy justice to provide strong market signals and investor confidence.** The recent announcement on new licences for oil and gas fields, rollback on target dated for banning petrol cars and gas boilers and the cancelation of HS2 has sent the wrong signal to investors on the UK's ability to stick to long-term infrastructure projects. Consistent, forward-looking energy policies are essential for a fair and stable transition to sustainable solutions.

2. **Accelerate market reforms which will enable flexibility trading.** National Grid should pursue a network design with the flexibility to accommodate assets which can reduce overall system costs, such as PV, LDES and onshore wind.

3. **Adopt and implement rapidly wholesale market reform** to introduce locational pricing to unleash innovation in UK supply demand, whilst delivering savings of £28-51bn in the period between 2025 to 2040.

4. **Distribution System Operators need to evolve to integrate and manage an increasingly more electrified and distributed demand side.** Reinforcement of transmission lines, cross border connections, offshore transmission, innovative power grid technologies should also be addressed. They may need support and increased resources to do this.

5. **Prioritise the permitting process for strategic assets.** Generation and storage projects which contribute to net zero goals should benefit from fast-tracked grid connection and permitting processes.

6. **Provide longer term clarity on energy efficiency regulations,** which can help to drive investment and gear up the relevant supply chains.

7. **Implement consistent standards for smart meters that encourage interoperability.** Interoperability is key to widespread adoption of innovative solutions which need to interact with smart meters.

8. **Carry out public engagement activity** to increase the rapid adoption of smart meters and provide information on how consumers can switch to electrification also for heating and transport.

9. **Implement strategies to increase training / upskilling of PV, heat pump, behind the meter storage and EV charging infrastructure installers.** Installation rates are already constrained in many areas by a lack of sufficiently qualified installers or service engineers. Increased rollout will require many more.

10. **Facilitate data availability for smaller innovators** through a data sharing framework.

Cleantech for UK

Introducing Cleantech for UK

Launched in February 2023, Cleantech for UK is an initiative which was set up to provide a collective policy voice for a group of climate focused, UK based investors. Cleantech for UK advocates for policy reforms to support and increase the flow of private investment into cleantech, to develop climate technology in all forms. The coalition comprises of a group of company builders and investors spanning the innovation lifecycle from company formation to IPO and beyond, united in trying to bring forward the next generation of UK clean industry. Further detail on the coalition can be found here.

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Lead Writers
Sarah Mackintosh, Cleantech for UK
Lucy Chatburn, Cleantech Group
Noah Ross, Cleantech Group
Holly Stower, Cleantech Group
Alex Crutchfield, Cleantech Group
Nino Lazariia, Cleantech Group

Key Contributors
Richard Youngman, Cleantech Group
Todd Allmendinger, Cleantech Group
Jules Besnainou, Cleantech for Europe
Selene Law, Cleantech Group

Contributors
Julia Reinaud, Alberto Toril, Tom Rollason, Mariano Berkenwald, Breakthrough Energy; James Woolner, 44.01; Michaela Kendall, Adelan; Stewart Arbuckle, AgriCarbon; Duncan Ross, Agri-EPI Center; Michelle Robson, AP Ventures; Jon Saltmarsh, BEIS; Steve Martin, BEIS; Natasha Fowlie, Beyond Net Zero; Gabriel Oke, Binding Solutions Limited; George Mills, British Patient Capital; Max Middleton, British Patient Capital; Sam Goodall, Sylvie Russell, Cambridge Cleantech; Laura Gillion, Aniruddha Sharma, Carbon Clean; Andrew Lever, David Aitken, Carbon Trust; Tom White, C-Capture; Beverley Gower-Jones and Maria Khan, Clean Growth Fund; Kavita Surana, Complexity Science Hub Vienna; Caitlin Wale, Counteract; Lorenzo Conti, Crover; Tyler Christie, Decarbonization Partners; Adam Tomassi Russell, Deep Science Ventures; Kamran Iqbal, Electric Aviation Group; Maria Sicilia Salvadores, Pharoah Le Feuvre, Enagas; Lynn Cote, Export Development Canada; Suzanna Hinson, Green Finance Institute; Paul McCorquodale, Grid Edge; Oscar Cantalejo Sanchez, Diego Diaz Pilas, Iberdrola; Ramana Nanda, Imperial College London; Bryony Livesey, Sarah

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Cleantech for UK

Thank you

Feel free to contact us with any questions you have

Sarah Mackintosh
Director
sarah.mackintosh@cleantech.com

Joel Boehme
Communications Officer
joel.boehme@cleantech.com